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Trends of fish and elasmobranch landings in Italy: associated management implications

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Elasmobranchs are extremely vulnerable to overexploitation, owing to their specific biology and life-history characteristics. However, European-managed shark fisheries have historically received less attention than fisheries targeting more commercially important fish species. We analysed and compared the national data of elasmobranch and fish landings in Italy between 1959 and 2004 to examine changes in fishery interest and the exploitation of elasmobranchs over time. Rays (*Raja* spp.) and smooth-hounds (*Mustelus* spp.) are the only elasmobranch categories present in the data, but also other similar species could have been mistakenly counted within these groups. Elasmobranch landings were steady until the beginning of the 1970s, peaked in the 1990s, then sharply declined. The mean annual landing for elasmobranchs between 1997 and 2004 decreased 77% compared with the previous years (1959–1982). This decrease may be attributed to overharvesting that occurred during the 1980s and 1990s in Italian seas. This was likely a direct consequence of the 41/82-law, which was developed to manage fish and not elasmobranchs. A direct effect of the 41/82-law was the establishment of an unreported and unregulated elasmobranch fishery since 1983 that lasted almost 10 years. We suggest that the conservation status of elasmobranch species in the Mediterranean and Black Seas be reconsidered.

Keywords: cumulative sum, elasmobranch fisheries, law 41/82, Mediterranean, *Red list*, shark conservation, shark management.

Introduction

The general biological characteristics of chondrichthyans (slow growth rate, late age at sexual maturity, low fecundity, long gestation periods, and a long lifespan) limit their capacity to sustain fisheries and recover from overexploitation, hence making them more susceptible to overfishing and to environmental changes compared with the majority of fish species (Camhi *et al*., 1998; Stevens *et al*., 2000; Caillet *et al*., 2005).

Many shark populations have been reduced to less than 10% of pre-exploitation biomass (Baum and Myers, 2004; Dulvy and Reynolds, 2009), and several species of large skates may have become extinct at the global level (Casey and Myers, 1998; Brander, 1981). The chondrichthyan fish fauna of the Mediterranean consists of ~80 species, including 45 species of sharks from 17 families, 34 batoid species from 9 families, and 1 species of chimaera (Compagno, 2001; Serena, 2005). Over 490 fish species are known along the Italian coast, of which 74 Selachii (43 Squaliformes, 30 Rajiformes, and 1 Chimaeriformes) have been recorded (Amori *et al*., 1993). Several species of sharks and skates that once were widespread and abundant are now uncommon and rare in Italian waters (Vacchi and Notarbartolo di Sciara, 2000).

The worldwide reduction in numbers of several elasmobranch species, mostly on the continental shelf, seems to be primarily related to trawl fisheries (Bertrand *et al*., 1997; Relini *et al*., 1999, 2000). A list of chondrichthyans fished during national fishery-independent trawl surveys (1985–1998) in all Italian seas comprised 44 species (17 Squaliformes, 26 Rajiformes, and 1 Chimaeriformes), which corresponds to 59% of all species that have been recorded along Italian coasts (Relini and Piccinetti, 1996; Relini *et al*., 2000). Cartilaginous fish currently represent a fishery bycatch in the Mediterranean Sea, although some species have an important commercial role as bycatch product (Castro *et al*., 1999; ICCAT, 2001). According to Megalofonou *et al*. (2000), at least ten species of pelagic sharks are captured as bycatch by the Mediterranean large pelagic fishery. Bycatch of sharks can only be crudely estimated, as capture by bottom trawlers and longlines is poorly documented and these data are rarely incorporated in national and international board statistics (Camhi *et al*., 1998). International markets are becoming more open to pelagic sharks for food consumption (Mejuto and de la Serna, 2000) suggesting that they might become target species with future increases in their market value.

Insufficient data exist to quantify the historical level of elasmobranch exploitation in the Mediterranean, as the long-term sources of information to assess shark removals are very rare in this region (Ferretti *et al.*, 2005). The IUCN Red List assessments indicate that 30% of elasmobranch species in the Mediterranean Sea are data deficient (lack of sufficient data), and roughly 70% require more thorough monitoring (Abdulla, 2004).

Time-series of fishery landings can provide important indications of changes in a fishery. Often, as for Mediterranean fisheries, this is essential in the absence of complete or independent information such as those on fishing intensity or fishing mortality affecting the stock. Italian management agencies currently lack a precise list of elasmobranch species caught, due to inaccuracy in onboard and landing recording over the past 50 years. A solution to this issue has been the implementation of fishery-independent trawl surveys along the Italian coasts such as the GRUND (Gruppo Nazionale Demersali) and MEDITS (International Bottom Trawl Survey in the Mediterranean) programs which began in 1985 and 1994, respectively. However, time-series data generated by these surveys (Relini *et al.*, 2000; Bertrand *et al.*, 2002) have often been dismissed as a means for estimating trends because of the shortness of the covered period (MEDITS) and the heterogeneity of the sampling methods (GRUND; Ferretti *et al.*, 2005). Therefore, historical fishery landing trends often provide the only indication that important changes have occurred over time (Fiorentini *et al.*, 1997).

The primary aim of this study was to compare historical landings data (1959–2004) of elasmobranchs (smooth-hound and ray species combined) with those of other fish landed in the same region. These data were analysed to quantify any temporal changes in elasmobranch landings relative to fish landings concurrently captured over the past five decades in Italian waters. A further goal was to interpret our findings within the framework of the most important Italian fishing legislation enacted during the study period: the 41/82 law, the "Plan for the rationalization and the development of commercial fishery" (http://faoadriamed.org/pdf/Legislation/Italy/Laws%2041-1982.html). This law is a national plan to reinforce the power of national fishing management authorities to promote a more sustainable national fishery and to control fishing effort. This law placed stricter requirements for the acquisition and maintenance of a fishing license, superseding the more permissive law 963/65 (Angelone, 2003). Fishing permits, according to the 963/65 law, were issued to fishers using a discretionary procedure that simply determined if a fisher had a subjective and objective requisites for the practice of commercial fishery. The granting of fishing licenses, as stipulated by the 41/82 law, is to be decided by the Ministry for Agricultural Policy (MAP) after consideration for the sustainability of fishing resources (Angelone, 2003). The law had also the objective of promoting a sustainable exploitation of fishing resources and to foster market demand differentiation, market national widening, and increase in national fishing products. Elasmobranch species were not included in this effort; thus, our analysis may indicate whether changes in elasmobranch landings could have been caused by a lack of management of the species or simply by a change in target species fishing effort as a direct result of the law implementation.

Material and methods

We analysed the historical data of both elasmobranch and fish landings in Italy recorded by ISTAT (Istituto Nazionale di Statistica) from 1959 to 2004 (data were absent for both 1973 and 1995). These data classify elasmobranch landings as "rays" (*Raja* spp.) and "palombo" (smooth-hound, *Mustelus* spp.). Two problems encountered in this analysis were (i) a lack of a detailed list of ray species caught and (ii) a potential misclassification of "palombo" species, such that small- and medium-sized sharks could have been generically recorded as "palombo". Classification schemes have also changed through time. From 1959 to 1981, the classification categories included "palombo" and "gattuccio" (small-spotted catshark, *Scyliorhinus* spp.) in one group and "rays and skates" in another. From 1982 to 2004, primary group classifications were "rays" and "palombo". To address the problem of cross-classification and no distinction between species within the data through time, we combined landings for all "elasmobranchs" together. Landings data from crustacean and mollusc fisheries were omitted, because smooth-hound and ray species are rarely caught by these fisheries in Italy.

Since days at sea were not recorded and vessel's engine power was not available for the whole study period, due to a change over time in the recording procedure, fishing effort is here expressed as vessel tonnages (nominal effort). Methodologically, it would be better to consider for a measure of effective effort, which reflects the amount of fishing gear of a specific type used on the fishing grounds over a given unit of time (e.g. hours trawled per day, number of hooks set per day or number of hauls of a beach-seine per day, etc.; FAO, 1997). Many studies in fishery use nominal measures when better information is not available, as it was the case here (Anderson, 2002). In the absence of uniform gear use, CPUE can be applied on a coarser scale utilizing whatever effort data are available (Morgan and Burgess, 2005). To account for changes in recording procedures, fishing grounds, different fishing techniques, bait types used by each fishery, and consequently the impossibility to standardize data, landings, and effort data (expressed as vessel tonnages) were log-transformed and used to calculate the nominal CPUE for both elasmobranchs (CPUEe hereafter) and fish (CPUEf hereafter) using the equation:

$$CPUE = \left[\frac{LOG_{\mathrm{landings}}}{LOG_{\mathrm{vesseltonnages}}}\right].$$

Differences in elasmobranch and fish annual landings, annual vessel tonnages, and the relative annual nominal CPUE were analysed for two distinct periods, and temporal trends were fitted over time by a LOESS (Locally Weight Scatterplot Smoothing) curve with tension at 0.05 (Cleveland and Devlin, 1988). The first period was before the implementation of the law 41/82 (1959–1982), which was issued in 1982. The second period was the post-law 41/82 implementation (1983–2004).

A cumulative sum (CUSUM) technique was employed to examine for temporal changes in elasmobranch and fish landings and relative CPUEs (expressed as landings/vessel tonnages as the CUSUM analysis does not require standardization). The CUSUM, introduced by Hurst (1950), is a visual statistical procedure commonly used in industry for quality control that allows the detection of temporal changes of a persistent process (Woodward and Goldsmith, 1964; Montgomery, 1991). It involves the subtraction of a control reference level from a series of points (for this study, the average value of a specific variable over a certain time). The CUSUM is calculated using the following equation (Barnard, 1959):

$$S_r = \sum_{i=1}^{r} (x_i - \mu),$$

where S_r is the CUSUM, x_i an individual time-series value, and μ the long-term mean value of the time-series. The goal of this exercise was to determine the point where the direction of change for each time-series occurred. For example, a period of positive slope in the CUSUM chart indicates that values are above the long-term mean, whereas a period of negative slope indicates values that are below the long-term mean. The point at which the slope switches from positive to negative (or *vice versa*) is termed the change point.

The relationship between CPUEe and CPUEf, before and after the issue of the law 41/82 was evaluated using the Pearson correlation coefficient *R*. Giving the presence of a large value of elasmobranch landings reported in 1994, a preliminary analysis was performed by a simple correlation analysis with and without the data for 1994, to explore whether these data are sensitive for this year. The exclusion of 1994 data did not affect the analysis for the period after the issue of the 41/82 law; therefore, it was not excluded from the analysis.

Results

Annual elasmobranch landings were quite steady until 1982, although a small increase occurred between 1975 and 1981 (Figure 1a). Annual landings increased from 1983 to 1994, with fluctuation between years and two distinctive peaks in 1985 and 1994 (Figure 1a). Elasmobranch mean annual landings (MALe hereafter) between 1959 and 1982 were 3896 ± 5.65 t. MALe between 1983 and 1994 was about 10 583 ± 2599 t. Between 1996 and 2004, MALe was 2014 ± 1681 t. Within the last 5 years of the study period (2000–2004), there was an MALe of 879 ± 37 t. Expressed as percentages, the landings of elasmobranchs decreased by 48 and 77% during the periods 1996–2004 and 2000–2004, respectively, compared with the 1959–1982 period. Comparatively, fish landings showed an annual increasing trend between 1959 and 1985, although with fluctuations present at the end of the 1960s (Figure 1a). Fish mean annual landings (MALf hereafter) during this period averaged 222 121 ± 57 771 t. After 1986, fish landings decreased annually until 2004, with a small increase recorded between 1991 and 1994. MALf between 1986 and 2004 was 200 972 ± 42 059 t.

Results for the CUSUM landings show that the trend for elasmobranch was similar to the trend for fish landings until 1974 (Figure 1b), suggesting that elasmobranchs were a major bycatch component of fish landings. Initiating in 1983, elasmobranch landings suddenly increased each year until 1994. After that period, the annual trend started to decrease again. The CUSUM trend for fish landings indicates a continuous decrease between 1959 and 1972 (Figure 1b). Starting in 1974 (but probably in 1973), this trend increased annually, reaching a peak in 1994, then starting again to decline until 2004.

Vessel tonnage increased annually until a peak in 1983, which was followed by a brief stable period (1984–1992) then a steady decline thereafter (Figure 2a). This trend was identical in shape to that of fisheries landings (Figure 2a).

The annual CPUEe and CPUEf showed a decreasing trend from 1959 to 1974 (Figure 2b). There was a higher annual CPUEe between 1983 and 1997, including the overall peak in the CPUEe trend for that period. The annual CPUEf trend showed a smaller fluctuation within the same period. The annual CPUEf trend remained quite constant between 1975 and 2004, although showing a small decrease starting in the second half of the 1980s. Meanwhile, after an evident increase starting in 1975, from the first half of the 1990s, the CPUEe showed a decreasing trend that reached very low values never recorded before since 1959.

The CUSUM results show that CPUEe and CPUEf trends were similar between 1959 and 1982 (Figure 3), which further support the idea that elasmobranch landings can be considered as a commercial bycatch component of fish landings within this period. However, starting from 1983, the trend for elasmobranch dramatically increased, reaching a peak in 1994. The period between 1994 and 2004 is characterized by a consistent annual decrease in CPUEe. The CUSUM for CPUEf shows an increase starting in

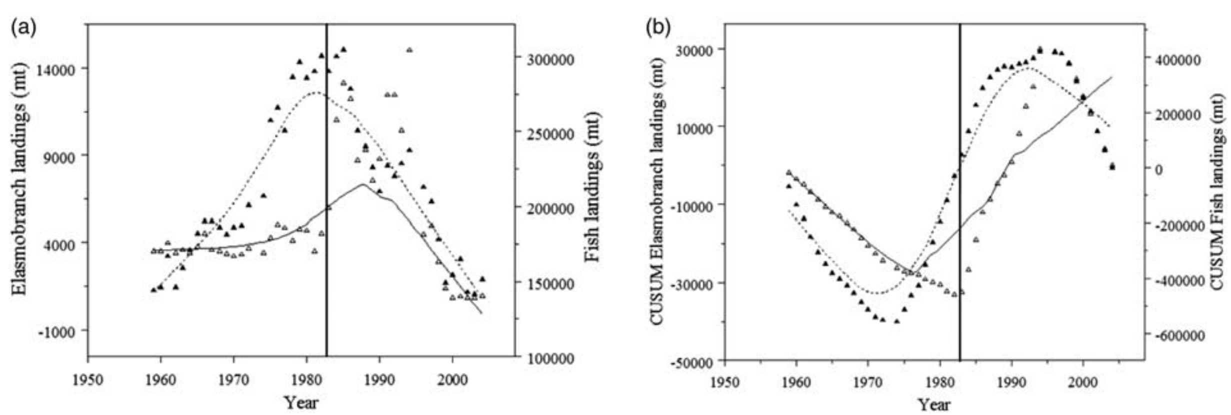

Figure 1. Annual elasmobranch landings (open triangles) in tonnes from 1959 to 2004 (data missing for 1973 and 1995) with a relative trend expressed as LOESS (solid line) with tension at 0.05, and annual fish landings (solid triangles) in tonnes with a relative trend expressed as LOESS (dashed line) with tension at 0.05 from ISTAT data. Elasmobranch landings are the sum of smooth-hounds and rays quantities (a). CUSUM for annual elasmobranch landings (tonnes; open triangles) from 1959 to 2004 (data missing for 1973 and 1995) with a relative trend expressed as LOESS (solid line) at tension of 0.05, and for annual fish landings (mt; solid triangles) with a relative trend expressed as LOESS (dashed line) at tension of 0.05 from ISTAT data (b). Black solid vertical line indicates the introduction of the law 41/82.

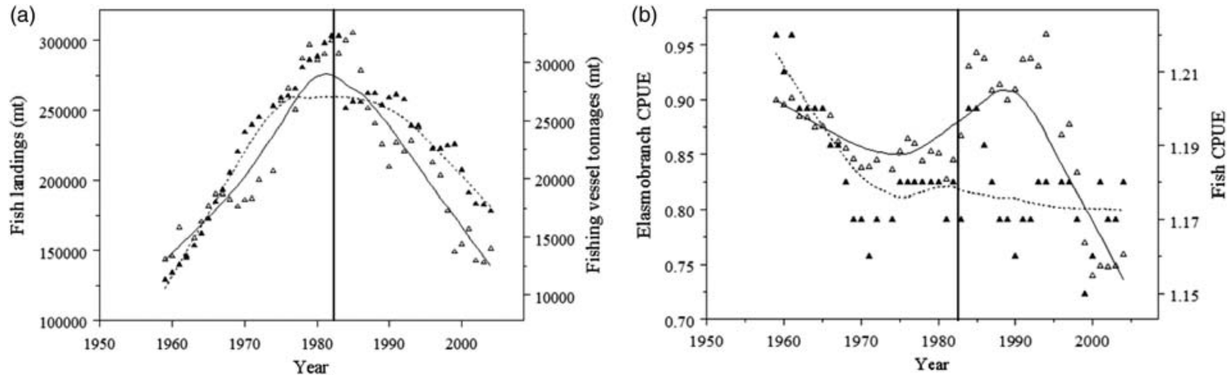

Figure 2. Annual fishing vessel tonnages (solid triangles) from 1959 to 2004 (data missing for 1973 and 1995) with a relative trend expressed as LOESS (dashed line) at tension of 0.05, and annual fish landings (open triangles) in tonnes with a relative trend expressed as LOESS (solid line) at tension of 0.05 from ISTAT data (a). Annual elasmobranch CPUE (open triangles) with a relative trend expressed as LOESS (solid line) at tension of 0.05, and annual fish CPUE (open triangles) with a relative trend expressed as LOESS (dashed line) at tension of 0.05 from 1959 to 2004 (data missing for 1973 and 1995) from ISTAT data. CPUEs are expressed as log landings/log vessel tonnages (b). Black solid vertical line indicates the introduction of the law 41/82.

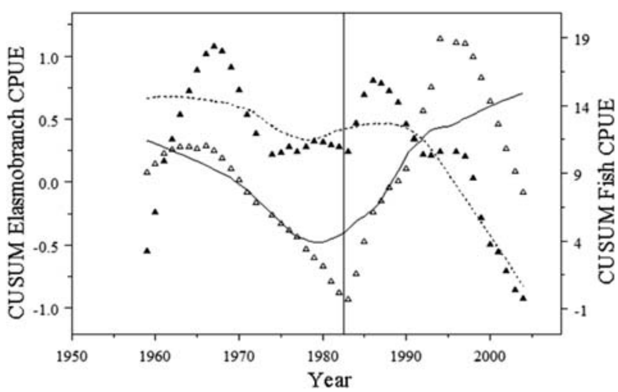

Figure 3. CUSUM of annual elasmobranch CPUE (open triangles) with a relative trend expressed as LOESS (solid line) at tension of 0.05, and annual fish CPUE (solid triangles) with a relative trend expressed as LOESS (dashed line) at tension of 0.05 from 1959 to 2004 (data missing for 1973 and 1995) from ISTAT data. CPUEs are expressed as landings/vessel tonnages. Black solid vertical line indicates the introduction of the law 41/82.

1984, with a peak in 1986, for then annually declining thereafter until 1992. The CUSUM CPUEf was stable for the next 4 years, for then declining again each year until 2004 (Figure 3).

The correlation analyses revealed significant differences between landings and effort during the pre- and post-law 41/82 periods. For the pre-law 41/82 period (Table 1), both CPUEf and CPUEe have significant negative correlations with vessel tonnages ($R = -0.857$, $p < 0.001$ and $R = -0.885$, $p < 0.001$, respectively, $n = 23$), and they are also positively correlated with each other ($R = 0.939$, $p < 0.001$, $n = 23$). For the post-law 41/82 period (Table 1), no significant correlation was found between effort and CPUEf, and the correlation between CPUEf and CPUEe almost halved its pre-law 41/82 period value ($R = 0.441$, $p < 0.05$, $n = 21$). A positive correlation was found between effort and CPUEe ($R = 0.813$, $p < 0.001$, $n = 21$).

Table 1. Pearson's correlation coefficient *R* between vessel tonnages, CPUEf and CPUEe for the pre-law 41/82 period (1959–1982) and for the post-law 41/82 period (1983-2004).

	Tonnages	CPUEf	CPUEe
Pre-law 41/82 period (1959–1982)			
Tonnages	–	−0.857**	−0.885**
CPUEf	−0.857**	−0.939**	
CPUEe	−0.885**	0.939**	–
Post-law 41/82 period (1983–2004)			
Tonnages	–	0.114	0.813**
CPUEf	0.114	–	0.441*
CPUEe	0.813**	0.441*	–

Data missing for 1973 and 1995, not included in the analysis
*Significance at $p < 0.05$.
**Significance at $p < 0.001$.

Discussion

The sharp increase in the Italian MALe trend at the beginning of the 1980s could be due to an enhancement in fishing effort or to a marked shift towards a direct elasmobranch fishery. Our results support the idea that, until 1982, elasmobranch species were not the fishing target, but constituted the major commercial bycatch (in terms of biomass; Figures 1b and 3). Within the pre-law 41/82 period, both the annual CPUEf and CPUEe decreased steadily until the beginning of the 1970s, but the annual CPUEe trend reflected the annual CPUEf trend (Table 1). We found a significant difference in elasmobranch landings and effort between the pre- and post-law 41/82 periods. A decrease in fishing effort (vessel tonnage) is evidenced after the adoption of the 41/82 law, due to the introduction of more strict restrictions in the issuing of fishing licences (Angelone, 2003). These restrictions were introduced to manage the fishery in a more sustainable way and to counteract the lack of management, as CPUE results suggest, before the 41/82 law implementation. That same conclusion was reported in an economic study (Moro, 2005) analysing fishing capture and fishing effort data, in which the author concluded that the increase in the fish CPUE trend between 1984 and 1995 could indicate that some political measure was taken, without discussing it further. Therefore, the decline in the annual fish landings since 1986 is likely to be a result of the 41/82 law implementation. The fishery was subjected to new, strict regulations and control measures, which caused the decrease in fishing effort and hence the absence of correlation we found between CPUEf and fishing effort. The increase in the elasmobranch annual landings and CPUEe trends between 1983 and 1994 were another direct consequence of the 41/82 law. A shift to elasmobranchs allowed fishers a more continuous source of income in an unregulated fishery. This is supported by the fact that for the period 1983–2004, we found a significant positive correlation between CPUEe and vessels tonnage, but not between CPUEf and vessel tonnage (Table 1).

Cheung and Sumaila (2008), who explored the trade-offs between conservation and socio-economic objectives in managing the Northern South China Sea multispecies fisheries, reported similar findings. They found that fishers were aiming at short-term economic benefits at the expense of long-term economic and ecological gains. They concluded that in multispecies fisheries the fishing effort required to achieve the maximum sustainable yield may overexploit, deplete, or even extirpate some of the least productive species or stocks, whereas the most productive stocks may be underexploited.

A common concern in multispecies fisheries is the lack of a detailed list of species caught and the combination of catches into coarse taxonomic groups ("sharks" or "skates"). This can mask the depletion of vulnerable species if others in the group increase (Dulvy *et al.*, 2000). In Catalonia (Spain), a study by Oltra Codina *et al.* (2007) proved that official national landing statistics are biased by the common fishers practice of classifying rays and sharks for auctions according to factors not related to species identification, like morphological similarities, species economic value, and size. During auctions, boxes were labelled according to three commercial species only: "Bestina" (Atlantic starry skates—*Raja asterias*) for skates and small-spotted catshark and blackmouth catshark (*Galeus melastomus*) for sharks. Seven different species of Rajidae were erroneously considered as "Bestina", and different species of sharks were sold as Scyliorhinidae, such as soupfin shark (*Galeorhinus galeus*), bluntnose sixgill shark (*Hexanchus griseus*), and kitefin shark (*Dalatias licha*). A similar scenario was reported in Italy for the North Adriatic Sea (Lanfredi and Rasotto, 2003) with different species enclosed in the category "asià": smooth-hounds, spiny dogfish (*Squalus acanthias*), thresher shark (*Alopias vulpinus*), and soupfin shark; and the lack of a detailed classification of ray species.

Therefore, the ISTAT landings data for "palombo" are likely to have included several small- and medium-sized species. It is also possible that morphologically similar species were incorrectly considered as rays. Table 2 summarizes a list of marketable species that could have been generically annexed in the "smooth-hound" and "ray" ISTAT categories within the study period, respectively, with their current IUCN conservation status (Cavanagh and Gibson, 2007). This species list is based on the results of previous publications, grey literature, and scientific survey reports (Relini and Piccinetti, 1996; Aldebert, 1997; Relini *et al.*, 1999, 2000; Vacchi and Notarbartolo di Sciara, 2000; Ragonese *et al.*, 2001).

Historically, the Italian fishery consisted of small-scale, artisanal fisheries (Ferretti *et al.*, 2005). Currently, its structure is characterized by the presence of both industrial and artisanal fisheries: 77% of the vessels belong to the 0–10 GRT (gross register tonnes) class, whereas only 7% are over 50 GRT (IREPA, 2002). Commercial fisheries became more active during the late 1970s, when advancement in the fishing technology allowed the exploitation of the larger geographical range of pelagic waters. In recent years, fishing in deep waters (>400 m) has increased as traditional shallow-water stocks have declined (Devine *et al.*, 2006). The increase in elasmobranch landings could also be explained by a shift in the Italian fishery towards more pelagic and deeper waters or by the possible disappearance of large predators, mainly pelagic sharks, starting at the end of the 1970s. It is generally recognized that the depletion of a dominant predator can result in large biomass increases in its prey species resulting from decreased predatory pressure (Fogarty and Murawski, 1998; Myers and Worm, 2005; Myers *et al.*, 2007).

To our knowledge, the disappearance of large pelagic shark species in the Mediterranean Sea has not been addressed adequately in the literature. However, the disappearance of Mediterranean sand tiger shark (*Carcharias taurus*) has been reported with the last apparent observation occurring in 1977 in Sicily (Ferguson *et al.*, 2002). Another study (Soldo and Jardas, 2002) reporting historical accounted records of large pelagic shark species in the Eastern Adriatic Sea (white shark, *Carcharodon carcharias*; shortfin mako, *Isurus oxyrinchus*; porbeagle shark, *Lamna nasus*; and smooth hammerhead shark, *Sphyrna zygaena*) indicates their disappearance between the late 1950s and the early 1990s, likely due to the decrease in their prey.

Table 2. Summary of all marketable species that could have been classified as "smooth-hound" or "ray" in ISTAT landings data, and their relative IUCN's red list status in the Mediterranean and Black Seas taken from Cavanagh and Gibson (2007), modified.

Scientific name	Common name	IUCN threatened status assessment
Smooth-hound and potentially misclassified smooth-hound species		
Oxynotus centrina	Angular roughshark	CR
Squalus acanthias	Spiny dogfish	EN
Heptranchias perlo	Sharpnose sevengill shark	VU
Mustelus mustelus	Smooth-hound	VU
Mustelus asterias	Starry smooth-hound	VU
Galeorhinus galeus	Soupfin shark	VU
Scyliorhinus stellaris	Nursehound	NT
Scyliorhinus canicula	Small-spotted catshark	LC
Galeus melastomus	Blackmouth catshark	LC
Dalatias licha	Kitefin shark	DD
Squalus blainvillei	Longnose spurdog	DD
Mustelus punctulatus	Black-spotted smooth-hound	DD
Rays and potentially misclassified ray species		
Rostroraja alba	White skate	CR
Leucoraja melitensis	Maltese skate	CR
Squatina squatina	Angelshark	CR
Pristis pectinata	Smalltooth sawfish	CR
Rhinobatos rhinobatos	Common guitarfish	EN
Raja polystigma	Speckled ray	NT
Raja clavata	Thornback ray	NT
Dipturus oxyrhynchus	Sharpnose skate	NT
Dasyatis pastinaca	Common stingray	NT
Pteroplatytrygon violacea	Pelagic stingray	NT
Raja miraletus	Twineye skate	LC
Raja asterias	Atlantic starry skate	LC
Raja montagui	Spotted skate	LC
Torpedo spp.	Electric ray	LC
Raja fullonica	Shagreen skate	DD

CR, critically endangered; EN, endangered; VU, vulnerable; NT, near threatened; LC, least concern; DD, data deficient.

The Italian fishery lacks detailed studies that highlight the importance of elasmobranchs as exploited species. Comparative analysis between fishery-dependent and fishery-independent data is one of the only available tools to help draft management regulations for elasmobranchs in Italy, but they have been rarely contemplated. Abella and Serena (2005) attempted an analysis of harvest data, but no clear trends were found in relative abundance for the four species studied, possibly due to the high variability among years and the relative short time-series. However, landings data, with abundance indices (expressed as catch in kg h^{-1} of towing), suggest a decreasing trend in all four species. Studies that compare fishery-dependent and fishery-independent data for elasmobranchs are urgently needed, since these can actually be the only available and reliable source of information to clearly define changes in elasmobranch species landings that will help managers in identifying the overexploitation of shark and ray species.

Conclusion

Our study shows that a direct effect of the 41/82 law was the establishment of an unreported and unregulated elasmobranch fishery since 1983 that lasted almost 10 years. The result was a substantial decline in landings of rays, smooth-hounds, and other similar species over the last years of the study period. It is almost impossible to determine the real elasmobranch quantities caught by Italian fisheries from 1959 to 2004; however, our analysis indicates that these quantities caused the overexploitation of small- and medium-sized sharks. The lack of detailed harvest data on shark and ray species prevents policy-makers from determining the real ecological status and the extent to which sharks are being affected by Mediterranean fisheries, both of which effectively hinder management. A viable solution would be the introduction of scientific on-board observer programmes, to start collecting a more detailed list of species caught and associated parameters, such as depth and sex, to provide critical information on habitat preferences and sexual distribution for less relevant commercial species not considered in previous scientific studies. There have also been no reliable records of bycatch discards for elasmobranchs. Fishers should be interviewed to collect historical data that would be useful in interpreting changes in species landings over time and would provide context to anecdotal information concerning species composition and bycatch and mortality estimates (Saenz-Arroyo *et al*., 2005). Although our results cannot point at a precise list of species, other research brought attention to the relationship between fishing exploitation and the diminishing of both Squalidae and Rajidae in Italian waters (Jukic Peladic *et al*., 2001; Gristina *et al*., 2006). Among Squalidae, the spiny dogfish life history makes the species more susceptible to overfishing (Compagno, 1984; Nammack *et al*., 1985). We strongly suggest that the spiny dogfish, and its analogous species the longnose spurdog, should be considered for a series of directed management actions towards its conservation along Italian coasts, along with more fishery-independent surveys targeting these species, to compare outcomes with historical fishery-dependent data. Such projects can give relevant information on the relation between the historical level of Squalidae exploitation and their actual distribution along Italian coasts, to identify stock positions and possible species hot spots relevant for their reproduction, which can be considered for direct management measures aimed at reducing fishing effort.

We also invite national and international wildlife protection boards and intergovernmental organizations, such as the IUCN, to reconsider the actual conservation status of elasmobranchs species in the Mediterranean and Black Seas at least for small- and medium-sized commercial species, given that in some Mediterranean areas, some species belonging to seven different elasmobranch families could be considered close to extinction according to their last sighting (Aldebert, 1997; Dulvy *et al*., 2003). It is essential to improve the collection, management and reporting of shark catches, landing, production, and international trade data. To assist countries achieve that, international fisheries boards should develop unique standardized internationally accepted guidelines, which could be used as a reference document by Mediterranean fisheries.

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