Review of the state of Mediterranean and Black Sea fishery resources

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Review of the state of Mediterranean and Black Sea fishery resources

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SUMMARY – The status and trends of the Mediterranean and Black Sea main fisheries resources is reviewed. In the Black Sea the small pelagic resources have more importance than the demersal ones and their history is characterized by the rise and fall of the small pelagics, mainly anchovy, between 1980 and 1990. In the Mediterranean demersals dominate catches although small pelagics are also very important. During the last ten years, demersal resources catches have decreased by 20% while small pelagics as a whole do not show any particular trend, although the increase of round sardinella should be noted. According to recent assessments the most important demersal species: hake, red mullets and some valuable crustaceans appear to be overexploited. Bluefin tuna fishing and farming are nowadays the most conflicting activities in Mediterranean fisheries.

Keywords: Status and trend Mediterranean and Black Sea fisheries.

RESUME – *"État des lieux des ressources halieutiques en Méditerranée et dans la mer Noire". La situation et les tendances des ressources halieutiques en Méditerranée et dans la mer Noire sont passées en revue. Dans la Mer Noire, les stocks de petits pélagiques ont plus d'importance que les populations démersales, et leur histoire se caractérise par l'essor et le déclin des petits pélagiques, principalement l'anchois, entre 1980 et 1990. En Méditerranée, les populations démersales prédominent dans les captures bien que les petits pélagiques soient également très importants. Sur les dix dernières années, les prises de poissons démersaux ont diminué de 20% tandis que les petits pélagiques dans leur ensemble ne montrent pas de tendance particulière, mis à part l'augmentation de l'allache. Selon des évaluations récentes, les espèces démersales les plus importantes : merlu, rougets et quelques crustacés de valeur, semblent être surexploitées. La pêche et l'élevage du thon rouge sont actuellement les activités les plus conflictuelles en matière de pêches méditerranéennes.*

Mots-clés : *Situation et tendances des pêcheries de la Méditerranée et de la mer Noire.*

Introduction

The surface of the Mediterranean and Black Sea contribute a 0.8% to the total world marine surface, however the fishing in 2005 corresponds to 1.5% of the world marine catch.

The Mediterranean and the Black Sea are very different entities from an environmental point of view. The Black Sea is characterized by a positive water balance, that is, the amount of water supplied by rivers and precipitation is greater than the evaporation, therefore it has to export water to the Mediterranean through the Bosphorus and the Dardanelles. The Black Sea water has a low salinity (between 18 and 18.5) and is anoxic at depths below 200 m. The Mediterranean, however, is a water deficitary sea which has to incorporate water from the Atlantic and the Black Sea. Its salinity is high (mean around 39), higher in the eastern basin and lower in the western. At present, the Black Sea and the Mediterranean are considered as two independent LMEs (Large Marine Ecosystems), justified for environmental causes. These differences have consequences on the fisheries, the Black Sea being more productive than the Mediterranean. In 2005 the volume of captures from the Black Sea reached 35% of those in the Mediterranean, even though its surface area does not surpass 20%.

The continental shelf is the area between the coastline and 200 m depth and where most fishing activity is concentrated, with exclusion of the large pelagic fisheries. It is relatively narrow and only the Adriatic, the Gulf of Lions, the Gulf of Gabes and the north of the Black Sea have large continental shelves.

There are no EEZs in the Mediterranean, but only jurisdictional waters, limited by 12 nautical miles,

in the majority of countries, and some fishery protection areas, therefore, most of the Mediterranean surface corresponds to international waters, or high seas. On the contrary, in the the Black Sea, EEZs have been established, limited by equidistant lines, as there is not enough space for 200 miles, therefore there are no international waters in the Black Sea.

Status of the resources

Nominal catches in FAO Area 37 (Mediterranean and Black Sea) (FAO, 2007) increased from slightly over 0.7 million tonnes in 1950, to near 2 million tonnes between 1982 and 1988. Catches declined steeply to 1.3 million tonnes as a result of the collapse of the sprat and anchovy fishery in the Black Sea. Total catches have subsequently increased to around 1.5 million tonnes in 2005 after some small fluctuations, 75% correspond to the Mediterranean and 25% to the Black Sea (Fig. 1).

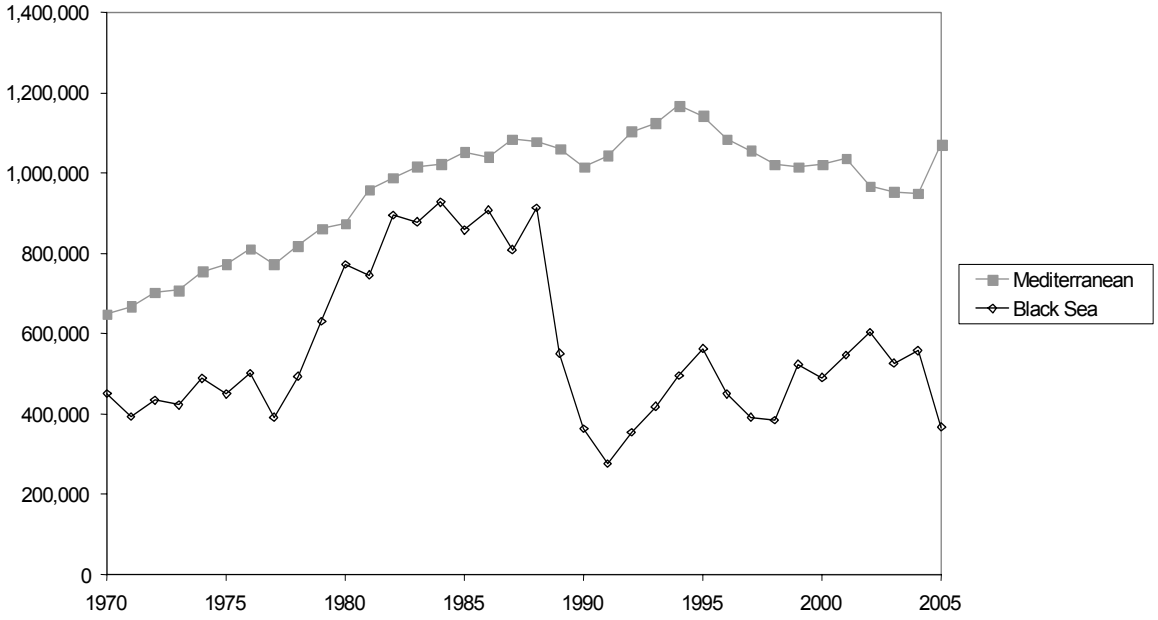

Fig. 1. Total catches (tonnes) in the Mediterranean and the Black Seas (FAO, 2007).

Drastic ecological changes have occurred in the Black Sea from the introduction, through ship ballast water, of *Mnemiopsis leidyi*, a ctenophore predator on larvae of anchovy and sprat. This species was largely responsible for the collapse of the small pelagics (Zaitsev and Öztürk, 2001) and, consequently, their predators. More recently another species of ctenophore (*Beroe cucumis* or *B. ovata,* depending on the sources), a predator on *M. leidyi*, has been reported in the Black Sea. This makes the history of the captures in the Mediterranean and the Black Sea very different. The small pelagics of the Black Sea presented an increase in captures that began in the 1980s, reaching 700,000 tonnes, which then collapsed, due to the cause mentioned, at the end of the decade bringing the captures down to little more than 100,000. Subsequently the captures increased, but without reaching the previous levels.

In the Mediterranean, however, the trend of the small pelagics captures remains stable from 1980 onwards at little more than 400,000 tonnes. The demersals presented a sustained increase of reported captures, up to a maximum of 600,000 tonnes in 1995, which later decreased to 450,000 in 2005. A growing number of Red Sea species are entering the eastern Mediterranean through the Suez Canal (Lessepsian migrants), and subsequently moving northwards and westwards.

The fisheries of the Mediterranean have shown a surprising resilience to fishing compared with some areas of the Atlantic. This is especially noteworthy since formal and coordinated measures for

fisheries management are largely absent in most Mediterranean countries, though more frequent activities and a revision of the terms of reference of the GFCM (General Fisheries Commission for the Mediterranean) and its Scientific Advisory Committee (SAC) is intended to remedy this from 2000. Caddy (1990), Farrugio *et al.* (1993), Farrugio (1996), Anonymous (2001), CIHEAM (2003), Oliver (2003), Lleonart and Maynou (2003), Lleonart (2004, 2005) and Bas (2006) among others, have reviewed Mediterranean fisheries.

Historical data on annual catch per country, species, and geographical zone are available in FAO (2007). Those data cover the period 1970-2005, include 242 species or groups of species, and four subareas (Western, Central, Eastern Mediterranean and Black Sea) split into ten divisions or "seas". The reliability of those data series in the Mediterranean is variable, the catch reported under groups of taxonomic level above family (as osteychthyes, mollusca or natantia) represents about 8% of the total catch with a slight decreasing trend. Data on effort are only present for some limited areas and periods. Given the complexity and diversity of Mediterranean fisheries the available data is probably not sufficient for regular and trustworthy assessments for most species. The very structure of Mediterranean fisheries (atomized fleets, a huge number of landing points, multi-species catches and the lack of large industries as it exists in other seas) makes it difficult and expensive to obtain data for stock assessment purposes.

The biological parameters of the main target species (hake, anchovy, sardine, red mullets, some sparids and flatfish, bluefin tuna, swordfish, some high priced crustaceans) are quite well known. However most of this knowledge has been obtained by specific scientific projects, without continuity in time. It is difficult to maintain and update series of biological data, size frequency distributions, etc. without long-term monitoring projects.

Assessment suffers from the same shortcomings, few formal stock and fisheries assessments have been carried out in the Mediterranean, largely because most of the stocks are not shared between countries. As consequence there is no pressure for assessing the resources and no adaptive management has been implemented. With the exception of large pelagics and some local fisheries (as striped venus, *Chamelea gallina*, in the Adriatic) fishery management does not involve TACs or quotas but is mainly based on effort limitation or other regulations on the activity or gears. From 2000 assessments are annually submitted to the Subcommittee on Stock Assessment (SCSA) of the GFCM[1].

A total of 42 species has been defined as "priority species" by the GFCM. Most of them correspond to the species with higher catches, but others are on the list for the economic value.

The Azov and Black Seas

The captures in the Black and the Azov Sea reached little more than 350 000 tonnes in 2005, of which, 63% corresponded to small pelagics, whilst the demersals reached only 25% (Fig. 2). The small pelagics are mainly anchovy (*Engraulis encrasicolus*), sprat (*Sprattus sprattus*) and Black Sea sprat (*Clupeonella cultriventris*), (Fig. 3) the latter very significant in the Azov sea but not included in the list of priority species of the GFCM.

Top Black Sea predators such as dolphins have seriously declined in abundance. Predatory fish, including mackerel (*Scomber scombrus*) and blue fish (*Pomatomus saltatrix*) which used to seasonally enter from the Sea of Marmara (also subject to heavy pollution and fishing), now rarely penetrate into the waters to the north and west of the Black Sea. Stocks of these species can be considered depleted, although not necessarily by fishing alone.

Anchovy (*Engraulis encrasicolus*)

The single largest resource in the Black Sea, its biomass increased in the late 1970s and early 1980s at a time when catches were also increasing, reaching more than half a million tonnes in 1984 and 1988. It collapsed in the late 1980s largely due to predation and feeding competition with the

[1] All the documents about assessments are available from http://www.icm.csic.es/rec/projectes/scsa/

ctenophore *Mnemiopsis leydei*. Effort subsequently decreased, allowing the species to recover somewhat but anchovy biomass and catches have not reached the previous values.

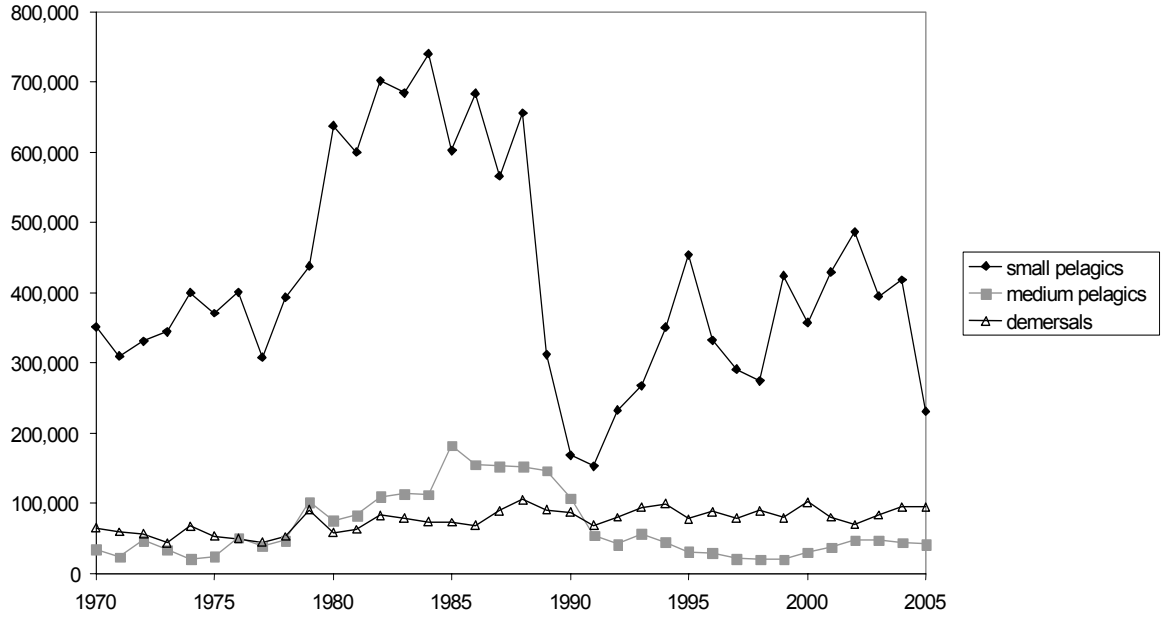

Fig. 2. Captures in the Black Sea (tonnes).

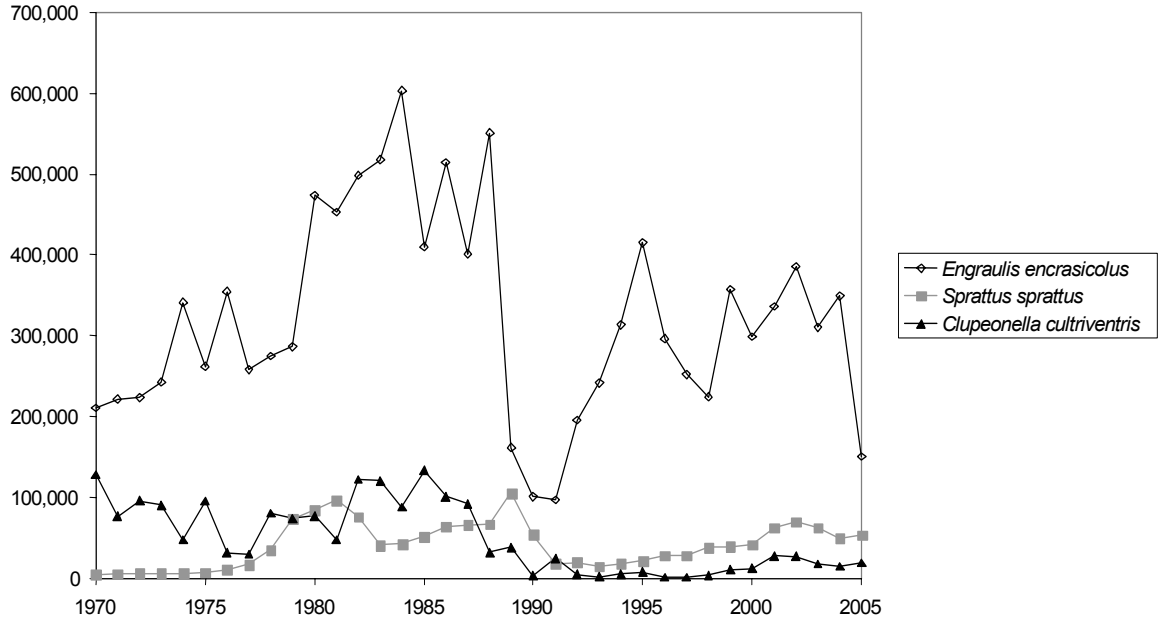

Fig. 3. Captures of small pelagics in the Black Sea (tonnes).

Sprat (*Sprattus sprattus*)

Almost all sprat catches reported to FAO comes from the Black Sea. After reaching 100,000 tonnes in late 80s this species also collapsed with anchovy and for the same reasons. By 2005 the catches are about 50,000 tonnes.

Black Sea sprat (*Clupeonella cultriventris*)

This species was very important in Azov Sea, with reported catches higher than 100,000 annual tonnes, but it collapsed in 1990, also due to *Mnemiopsis leidyi* and has not recovered. The catch in 2005 was less than 20,000 tonnes.

Medium sized pelagics

All pelagic species, particularly the most abundant medium sized: Atlantic horse mackerel (*Trachurus trachurus*), suffered from the same *Mnemiopsis* plague. Other important species, Mediterranean horse mackerel (*Trachurus mediterraneus*) and bluefish (*Pomatomus saltatrix*), present more stable catches (Fig. 4).

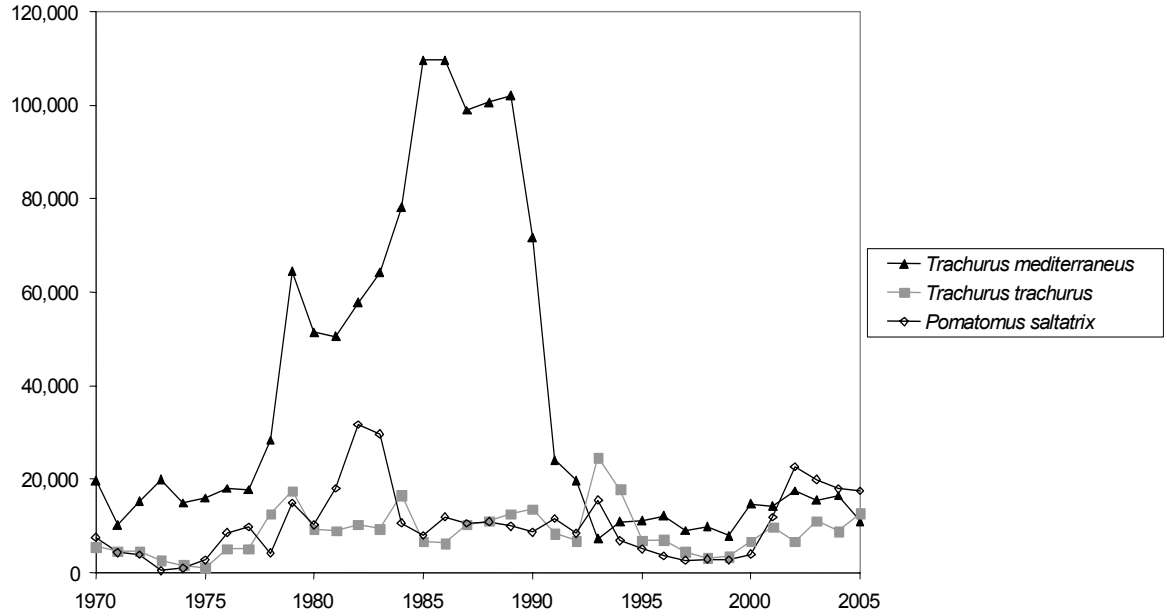

Fig. 4. Captures of medium-sized pelagics in the Black Sea (tonnes).

Whiting (*Merlangius merlangus*)

A main predator on Black Sea sprat, this species has been affected by the decline in sprat stocks. Whiting is largely taken as a bycatch to the sprat stock which is heavily exploited, with consequences in reducing the stock size of this predator.

Other demersals

According to Öztürk and Karakulak (2003) demersal fisheries continue to represent an important economic activity having a very significant impact on the coastal population and on marine ecosystems. Despite the problems of over-fishing, degradation of vital habitats, the demersal resources still have potential for recovery. The most important species besides whiting, are bivalves (*Chamelea gallina* and *Mytilus galloprovincialis*), turbot (*Psetta maxima maeotica*), blue whiting (*Micromesistius poutassou*), red mullet (*Mullus barbatus*), dogfish (*Squalus acanthias*), *Raja clavata*, and mullets (mugilidae) (Fig. 5). Most of them have declining catches in recent years. Cephalopodes are not found in the Black Sea because they cannot live in low salinity environments.

Sturgeons

For the most common species: *Acipenser gueldenstaedtii*, *Acipenser stellatus* and *Huso huso*,

figures show a decreasing trend during the last years (with different oscillations and slopes for different species and countries). *Acipenser sturio* and *Acipenser nudiventris* have almost disappeared. *A. sturio* and *A. brevirostrum* are in the CITES appendix I (threatened with extinction), the rest of Acipenseridae in appendix II (may become threatened with extinction unless trade is closely controlled) *A. guendelstaedtii*, *A. nudiventris, A. persicus, A. stellatus, A. sturio* and *Huso huso* are included in the IUCN Red List.

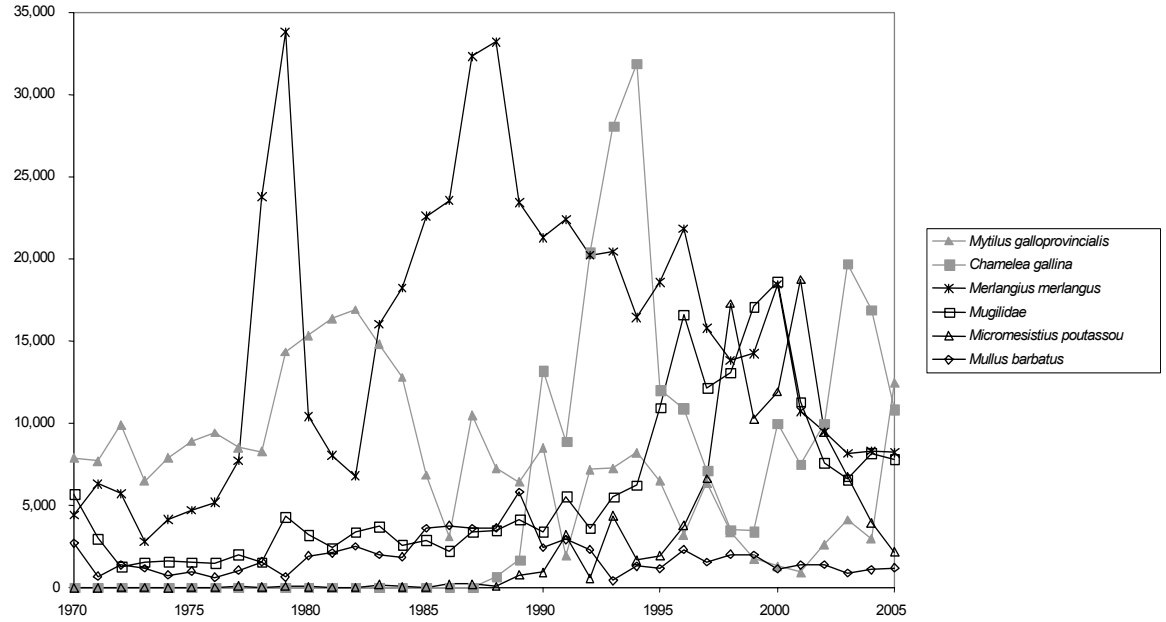

Fig. 5. Captures of demersals in the Black Sea (tonnes).

The Mediterranean

In 2005 the Mediterranean catches (excluding the Black Sea region) were slightly more than one million tonnes. The historical maximum was reached in 1994 with almost 1.2 million tonnes. The small pelagic species account for 35% of the reported catch, while the demersals are 37% (or 44% if we consider "Osteichthyes" as demersals) (Fig. 6).

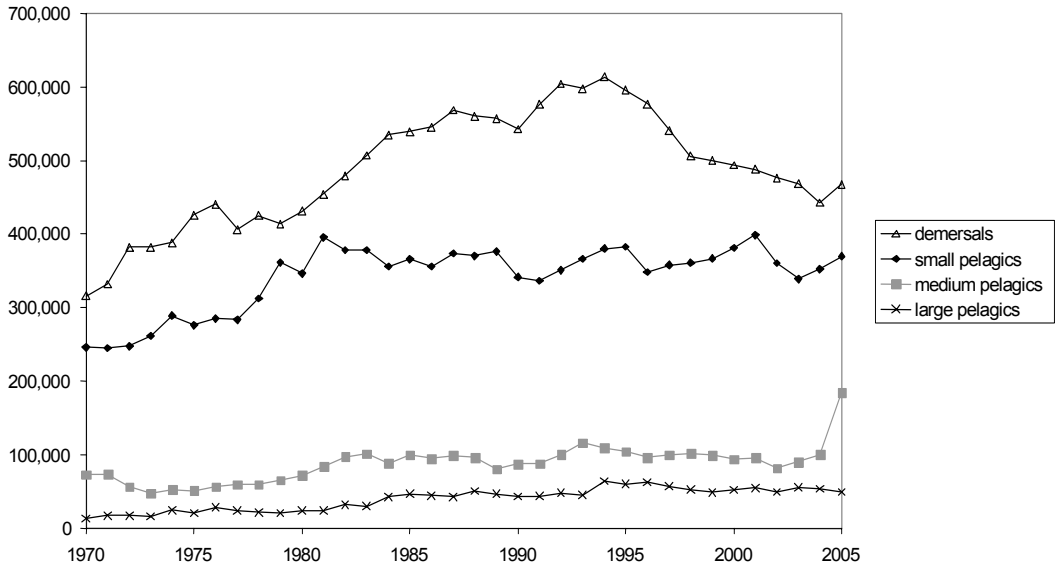

Fig. 6. Captures in the Mediterranean Sea (tonnes).

Small pelagics

Small pelagic species are mainly sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*) and round sardinella (*Sardinella aurita*) (Fig. 7). They are fished with purse seine (with or without light) and pelagic trawl. In some countries (i.e. Greece, Spain) pelagic trawl is forbidden.

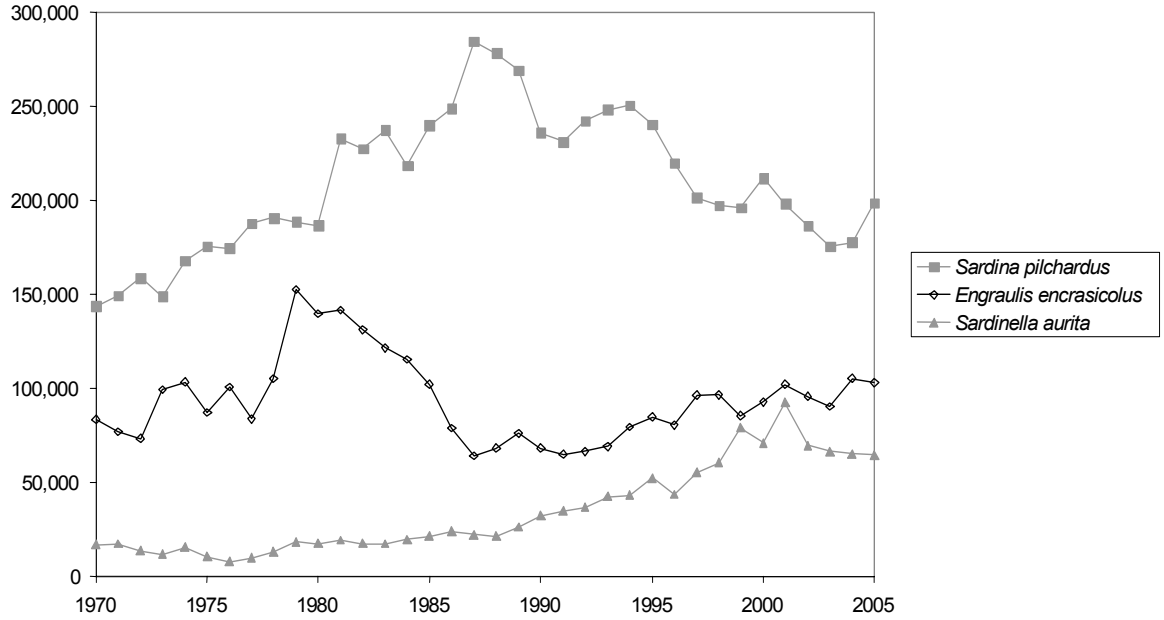

Fig. 7. Captures of small pelagics in the Mediterranean (tonnes).

*Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*)*

Monitoring of sardine and anchovy stocks over more than a decade in areas such as the Alboran Sea and North-western area, Adriatic and Aegean, has been done based on acoustic surveys. Daily Egg Production Methods (DEPM) have been used in the Mediterranean several times but they are not employed routinely on a year by year basis. These methods have been applied mainly to anchovy but also to the sardine in some instances.

The pattern of fluctuations is not obviously related to fishing intensity. In the Adriatic, anchovy catches peaked in 1980 and subsequently declined while local sardine stocks peaked in the mid 1980s. Anchovy stock biomass increased from 18,000 tonnes in 1989 to about 340,000 tonnes in 1991 which is, however, lower than earlier stock sizes in the 1970s and 1980s. The availability of long data series in the Adriatic has allowed VPA (Virtual Population Analyses) to be performed to assess sardine and anchovy (Cingolani *et al.*, 2005a; Cingolani *et al.*, 2005b; Santojanni *et al.,* 2005). Such analyses, tuned with acoustic biomass estimations, have shown a dramatic decrease of the stock of sardine, which seems opposed to the more optimistic results of some acoustic surveys (Tičina *et al.,* 2005).

In the Alboran Sea catches peaked in 1982 with 27,878 tonnes to subsequently decline to 1016 tonnes in 1988 (Abad and Giráldez, 1990). In the Gulf of Lions and northern part of Spain catches increased in 1989, probably because fleets moved from the southern part of Spain, where the anchovy catch had fallen off.

In the Aegean, as for most resources, mean catch rates for small pelagics declined until the mid-1970s before stabilizing, while total catches, especially in the eastern Mediterranean, have continued to increase, suggesting increasing productivity of formerly very low-nutrient waters. This suggestion gains credibility from the parallel increase in phytoplankton and zooplankton abundance as well as acoustic estimates of small pelagic biomass along a line from the northern Aegean to the south-eastern Mediterranean Sea (Stergiou *et al.*, 1997b). Pelagic biomasses are also generally low in Libyan waters (GFCM, 1995) except for a local seasonal upwelling in the Gulf of Sirte. In Tunisian

waters, some 40% of the sardine stock is estimated to be exploited annually, probably above optimum, and sardine and anchovy biomasses tend to fluctuate out of phase with one another.

The Subcommittee on Stock Assessment, of the GFCM, has expressed concern about the danger of recruitment overexploitation on anchovy in many Mediterranean areas due to the significant catch of immature specimens and claimed for an increase of the minimum legal size to, at least, that of first maturity (11-12 cm).

On the other hand the dependence of small pelagic stocks on river runoff has been demonstrated.

*Round sardinella (*Sardinella aurita*)*

A sharp decline in sardinella catches of the Levant region was observed following construction of the Aswan dam (Halim *et al.*, 1995). The recovery of pelagic production off the Nile delta following the decline mentioned above seems to be largely of *Sardinella* spp., the dominant small pelagic fish in the south-eastern Mediterranean. *Sardinella* show a clear increasing trend in the catches. Sabatés *et al.* (2006) found a positive correlation between *Sardinella aurita* landings and the temperature anomalies in the Western Mediterranean confirming the empiric observations indicating an increase of such a tropical species likely related to global warming.

Medium pelagics

The medium pelagics are mainly mackerels (*Trachurus* spp.), horse mackerels (*Scomber* spp.) and bonito (*Sarda sarda*) (Fig. 8).

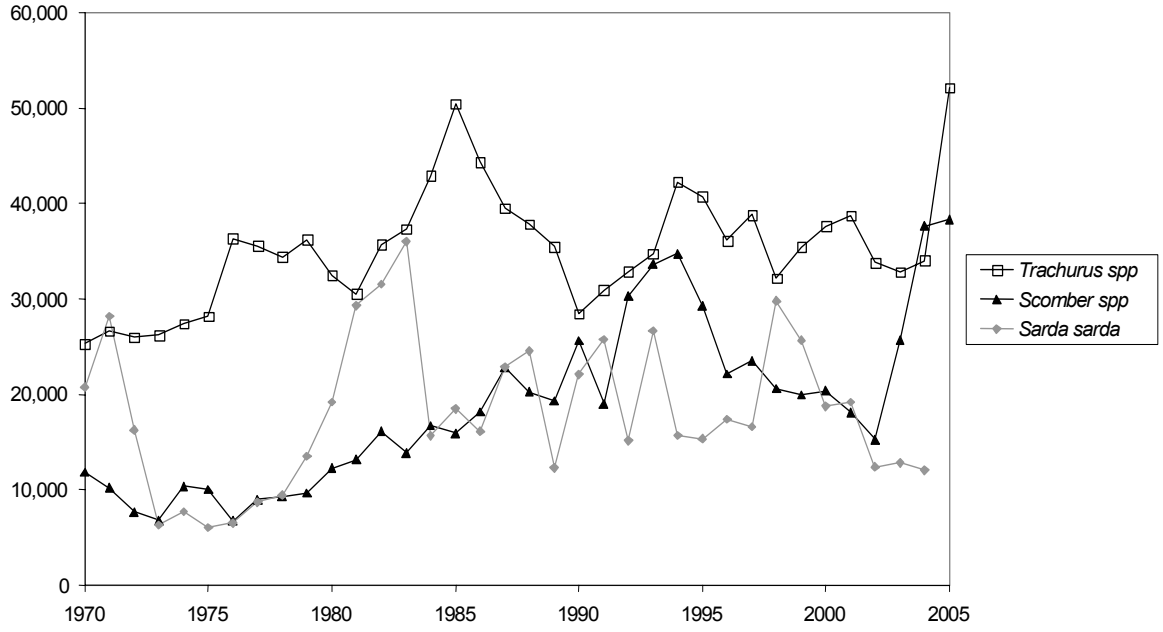

Fig. 8. Captures of medium-sized pelagics in the Mediterranean (tonnes).

*Mackerels (*Scomber *spp.), and jack and horse mackerels (*Trachurus *spp.)*

These medium sized pelagic species show high variability in catches. No specific assessments have been carried out on these species, however an increasing trend appears in the reported landings in the Mediterranean.

Large pelagics

Regarding large pelagics, although its percentage in the statistics is low, their economic as well the ecologic impacts is of paramount importance in the Mediterranean. Large pelagics are highly migratory and include tuna and tuna like species and pelagic sharks (Maguire *et al*., 2006). The main large pelagic species are tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*) and albacore (*Thunnus alalunga*). Due to the recent increase of fishing pressure on bluefin tuna, and subsequent socio-economic effects, probably the catch data of last years are underestimated (Fig. 9).

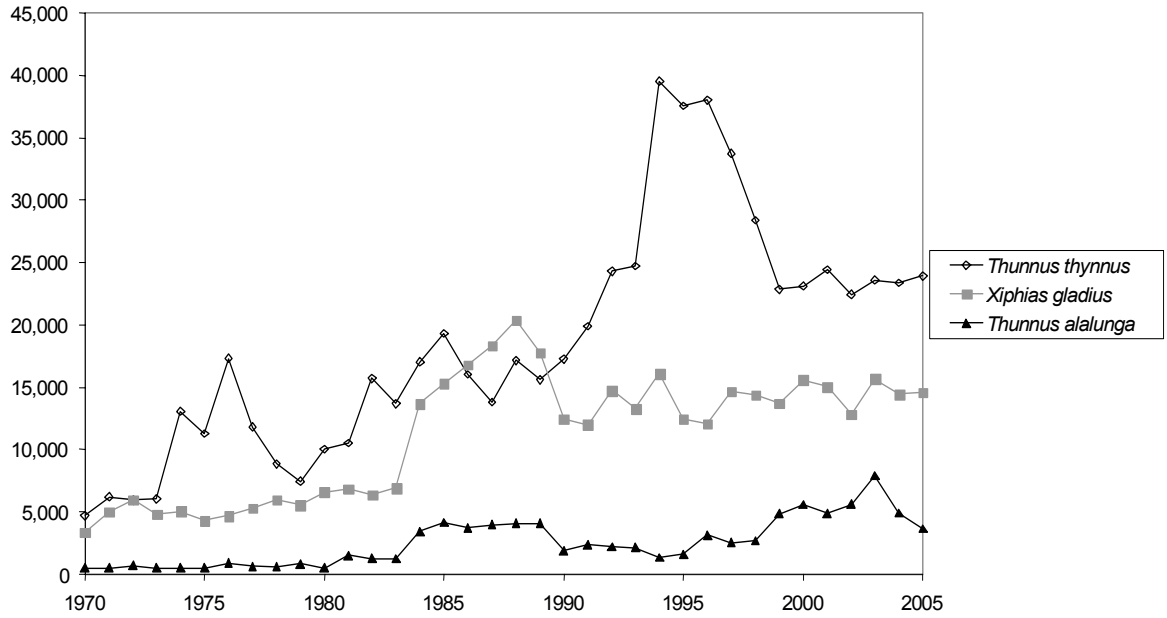

Fig. 9. Captures of large pelagics in the Mediterranean Sea (tonnes).

*Bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*)*

Bluefin tuna and swordfish are the most important large pelagic species in the Mediterranean. They represent around 3% of the total reported catches, but their economic importance is far greater. ICCAT (International Commission for the Conservation of Atlantic Tunas) considers a single stock of bluefin tuna for the Eastern Atlantic and the Mediterranean, and the Mediterranean holds the main spawning area. Longlines and seines exploiting bluefin tuna represent the only real industrial fleet in the Mediterranean. Driftnets have been banned by ICCAT and GFCM since 2005. Bluefin tuna reached a landing of almost 40,000 tonnes in 1994, the value has declined to around 23,000 tonnes in 2005, however due to the expanding tuna ranching activities, these figures are doubtful. Concern has rightly been expressed about the status of both species. In both cases the (apparently unrestrained) growth of fisheries over the last decade has increased vulnerability of these stocks as has regular fishing by non-coastal States on bluefin stocks. Recently the number of coastal cages to fatten the bluefin tuna caught in the open sea in order to increase quality and to make the market independent of the catch season has increased substantially. They are also believed to increase the fishing pressure, by opening new markets and because all catches may not be reported. These activities have an effect on many aspects of the assessment-management process as data collection and consequently the stock assessment. They have actual effects (statistical, biological, management) as well as potential ones (environmental, socio-economical, management).

Swordfish is the second large pelagic species in importance. ICCAT considers the existence of a distinct single Mediterranean stock. Swordfish is fished with longlines and illegal driftnets. Catches of swordfish have stabilized around 15,000 tonnes in the last 15 years. The high exploitation rate is also reflected in progressive decreases in mean size and mean age at capture.

*Bonito (*Sarda sarda*) and albacore (*Thunnus alalunga*)*

Fisheries for these species have not been specifically assessed, but there is indirect evidence that bonito has decreased its range. Bonito show no long-term trends (the value of 2005 could be an outlier) but a high variability in catches. Albacore catches have increased from 1980 showing fluctuations.

Demersals

Mixed bottom fisheries use small mesh trawls, gillnets, trammel nets, traps, pots and dredges capture a large suite of demersal (although some of them show a pelagic behaviour) fish and invertebrates (around 150) of high value for the fresh fish market, with no single species making up more than 10% of the total. Trawl is however the most important gear for demersal fisheries. Small mesh cod-end (40 mm is the minimum legal size in EU) is being used, targeting to immature 0+ to 2 year-old age groups of many species. In those areas where trawl fleets operate regularly, despite the inherent complexity of multispecies catches, there is an identifiable series of target species which in biomass or in economic terms, constitute an important basis of production. These species are hake (*Merluccius merluccius),* bogue (*Boops boops*)*,* deep-water rose shrimp (*Parapenaeus longirostris*)*,* striped venus (*Chamelea gallina*)*,* red mullets (*Mullus barbatus* and *Mullus surmuletus*)*,* grey mullets (mugilidae), Mediterranean mussel (*Mytilus galloprovincialis*)*,* octopuses (*Octopus vulgaris* and other species) and cuttlefishes (*Sepia offininalis* and other Sepiidae and Sepiolidae), blue whiting (*Micromesistius poutassou*), anglerfishes (*Lophius* spp.), *Pagellus* spp., picarels (*Spicara* spp.) red shrimp (*Aristeus antennatus*) and Norway lobster (*Nephrops norvegicus*). But there are also many other local and/or well priced species caught in relatively small quantities like some species of flatfishes, Scorpaenidae, Sparidae, Triglidae, Mugilidae, Serranidae, and some invertebrates. The whiting (*Merlangius merlangus*), only present in the Eastern Mediterranean, also shows this general pattern with maximum around 1990 (Fig. 10).

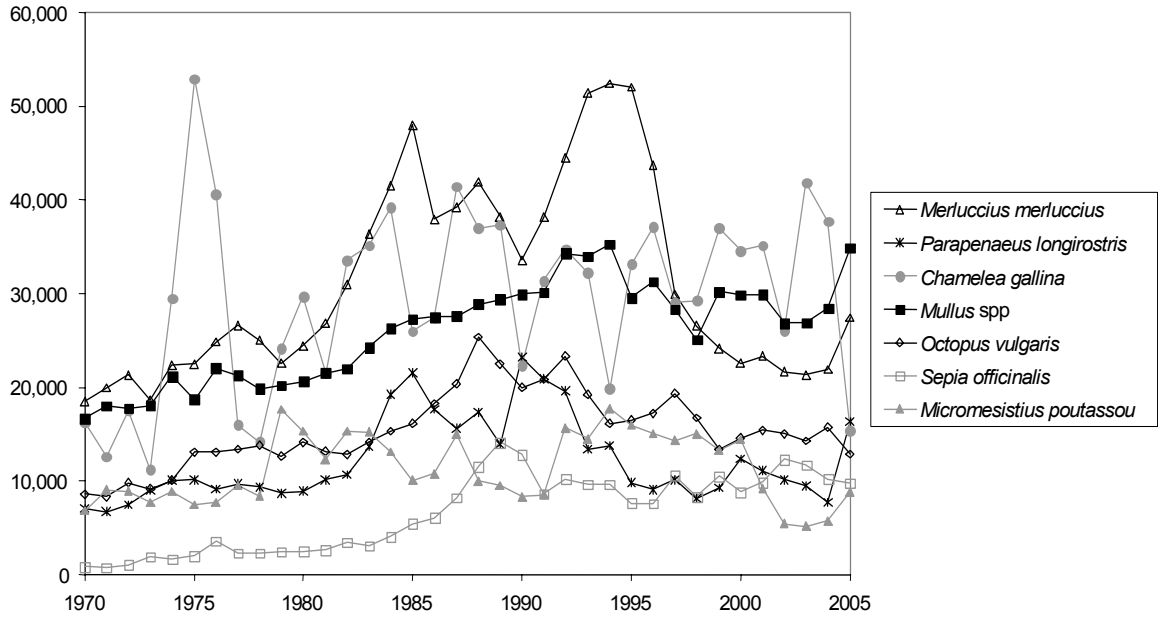

Fig. 10. Captures of demersals in the Mediterranean Sea (tonnes).

*European hake (*Merluccius merluccius*)*

This is the most widely studied species and a main target species for many trawl (with small mesh aimed at juveniles), longline and gillnet fleets, operating over rocky bottom or further offshore for larger individuals. Hake catches in the Mediterranean are around 25,000 tonnes, but the statistics are

dominated by the Italian catch in the Ionian sea in the period 1983-1997 with values comprised between 15,000 and 30,000 tonnes, while before and after that period and in all other Mediterranean seas the catches do not exceed 10,000 tonnes. Most hake caught in the Mediterranean is sexually immature. Hake first spawn at 35 cm of total length. In any case, the assessments presented at the Subcommittee on Stock Assessment of the GFCM demonstrate a clear overexploitation of this species. Elucidating the relative importance of increased escapement of juveniles and spawners remains an important focus for this and other Mediterranean demersal species, especially if the introduction of nursery areas and marine parks is to be considered.

*Striped (*Mullus surmuletus*) and red (*Mullus barbatus*) mullets*

These species are caught by trawlers and a various other small scale fishing vessels with a range of gears practically in all Mediterranean areas. The two species live in different habitats, in sandy bottoms the red mullet and in rocky bottoms the striped mullet. The fishery begins in age group 0 and in many areas the small individuals (caught in summer and early autumn) reach higher prices.

Catches of *Mullus barbatus* are around 20,000 tonnes with a decreasing trend the last years. According to the assessments, for Ligurian, Northern Tyrrhenian and Western Mediterranean the species appears to be fully exploited or overexploited. Seasonal and area closures were recommended in order to protect juveniles. Catches of *Mullus surmuletus* are stabilized around 10,000 tonnes.

Sparids, seabreams and pandoras

Sparids and sea breams play an important role in Mediterranean demersal fisheries and are generally heavily exploited. A high proportion of production of this *Sparus aurata* now comes from aquaculture. Pandoras (*Pagellus* spp.), as for groupers, appear to be one of the demersal species least resistant to heavy exploitation, and catch rates have declined in a number of areas.

Cephalopods

These are important incidental catches in trawl fisheries and there is a directed fishery for common and horned octopus (*Octopus vulgaris* and *Eledone cirrosa*) in some areas. A high proportion of short-lived species (squids, cuttlefish and octopus) in demersal catches from heavily fished areas such as the Adriatic tends to suggest that exploitation is high, where low catch rates are in part compensated by high unit prices.

*Grey mullets (*Mugilidae*)*

They are principally plant and detritus feeders and have presumably found favourable conditions in eutrophic estuaries. A move to the exploitation of small inshore fish such as silversides (Atherinidae) reflects the search for alternatives to heavily exploited nearshore resources.

Norway lobster

This is a quite well studied species. In 1998 a monographic volume on this species (Sardà, 1998) was published. This volume focuses on biological knowledge of the species including fisheries and exploitation, distribution, population dynamics and selectivity. The assessments presented to GFCM concluded that this species is slightly overexploited or fully exploited, technical improvement of the gear to avoid the capture of small individuals was recommended. The known behavioural characteristics of this species (large periods of time inside the burrows, from which it emerges periodically giving rise to diurnal and seasonal fluctuations in the catches) makes it less vulnerable than other species to the fishing pressure. Notwithstanding patchiness in population structure and density dependence phenomena could be related with cases of "local" stocks or "stocklet" overexploitation. Due to the burrowing behaviour it was considered important to reduce the impact of the otter trawl doors on the bottom to protect the burrows.

*Red shrimp (*Aristeus antennatus*)*

This high priced species is intensely exploited in the Western Mediterranean by bottom trawlers

fishing the continental slope together up to 800 m depth with significant catches of giant red shrimp (*Aristeomorpha foliacea*). The two species are probably not always well separated in the statistics, suggesting total catches of around 5000 tonnes a year. According to the assessments presented to the GFCM, the red shrimp appears to be overfished in the Western Mediterranean and a reduction of effort is recommended.

References

Abad, R. and Giráldez, A. (1990). *Descripción de la pesca de cerco en la región surmediterránea*. Informes Técnicos del Instituto Español de Oceanografía, No. 86. IEO, Madrid, 48 p.

Anonymous (2001). *Towards holistic fisheries management: A Mediterranean perspective*. Report of a workshop held in Heraklion, Crete (Greece), March 2001, under the auspices of the European Union. Accompanying Measures Programme, Contract Q5AM–2000–00002. 22 pp.

Bas, C. (2006). *The Mediterranean sea: Living resources and exploitation.* CIHEAM/IAMZ and FAO-COPEMED, Zaragoza, Spain, 509 p.

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

CIHEAM, International Centre for Advanced Mediterranean Agronomic Studies (2003). *Development and agri-food policies in the Mediterranean region, CIHEAM Annual Report 2002*. English version of the report available from: http://ressources.ciheam.org/fr/ressources/report2002.htm. French version of the report available from: http://ressources.ciheam.org/fr/ressources/rapport2002.htm.

Cingolani, N., Santojanni, A., Arneri, E., Berlardinelli, A., Colella, S., Donato, F., Giannetti, G., Sinovcic, G., Zorica, B. and Marceta, B. (2005a). *Sardine (*Sardina pilchardus*, Walb.) stock assessment in the Adriatic Sea: 1975-2004*. General Fisheries Commission for the Mediterranean (GFCM), Scientific Advisory Committee (SAC) Subcommittee on Stock Assessment (SCSA) - Rome, 26-30 September 2005.
Available from http://www.icm.csic.es/rec/projectes/scsa/Subcommittee_2005/Papers/

Cingolani, N., Santojanni, A., Arneri, E., Berlardinelli, A., Colella, S., Donato, F., Giannetti, G. Sinovcic, G., Zorica, B. and Marceta, B. (2005b). *Anchovy* (Engraulis encrasicolus, *L*.) *stock assessment in the Adriatic Sea: 1975-2004*. General Fisheries Commission for the Mediterranean (GFCM). Scientific Advisory Committee (SAC) Subcommittee on Stock Assessment (SCSA) - Rome, 26-30 September 2005. El original puede ser descargado de http://www.icm.csic.es/rec/projectes/scsa/Subcommittee_2005/Papers/

FAO (2007). *Yearbook of Fishery Statistics – Capture Production 2005*. FAO, Rome, vol. 100/1, 539p. data downloadable from http://www.fao.org/fi/statist/FISOFT/FISHPLUS.asp

Farrugio, H. (1996). *Mediterranean fisheries status and management. Evolution of the research and improvement of regional cooperation*. Diplomatic Conference on Fisheries Management in the Mediterranean, Venice, November 1996. 18 pp.

Farrugio, H., Oliver, P. and Biagi, F. (1993). An overview of the history, knowledge, recent and future research trends in Mediterranean fisheries. In: Lleonart, J. (ed.), Northwestern Mediterranean Fisheries. *Sci. Mar*., 57: 105-119.

GFCM (1995). *Report of the third technical consultation on stock assessment in the central Mediterranean*, Tunis (Tunisia), 8-12 November 1994, 19 p.

Halim, Y., Morcos, S.A., Rizkalla, S. and El-Sayed, M.Kh. (1995). The impact of the Nile and the Suez Canal on the living marine resources of the Egyptian Mediterranean waters (1958-1986). *FAO Fisheries Technical Paper,* No. 349: 19-58.

Lleonart, J. and Maynou, F. (2003). Fish stock assessment in the Mediterranean, state of the art. *Sci. Mar*., 67 (suppl. 1): 37-49.

Lleonart, J. (2004). A review of Mediterranean shared stocks, assessment and management. In: *Management of Shared Fish Stocks,* Payne, A.I.L., O'Brien, C.M. and Rogers, S.I. (eds). Blackwell, Oxford, pp. 113-130.

Lleonart, J. (2005). B5 – Mediterranean and Black Sea, FAO statistical area 37 (table D5). In: FAO Marine Resources Service, Fishery Resources Division, Review of the state of the world marine fishery resources. *FAO Fisheries Technical Paper*, No. 457. FAO, Rome, pp. 49-64 and 220-221. 235 p.

Maguire, J.-J., Sissenwine, M., Csirke, J., Grainger, R. and García, S. (2006). The state of world highly migratory, straddling and other high seas fishery resources and associated species. *FAO Fisheries Technical Paper*, No. 495. FAO, Rome, 84 p.

Oliver, P. (2003). Mediterranean Fisheries. In: *Development and agri-food policies in the Mediterranean region, CIHEAM Annual Report 2002*, Part III, pp. 151-214. English version of the report available from: http://ressources.ciheam.org/fr/ressources/report2002.htm. French version of the report available from: http://ressources.ciheam.org/fr/ressources/rapport2002.htm.

Öztürk, B. and Karakulak, F.S. (eds) (2003). *Workshop on demersal resources in the Black Sea & Azov Sea*. Publication No. 14. Turkish Marine Research Foundation, Istanbul, Turkey, 129 p.

Sabatés, A., Martin, P., Lloret, J. and Raya, V. (2006). Sea warming and fish distribution: The case of small pelagic fish, Sardinella aurita, in the western Mediterranean. *Global Change Biology*, 12: 2209-2219.

Santojanni, A., Cingolani, N., Arneri, E., Kirkwood, G., Belardinelli, A., Giannetti, G., Colella, S., Donato, F. and Barry, C. (2005). Stock assessment of sardine (*Sardina pilchardus*, WALB.) in the Adriatic Sea with an estimate of discards. *Sci. Mar.*, 69(4): 603-617.

Sardà, F. (ed.) (1998). *Nephrops norvegicus*: comparative biology and fishery in the Mediterranean sea. *Sci. Mar.*, 62 (supl. 1): 143.

Stergiou, K.I., Christou, E.D., Georgopoulos, D., Zenetos, A. and Souvermezoglou, C. (1997). The Hellenic Seas: Physics, chemistry, biology and fisheries. *Oceanog. Mar. Biol. Ann. Rev.*, 35: 15-538.

Tičina, V., Katavić, I., Dadić, V., Grubišić, L., Franičević, M. and Emrić Tičina, V. (2005). *Acoustic estimates of small pelagic fish stocks in the eastern part of the Adriatic Sea: September 2004*. General Fisheries Commission for the Mediterranean (GFCM), Scientific Advisory Committee (SAC), Subcommittee on Stock Assessment (SCSA), Rome, 26-30 September 2005. Available from: http://www.icm.csic.es/rec/projectes/scsa/Subcommittee_2005/Papers/

Zaitsev, Yu. and Öztürk, B. (eds) (2001). *Exotic Species in the Aegean, Marmara, Black, Azov and Caspian Seas*. Publication No. 8. Turkish Marine Research Foundation, Istanbul, Turkey, 267 p.