FISHERIES AND THE ENVIRONMENT IN THE MEDITERRANEAN SEA[1/]

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SPAIN
Crete, 12-14 Dec 1994

INTRODUCTION

Fisheries and other human activities in the Mediterranean sea have had significant effects on the state of the resource, and the potential future on the Mediterranean fishery. In view of the continually increasing pressure on stocks from human activity, it is essential that some form of effective management plan be drawn up, based on accurate and relevant scientific data which is currently unavailable, to provide for adequate environmental management of the sea.

This report seeks to examine the environmental effects of the regime of exploitation currently in operation under the sub-headings of; types of marine life currently being fished; the methods of exploitation and their effects on the environment; the overall impact of fishing on the Mediterranean environment,including an overview of the effects of non-fishery human activity on the ecological balance; in its conclusion it suggests methods of future management of the resource to preserve and ensure effective exploitation of the Mediterranean fishery.

1. ECOLOGY AND FISHERIES: THE MEDITERRANEAN CASE

Fishing has a long tradition in the Mediterranean countries, and many methods of exploitation of this resource have developed there from ancient times. This historical and cultural background is the reason for the diversity of gears in use, and the significance of so many small-scale fisheries that are found along the Mediterranean seashore.

In studies of the impact of fisheries, it is important to take into account that the marine ecosystem undergoes large natural changes and is strongly influenced by physical factors, e.g. changes in currents, salinity and temperature. This large natural variability makes it difficult to separate the effects of fishing from the effects of natural changes and other human activities influencing the system (pollution, eutrophication, etc.).

Some studies on the relationship between the ecosystem and fishing have been recently carried out by the Mediterranean Action Plan, sponsored by UNEP (Charbonnier et al., 1990) and ICES, (Anon., 1992). Another important reference source is a working paper of the European Commission (Anon., 1994). Although these works were devoted to the problems of the North Sea and Atlantic waters respectively, many of the conclusions reached can be easily transferred to the Mediterranean, and are synthesized in this paper. Furthermore, the European

1.This report does not necessarily reflect the views of the European Community and in no way anticipates the Community's future policy in this area

Parliament paper on pollution of the Mediterranean sea (Briand, 1993) is also an important reference point for this work.

2. THE MEDITERRANEAN BASIN

The Mediterranean Sea is an evaporation or concentration basin, (i.e. water losses by evaporation are greater than the gains from rivers and rain). Data Provided by Sverdrup et al. (1943) demonstrates that input from rivers is 45000 m3/s while losses from evaporation are 115000 m3/s; while exchange across the Straits of Gibraltar are 168.000 m3/s of water from the Mediterranean and 175000 m3/s from the Atlantic.

The general circulation pattern of the superficial water masses, is cyclonic along coastal areas, with some anticyclonic gyres on the Alboran sea, Gulf of Gabès and Lybian zone.

2.1 Topography: shelves, slopes and fisheries

The Mediterranean sea generally has narrow continental shelves. Only the Adriatic and the Gulf of Gabès have extensive continental shelves. Other areas with significant shelves, although narrower, are the Gulf of Lions, the south of Sicily and the Gulf of Valencia.

The demersal and the small pelagic fisheries are attached mainly to continental shelves, from the coast to 200 or 300 meters in depth. There are also some deeper fisheries on the continental slope but these are not as extensive as those on the continental shelf. As its topography implies, the Mediterranean does not present extensive and homogeneous fishing banks as in other zones.

According to the FAO the total marine catch reported in the Mediterranean and Black seas in 1992 reached almost 1.5 million tonnes. This figure represents 1.8% of the world catch (nearly 83 million tonnes) even though the surface of the Mediterranean Sea only represents 0.8% of the world marine surface. The historical evolution of the total catch (excluding the Black Sea) of the EU members states, has been more or less stable in recent years, whilst the total catch of other countries has increased in recent years.

3. EXPLOITED SPECIES IN THE MEDITERRANEAN SEA

3.1 Small pelagic

This category is comprised of fish which live in midwater or near the surface. Usually under 20 cm in length, their life-span rarely exceeds a few years. They form schools composed by many individuals, which allow fishermen using modern technology to catch them. Pelagic trawling and purse seine are the current gears used to catch these fish.

The main species of these fish are pilchard, anchovy, all mackerels, bogue, bonito and some squid. Despite the fact that the number of small pelagic species is much lower than the number of demersal species, they represent 40% of the total catch. Their economic importance is a function of the quantities caught rather than their relatively low prices.

3.2 Large pelagic

This category is comprised of large fish which live near the surface,and which are migratory and gregarious. Swordfish, tuna and pelagic sharks are included in this group. While they

represent only 4% of the total catch in the Mediterranean, they are commercially very valuable, and some species have strong markets in Japan. They are caught mainly with seines, surface longlines, traps and drift-nets.

There are some indications that the large pelagic fisheries usually exhibit an important by-catch of non commercial and protected species, mainly marine mammals and turtles.

3.3 Demersal

Those organisms which live near the seabed are known as Demersal species. Most commercial species (more than 100) belong to this group. Many different gears are used to exploit these species, including bottom trawls, gill-nets, trammel nets, traps, bottom longlines and a variety of drags. The depths exploited range from 0 m to 800m, but are mainly up to 400 m.

Demersal fish represent nearly 55% of the total catch. The catch is generally multispecific, heterogeneous and diverse. Catch per hour is generally small, but the prices obtained are high.

The most important environmental impact of demersal fisheries is on the seabed.

4. TYPES OF FISHING GEARS AND THEIR EFFECTS ON THE ENVIRONMENT

A great number of fishing gears are currently used in the Mediterranean. In this section the most important in use and their effects on the environment are outlined.

4.1 Dredges

Dredges are bag-nets fitted with a rigid frame in the mouth of the net.Used mainly by the small-scale fleet,they catch mainly shellfish and flatfish. These gears are used on sandy areas in the littoral zone near the coast line at a depth of less than 50 m. The environmental problems caused by them are related by their use close to seagrass beds, where they can cause damage by eroding the limits of the seagrass beds. Also, these gears cause disturbances on the structure of sandy bottoms by a scratching effect.

4.2 Seines

There are two types of seines depending on the target species:

- **Purse seines**, are extensively used in Mediterranean to catch small pelagics (anchovy, sardine) in competition with pelagic trawlers. They have no major effects on the ecosystem unless the lead lines are towed on the seabed.

- **Tuna seines**. These are large purse seines, whose impact on the ecosystem through the accidental catching of dolphins (Northridge, 1984) has not been quantified yet.

4.3 Trawls

Trawls are bag-nets towed through the water. Fish are caught by filtration through the moving gear. The negative impacts on communities captured by trawls are related to their lack of selectivity: they catch many different species with of a wide range of lengths. This allows a

high yield for trawling, but in the long term can collapse stocks. There are two different types of trawl:

- **The bottom trawl** is the main demersal gear in terms of number of vessels, fishing effort and catch obtained. It affects the seabed on which it is towed, and has a bad selectivity pattern (many lengths of a large variety of species are caught by it). This type of gear is however, very efficient in terms of amount of catch and species taken in the net.

- **The pelagic trawl** is towed in midwater. It is used to catch small pelagics (anchovy, sardine, etc.). Problems with this gear are related to its large dimensions which allows a large catch of small fish of the target species, and causes an significant increase on the mortality of these species.

4.4 Nets

- **Gillnets.** A gillnet is a panel of monofilament plastic net, suspended vertically like a curtain, in the water, by floats attached to the top of the panel and weights attached to the bottom. Adjusting the buoyancy can suspend the net at any depth. It is usually comprised of a short panel formed by several strips, laid on the bottom if targeting demersal species, or on the surface if targeting bonito. It is a passive fishing device which is acoustically and visually invisible to most marine animals.

The gillnet is a traditional fishing gear in most Mediterranean countries,and after a decay in its use, the introduction of new materials, principally monofilament plastic, a renaissance in its use has occurred. It is used by small-scale fishermen who usually alternate it with other gears (longlines, traps, etc.). It does not seem especially dangerous when used as described, with an apparently light induced mortality of sea mammals and turtles. Lost nets however can cause additional mortality, through ghost fishing, though the problem has not been quantified so far.

- **Trammel nets** are similar and are used in the same way as small-scale gillnets. The distinction between the gears is that the trammel-net is composed of three nets: two exterior ones with a wide mesh size and an inside net between them, with a smaller mesh size, which catches fish by entanglement.

- **Driftnets.** These are large scale surface gillnets deployed in the open ocean. They catch virtually all living things that swim into them, including the target species, mainly swordfish, as well as non target species (some tuna, shark etc.) and non commercial species (including turtles, mammals etc.). Discards can reach the 80% of the total catch (Gutierrez, 1994).

Since 1992, EU regulations have prohibited vessels keeping on board or using for fishing, one or more driftnets whose individual or total length exceeds 2.5 km (and drift-nets longer than 1 km must remain attached to the vessel). However, it seems that most of these nets used in the Mediterranean are much longer than 2.5 km (CGPM/GFCM, 1994) since the legal driftnet is not economically viable.

The use of driftnets constitutes a major problem in the Mediterranean fisheries.While in some countries these gears are allowed,they are banned in other countries (CGPM/GFCM, 1994). Because of the conflicts these gears cause, it is necessary to clearly regulate and control their use.

4.5 Hooks

Longlines are traditional gears in Mediterranean countries. They are mainly used by the small-scale fleet. There are several types of longline:

- **Surface longlines,** used to capture large pelagic species, have a heavy influence over many non-commercial and protected species, turtles being the most affected. It is the only longline used on a large scale; there are some foreign fleets in the Mediterranean, using surface longlines which are extremely long (around 100 km) (Gual, 1994). Foreign fleets which must fish outside the twelve mile territorial waters, usually use large-scale surface gears like longlines or drift-nets.

- **Demersal longlines.** It does not seem that demersal longlines damage the biotic or abiotic environment in addition to those effects due to removal of individuals of a target species. They have a good selectivity and the by-catch of non-commercial species does not affect protected species.

4.6 Traps

There are many gears which act as traps. Some of them are in decline. This is the case with the coastal traps for tuna which have diminished due to changes in the behaviour of tuna which now pass further off the coast. Other traps include the fish pots or fish baskets that are used by small-scale fishermen to catch species like the common spiny lobster or common octopus. These gears do not cause damage, the only negative effect, especially for fish baskets is the effect of ghost fishing, but due to the scale involved this is short-term damage.

4.7 Gear competition

Most Mediterranean resources are exploited by more than a single gear. Bottom trawl and trammel compete for red mullet; bottom trawl, gill-net and longline compete for hake; pelagic trawl and purse seine compete for anchovy, etc. The less selective a gear, the greater the catch it can obtain. Although the more selective gear usually gets higher market prices for its catch,the less selective gear is more efficient from the economic point of view, mainly for two reasons: despite of size of fish being small, traditionally smaller fish are appreciated in Mediterranean countries. Furthermore almost every species caught is commercialised. Using the less selective gear is advantageous as if one target species collapses the less selective gear can commercialize the rest of the catch without modifying its gear while a more selective gear in the same situation must modify to catch other species which requires reinvestment in technology and equipment to adapt to the new situation.

5. IMPACT OF FISHING ACTIVITIES ON THE ENVIRONMENT

Fishing modifies the environment, frequently to its own disadvantage. Fishing not only reduces the abundance of the target species (increasing at same time its productivity) but also, as a secondary effect, that of other species, reducing their abundance or modifying their relative size composition. These effects can be direct (by killing specimens) or indirect, through the alteration of transfers of energy through trophic chains, and a decrease in the number of species (Caddy & Sharp, 1986). An excessive fishing effort or an inappropriate exploitation pattern can produce dramatic effects on the whole marine ecosystem.

5.1 On marine communities

Target species are especially affected by reductions in their abundance. This has consequences for their predators, competitors and prey modifying the structure of the aquatic community. These effects would depend on the position of the exploited species in the food web and on the numerical and functional responses of the species in the system (density dependent growth). Beyond these numerical effects of removal, effects are also evident in the size structure of populations. In general, fisheries act to reduce the numbers of larger individuals and this may lead to consequent increases in smaller sized species owing to release from predation or competition. Reductions in planktivors like clupeids may cause top down effects on the planktonic base of the food chain. The global result is a rejuvenating of the population and an increase in productivity.

Fishing also imposes a selective pressure on determinate age classes and may affect the genetic make-up of populations in the longer term or can affect directly the success of reproduction in the case of hermaphrodite species with sex determination by age, or in the case of a catch based on juveniles. This last case is frequent in Mediterranean fisheries that usually fish on individuals that have not reached sexual maturity, risking the spawning success of the stock. The recently adopted European standarddoes not solve the problem of species which minimum legal size is lower than their length at first maturity. To improve this situation, less selective gears such as trawls could be limited in favour of others such as small-scale gill-nets, purse seines or longlines.

The effects on other species also affects the biodiversity. The Mediterranean is a sea with a high level of biodiversity that is concentrated mainly between 0 and 50 meters depth, whereas at a depth below 1.000 meters there are only 9% of the total amount of species. The impact of fishing activities is very important in the littoral zone, and an erosion of this biodiversity is evident not only in the sense of the disappearance of species, but also on the diminution of effective habitats. Furthermore, the survival rate of the majority of the discarded individuals caught is very low.

Significant impacts on protected species such as marine mammals are caused by drift-nets (e.g. dolphins and sperm-whales); in this sense the extensive use of this type of gear in the Mediterranean is worrying, where vessels are fishing with illegal nets more than 2.5 km long. The negative effect on marine mammals, especially dolphins and whales, was recorded some years ago (Northridge, 1984) and acts in two ways: firstly through accidental catching in nets, and secondly through direct competition between fishermen and mammals for some small pelagic resources such as anchovy or squid which are common in the diet of marine mammals.

For turtles the main causes of mortality are: drift-nets, pelagic longlines, and the ingestion of plastic and other debris that the turtle ingests as if it were jellyfish. Reproduction of this species is further threatened by the use of beaches for tourism. Some claim the decline of the turtle population is as a result of the recent Mediterranean jellyfish blooms.

The case of the monk seal is also dramatic (*Monachus monachus*). This species was hunted by fishermen due to its habit of feeding off animals caught in nets. This behaviour seems to be a consequence of the diminution of fish stocks which were its main source of food. The species has suffered the destruction of its natural habitats in coastal areas by the expansion of the tourist

industry. In the last 20 years, their effective numbers have declined from 1.000 to 300 registered individuals (150-170 in the Mediterranean) (Boudouresque, 1993). This species requires an urgent habitat protection programme.

In the case of birds, it does not seem that fisheries have significant negative effects on the population, however, there are no specific studies available to evaluate the possible effects of fisheries on marine birdlife.

Fisheries also modify the marine community by altering the food availability through the impact of discards. The amount of discards is a very important issue in fisheries throughout the world and represents a serious problem. Less selective gears that produce more discards such as trawls (pelagic and bottom) and driftnets, paradoxically produce more discards even though they are gears with a higher economic productivity. On the other hand, there are some species which are favoured by discards as a supplementary food source and feed extensively on discarded fish. Discards act as a primary food source for some species of birds that have adapted their behaviour to profit from them. Discards therefore lead to changes in the specific composition of marine communities.

Another secondary negative effect on species is the so-called ghost fishing, a phenomenon caused by lost gear (mainly nets or traps) that may continue fishing for a time after being lost. Gear constructed of non-biodegradable materials may exacerbate this problem.

5.2 On the seabed ecosystem

Several fishing activities can damage the seabed. The Benthos structure can be severely damaged, or even destroyed, by the inappropriate use of dredges, trawls, and other bottom towed gears. The importance of such damage depends on the fishing intensity, the sensitivity of the bottom, and the type of damage caused by the gear. Such damage can lead to sediment erosion by waves and currents which makes it difficult for species to re-establish. In the Baltic sea, experiments have been carried out to evaluate the effects of trawls on the seabed with observations of the proportion of tracks on the seabed. The results have shown that visible tracks in most disturbed regions covered up to 35% of the seabed area (mean value 25%), (Krost et al., 1990). Another negative effect caused by trawling is the increase in the suspended sediment, this effect can be dangerous in areas where contaminant concentrations are relatively high, for example areas affected by major industrialization (Anon., 1992).

Seagrass. Related directly to fishing is the decline of *Posidonia oceanica* seagrass beds and other shallow meadows of marine phanerogams (Boudouresque et al., 1990). These meadows provide key habitats for organic matter production; spawning and nursery areas for many species; and beach protection from waves. These ecosystems are threatened by trawling and drag-net activities and are in a clear regression. In addition, these habitats are affected by pollution of coastal waters and the influence of human beings such as beach regeneration and the extensive construction of leisure ports, close to seagrass beds near the coast in shallow waters (Lleonart, 1993).

Rocky and coral bottoms also support rich and complex communities which are threatened by the use of dragging gear for coral. These gears have recently been prohibited by Community law and the compliance with this provision should lead to better expectations for this type of habitat. In addition, the majority of recently created marine reserves are on this type of seabed.This type of seabed is also damaged by the rollers used by some bottom trawlers to pass over rocks without

damaging but which destroys benthic communities.

Sandy and muddy seabeds are poorer marine environments, and negative fishing effects are minor,but bottom trawlers affect grain size distribution, sediment porosity and chemical exchange processes (Anon., 1992). In general however, these ecosystems are more affected by the removal of sand to regenerate touristic beaches.

6. IMPACT ON EXPLOITED ECOSYSTEMS OF HUMAN ACTIVITIES OTHER THAN FISHING

6.1 Impact on marine communities

Introduction of new species. Non-native species have several means of access to the Mediterranean Sea:

- The Suez channel has been the cause of the introduction of around 350 species from the Red Sea. Their distribution is still limited to the Eastern Mediterranean, but some of them like herbivorous fishes are changing the species composition of benthic communities.

- Over 30 algae species and 50 invertebrate species have been introduced to the Mediterranean in various ways: fouling, fishing baits, aquariums, aquaculture, shipping...

- Aquaculture has caused the introduction of the shrimp Penaeus japonicus and of the Japanese oyster Crassostrea gigas, with their associated flora and fauna.

- Fouling and the introduction to the sea of aquaria species, are also responsible for the introduction of some species such as *Caulerpa taxifolia*.

The primary problem with these introduced species is their competition with local species. For example C. taxifolia seems to be responsible for the reduction in some seagrass beds on the French coast, where recovery of autochthones seaweeds in *C. taxifolia* communities, is 500 times lower than in natural ones (Boudouresque et al., 1991). Similarly *P. japonicus* is replacing *P. kerathurus* in the Eastern Mediterranean (Spanier and Galil, 1991). A further example concerns the proliferation of some exotic algae which can produce blooms that affect fisheries by obstructing nets.

Another type of impact specifically on planktonic communities are shipping activities which lead to seepage of oil and fuel in zones of heavy maritime traffic, such as shelf and coastal areas. As the Mediterranean has heavy maritime traffic, this can impact negatively on the marine communities.

6.2 Impact on the seabed ecosystem

The modification of coastal dynamics such as leisure ports, marinas, beach regeneration, modification of rivers, and the alteration of the coastal dynamics of water and sand can cause severe consequences on most shallow ecosystems.

Litter and marine debris found in the sea, while mainly inert materials (glass, plastics, etc.) or biodegradable materials (paper, organic matters, etc.) although unsightly, has few consequences for marine life (Anon., 1992).

Eutrophication and anoxic or hypoxic zones are caused by organic inputs and their main effect is the decline of the biodiversity. This type of pollution mainly affects the coastal communities. Fish mortalities have been reported in harbours, deltas, and coastal and estuarine lagoons, due to fertilizers, insecticides and anoxia or hypoxia produced by organic matter. Eutrophication seems to alter the energetic balance and can produce biomass blooms of organisms which can produce substances which are toxic to fish (red tides) or to humans.

Tourism represents a pollution source as great as industry and agriculture. In some parts of the Mediterranean coast, the proliferation of marinas has destroyed shallow ecosystems, and has altered the coastal dynamics, making beaches disappear. As a result, artificial sand transports from shallow waters to the beach are frequently needed, destroying sandy ecosystems or seagrasses and exploitable resources like shellfish. Furthermore, the disturbance suffered by shallow sensitive marine environments due to the massive presence of subaquatic recreative activities, is a constant threat to the stability of such ecosystems.

There are other activities carried out on the seabed which can directly affect the species composition of the community. Offshore structures such as platforms where local fishing operations are prohibited provide refuge sites of increased biomass and diversity for fish and benthos. Conversely, point sources from oil production and organic sewage alter benthic communities, frequently resulting in a dominance of short-lived, opportunistic species; this is comparable with the effects of certain types of intense bottom trawling (Anon., 1992).

7. MANAGEMENT AND ECOLOGY: THE ROLE OF MANAGEMENT TOOLS ON THE CONSERVATION-DEGRADATION OF EXPLOITED ECOSYSTEMS

Among all possible measures, we briefly present the main ones with indications to Mediterranean application.

7.1 Gear regulation

Several gears are banned in some countries, while allowed in others. This phenomenon can even happen in different regions of a country. Prohibition, or rigorous limitation of particularly destructive gears (beach seines, towed gears for coral, explosives,...) can be a good policy. Reconversion into more selective or less aggressive fishing practices can also yield good results.

Mesh sizes are commonly used to regulate fisheries. This is an important item for trawl regulation. The smallest mesh sizes for trawls in the world are found in the Mediterranean (Caddy, 1990). The goal of a 40 mm mesh size proposed by the GFCM, is still far from realistic in many Mediterranean countries. The relatively high price of small fish, the existence of some small species that would not be caught, and the short-term losses that would occur as a result of increasing mesh size are the main reasons which would make this measure difficult to apply. Furthermore, the control and surveillance of actual mesh sizes entails the difficulties involved in the individual examination of vessels at sea.

Another type of regulation is the development of gear modifications which try to minimise negative effects. For instance, the square mesh panels can be used to improve the selectivity of trawls.

7.2 Effort limitation

This is the most commonly employed limitation measure in the Mediterranean. The mechanisms used to regulate fishing effort include: limiting the number of vessels, limiting total and individual power, and limiting the fishing time (days in a week or hours in a day). In the case of power limitation, this can result in inappropriate regulation; for example, a vessel cannot increase its power but can improve the electronic tools for the detection of schools of fish or optimize its fishing gear etc., which results in the increase of possible catch.

Fish mortality is usually proportional to the fishing effort, therefore reducing fishing effort is a good measure to preserve the marine community, not only for target species, but also for the by-catch and discarded species.

7.3 Catch

In the Mediterranean, a frequently employed measure is the prohibition on the landing or commercialisation of undersized fish. Most countries have minimum size regulations for several species. The recent EU standards also provide minimal catch lengths for some target species.

The use of quotas or TACs, which are regularly used in the Atlantic, are almost absent in the Mediterranean, where the control and surveillance of TACs would be very difficult to carry out, due to the structure of fleets and landing points. In fact, the use of TACs present some problems as this system does not take into account the amount of discards, so there are discrepancies between catches at sea and landed catch.

7.4 Closed seasons

This measure is frequently employed, but in some cases the reasons for doing so are based more on economic factors than biological ones. Biological reasons for closure include the protection of ecosystem components during critical stages of their life history, such as spawning time, migration, etc.

7.5 Closed grounds

Closed grounds are zones which are protected. All countries protect areas closest to the coast from trawling with the objective of preserving seabeds and nurseries.Surveillance is not always easy, and illegal trawling in these shallow waters yield high profits. Artificial reefs are also used to assure protection against trawling. These can combine closed areas with closed seasons to improve the safeguarding of nursery areas, reduce catches of undersized fish and improve exploitation patterns. Another method of controlling trawling is the banning of more powerful trawlers from fishing near the coast, and ensuring that these more powerful trawlers expend their fishing effort on more distant fishing grounds.

Another form of permanent protection,which has been on the increase is the creation of marine reservations, to protect special or important species or ecosystems. Usually in zones around islands or near the coast. The level of protection of these zones can vary from absolute protection to permitting some subaqua activities. This protection is particularly effective for the conservation of benthic communities. The objective of this method is the conservation of an endangered species, habitat or community and the exportation of species to other zones with the increase on the profit for fishermen. Unfortunately, in the Mediterranean these areas are still limited.

An important consideration is that these measures of closure of areas are more effective if associated with a reduction in the fishing effort in neighbouring areas,as marine organisms are more difficult to constrain by arbitrary boundaries imposed by man than terrestrial ones, and also because many biological processes depend on input and output over these borders.

7.6 Artificial Reefs

This is a means of restoration of the natural habitat. There are three types of artificial reefs (CGPM/GFCM, 1990), depending on the objective. Firstly there are artificial reefs to obstruct illegal trawling on the littoral zone, the objective being to protect juveniles of a target species by providing zones of refuge. Secondly, artificial reefs can be specially placed to favour clam culture, this type of artificial reef is used in the Adriatic sea. Thirdly, artificial reefs with a particular shape to protect one specific species.

7.7 Maritime jurisdictions

In the Mediterranean this coincides with the 12 mile territorial sea limit. Every country has its own policy, with usually a low level of real control on fishing activity in that area. Nevertheless, most of the Mediterranean countries protect shallow coastal waters from trawling, so as to protect nurseries.

It is important to remember that the existence of shared stocks between different countries when considering fisheries conservation policy. There are some shared fishing grounds where this is remarkable like the Gulf of Lions, the Adriatic sea, the Alboran sea, etc.

7.8 Socio-economic considerations

Studies on fisheries economics in the Mediterranean are scarce. Economists require, as biologists do, an improvement in statistics available. Some particular problems have been identified. One of them is the existence of artificial mechanisms that favour overfishing. For instance the fuel tax exemptions for fishing vessels is a stimulus for fishermen to increase fishing effort and has had obviously negative consequences on the preservation of the resource (Lleonart, 1993).

8. PERSPECTIVES

The development of models appropriate to the Mediterranean are indispensable in providing a tool to diagnose the health of the resource, to evaluate its potential, and recommend management policies. However these models must be constructed with accurate data, if something more than a mere theoretical exercise is required. The lack of accurate data for Mediterranean fisheries has been pointed out by almost all researchers. The problems of sampling are related to the wide diversity of species, and with the high cost of fish, frequently caught in small quantities by small vessels. A special effort must be made to improve the quality of these data to make any real progress in this area. One method to enhance our knowledge in this area is the development and use of geographical information system (and other space structure methods) to be applied to fisheries as a management tool. This technology for this is being developed, however, the usefulness of such a tool has yet to be accurately quantified.

9. CONCLUSIONS

Fishing and the other human activities in the Mediterranean sea have had as a consequence the simplification of the marine ecosystem, the risk of eliminating species; changing the species proportion; and reducing the ecosystem diversity (i.e. a few species become dominant, while others diminish dramatically). As a result of these alterations the sea becomes more productive, but also more unstable.

There are some ecological environments, mainly littoral or coastal,which are very sensitive and need particular protection such as marine phanerogam beds and rocky bottoms, as well as nursery areas. To protect these habitats, measures to close areas or fisheries seasonally must be adopted. These measures must also take into account the rehabilitation of these sensitive environments.

Furthermore, in order to adopt correct management measures, it is necessary to carry out long-term scientific studies on the species and ecosystems to provide accurate and reliable data. Without these long-term studies, it is difficult to forecast the behaviour resulting from particular causes. It is also important that cooperation is established between different Mediterranean countries in research and data collection in order to improve the scientific knowledge of fisheries and their interaction with the environment in the Mediterranean.

Management measures must also be adopted, so as to avoid the catching of immature fish. The recent European standard (Council Regulation n° 1626/94) is still falling short of this objective for some important commercial species like anchovy or hake. This however must be balanced with socio-economic requirements such as market requirements and employment (Anon., 1992).

In addition, management measures must be easy enforceable. Fishing schedules (days in a week, or hours in a day), gear prohibitions, seasonal closures and protected zones would be more effective than quotas or mesh size regulations. More attention by governments is required in the application and enforcement of the law. Some banned gears are still been used such as fishing with explosives or using towed gears for harvesting coral; these gears are very injurious to marine communities and their environment and must be eliminated totally.

Investment in research to try to diminish negative effects of gear, and improve their efficiency is necessary. Selective fishing gear and practices should be further developed and applied in order to protect biodiversity, the aquatic environment and population structure.

Governmental intervention must contribute to protect the resource and optimize its use. In the Mediterranean this means the reduction of effort. While some regulations perform this objective, others, such as tax exemption for fuel have counter-productive results, leading to an increase in the fishing effort and consequently a degradation of the communities and the environment.

Finally, management measures should not only ensure the conservation of target species but also of other species belonging to the same ecosystem which are dependent or associated with target species. In order to make possible this conservation policy, it is essential to promote public awareness through education and training of the population, in particular the fishing communities on the suitability of responsible fisheries.

10 REFERENCES

Anon.- 1992. Report of the study group on ecosystem effects of fishing activities. ICES, C.M. 1992/G:11 Ref.: Session T, 144 pp.

Anon.- 1994. Report of the meeting on the data base for evaluation of biological impact of fisheries. Commission of the European Communities. SEC(94) 1453. 39 pp.

Boudouresque, C.F.- 1994. Etat actual de la biodiversité marine en Méditerranée. IN: Briand, F. (Ed).- 1993. Pollution of the Mediterranean Sea. Pollution Research and Environmental Monitoring. Analyses, recommendations and assessment of the scientific and technological options. STOA Report. European Parliament. 225 pp., 75-90.

Boudouresque, C.F., M. Avon and V. Gravez (Eds).- 1991. Les espèces marines à protéger en Méditerranée. GIS Posidonie publ. 448 pp.

Boudouresque, C.F., E. Ballesteros, N. Ben Maiz, F. Boisset, E. Bouladier, F. Cinelli, S. Cirik, M. Cormaci, A. Jeudy de Grissac, J. Laborel, E. Lanfranco, B. Lundberg, H. Mayhoub, A. Meinesz, P. Panayotidis, R. Semroud, J.M. Sinnassamy, A. Span and G. Vuignier.- 1990. Livre rouge "Gérard VUIGNIER" des végétaux, peuplements et paysages marins menacés de Méditerranée. UNEP public. 250 pp.

Briand, F. (Ed).- 1993. Pollution of the Mediterranean Sea. Pollution Research and Environmental Monitoring. Analyses, recommendations and assessemnt of the scientific and technological options. STOA Repport. European Parliament. 225 pp.

Caddy, J.F.- 1990. Options for regulation of Mediterranean demersal fisheries. Natural Resource Modelling, 4(4):427-475.

Caddy, J.F. and G.D. Sharp.- 1986. An ecological framework for marine fishery investigations. FAO Fish. Tech. Pap., 283: 152 pp.

CGPM/GFCM.- 1990. Report of the first session of the Working Group on Artificial Reefs and Mariculture. Ancona, Italy, 27-30 November 1989. FAO Fisheries Report. No. 428. Rome, FAO: 162 pp.

CGPM/GFCM.- 1994. Experto consultation on stocks of large pelagic fishes in the Mediterranean Area. Iraklion (Crete), Greece, 17-23 September 1992. FAO Fish. Rep. 494, Rome: 308 pp.

Charbonnier, D. et al.- 1990. Pêche et aquaculture en Méditerranée. Etat actuel et perspectives. Les Fascicules du Plan Bleu, n°1, Economica, Paris, 94 pp.

FAO.- 1992. Yearbook of Fishery Statistics, 1990. Catches and landings. Yearb. Fish. Stat., Vol 70:647 pp.

Gual, A.- 1994. Note on convenience-flag tuna longliners operating in the western Mediterranean. In: FAO Rapp. pêches, 494. Annex 14: 264-267.

Gutierrez, R.- 1994. Màs de 600 rederos arrasan el Mediterraneo. Mar, 320: 26-30.

Krost, P., Bernhard, M. Werner, F. and W. Hukreide.- 1990. Otter trawl tracks in Kiel Bay (Western Baltic) mapped by side-scan sonar. Meeresforsch, 32: 344-353.

Lacombe, H. and P. Tchernia.- 1972. Caractères hydrologiques et circulation des eaux en Méditerranée. In: D.J. Stanley (ed.). The Mediterranean Sea. Dowder, Hutchinson & Ross, Inc, Stroudsburg, pp. 25-36.

Lleonart, J.- 1993. Trends in Mediterranean fisheries yields. in: Briand, F. (Ed). Pollution of the Mediterranean Sea. Pollution Research and Environmental Monitoring. Analyses, recommendations and assessemnt of the scientific and technological options. STOA Repport. European Parliament. 225 pp. 103-114.

Northridge, S.P.- 1984. World review of interactions between marine mammals and fisheries. FAO Fish. Pap., 251:190 pp.

Spanier, E. and B.S. Galil.- 1991. Lessepsian migrations: a continous biogeographical process. Endeavour, 16(3): 102-106.

Sverdrup, H.V., M.V. Johnson and R.H. Flemming.- 1943. The Oceans: Their Physics, Chemistry and General Biology. Prentice-Hall. New York. 1087 pp.