SOME FUTURE PERSPECTIVES FOR ASSESSMENT AND MANAGEMENT OF MEDITERRANEAN FISHERIES FOR DEMERSAL AND SHELLFISH RESOURCES, AND SMALL PELAGIC FISH[1/]

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I. INTRODUCTION

A brief history of management in Mediterranean fisheries

Mediterranean resources have a long history of biological research (Farrugio et al 1994), but for many countries it is only relatively recently that research has been carried out specifically in support of management of fish populations, and the level of application of research recommendations in the management of marine fisheries is still generally low.

One example will suffice to illustrate the situation from the long history of the General Fisheries Council for the Mediterranean. In its second meeting in 1954, among its first recommendations on 'Production', the following were included:

"That, in view of the narrowness of the continental shelf:

a) ships with a wider range of action be used to avoid continual dragging of the same (i.e. inshore) fishing grounds;

b) The zone from 200m to 600m be explored for new working zones;

c) the continental shelf be given a rest by prohibiting trawling during the growing months of the fingerlings".

Some 37 years later, although recommendations a) and b) had long been accomplished for most of the northern Mediterranean shelf, a reduction in overall fishing effort, particularly for inshore trawling, still remains the main priority for management action, but little progress has yet been made in its implementation.

It seems fair to conclude then, that from a management perspective, the situation is not very different nowadays from the l950's except that the fleet is larger, and the fishing technology vastly

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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

superior. For northern, southern and eastern shelves of the Mediterranean, beyond 12 miles from the coast, fishing vessels are entitled to fish, and do so largely without restriction. It is only very recently that concern with overfishing looks like being translated into management action, as a result of a recent interest (discussed later in the paper) in transforming the General Fisheries Council into a management body that takes effective action.

As a result of the many analyses made recently, it would be unwise to assume that further expansion and development of Mediterranean fishing fleet will result in an increase in net earnings anywhere in the region: quite the contrary. The fleet expansion that has characterised the 1970's and 80's in most areas, has led to difficult economic conditions for most fishermen, is endangering the resources, and in many areas fishing fleets continue to increase in number and technological efficiency. Evidence provided by FAO and others over the last few years has shown that the opportunities for profitable investment no longer lie in the overcapitalization of fleets and fish plants: more effective investment can be aimed at the following:

- reduction of waste, both in terms of the elimination of wasteful fishing practices and in the duplication of vessels and plant, and excessive levels of fishing effort

- more rational planning of the sector, based on a proper assessment of the resources and their capacity to support fishing, and

- attention paid to questions of equity, scale, and the avoidance of conflicts between the small and large scale sectors.

- in some countries, fisheries still has an important role in food security and employment, and usually the small scale sector plays the key role here.

- a healthy small scale fishery and the associated coastal communities play a key role in economic activities in the fisheries sector, and it has been said,should be considered and provided for, in the decision-making process.

The overriding conclusion of most recent analyses however seems to be that the above considerations and opportunities are not realizable unless constrains are implemented on fishing effort, and in may cases, a significant reduction in fishing effort is achieved.

Changes in Mediterranean inshore fisheries since the 1940's: prospects for recovery?

The depletion of inshore resources occurred very quickly after the Second World War, during which stocks in the northern Mediterranean, (as for the better documented case of the North Sea), which had been heavily fished before the war, had recovered in biomass and individual size, due to a reduction of fishing pressure during the period of hostilities. What happened soon after this is instructive: thus, Doumenge (1968) documents that for red mullet (Mullus spp), after the Spanish civil war, catch per day from the port Castellon de la Plana dropped from 75 kg/day in 1943, to a plateau of just over 1Okg/day after 1952, and in the 1960's fell even below this.

Presumably, similar patterns occurred elsewhere in the northern Mediterranean inshore fishery after the second world war, although historical records are fragmentary, and need to be further analysed to allow a fuller picture to emerge. This example also has a hopeful aspect as it suggests that stock levels can recover, once effort levels are reduced, and that a reduction of fishing effort would lead to a rebuilding of stocks.

Some circumstantial evidence has more recently emerged, again as a result of several years of the virtual cessation of fishing in the eastern Adriatic caused by another of the tragic conflicts that mankind appears subject to. Anecdotal evidence from Croatia would seem to suggest that some stock recovery and more abundant and larger sizes of hake were evident in 1993, again, a consequence of a reduction of fishing effort, due to the effects of a prolonged period of hostilities on the operations of the fishing industry.

It is clear however that given free access to all fishing vessels from coastal and non-coastal States to waters beyond territorial seas, that a cooperative approach to addressing fisheries management problems is a sine qua non for their resolution, and the present Conference will hopefully be a step in this direction.

Demersal and invertebrate resources: Relatively few countries have taken management action to control increases in fishing effort despite the repeated recommendations of GFCM. Allowing for changes in fishing power, catch rates of demersals in inshore fisheries are still generally low, and present levels of landings are achieved by exerting a high fishing effort by large, overcapitalized fleets. The top priority is still therefore to correct the serious overfishing that exists immediately offshore from most Mediterranean littorals. It is highly probable that management action on this question is the key to success in increasing the yield, and more certainly, the economic return of the fishery. It seems likely also, that effort control is a precondition to the success of other management measures, such as increasing the size at first capture, and more importantly, increasing the spawning biomass and spawning success. At the same time, urgent measures need to be taken to protect inshore nursery areas from the adverse impacts of fishing and pollution.

The third recommendation of the 1954 GFCM meeting on the need for seasonal inshore closures mentioned earlier, also has its counterpart in modern thinking on management of Mediterranean fisheries. This measure has been applied in Cyprus since the mid 1980's (see Garcia and Demetropoulos 1986), and in 1988-89 with apparently similar effect, in Italian waters. Under conditions of limited access, a seasonal closure at the time of the recruitment of young-of-the year to the inshore grounds appears capable of producing significant increases in fisheries yield, and in some ways has comparable effects to mesh size regulation. Such a result can be achieved by improved surveillance, but protecting against inshore trawling on sensitive areas such as Posidonia beds, areas of rocky outcrops and nursery grounds, by means of passive devices, may in the future be a more cost effective approach. This can be combined with the technology of artificial reefs used for fish aggregation, aquaculture, etc.

Small Pelagic fish: For small pelagic fish, management measures to control fishing have been relatively limited, apart from restrictions on pelagic trawling in some countries, and few stock assessment recommendations have been made, except for the Gulf of Lions stock of sardines. The problem for most small pelagic fish except for anchovy, seems related more to difficulties in achieving effective utilization and marketing rather than overfishing. Large-scale fluctuations in stock size continue to occur for small pelagic fish (and to a lesser extent for demersals) which are as yet unexplained by science. It is presumed from the general similarity of such changes in many areas that they are environmentally driven, although the decline of anchovy in many areas (Fig 1) may suggest that this highly sought species is also subject to excessive fishing. There is some evidence that the productivity of some small pelagics, notably sardine, may have increased in some areas in recent years, (Fig 1). This may be as a result of moderate levels of nutrient enrichment, but could be due to other environmental or fishery-related changes that await elucidation. All that can be suggested is that management of sardine stocks in most areas is not usually as high a priority as it is for demersals, and in fact the management action appropriate in some areas would be to provide for some substitution of unsatisfied demand for demersal stocks.

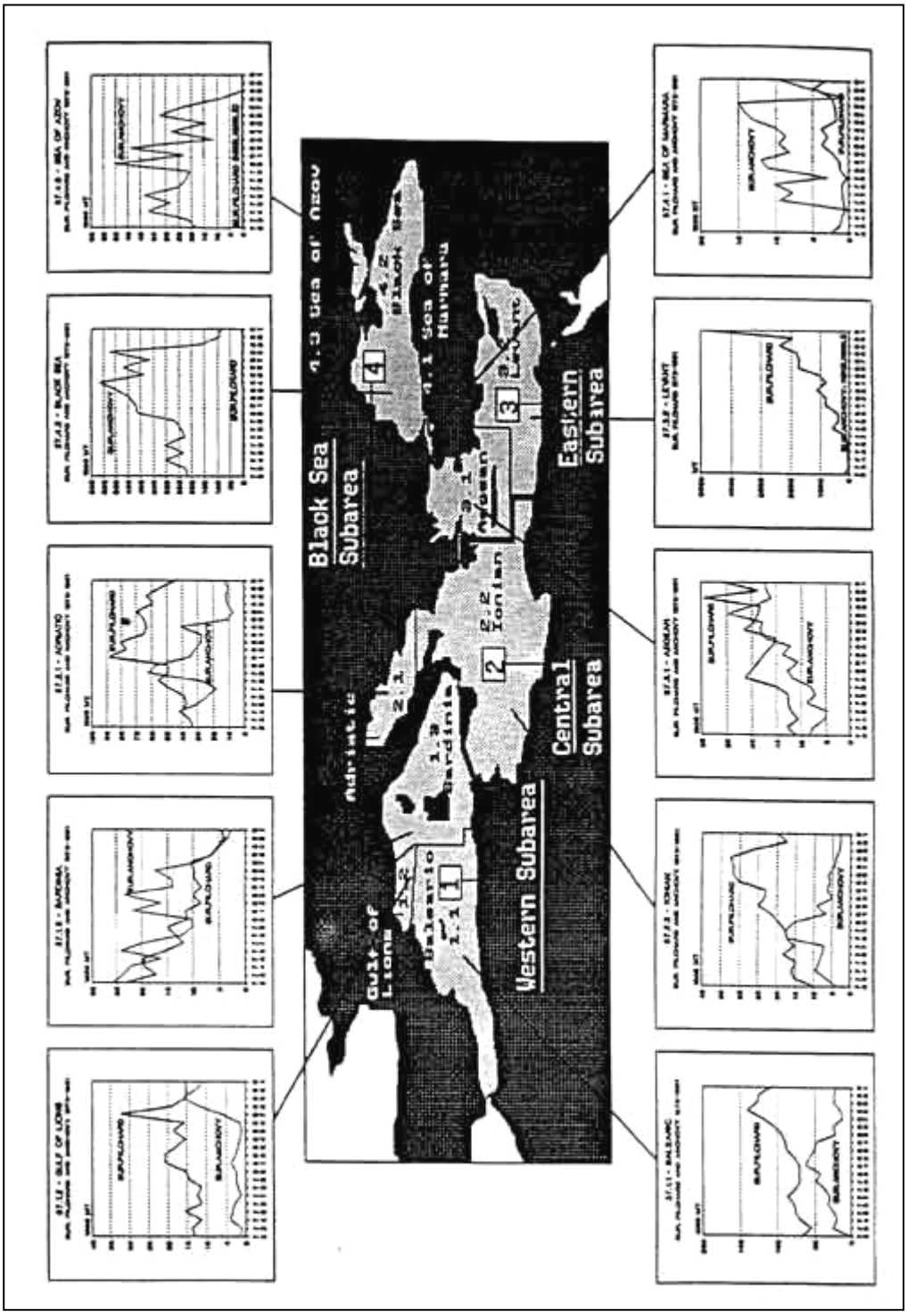

Figure 1 Production of European pilchard and European anchovy by statistical division

II. GEOGRAPHICAL AND POLITICAL CONSIDERATIONS RELATED TO MANAGEMENT OF UNIT STOCKS

A categorization of Mediterranean shelves

The context for a discussion of management of demersal resources is provided by the simple observation that with certain notable exceptions, the shelf and slope habitat of the exploitable demersal populations is narrow (Fig 2), and compressed between the littoral zone of the coastal State and the central areas of the Mediterranean which average some 2000 3000m in depth, and effectively separates the stocks of facing shelves, both for demersal, and for most small pelagic stocks.

From the point of view of the definition of fishable demersal stocks, the situation presented by figure 2 has other practical consequences. Legally, from the point of view of management jurisdiction, one must divide Mediterranean shelf areas into two categories in attempting to decide on a management framework for these resources. Using the 200m isobath as a deep water boundary for the edge of the shelf is arbitrary and questionable; for important deep water resources of the outer shelf and slope such as royal red shrimp, large hake, red coral, and the deeper water demersal resources of the Sicily Channel for example, a deeper outer boundary (perhaps down to 500m or more) for the demersal fish community would simply extend the international trawling areas slightly further offshore, given the generally steep slopes of Mediterranean shelves.

Table 1. Extensive areas of shelf that fall outside of national jurisdiction

ZONE	COASTAL STATES INVOLVED	DIVISION OF GFCM
Catalonian Shelf	Spain	1.1
Gulf of Lions	Spain, France	1.2
Adriatic Sea	Italy, Croatia, (others?) Albania	2.1
Gulf of Gabes	Tunisia, Lybia, Italy	2.2
Deeper water resources of Sicily Channel	Italy, Tunisia	2.2
Gulf of Iskenderun	Turkey	3.2
Northern Aegean	(Greece, Turkey?)	3.1

1) Extensive trawlable shelves: There are several extensive areas within the 200m isobath, where trawling is the key fishing method, and table 1 give some of their dimensions and the names of the key coastal States that are directly adjacent. Since these areas fall partly inside and partly outside territorial seas, their resources may be regarded as straddling, as well (where more than one coastal State is involved) as shared resources. (We may note, in passing, that with the exception of the Adriatic Sea, 50 nautical miles encompasses most demersal resources within 'coastal waters').

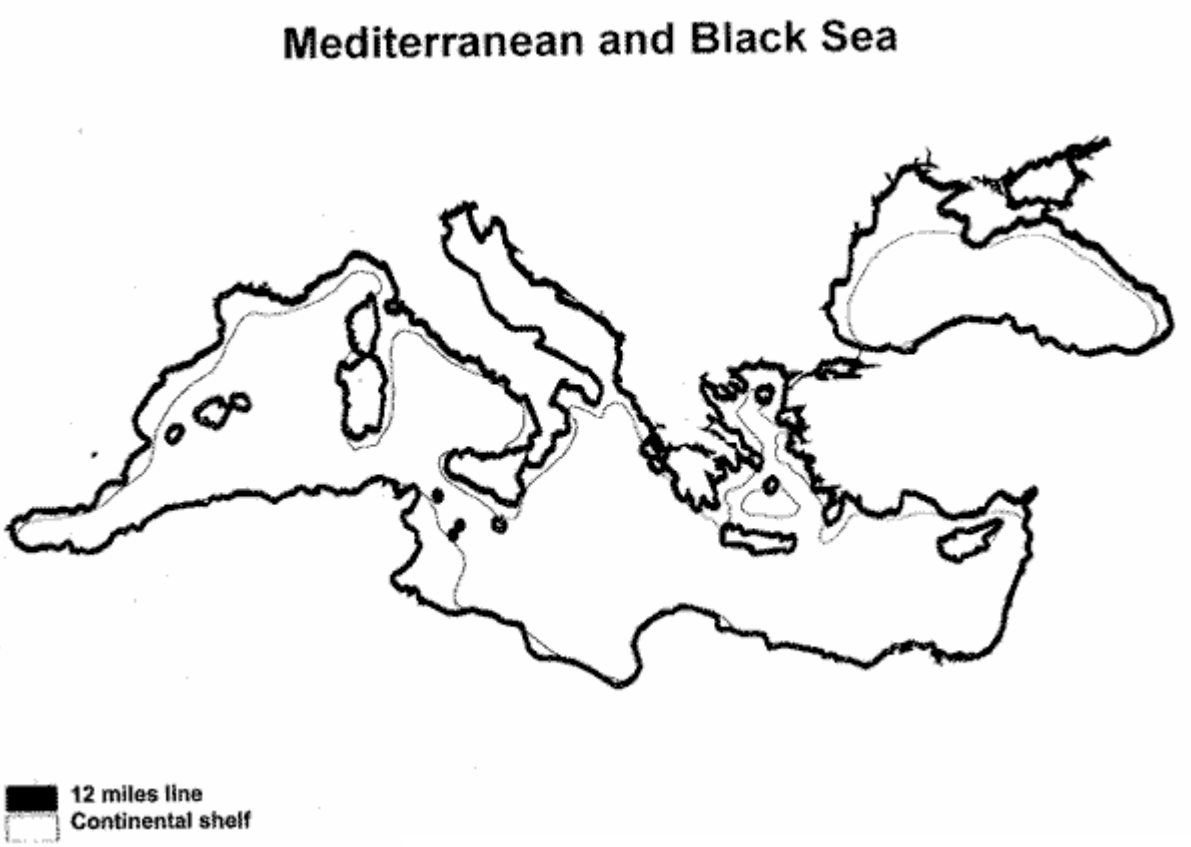

Figure 2 Mediterranean and Black Sea

This figure suggests that the main areas of straddling demersal stocks lying across national boundaries between territorial waters and international waters can be inferred to occur in the following areas:

a) The Catalan Coast
b) The Gulf of Lions
c) The Gulf of Gabes and Sicily Channel
d) The Adriatic Sea
e) The Aegean Sea

(Note: Most of these areas lie within 50 nautical miles of the coastline)

2) Fringing shelves within national jurisdictions: the rest of the Mediterranean shelf forms a narrow fringe between the littoral and deep water, largely within the limits of territorial seas. Some of this narrow strip is trawlable (e.g. along the coasts of Syria and Israel), but much of it is dominated by untrawlable bottom (e.g. along the Algerian littoral), and is fished predominantly by small scale vessels with fishing gears of a wide variety of types. By definition, the fisheries of these areas fall under national management and exclusive access.

Stock units

Demersal resources: From the point of view of the Mediterranean resources themselves, the key gradient along which seasonal, or life history migrations are likely to occur is not across an extensive shelf as in the case of the North Sea for example, but from a shallow littoral, often characterised by shallow lagoons and sea grass beds, (the critical habitat of young stages of many important species), to the deep water of the shelf edge and slope. This latter habitat is often an untrawlable spawning refuge for an important component of the adult stock. This picture is of course a gross simplification of the complex situation presented by a wide range of species each with distinct life history strategies, but without taking into account this zoogeographical difference from the large trawlable areas of (e.g.) North Atlantic shelves, it is difficult to explain how a fishery pursued close to shore with such a high level of fishing intensity has managed to remain productive, and in many cases, has even increased in productivity over several recent decades.

There is a divergence of views concerning the units of population to use for management purposes: the empirical view is that a stock unit is a geographically delimited part of the species range, for which it is possible to assume uniform population parameters, and negligible exchange with other stock units. In reality, there is little information as to the population units and extent of exploitable populations, since tag and recapture experiments and genetic investigations are still in their infancy in the Mediterranean region.

The genetic approach is to consider a stock as a self reproducing unit. This implies for species such as hake, that a significant part of the spawning stock may be in deep water or areas inaccessible to trawling. In other words, it is a reasonable hypothesis that spawning refuges may exist for some species, and these should be identified and protected.

Proceeding from the above classification into international shelf areas, and national fringing shelves, we might consider as a first hypothesis that the demersal fish resources of these areas are unit stocks. From a stock assessment perspective, the demersal and small pelagic resources of extensive international shelf areas fall into the category of straddling stocks currently being discussed in New York by the Conference on Straddling Stocks and Highly Migratory Stocks. Based on such considerations we may then look for the management frameworks which are most likely to be appropriate for the resources concerned. This discussion also makes clear that a different international management framework is needed from that for the national fringing shelves that separate them, which are matters that fall entirely under national jurisdiction.

Small pelagic resources: The above classification for demersal resources does not preclude considering the existing sub-divisions of FAO Statistical Area (37) in figure 1 as the management units to apply for demersal resources, but still more feasibly, management of small pelagic resources by subdivision remains the best option at present. Although sardine and other stocks of small pelagic fish often remain close to the coast in some areas, in others they may be associated with upwelling areas further from the coast. The conclusion is that most small pelagic fish resources should ideally be regarded as straddling stocks, and managed cooperatively within a given region.

III. THE DIVISIONS AND THEIR RESOURCES

The following sections on subregional fisheries (see fig.3. for the GFCM statistical divisions used in the Mediterranean) are necessarily very brief, and depend heavily on FAO sources and data for 1991; the last year for which statistics subdivided by division are available; and with respect to the state of assessment of resources, the contents of the tables also depend heavily on analyses provided at GFCM meetings. To avoid undervaluing work that may have been carried out but has not come to the attention of the authors,it has been preferred to place a question mark in boxes for which no information is available, rather than make judgements on the basis of inadequate information. Those resources, where (from our information) at least one stock has been adequately assessed in the subregion, are reported in capital letters. Nonetheless, all of the resources included in the tables (plus a number that are not included for lack of space), merit in the authors' view, proper evaluation; particularly those for which dramatic changes in the level of declared landings have been registered.

To give a view of the distribution and trends of fisheries production, we have compared the estimates of production (total production and the production of pelagic and demersal resources per shelf area) for 1969, 1979 and 1989 in the different statistical sub-areas of the Mediterranean (Caddy, Refk and Do Chi in press), in comparable units of measurement (Table 2): namely, the fishery production (obtained from the GFCM fishery statistics), expressed per area of surface (in terms of the area of shelf within each division inside the 200m isobath).

NOTE: *In the sections on the subregional fisheries of the Mediterranean, information is used from official FAO sources for example on catches and fleet sizes which may not represent up-to-date information, and it is quite likely that delegations at the Diplomatic Conference will have access to better and supplementary information not referred to here. If this is the case,the authors request to be made aware of this information.*

a) The general decline in production/shelf area with distance from the Gibraltar Strait is clear, with the notable exception of the Adriatic, where local nutrient runoff enriches nutrient-poor Mediterranean waters, which become progressively poorer to the east (Murdoch and Onuf 1972).

b) Overall production trends have been upwards in all areas, with the notable unexplained exception of the Sardinian Division, where a decline has been noted over the three decades.

c) The 2 areas/years with the highest total production were Gulf of Lion (6,47 t/km2), followed by Balearic (5,25 t/km2) all in 1989. These levels of overall production are at the upper end of the ranges of Maximum Sustainable Yield (all species) given by Gulland (1971) for the (then) total fish production from the NE and NW Atlantic, NW Pacific, and above those for tropical areas such as the Indian Ocean, South China Sea and West Central Atlantic.

The demersal production levels are comparable with, or exceed, figures given for demersal production for a range of tropical and subtropical shelves by Marten and Polovina (1982) which are in the range of 0,4-0,3 t/km2. None of the figures given for the northern basins, with the exception of Sardinia, are typical of nutrient-poor shelves, and seem to suggest that over the last three decades, the Mediterranean has approached, and perhaps has reached the productivity levels considered typical of moderately enriched shelf fisheries elsewhere.

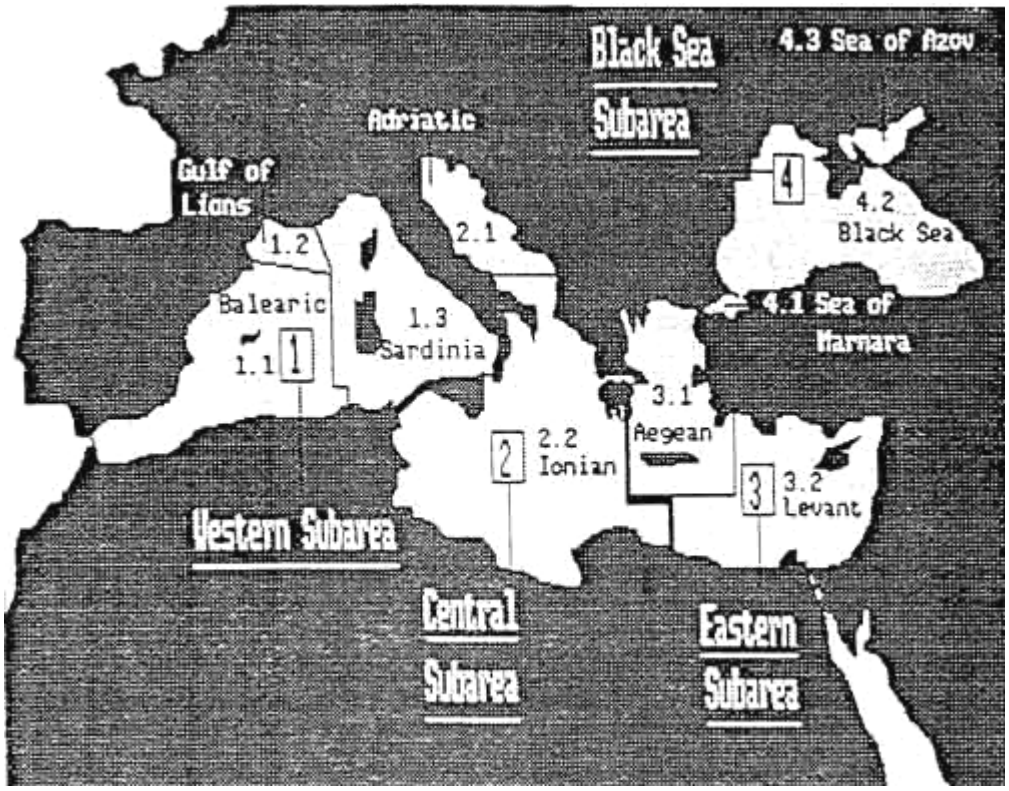

Figure. 3. Mediterranean and Black Sea statistical sub-areas And divisions

Table 2. Summary of fish production (tonnes)/shelf area (km2) in the Mediterranean Sea

1969	1.1 Balearic	1.2 G.Lion	1.3 Sardinia	2.1 Adriatic	2.2 Ionian	3.1 Aegean	3.2 Levant
DEM	0,76	1,15	1,21	0,67	0,28	0,29	0,32
PEL	1,64	2,15	1,54	0,89	0,28	0,36	0,23
TOT	2,40	3,40	2,76	1,58	0,56	0,65	0,55
1979							
DEM	1,40	1,43	0,66	1,13	0,41	0,33	0,43
PEL	3,37	1,79	0,87	1,80	0,55	0,66	0,39
TOT	4,78	3,41	1,55	2,94	0,95	0,99	0,82
1989							
DEM	1,15	0,71	0,43	0,18	0,40	0,63	0,53
PEL	4,09	3,41	0,56	0,99	0,60	1,24	0,73
TOT	5,25	6,47	1,40	2,81	1,43	2,20	1,56

(Given deficiencies in the data we are very conscious that the production per area figures are not accurate for different reasons). Some notable features of the data are as follows:

Table 3. Sizes of fishing fleets reported to the FAO and included in the 1991 Yearbook of fleet statistics for the Western Mediterranean.

COUNTRY/YEAR		NUMBER VESSELS	MEAN % ANNUAL CHANGE
Algeria	(1975)	633	
	(1987)	1,519	+ 7.3 %
France	(1980)	11,467	
(*)	(1986)	13,957	+ 3.3 %
Morocco	(1970)	932	
(*)	(1989)	2,584	+ 5.4 %
Spain	(1970)	15,245	
(*)	(1989)	13,747	- 0.5 %

(*) An unregistered (but considerable) proportion of vessels operate outside the Mediterranean.

A/ THE WESTERN MEDITERRANEAN

1. Division 1.1 Balearic

1.1. Resources and Environment

This is a area of relatively high productivity where the Atlantic inflow upwells in the Alboran Gyre and along the Algerian coast, and is associated there with significant small pelagic stocks, however, in many places the shelf is too narrow and rocky for large demersal stocks and a trawl fishery. The Mediterranean inflow is progressively less enriched as it moves north past Sardinia and Corsica and the Baleares, where deep water rocky bioecoenoses are associated with lobster and red coral. The Catalan coast is relatively productive due to land runoff and local upwellings.

1.2. Characteristics of the fleets and gear (Table 3)

Purse-seiners and trawlers predominate in this region, by volume and value of their catches. Apart from these "industrial" fleets, a well-developed small-scale inshore fishery takes a significant but imprecisely known proportion of catches using many types of fishing gears.

Moroccan fisheries are dominated by small pelagic fisheries, a limited number of trawlers and many 'petit metier' vessels exploiting demersal resources of the narrow shelf area.

Along the Algerian coast, purse-seining for small pelagics predominates with some midwater trawling for the same resource, and 'petit metier' operate over rocky areas for a wide range of predominantly demersal species. The fleet capacity has been growing at some 7,500t per year over the last years, and trawlers compete heavily on the narrow (and overfished) trawlable areas.

In Spain the fleet size and fishing effort is limited by an operational fleet census and licensing system, but a migration of purse-seiners from southern to northern Spanish Mediterranean coasts has been observed in spring and summer over the last few years, caused by the drop in anchovy catch in the Alboran Sea. Also increasing competition from bottom trawlers catching anchovy has been observed over the last years in some regions such as Catalonia.

Table 4. The national catch shares registered with FAO in 1991 in sub-area 1.1 Balearic

COUNTRY	Spain	Algeria	Morocco
Finfish	47 %	39 %	14 %
Crustaceans	62 %	35 %	3 %
Molluscs	90 %	7 %	3 %

1.3. State of exploitation and assessment (Tables 4 and 5)

Small pelagics

At least in the northern part of the division a lack of fishing pressure is observed on the stock of sardine, probably due to low market demand, and an increase in the biomass has been observed.

On the contrary, there has been a gradual intensification of exploitation of stocks of anchovy, which have shown some decline (Oliver 1994).

The results of the annual acoustic surveys carried out since 1982. 0n the Spanish continental shelf and the Virtual Population Analysis applied to sardine stocks, indicated an underexploitation, while in the case of anchovy the survey results and the analysis showed a trend towards overexploitation. The stock assessments carried out over the Algerian shelf show a situation of underexploitation (Ferhaoui 1986).

Demersal fishes and invertebrates

Assessments have been reported at the GFCM and other regional fisheries bodies for most of the resources in Table 6; including direct trawl and acoustic surveys, plus egg and larval surveys, and estimates based on catch sampling for size and age data (Oliver 1994). Time series of commercial catch and effort data are also available for a few species, and some production model estimates have been made. Time series of biological data are not generally adequate however (except for some hake, mullet and red shrimp stocks) to perform Virtual Population Analyses (VPA's). The assessments available suggest that the demersal stocks are fully or overexploited throughout the region, and some fishing effort has been diverted to deep water slope areas in search of large hake and red shrimp.

Table 5. Key species in sub-area.1.1 Balearic; with a tentative estimate of their state of evaluation.

SPECIES	1991 LANDINGS (t)	TREND 1972 to 1991	BIOLOGICAL STUDIES	VESSEL SURVEYS	ASSESSMENT PERFORMED ?
Sardine	109,250	rising	yes	Acoustic	Yes
Anchovy	20,912	stable	yes	Acoustic	Yes
Hake	4,509	rising	yes	Trawl	Yes
Red Mullet	3,548	stable	yes	Trawl	Yes
Angler	1,228	rising		Trawl	
Red shrimp	1,905	rising	yes	Trawl on slope	Yes
Octopus	5,679	rising	yes	?	?
Cuttle-fish	1,211	declining	yes	?	?

2. Division 1.2 Gulf of Lions

2.1. Resources and Environment

The western part of this division is characterized by a large crescent-shaped continental shelf of 45 miles maximum width near the 150 m isobath. Most of this shelf is covered by smooth,

muddy or sandy trawlable bottom. The eastern part is characterized by a rocky coast, with a narrow continental shelf; the depth increases sharply from the coast to 1000m some few miles offshore.

This area contains a series of characteristics which make it one of the highest producing areas in the entire Mediterranean, with the exception of the Black Sea and Northern Adriatic. Several mechanisms of fertilization occur in this area which notably increase productivity (Margalef 1985). Among these the most important are the existence of a permanent front or divergence which extends from the Ligurian Sea to Catalonia: the influence of river Rhone, the processes of formation of deep water and other more localized oceanographic occurrences that determine the carrying capacity of the system, and directly limit the biomass of planktivorous species such as the anchovy. All of that is also reflected in the very important shellfish culture activities of the sub-region, and in the fishing activity carried out by a wide variety of inshore and industrial gears.

Table 6. Key species in sub-area 1.2 Gulf of Lions

SPECIES	1991 LANDINGS (t)	TREND 1972 to 1991	BIOLOGICAL STUDIES	VESSEL SURVEYS	ASSESSMENT PERFORMED ?
Sardine	15,203	rising	yes	Acoustic	
Anchovy				Acoustic	
Hake	3,896	rising	yes	Trawl	yes
Mullets	2,201	rising	yes	Trawl	yes?
Eel	1,201	Stable	yes?	no	?
Sole	442	rising	yes	yes	yes
Mussel	16,148	stable	culture	no	?
Oyster	10,014	rising	culture	no	?

2.2. Characteristics of the fisheries and gear (Table 3)

The Spanish and French industrial fleets are mainly trawlers, but also longliners and gillnetters. They reached approximately their present size at least a decade ago, except the purse seiners whose numbers have increased spectacularly in recent years. Despite a limitation on number of licenses, and the small or even negative rates of increase in fleet size given in table 3, fishing power continues to grow as technical innovations are introduced. The use of high opening trawls by French fishermen results in a significant proportion of small pelagics supplementing a rather low net catch rate for demersals by this gear.

A highly diversified small scale fleet harvests a range of specialized resources with a wide variety of gears, including tangling and trammel nets, traps and dredges; both inshore, and in an extensive system of coastal lagoons, where aquaculture operations are well developed.

2.3. State of exploitation and assessment (Tables 6 and 7)

Small pelagics.

There has been a gradual intensification of exploitation by means of purse seiners and trawlers and a spectacular increase in the anchovy catch from 300 tons in 1980 to 8000 tons in 1989, landings then fell to about 2000 tons in 1993. The average fish size in catches passed from 16 cm in 1988 to 10 cm in 1990: under the length of first maturity.

Demersal fish and invertebrates.

A multispecies global analysis of the trawl fishery suggested that Maximum Sustainable Yield (MSY) conditions had probably been passed in 1991 for most demersals. This preliminary analysis has been confirmed and expanded during the recent EC-sponsored FARWEST program.

In the framework of the EC/DG XIV FARWEST project, a database (Farrugio et al 1994) has been designed to store catch information by port and by species including demographic structure, inventory and fleet activity. The programme package VIT (Lleonart and Salat 1992) has been specially developed and combined with this database, to be applied to the Mediterranean multigear fisheries, (VIT provides for flexible Length Cohort and Yield per Recruit Analyses). This programme was used to evaluate the hake stocks of the Gulf of Lions, based on the Spanish trawl and longline catches and French trawl and gill-net catches and had showed a recent situation of overexploitation, with effort double that required to achieve MSY level (Aldebert et al 1993). A Virtual Population Analysis was also applied to catches of the same stock by age class for 1988-1991 (Aldebert and Recasens 1993) obtaining similar results.

A highly developed small-scale fishery fishing inshore waters and lagoons takes a significant proportion of catches, and, a rare phenomenon in the Mediterranean region, has been investigated by biologists and socio-economists, who have confirmed the importance of this sub-sector for both local fish supply and employment. As elsewhere in the Mediterranean, this sector is poorly represented in the statistical database, and will probably prove to be a major component of the fishery in this and other regions when fully investigated.

Table 7. The national catch shares registered with FAO in 1991 in sub-area 1.2 Gulf of Lions.

COUNTRY	France	Spain
Finfish	69%	31%
Crustaceans	88%	14%
Molluscs	97%	3%

3. Division 1.3 Sardinia

3.1. Resources and Geographical characteristics

This zone is characterised by water masses of generally low productivity; narrow shelves with irregular sea-beds and steep slopes. A high diversity of fauna occurs on predominantly rocky

bottoms with red coral biocoenoses, palinurid lobster and sparid stocks, and relatively low productivity of small pelagic fish.

3.2. Characteristics of fleets and gear (Tables 3 and 10)

In this division the Italian fleet predominates and the results of the PESTAT programme which started in Italy in 1981, allows us to establish some idea of the complex fishing activity going on in this zone. Some 65 % of the Italian fleet operate in the Tirrenian Sea, largely in the northern part. The small scale fleet (boats of less than 10 GRT and 100 HP, using small-scale gears), represent more than 75% (and in Sardinia practically all) of the fleet, by number of vessels.

Table 8. The national catch shares registered with FAO in 1991 in sub-area 1.3 Sardinia.

COUNTRY	Italy	Tunisia	France
Finfish	70%	28%	1%
Crustaceans	90%	8%	2%
Molluscs	98%	2%	0%

Table 9. Key species in division 1.3 Sardinia

SPECIES	1991 LANDINGS	TREND 1972-1991	BIOLOGICAL STUDIES	VESSEL SURVEYS	ASSESSMENT PERFO MED ?
Sardine	4,520	declining	yes	?	no?
Anchovy	2,619	declining	yes?	?	no?
Hake	2,690	declining	yes	yes	yes
Dentex	1,069	rising	yes?	yes	no
Sole	1,030	rising	yes?	yes	no
Mantis shrimp	728	stable	?	?	?
Mussel	15,928	rising	culture		
Octopus	2,390	stable	?	?	?

3.3. State of exploitation and assessment (Tables 8 and 9)

Small pelagics

The exploitation of small pelagic stocks is not important in this sector, where the abundances are lower than in more productive areas like the Gulf of Lion or the Adriatic Sea. Despite this sardine and anchovy are still the most important species from the perspective of exploitation, although no assessments have been made to determine their state of exploitation.

Demersal fish and invertebrates

A number of demersal resources have been assessed in the Ligurian and Tyrrhenian Seas; predominantly by trawl survey and simple analytical techniques. The first estimates suggest that stocks of mullet, hake, Norway lobster, blue whiting, and red shrimp, are fully or overfished.

The inshore fishery resources of the rocky northern Tunisian coast are fished by small scale vessels, and are considered by national authorities to be somewhat underexploited.

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Table 10. Sizes of fishing fleets reported to the FAO and included in the 1991 Yearbook of fleet statistics for the Central Mediterranean.

COUNTRY/YEAR		NUMBER VESSELS	MEAN % ANNUAL CHANGE
Albania	(1975)	2	(fleet rebuilding underway)
	(1989)	2	-
Former Yugoslavian Republics	(1970)	162	
	(1989)	404	+ 4.8% (1)
Italy	(1980)	22,492	
(*)	(1989)	18,433	- 2.2%
Libya	(1970)	298	
	(1989)	32	- 11.7%
Malta	(1970)	450	
	(1889)	539	+ 0.9%
Tunisia	(1970)	4,281	
	(1989)	11,911	+ 5.4%

(*) A significant proportion of these vessels operate in the western Mediterranean, and a (small) proportion outside the Mediterranean.
(1) Some 300+ trawlers are said to have been purchased in recent years to renovate the fleet of the former Republic of Yugoslavia.
(2)This drop may be an artifact of changed reporting. Fleet reconstruction has been underway in recent years.

4. Division 2.1 Adriatic

4.1. Resources and Environment

This area consists of flat bottom or gentle slopes with mud and sand, this is an extremely productive and extensive area, subject to strong nutrient outflow from incoming rivers, and from agricultural/industrial and dense coastal populations, as well as receiving nutrient inflows of an apparently periodic nature from the Mediterranean proper. This combination occasionally leads to

anoxic die-offs of demersal and benthic resources in the northern and western Adriatic, and is conducive to high productivity of molluscan shellfish, including vongole (clams),mussels, scallops and a variety of small commercial invertebrates and fish of high unit value.

4.2. Characteristics of fleets and gear (Table 10)

The division is exploited by a multi-gear fishery of trawl, gill net and seine fisheries, and supports a hydraulic dredge fishery for 'vongole' in Italian waters. The Italian trawl fleet in 1986 made up 46% of all Italian vessels fishing in the Adriatic; close to 3,000 units, including, in the 1980's a specialized fleet of pelagic pair trawlers of around 250 vessels. These last vessels have progressively replaced the purse-seine fleet, which in 1987, consisted of some 130 vessels.

With respect to the eastern part of the Adriatic, the information registered with FAO for the trawl fleet of the former Republic of Yugoslavia is given in table 10. More recent information suggests that an important increase has occurred in fleet size, from 120 trawlers in the former Yugoslavia, to some 486 trawlers; the new boats reported being formerly part of the Italian Adriatic fleet.

Albanian fisheries have been predominantly for small pelagics (sardine), but following recent political upheavals, fishery reconstruction in Albania is underway. A new fleet of vongole dredges was introduced in 1986.

Table 11. The national catch shares registered with FAO in 1991 in the Adriatic sub-area 2.10.

COUNTRY	Italy	Former Yugoslav Republic (= Croatia?)	Albania
Finfish	(76%)	(24%)	No data
Crustaceans	(95%)	(5%)	No data
Molluscs	(99%)	(1%)	No data

4.3. State of exploitation and assessment (Tables 11 and 12)

The small pelagic fish

Total catches of anchovy, mainly fished by the Italian fleet, have fluctuated quite widely over the last decades and in particular, a severe drop was observed in the years 1986 and 1987. After this period catches have increased again but not to the level of the late 70s and early 80s. The biomass estimates and stock assessment of anchovy both show, in the last years, a positive trend and the stock seems to have recovered, at least partially, from the collapse of 1986 and 1987. The fishery relies heavily on recruitment, thus the collapse was very likely caused by two consecutive years of recruitment failure (Cingolani 1993). The resource can be considered as at least fully exploited. The sardine is caught by the same gears as anchovies, but for sardines the catches from the former Yugoslavia accounted for 50% and more of total. Italian sardine catches did not show a collapse as for anchovy. Also catches in the Southern Adriatic are relevant being the most important pelagic resource caught by Albania. Despite the uncertainties inherent in the assessments of sardine stocks all available evidence indicates that there have been no serious trends in level of stock biomass over the last 15 years.

The demersal fish and invertebrates

Assessments of demersal fish have been carried out on most species, using trawl surveys and largely length-based analytical techniques. These analyses confirm that in the late 1980's, the demersal resources (notably red mullet and hake, but probably also other associated species such as the common pandora) were fully to overfished according to conventional criteria. The 'fermatura biologica' (closed season) introduced by Italy, and the significant cutback in fishing effort in the eastern Adriatic due to the war in the former Republic of Yugoslavia, appear to have had some influence on increased recruitment or survival of juvenile hake and mullet, although the precise impact and relative influence of these two factors is not analysed.

The 'vongole' (clam) fishery is or was, perhaps the single most valuable fishery in the Mediterranean in terms of landed values, but has suffered in recent years collapses of the key species (Venus chione); apparently due to overfishing (Froglia and Fiorentini 1989). A similar fishery in Albanian waters is reported to have declined due to overfishing (Ferretti and Vaccarella 1991).

Table 12. Key species in sub-area 2.1 Adriatic

SPECIES	1991 LANDINGS (t)	TREND 1972-1991	BIOLOGICAL STUDIES	VESSEL SURVEYS	ASSESSMENT PERFO MED ?
Sardine	44,512	rising	yes	ACOUSTIC	yes
Anchovy	13,076	declining	yes	ACOUSTIC	yes
Hake	4,105	stable	yes	TRAWL	yes
Mullets	3,802	declining	yes	TRAWL	yes
Mantis shrimp	2,877	stable	yes	?	?
Norway lobster	2,024	rising	yes	TRAWL	yes
Mussel	52,559	rising	culture	?	?
Striped venus	25,419	stable	yes	dredge + diver	yes
Carpet shells nei	16,000	sharp rise	yes	dredge + diver	?

5. Division 2.2 Ionian

5.1. Resources and Environment

The shelf areas off Tunisia are the largest and the most productive fisheries of the Mediterranean after the Adriatic; varying from rocky areas in the north to trawlable sand and mud bottom on the south; otherwise, this area is generally of low to moderate productivity, receiving

inflows of enriched water from the north and west, but characterised by relatively low productivity shelves along the southern littoral.

5.2. The characteristics of fleets and gears (Tables 10 and 15):

The shelf areas off Sicily and more importantly off Tunisia support an important trawl fishery by fleets from both northern and southern Mediterranean countries: the latter, predominantly industrial-scale Italian vessels, also heavily exploit trawlable grounds in the Sicily Channel area. In the northern shelf waters of Tunisia, exploitation of demersals by multipurpose vessels is believed to be at below MSY levels, but the very intensive fishery in the southern waters of the Gulf of Gabes by trawling and a variety of other methodologies is clearly overexploiting key resources.

Table 13. Key species in sub-area 2.2 Ionian

SPECIES	1991 LANDINGS (t)	TREND 1972-1991	BIOLOGICAL STUDIES	VESSEL SURVEYS	ASSESSMENT PERFORMED ?
Sardine	19,854	rising	yes	Acoustic	yes
Sardin-ellas	15,364	rising	yes?	Acoustic	?
Trachur-us spp	6,116	rising	yes	Acoustic	?
Red mullets	6,209	stable	yes	trawl	yes
Sole	4,232	rising	yes	trawl	yes?
Shrimps; prawns	18, 084	rising	yes	trawl	yes
Mussels	32,069	rising	yes	culture	?
Cuttle-fish	8,671	rising	?	?	?
Octopus	8,671	rising	?	?	?

Table 14. National catch shares registered with FAO in 1991 in sub-area 2.2 Ionian.

COUNTRY	Italy	Tunisia	Lybia	Greece	Albania	Malta
Finfish	53%	34%	5%	4%	4%	0.3%
Crustaceans	92%	8%	-	0.26%	-	0.1%
Molluscs	80%	20%	0.3%	-	0.3%	0.1%

5.3. The state of exploitation and assessment (Tables 13 and 14)

The small pelagic fish

Stocks of pelagics in the northern Ionian Sea are smaller than in more productive Adriatic waters, but for anchovy, catches in the order of 3,500t are still estimated at about 40% of biomass levels, and similar low stock sizes apply for sardine. In the southern Ionian Sea, off northern Tunisia, although the earlier acoustic estimate of some 47,000t (dominated by sardine, mackerel and horse mackerel) are well above landings of some 8300t in 1993, this may be a case of a biomass overestimate, or lack of year-round access to the resource, rather than a very low exploitation rate, although undoubtedly problems of marketing and distributing seasonal gluts may be the key problem. In the more productive waters off the Gulf of Gabes, pelagic biomass was estimated by the same survey at some 90,000t; including here equal dominance by sardines and sardinellas, and again, the contrast with 1987 catches of 23,000t from this region suggests, but does not confirm, some limited room for expansion.

The demersal fish, shellfish and invertebrates

Fisheries in Tunisian waters are aimed principally at high value lobster, cuttlefish and shrimp stocks; particularly on easily trawled bottoms in the south, (Gulf of Gabes) where three quarters of the trawling fleet operates. This intense trawl effort in the Gulf of Gabes and other southern waters is aimed principally at shrimp (Penaeus kerathurus!, but catches have dropped despite this, from 102,000t in 1988 to 83,000t in 1993, and it is clear from production modelling that levels of effort corresponding to MSY were passed in 1988 by some 20%). This has led to social conflict, notable overexploitation and impacts on inshore Posidonia biocoenoses. Attempts to divert effort towards less easily trawlable grounds off northern Tunisia, where some slight increases in effort could be supported, have been frustrated by various factors including difficulties of replacing lost gear.

A significant growth in exploitation effort on the stocks of clams (Tapes decussatus) has doubled production between 1979 and 1993 as new grounds continue to be found. Resources of red coral are found off the north coast of Tunisia, the sponge Hippospongia communis is also exploited by divers; however stocks of this species have shown dramatic collapses (as in the rest of the eastern and southern Mediterranean) due to an epidemic, with some recent evidence of recovery.

Emphasis continues to be placed in the northern Ionian and Sicily Channel on trawl surveys of demersal stocks, and egg and larval/hydroacoustic surveys of small pelagics. The results of these estimates suggest a general state of full to overexploitation for resources such as hake, the rockfish (Heliolenus dactylopterus) and the forkbeard (Phycis blennoides) (Ragonese 1993; Papaconstantinou et al 1986; Papaconstantinou et al 1988; Tursi et al 1993). In southern waters, a considerable effort has been made to fit production models and perform yield per recruit estimations for the key demersal and shrimp resources.