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Overview on Mediterranean Shark's Fisheries: Impact on the Biodiversity

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Abstract

Bibliographic analysis shows that the Mediterranean Sea is a hot spot for cartilaginous species biodiversity, including sharks, rays, and chimaeras; 49 sharks and 36 rays were recorded in this region. However, they are by far the most endangered group of marine fish in the Mediterranean Sea. The IUCN Red List shows clearly the vulnerability of elasmobranchs and the lack of data; 39 species (53% of 73 assessed species) are critically endangered, endangered, or vulnerable. The biological characteristics of elasmobranchs (low fecundity, late maturity, and slow growth) make them more vulnerable to fishing pressure than most teleost fish. Overfishing, the wide use of nonselective fishing practices, and habitat degradation are leading to dramatic declines of these species in the Mediterranean Sea. In general, elasmobranchs are not targeted but are caught incidentally. In many fisheries, they are, however, often landed and marketed. A decline in cartilaginous fish species landings has been observed while fishing effort has generally increased. Better understanding of the composition of incidental and targeted catches of sharks by commercial fisheries are fundamentally important for the conservation of these populations. Moreover, problems encountered by elasmobranchs in the area are highlighted, and conservation measures are suggested.

Keywords: elasmobranchs, Mediterranean Sea, bycatch, biodiversity, fisheries

1. Introduction

The Mediterranean is known to be an important habitat for cartilaginous fish and is thought to encompass unique breeding grounds for species such as the white shark *Carcharodon carcharias* (Linnaeus, 1758) and the thornback ray *Raja clavata* Linnaeus, 1758. Forty-nine sharks and thirty-six rays were recorded in this region.

Elasmobranchs represent about 1 percent of the total fish landings. These landings decrease from about 26,000 tons in 1984 to about 14,000 in 2015 (official statistic FAO).

Going back in the history, it has been demonstrated that sharks in the Mediterranean Sea have declined by more than 97 percent in number and “catch weight” over the last 200 years. They risk extinction if current fishing pressure continues [1]. The last 200 years have seen a dramatic decline of large predatory sharks in the Mediterranean Sea. This loss of top predators could hold serious implications for the entire marine ecosystem, greatly affecting food webs throughout this region.

There is evidence that the elasmobranchs of the Mediterranean are declining in abundance, diversity, and range due to the intense fishing activity primarily in response to the rapidly increasing demand for shark fins, meat, and cartilage. However, this direct fishing mortality is not the only impact on elasmobranch populations. There are fishing impacts on habitats through disturbance of biotic communities and substrates. Shipping and underwater exploration, construction, mining, and electrical installation and aquaculture offshore in cages also affect habitats, and increasing ambient sound, light, electromagnetic fields, and chemical contamination stimulate the sensory systems of these fishes.

Cartilaginous species, including sharks, rays, and chimaeras, are by far the most endangered group of marine fish in the Mediterranean Sea; among 73 assessed species in the Mediterranean, the Red List status of Chondrichthyans shows that 39 (53% of all) are critically endangered, endangered, or vulnerable [2]. The biological characteristics of elasmobranchs (low fecundity, late maturity, slow growth) make them more vulnerable to fishing pressure than most teleost fish. Overfishing, the wide use of nonselective fishing practices, and habitat degradation are leading to dramatic declines of these species in the Mediterranean Sea. In general, elasmobranchs are not targeted but are caught incidentally. In many fisheries they are, however, often landed and marketed. Better understanding of the composition of incidental and targeted catches of sharks by commercial fisheries is fundamentally important for conservation of these populations.

In this chapter, we try to provide an overview on the bycatch of sharks in the Mediterranean, their impact on biodiversity, and some recommendations for the conservation of this group of fish. We refer when necessary to the Gulf of Gabès (Tunisia). The Gulf of Gabès is in fact a “marine biodiversity hot spot” of significant regional importance and the most important fishery area of the Tunisian fishing fleet. The Gulf is the preferred habitat for many iconic Mediterranean vertebrate species—a wintering and foraging area for the loggerhead turtle (*Caretta caretta* (Linnaeus, 1758)), a nursery for several elasmobranch species, and a suitable habitat to many other fish species such as groupers and tunas. Cetaceans, especially bottlenose dolphin (*Tursiops truncatus* (Montagu, 1821)), are encountered there.

2. Status of elasmobranchs in the Mediterranean Sea

2.1. Mediterranean elasmobranch fauna

Cartilaginous fishes belong to the Chondrichthyes class comprising sharks, batoids (skates, stingrays, guitarfishes, and sawfishes), and chimaeroid fishes and including about 1200 living species [3]. The chimaeras fall in the subclass of Holocephali and the sharks and rays in the

subclass of Elasmobranchii. For chimaeroid, two species occur in the Mediterranean, the common rabbitfish *Chimaera monstrosa* Linnaeus, 1758, and the large-eyed rabbitfish *Hydrolagus mirabilis* (Collett, 1904). The latter species is widespread; it is probably relatively common in the Northeast Atlantic and less common in the western and southern Atlantic [4]. In 2013, a large female was recorded in the eastern Mediterranean Sea for the first time by Hassan [5]. We deal in this review with this latter subclass, generally named elasmobranchs comprising sharks (Squalii and Pleurotremata) and rays (Batoidea and Hypotremata).

According to [6], 86 species of elasmobranchs thought to occur in the Mediterranean Sea. This number comprises 49 species of sharks from 17 families and 37 batoid species from 9 families.

Recently captures of the spinetail devil rays *Mobula japonica* (Müller and Henle, 1841) were reported from the northern coast of Tunisia (central Mediterranean) [7, 8] from Algerian coasts [9] and from Turkey [10]. Comparison with the partial mitogenome of *M. japonica* suggests sister-cryptic species complex and two different taxonomic units. However, the limited divergence within the species (>99.9% genetic identity) may be the result of a geographically and numerically restricted population of *Mobula mobular* (Bonnaterre, 1788) within the Mediterranean Sea [11]. Another genetic study combined genetic and morphological data challenges the notion that *M. mobular* and *M. japonica* are two separate species. However, additional and population-level sampling, combined with genetic analysis and morphological examination, are necessary before any conclusions can be drawn about the species status of *M. japonica* [12]. According to its status, *M. japonica* is not considered in this work.

2.2. Spatial distribution of elasmobranchs in the Mediterranean Sea

Historically, the diversity of Chondrichthyans was greatest in the western Mediterranean Sea, particularly in the coastal waters of North African countries (**Figure 1**). Diversity is slightly lower in the northwest Mediterranean countries [2]. This spatial distribution is also shown in works of [13, 14].

Within the Mediterranean, the distribution of elasmobranch fishes is not homogenous [15]. Some areas are considered critical habitat for elasmobranchs. However, a big lack of knowledge on critical habitats for this group was noted in the Mediterranean. For example, the Tunisian waters provide a nursery area for the white shark *C. carcharias* (center of Tunisia), for the sandbar shark *Carcharhinus plumbeus* (Nardo, 1827) [16, 17] (Gulf of Gabès, south of Tunisia), and for the blackchin guitarfish *Glaucostegus cemiculus* (Geoffroy Saint-Hilaire, 1817) [17].

2.3. Elasmobranch landings

Elasmobranch species are exploited mainly for their fins and meat. They are sometimes targeted by commercial fisheries, while in majority of the cases, they are incidentally caught as bycatch. In the Mediterranean Sea, elasmobranch fish catches represent only 1.15 percent of the total landings (Statistic FAO 1980–2015). A decline in cartilaginous species landings has been observed while fishing effort has generally increased. According FAO statistics of elasmobranchs, the catches show a decreasing trend: 26000 tons in 1983–1984 and 14,000 in 2015 (**Figure 2**).

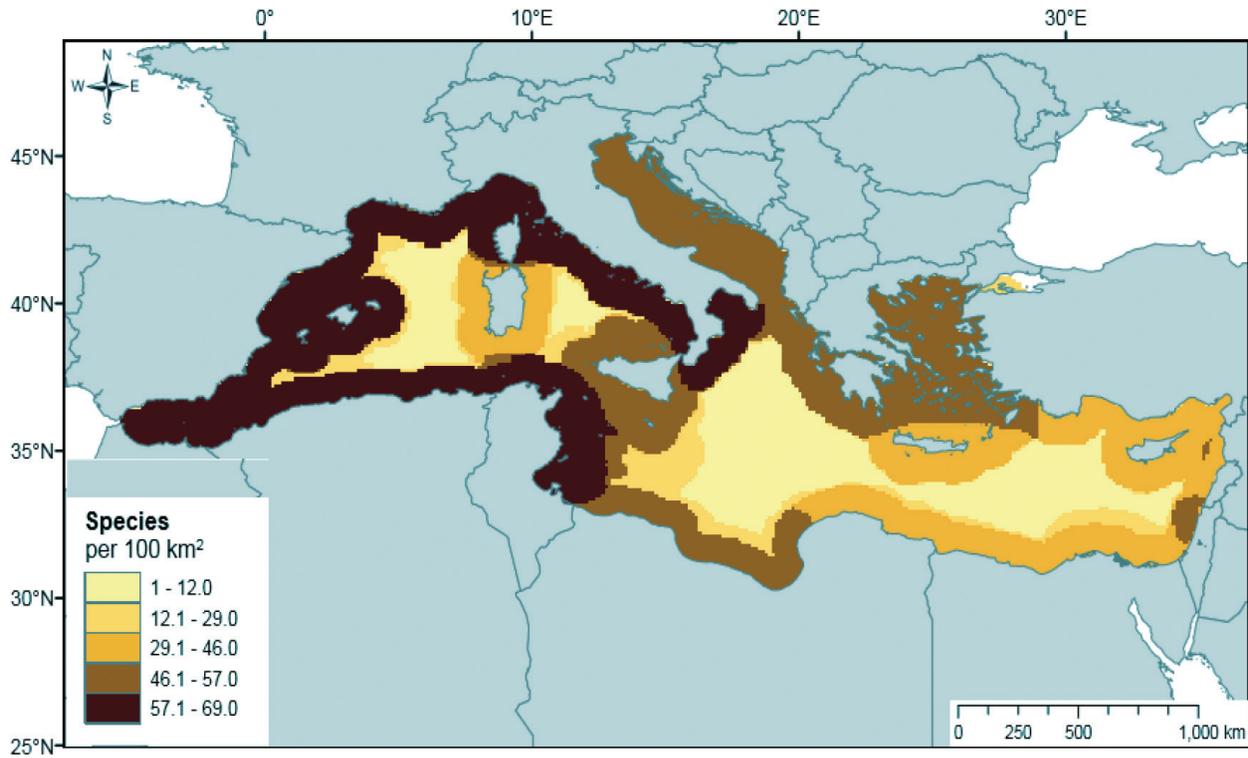


Figure 1. Historical species richness of Chondrichthyans within the Mediterranean Sea [2].

The increase of production noted after 2008 is not really related to augmentation of catch but to the contribution of new countries to the FAO official statistic such as Libya. The contribution of African countries is becoming noticeable; in fact, they contributed by more than 70% of elasmobranch production of the area during the last 7 years (Figure 2).

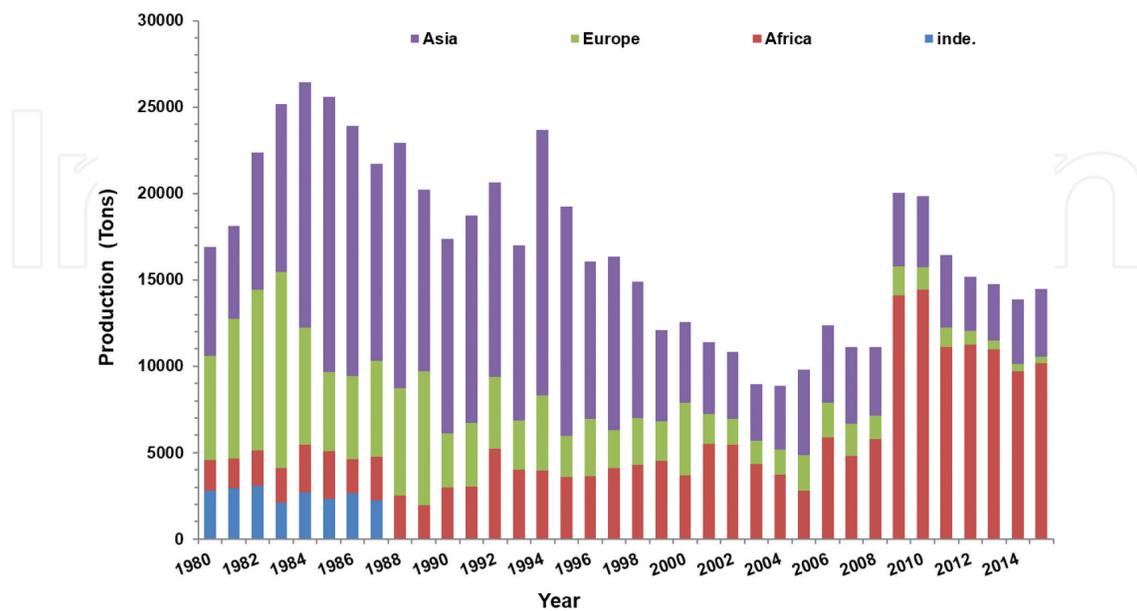


Figure 2. Mediterranean elasmobranch production according to FAO statistics from 1980 to 2015.

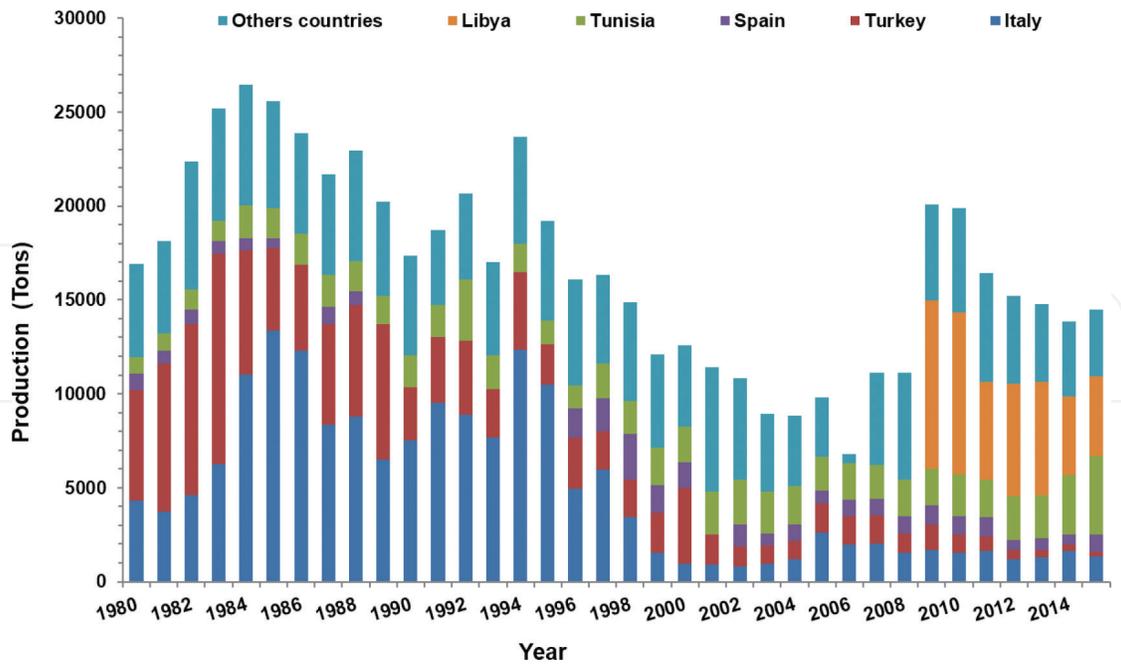


Figure 3. Contribution of some countries in the Mediterranean elasmobranch production according to FAO statistics from 1980 to 2015.

During the last 7 years, the major elasmobranch-fishing countries within the Mediterranean are Libya and Tunisia; in fact they contributed by more than 70% of production (**Figure 3**). Italy and Turkey known to be the major elasmobranch-fishing countries within the Mediterranean, between 1980 and 2008, register a dramatic decrease in catch. Tunisian landings did not show

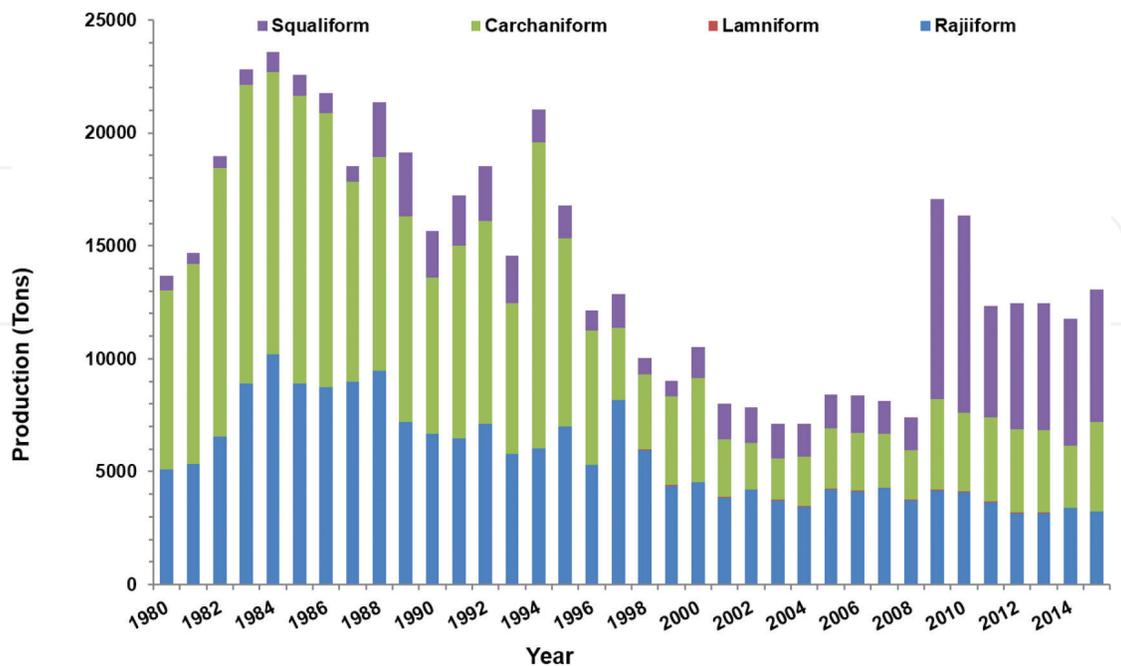


Figure 4. Landing evolution of some elasmobranch groups in the Mediterranean between 1980 and 2015.

any notable variations from 1980 to 2015. Those from Libya appear for the first time in FAO statistics and seem to be important (Figure 3).

It should be noted that the Mediterranean landings of Carcharhiniformes, the most represented group among the elasmobranchs and the most commercially fished, recorded notable decrease (Figure 4).

3. Elasmobranch fisheries

Effects of fishing on marine megafauna are widespread and diverse, primarily due to overexploitation and bycatch [18, 19]. The capture of threatened vertebrates in fisheries is an increasingly prominent international issue [20]. There are particular concerns on elasmobranchs as they are particularly vulnerable to fishing mortality because of their life histories including slow growth, late maturity, and low fecundity rates [21, 22]. Elasmobranchs are less able to sustain their populations under fishing pressures that are sufficient to sustain target teleost and invertebrate species [23]. According to [22], a decline in elasmobranch populations has been observed throughout the world and was particularly marked in the Indo-Pacific and Mediterranean Sea. The loss of some shark and batoid populations from aquatic ecosystems has socioeconomic and ecological consequences [24, 25].

The Mediterranean is considered a biodiversity hot spot for elasmobranchs [6, 22], being at the same time the area in the world with the highest proportion of threatened species because of unregulated fishing [2]. Besides fishery activities, Mediterranean elasmobranch populations are affected by pollution and habitat degradation resulting in drastic population declines [1]. In this area, some species are commercially targeted, but the majority are taken incidentally.

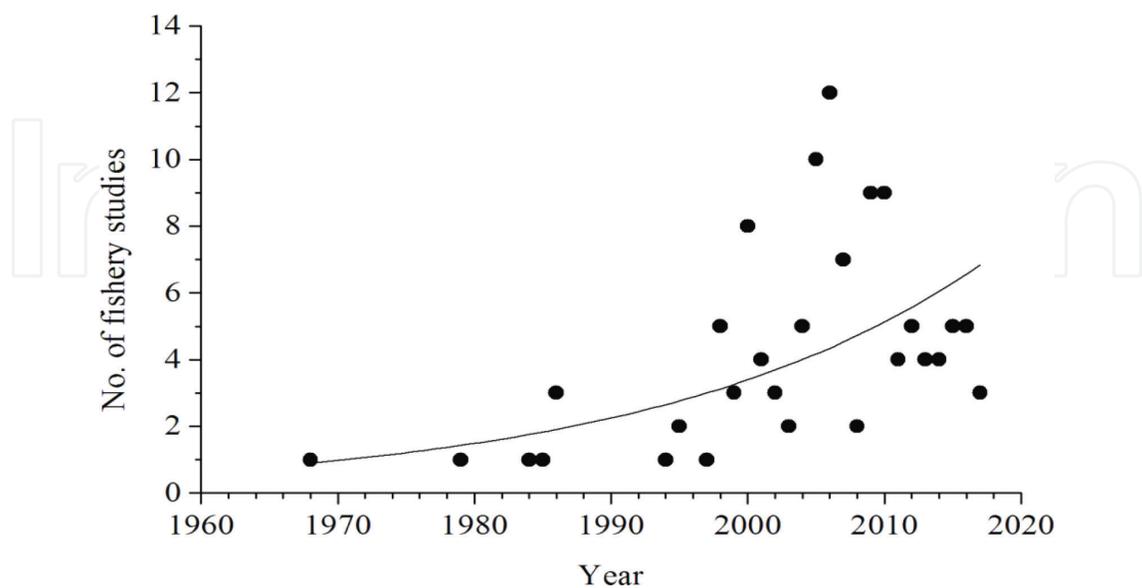


Figure 5. Temporal distribution of the number of published papers dealing with elasmobranch captures in the region in the Mediterranean Sea.

Mediterranean elasmobranch species are mainly coastal occurring within the range of fisheries, potentially producing high bycatch mortality [6].

The historically low economic value of elasmobranch products compared to bony fishes has resulted in a lower priority for research and conservation of these species in the Mediterranean Sea. The chronology of appearance of publications related to elasmobranch captures in the Mediterranean Sea shows an increased concern in recent year (**Figure 5**).

Given the socioeconomic and ecological consequences of declining shark and ray populations, there is an imperative to address declines by implementing effective conservation management.

3.1. Fisheries targeting elasmobranchs

In the Mediterranean Sea, few fisheries are targeting elasmobranchs; this fish group is mainly landed as bycatch [6, 26]. Elasmobranch species were targeted due to the decline of bony fish stocks and the increase in shark domestic consumption. The elasmobranch species were targeted mainly using specific gillnets and longline.

3.1.1. Gillnets

Fisheries targeting sharks in the Mediterranean Sea are generally seasonal and local [27–29]. These fisheries operate on the basis of the seasonal abundance of elasmobranch species. Furthermore, in some coastal communities, sharks represent a subsistence fishery between more profitable fishing seasons for teleosts, mollusks, and crustaceans [29]. These fisheries are very heterogeneous because the targeted species, the type of vessels, and the gears used vary locally and seasonally. Few studies have been undertaken to assess the biological characteristics and impact of these fisheries.

Smooth-hound sharks (*Mustelus* sp.) are targeted by specific gillnets in the north Adriatic Sea during spring [27] and in restricted area along the Mediterranean Turkish coasts [28]. In Tunisia, the fishery of smooth-hounds began in the mid-1980s using special gillnets called “Gattatia” from February to June along the Gulf of Gabès coasts (**Figure 6**). This gillnet has a stretched mesh size of 120–160 mm [29]. In recent years, sandbar sharks and the blackchin guitarfishes have become the object of directed artisanal fisheries using a special gillnet (stretched mesh size of 240–340 mm) locally known as “kallabia.” Sandbar sharks are targeted through April–June and, moreover, the guitarfishes during summer months [29]. In addition, *Carcharhinus* sp. and guitarfishes have become the object of directed artisanal fisheries along the Libyan coasts using gillnets [30, 31]. During the fishery season, gillnets are left in place and inspected daily.

3.1.2. Longlines

The longline targeting sharks is known mainly in Tunisia and Libya. Decline in catches of swordfish in the area has shifted the pelagic longline to target elasmobranchs. The sandbar sharks are fished through July–October [32]. During 2007/2008 the catch rates of *C. plumbeus* in pelagic longline were 15.22 individuals/1000 hooks [32]. On the other hand, *Carcharhinus* sp.



Figure 6. Elasmobranch species landed by specific gill nets in the Gulf of Gabès.

and guitarfishes are seasonally fished along Libyan coasts using bottom and pelagic longlines [30, 31]. Unfortunately, there is no data on species composition and catch rates about Libyan shark fisheries.

Although, these gears are considered selective, they bring several other nontarget species: *Scyliorhinus canicula* (Linnaeus, 1758); *Squalus acanthias* Linnaeus, 1758; *Scyliorhinus stellaris* (Linnaeus, 1758); *Myliobatis Aquila* (Linnaeus, 1758); *Pteromylaeus bovinus* (Geoffroy Saint-Hilaire, 1817); *Galeus melastomus* (Rafinesque, 1810); *Centrophorus granulosus* (Bloch & Schneider, 1801); *Raja radula* Delaroche, 1809; *Raja miraletus* Linnaeus, 1758; *Carcharhinus* sp.; *Dasyatis* sp.; etc. [27, 29–32]. Among sharks, *Mustelus* genus is the most targeted species throughout the whole Mediterranean Sea [27, 29–32]. Indeed, this genus is present in the entire Mediterranean Sea, while the other species such as guitarfishes and sandbar sharks are more abundant in Tunisia and Libya [30, 31, 33].

3.2. Incidental capture

Research on elasmobranch bycatches has focused mainly on industrial fisheries [34]. However, recently, it appears that small-scale fisheries are also an important source of mortality for marine vertebrates [35, 36]. In fact, all cartilaginous fishes are caught accidentally in most fishing gear in the Mediterranean [37].

3.2.1. Small-scale fisheries

Small-scale fisheries, including artisanal and traditional fisheries, comprise over 80% of the Mediterranean fleets [38]. In the Mediterranean Sea, small-scale fisheries represented essentially by set nets and bottom longline are included in various métiers that are characterized by different fishing grounds, seasons, and target species.

The small-scale fisheries capture mainly elasmobranch species inhabiting the continental shelf [38–42]. In general, species composition and importance varied regionally. In the Gulf of Gabès, trammel net captures were dominated by the smooth-hound sharks; however, sting-rays and skates were the most captured species in Balearic Islands, Corsica, and Aegean Sea [38–42].

Bottom longline targeting teleost fishes caught incidentally several demersal elasmobranch species [43–45]. In the Aegean Sea, skates (*R. radula*, *R. clavata*, and *R. miraletus*) represent 6 to 19% of the total catch. These rates vary with the hook size [43, 44]. In Adriatic Sea, bottom longline capture *Raja* sp., *G. melastomus*, and *Mustelus mustelus* (Linnaeus, 1758) [45]. Along the Lebanese coasts, small-scale fisheries capture incidentally more batoids than sharks: *Rhinobatos rhinobatos* (Linnaeus, 1758); *Torpedo marmorata* Risso, 1810; *R. miraletus*; *G. cemiculus*; and *C. granulosus* are the most fished species. [46]. Furthermore, small-scale fisheries affect mainly small species or newborns and juveniles of large species [42]. Among captured elasmobranch, discards and retained species varied also regionally based on its economic value [38–44].

The Mediterranean elasmobranch species are mainly coastal and benthic (80%), which make them vulnerable to fishing activities concentrated mainly on the coasts [6]. Considering the importance of small-scale fleet in the Mediterranean Sea, they represent a significant source of mortality for early-life stages of elasmobranch species. These fisheries operate mainly in nursery areas and coincide with the parturition period of most species. Because of the overlap of small-scale fisheries with critical area worldwide, they may be among the greatest current threats to nontargeted megafauna [35, 47].

3.2.2. Industrial fisheries

All cartilaginous fishes are caught accidentally in most industrial fishing gear in the Mediterranean [37]. It seems that trawlers, pelagic longlines, and purse seine constitute the most important threat to elasmobranch species.

3.2.2.1. Trawlers

Although trawlers represent about 10% of the Mediterranean fleet, they contribute by approximately 50% of the landed catch, which emphasize their importance. This technique generates several problems: juvenile catches, important discards, and negative impact on the environment [48]. In the Mediterranean, discards constitute over 40 percent of the catch [49].

For this fishing gear, very often the information concerns a listing of species without an estimate of catch rates by fishing effort. Recently, preliminary information on this issue was reported in the Aegean Sea [50], in the Gulf of Gabès [51], and in Turkish coasts [52].

All elasmobranch species are caught by trawlers; 62 species are listed in trawl fisheries in Greece, 62 species in Catalonia and 74 in Italian waters, 31 species in the Gulf of Gabès, and 20 species in Iskenderun bay [51–53]. However, demersal species, particularly *Etmopterus spinax* (Linnaeus, 1758), *G. melastomus*, *S. canicula*, *Mustelus* sp., and Rajidae are most caught [50, 54–56].

The proportion of elasmobranch in catch varied locally. In the Alboran Sea, elasmobranch species represent 4.91 to 8.24 percent by weight of total catches [56]. In Iskenderun bay and the Gulf of Gabès, elasmobranchs represent 23% and 5.4%, respectively [51, 52].

Among rays, it is noted that *R. clavata*, *R. radula*, and *R. miraletus* are the species most commonly caught in the Mediterranean trawling [53, 57]. This technique generates occasional catch of pelagic sharks as *Alopias vulpinus* (Bonnaterre, 1788); *Prionace glauca* (Linnaeus, 1758); *Isurus oxyrinchus* Rafinesque, 1810; *C. carcharias*; and rarely *Cetorhinus maximus* (Gunnerus, 1765).

3.2.2.2. Longlines

Generally, two types of longlines are used in the Mediterranean: bottom and surface longlines.

The surface longline targets, according to the hook size and immersion depth, swordfish (*Xiphias gladius* Linnaeus, 1758), albacore (*Thunnus alalunga* Bonnaterre, 1788), and tuna. This gear captures accidentally at least 12 species of sharks [58–62]. The most affected species are *P. glauca* and *I. oxyrinchus*. The catch rate of sharks was highest in the Alboran Sea followed by the Adriatic Sea [60–62].

Bottom longline catches especially batoids; in the Aegean Sea, the Rajidae (*R. radula*, *R. clavata*, and *R. miraletus*) represent 6 to 19 percent of the total catch. These rates vary with the hook size [42]. In the Gulf of Gabès, bottom longline targeting groupers captures incidentally the most abundant species such as *Mustelus* sp. and *Rhinobatos* sp. [31].

3.3. Impact of fisheries

Despite their sensible life-history characteristics, Mediterranean shark captures have historically received less attention than bony fish. Unfortunately, the overexploitation added to biological characteristics of the group has led many species to be threatened or disappeared from many areas [31].

Scarce data exist to quantify the historical level of elasmobranch exploitation in the Mediterranean, as the long-term sources of information to assess shark removals are very rare in this region [63]. The decline of elasmobranch species in the Mediterranean was recognized by IUCN [2] and also confirmed by fishers [64], while the rate of reduction in the different sectors of the Mediterranean is unclear by species. The decline importance varies locally in relation to fisheries importance (**Figure 7**).

Spatiotemporal analyses of large shark abundances in the Mediterranean Sea show that population status spatially ranges from overexploited to locally depleted and local extinction [1]. The case was also reported for *Squatina squatina* (Linnaeus, 1758) [65]. Recent analysis of the frequency of occurrence of smooth-hounds in fishery catch data showed that the species have declined by 80–90% since the beginning of last century to almost disappear in a large part of their original distributional range during the 1980s and 1990s [66]. Bibliographic data gathered in scientific bottom trawl surveys carried out off the southern coasts of Sicily from 1994 to 2009 and between a depth of 10 and 800 m indicated an

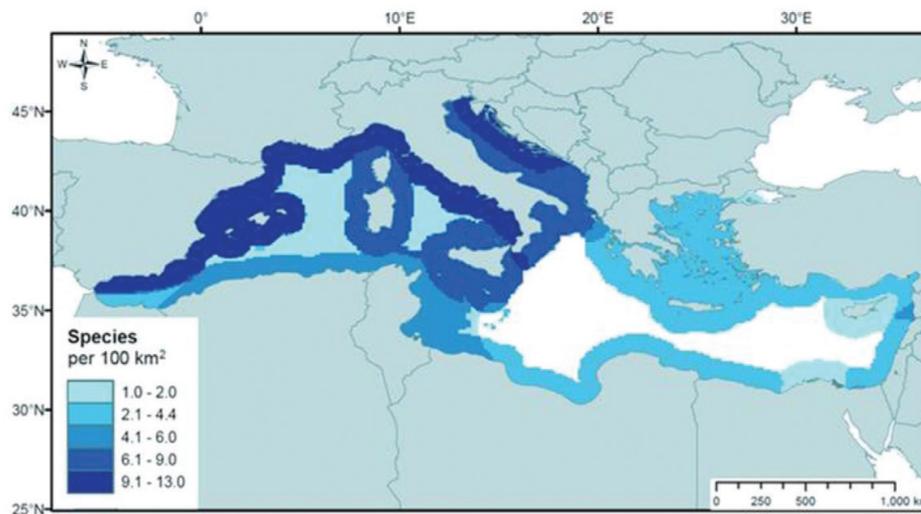


Figure 7. Extinct and possibly extinct species in the Mediterranean Sea, showing that local extinctions have been most prevalent in the NW Mediterranean Sea [2].

important decline in abundance of the most captured species [67]. Analysis of Italian annual landing for elasmobranchs between 1997 and 2004 decreased 77% compared with the previous years (1959–1982). This decrease may be attributed to overharvesting that occurred during the 1980s and 1990s in Italian seas [68]. Several species (*Rhinobatos* sp., *Carcharhinus* sp., *Mustelus* sp., etc.) previously considered as common along the Mediterranean Sea were absent on MEDITS trawling surveys between 1994 and 1999 and currently appear to be disappeared from the north coasts [53].

In the frame of ACCOBAMS-GFCM Project on mitigating interactions between endangered marine species and fishing, developed with the collaboration of the RAC/SPA and a substantial financial support from the MAVA foundation, results of a pilot action on mitigating bycatch and depredation of elasmobranchs, sea turtles, and cetaceans in surface and bottom longline fisheries operating in the Gulf of Gabes (2016–2017) indicate a significant decline in catch rates of the most targeted species mainly *C. plumbeus* comparatively to summer 2007/2008. In addition, there is a shift for other species habitually considered as unwanted such as *Dasyatis* sp.

This decline can be attributed to a number of factors, mainly the intense fishing activity throughout the coastal and pelagic waters of the basin, such as the Gulf of Lions [69], the Tyrrhenian Sea [63], and the Adriatic Sea [70]. Moreover, the lack of biological information and appropriate fishery databases limits the assessment and management plan of elasmobranchs in this area [36].

Today, it is thought that economically viable and biologically sustainable yields can be taken from some of the relatively more productive species, such as *Mustelus*, under careful management [36]. However, in the Mediterranean Sea, bycatch and direct fisheries are unregulated, unmonitored, and unreported to national or international management agencies.

4. Compilation of conservation and mitigation measures for elasmobranch bycatch

Given this situation, several conservation measures for these fish are taken or suggested at the national, regional, and international levels. We review some of them.

4.1. General measures

- The shark fin trade

The trade in shark fins consists of cutting and keeping the fins of the shark and throwing the mutilated living part back into the sea. This is a cruel and wasteful practice since only 2 to 5% of the shark is exploited. Although the actual extent of shark fin trade in the Mediterranean is unknown, this practice is now a major global problem.

According to GFCM regulations (REC.CM-GFCM, 36/2012/3), the removal of fins and their purchase and sale are prohibited. Similarly, the butchering of specimens onboard the vessel and prior landing is prohibited.

- Marine protected areas

Marine protected areas (MPAs) are recognized as effective tools for protecting the marine environment and as an approach that takes into account the ecosystem as a whole. Today, most of these protected areas occur in coastal waters in the north of the region, highlighting the importance of identifying MPAs along the southern and eastern coasts, as well as on the high seas.

- International conventions

Several conventions relating to the conservation and management of ichthyofauna in the Mediterranean Sea have been ratified by all Mediterranean countries.

4.2. Mitigation of incidental catches of elasmobranchs by longline

In the light of the experiences of several longline fisheries, the following recommendations should be noted:

- Plunge hooks deeper and the day.

The main species of pelagic sharks, as well as stingrays (*Dasyatis* sp.), are generally taken in surface waters, and shark activity is generally nocturnal.

- Avoid attracting sharks and rays.

In particular, avoid dumping garbage, viscera, and unmarketable fish into a fishing area if you do not want to attract scavengers like most elasmobranchs.

- Reduce the time of setting, to avoid that elasmobranchs are attracted in large numbers by captured prey.

- Avoid certain types of bait that may be more attractive than others; several observations made by professionals have shown that sharks are more attracted to squid than to fish. To avoid catching stingrays and sharks mackerel or horse mackerel should be used instead of sardines.

On the other hand, the development of artificial baits could be an important contributor to the reduction of catches of sharks and rays.

- Reduce the mortality caused by fishing operations.

Most of the elasmobranchs caught by longlines are alive at the time of longline recovery; it is advisable to be able to release them immediately by avoiding, if possible, any bruising. In general, the use of monofilament snoods, which sharks can more easily cut, is preferable than any other type of braided synthetic fiber or steel [57].

- Move elasmobranchs away from baited hooks.

Pretreatment of baits with some synthetically produced substances may keep Carcharinids away without affecting other fish.

- Small magnets of steel alloy, neodymium, and boron would be able to keep small sharks or skates away from baited hooks.
- Guidelines for Recreational Fishing for Sharks and Rays in the Mediterranean Prepared by RAC/SPA for recreational fishermen as a contribution to the Action Plan for the Conservation of Cartilaginous Fish in the Mediterranean Sea aim, among other things, to reduce the potentially harmful impacts of recreational fishing activities on the Mediterranean shark and ray populations by advocating release. This Code of Conduct recommends the use of circular hooks; J-hooks are more likely to be swallowed than circular hooks. Barbed hooks are difficult to remove and can cause damage to internal organs. Circular hooks generally cling to the jaw and are easier to catch for quick release.

In order to evaluate the efficiency of some measures to reduce bycatch in the Gulf of Gabes (Tunisia), we evaluated the effect of hook shape (circle hook) and bait nature during experimental trips (23 fishing sets) conducted during summer 2016.

The nature of the bait and the shape of the hook may have impact on CPUE of the sandbar shark and other endangered shark listed in appendix II of the SPA/BD Protocol.

The CPUE of sandbar shark varies from 6.73 (individual/1000 hooks) with mackerel or other teleost used as bait to 17.94 when using elasmobranch bait. The use of circular hooks increased shark catches and specimens size while allowing more easy release of captured shark.

We focus mainly on endangered species in appendix 2 of the protocol concerning specially protected areas and biological diversity in the Mediterranean because this list was adopted by the GFCM in the Recommendation GFCM/36/2012/3 on fishery management measures for conservation of sharks and rays in the GFCM area.

In fact, GFCM parties shall ensure a high protection from fishing activities to elasmobranch species listed in Annex II of the SPA/BD protocol of the Barcelona Convention (list of endangered or threatened species) that must be released unharmed and alive to the extent possible.

Specimens of sharks' species listed in Annex II of the SPA/BD Protocol cannot be retained on board, transhipped, landed, transferred, stored, sold, or displayed or offered for sale.

5. Conclusion

About 86 species of elasmobranchs are thought to occur in the Mediterranean Sea (49 species of sharks and 37 batoids). The distribution of elasmobranch fishes is not homogenous. Concentration of rays and sharks occurred in coastal waters of the western basin and the central Mediterranean, especially in the waters of Tunisia and Libya.

Some areas are considered as critical habitats for elasmobranchs such as the Gulf of Gabès (Tunisia).

Elasmobranchs are incidentally caught as bycatch, but sometimes they are directly targeted by commercial and recreational fisheries in some areas. Catches represent a mean of 1.1 percent of the total landings during the last 35 years. The catches show a decreasing trend from 1983 (about 26,000 tons) to 2015 (about 14,000 tons). The major elasmobranch-fishing countries within the Mediterranean are Libya and Tunisia for the last 7 years.

Small-scale fisheries, represented essentially by set nets and bottom longline, engender capture of several demersal species, with variable abundance among areas. All cartilaginous fishes are caught accidentally in most industrial fishing gear in the Mediterranean. It seems that trawlers, pelagic longlines, and purse seine constitute the most important threat to elasmobranch species.

Protection is currently granted to chondrichthyan fish species under various regional and international conventions where generally few species are considered. Few countries have developed their own legislation.

Taking action to collect reliable statistics on landings and bycatch of elasmobranchs should be a priority for shark's conservation. Thanks are given to the GFCM which started a program to collect data on bycatch in the Mediterranean Sea.

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