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MEDLEM database, a data collection on large Elasmobranchs in the Mediterranean and Black seas

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Abstract

The Mediterranean Large Elasmobranchs Monitoring (MEDLEM) database contains more than 3,000 records (with more than 4,000 individuals) of large elasmobranch species from 21 different countries around the Mediterranean and Black seas, observed from 1666 to 2017. The principal species included in the archive are the devil ray (1,868 individuals), the basking shark (935 individuals), the blue shark (622 individuals), and the great white shark (342 individuals).

In the last decades, other species such as the thresher shark (187 individuals), the shortfin mako (180 individuals), and the spiny butterfly ray (138) were reported with increasing frequency. This was possibly due to increased public awareness on the conservation status of sharks, and the consequent development of new monitoring programs. MEDLEM does not have homogeneous reporting coverage throughout the Mediterranean and Black seas and it should be considered as a database of observed species presence. Scientific monitoring efforts in the south-eastern Mediterranean and Black seas are generally lower than in the northern sectors and the absence of some species in our database does not imply their actual absence in these regions. However, the available data allowed us to analyse the frequency and spatial distribution of records, the size frequencies for a few selected the available data allowed us to analyse the frequency and spatial distribution of records, the size frequencies for a few selected species, the overall area coverage, and which species are involved as bycatch by different fishing gears.

Keywords: Bycatch; databases; geographical distribution; large elasmobranchs; Mediterranean and Black seas; sharks.

Introduction

Even if the Mediterranean Sea covers approximately 1% of the planet's ocean surface, it displays a relatively high fish diversity, with approximately 3-4% of the entire world's fish species inhabiting its waters (Fredj *et al*., 1992; Groombridge & Jenkins, 2002). In particular, the chondrichthyan richness is particularly high with 7% of the total number of cartilaginous fishes represented inside the basin (Compagno, 1984a; Compagno, 1984b; Séret & Serena, 2002; Last *et al*., 2016; Serena, 2005; FAO, 2018a; FAO, 2018b). Despite this high biodiversity, the Mediterranean Sea shows greater conservation concern for chondrichthyans than the rest of the world, as reported by the last IUCN Regional Red List assessment, which listed more than half of the 73 evaluated species as threatened (Dulvy *et al*., 2016). In addition, after ten years since the first assessment, 13 species are still considered data deficient, indicating large knowledge and data gaps characterising this geographic area (Walls & Dulvy, 2020).

Due to their life history characteristics, sharks and rays are particularly susceptible to over-exploitation and their populations have very low resilience. Species often show restricted distributions and small population sizes, dependent on mating, spawning, nursery, and breeding grounds or specific habitats (Stevens *et al*., 2000; Serena, 2005). In general, cartilaginous fish are exploited for fins, skin, jaws, and meat. Sometimes they are a direct target of 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 landings has been observed, while fishing effort has generally increased (Heithaus *et al*., 2008; McPhearson & Myers, 2009; Davidson *et al*., 2016). The global capture of sharks and rays reported to the Food and Agriculture Organization of the United Nations increased to a peak in 2003 and subsequently declined by 20% (Dulvy *et al*., 2014).

Since 2010, the General Fisheries Commission for the Mediterranean (GFCM) adopted measures to reduce bycatch rates and, after that, a reduction in sharks and rays landings has been observed in the Mediterranean area (FAOc, 2018). However, there is no evidence that the discard of these species has also been reduced. Moreover, many countries reported shark statistics without making any distinction at the species level or even not recording some species at all. The inadequate collection of landing information in many areas makes it difficult to quantify the impact of fishing drawdown.

Large cartilaginous fishes are mostly pelagic and highly migratory species not closely associated with the seabed but living primarily in the open seas, away from continental shelves. Their highly migratory nature and their behaviour generally do not reflect environmental boundaries. In the Mediterranean, both life-history traits and a very low catch rate resulted in several issues for the collection of robust scientific data. The most common monitoring schemes usually fail to reveal large pelagic shark occurrences and data collection is not supported by standardised assessment procedures (Damalas & Megalofonou, 2012). Although there is no real direct fishery targeting large cartilaginous fishes in the Mediterranean and Black seas, they are incidentally caught mainly by gillnets and longlines. In contrast, benthic rays and some smaller sharks, such as the smooth-hound and catsharks, constitute a lower bycatch portion in these fishing gears, whilst they are often important bycatches of the bottom-trawl and small-scale fisheries, widely operating throughout the basin. Large elasmobranchs are also caught by bottom longlines targeting European hake. The surface drifting longlines, targeting tuna and swordfish, also capture some pelagic shark species as bycatches or discards (Bonfil, 2002; Mejuto *et al*., 2002; Peristeraki *et al*., 2008; Damalas & Megalofonou, 2012; Garibaldi, 2015; Poisson *et al*., 2016).

In the Mediterranean area, the basking shark (*Cetorhinus maximus*), the devil ray (*Mobula mobular*), and the great white shark (*Carcharodon carcharias*) have been historically recognised as the species that require the most protection. Although they are not directly targeted by any Mediterranean fishery except, perhaps, the devil ray in the Gaza Strip (Palestine), they have been included in several conventions related to conservation of marine living resources: Barcelona Convention Protocol on Specially Protected Areas and Biological Diversity (SPA/BD) in the Mediterranean (all three species are listed in Appendix II), Bern Convention, on Appendix II of the Convention on International Trade in Endangered Species (CITES), and in some national and EU regulations.

To face the biodiversity loss and to increase the effectiveness of the conservation measures in the Mediterranean basin, it is important to establish a common procedure to collect data on shark specimens that are accidentally captured, sighted at sea or stranded. In this light, the MEDLEM database (Mediterranean Large Elasmobranchs Monitoring) aims at contributing to the improvement of knowledge on the presence, spatial distribution, and bycatch of large elasmobranch species present in the Mediterranean and Black seas. Hence, it may represent a useful tool for national and international organisations involved in the biodiversity management and conservation of this important semi-enclosed basin (e.g., the Food and Agriculture Organization/General Fisheries Commission for the Mediterranean (FAO-GFCM), the United Nations Environment Programme/Mediterranean Action Plan and IUCN SSC Shark Specialist Group, and the European Community Action Plan).

In more detail, the main aims of the MEDLEM programme are (1) collecting information on bycatch, sighting, and stranding events throughout the Mediterranean and Black seas, (2) establishing a common protocol, and (3) recording their spatial occurrence (Serena *et al.*, 2014). As an additional goal, MEDLEM stores scientific papers related to elasmobranchs in the Mediterranean and Black seas as well as any reliable information from newspapers and social media.

Established officially in 1985 (Mancusi & Serena, 2014), it became fully operational in 2000, beginning to record data on elasmobranchs catches, sightings, strandings, and historical records within a single database (Ben-Tuvia, 1971; Boero & Carli, 1979; Biagi, 1995; Megalofonou *et al.*, 2000; Lipej *et al.*, 2000; Bradaï *et al.*, 2002; Barrul & Mate, 2002; Soldo & Jardas, 2002a; Soldo & Jardas, 2002b; Morey & Massuti, 2003; Kabasakal, 2004; Morey *et al.*, 2006; Morey *et al.*, 2008; Ali & Saad, 2010; Kabasakal & De Maddalena, 2011; Kabasakal, 2013a; Kabasakal, 2013b; Carlucci *et al.*, 2014).

The MEDLEM programme directly links up with the FAO IPOA-Sharks and it was submitted to the discussion of the SAC Sub-Committee on Marine Environment and Ecosystems (SCMEE) of the GFCM, Scientific Advisory Committee on Fisheries (SAC) (Barcelona, 6-9 May 2002) as "subproject Basking shark". At the meeting of the SCMEE in Spain (Malaga, 10-12 May 2004), a common protocol for collecting field data was proposed and many Mediterranean countries showed the will to cooperate with this initiative and to conform to a standardised data collection framework. At the seventh session of the GFCM (Rome, 19-22 October 2004), the SCMEE reiterated the importance of wider uses of the MEDLEM protocols and information system, already adopted by several regional bodies, to favour the timely exchange of information on large elasmobranchs (FAO, 2005; Serena *et al.*, 2008; Serena *et al.*, 2009). The MEDLEM programme has also been presented at the European Elasmobranch Association annual conference (Mancusi *et al.*, 2005), the IUCN (Cavanagh & Gibson, 2007), and RAC-SPA (UNEP, 2009) meetings.

Materials and Methods

Study area

The Mediterranean Sea covers ca. 2,500,000 km^2, with 23 countries bordering its more than 45,000 km of coastline (EU, 2010). The basin spans from the Straits of Gibraltar to the Middle East for ca. 4000 km, reaching its maximum depth (5,267 m) in the eastern Ionian Sea (Calypso Pit) (Barale, 2008). The Mediterranean Sea can be roughly divided into two main sub-basins, the western and the eastern Mediterranean, separated by the Sicily-Tunisia ridge. The eastern basin is characterised by a higher oceanographic variability of SSTs (Sea Surface Temperatures) ranging between 17.82°C during winter and 29.71°C during the warmest months (Poulos *et al.*, 1997; Abboud Abi Saab *et al.*, 2013) and, also, a higher average salinity (39‰). By contrast, the western basin is generally cooler and relatively less salty, with an average sea surface temperature of 12°C during winter, 23°C during summer, and an average salinity of ca. 36‰ (Serena, 2005).

The MEDLEM database

The main features of the MEDLEM Database Application are: (i) the implementation of data collection, especially for bycatch evaluation; (ii) the standardisation of data entry procedures; (iii) effective data sharing among the participating countries, and (iv) free access for participants to the web site. The database was initially created in Oracle. Recently, the application has been written with Apache/Perl technology, allowing interfaces to a MySQL database (version 3.23.58); a migration from MySQL to Oracle has been necessary using the technology Zope/Plone or Apache/PHP (Serena *et al.*, 2006). The MEDLEM database is organised as shown in Table 1. The protocol characterises the word "large", which defines the nature of the database (Mediterranean Large Elasmobranchs Monitoring database). This refers to the

Table 1. Structure of the MEDLEM database.

Documentation of the archive	Contents of the documentation
BIBLIOGRAPHIES	Bibliographic references
BIOLOGICAL_PARAMETERS	Biological parameters (length, weight, sex, biometrics, etc.), if known, of the species insert in the database
GEARS	List of the fishing gears responsible for captures
SPECIES_DATA	Spatio-temporal data about catches, strandings or sightings (data, time, country, latitude, longitude, etc.);
SPECIES_LIST	List of all the species captured/sighted/stranded
USERS	Details of the users of the application

maximum size reached by each different species: we only consider sharks with more than 100 cm in total length (TL) and batoids with more than 150 cm in disc width (DW) (Serena *et al*., 2014). Applying this rule to our species in the Mediterranean and Black seas, we restricted for MEDLEM protocol the families listed in Table 2.

Thanks to the collaboration of several research institutes, military authorities, and professional and recreational fishermen a great amount of valuable information on catches, sightings, and strandings of large cartilaginous fishes has been archived into the MEDLEM database. Furthermore, the database gathered significant observations derived from social media, particularly Facebook and YouTube, with some videos and images allowing species identification. Thanks to the support of Facebook pages and citizen science platforms such as the "Mediterranean marine life" Facebook group, SharkPulse, the "Gruppo Ricercatori Italiani sugli Squali, razze e chimere (GRIS)", the SharksStudiesCenter, etc., we have been able to obtain valid data. Currently all information is collected by the medlemcontact@gmail.com account or directly on the field.

A data quality check is carried out on all newly received information. Unconfirmed information is discarded, and duplicated data is eliminated. The data collected allowed us to create records distribution maps for the most significant species, mad possible using a software called ModestR, which supports arranged databases in providing features to clean, manage, and analyse large species distribution datasets (García-Roselló *et al*., 2014).

Finally, to take into account biases related to differences in reporting rates between different historical periods, occurrence rates (specimens per year), were measured considering three different periods, arbitrarily designated: 1800–1865; 1866–1985 and 1986–2017. During the first period, named "ancient", events such as catches, sightings, etc., were reported in literature occasionally and ancillary information was absent or rarely included in the report. During the successive period, up to approximately 1985, even if several occurrences were recorded, they were often collected in a non-systematic manner, and with information quality and details depending only on the scientists' skills. In the most recent times, many better-defined monitoring programs have been activated, including MEDLEM, which unofficially recorded events as early as 1975. Previous recordings quoted in 1666 have been considered just as general information. As part of this program and thanks to the creation of an information network in the Mediterranean, it was possible to acquire more and higher quality information, although actual effort cannot guarantee complete spatio-temporal coverage and some occurrences are likely to still be lost. The amount of information collected in MEDLEM allowed us to carry out a first preliminary assessment of the elasmobranch bycatch in the Mediterranean as well as to enhance our knowledge of many biological aspects of some species. Indeed, due to these records, it was possible to estimate the length-weight relationships and the length-frequency distributions for some Mediterranean elasmobranch species.

Results and Discussion

The data recorded into the MEDLEM database and presented here refer to the period from 1666 to 2017. The archive contains a total of 4,963 specimens corresponding to 3,197 records, obtained from various research institutes belonging to 21 different countries. The higher number of records are mainly from Italy (2,248 records) followed by Palestine (1,084 records, almost entirely matching to exceptional *M. mobular* catches), Greece (301), Spain (286), Croatia (225), Turkey (159), Egypt (128), France (126), Syria (115), Malta (93), Tunisia (68), followed by the other countries (Fig. 1A).

The MEDLEM database includes 34 species and 2 categories (group of species) belonging to 16 different families and 7 orders (Tab. 2). The most frequent species reported is the devil ray (*M. mobular*) holding 37.6% of the total number of records, followed by the basking shark (*C. maximus*, 18.8%), the blue shark (*Prionace glauca*, 12.5%), the great white shark (*C. carcharias*, 6.9%), the thresher shark and bluntnose sixgill shark (*Alopias vulpinus* and *Hexanchus griseus* each with 3.8%), the shortfin mako (*Isurus oxyrinchus,* 3.6%), and the spiny butterfly ray (*Gymnura altavela*, 2.8%). All the other species account for ca. 9% of the available records (Fig. 1B). The highest occurrence of *M. mobular* records is ascribed to two specific events in March 2006 and February 2013, in which 279 and 299 specimens were landed in Gaza Strip (Levantine Sea) by a local purse seine, called "shinshula", and then slaughtered on the beach and used as food (Abudaya *et al*., 2017). Remarkably, it seems that the local fishery directly targeting *Mobula* has been operating in the area throughout the years, passing unnoticed until those events were reported (Cebrian, *pers. comm.*).

Other records in the database refer to less (*I. oxyrinchus, G. altavela, A. vulpinus, H. griseus*) or rarely observed species (*Alopias superciliosus, Sphyrna zygaena*, *Squatina squatina,* and *Squatina oculata*). Among the rarely sighted species, some observations can be considered as the first record of the species in the Mediterranean Sea: *Sphyrna mokarran* (Boero & Carli, 1977) and the recently well-documented first occurrence of *Galeocerdo cuvier* (Tobuni *et al*., 2016). Furthermore, some records reported the first observation of a species in national waters, such as *Taeniurops grabatus* in Italy and Syria (Serena *et al*., 1999a; Ali *et al*., 2013) and *Himantura uarnak* in Syria (Ali *et al*., 2010). The database also includes some questionable records of *Sphyrna tudes.* This species was initially described in the Mediterranean Sea by Tortonese (1951) and later confirmed by McEachran & Séret (1987), but needs confirmation.

Regarding the occurrence rates from 1800 to 1865, the average was 1.7 specimens/year, which increased to 5.3 specimens/year in the second period (1866-1985), based mainly on bibliographic sources. In the last 32 years (1986-2017), the recording rate has further increased to 87.3 specimens/year (Fig. 1E). However, this increase is likely to be attributed to the increased scientific community attention towards elasmobranchs and both the higher abilities and efforts attained in the identification and

Table 2. List of the orders, families and species recorded in the MEDLEM database. IUCN Categories are also considered (CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient; NE: Not Evaluated).

Group	Order	Family	Scientific name	Common name	IUCN Categories	Individuals	%
Batoid	MYLIOBATOFORMES	Mobulidae	Mobula mobular	Devil ray	EN	1868	37,6
Shark	LAMNIFORMES	Cetorhinidae	Cetorhinus maximus	Basking shark	EN	935	18,8
Shark	CARCHARHINIFORMES	Carcharhinidae	Prionace glauca	Blue shark	CR	622	12,5
Shark	LAMNIFORMES	Lamnidae	Carcharodon carcharias	Great white shark	CR	342	6,9
Shark	HEXANCHIFORMES	Hexanchidae	Hexanchus griseus	Bluntnose sixgill shark	LC	189	3,8
Shark	LAMNIFORMES	Alopiidae	Alopias vulpinus	Thresher shark	EN	187	3,8
Shark	LAMNIFORMES	Lamnidae	Isurus oxyrinchus	Shortfin mako	CR	180	3,6
Batoid	MYLIOBATOFORMES	Gymnuridae	Gymnura altavela	Spiny butterfly ray	CR	138	2,8
Shark	SQUALIFORMES	Echinorhinidae	Echinorhinus brucus	Bramble shark	EN	76	1,5
Batoid	MYLIOBATOFORMES	Dasyatidae	Dasyatis pastinaca	Common stingray	VU	69	1,4
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus plumbeus	Sandbar shark	EN	57	1,1
Shark	CARCHARHINIFORMES	Triakidae	Galeorhinus galeus	Tope shark	VU	51	1,0
Shark	LAMNIFORMES	Alopiidae	Alopias superciliosus	Bigeye thresher shark	EN	37	0,7
Batoid	RAJIFORMES	Rajidae	Rostroraja alba	White skate	EN	37	0,7
Shark	LAMNIFORMES	Lamnidae	Lamna nasus	Porbeagle	CR	27	0,5
Shark	SQUALIFORMES	Squatinidae	Squatina aculeata	Sawback angelshark	CR	26	0,5
Batoid	RAJIFORMES	Rajidae	Raiformes	Raja rays nei		22	0,4
Shark	CARCHARHINIFORMES	Sphyrnidae	Sphyrna zygaena	Smooth hammerhead	CR	21	0,4
Shark	HEXANCHIFORMES	Hexanchidae	Heptranchias perlo	Sharpnose sevengill shark	DD	10	0,2
Shark	LAMNIFORMES	Odontaspididae	Odontaspis ferox	Smalltooth sand tiger	CR	10	0,2
Shark	SQUALIFORMES	Squatinidae	Squatina oculata	Smoothback angelshark	CR	10	0,2
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus obscurus	Dusky shark	DD	9	0,2
Batoid	RHINOPRISTIFORMES	Rhinobatidae	Rhinobatos rhinobatos	Common guitarfish	EN	7	0,1
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus brachyurus	Copper shark	DD	6	0,1
Shark	SQUALIFORMES	Squatinidae	Squatina squatina	Angelshark	CR	6	0,1
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus spp	Carcharhinus sharks nei		5	0,1
Batoid	MYLIOBATOFORMES	Myliobatidae	Aetomylaeus bovinus	Bull ray	CR	3	0,1
Shark	CARCHARHINIFORMES	Carcharhinidae	Galeocerdo cuvier	Tiger shark	NE	3	0,1
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus falciformis	Silky shark	NE	2	0,0
Shark	CARCHARHINIFORMES	Sphyrnidae	Sphyrna tudes	Smalleye hammerhead	NE	2	0,0
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus brevipinna	Spinner shark	NE	1	0,0
Shark	CARCHARHINIFORMES	Carcharhinidae	Carcharhinus limbatus	Blacktip shark	DD	1	0,0
Batoid	RHINOPRISTIFORMES	Rhinobatidae	Glaucostegus cemiculus	Blackchin guitarfish	EN	1	0,0
Shark	HEXANCHIFORMES	Hexanchidae	Hexanchus nakamurai	Bigeyed sixgill shark	DD	1	0,0
Shark	CARCHARHINIFORMES	Carcharhinidae	Rhizoprionodon acutus	Milk shark	NE	1	0,0
Batoid	MYLIOBATOFORMES	Dasyatidae	Taeniurops grabatus	Round stingray	DD	1	0,0
				Total		**4963**	

Fig. 1: Number of the specimens recorded in the MEDLEM database by country (A). Proportional distribution of MEDLEM records by species (B). Details on circumstances the species has been found or captured (C). Type of gear used to catch the fished specimen recorded in the MEDLEM database (D). Others: rifle-harpoon 12; anchovy mid-water trawl 1; shrimp net 1; pole line 32. Number of registered records by year for each species (E). Number of records of the main species registered between 1990 and 2017 (F).

recording of shark species occurrences. However, the lack of both research programs and systematic sampling protocols concerning Mediterranean and Black seas' large elasmobranchs does not allow the reliable detection of temporal and spatial trends, so far. In this sense, the MEDLEM database is likely to provide an underestimation of the real value of the incidental catches.

In terms of species composition, the only recorded species before 1890 were the basking shark and the great white shark, with a sporadic presence of shortfin mako in 1870-1890. In the last decades, many other species were recorded (i.e., thresher shark, bluntnose sixgill shark, devil ray, and shortfin mako), reaching a total number of 34 species plus 2 categories of mixed species (Fig. 1F). Unfortunately, information on the fishing gears involved in the catches is often missing for most of the recorded specimens. Almost 40% of total records (approximately 1000 individuals) is related directly to the incidental catches that occur during normal fishing activities (Fig. 1C), mostly from trammel net, longlines and purse-seines. However, given that we know that during these activities the majority of incidental catches are not recorded, and occasional high catches sometimes occur such as the Gaza Strip events described above, such specific episodes can cause high bias in the final analysis (Fig. 1D).

The information' spatial coverage is more complete and more capillary in the Adriatic, Tyrrhenian, Aegean and Balearic seas and the Strait of Sicily. The south-central and south-western Mediterranean sectors provided less information, probably as a result of lower coverage of the collaborative research centres (Fig. 2). The great white shark (*C. carcharias*) has been reported throughout the Mediterranean with greater frequency in the northern Adriatic Sea (FAO-GFCM's Geographic Sub Area [GSA] 17), Straits of Sicily (GSA 16) and Tyrrhenian Sea (GSA9). It is also reported from Tunisian waters (Bradaï & Saidi, 2013), Turkish waters and the Marmara Sea (Kabasakal, 2003a; Kabasakal, 2008) (Fig. 3A). The basking shark (*C. maximus*) has been reported in different Mediterranean areas with some records distributed in all GSAs. The majority of other records was observed (in decreasing order) in the northern Tyrrhenian Sea (GSA 9) (Serena *et al*., 1999b), Balearic Islands, northern coasts of Spain (GSA 5 and 6), Adriatic Sea (GSA 17) (Mancusi *et al*., 2005), Tunisia (GSA 13 and 14) (Capapé *et al*., 2003b), Turkey (Kabasakal, 2013b), Syria (Ali *et al*., 2012) and northern Ionian Sea (Carlucci *et al*., 2014) (Fig. 3B). Data suggest seasonal hotspots of basking sharks around north Sardinia and Apulian coasts, where individuals were recorded mainly between January and March (De Sabata & Clò, 2010; Carlucci *et al*., 2014; De Sabata *et al*., 2014. The shortfin mako (*I. oxyrinchus*) has been recorded along the Italian coasts, mainly in the northern Tyrrhenian and Adriatic seas, but also in Cretan waters (GSA 23) and south Levantine waters (GSA 26) (Lteif, 2015); many records were reported also from Tunisian waters (Bradaï *et al*., 2002). The largest shortfin mako shark recorded in the Mediterranean Sea was caught off south-western Turkey, and it was ca. 580 cm in TL (Kabasakal & De Maddalena, 2011) (Fig. 3C).

The bluntnose six-gill shark (*H. griseus*) was reported in Maltese waters (20 specimens; GSA 15), in the northern Tyrrhenian Sea (45 specimens; GSA 9), in southern Adriatic Sea, northern Ionian Sea, south Sicily waters (21 specimens; GSA 18, 19 and 16 respectively), along the coasts of Tunisia (GSA 13 and 14) (Capapé *et al*., 2003a; Capapé *et al*., 2004) and in the Turkish waters (24 specimens). Kabasakal (2013b) states that 150 specimens of *H. griseus* were caught by commercial fishing vessels in the seas of Turkey between 16 July 1967 and 4 February 2013, 90 of which were recorded in the Marmara Sea (Fig. 3D). The bluntnose six-gill shark is also regularly captured along the coast of Lebanon (Lteif, 2015.) but currently not recorded in detail in the database. Also, there are some incidental catches of *H. griseus* mainly on deep bottom longlines as well as very rare incidental catches of *A. vulpinus* and *A. superciliosus* on surface longlines targeting swordfish in the Aegean Sea and the seas around Crete, but specific records could not be provided (Lanteri *et al*., 2017).

Even if its presence is known in many other areas, the thresher shark (*A. vulpinus*) has been mainly reported in the northern Tyrrhenian Sea (GSA9), Adriatic Sea (GSA 17) (Fortuna *et al*., 2010) and around Balearic Islands (GSA 5). The thresher shark is also regularly observed in the Gulf of Gabes (GSA 14) (Bradaï *et al*., 2002) but, more recently, it seems to be more frequent along the coasts of Tunisia (GSA 13) (Hattour & Nakamura, 2004) (Fig. 3E).

The devil ray (*M. mobular*) was reported mainly in the Tyrrhenian (GSA 9, 10 and 11) (Notarbartolo di Sciara *et al*., 2015), Adriatic (Fortuna *et al*., 2014), northern Ionian waters (GSA 17, 18 and 19), around Balearic Islands (GSA 5), Tunisia coasts (GSA 13 and 14) (Bradaï & Capapé, 2001) and in the Levantine basin (Gaza Strip, see above; Fig. 3F) (Abudaya *et al*., 2017).

All spiny butterfly rays (*Gymnura altavela*) were recorded in the Balearic Islands (GSA 5) and the Levant basin, along the Syrian coasts (GSA 27). In this last area, 114 specimens were collected by bottom trawlers and bottom longlines from July 2010 to March 2013 (Alkusairy *et al*., 2014). The species has also historically occurred along Tunisian coasts, where individuals at all maturity stages were observed (Capapé *et al*., 1992) but only one occurrence was recorded in the Italian waters (Psomadakis *et al*., 2006) (Fig. 3G).

Some species, like the blue shark (*P. glauca*), are more frequently caught as commercial bycatch, and thus reported by various countries in the context of the European Union

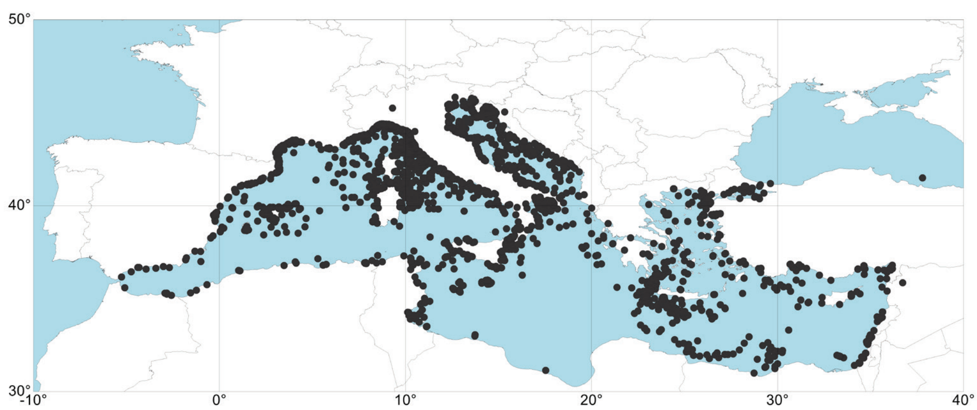

Fig. 2: Spatial distribution of all MEDLEM records.

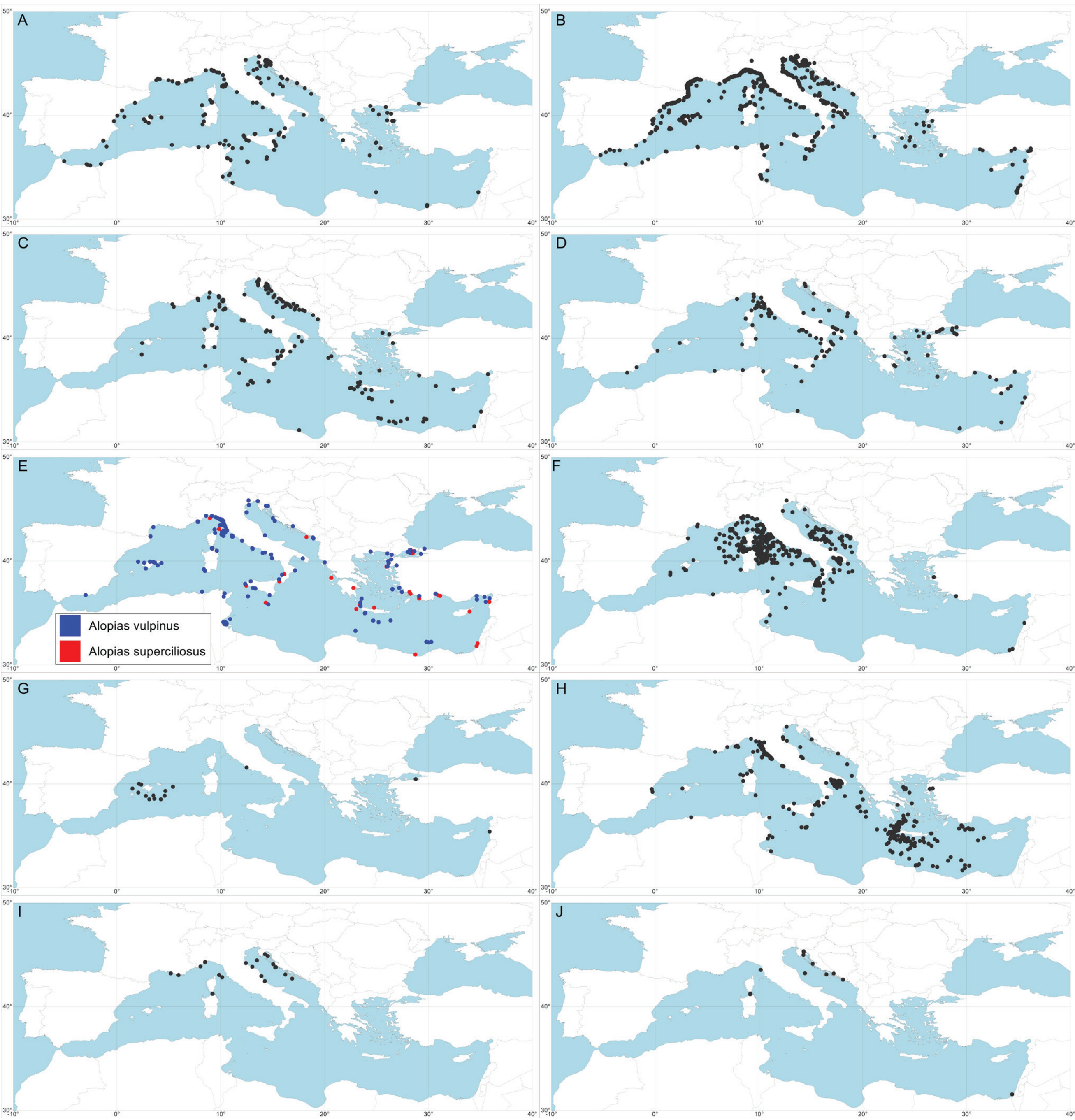

Fig. 3: Spatial distribution of the principal species represented in the MEDLEM database. Carcharodon carcharias (A), Cetorhinus maximus (B), Isurus oxyrinchus (C), Hexanchus griseus (D) Alopias vulpinus and bigeye thresher Alopias superciliosus (E), Mobula mobular (F; in order to maintain a standard representation, the exceptional catches recorded in the Gaza strip are not shown), Gymnura altavela (G), Prionace glauca (H), Lamna nasus (I) and, Sphyrna zygaena (J).

Data Collection Framework (EU DCF). The blue shark has been reported in both the western Ionian Sea (GSA 19) and eastern Ionian Sea (GSA 20) - Crete (GSA 23), north and south Levantine basin (GSA 24 and 26), Ligurian Sea (GSA 9) (Serena & Silvestri, 2018), Tunisian coasts (GSA 13 and 14), and more frequently in the southern regions of Tunisia (Bradaï *et al*., 2002) (Fig. 3H). However, such data are not included in the MEDLEM database, since the by-catch of this species is not considered as an unusual event. Therefore, the map reporting the geographical distribution of the blue shark is not representative of the actual distribution of the species.

The MEDLEM data provided some insights on the geographical distribution of other locally rare or uncommon species, such as *Lamna nasus* (Fig. 3I)*, Carcharhinus plumbeus, Galeorhinus galeus,* and *S. zygaena* (Fig. 3J). *A. superciliosus*. *I. oxyrinchus* and *G. altavela* were regularly present in Lebanese waters, whereas in the last decade *S. oculata* and *Sphyrna* spp. seem to have completely disappeared in Lebanon, where *M. mobular* has never been recorded (Lteif, 2015). The sandbar shark (*C. plumbeus*) has been mostly recorded and landed throughout the year in the Gulf of Gabes (Tunisia), and some authors suggest that this area might be a nursery for many species (Bradaï *et al*., 2005; Saidi *et al*., 2005; Saidi *et al*., 2007).

Whilst the two most recorded species, basking and great white sharks, can be found all around the Mediterranean (whenever data is available), they probably are not the most frequent species in this area. So far, the geographical coverage of data sources and providers is scattered and to obtain a sound indication on the "presence-absence" of the poorly represented species, the scientific network and reporting system should be intensified, particularly in areas where the observation effort is lower.

Finally, even though morphometric measurements are scarce, some inferences can be drawn at least for some species (Fig. 4A): for example, recorded specimens of great white and basking sharks show a maximum total length of 750 cm (with a minimum of 80 cm) for the white shark and 1,000 cm for the basking shark (with a minimum of 150 cm), respectively. For these two species, information allowed the definition of length-weight relationships which are shown in Figure 4 (B, C). In both cases an exponential tendency is observed with an acceptable model fitting, considering the low number of records at disposal.

MEDLEM permitted not only to establish collaborative interactions among many Mediterranean research institutes but also to collect meaningful historical information on the incidental captures of large and rare elasmobranchs in the last 350 years or so. This information shows significant fluctuations in occurrences over time and a prominent increase in the last ca. 30 years is likely due to the increasing interest of the scientific community on these species (Fig. 1E, 1F). Such an increase in record frequencies was probably due to an increasing perception of the importance of these species and their poor status of conservation, as a consequence of the development of specific studies and monitoring programs of marine resources (Fig. 1F). On the other hand, the improvement of fishing technologies and the consequent increase in fishing effort may have played a role of primary importance, determining a significant rise in incidental catches.

Some data from new scientific projects have recently been added to the MEDLEM database (e.g., the catches recorded with the Elasmoit Project (Relini *et al*., 2010) and Elasmostat Project (Serena *et al.*, 2014). A larger effort to retrieve all the historic information not yet available but included in governmental and scientific institutions archives is needed. It is important to transfer into the database the information on large elasmobranchs that was collected through other monitoring activities such as EU programmes (Reg. EC 1543/2000; Reg. EC 1639/2001; Reg EC 812/2004; Reg. EC 1581/2004; Fortuna *et al*. 2010). It is also pivotal to create an international network among the ongoing programs, such as SharkPulse (www.sharkpulse.org) and the CIESM forum (Soldo *et al*., 2014).

Because of its potential in collecting new information throughout the Mediterranean basin and the involvement of the various countries bordering the Mediterranean, the MEDLEM archive is currently moving to the GFCM server. This will enhance the collaboration among the countries and researchers interested in the studies of cartilaginous fishes in the Mediterranean and Black seas. In this sense, we have to take into account the GFCM Rec-

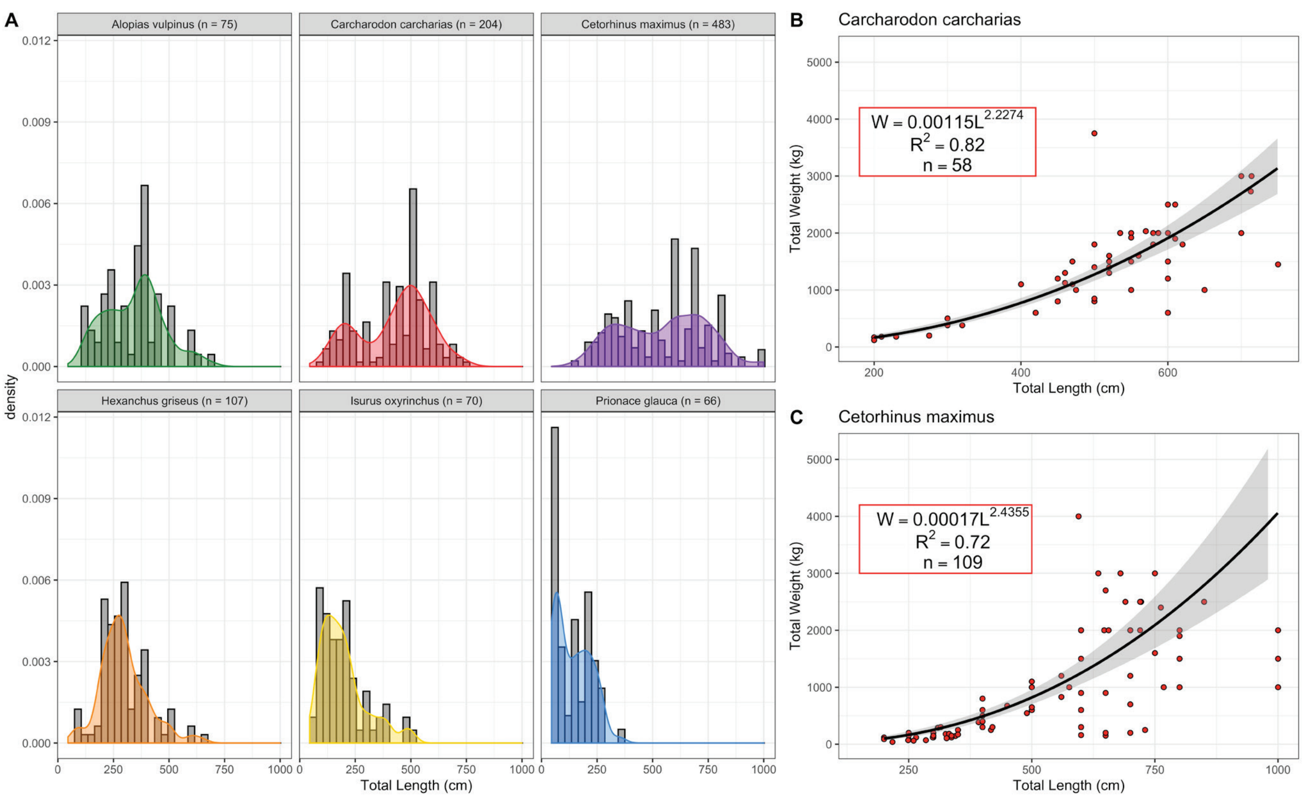

Fig. 4: Length frequency distribution of the main species recorded in the MEDLEM database (A). Length-weight relationship for the great white shark (B) and the basking shark (C) in the Mediterranean Sea.

ommendation 36/2012/3 and subsequent amendments (Regulation 2015/2102 Art. 16j) on setting new fisheries management measures for the conservation of sharks and rays in the GFCM area. Its scope is to ensure high protection from fishing activities to elasmobranchs species listed in Annex II of the SPA/BD protocol of the Barcelona Convention. Unfortunately, this Recommendation is not always implemented in the Mediterranean countries, as shown by the frequent accidental catches by the small-scale fisheries of *I. oxyrinchus*, *C. maximus*, etc. and *Squatina* spp. specimens found in the bottom trawlers' catches (Serena & Silvestri, 2018). A special case is the Palestinian fisheries in the Levantine basin targeting the devil ray. This is probably a consequence of the 1993 Oslo Agreements, which imposed important restrictions for Gaza fishers in terms of fishing area extent. These restrictions have highly reduced the fishing opportunities for the Palestinian fleet and likely forced the local fishermen to apply a subsistence fishing, less focused on specific target species.

Greater attention to accidental catches occurring in the various parts of the Mediterranean should be given and a more systematic recording of these opportunistic events should be facilitated. Several initiatives are taking place in the Mediterranean Sea: integration and coordination among them is pivotal (Bargnesi *et al*., 2020).This would make the MEDLEM database a more comprehensive tool that would not only enhance a pro-active collaboration among the various research institutes, but also represents an important source of information contributing to the improvement of our knowledge on the biology of these fishes, enabling the assessment of the status of the elasmobranchs and, lastly, the promotion of better conservation measures.

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