1. INTRODUCTION

The workshop was held on Kerkenna Island in Southern Tunisia from 23 to 25 September 1999. Eighteen scientists in all representing eleven countries from the entire periphery of the Mediterranean, plus two experts on fisheries management from Canada and FAO, attended at the invitation of CIESM.

The meeting was opened by Professor Amor El Abed, Director of the Institut National des Sciences et Technologies de la Mer (INSTM), who welcomed the Director General and the Secretary General of CIESM, the Delegate of Kerkenna along with all the participants, wishing them a good stay on the island. Prof. El Abed reminded everyone of the major importance of fisheries in Kerkenna, a main point for selecting the island as the venue for this workshop. He stressed the good quality of the relation between CIESM and Tunisia and its relevance for fishery research in his country. Prof. El Abed suggested that fishermen as well as administration and researchers should collaborate closely for reaching consolidating conclusions and forming the necessary legislation.

The Director General of CIESM, Professor Frederic Briand, thanked the National Representative of Tunisia, Professor El Abed, warmly for his kind words and for faciliting the organisation of the workshop in Tunisia. He considered the selection of Kerkenna for such a workshop to be ideal in view (1) of the historical importance of fisheries in the island, (2) of the maintenance of certain traditional fishing practices that are worthy of serious consideration in the framework of "modern" precautionary strategies, and (3) as an illustration of the excellent collaboration between CIESM and Tunisia. He expressed the hope that participation of scientists from many different Mediterranean countries would enrich the quality of the debates, by bringing in different cultural and scientific perspectives.

The Delegate of Kerkenna addressed the assembly with the hope that the selection of Kerkenna, an important fisheries location, home for more than 4,000 fishermen, would consolidate the efforts of the workshop. He welcomed all the participants on behalf of the Governor of the province of Sfax and wished them success in their work.

1. 1. Background and objectives

The past few decades have seen considerable innovation and development in the management and regulation of fisheries worldwide. However, this has met only with partial success. Recent fishery failures, combined with changing views on management philosophy, point to the critical need for new approaches. The recent collapse of major exploited fish stocks emphasises the urgency to develop management strategies that minimise the risk of falling below an undesirable threshold.

Some new ideas suggest an explicit way of considering precautionary considerations. Acting with precaution implies acting in advance, taking into account current uncertainty and the potential consequences of possibly being wrong. Precautionary fisheries management will aim at reducing and eliminating negative impacts of the fishery on the resource and the fishing community itself, to ensure sustainability of the fishery.

Principle 15 of the 1992 Rio Declaration states that: "*In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation*". In the aftermath, FAO (1995) proposed a document of definition of the precautionary approach to fisheries as well as an elaboration of the burden of proof. A major challenge is to translate this noble principle into action at the local and regional levels, and for scientists to set appropriate limit as well as target reference points in the face of uncertainty. The CIESM workshop aimed to discuss the scientific dimensions of this issue.

This meeting is the outcome of a series of consultations, both during and after the 1998 CIESM Congress in Dubrovnik, where the Committee of Marine Ecosystems and Living Resources and the DynPOP task force proposed the venue of a workshop on the "precautionary approach to local fisheries in the Mediterranean". The main objective of the workshop was to bring together experts from Mediterranean and non-Mediterranean countries with practical experience in the various fisheries science fields, so as to explore the adaptation of precautionary principles to fisheries management science in the Mediterranean region.

1. 2. Mediterranean specificity

As stressed by the participants and most explicitly by Jordi Lleonart (see pp. 15 in this report), Mediterranean fisheries represent a perfect test for developing a precautionary approach:

- fishing activity has steadily increased there over time, yet scientific information about it remains dispersed and /or scarce;
- the lack of reliable time series on which to base fishery models only amplifies the uncertainties of the predictions;
- adaptive management is usually absent, despite a context of fast and drastic changes in the biodiversity and hydrology of the Mediterranean sea;
- a rapidly growing population and urbanisation along the littoral, a record number of tourists, a scarcity of effective marine protected areas, render the objective of reaching sustainable fisheries particularly daunting.

Many participants agreed that the high specificity of the Mediterranean precluded the blind application of reference points of use in the rest of the world. A major scientific objective near term will be to define precautionary reference points applicable to the Mediterranean.

Such considerations are at the heart of this report. Hence, before going any further, the reader unfamiliar with the specificity of the Mediterranean fisheries and with the current state of the stocks is referred to recent reports of FAO/GFCM and to the 1998 paper of Farrugio and Papaconstantinou in CIESM Workshop Series n°5 "Gaps in Mediterranean Fishery Science". In addition essential socio-economic and demographic projections will be found in the series of Blue Plan Reports.

2. WHAT IS THE PRECAUTIONARY APPROACH ?

2. 1. Description of the concept

While aspects of a *Precautionary Approach* (PA) have been used in fisheries management in many parts of the world, it has been only relatively recently that the PA has been codified in legislation. Its first signs can be seen in the UN Convention on the Law of the Sea (1982). However, it was not until the Rio Declaration (1992) that the term *precautionary approach* was used (see Principle 15). The 1995 FAO Code of Conduct for Responsible Fisheries and the UN Straddling Stocks Agreement (1995) or UNFA added many specifics, including reversal of the burden of proof and a system of limit and target *Reference Points* (RP). It is noteworthy that few nations have legally binding legislation that explicitly addresses the PA. One exception is the Canada Oceans Act (1997) which explicitly calls for the Canadian government to adopt a precautionary approach in its management of ocean resources. It is likely that with time other nations will enact similar legislation.

It is important to clarify what a precautionary approach entails. The reader will find in Garcia (1996) a complete review of the PA (with definitions, history, etc.) applied to fisheries. The contribution by Lleonart in this report provides a thorough (re) examination of the principles involved, with a welcome emphasis on the risks associated with overfishing.

The essence of the PA is stated in UNFA Article 6.2 as "*States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation or management measures*". This has been referred to as erring on the side of caution. UNFA goes on to outline target and limit reference points as the primary mechanism for implementing the PA, suggesting that target RPs should not be exceeded on average, and that limit RPs should only have a very low probability of being exceeded. Both fishing mortality (F) and biomass (B) RPs are presented as guides. Since UNFA, a number of organisations have focused attention on defining the values of the RPs, and turning the PA into reality, the International Council for the Exploration of the Sea (ICES), and the Northwest Atlantic Fisheries Organization (NAFO) in particular. The focus in these efforts has been the definition of F and B targets for the single stocks, with issues of ecosystem productivity and biodiversity less well considered.

Recent work (on the Canadian East Coast in particular) has called for an expansion of the PA well beyond the RP focus (discussion paper in preparation). The PA should consider all aspects of the management system, from objectives to decisions making and not just RPs, which are only one element of a complex management system. For instance, one cannot consider management precautionary if the RPs cannot be implemented. This broader view of the PA may provide a useful framework in which to discuss Mediterranean fisheries.

To fully appreciate this approach, one must first define the elements of a management system. Management systems can be considered to be composed of both activities (objective and strategy setting, implementation of regulations and assessment & research) and institutions (for decision-making and information management) (O'Boyle, 1993). *Objectives* should be valid over long periods with the performance of the system being managed assessable against them. For instance, the maintenance of habitat productivity is a conservation-related objective. The productivity of directly impacted and ecologically dependent species as well as trophic balance needs consideration in this objective. Similarly, the maintenance of biodiversity (within populations and species and across species) is a conservation objective. Objectives are achieved through *strategies*, which define both performance indicators or measures (features of the population) and targets or *reference points* (specific values of the parameters). There should be a set of *Performance Measures* (PM) and RPs associated with each of the objectives. Table 1 illustrates the linkage among some hypothetical but realistic objectives, PMs and RPs necessary to achieve conservation. Note that the traditional F and B RPs are only a subset of the first objective of the maintenance of habitat productivity.

Table 1. Performance measures and reference points to meet conservation objectives

a) maintenance of habitat productivity

Objective	Performance Measure (PM)	Reference Point (RP)
• Maintenance of directly impacted species	1 - fishing mortality 2 - spawning stock biomass 3 - area of distribution 4 - by-catch	1 - $F_{0.1}$ 2 - SSB_{min} 3 - % areal distribution at moderate abundance 4 - % by-catch limit
• Maintenance of ecologically dependent species	1 - abundance of key predator 2 - condition of key predator 3 - % prey in predator diet	1 - minimum abundance of predator 2 - minimum condition of predator 3 - minimum % in predator diet
• Maintenance of Trophic level (TL) balance	1 - slope of size spectrum 2 - Pauly's FIB Index 3 - aggregate annual harvest by TL	1 - minimum slope 2 - minimum index 3 - % harvest from each TL

b) maintenance of biodiversity

Objective	Performance Measure (PM)	Reference Point (RP)
• Maintenance of ecosystem and species diversity	area of shelf disturbed by harvesting	% of each habitat type that is undisturbed
• Recovery of species at risk of endangerment	1 - no of individuals of species at risk 2 - geographic area of distribution	1 - min no and decline rate of species 2 - % areal distribution at moderate abundance
• Maintenance of genetic variability within species	1 - no of spawning populations of target species 2 - law selection differentials	1 - % reduction in species spawning area 2 - minimum selection differential
• Maintenance of genetic variability within population	1 - no of spawning components of stock 2 - law selection differentials	1 - % reduction in stock spawning area 2 - minimum selection differential

Regulations are controls implemented to either avoid the limit RPs or achieve the target RPs. Note that enforcement activities are considered as part of this. *Assessment and research* are those activities undertaken to both monitor the resource (assess the state of the PMs in relation to the RPs) and conduct research to improve understanding, particularly to improve the *strategies*. Regarding institutions or *governance*, there are typically two interacting bodies – the *decision makers* who set management plans and the *information managers* who provide the decision makers with options, based on technical analyses of gathered data.

Typically the *decision-making* consists of government/industry consultative and/or advisory committees. The *information managers* consists of not only the institutions that collect and analyze the scientific information (the research laboratories), but also those bodies used to peer review the advice before it is provided to the *decision makers*.

Erring on the side of caution is a new concept with the introduction of the PA. It implies both a predictive capability of the impact of the regulations and their effective implementation. Focus has so far been placed upon measures of uncertainty in stock status and risk analysis of various management options. A PA would also require monitoring the performance of the regulations, through specific PMs and RPs (*e.g.* by-catch limits, measures of the effectiveness of surveillance, etc). Thus, not only is the resource being monitored but so too is performance of the management system. Both *regulations* and *assessment and research* activities are concerned with this aspect of the PA.

The institutions of *decision-making* and *information management* relate to the implementation of a decision-making process. Decision rules are a key element of the PA and agreement on them is an essential role of the *decision makers*. Indeed, consultation with stakeholders on the PA is critical to its successful acceptance and implementation and thus having effective consultative structures is one of the key components.

It is evident that many of the elements of the PA already exist in current management systems. However, it is the integration of the elements working together to achieve stated goals that defines the PA. In this sense, the PA is more than the sum of the parts, with all elements of the management system present and effectively working together.

2. 2. Precautionary approach and Mediterranean fisheries

As stressed by Lleonart, Mediterranean fisheries are diverse, reflecting a great variety of cultures and approaches to sea products. Small-scale, family-based fishing is of paramount importance, relying on many different fishing methods, some of them sharing areas with landings in many points along the coast. It would be difficult to find targets applicable to all the areas or gears in the Mediterranean.

Nevertheless, the unity of the market leaves open two opposite approaches for consideration :

- a uniform policy for the whole Mediterranean; or
- a regionalised management with different areas applying different, adjusted rules.

3. Precautionary Management

3. 1. Management objectives

Objectives are essential to any management system. They determine where you are going and when you are there. One often stated objective is sustainable fisheries, which is compatible with maintaining ecosystems. However, the participants felt that attainment of sustainable fisheries was a longer-term objective, requiring more concretely defined short-term objectives to achieve. Indeed, without getting into specifics, it was considered that objectives could be nested from the general (sustainable fisheries) to the specific (reduce effort – but see comments below). However, it was pointed out that while objectives dealing with conservation and socio-economics are considered, there was a more general sense that the underlying objective in the current management system was the avoidance of problems in the fisheries. Under a PA, this is no longer enough and an explicit set of objectives is required.

The participants discussed what current and future objectives may exist in the Mediterranean. From this discussion, it was evident that there was confusion as to what an objective actually was. For instance, some considered that the redistribution or increase/decrease of effort was an objective. However, these are really means to some end. In this sense, they are regulatory activities. It is essential to be clear as to why a redistribution and increase/decrease in effort is being undertaken. What is the objective? Is it related to conservation of the resource, *e.g.* safeguarding a spawning area or stock biomass, or is it related to fleet profitability? These objectives need articulation. Some participants stated that measurement of the attainment of socio-economic objectives implied the use of cost-benefit analyses.

Having clarified the nature of objectives, the workshop considered what objectives are currently available in the Mediterranean. It soon became evident that most nations exploiting the resources of the Mediterranean need to develop explicit objectives.

Notwithstanding the above, the participants agreed that the most fundamental objective upon which all others rest is that of conservation, for which a concrete definition is required. Two aspects of conservation were considered, the productivity of the ecosystem and the species composition or biodiversity. Maintenance of ecosystem productivity would include the following parameters:

- maintenance of directly impacted species, which relates to the maintenance of species that are exploited by fisheries and is common in many fisheries management systems;
- maintenance of ecologically dependent species, which relates to those species that, while not caught by fisheries, are impacted through food chain linkages;
- maintenance of Trophic Level (TL) balance, which relates to the overall balance of productivity in the ecosystem.

Maintenance of biodiversity would include the following:

- maintenance of ecosystem and species diversity, which relates to species diversity at the ecosystem level;
- recovery of species at risk of endangerment, a special case of the considering the particular case of endangered species
- maintenance of genetic variability within species and within population, which relates to biodiversity (as defined by genetic variability) within species (the number of stocks) and with populations (the number of components within a stock).

3. 2. Targets / Reference points

A number of reference points have been proposed and adopted in fisheries management regimes outside of the Mediterranean; these are mainly based on levels of fishing mortality and biomass levels relating to single species management situations. However, it was apparent in the discussions that such single stock indices would have restricted application for most Mediterranean fisheries. Yet, there would be benefits in a close scrutiny of the feasibility, advantages and inconvenients of such reference points in situations commonly found in the Mediterranean.

Despite the apparent appeal of reference points as management aides or guides, few fisheries management regimes use reference points, particularly for the study area. Given the limited information that is available it appears, that to incorporate reference points into management measures in the Mediterranean, new indices must be developed on the basis of available information. They cannot be dependent on traditional stock assessment measures, as such analyses are rare in the Mediterranean.

It was noted that other management regimes have undertaken considerable work in reference point analysis using a modelling approach and that such work could be of great relevance to the situation in the Mediterranean.

3. 3. Ecosystem management

Many industrial sectors use the oceans: aquaculture, commercial and recreational fisheries, oil and gas, transport, tourism, and so on. Some employ formal plans to manage their activities, some do not. The term *ecosystem management* is a misnomer as ecosystems are not managed but rather human activities within them. It is therefore preferable to discuss the incorporation of ecosystem objectives within the conservation component of each of these sectoral plans (Sinclair *et al.*, 1999). In this report, *ecosystem management* is used in this context. For ecosystem management then, there is a need for the integration of sectoral plans into ecosystem management plans for designated areas of ocean in which the combined activities are managed such the ecosystem is not put at risk.

The issue of boundaries for ecosystem management was raised – the biological ecosystem, the administrative region, political unit, etc. The definition of ecological boundaries is difficult and fraught with difficulties and debate. On the other hand, administrative and political boundaries often do not agree with biological considerations. Thus, ecosystem management units will have to be defined using a combination of biology and practicality. The group felt that it is premature to define ecosystem management areas for the Mediterranean although some possibilities were discussed. These need to be further investigated in future meetings.

It is pertinent to ask that if fisheries were managed to achieve single species objectives, would conservation of the ecosystem be assured. Recent work by ICES, as discussed at the March 1999 ICES/SCOR symposium in Montpellier, shows that the answer is likely no. Genetic diversity of target species, by catch species and dependent species would all still be at risk and food web interactions would not necessarily be accounted for. The addition of ecosystem objectives to single species fishery plans, as well as to other sectoral plans, would be required to safeguard the ecosystem, particularly to address biodiversity and by-catch considerations, and thus make the plans precautionary from an ecosystem management perspective.

The Mediterranean has experienced significant species colonizations over the last decades, as it has over its history. These rapid changes in biodiversity present significant challenges to an ecosystem management approach but it is important to discriminate between natural and human induced changes, i.e. fisheries *versus* climate. The participants felt that management could only react to these changes and ensure that harvesting does not harm the ecosystem. A precautionary approach to this situation is to develop new fisheries in a gradual manner, scaled to the knowledge available. As knowledge grows, so too could the fishery. The workshop noted the lack of developing fisheries protocols for the Mediterranean and considered this a requirement for the whole region.

3. 4. Management tools

An array of tools is available to the manager to safeguard and enhance habitat productivity and biodiversity. Technical tools, which concern fishing procedures, measure of gears and catches, fishing periods, are reviewed here by Lleonart (see pp. 15). Other tools, focused on ecosystem protection or rehabilitation and on economic measures (taxes, subsidies), include :

3. 4. 1. artificial reefs

The continental shelf of the Mediterranean is not as broad as in other places around the world. Generally, it extends about 3 miles from the coast or to the 50-m isobath. If trawl fishing is forbidden within these limits, other gear and user group conflicts arise. Demersal resources show signs of overfishing by catches represented mainly by 0+ and age 1 year fish. In recent years, certain areas of the Adriatic, lower Tyrrhenian, and southern Sicily, have shown signs of reduced biomass in the demersal and some of the pelagic stocks. There is also evidence of increased nutrient load contributed to the inshore waters by the Mediterranean industrial countries. Artificial reefs and related forms of mariculture may contribute to solving some of these problems.

Many authors define artificial reefs as objects made by man, or natural objects, placed in selected zones for the purposes of creating and improving the habitat and, therefore, increasing productivity and harvests of desirable species. There is no doubt that ties exist between artificial reefs and open sea mariculture. It has been shown that artificial reefs support shellfish culture and that within artificial reef protected zones, suspended farming activities can be created. Also floating artificial structures can serve as supports for the settlement of "seed" of mussels, oysters and similar bivalves, thus furnishing a supply of seed to traditional shellfish farms. The floating shellfish farming structures additionally serve as trophic attractors for different fish species.

French experiences with artificial reefs date from 1982 and are oriented towards preventing illegal trawling and to attracting and concentrating fish and fauna. Different ecological ideas are behind these projects, hence different technologies are used, but with a common goal; to improve small-scale, local fisheries by increasing income and stimulating development of fishery cooperatives (self-managing restricted areas). Different technologies are employed according to the objective. Scientific and technological investigations continue. Small volume, local commercial fishermen are very interested in obtaining concessions to build new artificial reefs and authorities are looking favourably upon these requests in a more concerted effort to manage coastal resources and control fishing effort.

3. 4. 2. marine protected areas (MPA)

Recent evidence — see reviews by: Davis, 1989; Bohnsack, 1990; Roberts and Polunin, 1991; Pollard, 1993; Novaczek, 1995 from Lauck *et al.,* 1998; Allison *et al.,* 1998; Hall, 1998; and references therein — indicates that one of the most potentially effective management techniques to enhance the spawning success of inshore/demersal and reef fishes, and particularly those contributing to multi-species and multi-gear fisheries, is the creation of marine protected areas (MPAs), which represent an "extreme" case of the precautionary approach (Lauck *et al.,* 1998). Such protected areas, in which fishing is prohibited, allow a certain proportion of the stock to grow to a relatively large size at which overall fecundity is greatly increased. These areas provide not only an abundance of recruits to the surrounding fished areas, but also a certain proportion of the larger adult fishes which may stray out of the refuge areas into those that are fished (Pollard, 1993). Apart from the more immediate benefits in the enhancement of surrounding fished areas, the longer-term benefits of MPAs should be to decrease the trend for heavy evolutionary fishing selection for earlier maturity and reproduction and smaller adult fish size (Bohnsack, 1990). The management measures would not only provide protection for population age structure and genetic variability within the stocks, but also of the species composition of the fish community. MPAs thus provide a refuge in space rather than a refuge in numbers, the latter being the aim of most traditional fisheries management measures.

The MPA concept can be very efficient and is directly applicable to the Mediterranean fisheries because of their extreme multispecies and multigear nature, and the great difficulty experienced in effectively managing them by any other technical means. The advantages of MPAs can be generally summarized as:

(a) they protect the biomass and population structure of commercial species;
(b) they limit by-catch of juveniles and non-target species;
(c) they protect biodiversity including genetic diversity;
(d) they protect essential life stages of commercial species;
(e) they protect and enhance productivity;
(f) they decrease the trend for heavy evolutionary fishing selection for earlier maturity and reproduction and smaller adult fish size (longer-term effect);

(g) they provide a location of marine research;

(h) they protect artisanal and community fisheries;

(i) they enhance educational, recreational and economic opportunities;

(j) they hedge against inevitable uncertainties, errors in estimations, and biases in fisheries management; and finally

(k) there should be some areas where human impact is kept at a minimum – "*an argument that requires no science*" (Hall 1998).

Integrating science into the design of Mediterranean MPAs was the object of another CIESM Workshop (see CIESM Workshop Series n°8, 1999), to which the interested reader is referred.

3. 4. 3. management of invaded species in relation with ecosystem changes and long term changes

As is well known, the Mediterranean Sea is invaded by species from the Red Sea (i.e. Lessepsian migrants) and from the Atlantic Ocean (see CIESM Atlas of exotic species on www.ciesm.org). While the latter are still of less importance to the Mediterranean fisheries, Lessepsian migrants nowadays support important fisheries in the Eastern Mediterranean. The continuous process of colonisation of the Eastern Mediterranean Sea by Lessepsian migrants indicates that the ecosystem allows for additional links in the food web and thus that communities are loosely packed with competition most probably playing an important role in shaping the local communities. Competition can mediate adaptations such as habitat selection and/or resource allocation or extinction. Competitively mediated vertical habitat displacement of local species by Lessepsian migrants is generally the case in the Eastern Mediterranean Sea, the former usually maintaining themselves in deeper and cooler waters. Indeed, Lessepsian migrants have partially replaced other local species of commercial importance in the Eastern Basin (*e.g.* Israel). A typical example is the *Mullus barbatus* and *Upeneus mollucensis* complex, with the latter having displaced the former to deeper waters. Another example is *Siganus luridus* in the Dodecanese area, which varies greatly in abundance in response to the temperature changes in the area. Such changes require special management schemes inasmuch as factors other than fishing (*e.g.* climate) seem to play a very important role, sometimes possibly masking the effect of fishing. Given the lack of information for many of the invading species and their long-term ecological effects on the ecosystem as a whole, the application of the precautionary approach may be very important in such cases.

3. 4. 4. new fisheries in the Mediterranean

The Mediterranean is characterised by multispecies fisheries with various practices according to the local socio-economical context, as well as the climatic. Deep-water fisheries appear only in the Western Mediterranean and the Sicilian strait, FAD fisheries take place in the SW Mediterranean, while there are a lot of fishing techniques that are similar to each other and are used along the shallow coasts and lagoons of North Africa.

During the last years, because of the overexploitation of the marine biological resources and an increase of the fishing effort, there is a trend of applying fishing techniques in areas where they did not exist 10-15 years ago. The extension of tuna fisheries in Eastern Mediterranean and particularly in Greece in the mid-80's is quite characteristic: a great number of Greek fishermen became involved in tuna fisheries and equipped their vessels with the appropriate gears, while many fishermen changed their boats to larger ones. In the early 90's, however, tuna fisheries declined and a great number of fishermen returned to coastal fishing.

The narrow continental slope of the Mediterranean has compelled fishermen of the Western Mediterranean to extend fisheries in great depths (till 800 m, especially red shrimps). The limited development of trawl fisheries in the Eastern Mediterranean, because of rather low investments in fisheries, did restrict the harvesting of deep waters. During the last years however, a considerable effort has been exerted in Greece to extend the fisheries to the deep waters of the Ionian Sea, where significant red shrimp stocks appear to exist. This would lead to the diversification of fishing effort from relatively shallow areas to deep waters, thus alleviating the pressure on overburdened stocks.

Development protocol for new fisheries

The development of new fisheries should be made with particular caution, on the basis of appropriate research studies on the characteristics of the target-stock (i.e. the species biology, dynamics, geographical distribution, etc.). Such knowledge is a prerequisite, in order to design the protocol for the new fisheries that would aim to the rational exploitation of the stock. In the opposite case, the lack of relevant data would most probably result in the collapse or overexploitation of the population right after its intense fishing.

The study of the various fish stocks exploited in the diverse areas of the Mediterranean should be based on well organised research plans along properly designed protocols.

These protocols should provide a detailed description of the following:

- the sampling gear to be used;
- the target species of the research and their scientific names;
- the metric and meristic characters that will be measured and the exact way of measuring them;
- the biological characters that will be studied during the research, their collection and their description;
- the fishery data that will be used, their collection and definition;
- the socio-economic data of the fishery to be used, their collection and definition;
- the collection method of the ecological characters of the environment;
- the methodology to be used for population studies;
- the organisation of appropriate data banks for data input, storage and elaboration.

3. 4. 5. pilot areas for scientific and management purposes

Although there are significant differences in species composition from sub-region to sub-region, we can say that many of the commercially important shelf species are ubiquitous, but since they are confined to shelf areas, stock distributions are likely to occur in sequence along narrow shelves or form a clime of gradually changing characteristics.

Some local stocks, *e.g.* demersals lying on narrow shelves within territorial waters, are purely national and exclusively fished by the local port or ports. Here, as for lagoon fisheries, in consistency with the empirical approach of Gulland to defining stocks as "fishable units of adults", the smallest fishery unit would consist of one or several ports and their local fishing grounds. One would, of course, need to look more broadly in defining population reproductive units; however, it seems unlikely for shelf resources of a semi-enclosed sea with "deep basins" that larvae from stocks on one side of the sea recruit to shelf areas on the other.

In attempting to define Natural Management Areas as an ecologically diverse region as the Mediterranean Sea, Caddy (1998) reviewed five eco-geographical categories of use:

- the faunal province and the natural management area;
- the area occupied by a homogeneous ecological community (with its linkage to the related concept of the food web);
- the critical habitat and the refugium;
- the area occupied by a unit stock (the stock distribution area);
- the shelf area under the influence of a local fishing port.

to conclude that, until further data are acquired, it would be practical to use GFCM sub-areas as Natural Management Areas and within these larger units, especially for narrow shelves, to define arbitrary portground units as the smallest management units. For larger extensive shelf areas such as the Adriatic and the Gulf of Lions/Gabes, the conventional approach of assuming, unless otherwise evident, that unit stocks of the key species coincide with these areas, seems the logical interim course of action.

3. 4. 6. controls

Regulations must be practical – or they will be unenforcable – and appropriate to the circumstances which they are intended to control. And, self-evidently, they must be enforced with penalties appropriate to the nature of the infraction and the probability of detection. However, management systems should avoid the need for expensive enforcement costs by encouraging self-compliance and peer pressure on recalcitrants. Regulations should be reviewed regularly to monitor the effectiveness and their marginal costs and benefits. Where possible enforcement should be the responsibility of the fisheries department. The review of regulations could be part of an annual management process to ensure that they adapt to changes in the nature of the resource. Regulations should encourage/require behaviour that reduces uncertainty in management decision making. For example, regulations should require that appropriate data be provided when required by participants in the fishery as a condition of their fishing license.

When controls are difficult, consideration should be given to strictly enforced no take zones, which in order to function, must be off limits to all fishing activity. The status of the fauna (species diversity and abundance) should be monitored in these areas and appropriate penalties imposed for those who violate the regulations. Effective fisheries conservation can be greatly assisted by public pressure – and this means of building support for management should not be overlooked. Marine protected areas (such as no take zones) can play an important role in this regard through public education programmes. Monitoring programmes should be implemented where no take zones are implemented to determine and demonstrate their effectiveness. Such monitoring should include measures of their effect on surrounding fisheries.

3. 4. 7. monitoring

Fishery surveys are an absolute necessity since comprehensive studies of the biological status of most of the demersal fish stocks in the Mediterranean are entirely lacking Mediterranean countries must promote such studies and one way of doing so is to establish an international survey of the demersal stocks. It is hoped and expected that the collection and analysis of appropriate survey data will allow the countries to formulate scientifically-based proposals towards sustainability of the stocks. The primary objective of such surveys should be to provide data from which relative indices of abundance and demographic structures can be derived. Over a period of years, this will allow definition of trends and/or changes in spawning stock biomass, recruitment, etc., information central to fisheries management. Such data would also be useful for investigating further topics.

<u>Geographical area</u>

The surveys must cover both the continental shelf and slope, as:

- certain species exhibit seasonal migrations from the shelf to the slope;
- the juveniles of some species are found predominantly on the shelf and the adults predominantly on the slope;
- certain species of potential or actual commercial importance inhabit only the slope. Other species currently being exploited or potentially exploitable inhabit both the slope and abyssal plain or inhabit only the abyssal plain.

In recent years, the fisheries have increasingly fished on the slope to gain additional access to previously exploited stocks and to gain new access to previously unexploited stocks.

<u>Frequency and timing of the survey</u>

For some species, it is believed that there are two recruitments in the Mediterranean per year to the fishable stock. Some species recruit once per year either in spring or in autumn. For a number of species, the mortality rate is such that the number of individuals recruited in spring/autumn is greatly reduced by the following autumn/spring.

Thus, two surveys are required per year for the fishery survey in the Mediterranean, one in the spring and the other in the autumn. Furthermore, to better accommodate geographical variation in time of recruitment, work in the eastern Mediterranean might take place earlier than in the western area. More precisely, the two surveyed periods would be respectively April-May and September-October in the eastern area, and May-June and October-November in the western area.

<u>Statistical design</u>

The recommended statistical design is that used nationally, i.e. random sampling stratified by depth. Where national strata boundaries are adjusted to accommodate the international survey there should be little or no loss of statistical efficiency.

The allocation of sampling effort (replication) to each stratum could be optimised by minimising the variance of the overall index of a given species for a given cost of the survey. This is achieved by making the number of stations in each stratum proportional to the product of the area of the stratum and the standard deviation of the index within the stratum. In practice, however, this is compromised by the need to provide indices for more than one species, each of which expected to have a different standard deviation of index. Consequently, an allocation proportional to the surface of the strata would be the best compromise.

4. THE DECISION MAKING PROCESS

4. 1. Governance [1]

If fisheries management is to be effective, or in fact, if there is to be any fisheries management at all, appropriate methods of governance must be in place. To ensure this, there may be benefits in explicitly reviewing how fisheries governance works in selected fisheries on a case study basis together with an audit of its effectiveness and efficiency.

Good governance requires adequate consultation between those responsible for management decisions, those who advise them and those responsible for the technical analyses on which such decisions should be based. It was the view of the meeting that these linkages are weak, function poorly and are not well defined. These deficiencies extend to other activities associated with fisheries governance such as formulation of regulations and their implementation.

Good governance should move away from the common *command and control* type of paternalism towards co-management with effective participation of fishermen and other relevant stakeholders in review of management plans and other related activities.

There was common agreement that current fisheries management in the Mediterranean, to the extent that it exists at all, is reactive and not proactive; thus the opportunity to invoke precautionary management is usually forgone and stakeholders have no option but to consider remedial methods of management.

Of particular concern was the absence of clear understanding of management objectives and how objective formulation and articulation works. This process should be reviewed and clarified to ensure that as far as possible, decision making is guided by well expressed management objectives.

Effective management requires that all stakeholders are involved and that their expertise is fully used. Fisheries scientists should be involved in advising on the consequences of different management options and they should accept that this will require advice on the basis of their judgement, degrees of belief and other subjective approaches – sufficient scientific advice may not always be available and operational decisions usually cannot be deferred.

4. 2. providing stakeholders with incentives for conservation and good management

Rehabilitating fisheries resources is made difficult, if not impossible, when fishermen perceive that they will not benefit from the short-term sacrifices which they make. If others can enter the fishery (as its profitability improves) they have no incentive to accept short term costs.

The solution is the adoption of strengthened forms of property rights in the fisheries of a type appropriate to the fisheries in consideration. Such rights-based management methods have been found to encourage fishermen participation in management and encourage greater responsibility on their part, as they become the beneficiaries of improved management.

[1] For the purposes of this discussion, *governance* is considered to mean the system by which organizations are directed and controlled. It should not be concerned with day-to-day operational details but rather the giving of overall direction and control of executive actions of management, satisfying the legitimate expectations for accountability and regulation. Good governance usually involves openness or disclosure of information, integrity or straightforwardness in dealings with stakeholders and completeness and accountability by responsible managers. Clear allocation of responsibilities is a prerequisite for this. New government governance often includes incentive systems to encourage achievement of goals. Other attributes of good governance may be reputation, trust, reciprocity, and mutual dependence. Governance is usually broader than governments.

Efforts should be undertaken to see if experiences in rights-based management in other areas of the world would have applications and relevance to the situation of fisheries in the Mediterranean Sea.

It was agreed that subsidies could be destructive to fisheries ecosystems by encouraging further overfishing when, in the absence of interventions, fishing effort would decline in response to declining levels of stock abundance. In other management regimes, increased profitability was correlated with withdrawal of subsidies; where policies of cost-recovery are in place, there is noticeably greater involvement by the industry in co-management and support of management objectives and regulations.

It was noted that fisheries should not be penalised or favoured by tax systems in relation to other similar sectors of national economies. In collecting revenues from fisheries, the first emphasis should be on recovery of management costs, and only then on resource rents, if in fact, this was national policy (many management regimes opt to recover rent through standard tax procedures).

4. 3. implementation of precautionary management

An important component of the precautionary approach to fisheries management is the need to incorporate uncertainty into management advice and adopt an appropriate level of risk aversion in deciding upon management levels. It was noted that uncertainty can arise in many ways (*e.g.* model error, data variability, irreducible uncertainty from inability to predict future events, such as levels of recruitment and uncertainty about the effectiveness of management measures.

Several tactics exist whereby management uncertainty can be reduced. An important one is that of no take zones or marine reserves. Such zones will provide some insurance from overfishing, whether deliberate or arising from incorrect calculation of TACs or other management target points. Given the management situation in the Mediterranean, it is believed that such approaches have the greatest chance of being effective.

5. Main recommendations

The Mediterranean fisheries constitute a perfect case for considering and testing the precautionary approach. The context is one where fishing activity has been increasing along time but scientific information has remained scarce. Fitting models to poor fisheries data, without long historical standard data series can only yield highly uncertain results. Furthermore adaptive management is completely absent so mechanisms of learning from the exploited systems are lacking. To remedy this situation the CIESM workshop recommends that Mediterranean countries take the following steps:

- investigate the objectives of management available from their national offices and communicate them to proper agencies;
- adopt on an interim basis integrated conservation objectives such as those developed in this report, relating to the maintenance of ecosystem productivity and biodiversity,
- develop protocols governing the development of new fisheries in their area;
- document, analyse and review the effects of subsidies on the sustainability of Mediterranean fisheries.

Precautionary approach and Mediterranean fisheries

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1. Introduction

This paper will attempt to match theory and practice of the precautionary approach with the Mediterranean fisheries.

The *precautionary principle* is a set of criteria of prudence and avoidance of risks to be used in the management of natural resources. In particular it should be applied when the scientific knowledge of the exploited system is uncertain, and human activity likely to produce hazardous effects on the environment.

The application of the precautionary principle to the management of natural resources has been set up by several international documents and agreements: the UN Agenda 21 – Programme of Action for Sustainable Development (1992), The Rio Declaration (1992) and the Maastricht Treaty (1992) among others.

Although there is some discussion about the meaning of the expressions *principle* and *approach* about precaution (Garcia, 1996; ICES, 1997), in this paper *principle* is used as the philosophical basis of the precaution and *approach* as its practical application (Garcia, 1996). Therefore in most cases they will be synonymous.

In Garcia (1996) a complete review of the precautionary approach (with definitions, history, etc.) applied to fisheries can be found. The need of applying the precautionary principle to fisheries has been set up by many international documents and agreements reviewed also in Garcia (1996). Due to their importance, the Code of Conduct for Responsible Fisheries (FAO, 1995a) and the UN Conferences on straddling fish stocks and highly migratory fish stocks (1993-1995) should be mentioned. Many international commissions for fisheries have already analysed that in relation with their own fisheries and problems. In the particular case of the Northwestern Atlantic fisheries, mainly due to cod collapse, the literature is abundant: Finlayson (1994), Rogers (1995), Gordon and Munro (1996), Harris (1998).

The Mediterranean fisheries constitute a perfect case where the precautionary approach should be considered. The fishing activity has been increasing along time and the scientific information about it is scarce. Fitting models to poor fisheries data, without long historical standard data series, yields highly uncertain results. Furthermore, adaptive management is almost completely absent so the management procedure lacks mechanisms of learning from the exploited systems. The Mediterranean fisheries management mainly consists in a set of rules rarely based on scientific criteria and many of them not implemented.

2. THE PRECAUTIONARY PRINCIPLE

According to Pearce (1994), the precautionary principle implies: (i) an emphasis on prevention rather than cure and (ii) an emphasis in taking strong preventive action in a context of uncertainty. These characteristics imply a high degree of risk aversion, another key feature of precautionary approach. Regarding natural resources, the precautionary principle is attached to sustainability. No exhaustive description of the precautionary approach will be presented here, as there exists an abundant literature on the subject, both general (O'Riordan and Cameron, 1994) and applied to fisheries (FAO, 1995b, 1996; ICES, 1997). Nonetheless, the most general framework on that principle can be set up, among others, in the following points:

1. **role of science** : natural processes appear to operate in ways that are not fully understood by conventional scientific methods (O'Riordan and Cameron, 1994). Hence, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Point 15 of the Rio Declaration).
2. **anticipatory action** : prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly (O'Riordan and Cameron, 1994; FAO, 1995b).
3. **intergenerational equity** : consideration of the needs and rights of future generations and avoidance of changes that are not potentially reversible (Point 3 of the Rio Declaration; FAO, 1995b).
4. **paying for past ecological debts** (O'Riordan and Cameron, 1994)
5. **safeguarding of ecological space** or environmental room for manoeuvre as a recognition that margins of tolerance should not even be approached, let alone breached (O'Riordan and Cameron, 1994)
6. **promoting the cause of intrinsic natural rights** (O'Riordan and Cameron, 1994)
7. **uncertainty** : where the likely impact of resource is uncertain, priority should be given to conserving the productive capacity of the resource (FAO, 1995b).
8. **reversal of the burden of proof** : duty of care, or onus of proof on those who propose change. Systematically give to the resource the benefit of doubt.
9. use of precautionary *reference points* in order to prevent and avoid risks.

It should be pointed out that economics plays a very significant role on resource management, hence the precautionary approach needs to be developed not only with biological criteria but also taking into account economics (Pearce, 1994; Gordon and Munro, 1996; Huppert, 1996; Symes, 1999; Bailly and Franquesa, 1999). However not all economists agree on that. Economists belonging to the neo-liberal school explicitly refuse several of the main points defining the precautionary approach. Intergenerational equity and shifting the burden of proof are among them, often supplemented with an exaggerated confidence in technological progress to solve environmental problems and not believing that certain processes are actually irreversible (Mas-Colell, 1994).

3. SUSTAINABILITY, VARIABILITY, OVERFISHING AND RISKS

Overexploitation, or *overfishing* in their specific meaning in relation to fishing, can be defined as the excessive exploitation of a renewable resource so that it is put on danger of depletion, or the yields are inferior to those that would be obtained if less intensity or more selectively were applied.

The concept of *sustainability* goes associated to that of steady state that is an almost platonic ideal about fisheries management. The sustainable exploitation of a renewable resource implies the extraction, in a unit of time, of a biomass equivalent to that added, by growth and recruitment, to that resource in the same unit of time. The biomass is then kept at a constant level, below the carrying capacity of the system, while the equivalent biomass is extracted from the natural growth of the resource.

The causes of overfishing (and in general of the renewable natural resources overexploitation) are multiple, with three dominant ones : biological, economic and social. In this paper, I will mainly deal with biological causes. In any case overfishing is the result of a process led by the competition for a common renewable resource. Since this is a bio-economical activity without feedback mechanisms of self-regulation (Hardin, 1968) and under a high level of scientific uncertainty, the precautionary policy is one of the few procedures to prevent overexploitation. Other methods not discussed here but anyhow compatible with precaution, are based on the modification of the word "common" (in "common resource").

In the process of exploitation the resource goes out from the steady state and goes by phases of non-sustainable yields. It is known that when the fishery is developing, the yields are higher than those that would correspond to the steady state, giving place to an optimistic feeling about the resource productivity. The reciprocal is also true, the recovery of a depleted stock seeks to obtain lower captures to those that would be obtained in steady state. It is for this reason that it is so easy to overexploit a resource and so difficult to recover it.

Biomass changes are not easy to interpret. Sustainable exploitation involves being limited to obtain the surplus of the population growth, allowing its renovation. The temptation to take more than the bill is too strong. Furthermore, the signs of overexploitation are neither immediately seen nor easy to understand.

The resource fluctuations are natural. Man tends to adapt the exploitation industry to the maximum abundance, giving place to the overcapacity and overcapitalization of the extractive methods. It is also difficult to interpret a decline of the resource: is it due to fishing or to an environmental anomaly from which it will recover? Our fishermen, for example, have a certain tendency to attribute to the fisheries crisis pollution. The question is: what is the contribution of fishing, other anthropogenic causes and environmental conditions to the resource variability?

This question does not have a simple answer. In any event, it seems evident that fishing, as much as other actions or results of human actions (alteration of the coastal dynamics, construction of ports and marinas, beach regeneration, pollution, and many more), significantly contributes to the damage of the resource.

The effects of environmental fluctuations have both positive and negative effects on the resource. But it is clear that a resource confined at low levels of biomass will be much more sensitive and vulnerable to the adverse environmental conditions, and therefore the presumed "symmetry" of environmental effects disappears. In any case, in terms of environmental fluctuations, the Mediterranean is more stable than the Atlantic and other open oceans. At any rate, the demography of short-lived species are likely more influenced by environment than the long-lived ones.

The resource should be considered sensitive to fishing and, independently of the additive action (or maybe multiplicative) of other anthropogenic factors. Fishing, or rather bad fishing, practice is a main cause of the depletion of the resources.

When the fishery has reached a clear status of overfishing, the dilemma between short and long term appears. At short term, the effort increase or a selectivity decrease produces higher yields, although in the long term the situation will become worse. Furthermore the rate of discount of a fish in an open access fishery is infinity; it is preferable to get one unit of weight now than several the next year. Mediterranean fisheries are not open access fisheries *stricto sensu*, but the discount rate is high enough for fishermen to confer more importance to short term than to long term.

One of the consequences of the deterioration of the selectivity is the catch of species or sizes of impossible commercialisation, which are discarded. Therefore the existence of significant discards should be interpreted as a consequence of overfishing, not its cause. Another consequence of overfishing is the rise of social conflicts, which heat up when in an obvious way "there are more fishermen than fish".

Theoretically, there are many points allowing the steady state and hence sustainable exploitation. These steady state points constitute the well-known curves relating yield with effort or fishing mortality, and stock-recruitment relationship. Any of the points of such curves describes a level of sustainable exploitation of the resource. We see that from this point of view, the existence of sustainable overfishing is theoretically acceptable.

There are two very different concepts in the overfishing definition above, one affecting the viability of the resource, the other referring to the profit that man obtains from it. Classically this distinction is given between *growth overfishing* and *recruitment overfishing* (Cushing, 1996).

When *growth overfishing* occurs, the fish are caught before they have put on enough weight, the maximum sustainable yield is not reached. To recover a stock from growth overfishing you should decrease the effort (or fishing mortality) or increase the selectivity. That means travelling across the space of isoplets of yield per recruit defined by both parameters in the Beverton and Holt model. The isoplets define the steady state surface of this space. The journey path goes out of the equilibrium, it falls below the surface when recovering (ascending) and above it when overexploitation occurs. The growth overfishing causes a low yield of the fishery. Hence, the risk is for the fishery (as an economic activity), not necessarily for the stock.

Recruitment overfishing occurs when the spawning stock declines so far that the recruitment itself is reduced. Only a drastic reduction of fishing mortality could prevent the risk of stock collapse. Recruitment is a highly uncertain variable of exploited marine populations. It is difficult to forecast the strength of the recruitment when the spawning stock is healthy, but if its biomass is low then the prediction is easy: recruitment will be low. In an opposite way to what happened with the growth overfishing, the recruitment overfishing puts in danger the viability of the stock. It is a risk for the population, regardless of the fact that the yield could or not be improved.

Of course these two kinds of overfishing can (and actually do) coincide in the same fishery. But since it is much simpler to detect growth overfishing (the data is easy to get and the calculations are few) than recruitment overfishing (the stock-recruitment relationship is quite difficult to estimate), usually growth overfishing is kept more in mind than recruitment overfishing, which is, however, much more risky. This problem should be kept in mind regarding the precautionary approach to Mediterranean fishery.

4. The Mediterranean fisheries

Of the two paradigms of fishing formalised by Caddy (1990) the first one – or "minimum size limit paradigm" – corresponds to the most classic theory of population dynamics and it consists in avoiding the capture of the small sized individuals. It is recommended to catch only individuals of great size that have reproduced, at least, once. In this manner, it is possible to avoid recruitment overfishing as much as growth overfishing.

However, the Mediterranean works in a different way. This doesn't mean that it is something desirable but the verification of a fact. Caddy (1990) denominates it "spawning refuge paradigm". The selectivity has been degraded and very small individuals are caught, but the spawners are not fully available to the gear or they have natural refuges (a rocky bank, for example) so that they suffer a low fishing mortality. This causes a clear and demonstrable growth overfishing, but the existence of refuges avoids the recruitment overfishing.

Of course, regarding the trawl, this can be true for some species (hake) but not for others (red mullets) and it can be positive whenever the reproducers are really inaccessible. This could be invalidated if longliners or any other gear catching the large individuals enter the fishery.

The Mediterranean fishing manager should be aware of that. If he wants to maintain the growth overfishing *status quo*, he should, absolutely protect the reproducers and avoid longlines or entangling nets. If, on the contrary, he wants to follow the "Atlantic" model he should work in the improvement of the selectivity of the trawl.

Of these two paradigms, one of them should be chosen by the manager and he should act in consequence. To merge both paradigms could be difficult. Anyway, it is high-priority to avoid the recruitment overfishing: or the adults are protected or they are fished after giving them the opportunity to reproduce. A policy tending to avoid risks, or precautionary should avoid recruitment overfishing.

It is often said that Mediterranean fisheries appear to be in a situation of sustainable (growth) overexploitation. I believe that it is necessary to make some comments on this respect. The signs indicating that the current exploitation of Mediterranean fisheries are sustainable are not sufficiently clear. It is said that there have not been collapses (this is not completely true, since some species abundant in past times do not present commercial biomasses now), and that the catches are more or less stable. This does not necessarily mean sustainability, since a non-sustainable situation defined by an increment of the fishing mortality and a decrease of the biomass can yield a constant catch during a certain period. Disaggregated, long and good data series to support the hypothesis of sustainable exploitation do not exist. On the contrary, some indices seem to indicate the opposite, i.e. in a series of total catches for Catalonia presented in the figure 1 (it should be admitted that the concept of total catch is questionable and that the data are not very reliable) it is seen that after the great bloom of the 70's (from 20 to 60 000 tons), the captures stay oscillating between the 45 and 65 000 annual tons showing no particular trend. During this period the fishing mortalities have very probably increased (through technological progress), indicating diminishing biomass, and no sustainable fishing pattern. Furthermore according the precautionary approach the most pessimistic interpretation should be considered. On the other hand, the oscillations in the last period appear typically when the levels of biomass are low. In this case a series of bad environmental conditions can unbalance the situation and cause the collapse. When the level of biomass is higher, the oscillations are much less conspicuous (see period 1950-70).

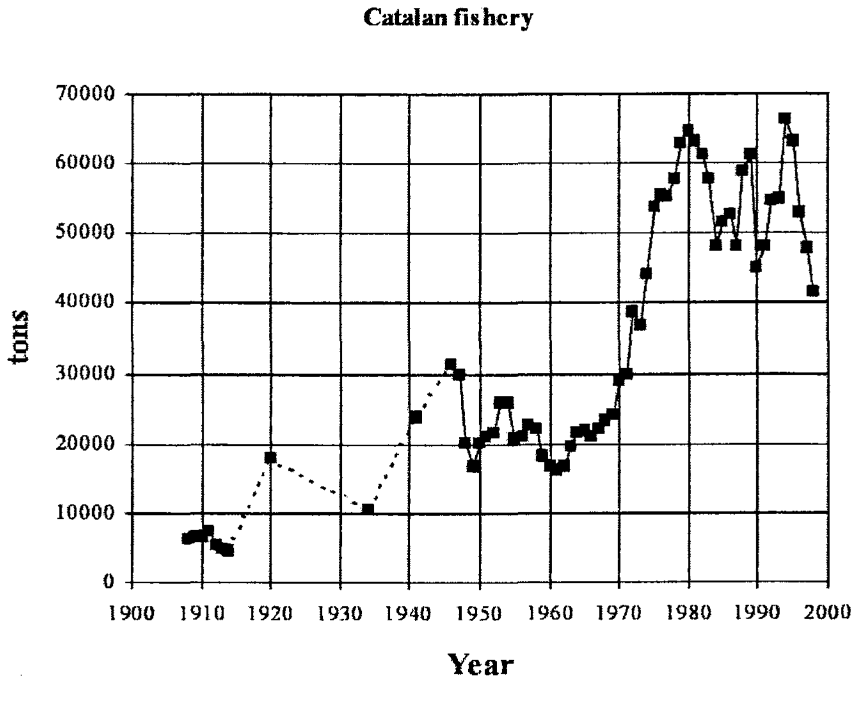

Figure 1. Historical series of total catches in Catalonia (see text).

In another example a series of catch per unit effort per boat and day of a Catalan port, Barcelona, show as the hake CPUE (a main target species) is diminishing at a rate of more or less 5%, while the total CPUE shows no particular trend.

Furthermore, it is utopian to speak of sustainable overexploitation. Although theoretically possible, sustainability is, in practice, a dynamic concept. Since the society (fisherman, technology, market, etc.) changes, it is not possible to reach the sustainability simply maintaining the effort frozen and doing nothing else. It is necessary to play the sensitive points of the fishing system to guide it, if not to recover it (that obviously would be the ideal thing) at least to maintain sustainability and this is something painful for the implied elements.

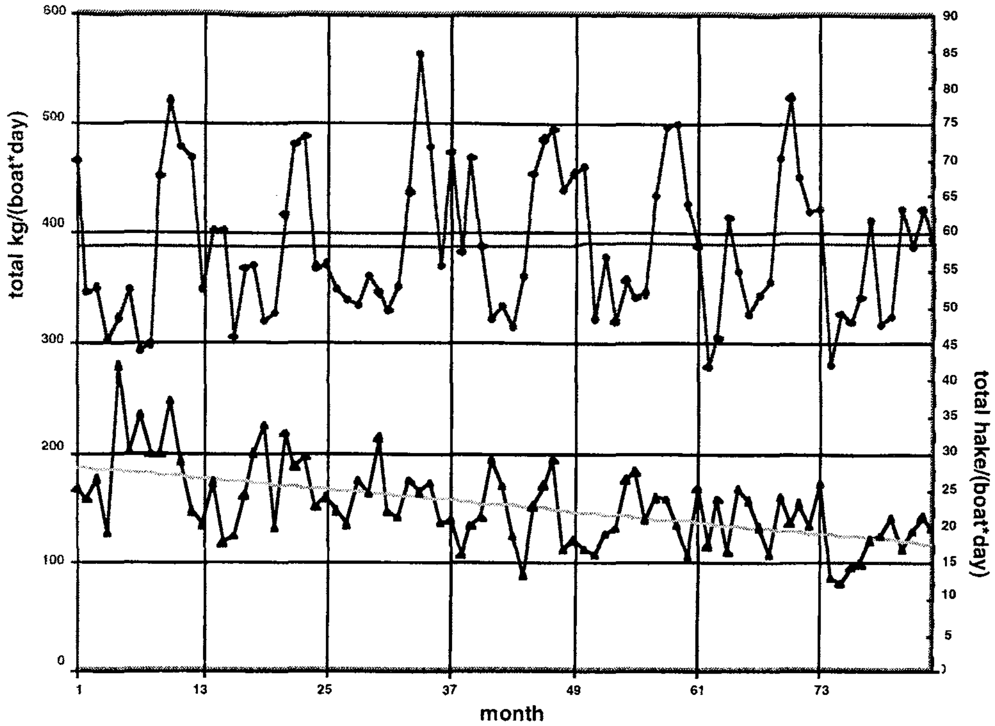

Figure 2. Series of trawl CPUE by boat for hake and total demersal catch

5. Reference points

Reference points are a main issue on fisheries assessment and of the precautionary approach. Caddy and Mahon (1995), Rosenberg and Restrepo (1996) and ICES (1997) present exhaustive lists of them. From a precautionary point of view, there are two kinds of reference points: target and limit. Most of them are fishing mortality values ($F_{0.1}$, F_{max}, F_{low}, F_{med}, F_{high}, $F^{MS}Y$, $2/3F_{MSY}$, $F_{30\%SPR}$, F_{crash}, F_{loss}, F_{confie}, F(M, F<M), total mortality (Z_{mbp}), or biomass (B_{MSY}, MBAL, $B_{50\%R}$, $B_{90\%R90\%surv}$, $B_{20\%B\text{-}virg}$, B_{loss}). All these reference points are related to population dynamics models: surplus production, VPA, Yield per Recruit and Stock-Recruitment relationships.

The Mediterranean poses a special case in this respect. Data are few, no regular assessments are routinely done and there are few or no estimates of the above mentioned reference points. In such a situation, Hilborn and Peterman (1996) recommend: (i) high priority to the collection of new data and the implementation of monitoring programs to ensure that appropriate data are gathered in a rigorous and usable form, and (ii) to allow very limited harvesting so as to no overharvest the resource and to prevent fishing power from increasing too rapidly. According to these authors "*... there are few risks associated with slowly developing a fishery, but many risks with rapid development. Slow development might be achieved through reversing the usual burden of proof. Currently the onus is on many management agencies to show that overharvesting is occurring before they take strong action to regulate the fishery industry*".

Reference points adapted to the Mediterranean particular issues and data should be developed. The possible reference points should be addressed to detect trends towards overexploitation. Some useful targets for studying possible reference points for the Mediterranean fisheries could be:

- monitor CPUEs, taking effort as fishing time per boat without technological improvements (or quantifying them) of the main target species;
- monitor the discards (as a measure of overexploitation);
- avoid the recruitment overfishing.

In any case, research addressed to analyse the different management strategies (Kirkwood and Smith, 1996; Francis and Shotton, 1997) is necessary, particularly in a bioeconomic framework for the Mediterranean case, in order to connect assessment with management, and evaluate the usefulness of different reference points and the management tools.

6. Management tools

The manager has a lot of elements, or tools, to play with in order to lead the fishery to the target. First of all the target (medium and long term) should be defined. There are a lot of possible targets often not compatible (avoid collapse, maximize employment, minimize resource fluctuations, maximize income, reach sustainability, etc.). Each tool has a cost and a result, and it can be more or less easy to implement, control and enforce. The available management tools can be classified into three sets: technical, ecological and economic. The technical ones affect the fishing procedures, measures of gears and catches, time fishing, etc. The ecological are more general and consist mainly in ecosystem protection. The economic tools allow leading the fishermen (economic) activity to the proper way to reach the management target.

A very interesting issue and also a method which combine all these tools is the implementation of pilot projects (Boutet, 1996) which allow to develop a small or medium scale, management regulations and analyse them from the biological, economical and social point of view. Some pilot projects have already been applied to the Mediterranean fisheries with very hopefully results: the Plan Castello (Suau, 1979), the management of Cyprus fisheries (Garcia and Demetropoulos, 1986), and the Golfo de Castellamare (Sicily) management project (Pipitone *et al.*, 1996, 1998).

Technical

There are many theoretically possible technical tools to manage fisheries. In the following table I have tried to present them classified according to two criteria: (i) considering the fishing mortality F as a scalar, a number affecting all the exploited population, or as a vector by size or age, and (ii) considering the way (necessarily indirect) to control F: through the catch, the effort or the catchability.

	CATCH	EFFORT	CATCHABILITY
F AS SCALAR	**TACs** and quotas	**Number of boats** **Fishing time** (hours per day, days per week, per year, temporal closures, etc.) **Size or number of items of several gears** (net length, number of hooks, etc.)	**Fishing power** (engine power, tonnage, etc.) **Technological progress**
F AS VECTOR	**Minimum size**	**Protected areas** **Spatial closures** **Temporal closures**	**Gears** (forbidden, permitted) **Gear characteristics** (material of the nets, type of the mesh [square], minimum mesh size, hook size, etc.)

Among all these technical tools I want to deal particularly with technological progress because it is the mechanism used by the Mediterranean fishers in order to increase the fishing mortality keeping constant the nominal effort. Research to analyse the technological progress and its effect on fishing mortality should be implemented (Boutet, 1996; Fitzpatrick, 1996).

Ecological

Although in the previous section protected areas have been mentioned, in this section I want to emphasise the importance of the ecological tools. In particular this approach has a special significance regarding the precautionary principle. The protection of the environment, particularly the most sensitive bottoms, as *Posidonia oceanica* and other seagrass, rocky bottoms, etc.

Economical

The economic tools are mainly taxes, subsidies and fines. The trouble with them is that, since its origin is not the management but economic issues, the effects are often opposite to those wanted in the resource management. Subsidies (actually tax exemption) to fuel favour the increase of effort, which is the contrary effect the managers are searching. Other subsidies, like those to new boat construction or improvement of technology, have arguable issues but they appear too as aids to the effort, and could be considered as "perverse" subsidies (Myers, 1998).

7. UNIFYING MANAGEMENT PROCEDURES *VERSUS* REGIONALISATION IN THE MEDITERRANEAN

Mediterranean fisheries are diverse. There are many cultures with different taste regarding the sea products. The small fishing is of paramount importance, it consist on many different fishing methods, some of them sharing areas, landing in many points along the coast. It is difficult to find targets applicable to all the areas or gears in the Mediterranean.

Nevertheless, the market is global and unique. It is problematic how will products obtained by different rules (perhaps from the same stock) compete in the same market.

Hence, two opposite approaches should be considered:

- uniform policy for the whole Mediterranean;
- regionalised management. It means different areas can dispose of different rules according its requirements.

Both have advantages and inconveniences:

	ADVANTAGES	INCONVENIENCES
UNIFORM POLICY	Management simple and easy to control	Regression in the management of the most advanced areas (i.e. introduction of pelagic trawl in areas where it is already forbidden)
REGIONALIZED MANAGEMENT	It allows the harmonic development of the regions according their biological, economical and social potentialities. Facilitates the implementation of pilot areas and pilot projects.	Border effects (the neighbours of a well-managed zone take advantage of that without any cost)

There are regionalisable and no-regionalisable rules. This difference is based on the management units and the market. Rules affecting only the area where are applied can be regionalised. For instance, different areas (I mean management units) could be regulated by different effort limits (engine power, time fishing, and number of boats) according to their particular stocks, fleets, tradition or socio-economic background. No regionalisable rules are those affecting shared stocks or market. Minimum legal sizes of fish cannot be regionalised since the fish goes to the same market. European hake (*Merluccius merluccius*) has a minimum legal size for the Mediterranean EU of 20 cm (EC 1626/94) and 26 for the Atlantic, but they are sold in the same market (what about a fish of 22 cm?).

8. Management policy

The method for which the manager decides (or receives) a management objective and the means to reach them define the management strategy. The three main management systems are reactive, adaptive and precautionary.

In the case of reactive management the manager acts when an event takes place and forces him to act. This is the current management method in the Mediterranean, where there are more or less invariant rules. When a problem appears the manager should implement additional administration measures or modify those that already exist. Under this strategy the manager goes trails behind the fishery, the bioeconomic mechanism that governs the fishery goes without the manager's active intervention, and when the problem emerges he/she should make quick decisions, usually without the necessary time to carry out a deep analysis of the problem.

The adaptive management (Walters, 1986; Caddy, 1999), used in many Atlantic fisheries, is based in a feedback process involving updated fisheries data, assessment and management. That is, obtaining data from the fishery, assessing it by independent experts' groups and providing the subsequent advise to the administration that, finally, outline the management actions that consider appropriate. This process implies dialogue among the three main agents: managers, fishers and scientists. The circuit "get data – assess – advice – manage" closes annually. This method allows learning from the fishery, its reaction to different management measures, and adapting the management to its necessities.

The precautionary management strategy is based in the approach of consistent caution in not making decisions that can put a natural resource at risk, especially when the scientific knowledge is very limited, and therefore the predictions are uncertain. This kind of management criterion is compatible with the adaptive one.

9. Conclusions

1. Fisheries monitoring should be developed. Standardised and routinised collection and gathering of data (including discards) should be implemented.
2. Promote international assessments starting with the main stocks and the shared ones. Later, even the national stocks, could be assessed by international bodies.
3. Mediterranean fisheries at this moment need to implement both: adaptive and precautionary management.
4. Use management tools (economic, ecological and technical) easy to implement and to control. Redundancy of management measures is precautionary.
5. Develop reference points to detect and prevent recruitment overfishing.
6. Regionalise, when possible and taking into account market and border effects, the management.
7. Any change to be introduced in the fishing policy should be clearly addressed to remove fishing mortality, improve selectivity or protect (or recover) ecosystems.
8. Special attention should be paid to the technological progress. In order to avoid increasing fishing mortality, the technological improvements should be analysed and compensate by decreasing effort.
9. Develop and implement pilot management projects.
10. Analyse different management strategies.

Risk assessment and risk management applied to Mediterranean fisheries

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1. Background

The concept of a Precautionary Approach to Fisheries Management has its origins in two factors:

i. the awareness that fisheries managers were inclined to take unwarranted gambles in their decisions on, *e.g.*, safe levels of fishing effort, fishing mortality or levels of permitted yields – the total allowable catch (TAC), that is, decision makers give themselves the benefit of the doubt in situations of uncertainty, and

ii. managers were taking decisions on the basis that there was insufficient "scientific" evidence to prove that the management action contemplated was in fact dangerous or harmful. This is one of the original impetuses for the concept and arose from the outcome of the UNCED conference in Rio de Janeiro in 1992. Principle 15 of the conference states that: "*lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*".

The phrase in italics is of particular interest, not least because of the operational issues raised about how cost-effectiveness is measured in an actual decision making environment. The concept implicit in this philosophy is sometimes referred to as the *Burden of Proof* in that it may be interpreted that actions should not be taken unless it can be demonstrated that the proposed action will not be harmful. In a fisheries context, this may be undertaking analyses to show that an intended harvest will not threaten the sustainability of the resource or the ecological bio-diversity of an area or fishery.

As is evident, an appropriate response to both these phenomena is to be "careful" – managers will appreciate the utility of this advice in industry negotiating sessions – and although the outcome in the form of the decision in both these cases may be the same, the underlying reason why a more prudent decision on level of harvest, etc, is taken, differs. It is important to understand the reasons because they have major operational implications. A further development has been the extension of the concept of the Precautionary Approach from solely that pertaining to decision making to a general approach to fisheries management. Included in this expanded view is that the Precautionary Approach includes what might be described conventionally as good management methods plus an appropriate treatment of, and response to, uncertainty in the models, parameters and other related issues influencing the outcome of a management decision. This extension leads to explicit treatment of *risk* in management decisions.

Some authors trace the base for development of the Precautionary Approach to fisheries management as far back as the mid 1950s when the concept was first raised in FAO forums dealing with decision making in fisheries management. However, it is in the last decade that this concept has gained widespread acceptance as a philosophy to be applied in fisheries management. In fact, proponents of its application have identified almost all aspects of fisheries activities as appropriate objects of this principle of management (FAO, 1995b). For example, FAO (1995b) found it appropriate to consider this form of management in relation to:

i. Fisheries management, in relation to:
- management planning;
- implementation, monitoring and enforcement;
- re-evaluation of management systems;
- implementation guidelines for new and developing fisheries, overutilized fisheries, fully utilized fisheries and traditional or artisanal fisheries.

ii. Fisheries research, in relation to:
- management objectives;
- observation and information bases;
- assessment methods and analysis.

iii. Fishing technology in relation to:
- the objectives of fishing;
- the impacts of fishing;
- the implementation of the management of fishery technology.

iv. Technology research and development

v. Species introduction, in relation to:
- deliberate introductions;
- unintended introductions.

FAO (1995b) provides a normative view of the precautionary approach, which would serve a useful purpose for developing the rest of this paper. This paper requires, *inter alia*:

a- consideration of the needs of future generations and avoidance of changes that are not potentially reversible;
b- prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;
c- that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, on a time scale not exceeding two or three decades;
d- that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;
e- that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further contained when resource productivity is highly uncertain;
f- all fishing activities must have prior management authorization and be subject to periodic review;
g- an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and
h- appropriate placement of the burden of proof by adhering to the requirements above.

Key concepts in past discussions of the precautionary approach have been the burden of proof and the standard of proof (i.e., the responsibility for providing the relevant evidence and the criteria to be used to judge that evidence). Often, the precautionary approach has been taken as requiring that human actions are assumed to be harmful unless proven otherwise (reversal of the burden of proof). In regard to these concepts, it is recognised that:

i- all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proved otherwise;
j- although the precautionary approach to fisheries may require cessation of fishing activities that have potentially serious adverse impacts, it does not imply that no fishing can take place until all potential impacts have been assessed and found to be negligible;

k- the precautionary approach to fisheries requires that all fishing activities be subject to prior review and authorization; that a management plan be in place that clearly specifies management objectives and how impacts of fishing are to be assessed, monitored and addressed; and that specified interim management measures should apply to all fishing activities until such time as a management plan is in place, and

l- the standard of proof to be used in decisions regarding authorization of fishing activities should be commensurate with the potential risk to the resource, while also taking into account the expected benefits of the activities.

There is no doubt that the concept of Precaution is increasingly becoming part of the approach in many national fisheries management regimes, though it is usually expressed in minister's, or other higher level, expressions of management intent rather than at the operational level. When decisions to reduce a TAC have not been taken, this is usually because of social circumstances such as the desire to maintain employment or not risk loosing markets. One international fisheries agency, The Commission for the Conservation of Antarctic Marine Living Resources, does reduce TACs if there is no current fishing activity on the basis that in the absence of fishing there are no data on which to establish TACs.

Thus, if one wishes, ones' perspective on the Precautionary Approach may be broad, limited only the bounds of what is manageable in the fisheries. However, I find such an unbounded approach not operationally helpful and I anticipate that the Precautionary Approach will evolve further, particularly with the respect to development of quantitative means of handling uncertainty.

2. Operationalization of uncertainty in management

In my experience, few people are against the Precautionary Approach to fisheries management, but equally commonly, few can provide an explicit and non-discursive explanation as to what it means in an operational fisheries management environment though it is usually recognized that the precautionary approach is a response to uncertainty in a management situation. If there is no uncertainty, and all that needed to be known about a management situation was known, appropriate management decisions could be confidently taken. As is well known, this is rarely, if ever, the case. There have been a variety of approaches adopted to handle management uncertainty and they have various characteristics and merits.

The most common approach has been the introduction of *reference points* (see *e.g.* Caddy and Mahon, 1995). Reference points may be set as a management target, that is annual management planning attempts to achieve the reference point through the control of fishing effort or the amount of catch that is taken, i.e. the TAC. In both cases these are usually proxies for a corresponding level of fishing mortality. A reference point, more common in the past, but alas, still not unusual, is the maximum sustainable yield, corresponding to a F_{msy}. The most common precautionary version of the target fishing mortality point is the infamous $F_{0.1}$ – widely misunderstood, or at least not understood by biologist and manager alike, as an absolute reference belonging to the set that includes c, the speed of light, π and e. What such target points do is define a point that is considered to be "safe" but without excessive loss of economic benefits. Clearly, this is a subjective field, but it has been one that many managers have been content to avoid exploring.

Among the assumptions of using target reference points are (a) that the value of the reference point (*e.g.* fishing mortality) can be accurately measured in practice so that managers know if they have been successful in not exceeding the target point, and (b), the manager can actually control the fishery so that he can (or may achieve the target point, but this is another story). By erring more and more on the side of caution, a management approach may be assumed to be more and more cautious.

An alternative, and possibly complementary reference, are limit reference points. These are values, at which a management action should automatically be taken. Perhaps the most common of these is the Minimum Biological Acceptable Level (MBAL), or Minimum Spawning Biomass (MSB) level, the latter being most useful if the concern is about possible recruitment failure. Here, the concept is that no action is needed it the stock is maintained above the danger level; but if it were to fall below this level, an unacceptable risk is posed and a management action would follow.

Several sources of concern exist. First is the issue of whether the biomass of the stock can be estimated. One traditional means the "Swept Area Method", relies on extrapolating from the catch obtained by a trawl survey. The common assumption is that the trawl covers a known fraction of the area in which the population occurs and all fish in front of the trawl are vulnerable to capture. Such an estimate is subject to both positive and negative biases, though it is the latter which are of concern. They arise from uncertainty as to the herding effect of the trawl doors so that the effective width swept is greater than the distance between the wings of the trawl or spread of the ground rope. Another commonly used method, the VPA estimate, depends on knowledge of the age structure of the population, information that is often unavailable, and often in error for year classes that have most recently entered the fishery (Mohn, 1999).

Minimum Spawning Biomass

The second concern is that of setting appropriate minimum biomass levels; this is often expressed in a probabilistic manner. For example, that a certain management strategy would have only a 10% probability of resulting in a biomass level below 20% of the virgin population biomass level during a 20 year management period. Should this happen, what the consequences might be for the stock are left for your reflection.

It is apparent from these discussions, that the traditional approach to reference points has had essentially a sole focus on unit stock situations and where data and analyses have been possible for such single species situations. Only a moments reflection will show that these situations are few and that there is a requirement to develop reference points for the much more common situation of multi-species fisheries where the species composition of the resources has already been changed by previous fishing effort.

3. Establishing management objectives

Most documents dealing with the Precautionary Approach to fisheries management stress the need for clear and careful articulation of management objectives. This is so because the issues at stake often may not be clear in an operational environment. The options that should, or may be considered, will depend on what the senior decision-makers want. Given the particular objectives that are sought, decisions that may appear irrational to some, will be found to be consistent with higher-level management objectives whether they be expressed or unexpressed (i.e. hidden). Articulating management objectives is not a trivial task, and formal elicitation techniques have been developed that ideally should involve all relevant stakeholders (i.e. those who are recognized as having legal standing in relation to the issues under discussion (Bell, Keeney and Raiffa, 1977; Keeney, 1988).

4. Risk, risk assessment and risk management

The notion of the precautionary approach arises from the uncertainty of an outcome, or outcomes, arising from certain management actions and the wish to avoid "undesirable" outcomes along the lines of "better safe than sorry". In this sense, such considerations are placed in the realm of that part of Decision Theory that has to do with *risk* and *utility*.

Most people are familiar with the concept of risk, though its variable uses in both vernacular and technical senses can cause confusion. The most common sense in fisheries is that it implies the probability of something bad happening (Francis and Shotton, 1997), that is,

Risk = P (bad event happening).

There is also a more restricted sense of which one should be aware as it is a common usage in Decision Theory. In this sense, *Risk* is the expected loss involved in a decision characterized by uncertainty, i.e. $Risk = E[l(\theta_i, d_i)]$. For example, consider three events θ_i, and corresponding decisions:

θ_1 Biomass deemed too low and (d^1) TAC set to zero

θ_2 Biomass deemed appropriate to allow a harvest of 1000t (d_2)

θ_3 Biomass deemed appropriate to allow a harvest of 2000t (d_3).

As usual, there is no certainty as to what is the true situation, but the following probabilities can be assigned:

$P(\theta_1) = 0.2$
$P(\theta_2) = 0.5$
$P(\theta_3) = 0.3.$

What is the "best" decision (and what would you do)? In the first situation, while the probability of this event is fairly low, if this is the true situation, then you might save the stock from collapse in future years by closing the fishery but in the immediate season, nothing would be caught. But, by closing the fishery for one year, you might permit harvests in following years. By taking this option you would be being *risk averse*. In the third situation, there is a probability of 0.3 that your harvest will be too high, and thus there may be a stock collapse. The decision to go with a harvest of 2000t could be considered *risk prone*.

The task of determining the probabilities associated with each possible biomass situation is considered to be part of the stock assessment process – and clearly it is a difficult task to do completely as all sources of uncertainty must be quantified. In practice, it may be sufficient to concentrate on the most significant parameters used in the assessment models : F, M, and if it is used, the catchability coefficient. It will be also be clear that the loss that a management decision would entail, given that subsequently the event θ_i occurs, must be calculated. While this is not a trivial task, it is not impossible, nor are the calculations much more complicated than many that are already an integral task of many stock assessments.

Once a risk assessment has been done the decision makers must make their choice. In the example above, one of the responses from the decision maker to the resource advisor may be in the form, "if I authorize a harvest of 2000t, are you sure that the stock will collapse?" And when that assurance cannot be provided, the 2000t decision is taken by the manager. This part of the risk process is referred to as risk management. In most fisheries management regimes, this process has yet to proceed much beyond the qualitative Precautionary Approach stage.

Studies of how people make decisions have shown results that to many are non-intuitive. For example, when a advantage is at stake, people tend to be risk averse, preferring a certain gain over a larger, but uncertain gain. For example, in the case of decision making in a fisheries management context, given the choice of a "safe" increase in the TAC, *e.g.* of 1000t (i.e. one that will not imperil the stock) or an unsafe increase of 2000t (i.e. one that might imperil the sustainability of the stock, but might not), then many people prefer the lower TAC. That is, in this situation they are risk averse. However, if the decision is between (a) having to take a certain reduction in the TAC of 1000t, or (b) taking a chance, or gamble, that by not reducing the TAC, good recruitment may occur thus saving the situation, most people will opt for the second option. That is, when a certain loss is involved, decision makers tend to be risk takers or *risk prone*. This happens when biological advice is offered that requires a reduction in the TAC and the decision makers (usually the Minister) decides that either no reduction is warranted, or that a lesser reduction is in order. To many, this is an example of cognitive disfunctionality, though in terms of the utility of the outcomes, an apparent rationality of behaviour may be apparent, especially when interpreted in terms of the time horizons of the decision makers involved. In other words, the utility of the same outcome may vary between different stakeholders.

5. Risk and risk management in the Mediterranean context

As noted above the concept of risk management involves:

i. uncertainty about the status of a situation, *e.g.*, the level of biomass of a resource or amount of fishing effort that might be expended;

ii. a decision being taken about a possible action, i.e., various TACs are possible, one must be chosen, including a zero TAC;

iii. an associated loss function depending on extent to which the decision is not optimal;

iv. usually a preference for a particular level of risk (based on the utility associated with the decision being taken).

What are possible Mediterranean situations to be dealt with? Are these possibilities?

Situation	Decision Options	Sources of Uncertainty
Pressure on albacore stocks	TACs	Stock structure in relation to management units; biomass status of stocks; unfished biomass; nature of stock-recruitment function and environmental effects
	Effort limitations	Accurate knowledge of amount of fishing effort being exerted; relation between fishing effort and fishing mortality; likely compliance with any effort limitation directives
	no action	Importance of fishery related factors in determining status of stock
Loss of bluefin sub-populations	Close fishery Restrict fishery Leave unimpeded	Efficacy of management regulations unknown; uncertainty in enforcement of regulations, etc.
Slope fisheries for... various species	Phased expansion "Open" access exploratory fishing	Ignorance concerning values of population biology parameters and hence parameterization of management models
Red Coral	Close fishery	Recovery rates; existence of unfished populations, etc.
Spiny lobsters	Introduce/enforce minimum carapace size; introduce property rights on catches	Uncertainty about enforcement costs and effectiveness; acceptability of policy
Sponges	Close fishery	Recovery rates; existence of unfished populations, etc.
Changes in mesh sizes trawl fisheries	Increase mesh size	Delay in achieving noticeable in increases in catches; species changes

6. Implementation of Precautionary Management

There is a realization that the old models for fisheries management have either failed or are doing poorly and that new approaches are needed. This provides administrators with an opportunity that should be seized, and the general acceptance of the Precautionary Approach may provide the required catalyst. However, while the Precautionary Approach concept is an extremely useful tool, it is worthwhile to explicitly consider its strengths and weaknesses.

The strengths of the Precautionary Approach, and the opportunities it offers, may be perceived as follows:

i. its elements make good common sense and little justification is needed to convince stakeholders of their merits;

ii. there is wide spread and growing acceptance of the concept; this makes it easier for Ministers to propose its use in the face of political opposition, real or perceived.

Among its weaknesses are the following:

i. there is unawareness of the operational difficulties of the Precautionary Approach, especially when the uncertainty of the outcome of remedial management actions is high – ultimately, precautionary management must be supplemented by sound policy cost-benefit analysis;

ii. it is not a guaranteed solution for management problems - it is an approach to be followed when uncertainty is high. Even "precautionary" decisions may be insufficient to prevent damage to a fishery;

iii. there could be challenges by stakeholders to what is perceived as subjectivity in its implementation and what degree of risk and time preferences should be adopted. In the absence of consensus, experience shows that this will be a problem but not an unsolvable one;

iv. many of the characteristics of the Precautionary Approach, as it is being developed, are common to "good" management and thus are not unique characteristics of this form of management approach.

As noted above, few dispute the need this approach to fisheries management. But, several impediments to successfully doing so exist. First, many managers, and those who advise them, are not familiar with the techniques of dealing with uncertainty, either qualitatively or quantitatively and neither are the means readily available to remedy this situation. In particular, only a start is being made to developing appropriate risk assessment techniques and even more importantly, the means of communicating to managers the consequences, as best they are understood, of uncertainty and the attendant risk associated with different management options. This is a field that will, no doubt, see considerable development over the next decade.

Precaution in fisheries within the context of ecological and environmental changes

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Fishing is one of the oldest human occupations : it was developed gradually when humans moved from random collection of things found in nature to the first utilization of food, applying experience and simple tools (Sahrhage and Lundbeck, 1992). Thus, about 100,000 years BP the Neanderthal man practiced fishing by hand whereas about 50,000 year BP, *Homo sapiens* started to use various gears, made of wood, bone, ivory and horn (Sahrhage and Lundbeck, 1992). However, humans at this early stage of fisheries development used highly selective fishing gears (*e.g.*, nets, hooks, harpoons) and their effect on aquatic ecosystems, being also spatially very localized, most probably approximated true predation (Stergiou, 1998a). During the past several centuries, however, the mechanization of fishing and other developments (*e.g.* technological innovations in vessel design, development of trading organizations and development of transport facilities) allowed fishing activities to expand spatially (*e.g.* Sahrhage and Lundbeck, 1992). Later technological innovations in vessel construction, in fishing gear material and construction, and in electronics (*e.g.* radar, echosounders), the use of highly selective and efficient gears (*e.g.* trawls) and the overcapitalisation of the fishing industry (Beddington, 1995) have allowed fishing effort to increase dramatically in recent decades. Thus nowadays fishing can be considered to approximate true "extermination".

Indeed 60% of the world fisheries stocks are fully to overexploited and 6% are considered depleted, whereas in most areas, fisheries catches approach levels that are unsustainable (FAO, 1997). Fishing, including by-catch, removes about 8% of the global marine primary production and this figure is much higher in upwelling and continental shelf areas (24-35%; Pauly and Christensen, 1995) and dramatically affects the mean trophic level of the aquatic catches (Pauly *et al.*, 1998). In addition, species extinctions (and near extinctions) in the marine environment, generally attributed to natural (i.e. epidemics, climatic change) and/or anthropogenic causes (habitat destruction and alterations, overexploitation, species introductions) seem to be much more frequent than it was thought before (see review by Roberts and Hawkins, 1999). Finally, there are numerous examples of fishing-induced collapse of stocks, with the collapse of the Canadian cod being considered as one of the biggest disasters of recent years (Spurgeon, 1997a). These observations, among others, clearly indicate that traditional fisheries management fails to fulfil the very cause of its existence.

Fishing has important effects on marine ecosystems (*e.g.* Jennings and Kaiser, 1998; Stergiou, 1998a), both at the community level (*e.g.* changes in species composition, changes in diversity, species extinctions, changes in predation and competition rates, invasions and competitive displacements, changes in trophic structure and energy flow, decrease in abundance) as well as at the level of the life-history of the individual species (*e.g.* decrease in mean size, decrease in mean size/age at maturity, changes in sex ratio, decrease in population reproductive potential). Yet, the situation gets more complicated inasmuch as most of the effects of fishing on communities and individual species (see Fig. 1) can also be brought about by, or related to, long-term climatic changes as indicated by several earlier and recent examples of the effect of climate on marine communities and stocks. Thus Jensen (1939), in his classic paper entitled "Concerning a change of climate during recent decades in the Arctic and Subarctic regions, from Greenland in the west to Eurasia in the east, and contemporary biological and geophysical changes" as well as Cushing and Dickson (1976), in their classic paper entitled "The biological responses in the sea to climatic changes", provide many examples of climate-induced changes in species composition, invasions, geographic distribution and abundance for a variety of marine organisms, resembling those of fishing-induced changes.

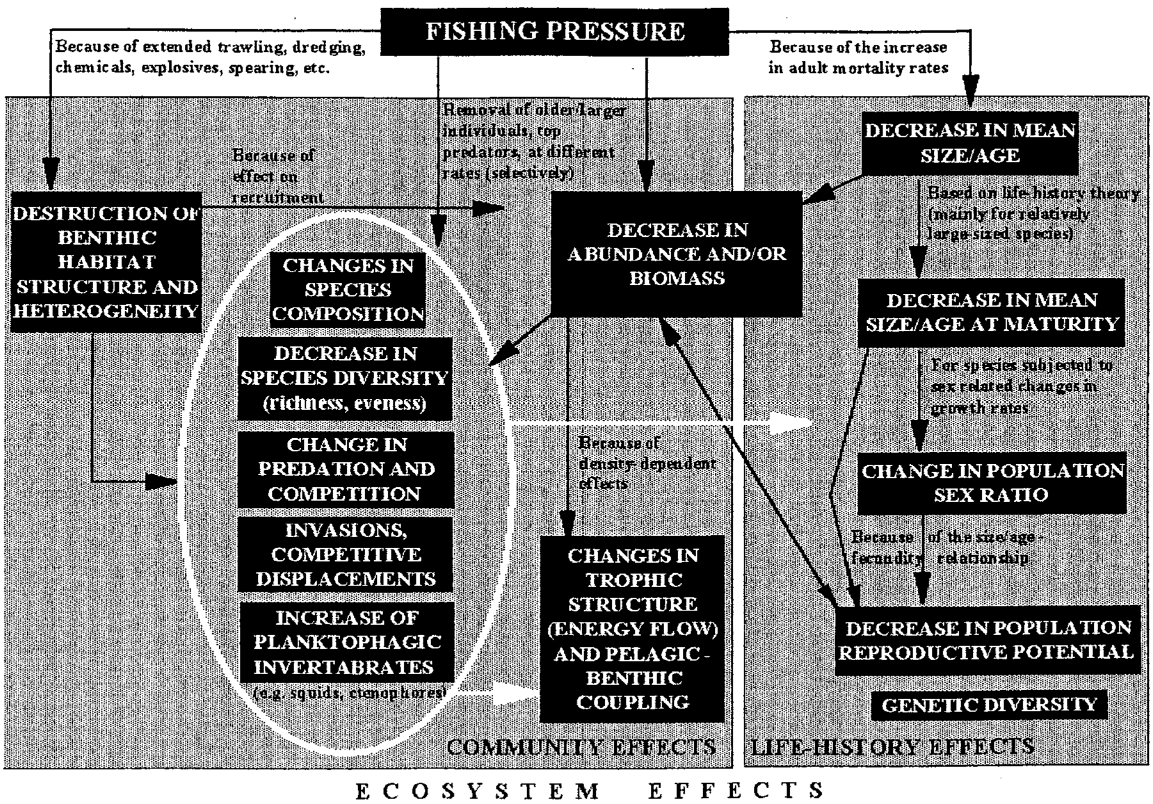

Fig. 1. Ecosystem effects of fishing.

Recent examples of the possible effects of anthropogenic nutrient enrichment (*e.g.* Caddy, 1993) and climate changes on marine communities and life-history of individual species in various areas of the world are also numerous (*e.g.* Dunbar, 1976, 1982; Aebischer *et al.*, 1990; Hagen and Quinn, 1991; Mariette, 1991; Cushing, 1995; Brander, 1995; Stergiou *et al.* 1997; Klyashtorin 1997; Lehodey *et al.* 1997; SAP 1998, 1999; Lloret *et al.*, 1999), with the case of "regime shifts" being worthy of mention here. Regime shifts are synchronized changes in several commercial stocks at long, interdecadal, scales (Fig. 2) and these changes, being produced or enhanced by climatic changes either natural or anthropogenic ones, can be linked to changes in other components of marine ecosystems such as planktonic invertebrates (Bakun 1997, 1998). Steele (1998) maintains that because of the "regime shifts", the "sustainability" concept is not directly applicable for marine ecosystems and especially to fisheries. He also advanced that management strategies may differ greatly according to the time scale of the changes of processes related to ecosystem variability. It must be pointed out here that the existence of long time series of both abiotic and biotic components is of paramount importance to the success of any mana-

"DOME SHAPED" POPULATION CURVE : RISING FROM MID-70s TO MID-80s

PEAKING IN MID-80s, FALLING THEREAFTER

SARDINE (JAPAN, PERU-CHILE, CALIFORNIA)
BENGUELA ANCHOVY
NORTH-PACIFIC GROUNDFISH (ALASKAN POLLOCK AND OTHER STOCKS)
LOBSTERS, SEA BIRDS, SEALS, REEF FISHES IN TROPICAL NORTH PACIFIC
NEW FOUNDLAND SPAWNING NORTHERN COD STOCK

IN DEPOSITE PHASE

ANCHOVIES (JAPAN, PERU-CHILE, CALIFORNIA)
BENGUELA SARDINE
NORTH PACIFIC ALBACORE

POPULATION EXPANSION BEGINNING IN MID-1970s

SARDINELLA AURITA (GULF OF GUINEA)
NORTH PACIFIC SALMON

"CRASHING" FOLLOWING MID-1980s

BRAZILIAN SARDINE (SARDINELLA)
NORTHERN COD STOCKS
BALISTES (W AFRICA)

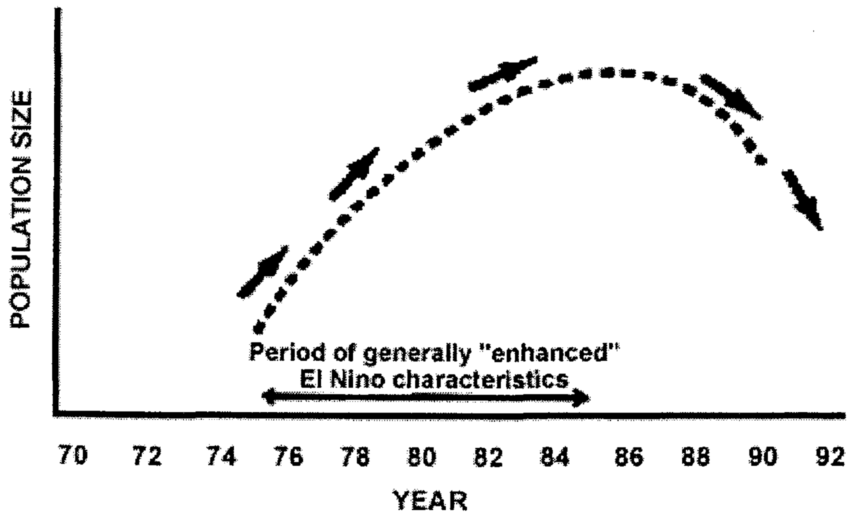

Fig. 2. Diagram characterizing the pattern of variation, observed in many marine fish populations, showing a period of increased abundance in the decade from the mid 1970s to the mid 1980s, followed by stock declines after the mid 1980s. Examples of various important fish populations whose stock fluctuations have been in phase with (or in opposite phase to) the pattern are listed (from Bakun 1997).

gerial scheme designed to deal with overfishing and/or environmental change. When the number of observations increase new patterns arise and the present is put under a different perspective that calls for multidisciplinary explanations. The failure of the traditional management schemes is generally attributed to the following :

a. fisheries resources are highly variable, partially because of the fluctuating environment (Stergiou, 1998b);

b. variability of fisheries resources increases with the time over which it is estimated (i.e. equilibrium yield is the exception rather than the rule;

c. fisheries estimates are uncertain, especially those referring to recruitment (*e.g.* Anonymous, 1995; Spurgeon, 1997b);

d. although managers are aware of such uncertainty, they generally ignore it (Lauck *et al.* 1998);

e. actual fishing mortality rates most often exceed target rates because of a variety of reasons (*e.g.* unreported catches, discarding, ghost fishing; Lauck *et al.*, 1998);

f. overfishing generally takes years to be detected (Lauck *et al.*, 1998); and

g. managerial decisions are also highly influenced by politics (Masood, 1997; Spurgeon, 1997b,c).

Thus management strategies should be more flexible and reconsidered in order to account for such aspects (see Mooney, 1998). In this context, the closed-area concept (i.e. marine protected areas, MPA), representing an extreme case of the precautionary approach (Lauck *et al.*, 1998), can be very efficient and directly applicable to the Mediterranean fisheries because of their extreme multispecies and multigear nature, the absence of adaptive management strategies and the great difficulty experienced in effectively managing them by any other means (*e.g.* Stergiou *et al.*, 1997).

MPAs, in which fishing is prohibited, provide a refuge in space rather than a refuge in numbers, the latter being the aim of most traditional fisheries management measures. Their advantages can be generally summarized as follows (Roberts and Polunin, 1991; Pollard, 1993; Novaczek 1995 from Lauck *et al.*, 1998; Allison *et al.*, 1998; Hall 1998 and references therein): (a) they protect the biomass and population structure of commercial species; (b) they limit by-catch of juveniles and non-target species; (c) they protect biodiversity including genetic diversity; (d) they protect essential life stages of commercial species; (e) they protect and enhance productivity; (f) they decrease the trend for heavy evolutionary fishing selection for earlier maturity and reproduction and smaller adult fish size (longer-term effect); (g) they provide a location for marine research that may be useful for the separation of the anthropogenic from the natural causes of changes; (h) they protect artisanal and community fisheries; (i) they enhance educational, recreational and economic opportunities; (j) they hedge against inevitable uncertainties, errors in estimations, and biases in fisheries management; and finally (k) there should be some areas where human impact is minimal "*an argument that requires no science*" (Hall, 1998).

Precaution and the conservation of biodiversity and incidentally captured species

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Since the 1992 Rio Declaration and the UN Conference on Straddling Fish Stocks and Highly Migratory Stocks, there has been considerable discussion, dialogue, and debate worldwide on what the implications of the Precautionary Approach (or PA for short) are for resource management. Much of the effort has focused on fisheries issues and specifically the development of target and limit reference points, and associated harvest control rules, by organizations such as the International Council of the Exploration of the Sea (ICES), the Northwest Atlantic Fisheries Organization (NAFO), and the International Commission of the Conservation of Atlantic Tuna (ICCAT). While there are still a number of challenges in fisheries management, so far there has been little consideration of what the PA implies for ocean management. Broadly speaking, the PA directs us to:

- define unacceptable outcomes
- take uncertainty into account
- implement a decision-making process

Item one requires the clear articulation of the objective that drive the management agency. For the most part, these have related almost solely to conservation but it is evident that socio-economic considerations must also be taken into account. Related to this is the definition of the so-called target and limit reference points that allow one to achieve the objectives. Again, socio-economic reference points are rarely seen in management systems.

While objectives and reference points have been a feature of management systems for some times, the explicit estimation of uncertainty has not. It is a relatively new feature and one that is causing concern by managers and users of the resource. How far does one go when erring on the side of caution? To take uncertainty into account implies not only having some predictive capacity on the reaction of the resource to some management action, but also that the management agency has some capacity to implement its management actions. It implies that not only the behavior of the resource is monitored but also that of the management system, through the use of performance indicators.

Lastly, the PA requires an effective decision-making and consultative process. Scientists, managers and stakeholders must understand their role in the management system and the consequences of their actions. In a very real sense, having effective consultation increases the chances of effective implementation of the PA and thus decreases uncertainty due to institutional arrangements. Interestingly, in fisheries management, the stakeholders are generally well defined and/or organized. Such is not necessarily the case with ocean management. It is necessary to not only develop new links with many ocean industries but also to develop new links among these stakeholders (*e.g.* aquaculture, oil and gas, transportation, fishing interests, tourism, etc.).

Many of the elements of the PA are already present in many management systems. However, the PA is more than the sum of its parts – it represents an integrated management system in which all components are working together to achieve stated objectives, in which the performance of the system and its components are monitored on a on-going basis, and in which the risk and uncertainty of achieving stated goals is accounted for in management decisions. To have a PA implies that ALL these elements are present and effectively working together.

In the context of biodiversity and incidentally captured species, the PA implies ecosystem management or more correctly, the application of ecosystem considerations in fishery management plans. This leads us to ask the question : if fisheries were managed to single species objectives, would the conservation of the ecosystem be assured? ICES tried answering this question and, while there were many caveats, it felt that no, genetic diversity and bycatch species would be at risk. As well, interactions in the food web could not be accounted for. Thus additions to the single species fisheries plans would be required to safeguard the ecosystem.

Regarding ecosystem objectives, the challenge is to define performance and reference points related to biodiversity and habitat productivity. A number of possibilities exist, although none can clearly be considered definitive at the moment. These would be layered on the existing single species reference points that already exist.

The implementation of the PA implies regulations similar to what is being used now, with perhaps different intentions in mind (e.g. marine protected areas to protect sensitive habitats) with no one method having a dominant usage. In relation to by-catch, there are emerging new gear technologies that may in fact reduce bycatch (but not entirely eliminate the problem). Exclusion grates are an example of these. Certainly, monitoring activities, both is support of regulations and assessment, and enhanced to consider ecosystem features, must be an integral component of the PA.

The implementation of an effective decision-making process as part of the PA has implications for the scale at which management decisions are to be made. Generally, for single-species, the area of consideration is that of the stock. When one considers broader ecosystem processes, the area must be expanded to include all the species being impacted in a certain Ocean Management Area (OMA). This has implications for governance. Indeed, in Canada as elsewhere in the world, consideration is being given to establishing OMAs in which all resource activities are being monitored and managed. The challenge is to establish an effective decision-making and governance process to manage these areas.

It is evident then that the Precautionary Approach is not just business as usual and has enhanced obligations to management agencies that control the use and exploitation of our marine ecosystems.

Les pêcheries méditerranéennes marocaines ? Etat d'exploitation et principales mesures d'aménagement

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1. Introduction

Pour ce qui concerne la Méditerranée, les ressources halieutiques (pélagiques et démersales) marocaines sont assez diversifiées. L'analyse des captures permet d'identifier différentes espèces de poissons. Ces espèces sont, parmi les petits pélagiques, la sardine (*Sardina pilchardus*) et l'anchois (*Engraulis encrasicolus*). Parmi les démersaux, le pageot (*Pagellus acarne*), la bogue (Boops boops), le rouget (*Mullus barbatus*), le merlu blanc (*Merluccius merluccius*), les céphalopodes (*Oligo vulgaris, Sepia officinalis* en particulier) et les grands pélagiques composés particulièrement de thon rouge (*Thunnus thynnus*) et l'espadon (*Xiphias gladius*).

Cette note dresse un constat sur l'état d'exploitation des principales pêcheries méditerranéennes marocaines et une revue des principales mesures rentrant dans le cadre de l'approche de précaution, instaurées pour leur préservation.

2. Niveau des connaissances sur l'état des stocks

Dans les eaux marocaines de Méditerranée, l'exploitation des ressources halieutiques est pratiquée par une flotte de pêche comprenant d'une part une flottille composée de chalutiers, de sardiniers, de palangriers, d'unités mixtes et de madragues et d'autre part, une flottille de petits métiers (barques), opérant particulièrement au niveau des sites de la pêche artisanale. L'effectif ainsi que les caractéristiques moyennes des types d'unités actives en Méditerranée sont indiqués en Table 1. La zone d'activité des flottilles s'étend à l'Est du Cap des Trois Fourches aux Iles Zafarinnes à l'Est et de Cap Quilates à Jebha ainsi que la région de Ksar Séghir à l'Ouest, y compris les baies D'Al Hoceima et Nador (Fig. 1). Ces flottilles opèrent généralement à des profon-

Table 1. Caractéristiques de la flotte des pêches côtières en Méditerranée.

Type	Caractéristiques			
	Effectif	TJB moy.	CV moy.	Age moy.
chalutiers	56	43.58	238	16
chal-sardiniers	76	41.33	243	15
chal-palangriers	13	29.79	193	10
palangriers	214	4.32	32	25
pal-sardiniers	57	10.40	71	19

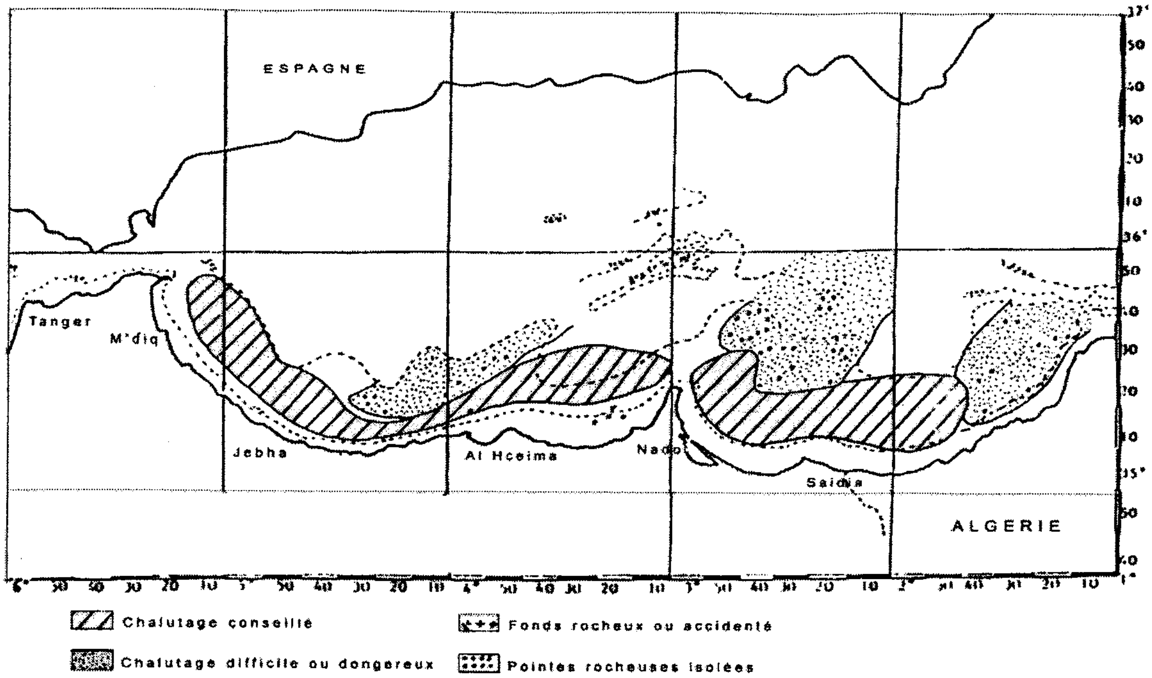

Fig. 1. Fonds de pêche.

deurs allant de 35 à 120 mètres. L'exploitation de ressources pélagiques s'effectue principalement à l'aide de la seine tournante (Srour, 1996). Les principaux stocks des démersaux sont exploités par la flottille chalutière. L'exploitation des thonidés (thon rouge, espadon, bonite et melva) s'effectue principalement par les madragues, le filet maillant dérivant et accessoirement la palangre et la seine tournante. Les évolutions des prises, de l'effort et des rendements (CPUE) des principales espèces exploitées sont données dans les figures 2 à 6. Comme unités d'effort, nous avons utilisé les sorties pour sardiniers et le produit sorties x puissance. Ces unités ont été considérées comme unités d'effort fiables (Brêthes, 1978; Bouchereau *et al.*, 1981; Zoubî, 1988).

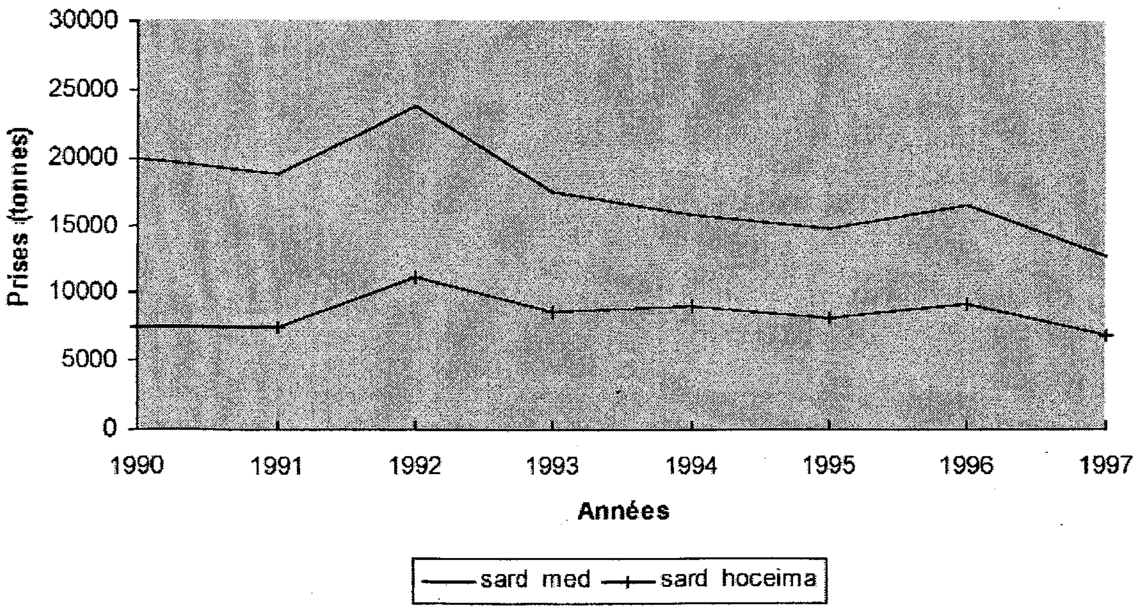

Fig. 2. Evolution des prises de la sardine débarquées en Méditerranée et au port d'Al Hoceima (1990-1997).

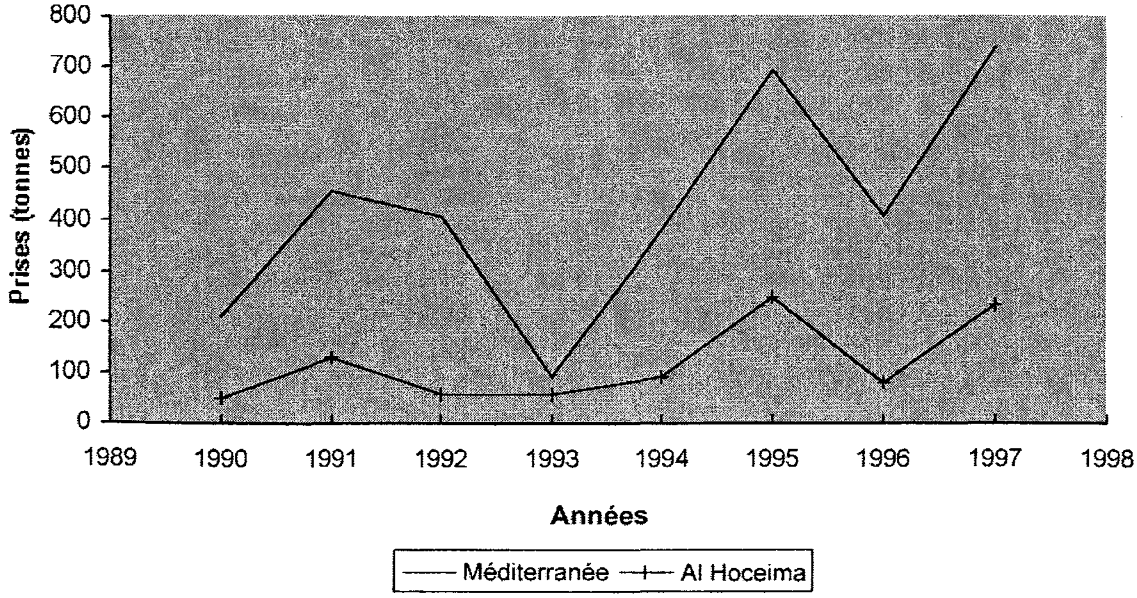

Fig. 3. Evolution des prises d'anchois débarquées en Méditerranée et au port d'Al Hoceima (1990-1997).

L'analyse des résultats obtenus permet de dégager par pêcherie les tendances suivantes :

- la pêcherie des petits pélagiques connaît une diminution des prises en ce qui concerne la sardine, par contre, une augmentation est constatée pour l'anchois, bien que le niveau de capture de cette espèce est relativement faible; pour la sardine, on constate une régression des rendements, due à une augmentation de l'effort de pêche. En ce qui concerne l'anchois, une reprise très faible est observée.
- la pêcherie des espèces démersales montre, elle aussi, une régression des prises. On constate une stagnation des CPUE qui pourrait s'expliquer également par une augmentation de l'effort de pêche.

Modélisation

La modélisation globale (modèles de Schaeffer, 1954 et Fox, 1970) de la pêcherie démersale méditerranéenne (Zoubî, 1995) a conduit à une prise maximale équilibrée calculée de 13 000 t (premier modèle) et 12 000 t (deuxième modèle). La comparaison des résultats obtenus avec les prises enregistrées pour les ressources démersales durant la période 1989-1997, permet de conclure que ces ressources se trouvent globalement dans un état de surexploitation.

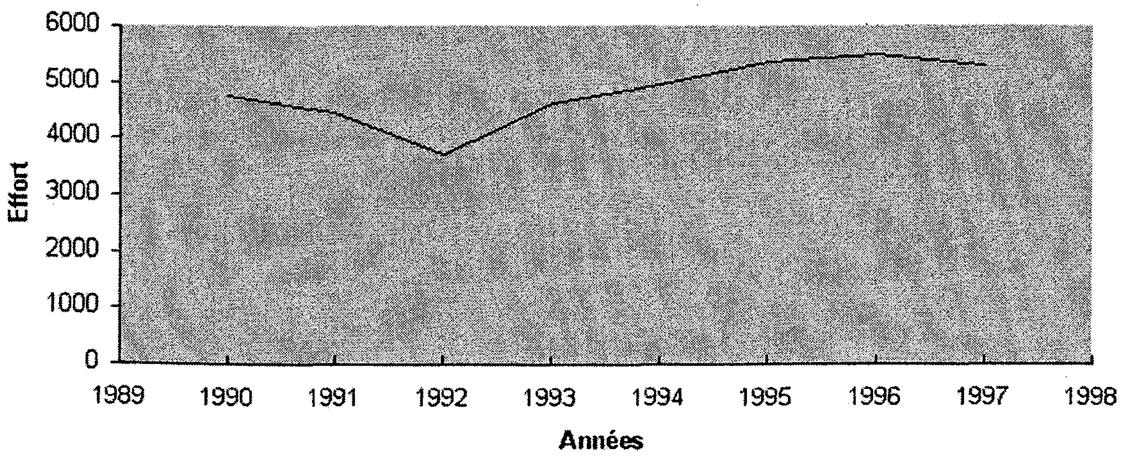

Fig. 4. Evolution de l'effort des sardiniers (en sorties) au port d'Al Hoceima (1990-1997).

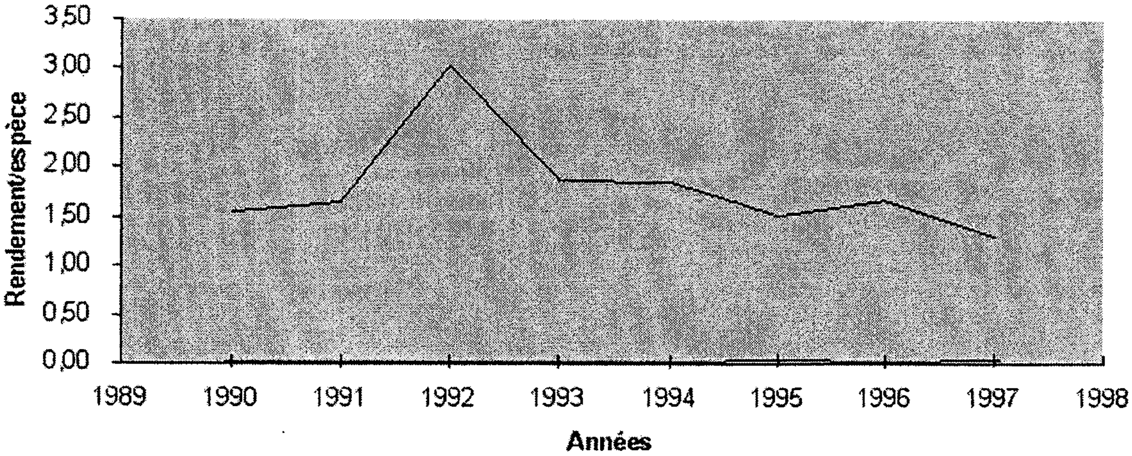

Fig. 5. Evolution des rendements (tonnes/sortie) de sardine et d'anchois au port d'Al Hoceima (1990-1997).

En effet, l'effort de pêche actuel, pour chaque espèce, se situe au-delà de l'effort de pêche optimal (Fopt) correspondant. D'autre part, les évaluations de ces ressources, basées sur les données de tailles (Zoubî, 1995) ont permis de faire le même constat de surexploitation. En effet, les tailles moyennes des ressources généralement très faibles se situent en-deçà de la taille de première maturité.

A partir de l'échantillonnage biologique des débarquements de la pêche côtière effectué en Méditerranée, durant la période 1987-1996, l'évaluation des coefficients de mortalité (Zoubî, 1995) permet l'estimation des taux d'exploitation des principales ressources démersales (sparidés et mullidés). A l'exception de la besugue qui paraît en état de pleine exploitation (E varie de 0,42 à 0,56), les stocks de rouget de vase et de bogue se trouvent dans un état de surexploitation. Leurs taux d'exploitation se situent au-delà de 0,5.

En général, les ressources halieutiques sont caractérisées par une grande variabilité, accentuée en Méditerranée par le caractère semi-fermé de la mer ainsi que la faible longévité des ressources qui la peuplent. Ces caractéristiques jointes à l'augmentation de l'effort de pêche durant la dernière décennie a conduit à une surexploitation quasi généralisée des ressources.

En référence d'une part, aux principes de la déclaration de la Conférence des Nations Unies (Rio de Janeiro, 1992) relative à l'application de l'approche de précaution pour gérer le risque d'effondrement des ressources et d'autre part, au principe général du Code de Conduite pour une Pêche Responsable, adopté par la FAO lors de la Conférence de 1995 et auquel le Maroc adhère pleinement, le département marocain chargé des pêches maritimes, conscient du danger encouru, a instauré un certain nombre de mesures rentrant dans le cadre de précaution prônée par ces principes et ayant pour objectif l'amélioration des connaissances sur les stocks, ainsi que la préservation de ces ressources et leur exploitation de manière durable.

Parmi ces mesures, il faudrait citer particulièrement le gel de l'effort de pêche et de l'investissement dans l'acquisition des navires de pêche; ceci en vue d'observer un arrêt d'émission de licences de pêche en attendant d'effectuer une étude typologique des flottilles actuellement actives à une fin de modernisation. Il y a lieu de signaler que la renégociation des accords internationaux vise également la limitation de l'effort de pêche jugé déjà très excessif.

Une autre mesure concerne la protection des zones de concentration des juvéniles et des nourriceries et ce, par l'instauration d'une zone d'interdiction de chalutage. A cet égard, les prospections de chalutage en routines dans la région permettent souvent la collecte des données dans les eaux côtières; le traitement de ces données détermine les lieux servant pour les concentrations des jeunes en vue d'une délimitation des nourriceries à des fins de préservation ;

S'agissant des essais de repeuplement en espèces jugées dans une situation d'exploitation critique, un projet de création des zones de réserves (refuges) est à l'étude, telle que celle prévue dans la région d'Al Hoceima (Zoubi, 1996), ce qui permettrait de consolider davantage cette

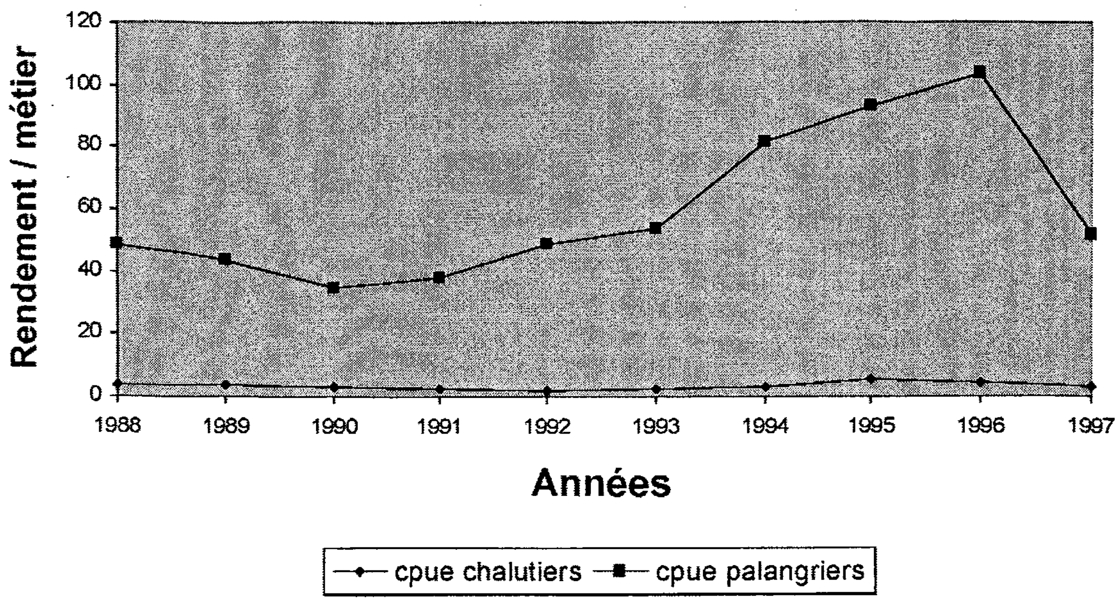

Fig. 6. Evolution du rendement de pêche des chalutiers (kg/ue) et des palangriers (kg/sortie) au port de Nador (1988-1997).

action de protection. Parallèlement à cette mesure, le Maroc mène actuellement à travers son Institut de Recherche (INRH), des essais qui permettront plus tard l'introduction en mer des alevins des espèces en état de surexploitation dans le cadre du projet de thon rouge installé à M'diq, notamment pour les espèces d'alose, de mérou et de thonidés. Actuellement la mesure d'interdiction de pêche de certaines ressources menacées de disparition, en particulier durant la période de reproduction (cas du mérou), est en vigueur.

L'application de la réglementation en ce qui concerne les engins utilisés dans la pêche des thonidés vise à respecter la taille de 2,5 km comme longueur maximale des filets maillants dérivants et la fixation d'un maillage minimum de 400 mm pour ces engins et l'interdiction d'utilisation du filet maillant dérivant pour les grandes unités de pêche dépassant 15 TJB. (Lahnin, 1996), et ce, conformément à la résolution 44/224 de l'Assemblée Générale des Nations Unies. Il y a lieu de signaler le respect des tailles marchandes et ce, à travers un contrôle des tailles des poissons au débarquement.

A partir d'octobre 1998, l'Institut National de Recherche Halieutique, dans le cadre de la décentralisation de la recherche jointe à son renforcement, a mis en place un Centre de recherche dans la région, à savoir le Centre Régional à Nador. Ce centre aura pour mission d'établir un programme de recherche pour les espèces spécifiquement méditerranéennes. Ce programme concernera les différentes composantes des principales pêcheries de la région (biologique, socio-économique et technologique).

Des enquêtes ponctuelles ont été entreprises afin d'améliorer la qualité des statistiques, lesquelles constituent un préalable nécessaire dans tout projet d'aménagement des ressources.

Conformément aux dispositions de précaution précitées, les travaux de recherche entrepris jusqu'à présent ont pour objectif ultime d'assurer une connaissance bien fondée sur les ressources et ce, à travers une collecte des données fiables sur les ressources. Toutefois la qualité et la quantité des données, qui restent à améliorer en permanence, n'a pas fait obstacle pour opérer, sur la base de celles qui existent, un diagnostic permettant d'adopter une stratégie de précaution pour la gestion des ressources méditerranéennes. Ce diagnostic est fait en se basant sur certains points de référence (Caddy et Mahon, 1995), tel que la production maximale soutenue (PME) des modèles globaux (Schaeffer, 1954 et Fox, 1970), et le rendement par recrue (Y/R) du modèle de production de Beverton et Holt. D'autres analyses ont été aussi basées sur l'analyse des données de mortalité et de taille à partir des structures démographiques des ressources.

3. DISCUSSION ET PERSPECTIVES DE DÉVELOPPEMENT

Des études menées au niveau des différents secteurs de la Méditerranée font état d'une surexploitation avancée des ressources démersales. En Algérie, un modèle de production globale a été appliqué aux démersaux (Chavance et Girardin, 1985). La conclusion en a été que la partie Ouest du pays est surexploitée. Une analyse plus récente, faite pour la pêcherie démersale de la zone Béni-saf (Djabali *et al.*, 1991), dans la partie Ouest du pays a mis en évidence une surexploitation et a amené à recommander une réduction de l'effort de pêche. Une étude similaire faite à l'aide d'un modèle de production globale au niveau de la région du Golfe du Lion, a recommandé une réduction de 30% de l'effort de pêche (Oliver, 1994). En ce qui concerne les ressources démersales du plateau continental, le Conseil Général des Pêches pour la Méditerranée a attiré l'attention depuis longtemps sur la surexploitation de certains stocks ayant un potentiel limité.

En matière de gestion de l'activité de pêche, le Maroc, à partir de 1981 – date de la création d'un département en charge du secteur des pêches maritimes – a procédé à la refonte de l'appareil législatif régissant le secteur des pêches maritimes, aussi bien en Atlantique qu'en Méditerranée. Le Maroc a ainsi inscrit parmi ses principales préoccupations la nécessité d'une exploitation rationnelle et équilibrée des ressources halieutiques, compte tenu de la situation de plus en plus alarmante des stocks de poissons dans cette région. Cela s'est traduit par la promulgation et la mise en application des mesures précitées à des fins de protection des ressources.

Espèces endémiques et espèces atlanto-méditerranéennes des côtes algériennes

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Les fluctuations qualitatives et quantitatives des espèces marines à différentes échelles temporelles constituent une information capitale dans l'étude de l'évolution du milieu marin. L'importance de telles observations ne se limite uniquement aux aspects économiques de l'exploitation halieutique, mais elle joue un rôle clé dans la stratégie de préservation et de conservation de la diversité biologique marine, préoccupation majeure des pouvoirs publics qui ont pris diverses mesures pour répondre aux termes de référence de projets régionaux qu'ils ont ratifiés.

Les premiers résultats obtenus dans l'étude menée dans ce cadre concernent l'inventaire des espèces marines des côtes algériennes, avec pour objectif essentiel, d'en dresser la liste. Leur classification selon divers critères, tels que l'éthologie trophique, la répartition bathymétrique, la tolérance haline, a non seulement permis de mieux connaître la ressource marine, mais aussi d'établir un état des lieux, une espèce de temps zéro susceptible de servir de base de comparaison ultérieurement. Le principe méthodologique retenu a consisté à :

- compiler l'ensemble des données disponibles dans la littérature scientifique publiée, ainsi que dans divers travaux de laboratoires menés dans le cadre de rapports de stage; dans ce dernier cas, des précautions ont été prises de manières à confirmer certains résultats qui ne présentent pas systématiquement la rigueur nécessaire;
- mener les opérations d'échantillonnage et traiter les prélèvements en laboratoire lorsque les informations disponibles se sont avérées insuffisantes;
- enquêter sur le terrain auprès des professionnels;
- enfin, synthétiser des notes personnelles de plus de quinze ans de pêche, au chalut, aux filets, aux palangres, ainsi que des observations *in situ* en plongée et/ou en apnée.

La première analyse a concerné la physico-chimie des masses d'eau, élément déterminant dans la distribution de la ressource biologique marine. La veine de courant atlantique qui pénètre par le détroit de Gibraltar, prend le nom de courant algérien lorsqu'elle arrive dans le sud de la mer d'Alboran et longe les côtes de l'Algérie. Cet hydrodynamisme est à l'origine d'importants phénomènes physico-chimiques qui se traduisent par un ensemble de tourbillons cycloniques et anticycloniques de 150 à 200 km de diamètre. Ces structures de moyenne échelle, identifiées grâce à l'image satellite, présentent divers intérêts, d'ordre fondamental et appliqué, notamment dans les mécanismes d'enrichissement et de renouvellement de la ressource halieutique.

L'influence de cette anomalie physico-chimique au niveau de la chaîne trophique pélagique, a été abordée par l'étude taxinomique et écologique du zooplancton de groupe zooplanctonique, le plus important est composé de copépodes parmi lesquels plus de 140 taxons à dominante néritique ont été identifiées, en présence de nombreuses espèces d'origine atlantique, démontrant un brassage conséquent des masses d'eau. Les indices écologiques utilisés indiquent que les densités moyennes sont faibles (101 individus.m^2), observation confirmée par les faibles biomasses (0,77 mg.m^3). Cette relative pauvreté, comparée à des zones similaires de la Méditerranée occidentale sud, provient de l'extrême variabilité spatio-temporelle de la production primaire, soumise aux fluctuations météo-climatiques.

Dans certaines régions particulières comme la zone ouest (01 00 00 à 02 00 00° E), l'approche structurale indique la présence de deux états de maturation de la copépodo-faune. L'analyse statistique multi-dimensionnelle confirme ces résultats; par contre les deux communautés diffèrent par l'abondance des copépodes, plus élevée là où les omnivores sont numériquement plus représentés.

Les structures étudiées montrent la meilleure faculté d'adaptation des espèces à faible préférence trophique. Cette caractéristique étho-écologique aura des incidences sur les maillons supérieurs de la pyramide alimentaire pélagique, en particulier au niveau du necton.

L'inventaire faunistique de la Méditerranée sud occidentale, en particulier pour les poissons n'indique aucune disparition d'espèce préalablement inventoriée, même si certaines montrent des tendances à la raréfaction. Cependant, la liste exhaustive et définitive n'est pas close, en raison :

- de l'éventuelle apparition de nouvelles espèces, totalement inconnues jusqu'à présent, ce qui est rarissime et concerne peut-être les espèces abyssales mal connues faute de moyens appropriés d'investigation;
- de l'arrivée d'espèces migrantes provenant de l'Atlantique ou plus vraisemblablement de l'Océan Indien via la mer Rouge et le canal de Suez, espèces lessepsiennes dont l'aire de distribution s'étend progressivement;
- du choix des documents de référence qui diffèrent aussi bien sur la spéciation selon la classification adoptée, que sur les limites de distribution géographique des taxons inventoriés.

Les deux premières causes de variation de la richesse spécifique ne vont pas révolutionner la liste dressée. L'apparition de nouvelles espèces en Méditerranée occidentale et *a fortiori* pour les côtes algériennes, ne peut revêtir qu'un caractère anecdotique. De même, l'apparition de nouvelles espèces lessepsiennes actuellement au nombre de deux (*Pomadosyx stridens* Forskall, de la famille des Leiognathidae et *Siganus luridus* Ruppel de la famille des Siganidae), information qui reste à vérifier, suppose que la frontière physico-chimique puisse être franchie, phénomène long, concevable uniquement pour des espèces dotées d'une tolérance remarquable aux fluctuations du milieu, aussi bien en termes physiques que biologiques, autrement dit pour des spécimens aux capacités d'acclimatation particulières.

La troisième cause mentionnée suscite plus de controverse. Les documents et travaux consultés divergent selon :

- l'époque de la publication, les ouvrages les plus récents ayant une tendance à comporter plus d'espèces;
- le degré de spécialisation des publications.

Les auteurs ne s'accordent pas pour certaines espèces; seul l'un d'eux mentionne l'esturgeon *Acipenser sturio*. Selon les ouvrages consultés, le nombre d'animaux marins varie de 303 à 387 espèces. Si la liste des poissons au nombre de 297 semble correcte, celles des autres taxons est incomplète. La situation est d'autant plus délicate en raison d'une certaine confusion en matière de classification. Le catalogue FAO cite 287 espèces de poissons en Méditerranée sud occidentale, parmi lesquelles les cartilagineux sont représentés par 45 squales et 29 raies. Dans ce groupe, 5 requins fréquentent uniquement la région ouest et deux autres sont douteux. Chez les raies, le phénomène contraire est signalé, aucune espèce ne caractérise la région ouest, alors que 3 sont mentionnées seulement dans l'est, et 2 sont douteuses.

Le document élaboré spécifiquement pour l'Algérie n'indique que 164 espèces de poissons osseux, soit un déficit de 123 espèces comparativement à la totalité de la faune piscicole de Méditerranée occidentale inventoriée. La dizaine d'espèces supplémentaires indiquées dans ce travail provient de quelques informations extraites de la banque de données Médifaune. Mais si cette source de données constitue un outil efficace, il reste encore insuffisamment précis pour les côtes sud méditerranéennes occidentales. Ce document montre que les espèces lessepsiennes qui occupent progressivement la Méditerranée orientale n'ont pas franchi le détroit sicilo-tunisien. Une investigation approfondie et permanente est la seule solution au problème de la connaissance de la biodiversité marine. Des espèces comme le sprat *Sprattus sprattus* ou le germon *Thunnus alalunga*, mentionnées au nord, semblent absents des côtes algériennes, même si d'après certains pêcheurs, le dernier mentionné aurait été capturé une ou deux fois.

La liste des poissons atlantique comporte 23 espèces pour la Méditerranée occidentale et 15 d'entre elles ont été confirmées en Algérie.

La liste des animaux marins est beaucoup plus riche, certains embranchements comme les annélides n'ont pas été systématiquement répertoriés, alors que d'autres groupes comme les Mysidacés, les Isopodes ou encore les Amphopodes, n'ont pas du tout été abordés. Les invertébrés de Méditerranée mentionnés sont au nombre de 353 espèces. L'embranchement des mollusques est représenté par :

- 131 espèces de gastéropodes dont 90 sont caractéristiques des côtes algériennes et parmi lesquelles deux sont absentes à l'est ;
- 90 bivalves alors que 56 sont propres aux côtes algériennes, dont une espèce n'est signalée qu'à l'est alors que 4 autres ne le sont qu'à l'ouest et que 3 sont douteuses ;
- 112 céphalopodes.

Chez les crustacés (phylum des Arthropodes), 153 espèces sont inventoriées en Méditerranée sud occidentale, représentées par :

- 68 crevettes dont 2 espèces sont caractéristiques de l'ouest alors qu'une est douteuse ;
- 2 Stomatopodes (squilles) dont une est absente à l'est ;
- 83 grands crustacés, crabes, langoustes, homards, langoustines dont deux espèces sont propres à l'ouest et une au centre.

Les tortues marines mentionnées sont au nombre de 4. Les mammifères marins sont composés de 6 dauphins, 3 baleines, un cachalot et un phoque, le phoque moine *Monachus monachus*, seule espèce réellement en danger actuellement.

Les vertébrés marins des côtes algériennes sont relativement bien connus mais un complément d'étude est obligatoire, pour enrichir l'inventaire actuel de tous les embranchements par de nouvelles espèces qui risquent d'apparaître, et procéder aussi à l'uniformisation des appellations. L'exemple de la moule *Perna picta* est édifiant. Cette espèce continue d'être appelée *Perna perna* alors qu'elle n'est indiquée dans aucune classification récent.

Si l'effort en matière d'identification concerne tous les embranchements, le cas des éponges (phylum des Spongiaires) mérite une attention particulière. Le niveau de connaissance est des plus réduits, d'autant plus que ces animaux à la fois filtreurs et accumulateurs, jouent un rôle des premier plan.

L'évolution des moyens scientifiques et techniques a pour conséquence d'affiner l'approche taxinomique en multipliant les taxons, qu'il s'agisse de familles, de genres ou d'espèces. Cette tendance peut faire croire à une augmentation du nombre d'espèces. Mais ce phénomène est illusoire, il pose le problème de la validation des découvertes.

Diagnostic des stocks exploités en Algérie

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ISMAL, Sidi-fredj, Staoueli, Algérie

Le fait que la pêche en Algérie se limite aux techniques traditionnelles d'une part et la vétusté de l'armement de pêche d'autre part, ont fait que la quasi totalité de la flottille opère uniquement sur le plateau continental très réduit et surexploité le long des côtes algériennes. En revanche, rares sont ceux qui exploitent le talus dont la pente douce est riche en espèces démersales telles que la crevette rouge (*Aristeus antennatus*), les merlus de grande taille (*Merluccius merluccius* L.), la mustelle (*Phycis blennoides*) et le gros yeux (*Pagellus erythrinus*) (Djabali,1988).

Au début des années 80, suite au déclin significatif des ressources démersales, dont les débarquements par chalutier ne dépassent jamais 20 kg de merlu (*Merluccius merluccius*), 40 kg de rouget de vase (Mullus barbatus), 80 kg de sparidés (statistiques de pêche du laboratoire halieutique de l'ISMAL), la quasi-totalité des chalutiers s'est armée, outre le filet de fond, du filet à grande ouverture verticale (filet quatre faces et filet à corde) leur permettant ainsi de cibler les espèces pélagiques tels que le saurel (*Trachurus trachurus*, taille de la première maturité sexuelle = 14,2 cm pour les femelles, Korichi, 1988), l'anchois (*Engraulis encrasicolus*, taille de sélection = 12,2 cm, Hemida, 1987) et la sardine (*Sardina pilchardus*, taille de sélection = 12 cm, Mouhoub, 1986); en effet, la quantité des petits pélagiques, dont la longueur totale est largement supérieure à la taille de sélection, débarquée par les chalutiers au port de Ghazaouet à l'ouest du pays, considéré comme le premier producteur en ressources halieutiques, passe de 1516,8 tonnes pour une puissance de 12998 chevaux en 1991 à 5527,8 tonnes pour une puissance de 14638 chevaux en 1993 après introduction du filet à corde en 1992 (ANDP, 1997). Concernant la région d'Alger, la quantité des petits pélagiques débarquée par les chalutiers passe de 281.7 tonnes en 1984, période à laquelle ou les stocks de l'anchois et de la sardine (représentant la quasi totalité des apports en pélagiques) étaient sous exploités (Mouhoub, 1986; Hemida, 1987), à 11 040,1 tonnes en 1992 après introduction du filet quatre faces en 1985 et le filet à corde en 1992.

En ce qui concerne les senneurs, ils opèrent près de la côte sur des fonds n'excédant jamais à 50 m de fond permettant ainsi la capture d'individus matures de sardine, d'anchois et de sardinelle (*Sardinella aurita*) pendant leur période de ponte et les immatures en dehors de celle-ci .

Encore faudrait-il noter que le total des petits pélagiques débarqués par les senneurs à Bou-Ismail (Alger) était de 7327,9 tonnes en 1986, dont 60% était représenté par des anchois (Hemida, 1987) et qu'en 1994 il atteignait 12 171,75 tonnes (syndic de Bou-Ismail) avec 90% de sardinelle. Ce pourcentage demeure valable à ce jour (com. pers.).

La prédominance de la sardinelle s'expliquerait par le fait que cette dernière échappe aux filets à grande ouverture verticale utilisés par les chalutiers.

Compte-tenu du déclin des ressources démersales et pélagiques, excepté la sardinelle dont l'augmentation de la production peut se faire au détriment de la biomasse (Lleonart et Salat, 1998), il serait urgent de recommander :

- l'interdiction de l'activité des senneurs près de la côte;
- le déplacement de l'effort de pêche en dehors des baies;
- l'exploitation du talus demeurant à l'heure actuelle presque vierge;
- l'encouragement des petits métiers à exploiter les grands fonds rocheux;
- la création d'une banque de données fiable et cohérente (statistiques de pêche, éléments d'écologie et de biologie des différentes espèces à intérêt commercial) afin de parvenir à des décisions prometteuses.

Les îles Kerkennah : un exemple méditerranéen typique de la pêche précautionnelle

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Le secteur de la pêche en Tunisie joue un rôle économique et social assez important dans le pays. En effet, il assure annuellement une production halieutique avoisinant les 90 000 tonnes et garantit environ 60 000 postes d'emploi permanents et saisonniers.

La région du golfe de Gabès située dans le sud tunisien participe très efficacement à cette activité halieutique tunisienne. Cette région constitue le lieu de concentration le plus important des crustacés (crevette royale *Penaeus kerathurus*), de céphalopodes (poulpe commun *Octopus vulgaris* et seiche *Sepia officinalis*) et de quelques espèces de poissons benthiques (pageot *Pagellus erythrimus*, sole *Solea aegyptiaca*, rougets *Mullus barbatus* et *Mullus surmuletus*, ...). Par conséquent, cette richesse attire une flottille de pêche assez importante et assez diversifiée.

Les hauts fonds de Kerkennah situés au nord du golfe de Gabès constituent depuis longtemps le lieu idéal pour l'utilisation d'un nombre assez important d'engins de pêche qualifiés de "doux" et de sélectifs. A ce propos, on cite essentiellement les gargoulettes et les pierres pour la pêche aux poulpes et la "Charfia" pour la capture des principales espèces de Sparidae.

Pour assurer un développement durable et soutenu du secteur de la pêche en Tunisie et particulièrement dans la région du golfe de Gabès, l'activité halieutique est soumise à une réglementation assez rigoureuse qui repose sur plusieurs mesures dont les plus importantes sont:

- interdiction de certaines zones et de certains engins de pêche;
- fixation d'une taille minimale de capture pour la majorité des espèces pêchées;
- organisation des campagnes de pêche pour les principales ressources halieutiques.

Pour conforter cette stratégie de pêche précautionnelle, la recherche scientifique constitue, depuis toujours, un support assez important. En effet, elle intervient au niveau de la réalisation des études d'évaluation des stocks et de leurs états d'exploitation, des propositions de solutions d'aménagement des pêcheries et du suivi de l'efficacité des mesures réglementant l'activité de la pêche en Tunisie.

Mentions d'espèces introduites dans les eaux marines tunisiennes

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RÉSUMÉ

Nous précisons dans cette note le statut de quelques espèces marines introduites et inventoriées dans la région du golfe de Gabès, faisant partie géographiquement du bassin oriental de la Méditerranée.

Nous évoquons à cet effet, la date d'installation, l'acclimatation de l'espèce aux conditions de la région et l'impact de cette installation de quelques espèces introduites de la mer Rouge via le canal de Suez ou d'autres régions.

1 - POISSONS

Famille Monacanthidae

• *Stephanolepsis diaspros* (Fraser-Brünner, 1940)

Migrant de la mer Rouge via le canal de Suez. Les premières mentions de cette espèce dans la région du golfe de Gabès se situent dans les années 1965-1966 (Chackroun, 1966).

Famille Priacanthidae

• *Priacanthus hamrur* (Forsskäl, 1775)

Migrant lessepsien observé pour la première fois en Méditerranée et en Tunisie le 7 avril 1980 à Mahdia - Est de la Tunisie (Abdelmouleh, 1981).

Famille des Siganidae

• *Siganus luridus* (Rüppell, 1828)

Ce migrant lessepsien a été capturé pour la première fois le 20 décembre 1969 dans le golfe de Tunis (Chakroun et Bouhlel, 1971). D'autres observations ont été mentionnées dans le golfe de Gabès (Ktari et Ktari, 1974 ; Bradaï *et al.*, 1992).

• *Siganus rivilatus* (Forsskal, 1775)

Migrant lessepsien signalé pour la première fois en Tunisie en 1974 dans la région du golfe de Gabès (Ktari et Ktari, 1974). En 1995, nous y avons observé deux individus de cette espèce.

Famille Tetraodontidae

• *Sphoeroïdes pachygaster* (Müller et Troschel, 1848)

Espèce typique de la faune ichtyologique de l'Atlantique oriental, tropical et subtropical, observée pour la première fois dans la région du golfe de Gabès en 1992 (Bradaï *et al.*, 1993).

• *Lagocephalus lagocephalus* (Linnaeus, 1758)

Lagocephalus lagocephalus a été signalé pour la première fois dans le golfe de Gabès par Chakroun (1966). Nous en avons observé deux spécimens, respectivement en 1996 et 1999.

• *Ephippion guttiferum* (Bennett, 1831)

Originaire des côtes africaines orientales de l'Atlantique, ce poisson a été observé pour la première fois en Tunisie dans le golfe de Tunis le 5 octobre 1980 (Hachaichi, 1981).

2 - CRUSTACÉS

Famille Penacidae

• *Metapenaeus monoceros*

Espèce lessepsienne, apparue dans la région du golfe de Gabès en 1994-1995 (Missaoui et Zaouali, 1995; Enzenross *et al.*, 1997).

• *Trachypenaeus curvirostris*

Espèce lessepsienne, apparue dans la région du golfe de Gabès en 1993 (Zaouali, 1993).

Famille Alpheidae

• *Alphaeus crassimanus*

Espèce lessepsienne, apparue en Tunisie depuis les années 50 (Forest et Guinot, 1956).

Famille Goneplacidae

• *Eucrate cranata* (De Hann, 1835)

Ce crabe de la mer Rouge s'est installé dans le golfe de Gabès depuis 1985 (Zaouali, 1992.)

Famille Majidae

• *Libinia dubia* (H. Edwards, 1834)

Originaire des côtes américaines, ce crabe est apparu dans le golfe de gabès depuis 1994 où il s'est bien adapté à l'écosystème (Enzenross *et al.*, 1997).

3 - MOLLUSQUES

Famille Pteriida

• *Pinctada radiata*

Ce bivalve de la mer Rouge s'est installé dans le golfe depuis 1895 (Dautzenberg, 1895).

Les pêcheries tunisiennes : état d'exploitation des principales espèces benthiques et éléments d'aménagement

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Une base de données, notamment les prises par unité d'effort et les structures en taille des captures des différentes flottilles exploitant les espèces benthiques ainsi que les paramètres biologiques de ces dernières, a été préparée de telle façon qu'elle soit accessible par les techniques d'analyse de cohortes et de rendement par recrue. Sont concernées par cette étude les deux espèces du rouget, le pageot, le merlu, la crevette et la seiche.

L'évolution historique des prises par unité d'effort des deux espèces du rouget et du pageot de la région "nord-est" est différente de celles du sud (golfe de Gabès), ce qui nous a permis de considérer les stocks de ces espèces comme des unités de gestion distinctes respectives à chaque région. Pour le merlu une seule unité de gestion a été retenue pour toutes les côtes tunisiennes. La crevette et la seiche, elles, ne sont pratiquement pêchées que dans le golfe de Gabès.

L'analyse des mortalités par pêche fait apparaître que :

- les espèces considérées (merlu, rouget et pageot) sont soumises à des mortalités par pêche élevées; de surcroît, la pêche dans le sud est surtout dirigée vers les juvéniles;
- la crevette et la seiche sont soumises à des mortalités par pêche, en grande partie dirigées vers les adultes.

L'analyse des rendements par recrue montre que :

- tout accroissement de l'effort actuel entraînerait à long terme, pour toutes les espèces à l'exception de la crevette, une diminution de la production globale et les pertes de la pêche artisanale seraient très importantes. En revanche, une légère amélioration durable de la production serait possible et ce, au prix d'une diminution importante de l'effort;
- toute augmentation du maillage procurerait des gains substantiels durables, notamment pour la pêche artisanale.

Enfin, il est important de noter que des mesures d'aménagement de précaution sont déjà instaurées à savoir :

- la limitation de l'accès à la ressource par les autorisations de pêche des unités participant à la campagne de pêche de la crevette;
- la limitation de la période de pêche de la crevette.

The current status of fisheries in Syria

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The marine fisheries of Syria are limited primarily to the narrow shelf, the lack of any major river, no upwelling, and the limited length of the coastline(183 km). Landings are reported to be around 2000-2500 tons (figure 1) from an approximate area of 1160 km², the number of fishermen, the condition of the boats and the current price for fish would indicate that this figure is underestimated.

The trawling area on the shelf is limited to about 310 km² and the main problem is the extremely low natural production. However, comparable data collected in Lebanon indicate a yield per unit area of about 1,6 ton/km², whereas Syria has only 0,9 tons/km².(Vilagas, 1983).

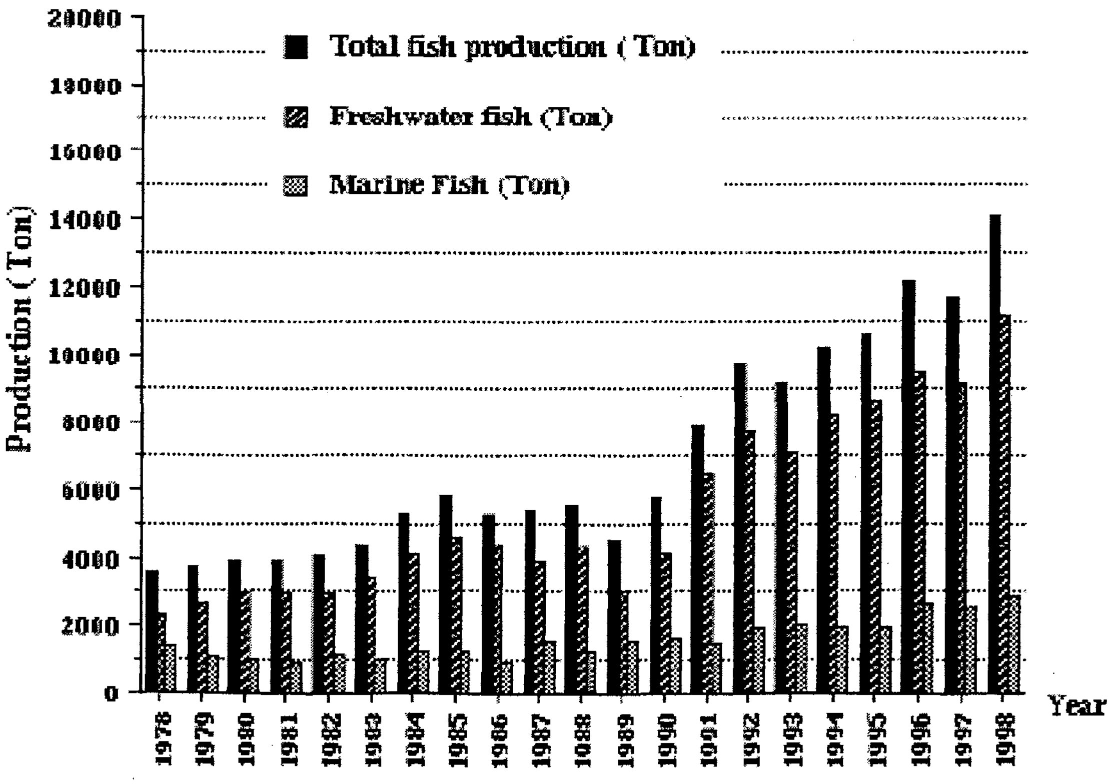

Fig. 1. Annual productionod marine and freshwater fishes in Syria during the period 1978-1988

This difference is believed to be caused by over-exploitation on the Syrian coastline. This appears to be very little scientific advice available to the industry, except for an occasional project by the Tishreen University – Lattakia – or by FAO, it is being more or less accepted that the resource is being harvested at or beyond its maximum sustainable yield (MSY).

The main problem regarding marine fishery is the extremely low national production. Demand is very high and fish is sold very quickly, non special effort being needed to market it. Statistics are difficult to obtain (except for GEFs production) because of the individualism of small-scale fisherman. To date there has been no mariculture research or development.

FISHING

Two types of vessels are employed. There are three steel trawlers, 22m long, belonging to the General Establishment of Fisheries (GEF). These three vessels, built in 1977, are equipped with hydraulic winches, an electric winch, a 360hp engine, sonar and central control. They need general maintenance and lack of spare parts. They trawl over a small area, 25-400m deep, from the South of Lattakia to Ras al Basit (at 30-40 km north of Lattakia), their home port, using trawls with a stretched mesh size of 20mm. Each vessel has a hold of 30 m^3. The annual catch of each of the three boats is about 33-40 t; the total for the three boats together was 124t in 1992, 178t in 1993, 157t in 1994, 112t in 1995, 100t in 1996, 93t in 1997, and 98t in 1998.

There are also two old wooden trawlers, with a total annual catch of about 40 t. It is planned to stop using these boats which belong to cooperatives. In 1994-1995, 17 private trawlers (22-27m) operated in international sea water but probably they are watch in territorial water. Fishing is also done by small fishermen using open wooden boat (4-6, and 8-12m long) fitted with fixed diesel engines of around 10-30 hp. They use gillnet and hooks-and lines. Banias, Jeble, Lattakia and Al-Baseet. In June-August the small artisanal boats fish for sardinella with small purse seines. The total annual catch by the artisanal fleet is about 1500t (example: 1497t in 1992, 1541t in 1993, and 1490t in 1994, and 1650 t. in 1998).

Syria's total catch of marine species is estimated at 1200-1500 t/ year during the period 1978 -1991 and augmented at 1600-2500 t/ year during 1992-1998 (see figure 1.) The recent augmentation of total catch is caused by the introduction of new trawler since 1994 in Syrian fleet of fisheries, but not by amelioration or augmentation of fish stock in the region.

ECONOMIC ROLE OF FISH AND THE FISHING INDUSTRY

The impact of fishing on the Syrian industry as a whole has until now been negligible; it represent less than 0.3 per thousand of the GNP. Syria was the lowest consumer of fish in the Mediterranean region (less than 0.9 kg/caput/year). At present, freshwater fish (carp, tilapia) presenting a serious problem, which hind few buyers although sold well below cost price.

FISHERMEN, BOATS AND GEARS

The total number of licensed fishermen, including full-time and part-time, is about 10000 and the number of 4891 boats (Lattakia: 2285, Jable: 296, Banais: 284, Tartous: 234, Arowad: 1792). Theses figures indicate a substantial increase from the 3600 men and 1600 boats in 1978 and the 7500 men and 3600 boats in 1990. The fishing boats are still majority of the felucca type except 5 trawlers operate since 1978 (more than 16 trawlers licensed in 1992-1995 for fishing in international sea water).

The feluccas for the most part have engines. The trawler include 20 larger vessels of about 15.5-26.6 m long, and 165-440 Hp. Trammel net are still the main fishing gear. Most of these use a mesh size of 20 40 mm between opposite knot when pulled closed, but some use a 50-60 mm mesh size. Gill net, shore-seines (with bag mesh of 14 mm) cast nets, bottom-set longlines (some with n.14 small hook) and handlines are used all the year round. Bouri net, feathered troll lines and lampara net with light are used in season. Dynamite, although illegal, is still used spasmodically.

CATCH COMPOSITION AND CATCH RATES

There are about 26 families of finfishes entering the various types of fisheries in Syria and they are represented by about 89 species – total number of family and species in Syrian sea water is about 71 families and 161 species described by Saad and Sbaihi 1994; Saad 1996, Saad, 1999. The general composition of the catch depends on the types of gear used, fishing season and fishing area. Unfortunately, the composition of the varieties caught by each type of gear used in different areas within Syrian water non known at present. In the trap fishery, the predominant varieties are the Carangidae family (flathead, amberjack, horse jack, leerfish, pompano, etc.), Scaridae family (Parrot fish), Sparidae family (sea bream), Mullidae family (red mullet, stried mullet, and goldband goatfish, large mackerel queen fush, jacks, etc.) Serranidae and Siganidae. The mesh six of the trap and its passiveness introduce some degree of selectivity of fish by size and behaviour, as evident from the difference in the catch composition for the fish trawl used in commercial fishery. Varieties, such as lizard fish Synodontidae, goatfishes (Mullidae), sardine (Clupeidae) enter travel fishery in addition to the varieties entering the trap fishery in addition to the varies entering the trap fishery.

The use of 40 mm mesh size for the cod end of the trawl net, reduce the selectivity by size and further, being an active gear, it catches more species than the traps. As a result, large quantities of undesirable varieties and also unmarketable size of desirable variety, are caught by the fish trawl. At present, fishing record are not maintained by the owners or the artisanal crafts or any statistical units in Syria for determined units effort and catch per effort, for various fishing methods.

ROLE OF IMMIGRANT FISHES IN SYRIAN FISHERIES

At present a least 26 Red Sea species can be identified in Syrian water (Saad, 1999). Many species are common enough of importance either as commercial fishes (*Upeneus moluccensis, U. pori, Siganus rivulatus, S. luridus, Sauida undosguamis, Scomberomorus commerson, Sphyraena chisotaenia, Himantura uarnak, Pranesus pinguis*).

The status of Greek fisheries

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With the increasing realisation that the management/conservation model has so far failed to keep fishing mortality under control on a worldwide basis, various countries have felt an urgent need to enforce stricter conservation regulations and to take measures that will ensure effective control of the fishing effort. While most of these measures may have a general applicability, the specific nature of fishing activities in the Mediterranean imposes a different mode of resource exploitation.

Investigation of the Mediterranean multi-species, multi-gear fisheries presents unresolved difficulties at all levels. These include the great diversity of the national fisheries legislation, the differences in the biological and socio-economic conditions both among and within the Mediterranean EU Marine Member States, the problem of defining management objectives, and the absence of simple and readily applicable biological multi-species models. A further difficulty is the lack of harmonisation with respect to administrative procedures, management rules and social priorities. The axes of the Mediterranean fisheries policy have not yet been defined, but it is envisaged that emphasis will be given to monitoring the fishing effort and to the application of stricter technical conservation measures. A central element is that catches of juvenile fish will be reduced. In essence, this will involve closed seasons and areas, restrictions on gear, an increase of mesh size, control of landing sizes, introduction of regulations concerning by-catches and discards, etc.

The Greek fishery is primarily practiced in the Aegean Sea and secondarily in the Ionian Sea. The geomorphological and biological conditions which characterize the Greek fisheries are: the great length of the coastline, the large number of small islands, the narrow continental shelf, the rocky nature of the bottoms, the limited extent of grounds suitable for trawling, the low productive capacity of the waters, the great number of exploited species, the long reproductive period, the short life span, and the multi-species nature of the fishing grounds. Such characteristics, along with the prevailing socio-economic structures, have favoured the development of small-scale, multi-gear fisheries addressed to numerous small-bodied species and operated close to the coast by small boats, mostly within the 100m contour line. The total number of fishing vessels operating in Greek waters in 1999 is 19,878. The total fisheries production is estimated at around 150-160,000 tons annually and covers 75-80% of the domestic fish consumption. Fisheries provide direct employment for 30,850 people, or about 1,2% of the national employment.

For administrative purposes, the Greek fishery industry is separated into three main categories using the operational characteristics of the vessels: (a) *coastal fisheries*, which is perceived as that operated in coastal waters by vessels employing set gear (gill nets, trammel nets, small surrounding nets, bottom longlines, hook lines, traps, etc.), drift gear (drift longlines) and certain types of towed gear (dredges and beach seines), (b) *medium fisheries*, which is that operated by trawlers and purse-seiners, and (c) *Atlantic (or overseas) fisheries*, which is operated by large trawlers fishing for fish and shrimp in the Atlantic Ocean.

Regarding the abundance and state of the stock in the Greek waters, the existing information is rather limited. This is particularly true for the resources exploited by the coastal fisheries which operate in the biologically sensitive coastal zone, where important nurseries and spawning aggregations of commercially important species are to be found, some of which are also important to the medium fisheries. It is the opinion of many greek fisheries scientists that most local stocks of species which fall to the share of the coastal fisheries are fully or at least overexploited. More information is available from research surveys on the resources exploited by the medium fisheries, but this information still does not permit reliable assessments of the state of the stocks. Many stocks of demersal species which are fished by trawlers are possibly fully exploited, while with the exception of anchovy, most stocks of small pelagic species which are fished mainly by night purse- seiners, are underexploited. Unfortunately, the greek fisheries statistic system does not effectively monitor the fishing effort, nor does it provide reliable assessments of landings, especially of those in the coastal fishery category. This, coupled with the widespread distribution of the fishing activities and the numerous landing places, makes it difficult to apply direct techniques of stock assessment, such as the VPA method, especially in the case of the numerous short-living species.

The greek fisheries legislation contains a great variety of conservation/ management measures which can be broadly separated into two major categories: those aiming to keep the fishing effort under control and those aiming to make the exploitation patterns more rational. The first set of measures is based on restrictions imposed on the number or fishing capacity of the vessels, rather than on catch limits and controls of discards and by-catches. The second set of measures (commonly known as technical measures) is based on prohibitions concerning season, area, gear, fishing practices and resource exploitation patterns.

MEASURES CONTROLLING FISHING EFFORT

These were gradually introduced as the greek fisheries policy evolved. Some aim at preventing the expansion of the number of fishing vessels through a licensing system, and can be characterised as direct. Other measures aim at placing upper limits on the fishing capacity of individual vessels, through engine power and tonnage limitations, and can be characterised as indirect. Under the existing management policy, two types of licenses are required for practicing professional fishing: an individual (fisherman's) license, and a boat license. Some form of capacity limitations exist for both trawlers and purse-seiners. Trawlers with an engine power higher than 500HP and purse-seiners with an engine power higher than 300 HP do not receive any kind of financial aid (loans, subsidies, etc.).

In the mid-90's, the Administration adopted the opinion that the number of fisheries vessels is not in balance with the availability of resources. In line with the new EU fisheries policy, a restructuring programme for the development of fisheries has been designed, based on permanent withdrawals, a small number of new constructions and modernisations. Historically, the first measures restricting the expansion of the coastal fisheries fleet were introduced in 1979 with the prohibition on issuing new licenses for beach-seining. The rest of the coastal fisheries fleet showed a steady increase in terms of number of fishing units until restrictive measures on the issuance of new licenses for net-longlining were introduced in 1988.

A limited entry scheme to the medium fisheries was already being applied in 1986, when restrictions on issuing new licenses were introduced. The scheme has generally been effective, preventing the uncontrolled increase of the number of vessels. In 1991, a general prohibition on the issue of new licenses was imposed.

TECHNICAL MEASURES

Technical measures concerning gear specification, gear deployment, fishing techniques and fishing seasons or areas comprise an important part of the greek management/conservation system. However, in the absence of satisfactory results from scientific investigations on spawning or nursery grounds, maturation sizes, mesh selectivity studies, etc., the adequacy, effectiveness and suitability of many measures have yet to be verified.The existing measures can be separated into nationwide and local, the first having general applicability over the whole country, the second concerning local restrictions. Almost all measures refer to particular gear or fishing techniques except those concerning minimum landing sizes which apply to all gear. The most important prohibitions by fishing category and gear are described below.

For the majority of the coastal fleet, which consists of bottom netter-longliners, there are no important nationwide restrictions, except those concerning landing sizes and the prohibition of using monifilament nets. However, there are several local restrictions which concern fishing in estuaries and sensitive zones close to the mouths of lagoons and aquaculture units, etc. In practice, technical measures concerning coastal fisheries exist only for the specialised fisheries branches as beach-seining and swordfish drift-longlining.

Medium fisheries are subjected to more severe restrictions in comparison to the coastal fisheries. The most important are: a general ban on trawling during the summer period and a prohibition on fishing within the three miles coastal zone or 50m in depth. In some regions, the seasonal ban can reach up to 6 or 9 months, while some gulfs are closed permanently to the trawl fishery. The minimum allowed mesh size in the bag is 40mm (stretched).

For purse-seiners a seasonal fishing prohibition has been established during winter time for night purse-seiners and during summer for day purse-seiners .For night purse-seiners, in addition, fishing is prohibited within 100 m from the shore or within the 30m depth contour line. The allowed minimum mesh size is 14mm, while for the day purse-seiners the minimum allowed size is 40 mm.

Marine protected areas as reference points for precautionary fisheries : a case study of trawl reserves in Greek waters

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One management approach that is being increasingly promoted as a tractable device for precautionary fisheries is the establishment of Marine Protected Areas (MPAs). Various levels of protection can be applied to a geographic region, ranging from strict exclusion of all fishing activity (so-called "no-take" areas) to more relaxed approaches which restrict fishing to certain gear types or particular seasons. Existing MPAs include marine reserves, restricted areas, single-species restricted areas, National Parks, estuarine protected areas, trawling reserves and offshore islands, declared under a variety of legislation. It should be underlined, however, that effects can differ dramatically between full and partial protection. The major objectives for such reserves is to protect critical spawning stock biomass to ensure recruitment supply to fished areas via larval dispersal, and possibly to maintain or enhance yields in areas adjacent to reserves by spill-over of adults.

Evidence from existing marine reserves indicates that increased abundance, individual size, reproductive output, and species diversity occurred in a variety of marine species in refuges of various sizes and shapes in communities ranging from coral reefs to temperate kelp forests. Growth in numbers is the most commonly documented effect of marine reserve protection, with a number of studies in both tropical and temperate regions showing the effect, when abundances in fished and protected areas are compared (Dugan and Davis, 1993; Watson and Ormond, 1994; Russ and Alcala, 1996). Another response that is observed is an increase in species richness in protected areas (McClanahan, 1994; Jennings *et al.*, 1996).

The establishment of MPAs must be justified on the grounds of the benefits that it offers. This is particularly true if the reserve is to be of any great size, since few authorities in either the industrialized or developing countries are willing to close off large areas to fishermen to keep conservationists happy. The possibility that MPAs might enhance fisheries themselves needs to be carefully addressed, since fishers are those who stand to be most disadvantaged by closure.

Closed areas may be especially attractive for multispecies fisheries, such as those practiced in the Mediterranean, with many artisanal or subsistence fishers using a wide variety of gears and landing their catch at many sites over a wide area. These features make it difficult to collect even the most basic information such as catch and effort data that are required for conventional management. Moreover, with respect to enforcement there are also clear advantages to a reserve system, especially one in which the local fishing community supports the initiative and polices it themselves.

The greek fisheries legislation contains a great variety of conservation/management measures, among which there are certain technical ones concerning restrictions on fishing seasons and/or areas. In particular, medium fisheries, which is that operated by trawlers and purse-seiners, is subjected to more severe restrictions, in comparison at least to the coastal fisheries. These restrictions range from a general ban on trawling during the summer period, to permanent closing of certain gulfs to the trawl fishery. Many studies underlined, however, the necessity for gathering appropriate scientific data, however, in order to verify the adequacy, effectiveness and suitability of the various measures.

This paper provides data on total biomass estimates, diversity of the demersal fish assemblages and body size distribution of certain so-called "target species" for the trawl fishery (i.e. *Merluccius merluccius, Mullus barbatus, Pagellus erythrinus*) in six neighboring regions of the Aegean Sea, three normally trawled and three closed to the trawlers. The study of the above mentioned parameters in the trawled and untrawled areas aims to detecting possible differences in total production, composition of the community data and community organization, that could be possibly related to trawling activities.

Samples were collected in the semi-enclosed area comprising the Pagassitikos Gulf, the Trikeri and Orei Channel, and the gulfs of the North and South Evoikos and Petali, by means of a commercial trawler having a cod-end mesh size of 14mm from knot to knot, during a two-year seasonal survey from 1986 to 1988. The Pagassitikos Gulf, the Orei Channel and the S. Evoikos Gulf are trawl reserves, while in the Trikeri Channel, the N. Evoikos Gulf and the Petali Gulf there is only a seasonal prohibition of trawling operations from the 1st of April till the 31st of September. Almost all the above areas present a rather limited bathymetry, their maximum depth being smaller than 100m, with the exception of a restricted region in the N. Evoikos where depth reaches 400m depth and of the Petali Gulf having a maximum depth of 160m. In relation to sea bed type, sandy-muddy substrates dominate, while certain sites in the trawled region present algae covered bottoms. An extended analysis of the sampling and the methodological strategy is provided by Papaconstantinou *et al.* (1989).

The data indicated that total biomass was higher in the untrawled areas in relation to the trawled ones (Fig. 1). A degree of disturbance detected in the trawled area, possibly influenced by trawl fishing, was evidenced by increased biomass values during the period summer-autumn, when operation of trawlers is strictly forbidden in Greek waters.

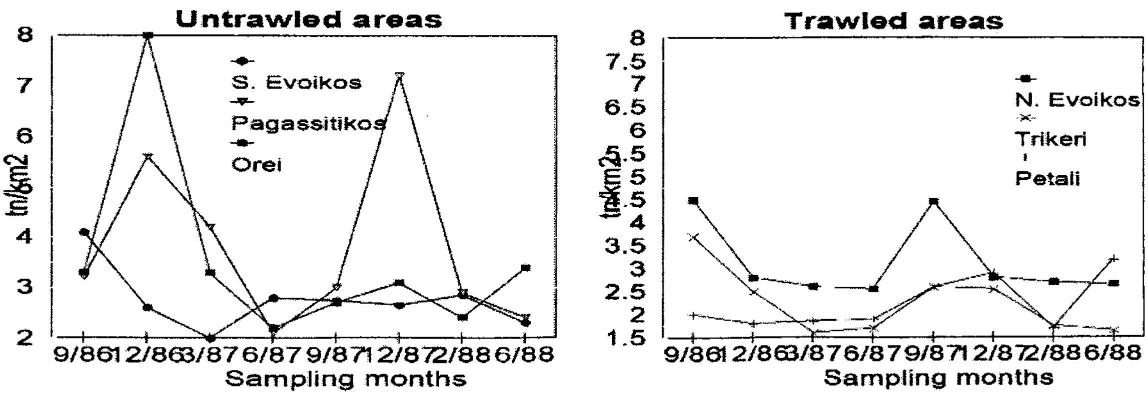

Fig. 1. Total biomass values (tn/km²) of fish stocks in the three trawled and the three untrawled areas of the study.

Then, data from trawled areas were pooled together and the same was done for the untrawled areas. The number of species (S), the number of specimens (N), the Margalef index of species richness (d), the Shannon-Wiener diversity index (H) and the Piellou index of species evenness (J) were calculated and are shown in Table 1. A greater number of fish species and a relatively higher species richness appeared to exist in trawled areas, while untrawled areas had a greater number of specimens. The Shannon-Wiener index and the evenness index did not exhibit significant differences. The fact, however, that the trawled regions were often deeper than the untrawled region suggested that depth might affect the results. Thus, when comparisons between trawled and untrawled areas were restricted to sites with depths smaller than 100m, although the number of specimens decreased in the trawled area, the number of species and species richness were still greater than in the untrawled region. A further restriction of the data excluding sites with bottom substrate other than sandy-muddy, changed the results. The number of species and species richness decreased considerably in the trawled area. Simboura *et al.* (1998) attributed the higher diversity of the benthic fauna in a trawled area of Petali as compared to that of an untrawled region in S. Evoikos to the difference of sediment characteristics between the two areas. The above underline the effect of habitat type on fish assemblages, suggesting that habitat differences should be always accounted for during the interpretation of results.

Table 1. The number of species (S), the number of specimens (N), the Margalef index of species richness (d), the Shannon-Wiener diversity index (H) and the Piellou index of species evenness (J) in the trawled and untrawled areas: a) when all data were used, b) when data from sites shallower than 100m were used and c) when data restrictions were made both on the basis of the bathymetry and the bottom type.

	Trawled	Untrawled	Trawled	Untrawled	Trawled	Untrawled
Habitat type	All		depth<100m		dep.<100m &mud. bottom	
No species (S)	125	109	112	108	87	108
No specimens (N)	250712	286189	135333	284452	82669	284376
Richness (d)	9.89	8.59	9.39	8.52	7.51	8.52
Shannon-Wiener (H)	2.61	2.67	3.04	2.66	2.91	2.66
Evenness (J)	0.54	0.57	0.64	0.57	0.65	0.57

The study of the 95% confidence intervals of the mean body length of *M. merluccius, M. barbatus* and *P. erythrinus* (Fig. 2), which are the three most important commercial species for the trawl fishery in the Mediterranean, did not suggest the existence of a specific trend for body size distribution between trawled and untrawled areas. Fishing is often size-selective, but in this case

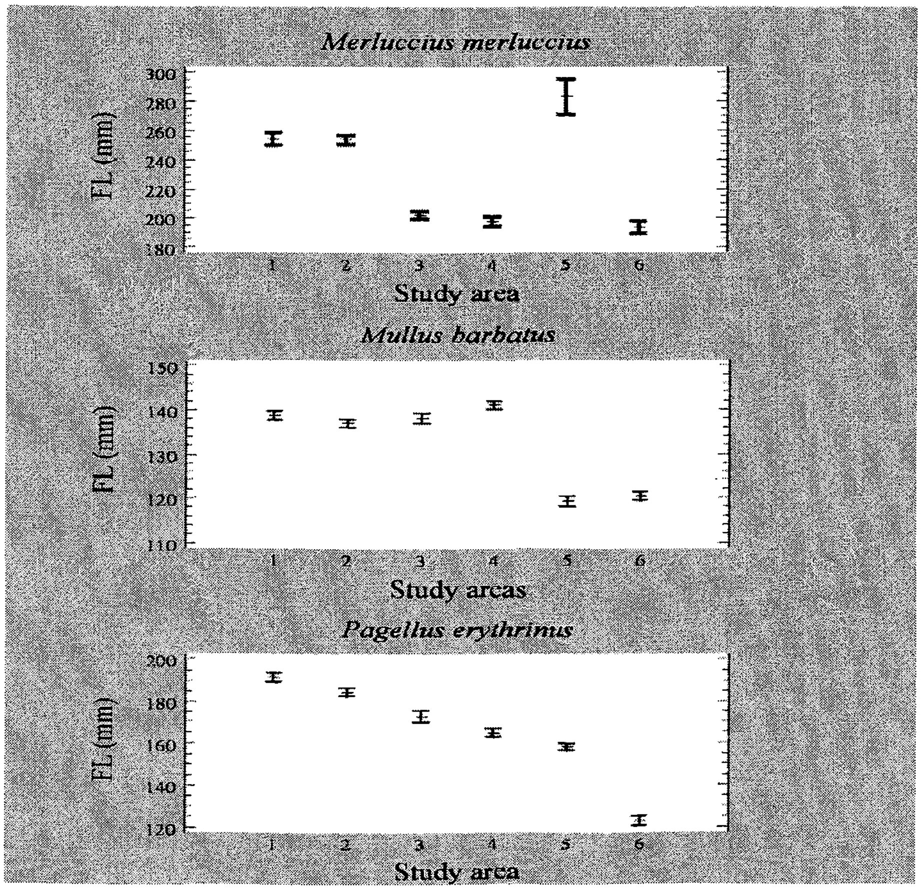

Fig. 2. 95% confidence intervals of the mean body lengths (TL: total length, FL: fork length) of the three target species in the six study areas. (trawled areas: 1, 3, 6; untrawled areas: 2, 4, 5).

trawling-related mechanisms that might have lead to changes in size structure can be possibly obscured, by spill-over of specimens in areas adjacent to reserves. This spatial rotation of trawling prohibition, in terms of one area open and the next closed to trawlers appears to compensate to a degree the effect of trawling on fish stocks, which in enclosed regions such as those of the present study is significantly more pronounced.

Further research is needed in order to increase information about trawl reserves and MPAs in general, investigating their role on the conservation and long-term sustainability of living aquatic resources, contributing thus to the perspective of precautionary approach to managing fisheries more effectively. In fact, identifying appropriate sizes and locations for closed areas requires consideration of the relative proportions of the populations and communities of interest within the protected region, their potential to serve as source populations for unprotected areas and the location of any sensitive habitats, which need to be included in the protected area to maximize the benefits of the approach. Initiatives to optimize fishery production will usually need to be coupled with efforts to limit entry to the fishery. Indeed, without other actions, establishing a closed area may simply displace effort elsewhere, with consequent increases in conflict between users of different gear types and continued political pressure to maintain access. Coupling area closures with reductions in fishing capacity seems to be the better strategy for the rational management of fishery resources.

Recent changes of Adriatic ichthyofauna : threat or benefit to local fishery

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During the last ten years, there are frequent records of new fish species in the Adriatic Sea, as well as spreading and changes of distribution of species previously described only in South-eastern Adriatic. Most of the new species are termophilic and has tropical origin. Dulçiç *et al.* (1999) published list of 30 new termophilic species recorded in Adriatic during the last 25 years. Few species are of interest for local fishery, and among them groupers of *Epinephelus* genus are of highest market value.

The presence of new species in native Adriatic coastal fish communities will initiate changes, which could be either threat or benefit to local coastal fishery. The colonisation of groupers exhibits similar patterns, as with other termophilic species. Firstly, we observed a migration of adult specimens of dusky and golden grouper, events often reported by divers. After adaptation to conditions of new habitats, reproduction and recruitment of fingerlings started. However, reproduction and recruitment was unstable and different from year to year, as observed with *E. marginatus* and *E. caninus* in the water around Dubrovnik area (Glamuzina *et al.*, 1999a).

However, new intruders in Adriatic surely induce changes in autochthonous communities, especially coastal fish assemblages. Furthermore, their presence could potentially present a new fishing resource. This presentation will focus on present status of groupers of genus *Epinephelus* in Adriatic, changes of their distribution and abundance, and estimations of their influence on local fishery.

Groupers are top carnivorous fish in food chains as well as among the biggest fish of coastal marine waters. They have a high market value and are object of intensive fishing efforts. Up to the nineteen's groupers were relatively rear in Adriatic, mostly distributed in southern part. During the last ten years, we observed many unusual events in their populations. Good recruitment of dusky grouper, *Epinephelus marginatus*, golden grouper, *Epinephelus costae*, and dog-tooth grouper, *Epinephelus caninus* fingerling were recorded in some years, but also lack totally in other years. In the waters around Dubrovnik, we catch fingerlings of white grouper, *Epinephelus aeneus*, and this was the species first record in Adriatic waters (Glamuzina *et al.*, 1999b).

Changes in grouper distribution, abundance and colonisation of new areas would have a significant influence on autochthonous communities. Grouper juveniles inhabit shallow coastal rocky habitats representing competitors in food chain to many other important fish species. Adult specimens represent the biggest predators in coastal waters.

New populations of different grouper species represent a new fishery resource and they rise values of coastal fishery. However, taking into account only few biological characteristics of groupers, such as growth, distribution, abundance, survival, feeding, predator-prey relationship and territoriality, we could estimate possible damage and benefit of these species on ecosystems and fishery.

The growth of groupers in Adriatic is lower if compared to tropical populations of same or similar species. This means also that feeding frequency and quantity of consumed food is lower. I estimate, based on literature data and results of our aquaculture experiments (Glamuzina, 1998), that grouper of 3-kg weight consumed during its life around 30 kg of prey. The value of 3-kg grouper is approximately 30 US$. Secondly, we have to estimate value of consumed prey. According to literature the main grouper preys are octopus, fish and crustaceans, but the percent of each prey varies with habitats (Jardas, 1996). So, if octopus as a prey dominates in grouper diet, calculated value of prey is around (3 US$ per kg of octopus) 60 US$, which is fairly higher than grouper value itself. However, if the diet consists of fish, mostly of no economical value and interest (species from Gobidae, Blennidae or Serranidae families), than the value of grouper is higher and represents new benefit to local fishery.

It is clear that these calculations don't integrate many factors, which influence growth and survival of groupers and their prey, as well as properties of different coastal ecosystems. New investigations has to be initiated on ecology of new species in new habitats, to give a more precise and definitive answer about their status and benefit to local fishery.

Precautionary approaches for the management of demersal fisheries of the Northern Tyrrhenian Sea

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The precautionary approach for fisheries as specified by the FAO Code of Conduct (1995a) is related to the conservation, management and exploitation of the living resources in order to protect them and preserve the aquatic environment. In implementing a precautionary approach, the administrators need to improve decision-making for resources conservation and management. Decision making should be based on sound scientific evidence allowing to define stock specific target and limit reference points as well as the actions to be taken if they are exceeded. This is achieved with the best scientific available information and implementing improved techniques for dealing with risk and uncertainty. Uncertainty is intrinsic of any considered aspect of the fisheries system: in measurement of size and productivity of the stocks, in the chosen reference points of levels and distribution of fishing mortality, in the impact of fishing on non-target and associated or dependent species as well as in the environmental and socio-economic conditions.

The management of many stocks in Italy is not conform with the precautionary approach, probably because management policies were established before its formulation. There is also a lack of a clear identification of the management objectives or goals and of the strategies which may be employed to meet such goals. In recent years, in order to define the state of some fisheries of demersal stocks, scientists made some attempts to employ different biological reference points. The reference points that were used (F_{max}, $F_{(Fmsy=M)}$ and $F_{0.1}$) however are considered by several authors not precautionary (Caddy and Csirke, 1983; Clark, 1991; Mace and Sissenwine, 1993; Caddy and Mahon, 1995; Die and Caddy, 1997). This is because they are extremely dependent of both the specific stock biological characteristics (reproductive capacity, resilience) and of the characteristics of fisheries exploiting the stock. The age of recruitment to the gear and age of maturity schedules, natural mortality rates and other biological parameters of each single species have a very important role.

This paper describes the recent attempts of proposing suitable precautionary approaches as management tools for the demersal fisheries of the Northern Tyrrhenian Sea. The reference points considered are all expressed in terms of fishing or total mortality rates. The identification of these reference points suitable for the studied area was mainly done by identifying those that were compatible with the current knowledge of the resources, with their biological characteristics and with the employed fishing strategies. A previous discussion on this topic is included in the report of the 1994 CIESM expert meeting in Tunis (Abella, 1995). The final choice fell on certain reference points that are generally considered conservative and that take in consideration (directly or indirectly) reproductive aspects of the resources. The goal was the choice of measurable indices of level of exploitation that provide a good compromise between approximating the best obtainable yields and a good probability of avoiding stock collapse. It was necessary to estimate, based on the chosen points of reference, which was the risk to conduct the stocks below some limit (overharvesting) or to a very conservative threshold characterised to extremely reduced yields (underharvesting).

An assessment of the state of the fisheries of *Merluccius merluccius*, *Mullus barbatus* and *Nephrops norvegicus* in the whole Western Italian coast and the Eastern coast of Corsica was performed (Abella *et al.*, 1999) by using trawl surveys data from the MEDITS European research program. The assessment was done by means of the application of a composite model with the Caddy and Csirke (1983) variant of Surplus Production Modelling. The instantaneous total mortality rate Z was used as a direct index of effort and catch per unit effort as an abundance index. A "Composite Model" (Munro, 1980) that includes spatial information proceeding from ecologically similar sub-areas exploited at different rates was applied. This approach allowed to calculate the situation of each single sub-area relative to the total mortality rate, and in particular to calculate its position relative to the value of the Total Mortality Rate Z at the Maximum Biological Production (Z_{MBP}) (Figs. 1 and 2). The Maximum Biological Production is a useful reference point that considers both harvests by fishermen and losses due to natural mortality. As noted by Die and Caddy (1997) this reference point corresponds to a slightly lower exploitation rate than that corresponding to the Maximum Sustainable Yield, and is relatively stable and easy to calculate. The choice of the mentioned approach avoids the many problems related to the lack of availability of series of fishing effort, and spatial partitioning of effort in the multispecies-multigear fisheries operating inside the study area.

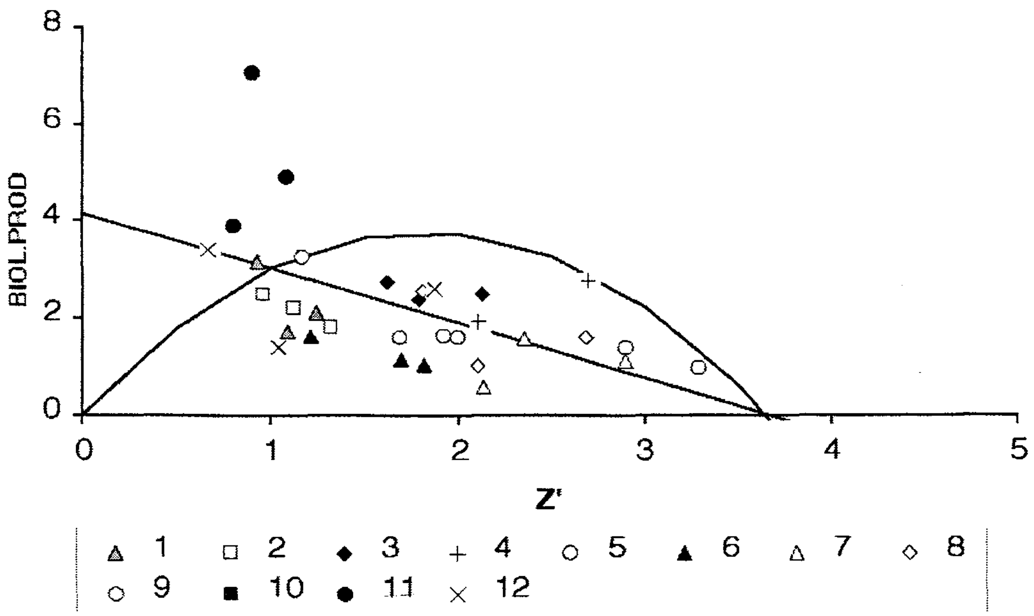

Fig.1. Distribution of couples of estimates of Z and CPUE (Kg/h) for hake. Each symbol corresponds to data from one sub-area. The regression lines obtained assuming both, a Schaefer and a Fox model as well as the two biological production curves derived from these models are also represented. (From Abella *et al.* 1999)

Results of an assessment of the state of the fishery of *Nephrops norvegicus* populations of the Northern Tyrrhenian-Ligurian Sea was presented in another paper (Abella and Righini, 1998), where the suitability of several fishing mortality based target and threshold reference points, their practical application, the accuracy of their estimates and uncertainty levels are also discussed (Figure 3). The analysed reference points were F_{max} (the fishing mortality rate that gives the maximum yield for a given fishing strategy), $F_{0.1}$ (the optimal F rate at which the slope of the Y/R curve falls to 10% of its value for F=0), F_{50} (the F value that reduces to one half the unfished bio-

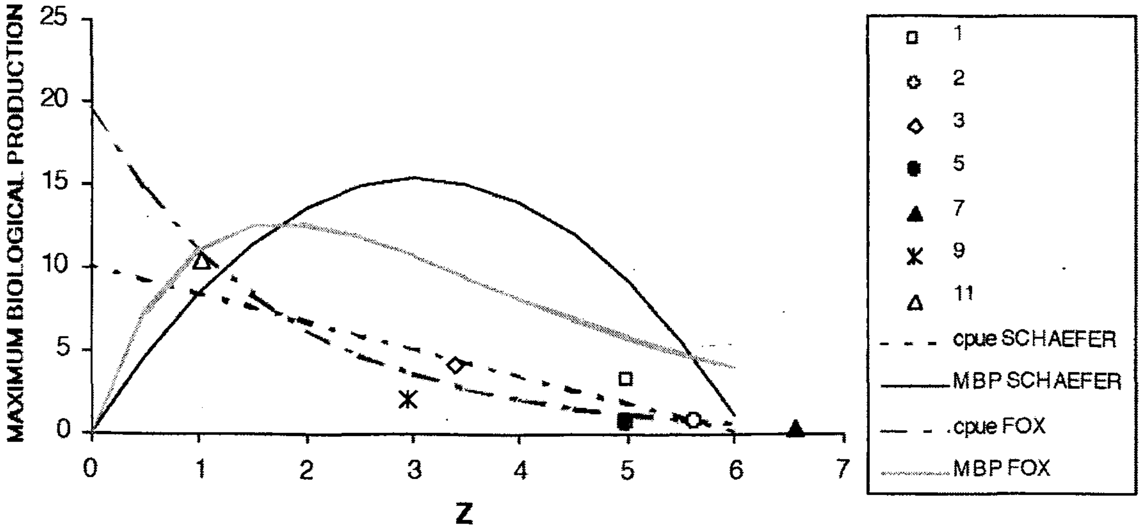

Fig. 2. Distribution of couples of estimates of Z and CPUE (Kg/h) for red mullet. Each symbol corresponds to data from one sub-area. The regression lines obtained assuming both, a Schaefer and a Fox model as well as the two biological production curves derived from these models are also represented. (From Abella *et al.*, 1999).

mass), $F_{\%SSB}$ (the level of fishing mortality that maintains the spawning stock biomass over a certain threshold regarding to the unfished level), $F_{(Fmsy=M)}$ (the level of F associated with maximum sustainable yield that equals the natural mortality rate M) and $F_{\%SR/R}$ (the F value at which the cohort will just replace itself) The study demonstrated the inadequacy of Fmax as a target reference point under biological and economic points of view. When a choice among different reference points for management purposes have to be done, the risk related to their utilisation must be considered. The authors agree with the statement of Clark (1991) that reference points based on spawning-per-recruit are likely to be better than those derived from yield-per-recruit because they should prevent recruitment overfishing.

The need of an appropriate definition of the real state of the fishery related to the optimal combination of age at first capture and exploitation rate is discussed in another paper regarding to the stock assessment of *Merluccius merluccius* (Abella *et al.*, 1997). In this case the analysis is based on yield per recruit and fecundity per recruit. The implications of the utilisation in yield-per-recruit computations of two different hypotheses for the natural mortality rates at age – a constant

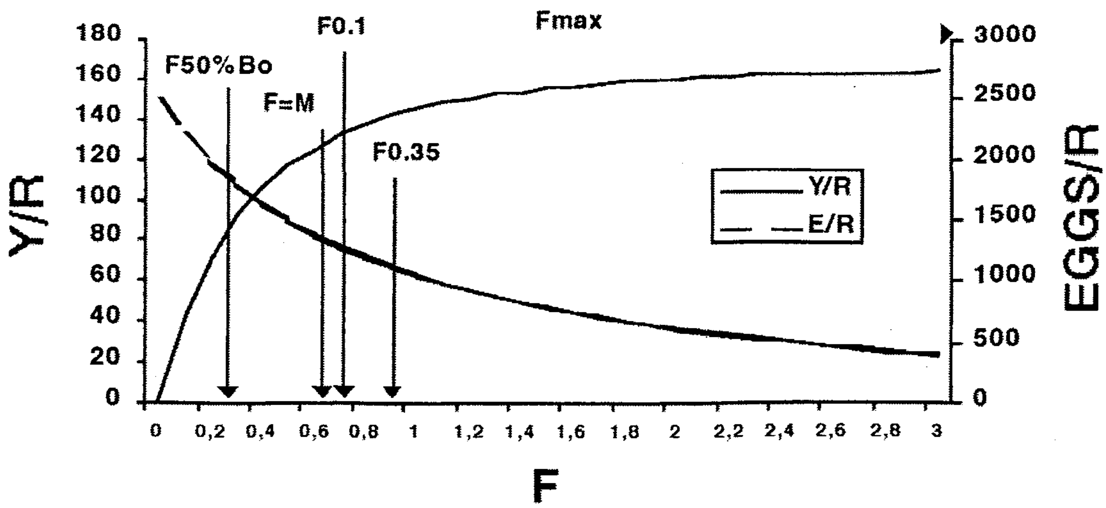

Fig.3. Current state of the Norway lobster fishery in the Northern Tyrrhenian Sea (circle) compared to different biological reference points. (From Abella and Righini, 1998).

value for the species whole life and a vector of M based on the above described Caddy (1991) reciprocal equation – as well as of the asymptotic or dome-shaped vulnerability-at-age were explored. Quite different results can be obtained regarding the definition of the current status of the fishery as well as relative to the choice of an optimal combination of fishing mortality rate and mean size at first capture under conventional assumptions (constant M and asymptotic vulnerability) and with the new ones (M-at-age vector and dome-shaped vulnerability). The results suggest that although fecundity per recruit would be increased somewhat by increasing the mesh size, it is not clear that this will necessarily increase yield per recruit markedly, and which means that active measures would have to be taken annually to assure that fisheries targeted on larger fish do not deplete the spawning stock. Figure 4 shows what would happen if longlining is increased. Imposing larger mesh sizes is not therefore as precautionary as it seems at first sight, and in the Mediterranean may not protect the stock from recruitment overfishing. In fact, a precautionary management approach here would be to prevent expansion of such fisheries directed to big fish (in this case adult hakes), at least until trawl effort has been seriously reduced, and juvenile survival has been greatly improved. Conservation of spawning stock might better be achieved directly by discouraging fisheries on large hake, and protecting deeper water areas of adult concentrations, following a "refugium" concept.

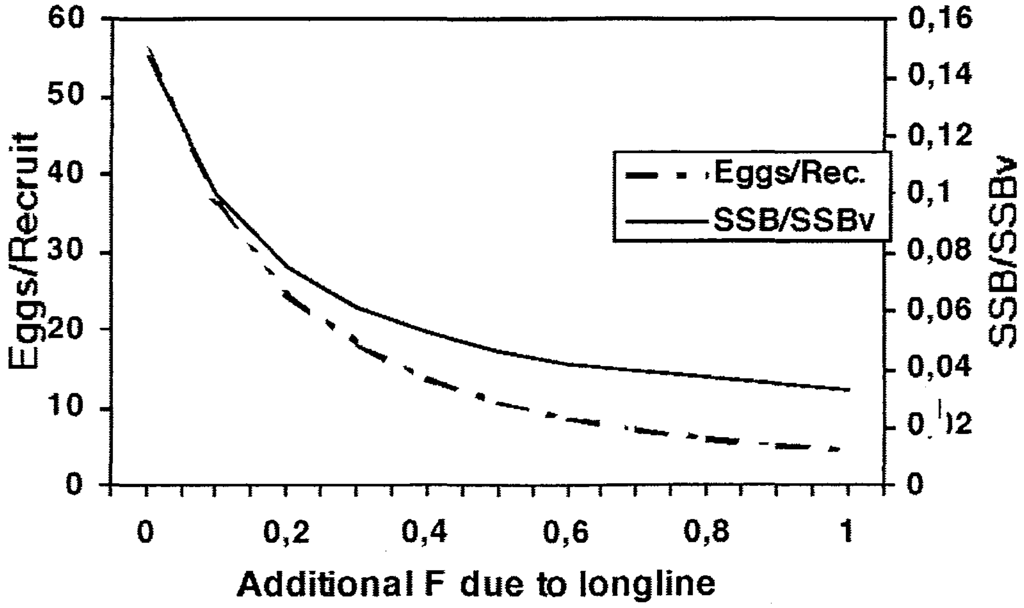

Fig.4. Inferred effects on the population eggs/recruit and exploited spawning stock/unfished stock ratio caused by increasing the stimated current F values due to longlining in the Northern Tyrrhenian fisheries (From Abella *et al.*, 1997).

In selecting a target reference point, it is necessary to be sure that it is a guarantee for the sustainability of a fishery fishing at any level of effort up to this rate, and is also necessary to take into account likely errors in the estimate of the current state of the stock. Caddy and Csirke (1983) suggested that the utilisation of the Z_{MBP} as a target allows managers to avoid serious consequences for the fishery "due to ecological perturbations", since F at Maximum Biological Production is lower than the F at Maximum Sustainable Yield. Sissenwine (1978) and Sissenwine *et al.* (1988) note that for stocks subject to density-independent fluctuations, yield becomes increasingly variable as fishing mortality increases, and confirms that environmentally-caused instability in recruitment in conjunction with errors in estimation of parameters of the yield models means that in practice the long-term Maximum Average Yield (MAY) should be maintained at a level below that providing the MSY. Doubleday (1976) has also noted that where recruitment fluctuates, a fishing strategy that produce catches attaining the MSY each year could lead to the collapse of the stock. The level of effort for a fishery operating at the Maximum Biological Production point, where total production from the stock (predators + fishery) is maximised, should be safer reference point. Economic considerations also suggest that the optimal economic return from a fishery is obtained at levels of effort lower than the corresponding to the MSY level, hence we may consider that in absence of an economic analysis, a fishery targeted at MBP will approximate better than MSY to such a sustainable situation.

However more research effort must address the Stock/Recruitment relationship and population's compensatory density-dependent controls. The application of new approaches for stock assessment like Bayesian methods can give an important basis for quantifying the uncertainty in assessments and, when combined with decision analysis, could communicate this uncertainty to fishery managers (Hilborn *et al.*, 1994). Studies like those of Caddy and McGarvey (1996) are also very useful because they explore the level of risk of a management action (in this case the risk is expressed as a probability that the current fishing mortality rates will exceed the chosen Limit Reference Point and assuming two different statistical distributions of uncertainty for the current F). The last mentioned simple approach to estimate uncertainty allows the calculation of a safe target control value for any variable used by managers for the monitoring of exploitation rates.