Chapter 2

A Tale on the Demersal and Bottom Dwelling *Chondrichthyes* in the South of Sicily through 20 Years of Scientific Survey

Michele Luca Geraci, Sergio Ragonese,
Giacomo Norrito, Danilo Scannella,
Fabio Falsone and Sergio Vitale

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69333

Abstract

In the present work, an overview of the demersal (sharks-chimaera) and bottom dwelling (batoids) of experimental survey international bottom trawl survey in the mediterranean (MEDITS) data, from 1994 to 2013, is provided. The analysed data refer to a wide area located off the southern coast of Sicily, namely south of Sicily (according to the general fisheries commission for the mediterranean (GFCM) classification, Geographical Sub-Area 16). A checklist of the recorded *Chondrichthyes* was integrated by density index, D.I. (N/Km^2) and average individual weight (as the ratio between biomass index, D.I. (N/Km^2) and D.I.). Results suggest that most of the *Chondrichthyes* in South of Sicily are in a steady state, although in the last few years, they seemed to recover. The spatial distribution of sharks-chimaera in the geographical sub-area (GSA) 16 is mainly concentrated in the southern and north-western zones. Nevertheless, possible management actions to promote the recovering of these very important ecological and threatened species are discussed.

Keywords: sharks, chimaera, batoids, checklist, abundance, South of Sicily, Mediterranean Sea

1. Introduction

Marine cartilaginous species present unique challenges for conservation assessment (in Refs. [1, 2]). They are considered the most vulnerable species to fishing activity. Groundfish sharks and chimaera, together with bottom dwelling batoids, share several biological traits, for example: high position in the trophic food webs, slow growth, delayed sexual maturity, low fertility and long life spans. Generally, they form small local stock (the so-called stock-let) with limited or low connectivity to each other (in Refs. [3–5]). The assumption that marine fish are not vulnerable to extinction because they live in open seas where their movements are unlimited is unfounded. Fisheries have caused severe declines in many species, and although there are still no documented cases of complete extinction, there is considerable debate as to whether marine species could become extinct (in Refs. [2, 6, 7]).

In many areas of the world, a generalised decline of cartilaginous fish species standing stocks is generally recognized mainly because of fishing effort increase; the apparent paradox of a corresponding increase in landings of some stock likely reflects the reduction of the discarded catch due to the general crisis of the sector. Overfishing, habitat degradation and slow recovery rates are potential factors that lead to such dramatic declines, especially in areas such as the Mediterranean Sea where fishing (both legal and illegal) has long been a way of life and continues to be intense. As a matter of fact, *Chondrichthyes* in the Mediterranean Sea have always been considered as low-economic level bycatches and even a nuisance in the past and hence massively discarded, which is currently the case of *Galeus melastomus* in the South of Sicily (in Ref. [8]). That notwithstanding, they continue to decline as an indirect effect of fisheries aimed at more valuable species as generally recognized (in Refs. [2, 9–11].

In this context, current Mediterranean elasmobranchs are represented by ~85 shark and batoid species (in Ref. [12]) more or less in an over-exploited condition (i.e. standing stock very reduced); in particular, 31 species (40%) are regionally classified as threatened categories (critically endangered, endangered or vulnerable) (in Ref. [13]). The Mediterranean catches are multi-species with a rich marine community, including selachians, historically exploited by different fisheries (in Ref. [14]). In the wide area between the Southern Sicily and the Northern Coasts of Africa, *Chondrichthyes* have always represented a common bycatch of the bottom trawl fleets since the 70s. As observed worldwide, also in the above-reported area, bottom trawls are increasing in size, power and efficiency, as well as in their fishing activities, mainly towards the offshore grounds (in Ref. [4]). Due to the bycatch nature and high discard rate, long-term sources of information to assess *Chondrichthyes* gross catch are very limited in this region. In this context, fishing activity has determined a severe impact on *Chondrichthyes* communities for three main reasons. First of all, the aim of the fishermen was to increase the abundance of highly-prized shrimps through a regular harvest of low valuable demersal shark, a concept recognizable also in the old scientific literature, considering the sharks as predators of red shrimps and human's competitor (in Refs. [15–17]). However, successive studies have shown that sharks do not feed on red shrimps (in Refs. [3, 18, 19]).

Secondly, in the past poor data were recorded on these *taxa* since the scattered retention of large specimens as well as few categories were documented in the official Italian statistics (in Refs. [20, 21]). Nowadays, a dedicated regulation and data collection is in place (in Ref. [22]).

Thirdly, the scarce selectivity of the commercial trawling cod-end (diamond, 20–30 mm side stretched; in Ref. [19]) together with the 5–6 hours for haul, has determined a huge catch of *Chondrichthyes*, mainly rejected at the sea. The fishing activity above-reported took place in the past (in Ref. [23]) and, although the Reg. (EC) n. 1967/2006 imposed an increased mesh size (square, 40 or 50 mm diamond) in the cod-ends, almost all the shark specimens continue to be retained by the cod-end (in Ref. [24]). Regarding the GFCM geographical Sub-Area no 16, named South of Sicily, a standardized scientific data base was obtained after the implementation of MEDITS international program, launched in 1994, and based on a high vertical opening (ca 2–3 m) trawl net.

To improve the knowledge on *Chondrichthyes* occurring in the South of Sicily, a time series of data collected during the experimental MEDITS survey were analysed.

2. Overview of the *Chondrichthyes* knowledges

The used data were gathered during MEDITS survey program and specifically referring to the South of Sicily (geographical sub-area (GSA) 16 according to GFCM classification). This area extends for about 34,000 km^2 and is characterized by the entry of the modified Atlantic Water (AW), which flows towards east in proximity of the surface (up to around 200 m), and from the spillage of warmer and salty water (200–500 m), the levantine intermediate water (LIW), which flows towards west, along the Sicilian slope (**Figure 1**).

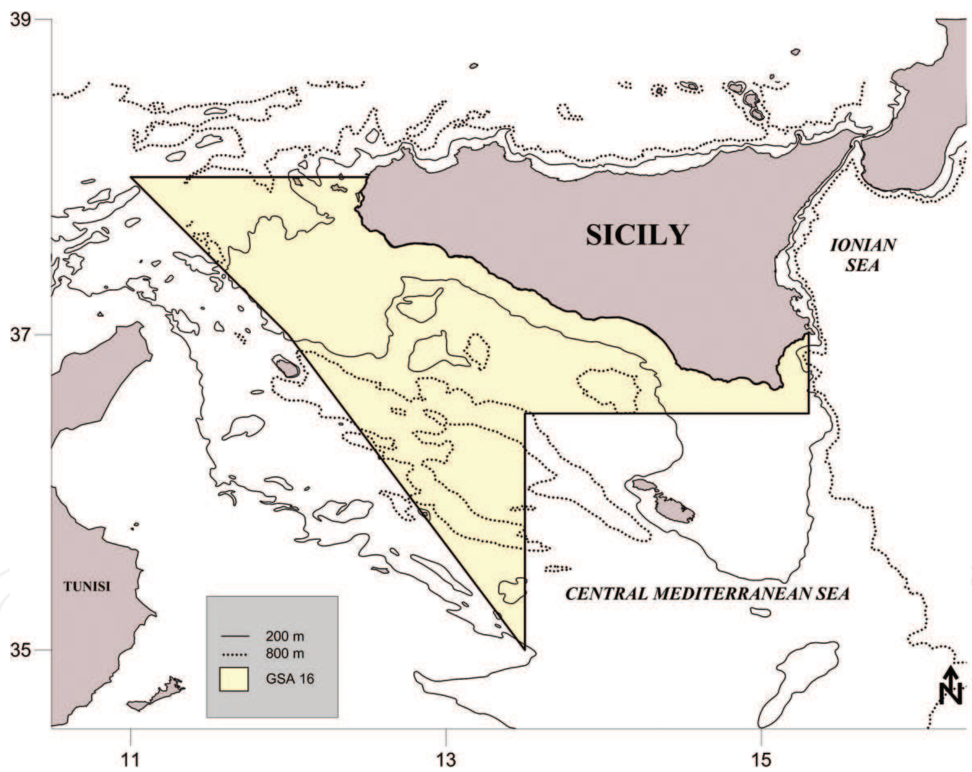

Figure 1. The geographical zone considered in the present paper is South of Sicily (GSA 16) with an overall extension of about 34,000 km^2. The solid and dotted lines denote the 200 and 800 m depth levels.

In the investigated area, bottom trawling is forbidden (but such a measure is rarely enforced within 50 m of depth) from the Sicilian coasts and in some specific grounds (such as the Egadi Islands marine protected area, MPA). The data referring to the MEDITS Survey from 1994 to 2013 were carried out with a commercial stern trawler harboured in Mazara del Vallo, the Sant'Anna (32.2 m length overall; powered with a 736 kW engine). The sampling stations have been distributed applying a stratified sampling scheme with random drawing inside the following bathy-metric limits: 10–50 m (a *stratum*), 51–100 m (b), 101–200 m (c), 201–500 m (d), 501–800 m (e). 30 and 60 minutes day light hauls were performed on shelf (10–200 m) and slope (201–800 m) grounds respectively. The mean D.I. performed through number of hauls per year and the ratio between B.I./D.I. were computed for each species collected at least once in the MEDITS surveys and consequently pooled together.

In the present study, a checklist of *Chondrichthyes* recorded in the GSA 16 during the MEDITS survey was also produced and presented in phylogenetic order and within this in alphabetic order. Furthermore, an overall D.I. maps for sharks-chimaera and batoids as well as their spatial occurrences are displayed. The spatial analysis was performed using geostatistical methods (ordinary kriging) across the timeframe from 1994 to 2013.

In the South of Sicily, overall 37 species were recognized as captured at least once: 16 demersal sharks-chimaera and 21 batoids. In particular, four sharks-chimaera orders (*Chimaeriformes*, *Hexanchiformes*, *Squaliformes* and *Carcharhiniformes*; **Table 1**) and three batoids orders (*Myliobatiformes*, *Rajiformes* and *Torpediniformes*; **Table 2**) were found. Synthetic comments concerning the 16 sharks-chimaera and 21 batoids *taxa* are reported hereafter in phylogenetic order.

Class: Chondrichthyes			
Order *Carcharhiniformes*			
Family *Scyliorhinidae*	*Galeus melastomus* Rafinesque, 1810a	*Scyliorhinus canicula* Linnaeus	*Scyliorhinus stellaris* Linnaeus, 1758LC
Family *Triakidae*	*Mustelus asterias* Cloquet, 1821	*Mustelus mustelus* Linnaeus, 1758	*Mustelus punctulatus* Risso 1827
Order *Chimaeriformes*			
Family *Chimaeridae*	*Chimaera monstrosa* Linnaeus, 1758		
Order *Hexanchiformes*			
Family *Hexanchidae*	*Heptranchias perlo* Bonnaterre, 1788	*Hexanchus griseus* Bonnaterre, 1788	
Order *Squaliformes*			
Family *Centrophoridae*	*Centrophorus granulosus* Bloch and Schneider, 1801	*Centrophorus uyato*	
Family *Dalatiidae*	*Dalatias licha* Bonnaterre, 1788		
Family *Etmopteridae*	*Etmopterus spinax* Linnaeus, 1758		
Family *Oxynotidae*	*Oxynotus centrina* Linnaeus, 1758		
Family *Squalidae*	*Squalus acanthias* Linnaeus, 1758	*Squalus blainville* Risso, 1827	

Table 1. Checklist of the sixteen *taxa* (sharks-chimera) caught during the MEDITS survey from 1994 to 2013 in the South of Sicily (GSA 16).

http://dx.doi.org/10.5772/intechopen.69333

2.1. Blackmouth catshark—*G. melastomus* Rafinesque, 1810

This small-sized shark lives in deep waters from 150 to more than 2000 m (in Ref. [25]), even though it can be occasionally (especially juveniles) found over the inner shelf (50–60 m) (in Refs. [25, 26]). In the Mediterranean, it reaches a maximum size of 63 cm total lenght (TL) (in Refs. [27]). *G. melastomus* feeds mainly on shelf-living species, natantian and reptantian crustaceans together with teleosts (in Ref. [28]). Analysis of the stomach contents of individuals caught in the northern Tyrrhenian Sea also found galley leftovers (in Ref. [28]). Blackmouth catshark is generally considered as having an awful taste and Sicilian fishers discard it immediately (in Refs. [8, 17, 29]) with a very low possibility of surviving.

2.2. Small-spotted catshark—*Scyliorhinus canicula* Linnaeus, 1758

A bottom dweller shark measuring up to 90–100 cm of TL (in Refs. [30, 31]) lives in gravel, sandy and muddy bottoms down to 800–1000 m, but preferably within the 400–500 m depth range (in Refs. [32, 33]). The Small-spotted catshark is an opportunistic predator on a wide range of macrobenthic fauna (generalist feeder). In particular, natantian and reptantian crustaceans together with teleosts were the most important preys (in Ref. [28]). *S. canicula* is taken in commercial fisheries across its range but only larger individuals are usually retained for human consumption; the juveniles discarded seem to have some possibility to survive.

2.3. Nursehound—*Scyliorhinus stellaris* Linnaeus, 1758

Its habits are similar to the Small-spotted catshark, but it prefers the rocky zones from 20 to 100 m (in Refs. [30, 31]), although it is even able to go down to 800 m (in Ref. [30]). In the Mediterranean, its maximum size is 150 cm TL (in Ref. [34]). The Nursehound feeds on benthic prey, mainly on crustaceans, molluscs, some bony fishes and on its congeneric small spotted catshark, *S. canicula* (in Ref. [31]). It is not appreciated by Sicilian consumers and so often discarded (in Ref. [29]). Nowadays, it has almost disappeared in many Sicilian fishing grounds and remains common only in Tunisian (in Ref. [26]) and Maltese waters (in Ref. [35]).

2.4. Starry smooth-hound—*Mustelus asterias* Cloquet, 1821

A slender shark measuring up to 140 cm TL (in Ref. [31]), though occurring below, from a few metres to about 100 m (in Ref. [32]), can be caught below 300 m (in Ref. [30]) and sometimes deeper at 500 m (in Ref. [34]). Starry Smooth-hound feeds predominantly on crustaceans, including squat lobsters and crabs, and especially swimming crabs. Predation on other taxa is low (in Ref. [36]). In the Mediterranean Sea, trawling and artisanal fishing have largely exploited the *Mustelus* species that were regularly commercialized for human consumption (in Ref. [37]).

2.5. Smooth-hound— *Mustelus mustelus* Linnaeus, 1758

This species measures up to 160 cm TL (in Ref. [34]) and lives at 800 m depth (in Ref. [32]), but shows a preference for shallow sandy-muddy bottoms, especially at 5–50 m depth (in Refs. [30, 31]. Gracan et al. (in Ref. [38]) declared that *M. mustelus* feeds mainly on crabs. Decapod malacostracans were the dominant prey group, with *Liocarcinus corrugatus*, *Liocarcinus depurator* and *Pilumnus sp*. as the most frequent prey; they were followed by ray-finned fish, mostly *Engraulis encrasicolus* and cephalopods, consisting mainly of *Sepia elegans*. In the Mediterranean Sea, smooth-hound is captured with demersal trawls, trammel nets, gillnets and longlines. It is a commercial species, mostly taken as bycatch and marketed (in Ref. [4]).

2.6. Blackspotted smooth-hound—*Mustelus punctulatus* Risso, 1827

As the similar species of *M. mustelus* (with which it is often confused (in Ref. [39]), this shark measures up to 190 cm TL and is reported in the whole Mediterranean (in Ref. [30]). *M. punctulatus* feeds mainly on crustaceans, teleosts and molluscs although its diet changes during the life cycle (in Ref. [39]). Like the other, *Mustelus* species is captured, as bycatch, with demersal trawls, trammel nets, gillnets and longlines and often landed (in Ref. [36]).

2.7. Rabbitfish—*Chimaera monstrosa* Linnaeus, 1758

This Atlanto-Mediterranean deep-water animal prefers cold waters and occurs in all the Mediterranean, except the North Adriatic (in Ref. [40]). Its depth limits range from the outer shelf down to ca. 1600 m (in Ref. [40]). Maximum length is 150 cm TL and maximum age is 26 and 30 years for females and males, respectively (in Ref. [41]). *C. monstrosa* feeds on benthic organisms and it has a very close relationship with the seabed in its feeding habits. The diet is composed mainly by crabs, particularly the angular crab *Goneplax rhomboides* which represents nearly half of the diet by volume, ophiuroids, echinoids, crinoids, amphipods, polychaetes, pagurids, cnidarians and other medium-sized benthic prey (in Refs. [42, 43]). In the Mediterranean, *C. monstrosa* is usually caught by offshore trawlers mostly between 500 and 800 m (in Refs. [32, 44]) and immediately discarded (in Ref. [8]).

2.8. Sharpnose sevengill shark—*Heptranchias perlo* Bonnaterre, 1788

This shark is easily recognizable for the presence of seven gill slits and occurs in the whole Mediterranean showing a wide depth-distribution from 0 to 50 m down to 800 to 1000 m (in Refs. [8, 31]). The newborn is ca. 30 cm TL and during adulthood reaches 90–100 cm TL, attains a maximum size of up to 140 cm TL (in Ref. [31]) and feeds on small sharks and rays, small bony fish, shrimps, crabs, lobsters, squid and cuttlefish (in Ref. [45]). It is taken by a wide variety of demersal fisheries and sold at the supermarket.

2.9. Bluntnose sixgill shark—*Hexanchus griseus* Bonnaterre, 1788

Bluntnose sixgill shark lives up to 2500 m depth (in Ref. [46]) although during the night it was noticed at a depth around 30–40 m in the Straits of Messina (in Ref. [47]). The maximum TL recorded was 600 cm (in Ref. [46]). This shark is taken as bycatch in handlines, longlines, gillnets, traps, trammel nets, and both mid-water and bottom trawls. There are some small-scale fisheries for this species in the Mediterranean (in Ref. [46]). In the mid 80s, large sized animals were commonly found at the fish market in Mazara (Sicily) and sold as slices of 'Palumbo' (the Sicilian name for *Mustelus* spp.). Nowadays, it's not sold and discarded at sea (in Ref. [4]).

2.10. Gulper shark—*Centrophorus granulosus* Bloch and Schneider, 1801

A common deep-water species (often confused with the congener *Centrophorus uyato*, see below) which grows up to 120 cm TL (in Ref. [30]) and lives in a depth range from 50 to 1400 m. The diet of the Gulper shark is poorly understood but it is thought to prey on hake, lanternfish, squid and epigonids, as well as a variety of other benthic and mesopelagic bony fish and invertebrates (in Ref. [48]). Marketed smoked and dried salted for human consumption; also processed into fishmeal and a source of liver oil for squalene (in Ref. [31)].

2.11. Little Gulper shark—*Centrophorus uyato* Linnaeus, 1758

Demersal on the continental shelf and upper-middle continental slope at depths of 50 to 1,400 m, This invalid *taxon* was distinguished from the similar species *C. granulosus* mainly according to the shape of the superior teeth and features of the dermal denticles on the sides of the body (in Refs. [23, 31]. Maximum recorded TL is 110 cm (in Ref. [49]). The diet consists of bony fishes and cephalopods (in Ref. [50]) but also includes crustaceans (in Ref. [51]). However, Sicilian fishers do distinguish between the two 'forms', which are often landed and commercialized (in Ref. [4]).

2.12. Kitefin shark—*Dalatias licha* Bonnaterre, 1788

A benthic to mesopelagic deep-water shark occurring at depths between 90 and 1400 m (in Ref. [52]), which grows up to 180 cm TL (in Ref. [30]); however, 120 cm is a more common length (in Ref. [34]). Navarro et al. (in Ref. [53]) revealed a preference for small sharks; however, finfish, crustaceans and cephalopods were also found. The species occurs within the range of fisheries in many areas of its range, where it is taken as bycatch. It is sometimes sold at the fish markets, but normally it is discarded (especially by Sicilian red shrimp trawlers) (in Ref. [8]).

2.13. Velvet belly—*Etmopterus spinax* Linnaeus, 1758

This Atlanto-Mediterranean deep-water shark has a benthic life on the shelf and bathyal zones, from 70 to about 2500 m (in Ref. [54]) but mostly below 200 m depth (in Ref. [32]). *E. spinax* fed mainly on cephalopods (in Ref. [28]). The diet of *E. spinax* was composed primarily of mesopelagic fish, with decapod crustaceans and cephalopods of secondary importance (in Ref. [55]). A non-commercial species, all specimens captured as bycatch by commercial fishing vessels are discarded thus limiting the data available (in Ref. [56]).

2.14. Angular roughshark—*Oxynotus centrina* Linnaeus, 1758

Angular roughshark lives in a bathymetric range from 60 to 660 m (in Ref. [31]); however, it can reach a depth up to 800 m (in Ref. [44]). The maximum TL recorded was 150 cm (in Ref. [30]). The reported diet of this species is mainly characterized by small crustaceans (in Ref. [57]), polychaetes (in Ref. [31]) and teleosts (in Ref. [58]). Guallart et al. (in Ref. [59]) considered *O. centrina* to be a suction feeder specializing in worm-like prey. It is caught by trawling or accidentally bottom longlining, from a few metres to deeper waters. It is immediately discarded to the sea by fishers from Mazara because they think it will bring bad luck (in Ref. [4]).

2.15. Piked dogfish—*Squalus acanthias* Linnaeus, 1758

Piked dogfish is a small bottom-dwelling shark with a maximum recorded size of 160 cm TL and maximum weight of 91 kg (in Ref. [31]) with a maximum depth of 800 m (in Ref. [60]). It can be considered an opportunistic feeder. Their natural diet composed mainly of teleost fishes, followed by crustaceans, nematodes and actinarians (= sea anemones) (in Ref. [61]). It's taken as bycatch in demersal fisheries and sold at supermarket (in Ref. [4]).

2.16. Longnose spurdog—*Squalus blainville* Risso, 1827

It is a small shark measuring up to 110 cm TL and occurring at 700 m depth (in Ref. [60]). In the stomach, contents of *S. blaiville* crustaceans and teleosts were the dominant prey items, and molluscs, polychaetes, echinoderms and sipunculids were found in lower abundance (in Ref. [62]). *S. blainvellei* is of limited fisheries importance compared to *S. acanthias*, but may also have been impacted by fishing pressure in this area (in Ref. [63]). It is very common and sold at the supermarket (in Ref. [4]).

Class: Chondrichthyes			
Order *Myliobatiformes*			
Family *Dasiatidae*	*Dasyatis pastinaca* Linnaeus, 1758	*Pteroplatytrygon violacea* Bonaparte, 1832	
Family *Myliobatidae*	*Myliobatis aquila* Linnaeus, 1758	*Pteromylaeus bovinus* Geoffroy St. Hilaire, 1817	
Order *Rajiformes*			
Family *Rajidae*	*Dipturus batis* Linneo, 1758	*Dipturus oxyrinchus* Linneo, 1758	*Leucoraja circularis* Couch, 1838
	Leucoraja fullonica Linneo, 1758	*Leucoraja melitensis* Clark, 1926	*Leucoraja naevus* Muller & Henle, 1841
	Raja asterias Delaroche, 1809	*Raja brachyura* Lafont, 1873	*Raja clavata* Linneo, 1758
	Raja miraletus Linneo, 1758	*Raja montagui* Fowler, 1910	*Raja polystigma* Regan, 1923
	Raja radula Delaroche, 1809	*Rostroraja alba* Lacépède, 1803	
Order *Torpediniformes*			
Family *Torpedinidae*	*Torpedo marmorata* Risso, 1810	*Torpedo nobiliana* Bonaparte, 1835	*Torpedo torpedo* Linnaeus, 1758

Table 2. Checklist of the twenty-one taxa (batoids) caught during the MEDITS survey from 1994 to 2013 in the South of Sicily (GSA 16).

2.17. Common stingray—*Dasyatis pastinaca* Linnaeus, 1758

It occurs from the shore to about 200 m depth, but is more commonly found in shallow waters <50 m (in Refs. [12, 64, 65]). It feeds on a wide variety of bottom-dwelling organisms. In a study by Ismen [66], crustaceans represented more than 99% of the diet when pooling all size classes, but teleost fish were of increasing importance in the diet of larger stingrays. The common stingray has been reported to reach a disc width (DW) of 1.4 m and a TL of 2.5 m, though a DW of 45 cm is more typical. Common stingrays are caught incidentally by commercial fisheries across many parts of its range, using bottom trawls, gillnets, bottom longlines, beach seines, and trammel nets (in Ref. [30]).

It is discarded after fishermen cut off the dangerous tails (in Ref. [67]), which have caused at least one fatality among fishers from Mazara.

2.18. Blue stingray—*Pteroplatytrygon violacea* Bonaparte, 1832

It occurs from over the edge of continental and insular shelves into the open water but has been reported at 238 m depth. In the Adriatic water, the diet consisted of two main taxonomic groups such as teleost fish and cephalopods, but few specimens of crustaceans were also recorded (in Ref. [68]). This species is captured by pelagic longline fisheries operating in the Mediterranean Sea (in Ref. [68]). *P. violacea* is almost certainly the most discarded elasmobranchs. In Italian seas, pelagic stingrays are the most commonly caught elasmobranch species in the Albacore long line fisheries and the second most common elasmobranch catch in swordfish long line fisheries (in Ref. [69]).

2.19. Common eagle ray—*Myliobatis aquila* Linnaeus, 1758

The common eagle ray in the Mediterranean is reported on sandy and muddy substrates, from shallow water to 200 m depth, although it was reported at the depth of 537 m off southern African coast (in Ref. [70]). It is a relatively small ray, attaining a maximum size of 80 cm DW (in Ref. [71]). It feeds on invertebrates such as crabs, mole crabs and bivalves, and on small bony fishes. The wings are said to be good eating and along the African coast are regularly used for human consumption. The species represent a regular bycatch in mixed species fisheries (in Ref. [70]).

2.20. Bull ray—*Pteromylaeus bovinus* Geoffroy St. Hilaire, 1817

It has a moderate depth range from costal water to about 30 m, occasionally in oceanic water up to100 m of depth. In Eastern Mediterranean Sea, Dulcic et al. (in Ref. [72]) found a max TL of 2940 cm and 220 cm DW for female. Regarding feeding aspects, it is known that they prey on bottom-living invertebrates such as crustaceans (crabs, prawn) and mollusks (squids, bivalve) (in Ref. [73]). Bull rays are very rare and not commonly caught by fisherman; they are mainly discarded at sea (in Ref. [74]).

2.21. Gray skate—*Dipturus batis* Linneo, 1758

Gray skate is found from shallow coastal waters to depths of 600 m, but most commonly found at 200 m depth. Maximum-recorded TL is 250 cm (in Ref. [30]). *D. batis* preys mostly on crustaceans and teleost fish, although Steven (in Ref. [75]) reported several species of elasmobranch, including other species of rajid, in the stomach contents. It is caught as bycatch of multi-species trawl fisheries, which cover much of its shelf and slope habitat. It is mainly landed in northern Europe where it is fished by trawlers and longliners (in Ref. [30]).

2.22. Longnosed skate—*Dipturus oxyrinchus* Linneo, 1758

Longnosed skate is found in water from 90 to 900 m, commonly around 200 m (in Ref. [76]). In the Mediterranean Sea, typical TL varies between 60 and 100 cm but it can reach a maximum TL of 150 cm (in Ref. [77]). The diet comprised crustaceans and molluscs. Early life stages were characterized by a benthic diet, which changed to benthopelagic during growth (in Ref. [78]). *D. oxyrinchus* is captured as part of the bycatch of multispecies trawl fisheries.

2.23. Sandy ray—*Leucoraja circularis* Couch, 1838

Demersal on sandy and muddy bottoms from the outer shelf and upper slope to 275 m depth, commonly found at 100 m depth (in Ref. [30]), maximum recorded size is 120 cm TL, but most individuals caught are between 70 and 80 cm TL (in Ref. [30, 65]). Its diet is poorly understood but it is most likely that it feeds on various bottom dwelling invertebrates, particularly crustaceans, and small teleost fish (in Ref. [79]). Species of local fishery importance are caught by bottom trawl fisheries.

2.24. Shagreen ray—*Leucoraja fullonica* Linneo, 1758

Demersal on rough ground on outer shelf and upper slope in about 30 to 550 m depth, maximum length is 120 cm; however, most specimens usually are 70 to 80 cm TL (in Ref. [65]). It feeds on a variety of bottom dwelling species but most probably prefers fish and crustaceans (in Ref. [80]). In the Mediterranean Sea, it is caught as bycatch by both bottom trawl and longline fisheries (in Ref. [30]).

2.25. Maltese ray—*Leucoraja melitensis* Clark, 1926

Maltese ray deep range is from 60 to 600 m. This small ray grows up to 50 cm TL (in Ref. [30]). It feeds on crustaceans mainly amphipods (in Ref. [85]). While this skate is not known to be targeted by commercial fisheries, it is taken as bycatch in bottom trawl, gillnet, and bottom longline fisheries and often discarded (in Ref. [81]).

2.26. Cuckoo ray—*Leucoraja naevus* Muller & Henle, 1841

Demersal on sandy and course bottoms on the shelf from 30 to 200 m depth, it is found on the continental shelf and slope at depths of 20–500 m (in Ref. [30]), but it is most common between

50 and 200 m depth (in Ref. [65]). The maximum TL is 75 cm for females and 68 cm for males (in Ref. [65]). Juvenile Cuckoo Rays feeds mainly on small crustaceans while adults also feed on polychaetes and bony fish (in Ref. [82]). Bycatch of bottom trawl fisheries (in Ref. [30]).

2.27. Starry ray—*Raja asterias* Delaroche, 1809

Starry skates are found predominantly on the Italian and Corsican continental shelves between shallow waters and 150 m depth. Maximum size is estimated at 72 cm TL and 76 cm TL for males and females, respectively (in Ref. [83]). *R. asterias* is a predator of crustaceans (crabs and shrimps) and to a lower extent on teleosts, molluscs and polychaetes (in Ref. [84]) and is regularly caught as bycatch in the bottom trawl fisheries. As secondary target species is caught by beam trawl, juvenile specimens are frequently caught by trammel net in very shallow waters (2–15 m) and discarded alive (in Ref. [30]).

2.28. Blonde ray—*Raja brachyura* Lafont, 1873

Demersal on sandy grounds from inshore to upper slope exceptionally as deep as 900 m, it reaches a maximum size of ~120 cm (TL) and commonly reaches 40–100 cm TL (in Ref. [85]). Fish were a major prey item for all sizes of *R. brachyura.* Excluding bony fish, polychaetes were the most common prey followed by shrimps and brachyuran crabs and cephalopods (in Ref. [82]). It is taken as bycatch in mixed demersal fisheries using trawl, gill nets and longlines elsewhere in its range (in Ref. [86]).

2.29. Thornback ray—*Raja clavata* Linneo, 1758

A relatively common skate from close in-shore shallow waters to the outer continental shelf and upper slope from 10 to 300 m depth (in Ref. [77]), maximum-recorded TL is 110 cm (in Ref. [87]). Thornback ray feeds mainly on teleosts, crustaceans and cephalopods, whereas gastropods and polychaetes are occasionally consumed (in Ref. [88]). In the Mediterranean Sea, the Thornback skate is frequently caught as bycatch in trawl fisheries targeting the Rose Shrimp (*Parapenaeus longirostris*) and the European Hake (*Merluccius merluccius*). There are localized and targeted fisheries for this species in the Mediterranean Sea (in Ref. [89]). Recently, Bottari et al. (in Ref. [93]) have supported the stock in GSA 16 as a different Unit stock from the surrounding GSAs.

2.30. Brown ray—*Raja miraletus* Linneo, 1758

Demersal on soft bottom from shallow shelf to about 530 m depth, mainly at 50 to 150 m (in Ref. [30]), *R. miraletus* is a small ray that can reach maximum TL of 60 cm (in Refs. [30, 90]). In Brown ray diet, crustacean represented the main prey in all size groups. Amphipoda Gammaridea was the predominant prey for small individuals and was replaced in medium and large specimens by decapods (in Ref. [91]). It is caught as bycatch in bottom trawl, trammel net and long-line fisheries. It is landed and commonly sold in the market (in Ref. [92]).

2.31. Spotted ray—*Raja montagui* Fowler, 1910

Demersal on soft substrate on shelf at 30–150 m depth, rarely as deep as 530 m, most individuals attain a TL of 40–60 cm (in Ref. [34]) and the maximum-recorded TL is 80 cm (in Ref. [94]). For *R. montagui,* most important preys were various crustaceans and polychaetes, while large females predated primarily on fish (in Ref. [82]). *R. montagui* is captured in Mediterranean trawl fisheries as bycatch (in Ref. [95]).

2.32. Speckled ray—*Raja polystigma* Regan, 1923

R. ploystigma is caught predominantly on the shelf living on soft bottoms from 100 to 400 m (in Refs. [30, 95]). Its maximum size is about 50–60 cm TL and it feeds mainly on crustaceans and bony fishes depending on the sex, size and also partly on the season (in Ref. [28]). The species is caught as bycatch in demersal trawl fisheries but is also fished with gillnets, longlines and handlines in artisanal fisheries (in Ref. [34]).

2.33. Rough ray—*Raja radula* Delaroche, 1809

Rough ray occurs in coastal water up to 350 m depth (in Ref. [30]). Maximum size is about 50–60 cm TL (in Refs. [30, 76]). The diet of juvenile specimens of *R. radula* consisted mainly of crustacean decapods followed by algae, polychaetes and molluscs (in Ref. [96]). *R. radula* is frequently caught as bycatch in demersal trawl, gillnet, trammel net and bottom longline fisheries (in Refs. [30, 96]).

2.34. White skate—*Rostroraja alba* Lacépède, 1803

White skate is a demersal species found on the continental shelf and upper slope from shallow water to 400 m, exceptionally to 500 m depth on sand and loose rocky substrate (in Refs. [30, 85]). Recorded maximum TL is 200 cm, though common between 60 and 150 cm of TL (in Refs. [34, 97]). Regarding diet aspect, it is known to prey mainly on fish and to lesser extent on crustaceans (in Ref. [98]). It is taken mainly as bycatch of bottom trawl fisheries (in Ref. [97]).

2.35. Marbled electric ray—*Torpedo marmorata* Risso, 1810

Marbled electric ray lives in inner shelves on soft and stony bottom to about 40 m depth, rarely deeper to about 100 m (in Refs. [30, 65]). *T. marmorata* commonly grows to 40 cm TL (in Ref. [99]) but it may grow up to 100 cm (in Ref. [30]). Marbled electric ray is an active feeder, consuming mostly fish and to a lesser extent cephalopods (in Ref. [100]). Bycatch of bottom trawls demersal fisheries in coastal grounds (in Ref. [30]).

2.36. Electric ray—*Torpedo nobiliana* Bonaparte, 1835

T. nobiliana occurs from the surface to depths of ~800 m. Juveniles are mainly benthic occurring on soft substrates and coral reef habitats, from 10 to 50 m depth (in Ref. [32]). It is the biggest of Mediterranean Electric Ray and may reach the notable size of 180 cm TL (in Ref. [65]). The diet is predominantly fish, sometimes quite large. Usually discarded at the sea, it is sometimes a bycatch in bottom trawl and artisanal demersal fisheries in coastal grounds (in Ref. [65]).

2.37. Common torpedo—*Torpedo torpedo* Linnaeus, 1758

Mainly a benthic species found in near shore habitats and on soft bottoms, but also to about 70 m depth and occasionally deeper. *T. torpedo* TL usually ranges from 44 to 47 cm TL (in Ref. [101]) but it can reach about 60 cm TL (in Ref. [30]). Common torpedo is an active feeder, consuming mostly fish and to a lesser extent crustaceans (in Refs. [102, 103]). Bycatch in bottom trawls coastal fisheries (in Ref. [30]).

3. State of the art of *Chondrichthyes* in South of Sicily

Among the seven orders of *Chondrichthyes* (*Chimaeriformes*, *Hexanchiformes*, *Squaliformes*, *Carcharhiniformes*, *Myliobatiformes*, *Rajiformes* and *Torpediniformes*) detected in the GSA 16, 37 species are under discussion in order to better define the right systematic position or taxonomic issue. The doubts are mainly due to the similar morphological and morphometric characters. For example, in the Gulf of Gabès (southern Tunisia), the species status of longnose spurdog has been questioned, and in fact the meristic data along with genetic analysis support the assignation of longnose spurdog to shortnose spurdog (*Squalus megalops*, Macleay) (in Refs. [12, 104]). Another famous case of systematic confusion relates to the already cited Gulper sharks *C. granulosus* and *C. uyato*; both were listed as valid species for a region but it has to be noted that the whole genus needs revision worldwide (in Ref. [105]).

Regarding batoids, another potential taxonomic misidentification could be related to speckled ray and spotted ray as well as to marbled stingray (*Dasyatis marmorata*, Steindachner, 1882) and common stingray.

In conclusion, for many *Chondrichthyes*, there seems to be required an improvement on the taxonomic issue through genetic studies, with the aim to formally resolve the uncertainty identification.

In the investigated area, the analysis of the D.I. and B.I./D.I. temporal evolution from 1994 to 2013 highlights a slight recovery of sharks-chimaera (**Figure 2**) while it seems to be in steady state for batoids (**Figure 3**).

Observing the temporal evolution of the sharks-chimaera D.I. a stable trend is pointed out up to 2003, while a marked increment is underlined until 2008, while in the remaining five years, the D.I. seems fluctuate. Regarding batoids, the D.I. seems to fluctuate, although a clear increase is recorded between 2003 and 2010. The B.I./D.I. ratio seems more heterogeneous for batoids. This might be due to the different gear recruitment between the two investigated taxa as well as behaviour aspects (e.g. aggregation, swimming capability, feeding habits, etc.), relation with the bottom and life history traits. Detailed knowledge of elasmobranch habitat requirements is essential for biodiversity conservation and fisheries management, but this is often hampered by a poor understanding of their spatial ecology (in Ref. [5]). Indeed, the

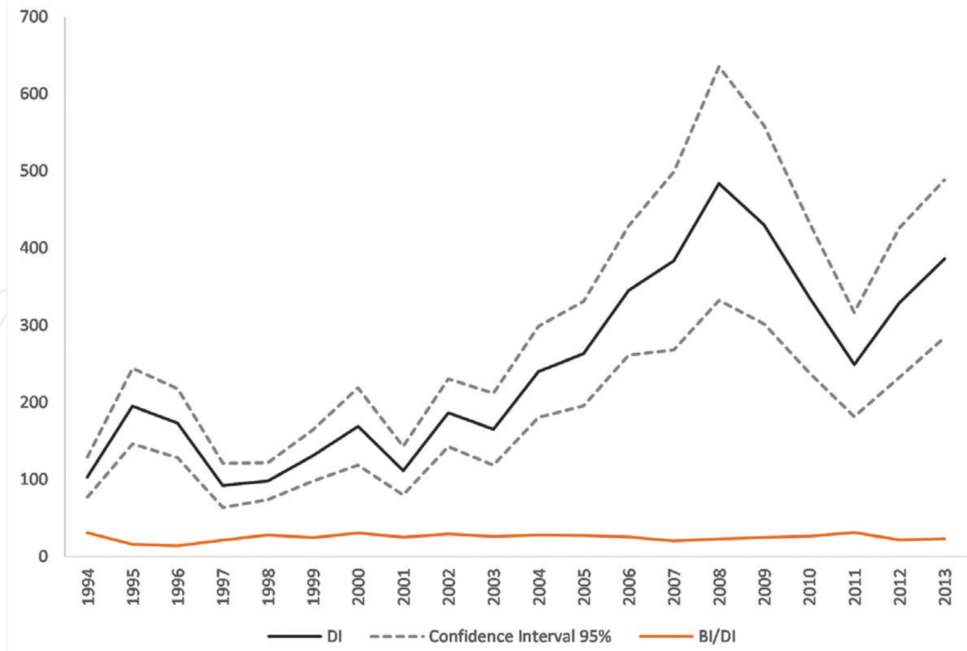

Figure 2. Annual (X ax) trend of density index (D.I. N/km^2; Y ax) and ratio between biomass index (B.I. Kg/km^2)/D.I. (Y ax), averaged across all the species, for the retained sharks and chimaera during the MEDITS survey in South of Sicily (GSA 16).

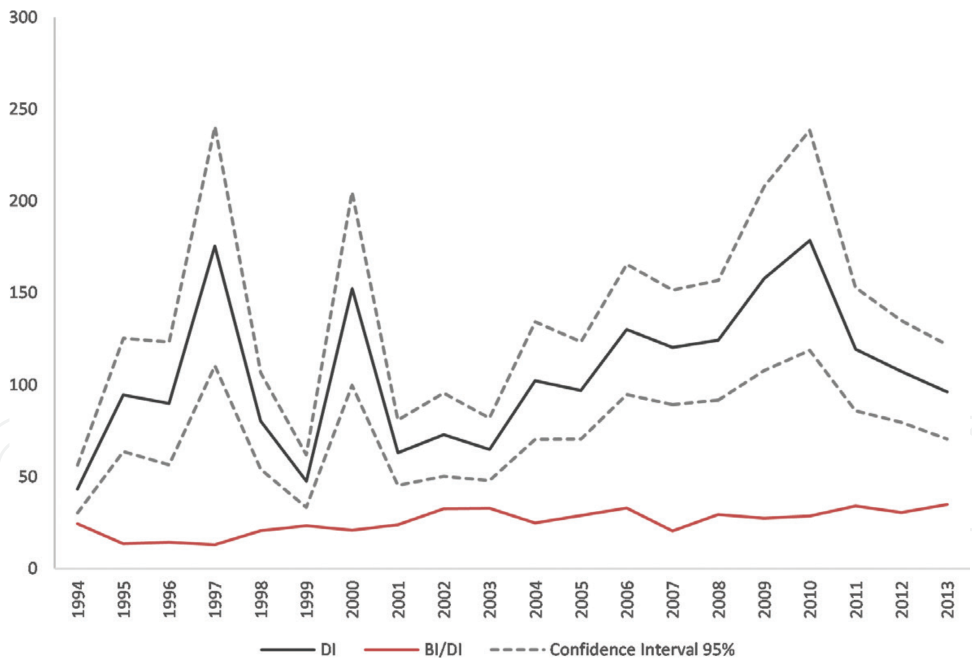

Figure 3. Annual (X ax) trend of density index (D.I. N/km^2; Y ax) and ratio between biomass index (B.I. Kg/km^2)/D.I. (Y ax), averaged across all the species, for the retained batoids during the MEDITS survey in the South of Sicily (GSA 16).

trends displayed above suggest that excluding the traditional considered rare species (such as *O. centrina, P. violacea, D. batis*, etc.), the response to fishing activities is not always the same. Valuable differences in resilience might be mainly related to the interaction between different factors (e.g. overall body shape, surviving capabilities after discarding, commercial value, etc.). In this context Ragonese et al. (in Ref. [81]) highlighted among sharks the most vulnerable and prone to decline and local extinction seems to be the neritic (such as *S. stellaris*), ovoviviparous and valuable/appreciated sharks (*Mustelus spp*. and *Squatina spp*.). *Mustelus spp*, which exhibit a big curiosity towards divers, and are also heavily speared by recreational fishers (Ragonese pers.obs.) Regarding batoids, Bradai et al. (in Ref. [12]) underline some neritic species that are almost disappeared locally (*e.g. R. alba*) or highly depleted (*R. polystigma*), whereas few species are quite stable (e.g. *R. clavata; R. miraletus*) although in a depressed abundance (in Ref. [93]).

The spatial distribution of sharks-chimaera in the GSA 16 (**Figure 4**) is mainly concentrated in the southern and north-western zones. The D.I. distribution is characterized by several patches reaching values until 1600 N/km^2, although in the north-western a hotspot is recorded with values up to 2400 N/km^2. This pattern mainly reflects the abundance and distribution of the small catsharks *S. canicula* (which prefers the outer shelf)) and *G. melastomus* (which is more abundant next to the deep basins of GSA 16) (in Ref. [25]).

Compared to sharks-chimaera, the spatial distribution of batoids (**Figure 5**) is more circumscribed within two main zones, one biggest in the north-western and the other in the southern part of the GSA 16. A small patch is recognized along the Sicilian coast with D.I. values up to 1200 N/km^2. In the north-western zone, higher values of D.I. (1600 N/km^2) are recorded.

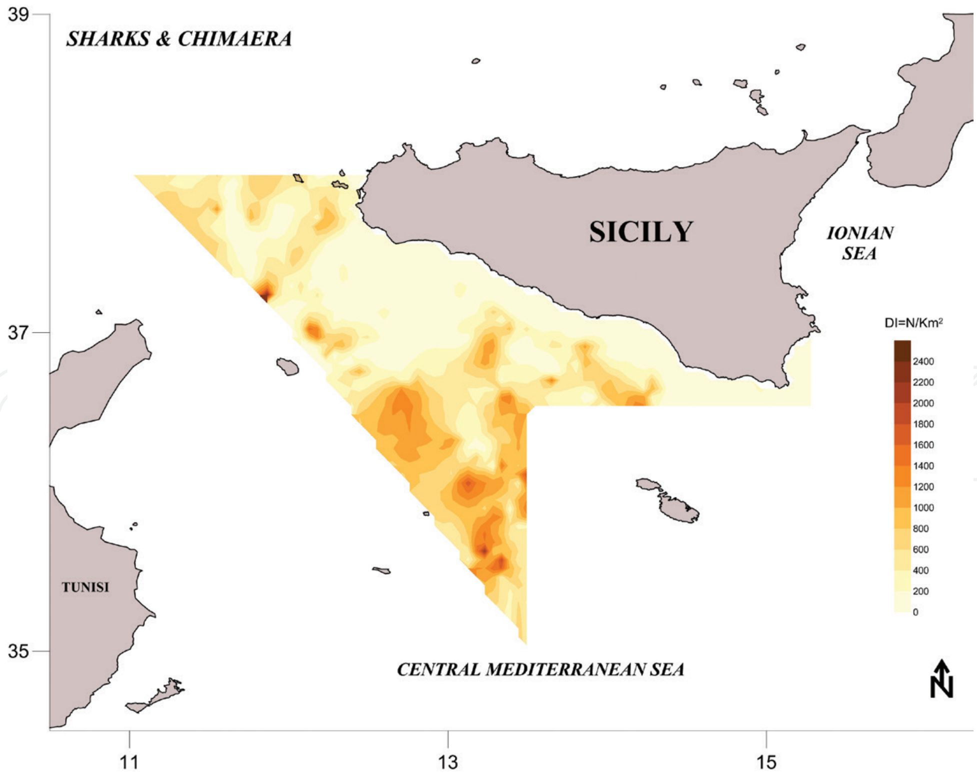

Figure 4. Spatial distribution of sharks-chimaera density index (D.I. N/km^2) in the South Sicily (GSA 16) from 1994 to 2013.

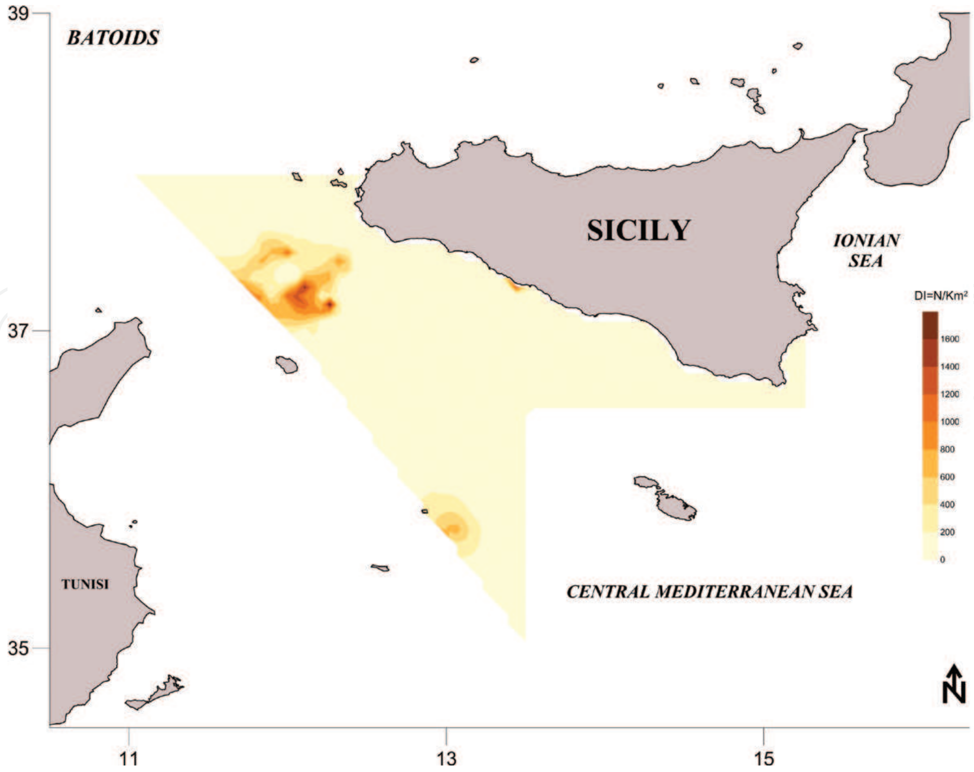

Figure 5. Spatial distribution of batoids density index (D.I., N/km^2) in the South Sicily (GSA 16) from 1994 to 2013.

Taking into account the published data on fishing effort (F) recorded by vessel monitoring system (VMS) in the years 2006–2010 (in Ref. [106]), an astonishing overlap is observed between the highest rate of fishing effort and the lowest of D.I. for both taxa. The above-mentioned considerations emphasize the importance to adopt an eco-sustainable fishery in the near future, at least in the recorded zones with higher values of D.I.

The present results are in agreement with Ragonese et al. (in Ref. [4]) who reported that in the same investigated area, the state of sharks and chimaera seems quite stable or even improving (for some species). In the same area Gancitano et al. (in Ref. [107]), carried out a similar study considering all the cartilaginous fishes together. Similarly, a slight increase of D.I. trend was displayed from the first 2000s until 2008 although a marked increase is showed by two years forward predications (2014–2015).

In the central Mediterranean Sea, Lauria et al. (in Ref. [5]) implemented habitat models considering only species with percentage of occurrence (always using MEDITS data) >5% and defined as 'Near Threatened', 'Vulnerable', 'Critically Endangered' or 'Data Deficient' in the international union for conservation of nature (IUCN) Red Lists. The authors found a negative trend at a regional scale, mainly for rays (e.g. *R. clavata*) and sharks (e.g. *Mustelus* spp.).

The overexploitation of sharks has become an urgent Mediterranean ecological issue that requires an international management strategy able to take into account the biological, socio-economic and ethical aspects to preserve the natural equilibrium of the marine ecosystem. Mitigation measures (such as the inclusion of excluder's devices in the trawls or the release of caught or still living specimens) could be introduced for the reduction of fishing impact.

A stronger effort should be sustained to educate fishermen for a responsible activity, as well as collaboration between enterprises and generally among the stakeholders, is highly recommended, also with the goal to define innovative technical solutions.

Acknowledgements

This work was carried out within the Data Collection Regulation and Framework-module trawl surveys MEDITS funded by the European Union and the Italian Ministry of Agricultural, Food and Forestry Policies. We thank all the technical staff of CNR - IAMC UOS of Mazara del Vallo (Italy) involved in data collection and processing.

Author details

Michele Luca Geraci, Sergio Ragonese, Giacomo Norrito, Danilo Scannella, Fabio Falsone and Sergio Vitale*

*Address all correspondence to: sergio.vitale@cnr.it

Institute for Coastal Marine Environment—IAMC National Research Council—CNR, Mazara del Vallo, Italy

References

[1] Vincent ACJ, Hall HJ. The threatened status of marine fishes. Trends in Ecology and Evolution. 1996;**11**:360-361. DOI: 10.1016/0169-5347(96)30041-4

[2] Roberts CM, Hawkins JP. Extinction risk in the sea. Trends in Ecology & Evolution. 1999;**14**(6):241-246. DOI: 10.1016/S0169-5347(98)01584-5

[3] Castro JI, Woodley CM, Brudeck RL. A Preliminary Evaluation of the Status of Shark Species. FAO Fisheries Technical Paper No. 380. Rome: FAO. 1999

[4] Ragonese S, Vitale S, Dimech M, Mazzola S. Abundances of demersal sharks and chimaera from 1994-2009 scientific surveys in the central Mediterranean Sea. PloS one. 2013;**8**(9). DOI: e74865

[5] Lauria V, Gristina M, Attrill MJ, Fiorentino F, Garofalo G. Predictive habitat suitability models to aid conservation of elasmobranch diversity in the central Mediterranean Sea. Scientific Reports. 2015;**5**:13245. DOI: 10.1038/srep13245

[6] Hutchings JA. Influence of population decline, fishing, and spawner variability on the recovery of marine fishes. Journal of Fish Biology. 2001;**59**(sA):306-322. DOI: 10.1006/jfbi.2001.1756

[7] Jennings S, Pinnegar JK, Polunin NV, Warr KJ. Impacts of trawling disturbance on the trophic structure of benthic invertebrate communities. Marine Ecology Progress Series. 2001;**213**:127-142. DOI: 10.3354/meps213127

[8] Arena P. Studio sulla possibilità di razionalizzare e rendere più produttiva la pesca a strascico nel Canale di Sicilia e nel Mediterraneo. Palermo: ESPI. 1985. p. 214

[9] Brander K. Disappearance of common skate, *Raia batis*, from the Irish Sea. Nature. 1981;**290**(5801):48-49. DOI: 10.1038/290048a0

[10] Casey JM, Myers RA. Near extinction of a large, widely distributed fish. Science. 1998;**281**(5377):690-692. DOI: 10.1126/science.281.5377.690

[11] Dulvy NK, Metcalfe JD, Glanville J, Pawson MG, Reynolds JD. Fishery stability, local extinctions, and shifts in community structure in skates. Conservation Biology. 2000;**14**(1):283-293. DOI: 10.1046/j.1523-1739.2000.98540.x

[12] Bradai MN, Saïdi B, Enajjar S. Elasmobranchs of the Mediterranean and Black sea: status, ecology and biology. Bibliographic analysis. In: Studies and Reviews. General Fisheries Commission for the Mediterranean. Vol. 91. Rome: FAO. 2012. p. 103

[13] Malak DA. Overview of the Conservation Status of the Marine Fishes of the Mediterranean Sea. IUCN; 2011

[14] Farrugio H, Oliver P, Biagi F. An overview of the history, knowledge, recent and future research trends in Mediterranean fisheries. Scientia Marina. 1993;**57**(2-3):105-119

[15] Dimech M, Kaiser MJ, Ragonese S, Schembri P. Ecosystem effects of fishing on the continental slope in the Central Mediterranean. Marine Ecology Progress Series. 2012;**449**:41-54. DOI: 10.3354/meps09475

[16] Sarà R. La Pesca a Strascico sui Fondali della Scarpata continentale (Settori di Levanzo e Pantelleria). Rome, Italy: Mem Min Marina Mercantile; 1969. p. 74

[17] Arena P, Li Greci F. Indagine sulle condizioni faunistiche e sui rendimenti di pesca dei fondali batiali della Sicilia occidentale e della bordura settentrionale dei banchi della soglia Siculo-Tunisina. Quad Lab Tecnol Pesca. 1973;**1**:157-201

[18] Macpherson E. Regime alimentaire de *Galeus melastomus* Rafinesque, 1810, *Etmopterus spinax* (L., 1758) et *Scymnorhinus licha* (Bonnaterre, 1788) en Mediterranee occidentale. Vie Milieu. 1980;**30**:139-148

[19] Ragonese S, Di Stefano L, Bianchini ML. Capture and selectivity of cartilaginous fishes in the red shrimp fishery: Strait of Sicily. Biologia Marina Mediterranea. 2000;**7**:400-411

[20] Cingolani N, Coppola SR, Mortera J. Studio di fattibilità per un sistema di rilevazione campionaria delle statistiche della pesca (PESTAT). Quad Ist Ric Pesca Marittima. 1986;**5/l**(2):283-753

[21] Dell'Apa A, Kimmel DG, Clo S. Trends of fish and elasmobranch landings in Italy: associated management implications. ICES Journal of Marine Science. 2012;**69**:1045-1052. DOI: 10.1093/icesjms/fss067

[22] Serena F, Mancusi C, Vacchi M. Threatened species of the Mediterranean Sea. The case of Elasmobranchs fishes: Assessment of their status and international actions for their conservation. In: Gertwagen R, Raicevich S, Fortibuoni T, Giovanardi O, editors. Le interazioni tra uomo ed ambiente nel; Mediterraneo dall'Epoca Romana al XIX secolo: una visione storica ed ecologica delle attivita di pesca. Atti II Workshop Int HMAP Mediterraneo Mar Nero Chioggia, 27-29 settembre 2006; 2008. pp. 127-142. Supplemento ai Quaderni ex ICRAM, 219 p (in Italian with English abstract)

[23] Bombace G, Sara R. La pesca a strascico sui fondali da -500 a -700 metri nel settore a sud-est di Pantelleria. Mem MIN Mar Mercantile. 1972;**33**:63-77

[24] Brčić J, Herrmann B, De Carlo F, Sala A. Selective characteristics of a shark-excluding grid device in a Mediterranean trawl. Fisheries Research. 2015;**172**:352-360. DOI: 10.1016/j.fishres.2015.07.035

[25] Ragonese S, Nardone G, Ottonello D, Gancitano S, Giusto GB, Sinacori G. Distribution and biology of the Blackmouth catshark *Galeus melastomus* Off the southern coasts of Sicily (Central Mediterranean Sea). Marine Science and Engineering. 2009;**10**(1):55-72. DOI: 10.12681/mms.122

[26] Bradai MN, Saidi B, Ghorbel M, Bouain A, Guelorget O, et al. Observations sur les requins du golfe de Gabes (Tunisie meridionale, Mediterranee centrale). Mesogee. 2002;**60**:61-77

[27] Campillo A. Les pecheries francaises de Mediterranee: Synthese des connaissances. RIDRV-92/019-RH Sete. 1992. p. 206

[28] Valls M, Quetglas A, Ordines F, Moranta J. Feeding ecology of demersal elasmobranchs from the shelf and slope off the Balearic Sea (western Mediterranean). Scientia Marina. 2011;**75**(4):633-639. DOI: 10.3989/scimar.2011.75n4633

[29] Scacco U, Andaloro F, Campagnuolo S, Castriota L, Vacchi M. Cartilaginous Fishes as a Component of Trawl Discard in Strait of Sicily. NAFO SCR Doc; 2002, 02/87

[30] Serena F. Field Identification Guide to the Sharks and Rays of the Mediterranean and Black Sea. Rome, Italy: FAO Species Identification Guide for Fishery Purposes; 2005. p. 97

[31] Compagno LJV. Sharks of the World: An Annotated and Illustrated Catalogue of Shark Species Known to Date. Volume 4, Part 1. *Hexanchiformes* to Lamniformes. Rome, Italy: FAO. 1984. DOI: 10.1002/iroh.19860710229

[32] Baino R, Serena F, Ragonese S, Rey J, Rinelli P. Catch composition and abundance of elasmobranchs based on the MEDITS program. Rapport Commission International Mer Méditerranée. 2001;**36**:234

[33] Quero JC Scyliorhinidae. In: Whitehead PJP, Hureau JC, Nielsen J, Tortonese E, editors. Fishes of the Northeastern Atlantic and the Mediterranean. Paris: Unescopp; 1984. pp. 95-100. DOI: 10.1017/s0025315400019640

[34] Bauchot ML. Requins. In: Fischer W, Schneider M, Bauchot ML, editors. Fiches FAO d'identification des especes pour les besoins de la peche Mediterranee et mer Noire, Zone de Peche 37, Revision 1. Rome: FAO; 1987. pp. 767-890

[35] Schembri T, Fergusson JK, Schembri PJ. Revision of the records of sharks and rays species from the Maltese Islands (*Chordata*: *Chondrichthyes*). Cent Medit Nat. 2003;**4**(1):71-104

[36] Serena F, Mancusi C, Ellis J. *Mustelus asterias*. The IUCN Red List of Threatened Species. 2009: e.T39357A10214084. DOI:10.2305/IUCN.UK.2009-2.RLTS.T39357A10214084.en

[37] Fischer W, Bauchot ML, Schneider M. Fiches FAO d'identification des espèces pour les besoins del la péche. Méditerranée er Mer Noire. Zone de Péche 37. Rome, Italy: FAO; 1987

[38] Gracan R, Mladineo I, Lazar B. Insight into the diet composition and gastrointestinal parasite community of the common smooth-hound, *Mustelus mustelus* (*Carcharhiniformes*: *Triakidae*), in the northern Adriatic Sea. Natura Croatica. 2014;**23**(1):35

[39] Saidi B, Mohamed N, Bradai MN, Abderrahman B. Reproductive biology and diet of *Mustelus punctulatus* (Risso, 1826) (*Chondrichthyes*: *Triakidae*) from the Gulf of Gabes, central Mediterranean Sea. Scientia Marina. 2009;**73**:249-258. DOI: 10.3989/scimar.2009.73n2249

[40] Dagit DD, Hareide N, Clo S. *Chimaera monstrosa*. In: IUCN 2012. IUCN Red List of Threatened Species. Iucn website. 2007. Available from: www.iucnredlist.org. [Accessed: 18 October 2012]

[41] Muus BJ, Nielsen JG. Sea fish. In: Muus BJ, Nielsen JG, Dahlstrom P, Nyström BO, editors. Scandinavian Fishing Year Book. Denmark: Hedehusene; 1999. p. 340

[42] Albo PM, Navarro J, Coll M, Aguzzi J, Cardona L, Sáez-Liante R. Feeding ecology and trophic position of three sympatric demersal chondrichthyans in the northwestern Mediterranean. Marine Ecology Progress Series. 2015;**524**:255-268. DOI: 10.3354/meps11188

[43] Torres MA, Ramos, F, Sobrino I. Length–weight relationships of 76 fish species from the Gulf of Cadiz (SW Spain). Fisheries Research. 2012;**127**:171-175. DOI: 10.1016/j.fishres.2012.02.001

[44] Sion L, Bozzano A, D'Ongia G, Capezzuto F, Panza M. *Chondrichthyes* species in deep waters of the Mediterranean Sea. Scientia Marina. 2004;**68**:153-162. DOI: 10.3989/scimar.2004.68s3153

[45] Compagno LJV, Ebert DA, Smale MJ. Guide to the Sharks and Rays of Southern Africa. London: New Holland Ltd.; 1989

[46] Celona A, De Maddalena A, Romeo T. Bluntnose sixgill shark, *Hexanchus griseus* (Bonnaterre, 1788), in the Eastern North Sicilian waters. Boll Mus civ St nat. Venezia. 2005;**56**:137-151

[47] Potoschi A, Iaria G, Spano N. Shark records in the strait of Messina (Central Mediterranean Sea): *Hexanchus griseus* (Bonnaterre, 1788). Rapp Comm Int Mer Medit. 2010;**39**:636

[48] Guallart J, Serena F, Mancusi C, Casper Bm, Burgess GH, Ebert DH, Clarke M, Stenberg C. *Centrophorus granulosus*. In: IUCN 2008. IUCN Red List of Threatened Species. Available from: www.iucnredlist.org

[49] Reiner F. Catálogo dos peixes do arquipélago de Cabo Verde. Publ. Avuls. Inst. Port. Invest. Mar. 1996;**2**:339

[50] Springer VG, Last PR, Stevens JD. Sharks and rays of Australia. Copeia. 1994(4). p. 1055. DOI: 10.2307/1446735

[51] Daley RK, Stevens JD, Last PR, Yearsley GK. Field guide to Australian sharks and rays. CSIRO Div. of Marine Research/Fisheries Research & Development Corporation; 2002. p. 84

[52] Golani D. On deep-water sharks caught off the Mediterranean coast of Israel. Israel Journal of Zoology. 1986;**34**:23-31

[53] Navarro J, López L, Coll M, Barría C, Sáez-Liante R. Short-and long-term importance of small sharks in the diet of the rare deep-sea shark *Dalatias licha*. Marine Biology. 2014;**161**(7):1697-1707. DOI: 10.1007/s00227-014-2454-2

[54] Jones EG, Tselepides A, Bagley PM, Collins MA, Priede IG. Bathymetric distribution of some benthic and benthopelagic species attracted to baited cameras and traps in the deep eastern Mediterranean. Marine Ecology Progress Series. 2003;**251**:75-80. DOI: 10.3354/meps251075

[55] Fanelli E, Rey J, Torres P, Gil de Sola L. Feeding habits of blackmouth catshark Galeus melastomus Rafinesque, 1810 and velvet belly lantern shark *Etmopterus spinax* (Linnaeus, 1758) in the western Mediterranean. Journal of Applied Ichthyology. 2009;**25**(s1):83-93. DOI: 10.1111/j.1439-0426.2008.01112.x

[56] Coelho R, Blasdale T, Mancusi C, Serena F, Guallart J, Ungaro N, Litvinov F, Crozier P, Stenberg C. *Etmopterus spinax*. The IUCN Red List of Threatened Species. 2009. Available from: https://doi.org/10.2305%2Fiucn.uk.2009-2.rlts.t161388a5412576.en

[57] Capapé C. Observations sur le régime alimentaire de 29 Sélaciens pleurotêmes des côtes tunisiennes. Archives de l'Institut Pasteur de Tunis. 1975;**52**:395-414

[58] Capapé C. Diet of the angular rough shark *Oxynotus centrina* (*Chondrichthyes*: Oxynotidae) off the Languedocian coast (southern France, north-western Mediterranean). Vie et Milieu. 2008;**58**:57-61

[59] Guallart J, García-Salinas P, Ahuir-Baraja AE, Guimerans M, Ellis JR, Roche M. Angular roughshark *Oxynotus centrina* (*Squaliformes*: *Oxynotidae*) in captivity feeding exclusively on elasmobranch eggs: An overlooked feeding niche or a matter of individual taste? Journal of Fish Biology. 2015;**87**(4):1072-1079

[60] Serena F, Papakonstantinou C, Relini G, Gil De Sola L, Bertrand JA. Distribution and abundance of Spiny dogfish in the Mediterranean Sea based on the Mediterranean International Trawl Survey program. In: Gallucci V, McFarlane G, Bargmann G, editors. Biology and Management of Dogfish Sharks. American Fishery Society; 2009. p. 139-149

[61] Avsar D. Age, growth, reproduction and feeding of the spurdog (*Squalus acanthias* Linnaeus, 1758) in the South-eastern Black Sea. Estuarine, Coastal and Shelf Science. 2001;**52**(2):269-278. DOI: 10.1006/ecss.2000.0749

[62] Martinho F, Sá C, Falcão J, Cabral HN, and Pardal MÂ. Comparative feeding ecology of two elasmobranch species, *Squalus blainville* and *Scyliorhinus canicula*, off the coast of Portugal. Fishery Bulletin. 2012;**110**(1):71-84

[63] Ebert DA, Serena F, Mancusi C. 2009. *Squalus blainville*. The IUCN Red List of Threatened Species. 2009: e.T161536A5446109. Available from: http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T161536A5446109.en

[64] Whitehead PJP, Bauchot ML, Hureau JC, Nielsen J, Tortonase E, editors. 1984: Fishes of the North-eastern Atlantic and the Mediterranean. Vol. 1. Paris, France: UNESCO; 1984. p. 510. DOI: 10.1017/s0025315400019640

[65] Ebert DA, Stehmann MF. Sharks, batoids and chimaeras of the North Atlantic. Vol. 7. Roma (Italia): FAO; 2013. p. 523

[66] Ismen A. Age, growth, reproduction and food of common stingray (*Dasyatis pastinaca* L., 1758) in Iskenderun Bay, the eastern Mediterranean. Fisheries Research. 2003;**60**(1):169-176. DOI: 10.1016/s0165-7836(02)00058-9

[67] Notarbartolo di Sciara G, Bianchi I. Guida degli squali e delle razze del Mediterraneo. Muzzio; 1998. p. 388

[68] Lipej L, Mavrič B, Paliska D, Capapé C. Feeding habits of the pelagic stingray *Pteroplatytrygon violacea* (*Chondrichthyes*: Dasyatidae) in the Adriatic Sea. Journal of the Marine Biological Association of the United Kingdom. 2013;**93**(02):285-290. DOI:10.1017/s0025315412000197

[69] Orsi Relini L, Cima C, Garibaldi F, Palandri G, Relini M, Torchia G. La pesca professionale con i palamiti galleggianti nel "Sautuario dei cetacei" del Mar Ligure: si tratta di attivita' ecocompatibili? Biologia Marina Mediterranea. 1999;**6**:100-109

[70] Holtzhausen JA, Ebert DA, Serena F, Mancusi C. *Myliobatis aquila*. International Union for Conservation of Nature. IUCN Red List of Threatened Species, version 2014.3. Available from: www.iucnredlist.org. 2009

[71] Mollet HF, Ezcurra JM, O'Sullivan JB. Captive biology of the pelagic stingray, *Dasyatis violacea* (Bonaparte, 1832). Marine and Freshwater Research. 2002;**53**:531-541. DOI: 10.1071/mf01074

[72] Dulcic J, Lovrenc L, Bonaca M, Jenko R, Grbec B, Guélorget O, Capapé C. The Bull ray in the Adriatic Sea. Cybium. 2008;**32/2**:119-123

[73] Froese R, Pauly D. *Aetomylaeus bovinus* in FishBase January 2016 version. Available from: http://www.fishbase.org/

[74] Wintner S. *Aetomylaeus bovinus*. The IUCN Red List of Threatened Species. 2016. Available from: http://www.fishbase.org/

[75] Steven GA. The British raiidae. Science Progress, London. 1947;**35**:220-236

[76] Yıgın C, Ismen A. Age, growth, reproduction and feed of longnosed skate, *Dipturus oxyrinchus* (Linnaeus, 1758) in Saros Bay, the north Aegean Sea. Journal of Applied Ichthyology. 2010;**26**(6):913-919. DOI: 10.1111/j.1439-0426.2010.01510.x

[77] Serena F, Mancusi C, Barone M. editors. Field guide to the identification of the skates (Rajidae) of the Mediterranean Sea. Guidelines for data collection and analysis. Biologia. Marina Mediterranea. 2010;**17**(Suppl. 2):201

[78] Mulas A, Bellodi A, Cannas R, Cau A, Cuccu D, Marongiu MF, Follesa MC. Diet and feeding behaviour of longnosed skate *Dipturus oxyrinchus*. Journal of Fish Biology. 2015;**86**(1):121-138

[79] Agustin LQ. *Leucoraja circularis*. Sandy Ray. 2009. Available from: http://www.fishbase.org/

[80] Zidowitz H, George M, Fordham S, Kullander SO, Pelczarski W. Sharks in the Baltic: Distribution, Use and Conservation of Cartilaginous Fishes in the Baltic Sea. 2008. Available from: The Shark Alliance. www.sharkalliance.org

[81] Ragonese S, Cigala Fulgosi F, Bianchini ML, Norrito G, Sinacori G. Annotated checklist of the skates (*Chondrichthyes*, *Rajidae*) in the Strait of Sicily (Central mediterranean). Biologia Marina Mediterranea. 2003;**10**:874-881

[82] Farias I, Figueiredo I, Moura T, Serrano Gordo L, Neves A, Serra-Pereira, B. Diet comparison of four ray species (*Raja clavata*, *Raja brachyura*, *Raja montagui* and *Leucoraja naevus*) caught along the Portuguese continental shelf. Aquatic Living Resources. 2006;**19**(2):105-114. DOI: 10.1051/alr:2006010

[83] Bono L, De Ranieri S, Fabiani O, Lenzi C, Mancusi C, Serena F. Studio sull'accrescimento di *Raja asterias* (Delaroche, 1809) (*Chondrichthyes*, *Rajidae*) attraverso le analisi delle vertebre (Study of the growth of *Raja asterias* (Delaroche, 1809) (*Chondrichthyes*, *Rajidae*) through the analysis of vertebral sections). Biologica Marina Mediterranea. 2005;**12**:470-474

[84] Navarro J, Coll M, Preminger M, Palomera I. Feeding ecology and trophic position of a Mediterranean endemic ray: Consistency between sexes, maturity stages and seasons. Environmental Biology of Fishes. 2013;**96**(12):1315-1328. DOI: 10.1007/s10641-013-0109-7

[85] Stehmann M, Bürkel DL. *Rajidae*. In: Whitehead PJP, Bauchot ML, Hureau JC, Nielsen J, Tortonese E, editors. Vol. 1. Fishes of the North-eastern Atlantic and Mediterranean. Paris: UNESCO; 1984. pp. 163-196. DOI: 10.1017/s0025315400019640

[86] Gibson C, Valenti SV, Fowler SL, Fordham SV. The Conservation Status of Northeast Atlantic Chondrichthyans; Report of the IUCN Shark Specialist Group Northeast Atlantic Regional Red List Workshop. IUCN SSC Shark Specialist Group; 2006. VIII + p. 76

[87] Kadri H, Marouani S, Saïdi B, Bradai MN, Bouaïn A, Morize E. Age, growth, sexual maturity and reproduction of the thornback ray, *Raja clavata* (L.), of the Gulf of Gabes (south-central Mediterranean Sea). Marine Biology Research. 2014;**10**(4):416-425. DOI: 10.1080/17451000.2013.797584

[88] Kadri H, Marouani S, Bradai MN, and Bouaïn A. Diet and feeding strategy of thornback ray, *Raja clavata* (*Chondrichthyes*: *Rajidae*) from the Gulf of Gabes (Tunisia—Central Mediterranean Sea). Journal of the Marine Biological Association of the United Kingdom. 2014;**94**(7):1509-1516. DOI: 10.1017/s0025315414000587

[89] Ellis JR, Dulvy NK, Serena F. *Raja clavata*. The IUCN Red List of Threatened Species. 2016. Available from: http://www.iucn.org/

[90] Kadri H, Marouani S, Bradai MN, Bouain A, Morize E. Distribution and Morphometric characters of the mediterranean brown ray, *Raja miraletus* (*Chondrichthyes*: *Rajidae*) in the gulf of gabes (Tunisia, Central Mediterranean). American Journal of Agriculture and Forestry. 2014;**2**(2):45-50. DOI: 10.11648/j.ajaf.20140202.15

[91] Follesa MC, Mulas A, Cabiddu S, Porcu C, Deiana AM, and Cau A. Diet and feeding habits of two skate species, *Raja brachyuran* and *Raja miraletus* (*Chondrichthyes*, *Rajidae*) in Sardinian waters (central-western Mediterranean). Italian Journal of Zoology. 2014;**77**(1):53-60. DOI: 10.1080/11250000802589600

[92] Smale MJ, Ungaro N, Serena F, Dulvy N, Tinti F, Bertozzi M, Mancusi C, Notarbartolo di Sciara G. *Raja miraletus*. The IUCN Red List of Threatened Species. 2009. Available from: http://www.iucn.org/

[93] Bottari T, Rinelli P, Bianchini ML, Ragonese S. Stock identification of *Raja clavata* L. (*Chondrichthyes*, *Rajidae*) in two contiguous areas of the Mediterranean. Hydrobiologia. 2013;**703**:215-224. DOI: 10.1007/s10750-012-1361-0

[94] Ellis JR, Cruz-Martinez A, Rackham BD, Rogers SI. The distribution of chondrichthyan fishes around the British Isles and implications for conservation. Journal of Northwest Atlantic Fishery Science. 2005;**35**(195-213):113. DOI: 10.2960/J.v35.m485

[95] Relini G, Biagi F, Serena F, Belluscio A, Spedicato MT, Rinelli P, Follesa MC, Piccinetti C, Ungaro N, Sion L, Levi D. I Selaci pescati con lo strascico nei mari italiani. Biol. Mar. Medit. 2000;**7**(1):347-384

[96] Consalvo I, Iraci Sareri D, Bottaro M, Tudisco A, Cantone G, Vacchi M. Diet composition of juveniles of rough ray *Raja radula* (*Chondrichthyes*: *Rajidae*) from the Ionian Sea. Italian Journal of Zoology. 2010;**77**(4):438-442. DOI: 10.1080/11250000903390197

[97] Kadri H, Marouani S, Bradai MN, Boua ÃA, Morize E. Age, Growth, Mortality, longevity and reproductive biology of the white skate, *Rostroraja alba* (*Chondrichthyes*: *Rajidae*) of the Gulf of Gabès (Southern Tunisia, Central Mediterranean). Turkish Journal of Fisheries and Aquatic Sciences. 2014;**14**(1). DOI: 10.4194/1303-2712-v14_1_21

[98] Yiğin CÇ, İsmen A, Umur ÖNAL, Arslan M. Cartilaginous fishes and fisheries in the Aegean Sea. The Aegean Sea. 2015;p. 286

[99] Duman ÖV, Basusta N. Age and growth characteristics of marbled electric ray *Torpedo marmorata* (Risso, 1810) inhabiting Iskenderun Bay, North-eastern Mediterranean Sea. Turkish Journal of Fisheries and Aquatic Sciences. 2013;**13**(3). DOI: 10.4194/1303-2712-v13_3_19

[100] Capapé C, Crouzet S, Clement C, Vergne Y, Guelorget O. Diet of the marbled electric ray *Torpedo marmorata* (*Chondrichthyes*: *Torpedinidae*) off the Languedocian coast (Southern France, Northern Mediterranean). ANNALES Series Historia Naturalis. 2007;**17**:17-22

[101] Consalvo I, Scacco U, Romanelli M, Vacchi M. Comparative study on the reproductive biology of *Torpedo torpedo* (Linnaeus, 1758) and *T. marmorata* (Risso, 1810) in the central Mediterranean Sea. Scientia Marina. 2007;**71**(2):213-222. DOI: 10.3989/scimar.2007.71n2213

[102] Romanelli M, Consalvo I, Vacchi M, Finoia G. Diet of *Torpedo torpedo* and *Torpedo marmorata* in a coastal area of Central Western Italy (Mediterranean Sea). Marine Life. 2006;**16**:21-30

[103] Abdel-Aziz SH. Observations on the biology of the common torpedo (*Torpedo torpedo*, Linnaeus, 1758) and marbled electric ray (*Torpedo marmorata*, Risso, 1810) from Egyptian Mediterranean waters. Marine and Freshwater Research. 1994;**45**(4):693-704. DOI: 10.1071/mf9940693

[104] Marouani S, Chaâba R, Kadri H, Saidi B, Bouain A, et al. Taxonomic research on *Squalus megalops* (Macleay, 1881) and *Squalus blainvillei* (Risso, 1827) (*Chondrichthyes*: *Squalidae*) in Tunisian waters (central Mediterranean Sea). Scientia Marina. 2012;**76**(1):97-109. DOI: 10.3989/scimar.03440.22b

[105] Iglésias SP. Chondrichtyens du Nord-est Atlantique et de la Méditerranée, (Une classification naturelle basée sur des spécimens de collection, avec barcodes DNA et photographies standardisées), Volume I (plates), Provisional Version 06, 01 avril 2012. p. 83. Available from: http://www.mnhn.fr/iccanam/ [Accessed: 23 November 2012]

[106] Russo T, Parisi A, Garofalo G, Gristina M, Cataudella S, Fiorentino F. SMART: A spatially explicit bio-economic model for assessing and managing demersal fisheries, with an application to Italian trawlers in the strait of Sicily. PLoS ONE. 2014;**9**(1):e86222. DOI: 10.1371/journal.pone.0086222

[107] Gancitano V, Enea M, Colloca F, Gancitano S, Ingrande G, Massi D, Rizzo P, Titone A, Fiorentino F. Temporal dynamics of demersal resources in the south of sicily (GSA 16) during the last twenty years. Biologica Marina Mediterranea. 2015;**1**. ISSN 1123-4245