INTRODUCTION

After a long period of adaptation starting 450 million years ago, since the Cretaceous (about 100 million years) the cartilaginous fish have not experienced any further noticeable morphological or physiological changes. Today the group occupies almost all aquatic environments: rivers, lakes, estuaries, coastal lagoons, coastal waters, open seas and deep seas, extending as far as the Antarctic convergence. This may be facilitated by the fact that sharks are mostly predators, and have adapted to all sort of diets, some being scavengers. The few species that are plankton-feeders are characterized by large dimensions, which discourages predation.

This guide provides a list and brief description of the species of sharks, batoid fishes and chimaeras living in the Mediterranean and Black Sea. While for some species there are no doubts regarding their presence in the area, for other rare species, their presence remains doubtful pending further information.

Commercial fishing samples constitute the main source of cartilaginous specimens, in particular, for rare species. Some species, once considered rare, may become common due to the increased use of a particular gear or during fishing on new grounds.

Fishing may produce negative effects on biodiversity: overexploitation of resources may directly or indirectly lead to the depletion of some species, especially those that do not have a good resilience as regards to fishing disturbance, such as the cartilaginous fish. In these cases it is quite frequent to observe the disappearance, albeit locally, of some species.

One major problem using official landing statistics in any analysis is the difficulty to secure correct identification of the species of cartilaginous fish, as they are often grouped in collective codes. Apart from spotted dog sharks, thorn rays and a few other species, caught as bycatch, a targeted fishery aiming at catching cartilaginous species does not exist in the Mediterranean and Black Sea, and for the time being, finning is not mentioned either. In trawl fisheries discard may be a critical aspect especially for juveniles of some species.

Physical and Chemical Characteristics of the Region

Geology and Physical Features

The Mediterranean Sea, Black Sea excluded, constitutes 0.81% (2.514 million km^2) of the total water surface of the planet. Twenty-two different countries border its coastline. It extends from the Straits of Gibraltar to the Bosphorus for about 4 000 km. The Mediterranean reaches its maximum depth (5 121 m) in the Ionian Sea.

The birth of the Mediterranean was caused by the collision of the African and European continents about 50–60 million years ago in the area presently called Gibraltar. During the “Messinian regression” the Mediterranean basin became completely closed and the water level descended reaching its minimum 6 million years ago. About 5.5 million years ago, communication through the Straits of Gibraltar opened again and Atlantic waters invaded the Mediterranean basin. From then on the Mediterranean Sea began a new life and assumed the characteristics of a temperate sea.

The Mediterranean Sea can be divided into two main basins: western and eastern separated by the Sicily-Tunisia ridge. Within these basins, regional seas may be defined, connected by channels and straits (Fig. 1). The eastern basin is characterized by a great oceanographic variability on the surface with temperatures of 16°C in winter and up to 29°C in summer, as opposed to 12° and 23°C in the western basin and salinities of 39‰ to the east as opposed to 36‰ in the west.

Currently the Gibraltar threshold, with a maximum depth of about 320 m and a distance of only 25 km between the European and African continental masses, allows the passage of the Atlantic upper layers with an average temperature of about 15°C.

The slow circulation of water masses, the rate of exchange of Mediterranean waters and the consequent poor water replacement, contributes in keeping the temperature constant year round, particularly in deep waters.

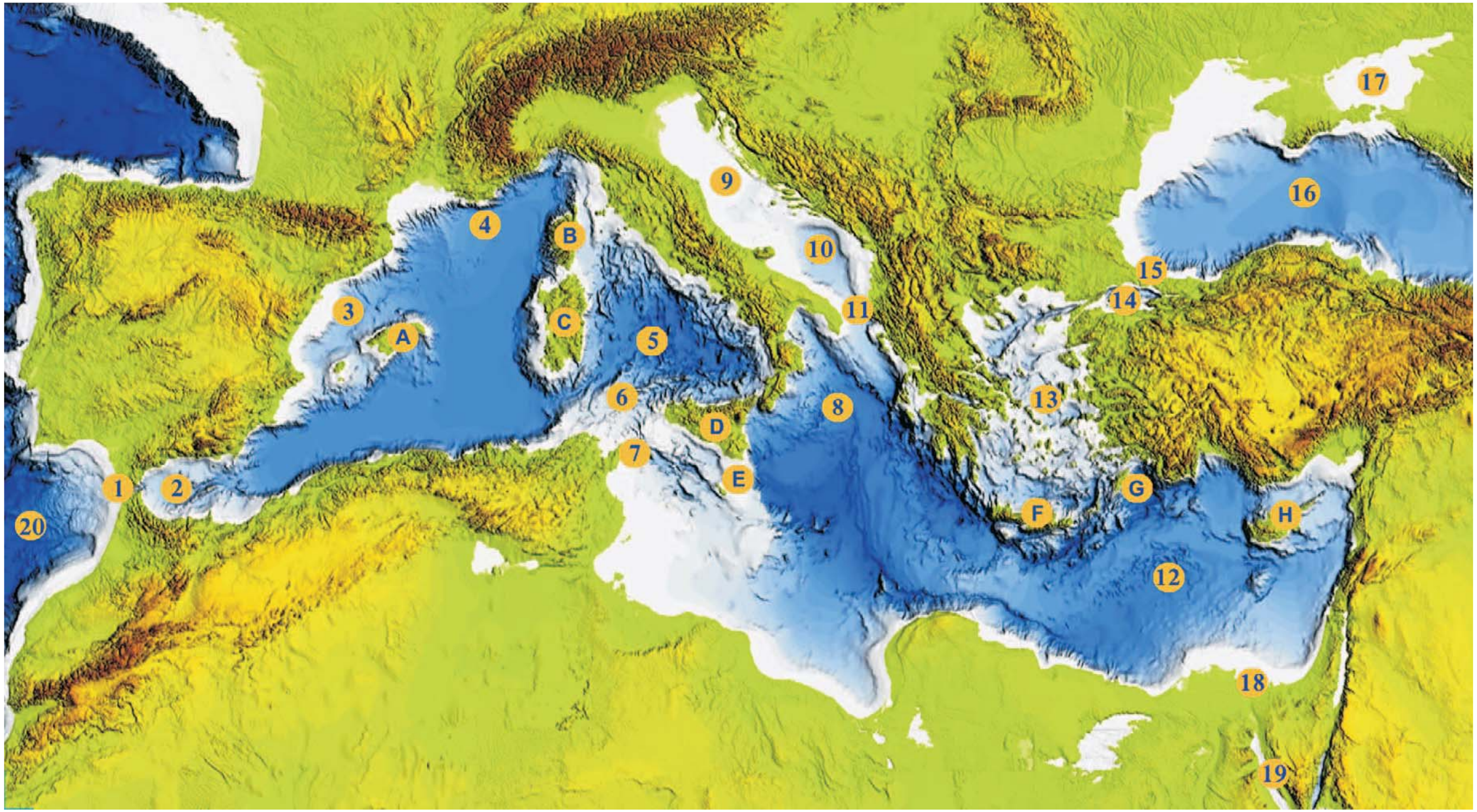

Fig. 1 Mediterranean geography and its main sub-basins

A = Balearic Islands; **B** = Corsica; **C** = Sardinia; **D** = Sicily; **E** = Malta; **F** = Crete; **G** = Rhodes; **H** = Cyprus

1 = Straits of Gilbraltar; **2** = Alboran Sea; **3** = Catalan Sea; **4** = Liguro-Provençal Basin; **5** = Tyrrhenian Sea; **6** = Sicily Tunisian Ridge; **7** = Cape Bon; **8** = Ionian Sea; **9** = Adriatic Sea; **10** = Pomo Pit; **11** = Dalmato Garganic Threshold; **12** = Levantine Sea; **13 =** Aegean Sea; **14** = Marmara Sea; **15** = Bosphorus; **16** = Black Sea; **17** = Azov Sea; **18** = Suez; **19** = Red Sea**; 20** = Atlantic

Compiled by D. Amblàs and J.L. Casamor, GRC en Geociències Marines, Universitat de Barcelona (Spain); after International Ocean Commission, International Hydrographic Organization and British Oceanographic Data Centre - IOC/IHO/BODC (2003): Centenary Edition of the GEBCO Digital Atlas, published on CD-ROM. Liverpool (UK).

The Black Sea occupies an area of about 465 000 km^2 and has a maximum depth of 2 245 m. The Marmara Sea connects the Black Sea with the Mediterranean. Its salinity is low and does not exceed 22‰ throughout the whole water column, however surface waters may have lower values, down to 16–18‰. In winter the surface temperature decreases to 3–6°C and often, in some coastal areas, the water freezes, especially in the Azov Sea. At depths over 150 m the temperature is practically constant, about 9°C. The waters of the southern coasts (Anatolia) show greater average temperatures and are separated by an isothermal front of 15°C. One of the main characteristics of this sea is the complete lack of dissolved oxygen at depths over 150–200 m; from this depth to the bottom sulphurous concentration is very high (Murray, 1991; Oguz, 1992, 1993).

Oceanographic Features

The distribution of marine organisms in the environment is clearly related to bottom characteristics, nutrients abundance and oceanographic conditions. These circumstances are naturally linked to water masses large movements, both near the surface and in deep waters, and are also influenced by meteorological conditions such as wind intensity, surface temperature and chlorophyle concentration (Figs 2, 3 and 4).

The superficial layers of Atlantic waters flow in through the Straits of Gibraltar, progressing over the entire surface of the Mediterranean basin area. These waters become warmer and progressively saltier due to evaporation and their great density as they sink. Part of the general flow will return to the Atlantic as intermediate waters, while another part will mix with deep waters. Heburn (1992) and Garibaldi and Caddy (1998) distinguish three different ecological areas based on species distribution. Three types of water that fundamentally characterize the balance of the whole Mediterranean can be suggested:

– The Modified Atlantic Water (MAW), which mainly constitutes the surface water (0–200 m) of the whole area. It initially flows close to the North African coasts, from Morocco to Cape Bon and then splits into three main directions: the first one constitutes the cyclonic circuit of the Balearic Islands, the second moves towards the Tyrrhenian Sea (Astraldi *et al*., 1999) and the last one towards the Levantine Sea (Millot, 1999) (Fig. 5).

– The Levantine Intermediate Water (LIW) (200–1 000 m, mainly around 400 m depth) that constitutes the main component of the returning flow towards the ocean. This water is mainly produced in the eastern basin (Lascarotes *et al*., 1992, 1993) and, to a lesser extent in the western basin contributing to the Tyrrhenian movement (Fig. 6).

– The Mediterranean Eastern and Western Deep Waters (MDW, Mediterranean Deep Water) (>1 000 m), that are produced respectively in the Liguro-Provençal area of the basin (Send and Shott, 1992) and in the Southern Adriatic Sea (Fig. 7).

The general circulation in the Black Sea consists of several sub-basin scale gyres. The anticyclonic coastal eddies appear to play a fundamental role on the ultimate distribution of the Cold Intermediate Water (Oguz *et al*., 1992, 1993; Millot, 2005; Korataev *et al*., 2003) (Fig. 5).

In the area of entrance of the Atlantic waters (the Alboran Sea), there are important phenomena having repercussions on the entire Mediterranean basin (Fig. 8). These waters show an almost permanent anticyclonic gyre in the west and a more variable circuit in the east, (Allain, 1960; Lanoix, 1974; Heburn and La Violette, 1990; Davies *et al*., 1993; Viudez *et al*., 1996). The main flow is from Spain to the Algerian coast, commonly named “the Almeria-Oran jet” (Prieur and Sournia, 1994). After about 80–100 years the Mediterranean waters (LIW and MDW) return to the Atlantic Ocean with different velocity running below the surface (Bryden and Kinder, 1991) (Fig. 9).

Biodiversity and Biogeographical Characteristics of the Region

The current level of biodiversity of the Mediterranean and Black Sea fauna was defined by the alternation of periods of glaciation and interglaciation, which brought about dramatic changes in climatic conditions. Also in recent times, biodiversity has been enriched both through internal speciation phenomena and through species colonization from outside Mediterranean areas (Golani *et al*., 2002).

Even though the Mediterranean and Black Seas represent less than 1% of the total area of world seas, the fish biodiversity and absolute number of species are relatively high. In fact, it is possible to find about 6% of the entire world’s species in this area (Fredj *et al*., 1992) and probably the 84 cartilaginous fish species found in the area represent about 8% of the total number of species of this group in the world.

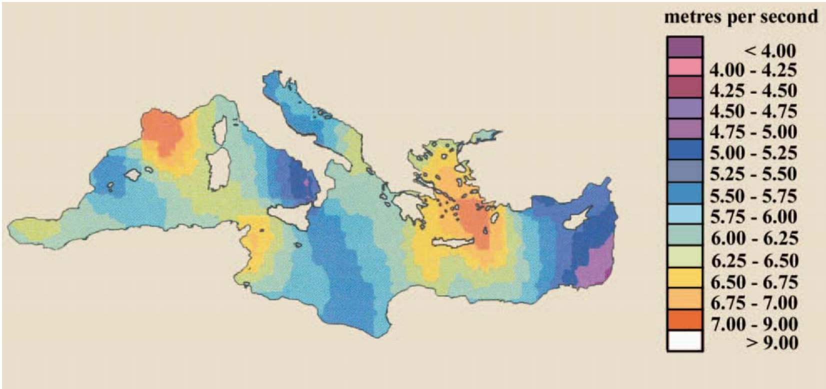

Fig. 2 Average wind speed (metres per second)
The Gulf of Lion and the Aegean Sea close to the island of Rhodes are the most windy areas
(Satellite imagery: © OCEAN Project, 2000)

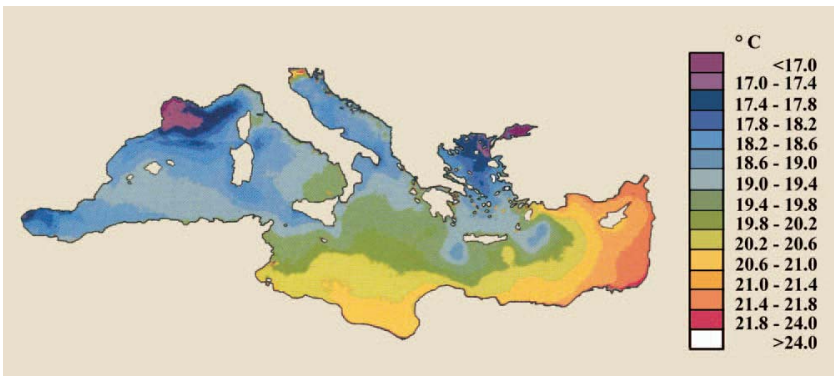

Fig. 3 Average sea surface temperature (°C)
The Gulf of Lion and the northern part of Aegean Sea are colder areas
(Satellite imagery: © OCEAN Project, 2000)

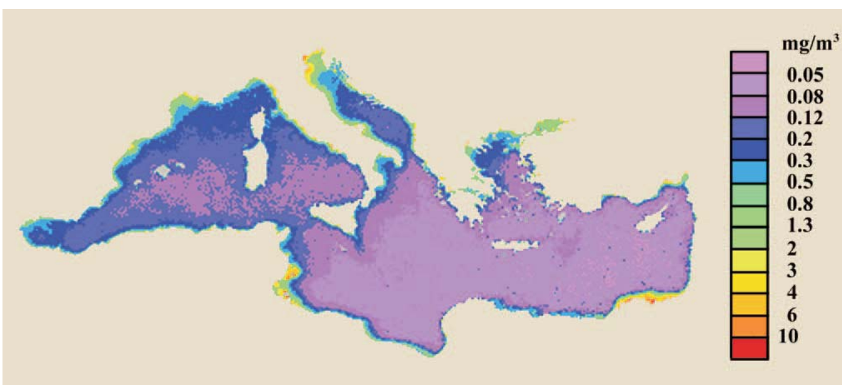

Fig. 4 Average concentration of chlorophyll (milligrammes per m^3)
The Gulf of Lion and Adriatic Sea are richer areas
(Satellite imagery: © OCEAN Project, 2000)

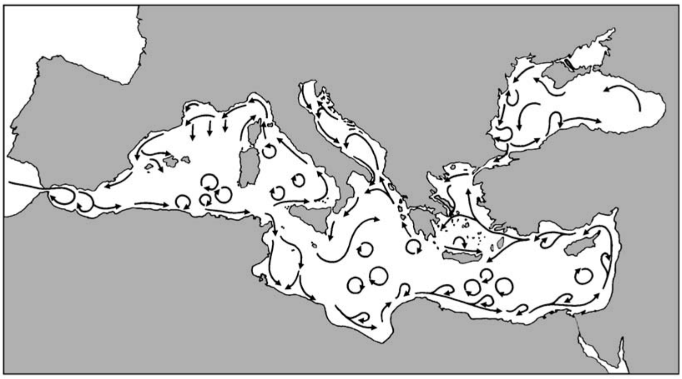

Fig. 5 General circulation of the superficial currents (~0–200 m depth)
(redrawn from Millot (1999) for the western basin also considering information from Heburn and La Violette (1990) and Tziperman and Malanotte-Rizzoli (1991). The dynamics of the eastern basin come from the information of Robinson and Golnaraghi (1994) *in* Malanotte-Rizzoli and Robinson (1994) and Millot and Taupier-Letage, 2004).

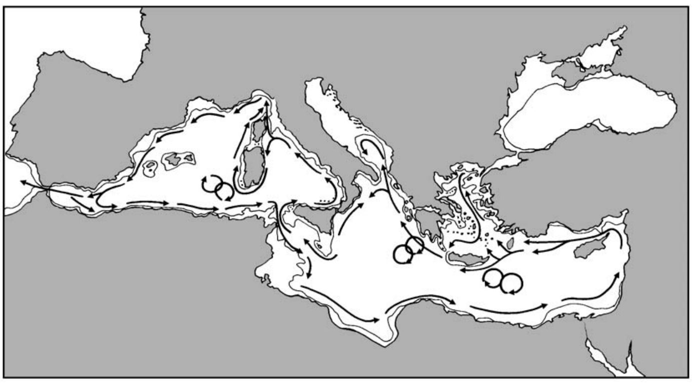

Fig. 6 The dynamics of the Intermediate Waters (~200–1 000 m)
(from Millot (1987), Robinson and Golnaraghi (1994) for the western basin and Malanotte-Rizzoli *et al*. (1999); Millot and Taupier-Letage, 2004 for the eastern basin, modified)

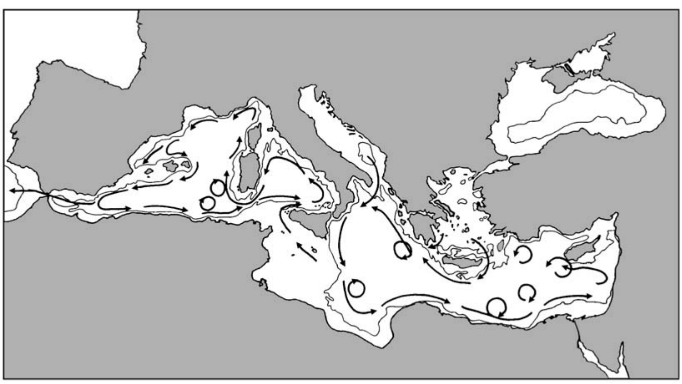

Fig. 7 The dynamics of Deep Waters (<1 000 m depth)
(after Millot (1987), Lacomb *et al*. (1985) for the western basin. The movements of the deep currents in the eastern basin have been simplified (Anati, 1977; Roether and Schlitzer, 1991; Millot and Taupier-Letage, 2004)

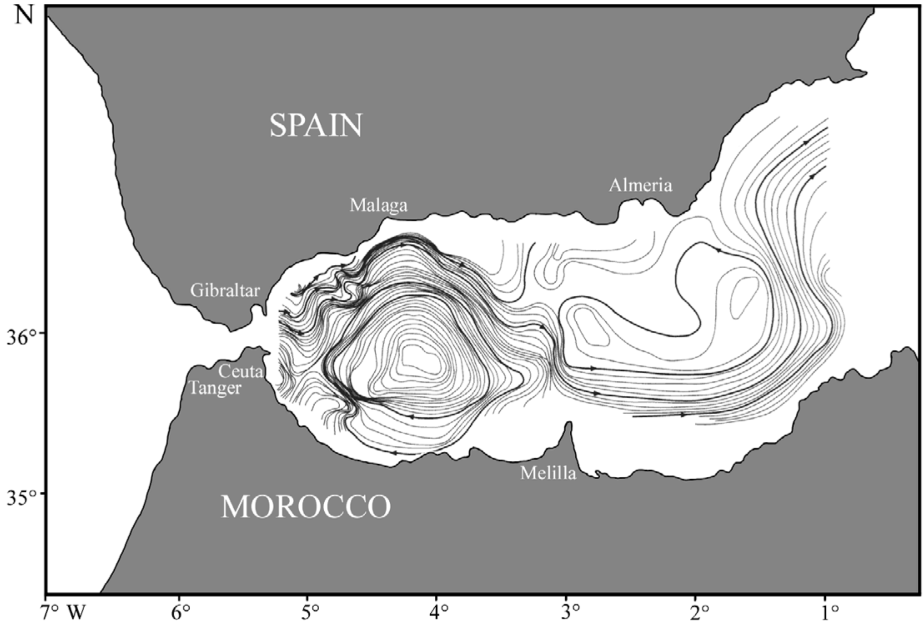

Fig. 8 Noteworthy dynamic superficial waters referring to 200 m depth
(from Lanoix, 1974 *in* La Violette, 1984)

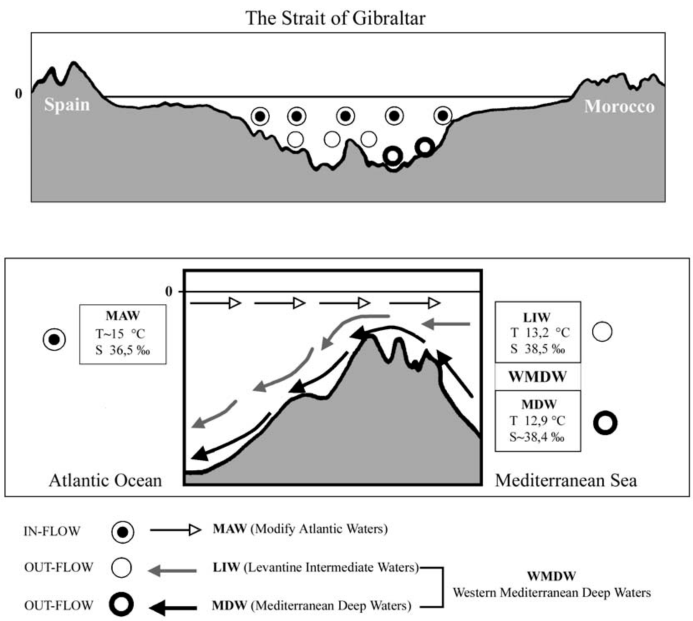

Fig. 9 Inflow and outflow currents through the Strait of Gibraltar:
a) transversal section, b) longitudinal section.

LIW spreads and mixes but remains a distinct water mass all the way to the Gibraltar Strait (Gascard and Richez, 1985); LIW and MDW probably do not mix completely and flow out of Gibraltar Strait with different velocity (Millot, 1999). The yearly average temperatures and salinity of LIW, MDW and MAW are illustrated respecitvely (Kinder and Bryden, 1990; Millot, 1999; Robinson and Golnaraghi, 1994; Tintoré *et al*., 1988; Kinder and Parrilla, 1987). The renewal of the waters of the entire Mediterranean basin is not known exactly; the eastern circulation is now known to consist of a single cell encompassing both the Ionian and Levantine basins, with a turnover time extimated at about 125 years. More research is needed to define the western cell (Roether and Schlitzer, 1991).

Two main features can be highlighted concerning Mediterranean fish communities:

– Biodiversity decreases from west to east, probably due to physical conditions such as the presence of threshold-strait or canal effects (Gibraltar, Sicly-Tunisia, Bosphorus, and Suez). The diversity in number of species shows the same negative eastward gradient that has been found for nutrients (Murdoch and Onuf, 1972). Minimum biodiversity is present in the Adriatic and Black Sea (Fredj and Maurin, 1987; Garibaldi and Caddy, 1998).

– There is a meridionalization from the southern to the northern coasts (Riera *et al*., 1995) and a warming trend in the deep waters of the western Mediterranean (Berthoux *et al*., 1990).

There are approximately 1 170 valid species of cartilaginous fish in the world’s waters; about 50 of them are chimaeras, 650 batoids and 470 sharks. In the Mediterranean and Black Sea, 7 orders are represented by 23 families, 42 genera and a total number of species of about 47 sharks, 34 batoid fishes and 1 chimaera. Endemism is low; up to four species of rays could be considered indigenous.

In the Adriatic Sea, the presence of cartilaginous fish species is scarce especially in the northern part. Besides its oceanographic characteristics that may limit biodiversity, this area was populated more recently than other parts of the Mediterranean. This occurred after the sinking of the Dalmato-Garganic threshold, which was still above sea level in the Pleistocene. A total of 52 species of cartilaginous fish have been recorded in the Adriatic Sea. Only 10 species are widely distributed. Some bathyal species of the group inhabit exclusively the central and southern parts of this sea (Jardas, 1984).

In the Black Sea the number of cartilaginous fish species is less. The Pontic fauna is composed of Mediterranean species and most of the organisms present are eurythermic and euryhaline. Twelve cartilaginous fish species are assumed to live in the Black Sea (Tortonese, 1969; Bouchot, 1984; Roux *in* FNAM, 1984; McEachran and Capapé, *in* FNAM, 1984; Fredj and Maurin, 1987). Murat *et al*. (2002) consider only 8 elasmobranchs along the Turkey coast of the Black Sea.

The Mediterranean Sea comprises several sub-basins characterized by more or less widely diverging oceanographic conditions and faunistic features. Bearing this situation in mind, and also considering the proximity of the Mediterranea Sea to the Atlantic Ocean, strictly speaking the Mediterranean fauna can be defined as the fauna of a single, well-known, well-defined basin, and in a wider sense the term also covers the forms existing in the adjacent part of the Atlantic, between Portugal and Mauritania including the Azores, Canary and Madeira islands (Tortonese, 1989).

For the last 5.5 million years, the Straits of Gibraltar have never constituted a rigid boundary, and there is, therefore a reciprocal influence between the Atlantic Ocean and the Mediterranean Sea. Infact, the classical statement of Ekman (1953) considers the Atlantic-Mediterranean area as a single faunistic unit, and divides it into three areas: Lusitanic, Mauretanic and Mediterranean Region.

Even if considering only the Mediterranean basin, the distribution of cartilaginous fish species is not homogeneous. This phenomenon is often linked to the typology of the sea bottoms or to the chemical and physical characteristics of the different sub-basins. Basically, the bathymetry delimits three distinct ecological areas, which can be used to categorize species distribution patterns and hence habitat preference. Obviously, species could belong to more than one category or to all of them (Garibaldi and Caddy, 1998): **1)** those living over the shelf (0–200 m); **2)** demersal on the slope, oceanic and mesopelagic species within the water column over the 200–1 000 m depth; and **3)** oceanic, mesopelagic and bathypelagic species occupying waters over 1 000 m depth.

The superficial Atlantic current, which comes through the Straits of Gibraltar, is of crucial importance for Mediterranean Sea life as it facilitates the immigration of oceanic species. In a very synthetic way we can state the following biodiversity considerations on several biogeographical areas of the Mediterranean basin:

– The Alboran Sea is rich in Atlantic species.

– The northwestern area of the Mediterranean, including the Catalan, Ligurian and north Tyrrhenian seas, is characterized by the presence of Atlantic boreal elements.

– The central zone, that includes waters around the Balearic Islands, Corsica and Sardinia and the northern coasts of Sicily, shows specific Mediterranean or Atlantic-Mediterranean characteristics; many subtropical species are found in this area.

– The Tunisian and Libyan coasts, characterized by the presence of rare tropical Atlantic species, are the southernmost areas and are closest to subtropical in their characteristics.

– The eastern region, that includes the coasts of Egypt, Israel, Lebanon and Syria, is inhabited by many species coming from the Red Sea.

– The Adriatic Sea that does not reach great depths (50–60 m in average), apart from the “Pomo Pit” (south Adriatic Sea) where depth reaches about 1 200 m; the most abundant marine organisms in this area are prevalently species of Atlantic-boreal origin.

– The Black Sea is characterized by species of Sarmatic origin.

The Fishery

In all the seas of the world, the cartilaginous fish species are exploited for their fins, skin, jaws or meat (Vannuccini, 1999). Sometimes they are directly targeted by commercial and recreational fisheries while in other cases they are incidentally caught as bycatch. In many areas of the world a decline in cartilaginous fish species landings has been observed while fishing effort has generally increased. This especially applies to fisheries targeting shark fins. Moreover, most countries report shark statistics without distinction between species or, worse still, the species are not recorded at all. As a result, it is impossible to identify the species in multispecific fishery and hence estimate and monitor fishing mortality.

Because of their life history characteristics, sharks and rays are especially susceptible to over-exploitation and it is very difficult to restore depleted populations. Very often species have restricted distribution, small population size, dependence on mating, spawning, nursery and breeding grounds or specific habitats. Well- documented cases of collapsed shark fisheries have been reported (Musick *et al*., 2000). In such cases a sudden collapse of yields can occur and consequently the local extinction of a particular species.

No marine fish is yet known to have been driven to biological extinction due to fishing (Musick, 1999) but regional stocks of some species can be considered to have disappeared, such as *Squatina* sp. (Vacchi and Notarbartolo di Sciara, 2000). The assumption that marine fish are not vulnerable to extinction because they live in open seas, where their movements are unlimited, is unfounded. Sharks also constitute a bycatch in open sea fisheries targeting highly migratory species such as tunas.

The fishing methods used to catch cartilaginous fish species in the Mediterranean are highly varied: the two most efficient gears for sharks are gillnets and longlines, while a frequent method for catching batoids in general and some smaller sharks like smoothhound, catsharks, etc. is the bottom trawl. This fishing gear is probably responsible for a large amount of bycatch and discard of cartilaginous fish throughout the world (Bonfil, 2002).

Bottom trawl fishing activity is commonly performed throughout the Mediterranean area. The cartilaginous fish species most frequently caught with these gears are *Galeus melastomus*, *Scyliorhinus canicula*, *Etmopterus spinax*, *Raja clavata*, *Squalus acanthias* (Bertrand *et al*., 2000; Relini *et al*., 2000; Baino *et al*., 2001; Serena *et al*., 2005). Some species such as the starry ray (*Raja asterias*) are constantly captured as bycatch and in large amounts in several Italian fisheries, especially in the Tyrrhenian Sea. The fishing gear employed is a modified beam trawl targeting sole (Minervini *et al*., 1985; Serena and Abella, 1999; Abella and Serena, 2005).

Even in the Adriatic Sea, accessory catches of many species of cartilaginous fish species are carried out with set gears and the most frequent species caught are *Squalus acanthias*, *Mustelus* spp., *Raja* spp., *Torpedo* spp., *Scyliorhinus* spp., *Galeorhinus galeus*, *Alopias vulpinus* and juveniles of *Carcharhinus plumbeus* (Costantini *et al*., 2000).

Large individuals of *Hexanchus griseus* as well as those of *Galeus melastomus*, *Centrophorus granulosus*, etc. are captured with bottom longlines targeting hake. The drifting longlines set near the surface, targeting tuna and swordfish, also capture *Prionace glauca*, *Pteroplatytrygon violacea*, *Alopias vulpinus*, *Isurus oxyrinchus*, *Lamna nasus*, *Sphyrna (Sphyrna) zygaena*, *Hexanchus griseus*, *Carcharhinus* spp., *Mobula mobular*, etc. (Fleming and Papageorgiou, 1997; Kabasakal, 1998; Hemida, 1998; De Metrio *et al*., 2000; Garibaldi and Orsi Relini, 2000; Orsi Relini *et al*., 2000).

Driftnets are largely used to catch cartilaginous fish species, and in the recent past they were extensively utilized throughout the Mediterranean. Fortunately nowadays their use is prohibited in European countries. It is advisable that the use of this gear be prohibited, and this should be extended to all Mediterranean countries in order to find a definitive solution to the problem. The main species caught with driftnets are *Prionace glauca*, *Alopias vulpinus*, *Isurus oxyrinchus*, *Lamna nasus*, *Carcharhinus* spp., *Cetorhinus maximus*, *Sphyrna* spp., *Mobula mobular*, *Pteroplatytrygon violacea* (De Metrio *et al*., 2000).

Occasionally, species such as *Prionace glauca*, *Cetorhinus maximus*, *Sphyrna* spp. and *Mobula mobular* are caught with purse seines (Notarbartolo di Sciara and Serena, 1988). In such cases the catches have to be considered incidental rather than accessory, the same applies to some artisanal fisheries (Serena *et al*., 1999a, b). No official practice of "finning" has been reported in the Mediterranean Sea so far, but mortality through discarding from trawls, gillnets, purse seines and longlines is significant (De Metrio *et al*., 1984). However, in the past the fishing activity with the greatest incidence in cartilaginous fish species catches was tuna traps. Some years ago, these fishing structures were widely distributed all around the Mediterranean area. In countries such as Spain, France and Turkey, and particularly along the Italian coasts, the use of the tuna trap was due to the presence of the prevailing migration routes of tuna, directed towards not only the rich waters of the Liguro-Provençal basin but also in the Adriatic Sea (FAO, 1985). Between 1890 and 1914, there were 37–54 tuna traps (Cushing, 1988) in Italy. Today only a few units are still present, mainly concentrated on the major Italian islands. The large-sized cartilaginous fish species more commonly present in catches were *Alopias vulpinus*, *Cetorhinus maximus*, *Sphyrna mokarran*, *Prionace glauca*, *Mobula mobular* and sometimes *Carcharodon carcharias* (Boero and Carli; 1979, Vacchi *et al*., 2002).

Significant bycatch mainly constituted by *Alopias vulpinus* and *Prionace glauca* is caught by fishing performed with small swordfish-driftnets targeting swordfish, carried out mainly in the southern part of the Mediterranean by Italy, Malta, Morocco, Tunisia, and others. Very few and geographically localized fishing activities can be considered, targeting species of this group in the Mediterranean. Traditionally *Hexanchus griseus* is caught with bottom longlines in the Ligurian Sea (Aldebert, 1997) and also along the southern Italian coasts. In this area, drifting surface longlines, called "stese" are also utilized in spring for the catch of large individuals of *Prionace glauca*. These are short lines with hooks that are set near the surface. In the northern Adriatic, gillnets are utilized to catch *Mustelus mustelus*, *Mustelus punctulatus*, *Squalus acanthias*, *Scyliorhinus stellaris*, *Myliobatis aquila* and *Galeorhinus galeus* during winter and spring; and *Prionace glauca*, *Pteromylaeus bovinus* and *Alopias vulpinus* during summer (Costantini *et al*., 2000).

Important catches of Carcharhinidae species (*Carcharhinus brachyurus*, *Carcharhinus brevipinna*, *Carcharhinus falciformis*, *Carcharhinus obscurus*, *Carcharhinus plumbeus* and *Carcharhinus altimus*) are also made by offshore pelagic longline fishery operating from ports in the east of Algeria (Hemida and Labidi, 2000). The recent FAO-COPEMED-MBRC report by Lamboeuf (2000) analyses the artisanal fishery in Libya showing some examples of fisheries targeting cartilaginous fish such as Carcharhinidae, Lamnidae, *Rhinobathos* and *Squatina squatina* caught by fixed gillnet, bottom set and drifting longlines.

Finally, we cannot neglect the role of recreational fishing that has recently grown in popularity causing concern. Following the development that occurred in the United States and in Australia, the number of angler associations has also notably increased in the Mediterranean, mainly in the northern Adriatic (Bianchi *et al*., 1997) and in the Tyrrhenian but also in other countries such as France and Spain. The targets of game fishing are essentially *Alopias vulpinus*, *Prionace glauca* and *Hexanchus griseus*. However, juveniles compose most of the catch and, sometimes, they are recently born individuals. Currently, there are no specific laws or a suitable control aimed at the protection of any cartilaginous fish. This may soon lead to a rarefaction of the populations of the two above-mentioned species as has already occurred in Cornwall, United Kingdom (Vas, 1995).

Cartilaginous fish catches in the 1970–2002 period represent only 1.1% of the total landings in Mediterranean ports (FAO, 2000a). The most important landings of this group occurred in the Ionian and Black seas each one with 30% of the total Mediterranean catches; Sardinian, Adriatic and Balearic waters show catches of 12%, 8% and 7%, respectively of the Mediterranean total.

The catches during the last 30 years (Fig. 10) show an increasing trend from 10 000 to 25 000 tonnes attained in 1985 and since then a regular decrease to 15 000 tonnes to present (FAO, 2000b). This is mainly due to the Turkish and Italian catches of sharks and rays in the Black and Ionian seas, respectively. Unfortunately it cannot be stated whether these variations are real or if they are simply due to changes in recording procedures (i.e. in some years at least part of them were reported as sharks and in others generically as marine fishes).

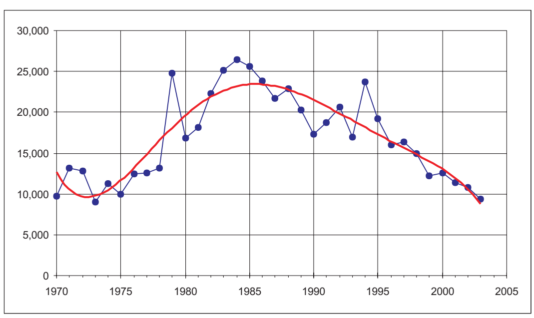

Fig. 10 Mediterranean and Black Seas trend of cartilaginous catches in the last 30 years

Fishery Management

The life history strategy of cartilaginous fish species suggests the need for conservative management of a balanced population and a compatible fishery activity. However, most shark fisheries are completely unmonitored and unmanaged (Shotton, 1999). About 50% of the estimated global catch of cartilaginous fish species is gathered as bycatch and these are not mentioned in official fishery statistics (Stevens *et al*., 2000).

In general, the contribution of cartilaginous fish to the market is low because of their scarce economic value. Consequently they are also a low priority for research and management if compared to bony fishes, although recently, certain products such as shark fins have become important in the trade.

Cartilaginous fish resources management needs particular attention, above all in order to maintain biodiversity and ecosystem structures. The interactions between species in marine ecosystems, as well as the impact of the removal of top predators on other marine organisms on the functionality of the whole ecosystem are poorly understood. Basically, besides an adequate identification guide, we need to know the abundance of each species, life history characteristics, fishing effort, catches, discards, etc. In the case of the Mediterranean, many fisheries belonging to different countries are taking place and the resources are often shared between nations. This situation requires cooperative management at the intergovernmental level and a precautionary approach for their exploitation (FAO, 1995a, 1995b, 1996).

Finally, for the successful management of cartilaginous fish species we must simultaneously consider biological and fishery information. The choice of suitable mathematical models for stock assessment of these resources is not easy and it has to take into consideration the long life span and late maturation of many sharks and rays. Therefore, the effects of changes in fishing effort and other management measures will be apparent only many years later.

Conservation

The cartilaginous fish species belong to an ancient, conservative taxonomic group that was formerly very abundant in the world's oceans. Despite the evolutionary success of the species which have survived until the present day, some are now threatened with extinction, regionally or globally, often as a result of human activities. The main reason for this is that a K-selected life-history traits characterize many species; they grow slowly, mature at a relatively late age, have only a few young with low natural mortality rates, and their populations increase very slowly (Hamlett, 1999, 2005). As apex predators occupying the top of the marine food web, many cartilaginous fish species are also naturally rare compared with other fish species but have a vital role in maintaining the balance of marine ecosystems. Their biological characters make them susceptible to population depletion as a result of anthropogenic activity, including unsustainable fisheries supplying local demand or international trade, bycatch, habitat modification and persecution (particularly of species perceived as dangerous to man) (Myers and Worm, 2003).

The IUCN–World Conservation Union Species Survival Commission's Shark Specialist Group is currently assessing global- and regional-extinction risks for all species of sharks and their relatives, including Mediterranean populations. This list is updated annually as new information becomes available and may be consulted on www.redlist.org. The Red List has no legal standing, but is widely used to monitor changes in the status of biodiversity and to set conservation and management priorities. Regional networks of experts are involved in assessing and reassessing the Red List status of species, drawing upon information collected by stock assessment and other research projects within the region (Fowler *et al*., 2005).

Recognition of the threatened status of sharks and their relatives has been recognized through the addition of several species to national, regional and international species and fisheries conservation and management instruments. A number of species of sharks and rays are listed in the Appendices of the Barcelona Convention for the protection of the marine and coastal environment of the Mediterranean (Protocol concerning Specially Protected Areas and Biological Diversity) and the Bern Convention for the Conservation of European Wildlife and Natural Habitats, which specifically cover populations in the Mediterranean. Other species are listed in the Convention on Migratory Species, the Convention on International Trade in Endangered Species (CITES), and the UN Fish Stocks Agreement. Since some of these lists change fairly regularly readers are advised to consult the appropriate Convention web pages for the most up-to-date information.

It is important to note that the biological vulnerability of sharks[1/], recognized in the FAO International Plan of Action for the Conservation and Management of Sharks (FAO IPOA-Sharks, 1998) means that it is important to monitor the status of all species and to ensure that appropriate management measures are introduced in order to guarantee the sustainable use of all shark stocks, not only those which are listed in the Conventions or the IUCN Red List of Threatened Species.

Concerns over the sustainability of shark fisheries led to the development and adoption in 1999 of the FAO IPOA-Sharks, 1998, elaborated within the framework of the Code of Conduct for Responsible Fisheries (FAO, 2000). This voluntary plan urges states to carry out a regular assessment of the status of shark stocks subject to fishing, in order to determine if there is a need for development of a shark plan, and to adopt a national plan of action (Shark-plan) for conservation and management of shark stocks (if their vessels conduct directed fisheries for sharks or if their vessels regularly catch sharks in non-directed fisheries). It also recognizes the importance of international collaboration for the sustainable management of transboundary, straddling, highly migratory and high seas shark stocks, including, where appropriate, the development of subregional or regional shark plans.

The European Union considers that sharks are fish species whose conservation falls within the domain of the Common Fishery Policy, therefore their management should be addressed by measures dictated by the EC for implementation within EU countries. The European Plan of Action, announced at the FAO Committee on Fisheries (COFI) meeting held in Rome in February 2001, is still to be released. Meanwhile, two meetings of the *ad hoc* Elasmobranch's Working Group of the Scientific, Technical and Economic Committee for Fisheries-Subgroup on review of stocks (STECF-SGRST) have been held (2002 and 2003) in order to address elasmobranch fisheries with a view to preparing a Community Plan of Action as requested by the FAO-IPOA Sharks. The draft Italian National Shark Action Plan recognizes the need for regional cooperation in addition to national action for Mediterranean shark species. This was the starting point for Italy's active involvement within the relevant international and regional organizations, such as FAO and UNEP-MAP 2003. This stimulated the formulation of a Mediterranean Action Plan for the conservation and management of cartilaginous fishes, proposed during meetings of the GFCM-SAC working group on the environment in 2001 and 2002, and accepted by the National Focal Points to the SPA Protocol in 2001. The approved Action Plan was scheduled for adoption in November 2003. It strongly recommended that the representative parties grant urgent legal protection status to a list of priority species assessed as Critically Endangered or as Endangered by the IUCN at the Mediterranean level and urges assessment of the extinction risk to species, such as hammerhead sharks and guitarfishes, for which data are lacking. The representative parties are also asked to develop management programmes for sustainable fisheries for a number of commercially important species, to identify and protect critical habitats and to develop research, monitoring and training programmes.

Although legal instruments for the conservation of some cartilaginous-fish species in the Mediterranean have been in place for over eight years, implementation has not yet followed. For example, species listed under Appendix III of both the Barcelona and the Bern Conventions, which call for the regulation of their exploitation, have continued to decline without any management during this period. There is now a critical need for a concerted action and synergy of both fisheries and environmental agencies throughout the region to ensure the conservation and sustainable use of this vulnerable group, and hence the maintenance of the stability of the Mediterranean ecosystem. Such action should stem from the frameworks of all those institutions whose mandate involves environmental and fisheries policies within the Mediterranean basin and the application of the ecosystem approach and precautionary principle. It should also be mentioned that an Action Plan for the Conservation of Cartilaginous Fishes in the Mediterranean has been proposed (UNEP MAP RAC/SPA, 2003).

Codes for Conservation and Exploitation Status

With the aim of assigning status categories regarding the overall human utilization of sharks, the FAO (Castro *et al*., 1999) allocated sharks species into two main groups: "exploited" and "not exploited" species. The group "exploited species" is successively divided into five numerical categories. These categories and criteria for inclusion are explained as follows. Unfortunately batoids are not yet considered in the FAO status evaluation.

1/ The term "shark" is used here in the sense of the Convention on International Trade in Endangered Species (CITES) and the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-SHARKS).

A. **Not exploited species**: species that are not currently targeted by fisheries and are not normally found as bycatch of any fisheries.

B. **Exploited species**: species that are directly exploited by fisheries or caught as bycatch.

Category 1: exploited species that cannot be placed in any of the subsequent categories because of lack of data.

Category 2: species pursued in directed fisheries and/or regularly found in bycatch, whose catches have not decreased historically, probably due to their high reproductive potential.

Category 3: species that are exploited by directed fisheries or bycatch and, due to a limited reproductive potential and/or their life history characteristics, are especially vulnerable to overfishing and/or are being fished in their nursery areas.

Category 4: species that show substantial historical declines in catches and/or have become locally extinct.

Category 5: species that have become rare throughout the ranges where they were formerly abundant, based on historical records, catch statistics or experts' reports.

The conservation and exploited status of the Mediterranean Chondrichthyans fish have been discussed in several meetings, UNEP-RAC/SPA in Rome, December 2002 (UNEP 2003), STECF in Brussels, July 2003, (STECF 2003) and IUCN-SSG in San Marino, September 2003 (IUCN 2003). Some other information proceeding from elaborations of the data gathered during national and international surveys (GRUND, MEDITS, project N° 97/50 DG XIV/C1, etc.) (Relini *et al*., 2000; Bertrand et al., 2000; Megalofonou *et al*., 2000; Baino *et al*., 2001).

Some species as *Chimaera monstrosa*, *Galeus melastomus*, *Raja miraletus* and *Raja clavata*, are referred to as having a "stable biomass" in some areas from the exploitation point of view (Abella and Serena, 2005; Serena *et al*., 2003).

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