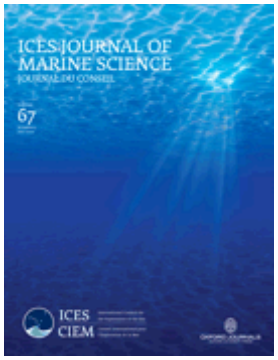

Recreational and small-scale fisheries threaten vulnerable species in coastal and offshore Mediterranean waters

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Abstract

This study evaluates the fishing pressure exerted by the most common recreational and professional, small-scale fishing practices on vulnerable target and by-catch species in western Mediterranean coastal waters (less than, approximately, 12 miles from the shore) and offshore waters (more than, approximately, 12 miles from the shore). By combining multiple data sources, we assembled a unique dataset on catches at multiple sites in these areas by small scale and recreational fisheries, covering the period from 1997 to 2015. Furthermore, a framework with which to identify the vulnerable species among all the species caught is provided; it is based on the IUCN Red List, international conventions for the protection of flora and fauna, the Habitats Directive and the intrinsic vulnerability index of marine fish. Overall, the available data shows that, in coastal waters, 35 vulnerable species were caught and landed by small-scale and recreational fisheries; these vulnerable species, if we take into account all fishing methods and gears combined, comprised nearly half of the total small-scale fisheries catch and about 20% of the total recreational catch. Meanwhile, in offshore waters, all of the species caught – three by recreational fishing and four species by small-scale fishing – were vulnerable species. When fishing method or gear is taken into account, four fishing methods – offshore recreational boat fishing, offshore small-scale pelagic longlining, recreational spearfishing and small-scale bottom

longlining – were particularly detrimental, with higher percentages of vulnerable species among the total catch (reaching 100% in the case of the offshore fisheries); these four methods also had the highest weighted indices of vulnerability. However, vulnerable species were not only found among the target species. Among the species caught as bycatch in both areas by SSF and recreational fisheries, there was a total of 27 vulnerable vertebrate species, which included birds, cetaceans, elasmobranchs and sea turtles. Our results indicate that although recreational and small-scale fisheries are often considered to have a relatively low ecological impact, a range of different fishing methods are negatively affecting vulnerable species in coastal or offshore waters in the Mediterranean Sea, be they targeted or taken unintentionally as by-catch.

Keywords: coastal and offshore fisheries, extinction, target and by-catch, marine protected areas, small-scale fishers (SSF), management

Introduction

The magnitude of the ongoing extinction crisis has generated a huge effort aimed at evaluating and monitoring the risk of extinction faced by species worldwide. The trade-offs between economic, social and conservation objectives become severely problematic when the vulnerability of exploited species to fishing is high and the economic value of these species is also high (Norse *et al.,* 2012). Increasing global consumption of marine resources, together with environmental changes, has led to widespread loss and degradation of marine ecosystems, with potentially serious consequences for biodiversity and ecosystem services (Bianchi and Morri,

2000; McCauley *et al.,* 2015; Webb and Mindel, 2015). Throughout the world, many exploited marine species are experiencing declines in population because of overfishing and other factors, including climate change. Moreover, the systematic differences among different species in their sensitivity to fishing is partly responsible for the increasing dominance of less vulnerable fish species in global catches, as the vulnerable ones become easily overexploited (Cheung *et al.,* 2007). Consequently, global, regional, national, and local lists of threatened species, including those listed in the international conventions for the protection of flora and fauna, have proliferated over the past decades (Burton, 2003) and these lists and conventions have undeniably become valuable tools for conservation (Rodrigues *et al.,* 2006; Miller *et al.,* 2006; Dulvy *et al.,* 2006). Recently, the IUCN Red List has been proposed as a tool to complement or enhance existing indicators for sustainable use of marine resources, as described in the European Community's Marine Strategy Framework Directive for monitoring, which applies an ecosystem approach to fisheries management (EC, 2014). Furthermore, quantitative indices, such as the intrinsic vulnerability index of marine fish (Cheung *et al.,* 2007), have been developed to address the specific vulnerability of fish to external pressures.

Recreational and small-scale (professional) fishing are important socioeconomic activities in the Mediterranean, taking place in coastal areas, particularly in marine protected areas, as well as in offshore waters (reviewed by Lloret *et al.,* 2018). Recreational fishing is particularly popular in the Mediterranean because of the extensive coastline, the huge number of people living in coastal areas (250 million people) and the increasing importance of fishing as a leisure or tourist activity (Hyder *et al.,* 2018). In coastal waters (less than, approximately, 12 miles from the shore), recreational fishing methods are highly diverse, including boat fishing, shore fishing, spearfishing

and shellfish gathering, sometimes carried out individually and sometimes in groups (for example in competitions and on chartered boats) (Font et al. 2012). In offshore waters (more than, approximately, 12 miles from the shore), various gears are used by recreational boat fishers, such as rods with line and reel and trolley rigs, and they mainly target large pelagic predator fish species, which include sharks, although information is scarce (ADAP, 2017, Fowler *et al.,* 2005).

Professional, small scale fishing (referred to as SSF throughout this paper) is defined, according to the Common Fisheries Policy (CFP), as "fishing carried out by fishing vessels of an overall length of less than 12 m and not using towed fishing gear". They have smaller crews (1–3 fishers per vessel) and use a wide variety of fishing techniques, including trammel net, gillnet, longline and pound nets, which are mostly passive gears targeting a wide array of seasonally changing benthic and pelagic coastal species (Lloret et al 2018). Offshore SSF mostly targets large pelagic predatory fish using, in most cases, pelagic longlines (Biton-Porsmoguer and Lloret, 2018). Although there are also other offshore fishing vessels using bottom longlines and gillnets to target benthic demersal fish, such as European hake (*Merluccius merluccius*) and blackspot seabream (*Pagellus bogaraveo)*, these vessels are usually larger than 12 m length and therefore cannot be considered as SSF (Ungaro *et al.,* 2015). SSF is of great importance in terms of job opportunities and their contribution to the economy of coastal communities in Europe: they have been estimated to generate about half of all direct employment within the EU fishing sector, representing approximately 83% of the fishing vessels and a quarter of the catch value (Guyader *et al.,* 2013; FAO, 2018).

Recreational fishing and SSF in European waters, and particularly in the Mediterranean, involve smaller catches, lower impact on habitats, lower annual fuel oil consumption, less

bycatch and discards and less of the catch is reduced to fishmeal and oil than is the case with large-scale fisheries such as trawling and purse-seining (Lloret *et al.,* 2018; Tsagarakis *et al.,* 2014; Kelleher, 2005). Consequently, they are often considered to have a smaller ecological impact. However, from a biological standpoint, there are several features of these fisheries that may threaten the sustainability of certain species (Lloret *et al.,* 2018). Such species include benthic and pelagic long-lived and slow-growing species with low reproductive potential and a narrow geographic range (see e.g. Lloret and Font, 2013; Luna-Pérez, 2010; Lloret *et al.,* 2016; Biton-Porsmoguer and Lloret, 2018). Furthermore, there is a widespread international agreement that bycatch in many fisheries raises ecological concerns that require the urgent attention by fisheries management (Zeller *et al.,* 2018). Although some studies have looked into the impact of specific small-scale and recreational fishing gears on particular vulnerable species in the Mediterranean (e.g. Morales-Nin et al. 2010; Font and Lloret, 2014, Biton-Porsmoguer and Lloret, 2018), none of these studies have assessed the overall impact of small-scale and recreational fisheries on vulnerable species in an integrated way, taking into account both coastal and offshore waters, as well as target species and bycatch species, and the different fishing gears employed.

In this context, the goal of this study is to evaluate and compare the fishing pressure exerted by SSF and recreational fisheries operating in coastal and offshore waters of the western Mediterranean Sea on the vulnerable species exploited in these waters (target species and bycatch), taking into account, when possible, the differentiated effect of each small-scale and recreational fishing method or gear. To our knowledge, this is the first holistic study of its kind because till now, only limited results have been published focusing on particular fishing sites, specific areas, fishing gears or species. The study also proposes a number of management

recommendations for a more effective protection of vulnerable exploited species in coastal zones and offshore, particularly in marine protected areas (MPAs) and the so-called "Special areas of conservation" (SACs) in the Mediterranean Sea. In this sense, this study proposes a framework to identify which of the exploited species can be described as vulnerable to fishing pressure from SSF and recreational fisheries, and for which, consequently, priority management measures should be undertaken in order to attain the favorable conservation status (FCS) for these species and the habitats they inhabit.

Methods

Catch of target species

By combining multiple data sources, including reports, scientific literature and catch data provided by fisheries and MPA managers, we assembled a dataset on SSF and recreational catches at multiple sites, covering both coastal and off-shore areas, in the Mediterranean Sea.

Information on recreational fishing (RF) in 20 coastal areas (14 of which are MPAs; Figure 1) from three EU Member States (Spain, France, and Italy) was gathered, within the framework of the EU SAFENET project (Sustainable Fisheries in EU Mediterranean waters through a network of Marine Protected Areas). These areas include the north-eastern part of the Catalan Sea, the Gulf of Lion, the Ligurian and the northern Tyrrhenian Seas, and the islands of Corsica and Sardinia.

Information was collected from a total of 40 studies comprising scientific articles (8) as well as grey literature (32) including unpublished reports and documents provided by researchers and managers of MPAs, where most of the research regarding RF in the Mediterranean has been

carried out. These studies were carried out in a variety of ways encompassing a diverse range of sampling periods, duration and different recreational fishing types (Supplementary Table SB1). For the purpose of this study, fishing types are defined as: boat fishing (BF), shore fishing (SF) and spearfishing (SP). Although some of these studies did not always consider the data according to fishing methods, and for certain areas there is a lack of information regarding particular fishing types, those we have reviewed represent the best source of available information so far. It must be pointed out, nevertheless, that there is very little information on recreational fisheries outside spring and summer, during which the vast majority of samplings (90%, all areas combined) were carried out (Supplementary Table SB1). Therefore, our analysis is representative of the warmer season only, which is nevertheless the high season for recreational fisheries in most of the areas (Font and Lloret, 2013, 2014). In addition to the revision of literature, the managers of each MPA and seven local scientists specializing in coastal fisheries were contacted by email in order to obtain information on the catch of vulnerable species by recreational fishers through standardized questionnaires that were designed specifically to gather the same information from each area (i.e. the presence of vulnerable species in the catch of recreational fishermen). Around 65% of the managers and scientists contacted provided the information required for further analysis. The rest were unable to provide information because their MPAs had only recently been created, which meant sufficient data on RF activity had not yet been collected. In addition to the questionnaires,

The available information from SSF was provided by monitoring in three MPAs where these fisheries are still important and where information was available: Cap de Creus (Spain), Côte Bleue (France) and Cerbère-Banyuls (France). Studies in Cap de Creus MPA were conducted in

2008, 2009, 2010, 2011, 2013 and 2015 via 572 onboard samplings, mostly carried out in spring and summer. The sampling scheme had two components. The first involved interviewing small-scale fishers and conducting on-board inspections. The second, employing an increasingly common method for collecting fishery data, consisted of a self-sampling program by the fishers themselves enabling them to provide information from their own fishery. Overall, different boats from the various ports in the Cap de Creus area where small-scale fishers land their catches were sampled to gather information according to fishing type (trammel net, gillnet, longline and pound net). Meanwhile, data on species and catches from the Côte Bleue MPA was gathered during 261 small scale fishing operations – involving trammel net, gillnet and longline – that were carried out in all seasons from 2012 to 2015. In this MPA, some species (mainly small-sized species such as labrids and serranids with little or no commercial value) were not taken into account because of insufficient data. Finally, the data on species and catches from the Cerbère-Banyuls MPA was gathered during 2015 (spring and summer), but only for trammel net fishing operations. The available information from these three MPAs was then collated with the aim of studying the effect of fishing type. Unfortunately, a wide range of sources were used to gather all the available information, which meant the data was heterogeneous in terms of fishing gears, years and seasons (i.e. the same data on all types of gears or years or seasons was not available for each area). Therefore, we proceeded to pool what data we had from all areas and only considered testing the effect of fishing type. Further details of the sampling methodology employed to monitor SSF in Cap de Creus, Côte Bleu and Cerbère-Banyuls MPAs are given in Lloret *et al.* (2015), Charbonnel *et al.* (2013, 2017) and Prats (2016), respectively.

Information relating to offshore catches was only available for the Spanish Mediterranean coast. Data on the catch of pelagic species by recreational fisheries, gathered in 2017, was provided by the Spanish General Secretary of Fisheries. The raw data gives the number of individuals caught; hence, the total weight of the catch by species was estimated by multiplying the number of individuals caught by the estimated weight of the individuals (we estimated an average weight of 15 kg for each specimen, given that the Spanish authorities stated that individuals weighed less than 20kg and the minimum legal weight is 10 kg). With regard to the SSF catch of pelagic species, data was obtained for 2017 from the landing statistics recorded by the Autonomous governments of Andalucía, Murcia, Valencia, Catalonia and the Balearic Islands.

Vulnerability of target species

From the catch made by SSF and recreational fisheries in coastal waters and offshore, we first identified those exploited species that can be considered as "vulnerable to fishing" (Table 2). To do so, we first selected all the species in the catch that are included in the IUCN Red List - Mediterranean regional assessment (www.iucnredlist.org) as *Threatened* (i.e. *Critically Endangered-CR*, *Endangered-EN* and *Vulnerable-VU*) and *Near Threatened-NT*. The IUCN Red List is recognized as one of the most reliable sources of information on the global conservation status of plants and animals (Rodrigues *et al.,* 2006) and classifies species at high risk of global extinction under different categories following well established criteria (IUCN, 2015).

Second, we selected those species included in the IUCN Red List as *Least Concern-LC* but with an index of vulnerability (IV) higher than 60 (i.e. high to very high vulnerability; Cheung *et al.,*

2007). The IV index of a species defines the intrinsic vulnerability of marine fish to fishing, calculated using a fuzzy logic expert system, and is based on the life history traits and ecological characteristics of marine fish, such as maximum body length, age at first maturity, the von Bertalanffy growth parameter k, natural mortality, maximum age, geographical range, fecundity and the strength of aggregation behavior (Cheung et al. 2005). Generally, the most vulnerable fish are deemed to be species with larger body size, higher longevity, higher age at maturity, lower growth rates, a low reproductive potential and a narrow geographical range. These IV values were obtained from FishBase platform (Froese and Pauly, 2016; http://www.fishbase.org/) in the case of fish, and from the SealifeBase platform (http://www.sealifebase.org/) for organisms other than fish. Thirdly, we included in the selection of vulnerable exploited species three decapod species (*Homarus gammarus, Scyllarus arctus* and *Scyllarides latus*) which, despite being on the IUCN Red List as *Least Concern* or Data Deficient and having an IV index lower than 60, were nevertheless included in the Barcelona, Bern, and CITES conventions, and/or in the EU Habitats Directive.

In addition, for SSF and recreational fisheries, we computed the mean intrinsic vulnerability index of the overall catch (weighted mean IV index) by gear, when catch data was available by gear. The weighted mean IV index gives a measure of the vulnerability of the overall catch (Cheung *et al.,* 2007) and was calculated from the IV of all species weighted by their catch following the procedure described in Font and Lloret (2011) and Lloret and Font (2013). In coastal waters, the weighted mean IV index could be computed in only nine of the coastal study areas because information on catches in other areas was incomplete. Regarding offshore fisheries, the

mean intrinsic vulnerability of the overall catch was computed without taking into account the fishing gear (because catch data was not available by gear).

Vulnerability of the by-catch

The vulnerability of the species in the bycatch was also evaluated. In this study, bycatch refers to all unintentional catch returned to the sea for whatever reason (unwanted, unsellable or impermissible). Existing information about the bycatch of vulnerable species caught by SSF and recreational fisheries in the Mediterranean coastal and offshore waters was gathered from scientific papers and reports available in the literature. This review of the bycatch focused on vertebrates, including marine birds, elasmobranchs and marine mammals, that are categorized in the IUCN Red List as Near Threatened or higher, or listed in the Habitats Directive or in international conventions for the protection of the flora and fauna (Barcelona, Bern and CITES). This analysis considers coastal and offshore fisheries together because many bibliographic sources did not distinguish between gears deployed in coastal waters and the gears deployed in offshore waters.

Results

Coastal waters

Taking into consideration all types of SSF and recreational fishing, and all coastal water areas reviewed here, a total of 152 different species were caught, 35 of which (i.e. 23% of the total)

were deemed vulnerable (Supplementary Table SB2; Figure 2). SSF caught a total of 90 species (73 by trammel net; 61 by gillnet; 36 by longline and 25 by pound net) of which 26 (29%) were deemed vulnerable). Recreational fishers caught 136 different species (111 by boat fishing; 102 by shore fishing and 48 by spear fishing), 29 of which (21%) were deemed vulnerable (Supplementary Table SB2, Figure 2). The fishing methods targeting the highest number of vulnerable species are, in order, trammel net (25 vulnerable species), boat fishing (24), gillnet (17), shore fishing (16), spearfishing (12), longlines (10) and pound nets (7) (Figure 2).

Considering the catch in weight, and taking all fishing methods into account, vulnerable species constituted, by weight, 45.4% of the total SSF catch and 18.5% of the total recreational catch in coastal waters. The proportion of vulnerable species was particularly heavy in the longline catch, 79% of which comprised vulnerable species (Supplementary Table SB2). For certain fishing methods, there were individual vulnerable species that made up 10% or more of the total catch (Supplementary Table SB2): 54% of the total longline catch consisted of *Conger conger*; 23% of total gillnet catches were *Merluccius merluccius*; 16% of total spearfishing catches were *Epinephelus marginatus;* 13% of the total trammel net catches were *Scorpaena scrofa* and 10% of the total shore fishing catch was *Dicentrarchus labrax*. Boat fishing and pound nets were the only methods where no individual vulnerable species exceeds 5% of the total catch (Supplementary Table SB2).

Some vulnerable benthic species caught by SSF and recreational fisheries in coastal waters, such as *Angulla anguilla*, *E. marginatus, Sciaena umbra* or *Dentex dentex* were among the most vulnerable in terms of the IV index (>60) and are under threat according to the IUCN Red List (*A. anguilla*: CR; *E. marginatus*: EN; *S. umbra* and *D. dentex*: VU). Furthermore, nine of the coastal

species targeted by small-scale and recreational fisheries were included in Annex III of the Barcelona and/or Bern conventions; one species is included in CITES-Annex II (*A. anguilla*) and another (*S. latus*) is included in the Habitats Directive-Annex V.

Of all the fishing methods in use in coastal waters, the average intrinsic vulnerabilities (IV) were highest in the longline and spearfishing catch, with 72.6 and 64.7 (out of 100) respectively; such levels are considered as 'high to very high' (Figure 3). The lowest average IV value was in the pound net catch (38.3; low to moderate vulnerability) while the average IV for the catches by the other coastal fishing methods (boat fishing, shore fishing, trammel net and gillnet) ranged from 43 to 51 (moderate vulnerability).

Offshore waters

In offshore waters, small-scale fishermen fishing with pelagic longlines caught four species, *T. thynnus, Xiphias gladius*, *T. alalunga* and *Prionace glauca*, all of which, again, are vulnerable (Supplementary Table SB2, Figure 2). At the same time, recreational boat fishers caught three species, *Thunnus thynnus*, *T. alalunga* and *M. merluccius*, all of which are vulnerable (Supplementary Table SB2, Figure 2). In other words, 100% of the offshore SSF and recreational catch comprises vulnerable species. In 2017, Spanish recreational boat fishers declared a catch of 0.87 tonnes of *T. thynnus*, 0.75 tonnes of *T. alalunga* and 0.002 tonnes of *M. merluccius*. Hence, *T. thynnus* and *T. alalunga* are by far the two main constituents of the total offshore recreational catch (99.8%). Also in 2017, Spanish offshore SSF operating with pelagic longlines, landed a total of 1,329 tonnes of swordfish (*X. gladius*), 207 tonnes of *T. alalunga*, 32 tonnes of *P. glauca* and

0.13 tonnes of *T. thynnus*. In this case, 84.8% of the offshore pelagic longline catch consisted of swordfish alone.

These five vulnerable species caught in offshore waters were among the most vulnerable both in terms of their IV values (60 or higher in each case) as well as in their classification in the IUCN Red List, because, with the exception of *T. alalunga,* which is classified as LC, all of these pelagic species are threatened (*T. thynnus:* EN*; P. glauca:* CR) or NT (*X. gladius*). Furthermore, *T. thynnus, X. gladius,* and *P. glauca* are included in Annex III of the Barcelona and Bern conventions.

In the case of offshore fisheries, the average IV index of the SSF catch was 62.58 while that of the recreational fishing catch was 62.23, both corresponding to levels considered as 'high' (Figure 3).

Bycatch of vulnerable species

Due to a lack of specific data on the methods used, the bycatch of vulnerable species could not, as we mentioned earlier, be analyzed separately for coastal and offshore waters. The combined bycatch in both areas by SSF and recreational fisheries included a total of 27 vulnerable vertebrate species, which are listed in Supplementary Table SB3. Small-scale fishing methods led to the unintended capture of 6 mammal species, 3 turtle species, 8 elasmobranchs, 1 osteichthyes and 6 different species of seabirds. Longlines (demersal, pelagic and drifting) were responsible for the highest number of vulnerable species in the bycatch (20 species), followed by driftnets (11), gillnets (8) and trammel nets (8). Meanwhile, recreational fisheries unintentionally catch 8 vulnerable species: 3 elasmobranchs, 1 osteichthyes and 3 seabirds. The vulnerable

species appearing in the bycatch include 4 elasmobranchs (*Isurus oxyrinchus, Sphyrna zygaena, Lamna nasus* and *P. glauca*) and one bird (*Puffinus mauretanicus*) that are on the IUCN Red List as critically endangered species. There is also one mammal (*Physester macrocephalus*) and three sea turtles (*Caretta caretta, Dermochelys coriacea* and *Checlonia mydas*) which are listed in Annex I of the CITES convention (Annex I lists the most endangered species recorded in CITES records, i.e., those under threat of extinction). In addition, the bycatch includes a number of other chondrichthyans, including *Cetorhinus maximus, S. zygaena, L. nasus* and *Alpias vulpinus* listed in Annex II of CITES (Annex II lists species that may not, as yet, be under imminent threat of extinction).

Discussion

From a conservation perspective, this paper provides new information on the vulnerability of the catch and bycatch associated with recreational and small-scale fisheries operating in coastal and offshore waters in the western Mediterranean Sea. Although generally speaking these fisheries have a smaller ecological impact than large-scale ones (i.e. smaller catches, lower impact on habitats, lower annual fuel oil consumption, less bycatch and discards and less of the catch is reduced to fishmeal and oil; Kelleher, 2005; Tsagarakis *et al.,* 2014; Lloret *et al.,* 2018), the results of this study show that they do pose a significant threat to vulnerable species. In order to identify the vulnerable species among all the species caught, a framework is provided, based on the IUCN Red List, international conventions for the protection of flora and fauna, the Habitats Directive and the intrinsic vulnerability index of marine fish. Overall, about a quarter of exploited species

targeted by SSF and recreational fisheries in coastal waters were vulnerable, making up nearly 50% of the total SSF catch and nearly 20% of the total recreational catch (by weight; all fishing methods combined). In offshore waters, 100% of the recreational and SSF catch is made up of vulnerable species.

A number of studies in the Mediterranean have already indicated the pressure being placed on particular vulnerable benthic species by coastal small-scale and recreational fisheries. For example, Marengo et al. (2015) found in the Bonifacio Strait Natural Reserve, that recreational fisheries contributed significantly to fishing mortality of *D. dentex,* magnifying the negative effects of SSF. Harmelin *et al.* (2015) showed how spear fishing contributed to the decline of the brown meagre (*S. umbra*) population in the MPA of Scandola (Corsica). Other vulnerable benthic species in coastal waters, such as *Labrus viridis* and *D. dentex* have also experienced declines in population of between 30 and 50% in the Mediterranean region, a fact that was attributed to the impact of spearfishing (Abdul Malak, 2011). In addition, the status of the main large pelagic species fished offshore, such as *X. glad*ius and *P. glauca*, shows clear signs of overexploitation (Biton-Porsmoguer, 2017; Biton-Porsmoguer and Lloret, 2018).

These results also highlight the need to differentiate between different fishing methods or gears when studying the fishing impacts, because the small-scale fishing fleets and recreational fisheries in the Mediterranean comprise many types of gears that catch different vulnerable species. For example, in coastal waters, recreational boat fishing and trammel nets used by small-scale fishers target the greatest variety of vulnerable exploited species. However, professional longlines and recreational spear fishing appear to be the two coastal fishing methods that most affect vulnerable species when we consider the percentage of vulnerable species in the catch

(about 50% and 80%, respectively). This is borne out by the weighted mean index of vulnerability (IV) in these two cases: 73 for the longline catch and 65 for the spear fishing catch, both of which far exceeded the average vulnerability indices of all world-wide exploited coastal fish species (which stands at 48 according to Cheung *et al.,* 2007).

In offshore waters, all of the target species of recreational boat fishing and professional pelagic longlines are vulnerable species, with an average IV index of the catches of 62, which also exceeds the average vulnerability of all world-wide exploited coastal fish species (Cheung *et al.,* 2007). It must be noted, however, that it is not only the fishing method (small-scale, recreational, boat, shore, etc.) that may cause more or less important impacts on resources and vulnerable species, but also the fishing gear used within each method (e.g. trolling, bottom fishing, jigging, spinning, trammel net for cuttlefish, trammel net for red mullet, etc) all of which may have different impacts. Although we did not have the data classified by gear, it would be advisable in future monitoring programs to collect the information by fishing gear/method in order to identify which fishing types and methods have the greatest impact, in order to establish more gear-oriented restrictions and management actions.

In addition, this study has highlighted the fact that there were many vulnerable species of mammals, elasmobranches, turtles and birds caught as by-catch by small-scale and recreational fishing gears in coastal and offshore waters. These species are listed in the various annexes of the Habitats Directive and Birds Directive, which represent greater protection needs than the international conventions for the protection of biodiversity (i.e. Barcelona, Bern, Bonn, CITES), the IUCN Red List and/or the EU Habitats Directive. SSF are responsible of the largest number of

species in the bycatch, with trammel nets and driftnets being the fishing gears that unintentionally catch the greatest number of vulnerable species.

Elasmobranchs are a group of fish that appear in both the list of target and by-catch species caught by SSF and recreational fisheries operating in coastal and offshore waters. They are generally vulnerable to fishing because of certain characteristics of their life cycle (low fertility rate, slow growth and late maturity; Dulvy *et al.,* 2003; Gibson *et al.,* 2008). As a result, these species, which play a key role in maintaining the balance in marine ecosystems (Ferretti *et al.,* 2010), have a generally limited capacity to restore their population and consequently can be more easily endangered by fishing (Fowler *et al.,* 2005, Gibson *et al.,* 2008). For example, recent studies highlight the current population decline – or even, in some cases, local extinction – of several elasmobranchs in waters around the Balearic Islands, where they had previously been quite common (Farriols *et al.,* 2016; Mayol *et al.,* 2000; Grau *et al.,* 2015; Ligas *et al.,* 2013; Ferretti *et al.,* 2008). Similar rarefactions have also been documented in other Mediterranean areas (Maynou *et al.,* 2011; Ligas *et al.,* 2013; Coll *et al.,* 2014) and in other seas and oceans (Ferretti *et al.,* 2008).

Mediterranean fisheries are expected to continue to exert a significant impact on vulnerable target and by-catch species in the foreseeable future, but the scale of the impact will be different for each sector. For SSF, the impact will remain high but decreasingly so in many coastal areas if the recent decline observed in SSF continues in these areas in the coming years (Lloret *et al.,* 2018). In contrast, it appears that the impact on vulnerable species by recreational fisheries will continue to rise with increased activity from this sector reported not only in coastal waters (Lloret *et al.,* 2018), but also in offshore waters, where considerable growth in the number of sport

fishers has been observed over the past few years off the Italian, Spanish and French coasts. For example, the number of Spanish recreational boats with special authorization to fish large pelagic fish species in the Mediterranean increased between 2015 and 2017, from 661 to 917. Moreover, if the Andalucía & Gulf of Cádiz region is also taken into account (although this fleet includes an unknown number of vessels fishing in the Atlantic), the increase during this period is from 1,270 to 1,689 vessels authorized to land large pelagic fish (Annex II of the Spanish law RD 347/2011). The data analyzed in this paper suggests that, in offshore waters, the current impact of SSF is much higher than that of recreational fisheries (with the SSF catch of pelagic species being several times greater in comparison). Despite this, the impact of each sector in coastal waters has been found to be similar in some areas such as, for example, in the MPA Cap de Creus (Lloret *et al.,* 2008b).

It is imperative that monitoring and assessment plans for all these vulnerable species are developed and carried out. Studies on the status of these species are needed to better understand the impact exerted on them by recreational and small-scale fisheries, given the lack of data and evaluations of most of the vulnerable target and by-catch species in the Mediterranean. In this sense, the impact on survivability/mortality of vulnerable target and by-catch species caused by fishing should be assessed for the various types of fishing gear and methods currently being employed. The problem with the lack of accurate, gear-specific data is of particular concern in the case of offshore recreational fisheries, especially with regard to by-catch. In Spain, for example, recreational fishermen fishing offshore for pelagic species are, in theory, under a legal obligation to declare their catches (including by-catch) to the administration; however, in reality, the downward trend of catches reported – with low total

catches and a relatively small number of species affected – is incompatible with the number of recreational boats authorized at a time when the number of such boats is high and increasing. It is highly likely that the catches reported by recreational offshore fishermen are well below the real values.

The findings of this study should help to provide basic guidelines for both managers and policy makers in their work to develop specific management measures that will ensure the protection of vulnerable species caught by small-scale and recreational fisheries in the Mediterranean Sea, while safeguarding small-scale fisheries in accordance with the FAO guidelines on SSFs (FAO, 2015) and ensuring the sustainability of recreational activities, which are becoming increasingly important in the economies of a number of Mediterranean countries (Lloret *et al.,* 2018). These measures could include reducing the fishing pressure on certain vulnerable species (e.g. by regulating fishing gears and baits) or, in some cases, prohibiting their capture, at least in specific areas, such as marine protected areas (MPAs), and/or in particular seasons of the year. A number of studies have demonstrated the valuable role played by Mediterranean MPAs in protecting and rebuilding the populations of vulnerable species (Harmelin-Vivien *et al.,* 2015), and that seasonal closures during the reproductive season are effective in the protection of spawning aggregations of vulnerable species (Sadovy de Mitcheson *et al.,* 2013). Furthermore, minimum landing sizes should be implemented for all vulnerable species, whereas maximum landing sizes should be also implemented for sex-changing species in order to preserve their reproductive potential (Lloret *et al.,* 2012). In fact, among the list of vulnerable species caught by recreational and small-scale fisheries in coastal waters in the Mediterranean, some are sex-changing species (e.g. *E. marginatus, Pagrus pagrus* and *L. viridi*s) and it is known that certain fishing methods can

negatively affect their reproduction because some fishing gears are size/sex selective and can disproportionately kill members of one sex or the other, thereby skewing sex ratios (Lloret *et al.,* 2012). In light of recent evidence of strong competition between illegal and legal fishing (by both professional and recreational fishers) in the Mediterranean Sea (Ben Lamine *et al.,* 2018), it is also paramount to combine protective measures with an effective enforcement (Sadovy de Mitcheson *et al.,* 2013), and to promote greater public awareness, which can lead to support for legislation and action at the consumer end of the supply chain by empowering customers to make better seafood choices, for example, by avoiding the consumption or the catch of vulnerable species. In this sense, public awareness will contribute to the so-called "rewilding" initiatives, which are emerging as a promising restoration strategy in a human-dominated world to promote self-sustaining ecosystems and enhance the conservation status of biodiversity (Torres *et al.,* 2018). Finally, technical solutions aimed at avoiding/minimizing by-catch are needed to avoid the catch of vulnerable elasmobranchs, sea birds, mammals and turtles, including the prohibition of fishing in particular areas and seasons in which these animals appear in greater abundance.

These protective measures are not only necessary to safeguard vulnerable species from overfishing or extinction, but are also important in ensuring the favorable conservation status (FCS) of Special Areas of Conservation (SACs), which are strictly protected sites designated under the EU Habitats Directive in European waters. The vulnerable species affected by small-scale and recreational fisheries in coastal waters of the Mediterranean inhabit different habitats included in this Directive, such as Posidonia meadows and coralligenous assemblages. Because it is EU Member States that establish the necessary conservation measures in the SAC sites in order to

safeguard the status of the species found in them, the protection of vulnerable species that are typical in these habitats is necessary to attain the desired FCS in European waters.

In some cases, the EU, national and/or regional managers have already begun to implement rules to protect vulnerable species from overfishing, enabling certain populations to recover – although such measures remain somewhat limited, particularly in coastal waters. There is, for example, in French Mediterranean coastal waters (not including Corsica), a ban on recreational hook and line fishing and spear fishing for brown meagre (*S. umbra*) until at least 2018, and for groupers (*Epinephelus* spp., *Mycteroperca rubra* and *Polyprion americanus*) until at least 2023. Also, recreational fishers are not allowed to catch the vulnerable decapods *Palinurus elephas* and *Scyllarides latus* in Spain, nor *S. latus* in France and Italy. In Italy, it is forbidden to fish mature female of *P. elephas* and *Hommarus gammarus* by any recreational fishing method, and any crustacean with spearfishing. Although there is very little published information on illegal fisheries, there are, nevertheless, indications that poaching does occur; for example, in the MPA of Calanques (France), poachers are reported to be targeting the larger, older females of two protected species, the dusky grouper (*E. marginatus*) and the brown meagre (*Sciaena umbra*) (Astruch *et al.,* 2018).

In offshore waters, some legislative measures to protect vulnerable species are also in place. France for example has forbidden the on-board presence, landings and sale of swordfish by recreational fisheries (although catch and release is allowed in particular months). Also in France, the recreational fishing of *T. thynnus* requires a special authorization from the administration. Restrictive measures in France affect other pelagic vulnerable species, such as *Raja undulata*, fishing of which is forbidden. In Spain, recreational fishers cannot fish for pelagic sharks, such as

P. glauca, although they have no obligation to report bycatch. As with recreational fisheries, the commercial fisheries of large pelagic fish are often regulated by specific national regulations. For example, in Spain, professional fishermen are obliged to request specific authorization, and a catch and release declaration must be completed. Furthermore, protective measures have been established for several large pelagic vulnerable species that can be caught by recreational fishing, including *T. alalunga, T. thynnus, T. obesus, Makaira spp., Tetrapturus spp., Istiophorus albicans* and *X. gladius.* Other regulations have also been established by the European Commission (EC), banning the catch, trade or landing of several shark species, including *C. maximus, Z. zygaena, L. nasus* and *A. vulpinus*, by recreational and professional fisheries. Furthermore, the EU, in the case of recreational fishing, authorizes the catch of only one individual swordfish per day and boat, with a minimum fork length of 100 cm or a minimum weight of 10.2 kg. Furthermore, the EC has banned the fishing of certain shark and elasmobranch species for all professional and recreational fishing fleets, while fishing for *T. thynnus* and *X. gladius* in the Mediterranean by small-scale fisheries is subject to closed seasons and quotas established by ICCAT in all contracting countries. Finally, some of the large vulnerable pelagic species such as Bluefin tuna and swordfish are subject to recovery plans that establish specific measures for small-scale and recreational fisheries throughout the Mediterranean or in certain specific areas.

In short, the results from this study indicate that despite the fact that recreational and small-scale fisheries in the Mediterranean are often considered “low impact fisheries” compared to other larger-scale fishing methods, such as trawling and purse seining, they can still have a serious impact on vulnerable species, whether they inhabit coastal or offshore waters, and whether they are targeted and commercialized, or unintentionally taken as by-catch and

discarded. This impact may very well compromise the conservation of these vulnerable species – as well as the fisheries associated with them – if urgent and effective management actions are not undertaken to protect them.

Supplementary data

Supplementary material is available at the ICESJMS online version of the manuscript

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References

Abdul Malak, D., Livingstone, S.R., Pollard, D., Polidoro, B.A., Cuttelod, A., Bariche, M., Bilecenoglu, M., Carpenter, K.E., Collette, B.B., Francour, P., Goren, M., Hichem Kara, M., Massuti, E., Papaconstantinou, C., and Tunesi, L. 2011. Overview of the Conservation

Status of the Marine Fishes of the Mediterranean Sea. Gland, Switzerland and Malaga, Spain: IUCN. vii + 61pp.

ADAP. 2017. Estudio socioeconómico, ambiental y legislativo de la pesca recreativa en el litoral español. 388p.

Ben Lamine, E., Di Franco, A., Salah Romdhane, M., and Francour, P. 2018. Comparing commercial, recreational and illegal coastal fishery catches and their economic values: a survey from the southern Mediterranean Sea. Fisheries Management and Ecology, 25:456-463

Bianchi, C.N., and Morri, C., 2000. Marine biodiversity of the Mediterranean Sea: situation, problems, and prospects for future research. Marine Pollution Bulletin 40, 367–376.

Biton-Porsmoguer, S. 2017. Análisis de la explotación del pez espada (*Xiphias gladius*) y de la tintorera (*Prionace glauca*) en el Mediterráneo occidental por la flota palangrera catalana durante el periodo 2010-2015. Revista de Biología Marina y Oceanografía, 52(1): 175–179.

Biton-Porsmoguer, S., and Lloret, J. 2018. Potential unsustainable fisheries of a critically endangered pelagic shark species: The case of the blue shark (*Prionace glauca*) in the Western Mediterranean Sea. Cybium, 42 (3): 299–302.

Burton, J. A. 2003. The context of red data books, with a complete bibliography of the IUCN publications. Pages 291–300 in H. H. De Iongh, O. S. Banki, W. Bergmans, and M. J. van der Werff ten Bosch, editors. The harmonization of red lists for threatened species in Europe. The Netherlands Commission for International Nature Protection, Leiden.

559 Cheung, W.W.L., Pitcher, T.J., and Pauly, D. 2005. A fuzzy logic expert system to estimate intrinsic
560 extinction vulnerabilities of marine fishes to fishing. Biological Conservation, 124: 97–111.

561 Cheung, W.W.L., Watson, R., Morato, T., Pitcher, T.J., and Pauly, D. 2007. Intrinsic vulnerability in
562 the global fish catch. Marine Ecology-Progress Series, 333: 1–12.

563 Coll, M., Carreras, M., Ciércoles, C., Cornax, M.J., Gorelli, G., Morote, E., and Saez, R., 2014.
564 Assessing fishing and marine biodiversity changes using fishers' perceptions: the Spanish
565 Mediterranean and Gulf of Cadiz case study. PLoS ONE 9, e85670.

566 Dulvy, N.K., Sadovy, Y., and Reynolds, J.D., 2003. Extinction vulnerability in marine populations.
567 Fish and Fisheries 4, 25-64.

568 Dulvy, N.K., Jennings, S., Rogers, S.I., and David, L. 2006. Threat and decline in fishes: an indicator
569 of marine biodiversity. Canadian Journal of Fisheries and Aquatic Sciences, 63(6): 1267–
570 1275

571 EC, 2014. Report from the Commission to the Council and the European Parliament. The first
572 phase of implementation of the Marine Strategy Framework Directive (2008/56/EC). The
573 European Commission's assessment and guidance, 10.

574 FAO, 2018. The state of Mediterranean and Black Sea fisheries 2018. General Fisheries
575 Commission for the Mediterranean, Rome. 172 pp.

576 Farriols, M.T., Ordines, F., Somerfield, P. J., Pasqual, C., Hidalgo, M., Guijarro, B. and Massutí, E.
577 2016. Bottom trawl impacts on Mediterranean demersal fish diversity: not so obvious or
578 are we too late? Continental Shelf Research, http://dx.doi.org/10.1016/j.csr.2016.11.011

579 Ferretti, F., Worm, B., Britten, G. L., Heithaus, M. R., and Lotze, H. K. 2010. Patterns and
580 ecosystem consequences of shark declines in the ocean. Ecology letters, 13(8): 1055-
581 1071.

582 Ferreti, F., Myers, R.A., Serena, F. and Lotze, H.K. 2008. Loss of large predatory sharks from
583 the Mediterranean Sea. Conservation Biology, 22(4): 952–964.

584 Font, T. and Lloret, J. 2011. Biological implications of recreational shore angling and harvest in a
585 marine reserve: the case of Cape Creus. Aquatic Conservation: Marine and Freshwater
586 Ecosystems 21: 210–217.

587 Font, T. and Lloret, J. 2014. Biological and ecological impacts derived from recreational fishing in
588 Mediterranean coastal areas. Reviews in Fisheries Science and Aquaculture, 22(1): 73-85.

589 Fowler, S.L., Cavanagh, R.D., Camhi, M.; Burgess, G.H., Cailliet, G.M., Fordham, S.V.,
590 Simpendorfer, C.A., and Musick, J.A. (Ed.). 2005. Sharks, rays and chimaeras: the status
591 of the Chondrichthyan fishes. Status survey. IUCN/SSC Shark Specialist Group: Gland.
592 ISBN 2-8317-0700-5. X, 461 pp.

593 Froese, R., and Pauly, D. (Eds.) World Wide Web electronic publication
594 (2016) www.fishbase.org, version (06/2016).

595 Gibson, C., Valenti, S.V., Fordham, S.V. and Fowler, S.L. 2008. The Conservation of Northeast
596 Atlantic Chondrichthyans: Report of the IUCN Shark Specialist Group Northeast Atlantic
597 Red List Workshop. viii + 76pp

598 Grau, A.M., Mayol, J., Oliver, J., Riera, F., and Riera, I. 2015. Llibre vermell dels peixos de les Illes
599 Balears. Conselleria de Medi Ambient, Agricultura i Pesca, 150 pp.

Guyader, O., Berthou, P., Koutsikopoulos, C., Alban, F., Demanèche, S., Gaspar, M.B., Eschbaum, R., Fahy, E., Tully, O., Reynal, L., Curtil, O., Frangoudes, K., and Maynou, F. 2013. Small scale fisheries in Europe: a comparative analysis based on a selection of case studies Fisheries Research 140: 1-13

Harmelin-Vivien, M., Cottalorda, J-M., Dominici, J-M., Harmelin, J-G., Le Diréach, L., and Ruitton, S. 2015. Effects of reserve protection level on the vulnerable fish species *Sciaena umbra* and implications for fishing management and policy. Global Ecology and Conservation 3: 279–287.

Heupel, M.R., Knip, D.M., Simpfendorfer, C.A., and Dulvy, N.K. 2014. Sizing up the ecological role of sharks as predators. Marine Ecology Progress Series 495:291-298

Hyder K, Weltersbach MS, Armstrong M, Ferter K, Townhill B, Ahvonen A, et al. 2018. Recreational sea fishing in Europe in a global context-Participation rates, fishing effort, expenditure, and implications for monitoring and assessment. Fish and Fisheries, 19: 225–243

Kelleher, K. 2005. Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper. No. 470. Rome, FAP. 2005. 131p.

Ligas A., Osio G.C., Sartor P., Sbrana M., and De Ranieri S. (2013). Long-term trajectory of some elasmobranch species off the Tuscany coasts (NW Mediterranean) from 50 years of catch data. Scientia Marina, 77 (1): 119-127.

Lloret, J., Zaragoza, N., Caballero, D., and Riera, V. 2008a. Biological and socioeconomic implications of recreational boat fishing for the management of fishery resources in the marine reserve of Cap de Creus (NW Mediterranean). Fisheries Research, 91: 252–259.

Lloret, J., Zaragoza, N., Caballero, D., Font, T., Casadevall, M., and Riera, V. 2008b. Spearfishing pressure on fish communities in rocky coastal habitats in a Mediterranean Marine Protected Area. Fisheries Research, 94: 84–91.

Lloret, J., Muñoz, M., abd Casadevall, M. 2012. Threats posed by artisanal fisheries to the reproduction of coastal fish species in a Mediterranean marine protected area. Estuarine, Coastal and Shelf Science, 113: 133–140.

Lloret, J. and Font, T. 2013. A comparative analysis between recreational and artisanal fisheries in a Mediterranean coastal area. Fisheries Management and Ecology, 20: 148–160.

Lloret, J., Cowx, I.G., Cabral, H., Castro, M., Font, T., Gonçalves, J.M.S., Gordoa, A., Hoefnagel, E., Matić-Skoko, S., Mikkelsen, E., Morales-Nin, B., Moutopoulos, D.K., Muñoz, M., Neves dos Santos, M., Pintassilgo, P., Pita, C., Stergiou, K.I., Ünal, V., Veiga, P., and Erzini, K. 2018. Small-scale coastal fisheries in European Seas are not what they were: Ecological, social and economic changes. Marine Policy, 98: 176-186

Luna - Pérez, B., 2010. Anthropic impacts in Mediterranean Marine Protected Areas. Ph.D. Thesis. University of Alacant.

Marengo, M., Culioli, J.-M., Santoni, M.-C., Marchand, B. and Durieux, E.D.H. 2015. Comparative analysis of artisanal and recreational fisheries for *Dentex dentex* in a Marine Protected Area. Fisheries Management and Ecology, 2015(22): 249–260.

Maynou, F., Sbrana, M., Sartor, P., Maravelias, C., Kavadas, S., Damalas, D., Cartes, J., and Osio, G., 2011. Estimating Trends of Population Decline in Long-Lived Marine Species in the Mediterranean Sea Based on Fishers' Perceptions. PLoS ONE 6, e21818.

McCauley, D.J., Pinsky, M.L., Palumbi, S.R., Estes, J.A., Joyce, F.H., Warner, R.R. et al. (2015) Marine defaunation: animal loss in the global ocean. Science 347m 1255641. DOI: 10.1126/science.1255641

Mayol, J., Grau, A.M., Riera, F., and Oliver, J. 2000. Llista vermella dels peixos de les Balears. Documents Tècnics de Conservació, II(7): 1-126.

Miller, R.M., Rodríguez, J.P., Aniskowicz-Fowler, T., Bambaradeniya, C., Boles, R., Eaton, M.A., Gärdenfors, U., Keller, V., Molur, S., Walker, S., and Pollock, C. 2006. National Threatened Species Listing Based on IUCN Criteria and Regional Guidelines: Current Status and Future Perspectives. Conservation Biology, 21(3): 684–696.

Morales-Nin, B., Grau, A.M. and Palmer M. 2010. Managing coastal zone fisheries: A Mediterranean case study. Ocean and Coastal Management, 53: 99–106.

Norse, E.A., Brooke, S, Cheung, W.W.L., Clark, M.R., Ekeland, I., Froese, R., Gjerde, K.M., Haedrich, R.L., Heppell, S.S., Morato, T., Morgan, L.E., Pauly, D., Sumaila, R., and Watson, R. 2012. Sustainability of deep-sea fisheries. Marine Policy, 36: 307−320.

Rodrigues, A. S. L., Pilgrim, J. D., Lamoreux, J. F., Hoffman, M and Brooks, T. M. 2006. The Value of the IUCN Red List for conservation. Trends in Ecology and Evolution, 21: 71–76.

Sadovy de Mitcherson, Y., and Cheung, W.L. 2003. Near extinction of a highly fecund fish: the one that nearly got away. Fish and Fisheries, 4: 86−99.

Sadovy de Mitcheson, Y., Craig, M.T., Bertoncini, A.A., Carpenter, K.E., Cheung, W.W. L., Choat, J. H., Cornish, A. S., Fennessy, S. T., Ferreira, B. P., Heemstra, P. C., Liu, M., Myers, R.F., Pollard, D. A., Rhodes, K.L., Rocha, L.A., Russell, B. C., Samoilys, M.A. and Sanciangco, J. 2013. Fishing groupers towards extinction: a global assessment of threats and extinction risks in a billion dollar fishery. Fish and Fisheries, 14: 119-136.

Torres, A., Fernandez, N., zu Ermgassen, S., Helmer, W., Revilla, E., Saavedra, D., Perino, A. et al. (2018) Measuring rewilding progress. Phil. Trans. R. Soc. B 373: 20170433. http://dx.doi.org/10.1098/rstb.2017.0433

Tsagarakis, K., Palialexis, A., and Vassilopoulou, V. 2014. Mediterranean fishery discards: review of the existing knowledge. ICES Journal of Marine Science, 71(5): 1219–1234.

Webb, T.J., and Mindel, B.L. 2015. Global patterns of extinction risk in marine and non-marine systems. Current Biology, 25, 506-511.

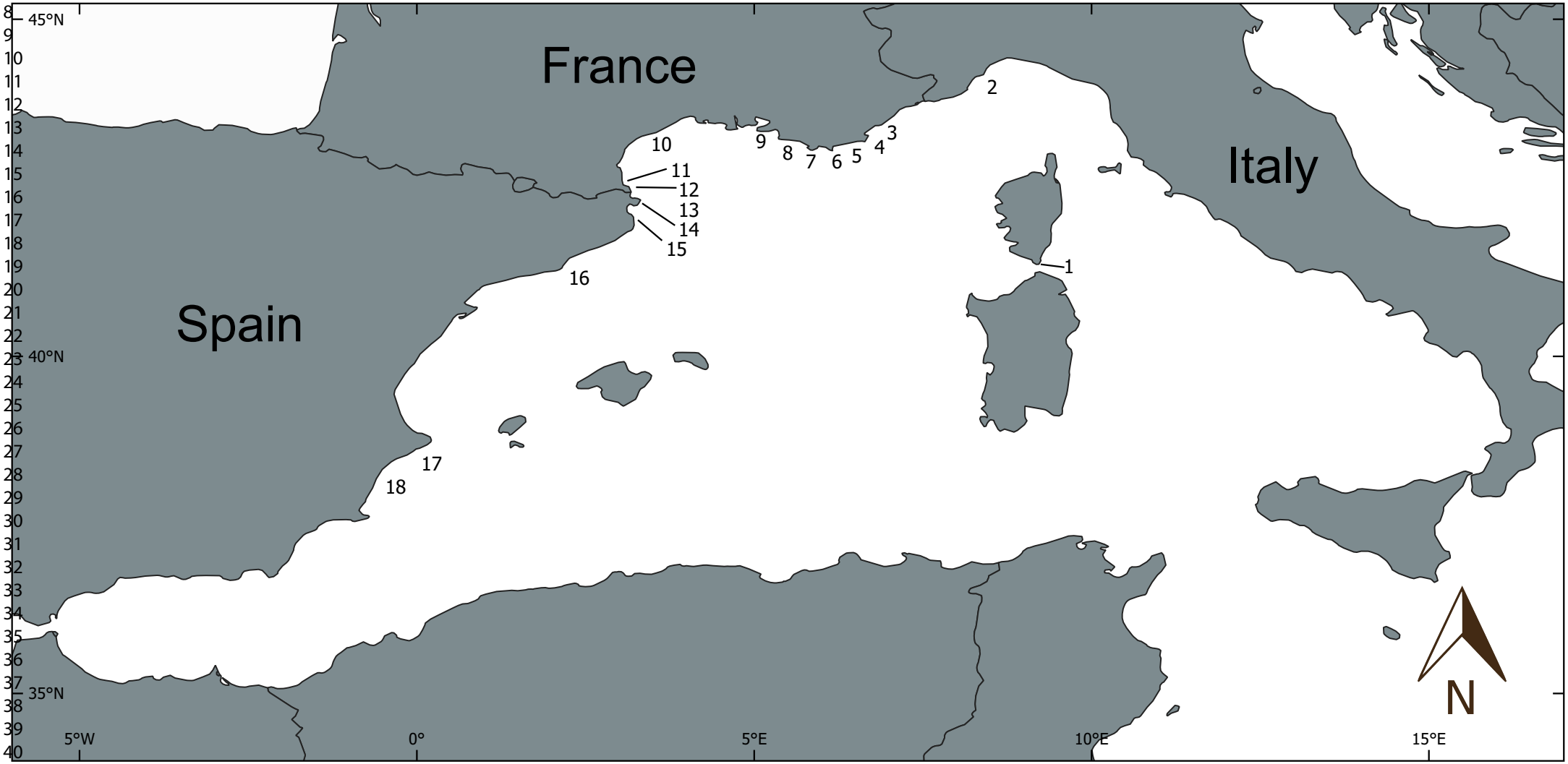
Zeller, D., Cashion, T., Palomares, M. and Pauly, D. 2018. Global marine fisheries discards: a synthesis of reconstructed data. Fish and Fisheries 19:30-39

FIGURE CAPTIONS

Figure 1: Map of the study area showing the coastal areas and marine protected areas considered. The code numbers are: 1-Bonifacio; 2-Bergeggi, 3-Cap Roux (adjacent area), 4-French Riviera, 5-Port Cros, 6-Porquerolles, 7-Les Embiez, 8-Archipel de Riou, 9-Côte Bleue, 10-Cap d'Agde, 11-Côte sableuse catalane, 12-Posidonies Côte des Albères - Gulf of Lion, 13-Cerbère-Banyuls, 14-Cap de Creus, 15-Medes Islands, 16-Coast of Catalonia, 17-Serra Gelada, 18-Tabarca

Figure 2: Number of vulnerable species caught by each fishing method operating in coastal and offshore waters. The fishing methods are: Recreational fisheries (BF: boat fishing; SF: shore fishing; SP: spearfishing; OBF: offshore boat fishing) and small-scale fisheries (TR: trammel net; GN: gillnet; LL: longline; PN: pound net; OLL: offshore long line). The vulnerability categories are: LC: least concern with vulnerability index (IV)>60; NT: near threatened; VU: vulnerable; EN: endangered; CR: critically endangered; Other: species not on the IUCN Red List, but which are included in International Conventions (Barcelona, Bern and CITES conventions) and/or the EU Habitats Directive.

Figure 3: Weighted mean intrinsic vulnerability index (IV) by fishing type operating in coastal and offshore waters. Recreational fisheries (BF: boat fishing; SF: shore fishing; SP: spearfishing; OBF: offshore boat fishing) and small-scale fisheries (TR: trammel net; GN: gillnet; LL: longline; PN: pound net; OLL: offshore long line)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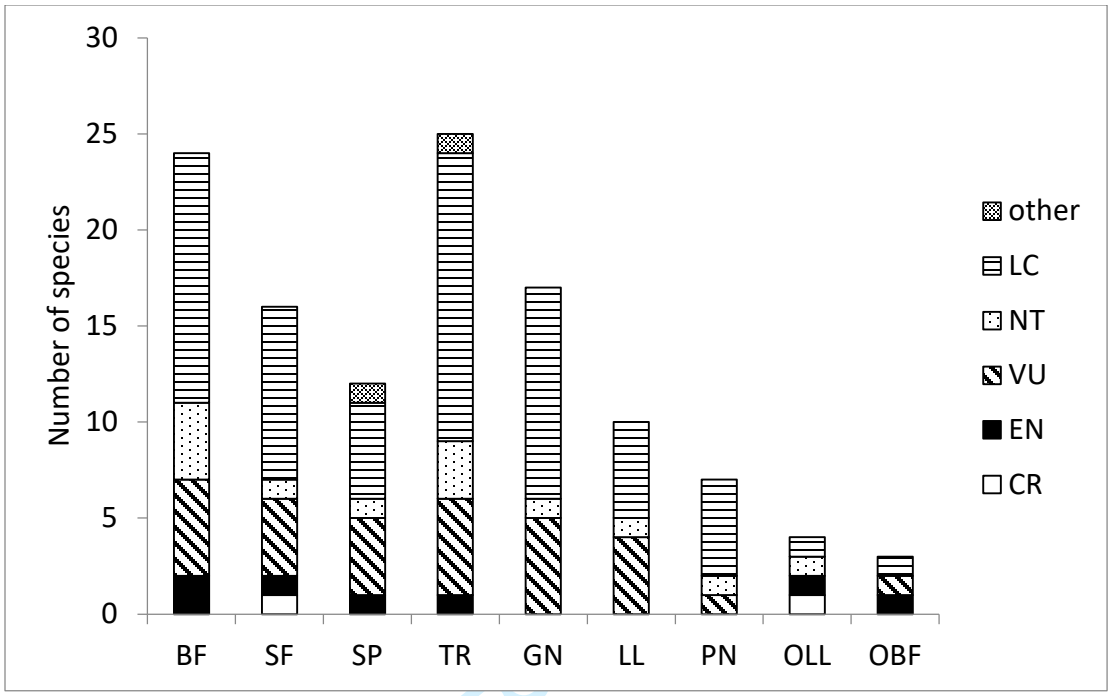

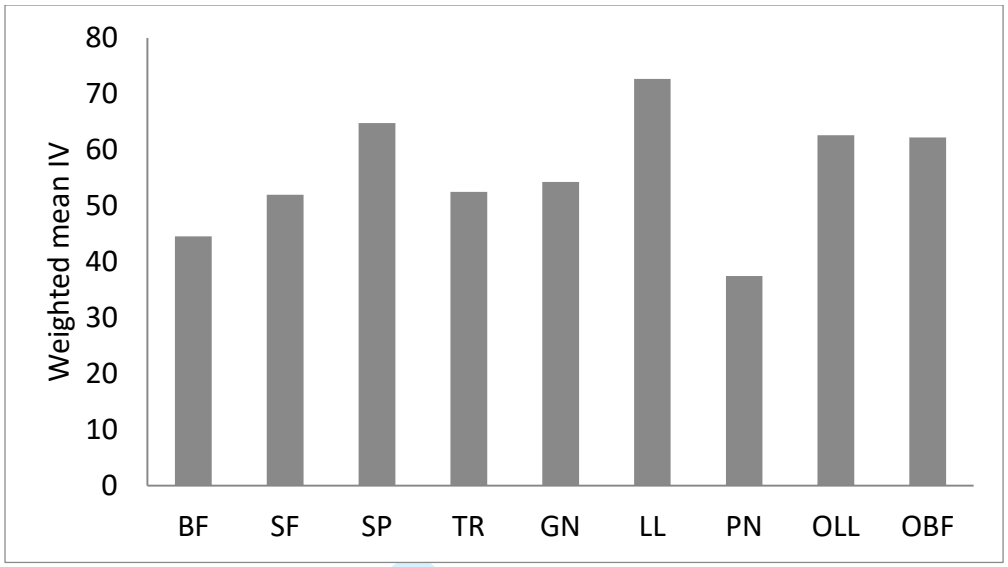

Supplementary Table SB1: The areas and MPAs reviewed. **Sampling effort**: number of fishers surveyed, considering all the studies carried out in a given area and all fishing types; **Sampling year/season:** when the studies were carried out.; **Fishing type:** BF: recreational boat fishing; SF: recreational shore fishing; SP: recreational spearfishing.; SSF: small-scale (professional) fishing. n/a: information not available

MPA/Area	References	Sampling effort	Nr. of studies	Sampling year/season	Fishing type
(1) Bonifacio	Alban, 2008 Rocklin *et al.*, 2011	n/a	3	2005 - 2006, 2011: n/a	SP
(2) Bergeggi (adjacent area)	Ferrando, 2012 Roveta, 2013	98	1	2012: spring	SF
(3) Cap Roux (adjacent area)	Bodilis *et al.*, 2009	88	1	2009: spring and summer	BF
	Bodilis *et al.*, 2012	77	1	2011: spring and summer	BF
(4) French Riviera	Chavoin and Boudouresque, 2004	33	1	1996: spring and summer	SP
(5) Port Cros	Combelles, 1991	n/a	1	1987 - 1988: autumn, winter and spring	BF
(6) Porquerolles	Bonhomme *et al.*, 2007, 2008, 2010	267	3	2006, 2007, 2010: summer	BF
(7) Les Embiez	Bodilis *et al.*, 2012	145	1	2011: spring and summer	BF

(8) Archipel de Riou	Bernard *et al.*, 1998 Bonhomme *et al.*, 1999	181	2	1997 - 1998: summer and winter 1999: spring	BF, SF, SP
(9) Côte Bleue	Vo Van, 2007 Bonnard, 2009 Ollier, 2009 Charbonnel *et al.*, 2010, 2011	2518	4	2007 - 2009: whole year 2008: summer and autumn 2011: autumn	BF, SF, SP
	Charbonnel *et al.*, 2013, 2017	261	n/a	2012-2015: whole year	SSF
(10) Cap d'Agde	Blouet *et al.*, 2005, 2012 Adam de Villiers, 2011 Cimiterra *et al.*, 2013	623	4	2005, 2011, 2012: summer 2013: spring and summer	BF, SF
(11) Côte sableuse catalane	Ageorges, 2007	503	1	2007: winter and spring	SF
(12) Posidonies Côte des Albères - Gulf of Lion	Lassus-Debat, 2011 Sebesi, 2011	2522	2	2010 - 2011: whole year	BF, SF
(13) Cerbère-Banyuls	Dubreuil and Rat, 2005 Claisse, 2008 Hartmann, 2009	3142	4	2005, 2008, 2009: spring and summer 2010: whole year	BF, SF

	Ivanoff, 2010				
	Prats, 2016	n/a	n/a	2015: spring and summer	SSF
(14) Cap de Creus	Lloret *et al.*, 2008a,b Font and Lloret, 2010,2011	822	6	2006: summer 2007: summer 2009: spring, summer and autumn	BF, SF, SP
	Lloret, 2011, 2015	572	6	2008, 2009, 2010, 2011, 2013, 2015: spring and summer	SSF
(15) Medes Islands	Sacanell, 2012	36	1	2012: summer	BF
(16) Coast of Catalonia	Gordoa, 2009	n/a	1	2002-2005: n/a	SF
(17) Serra Gelada	Luna-Pérez, 2010	n/a	1	2007: spring	BF
(18) Tabarca	Luna-Pérez, 2010	n/a	1	2003 - 2005: whole year	SF

References cited in this table

Adam de Villiers, O., Blouet, S., Chéré, E., Coulon, J., Dupuy de la Grandrive, R., and Foulquié, M. 2011. Suivi de la pêche de loisir dans l'Aire Marine Protégée du Cap d'Agde, Année 2011.Site Natura 2000 « Posidonies du Cap d'Agde » FR-9101414. ADENA publications. Fr. : 32pp.

Ageorges, C. 2007. Caracterisation de la pêche de loisir pratiquée du bord, le long de la côte sableuse catalane. Mémoire de Master «Mention Sciences de l'Univers, Environnement, Ecologie», «Spécialité Océanographie et Environnements Marins » Année 2006 – 2007.

Alban F., Person J., Roncin N. and Boncoeur, J. 2008. Analysis of Socio-Economic Survey Results. EMPAFISH Project. 139 pp.

Astruch, P., Boudouresque, J.C., Rouanet, E., le Diréach, L., Bonhomme, P., Bonhomme, D., Goujard, A., Ruitton, S., and Harmelin, J.G. 2018. A quantitative and functional assessment of fish assemblages of the Port-Cros Archipelago (Port-Cros National Park, north-western Mediterranean Sea). Sci. Rep. Port-Cros National Park, 32: 17-82

Bernard G., Bonhomme P., and Daniel B. 1998. Archipel de Riou (Marseille, France): Etude socio-économique sur la plaisance, la pêche amateur, la plongeé, et la chasse sous-marine (périodes estivale et hivernale). Contrat Ville de Marseille, Direction de l'Environnement et des Déchets & GIS Posidonie. GIS Posidonie Publications, Marseille, Fr.: 1-154 + annexes.

Blouet S., and Dupuy de la Grandrive R. 2005. Etude socio-économique et spatialisée de la pêche récréative en mer dans la zone marine agathoise. Association de Défense de l'Environnement et de la Nature des pays d'Agde (ADENA). Fr : 55pp.

Blouet S., Chéré E., Pereira J., Hassid T., and Dupuy de la Grandrive, R. 2012. Suivi de la pêche de loisir dans l'aire marine protégée du Cap d'Agde. Site Natura 2000 « Posidonies du Cap d'Agde » FR-9101414. ADENA publ. Fr. : 46 pp.

Bodilis P., Pastor J., Jarraya M., Ivanoff P., Payrot J., Pelletier D., Alban F., Cheminée A., and Francour, P. 2009. Recreational fishing around the Cap Roux MPA (Northwestern Mediterranean Sea): evaluation, impacts, consequences for the future of the Marine Reserve. (Poster).

Bodilis, P., Marine, C., and Francour, P. 2012. Suivi des biocénoses et des peuplements de poissons de 4 sites non protégés du littoral varois. Université Nice. ECOMERS.

Bonhomme, P., Bernard, G., Daniel, B. and Boudouresque, C.F. 1999. Archipel de Riou (Marseille, France): Etude socioéconomique sur la plaisance, la pêche amateur, la plongée et la chasse sous-marine (période de printemps). Contrat Ville de Marseille. Direction de l'Environnement et des Déchets & GIS Posidoine. GIS Posidoine Publications, Marseille, Fr.: 1.83.

Bonhomme, P., Riviere, T., Le Direach, L., and Garcia, J. 2007. Premier suivi de la pêche récréative autour de l'île de Porquerolles (Hyères les Palmiers, Var) – Saison estivale 2006. Contrat PNPC & GIS Posidonie. GIS Posidonie publications, Fr. : 1–54.

Bonhomme, P., Le Direach, L., and Boudouresque, C.F. 2008. Suivi de la pêche récréative autour de l'île de Porquerolles (Hyères les Palmiers, Var) – Saison estivale 2007. Contrat PNPC & GIS Posidonie. GIS Posidonie publications, Fr. : 1–55.

Bonhomme, P., Le Direach, L., and Boudouresque, C.F. 2010. Suivi de la pêche récréative autour de l'île de Porquerolles (Hyères les Palmiers, Var). Saison estivale 2010. Partenariat Parc national de Port-Cros & GIS Posidonie. GIS Posidonie publications, Fr. : 1–67.

Bonnard, M. 2009. La pêche récréative dans le Parc Marin de la Côte Bleue. Évaluation et enquêtes sur l'influence des Aires Marines Protégées. Rapport stage Master2 Université de la Méditerranée. COM/GIS Posidonie/Parc Marin de la Côte Bleue, Fr. : 1-35 + annexes.

Chavoin, O., and Boudouresque, C. F. 2004. An attempt to quantify spear fishing catches in a French Riviera Mediterranean area. Science Report Port-Cros National Park Fr. 20: 161–171.

Charbonnel E., Le Direac'h, L ., Letourneur, Y., Ollier, C., Bonnard, M., Leleu, K., Soler, L., Vo Van, M., Bechagra, A., Bricout, R., Bachet, F., Alban, F., and Pelletier. D. 2010. Caractérisation de la pêche récréative dans le Parc Marin de la Côte Bleue. Etude des pratiques et des captures sur un cycle annuel. Journées Nationales Pêches Récréatives. 16,17 mars 2010, Rochefort.

Charbonnel, E., Le Direach, L., Simon, M., Ollier, C., Bonnard, M., Monin, M., Bachet, F., Vo Van, M., Soler, L., Bricout, R., Gamp, E., Alban, F., and Pelletier, D. 2011. Bilan des suivis de la pêche récréative et de la fréquentation dans le Parc Marin de la Côte Bleue, Rapport Parc Marin de la Côte Bleue publ.Fr.: 1–38.

Charbonnel E., Leleu K., and Bachet F., 2013. Bilan des suivis de la pêche professionnelle et récréative dans le Parc Marin de la Côte Bleue. Rapport Parc Marin de la Côte Bleue, Conseil Consultatif Régional de la mer PACA, Fr. : 1-93.

Charbonnel E., Bachet F., Bravo-Monin M., and Cadville B., 2017. Suivis scientifiques du site atelier sur les peuplements de poissons et les mesures de gestion sur la Côte Bleue. Rapport de synthèse 2015-2016. Convention Parc Marin de la Côte Bleue & Agence de l'Eau RMC. Rapport Parc Marin de la Côte Bleue publ. Fr. : 1-169.

Cimiterra, N., Blouet, S., Chéré, E., Dupuy de la Grandrive, R., and Monjol, J. 2013. Suivi de la pêche de loisir dans l'aire marine protégée agathoise. Année 2013 et bilan des suivis de 2011 à 2013. Site Natura 2000 « Posidonies du Cap d'Agde » FR-9101414. Mémoire Master 2 Université de Perpignan. Ville d'Agde publ. Fr. : 32pp.

Claisse, N. 2007-2008. Etude de l'impact de la pêche de loisir dans la région de Banyuls-sur-Mer. Caractérisation de l'activité, productions et effort de pêche. Propositions de gestion du patrimoine. Master 2 professionnel «Génie des Anthroposystèmes Littoraux». Université de La Rochelle.

Combelles, S. 1991. Pêche amateur dans les eaux du Parc National de Port-Cros. Rapport final, Parc National de Port-Cros, Laboratoire de zoologie et d'écologie, Université d'Orsay.

Dubreuil J., and Rat C. 2005. Caractérisation de la pêche de loisir dans la région de Banyuls-sur-mer: Typologie, productions "effets réserve". Master «Environnements Méditerranéens et Développement Durable», Option «Biodiversité et Gestion des Ressources Vivantes», Université de Perpignan. Organisme d'accueil: Réserve Naturelle Marine de Cerbère-Banyuls.

Ferrando, T. 2012. Caratterizzazione delle attività antropiche nell'Area Marina Protetta Isola di Bergeggi. Area scientifico disciplinare Scienze biologiche; Programma di Ricerca n° 8. L'Università degli Studi di Genova.

Font, T., and Lloret, J. 2010.Impacte ambiental i característiques socioeconòmiques de la pesca recreativa al Parc Natural de Cap de Creus. Generalitat de Catalunya. 56 pp

Font, T. and Lloret, J. 2013. Análisis de la pesca de recreo en las 10 Áreas LIC del proyecto LIFE+INDEMARES. Universidad de Girona – Ministerio de Agricultura, Alimentación y Medio Ambiente - Fundación Biodiversidad.

Gordoa, A. 2009. Characterization of the infralittoral system along the north-east Spanish coast based on sport shore-based fishing tournament catches. Estuarine, Coastal and Shelf Science, 82: 41–49.

Hartmann, V. 2009. Caractérisation de la pêche de loisir dans la région de Banyuls-sur-Mer: Caractérisation des pêcheurs, production et effort de pêche. Mesures de gestion. Master 2 professionnel «Biodiversité et développement durable». Université de Perpignan.

Ivanoff, P., Payrot, J., and Verdoit-Jarraya, M. 2010. A recreational fishery survey inside and outside a marine protected area (north-western Mediterranean) over one year: typology, seasonal variability and reserve's influence. Mémoire Master. Université de Montpellier.

Lassus-Debat, A. 2011. La pêche récréative sur le Site Natura 2000, «Posidonie de la côte des Albères»: approche socio-économique. Université de Perpignan Via Domitia.

Lloret, J. 2011. Seguiment de la pesca artesanal al parc natural de Cap de Creus. Generalitat de Catalunya. 52pp.

Lloret, J. 2015. Seguiment de la pesca artesanal al parc natural de Cap de Creus. Any 2015. Generalitat de Catalunya – Universitat de Girona.

Ollier, C., 2009. Evaluation de la pêche récréative sur les ressources halieutiques du Parc Marin de la Côte Bleue. Influence des Aires Marines Protégées sur les pratiques et les captures annuelles. Rapport stage Master2 professionnel. Parc Marin de la Côte Bleue/GIS Posidonie/COM., Fr. : 1-38+annexes.

Prats. L. 2016. Etude de la variabilité spatiale et temporelle dans la Réserve Naturelle Marine de Cerbère-Banyuls et à proximité : caractérisation de la pêche professionnelle, étude de l'effet réserve et des espèces à protéger. Rapport de Master 2. Pages 1-21.

Rocklin, D., Tomasini, J-A., Culioli, J-M., Pelletier, D., and Mouillot, D. 2011. Spearfishing Regulation Benefits Artisanal Fisheries: The ReGS Indicator and Its Application to a Multiple-Use Mediterranean Marine Protected Area. PLoS ONE 6(9): 23820. doi:10.1371/journal. pone.0023820.

Roveta, A. 2013. Caratterizzazione della pesca ricreativa in mare nell'Area Marina Protetta Isola di Bergeggi e nel territorio limitrofo. Scuola di Scienze Matematiche Fisiche e Naturali. Tesi di Laurea in Scienze Ambientali.

Sacanell, M. 2012. Study on recreational fishing in Medes islands marine protected area. Parc Natural del Montgrí, les Illes Medes i el Baix Ter. MedPAN North Project.

Sebesi, L. 2011. A recreational fishery study inside a Natura 2000 protected area (Gulf of Lion - Mediterranean Sea): temporal and spatial variability of catches, impacts on species and marine habitats. CEFREM / University of Perpignan.

Vo Van, M. 2007. La pêche de loisirs sur la Côte Bleue au printemps. Pêche à la ligne du bord, pêche embarquée, chasse sous-marine : pratiques et captures. Parc Marin de la Côte Bleue & GIS Posidonie publications. Fr. : 34 pp + annexes.

Supplementary Table SB2: List of target (landed) vulnerable species caught using various fishing gears and methods. Percentage of catch (by weight) of each vulnerable species respect to the total catch, per fishing type, in coastal waters: **%BF** (boat fishing), **%SF** (shore fishing), **%SP** (spearfishing), **%TR** (trammel net), **%GN** (gillnet), **%L**L (longline) and **%P**N (pound net); and offshore: **%OLL**: offshore SSF (professional) pelagic long line; **OBF**: Offshore recreational boat fishing. The symbol X denotes cases in which the species is known to have been caught by a particular gear or method, but data on the catch is lacking. **IV** is the intrinsic vulnerability index; **IUCN category** indicates designated category on the Mediterranean red list (except those marked * which were from global red list): LC (least concern), VU (vulnerable), NT (near threatened), EN (endangered), CR (critically endangered).

Species	IV	IUCN category	International Conventions	%BF	%SF	%SP	%TR	%GN	%LL	%PN	%OLL	%OBF
Anguilla anguilla	64	CR*	Barcelona (Annex III); CITES (Annex II)		0.01							
Chelon labrosus	63	LC		0.01	0.33	0.21	1.51	5.93				
Conger conger	86	LC		0.60	2.74	4.67	1.58	0.37	54.19			
Dentex dentex	66	VU		1.00	8.19	5.68	1.42	1.04	7.27	0.56		
Dicentrarchus labrax	49	NT		0.69	9.60	8.06	3.17	3.31	7.99	0.04		
Dicentrarchus punctatus	67	LC			X							
Diplodus sargus	63	LC		0.58	9.41	7.32	1.42	5.37	2.46	0.02		
Epinephelus marginatus	72	EN	Barcelona & Bern (Annex III)	0.15	0.69	15.70	0.78					
Helicolenus dactylopterus	67	LC		0.03			0.06		2.03			
Homarus gammarus	46	LC	Barcelona & Bern (Annex III)				2.32					

Species	IV	IUCN category	International Conventions	%BF	%SF	%SP	%TR	%GN	%LL	%PN	%OLL	%OBF
Labrus mixtus	67	LC		0.10	X		0.02					
Labrus viridis	34	VU		0.17	0.04	0.58	0.07	0.02	0.07			
Lophius budegassa	68	LC					0.20					
Lophius piscatorius	72	LC			0.12		5.46	0.85				
Merluccius merluccius	64	VU		0.18			9.44	23.30	0.43			0.12
Muraena helena	79	LC		0.05	3.66	1.28						
Mustelus mustelus	74	VU	Barcelona (Annex III)		X	X						
Pagrus pagrus	66	LC		0.66	0.11		0.47	0.59	1.63	0.04		
Palinurus elephas	40	VU*	Barcelona & Bern (Annex III)				4.24	0.09				
Prionace glauca	77	CR	Barcelona & Bern (Annex III)								2.04	
Raja asterias	50	NT		X			0.51					
Raja clavata	72	NT		X			0.51					

Species	IV	IUCN category	International Conventions	%BF	%SF	%SP	%TR	%GN	%LL	%PN	%OLL	%OBF
Sciaena umbra	64	VU	Barcelona & Bern (Annex III)	0.04	3.55	3.33	1.11	0.12	0.01			
Scorpaena elongata	63	LC					0.18					
Scorpaena scrofa	68	LC		0.22	0.41	0.77	12.92	0.14	2.57	0.08		
Scyliorhinus canicula	62	LC		0.12			0.04	0.02				
Scyllarides latus	35	DD	Barcelona & Bern (Annex III); Habitats Directive (Annex V)			X	0.48					
Scyllarus arctus	10	LC	Barcelona & Bern (Annex III)				0.14	0.04				
*Sphyraena sphyraena***	73	LC					0.94	0.14				
Sphyraena viridensis	69	LC		X				13.84		4.08		
Thunnus alalunga	60	LC		X							13.20	46.24
Thunnus thynnus	64	EN	Barcelona (Annex III)	X							0.01	53.64
Trigla lyra	63	LC		0.02								

Species	IV	IUCN category	International Conventions	%BF	%SF	%SP	%TR	%GN	%LL	%PN	%OLL	%OBF
Umbrina cirrosa	40	VU	Barcelona & Bern (Annex III)	X								
Xiphias gladius	62	NT	Barcelona (Annex III)	X							84.75	
Zeus faber	68	LC		0.05			0.08	0.08		0.01		
			TOTAL%	4.7	38.86	47.60	49.07	55.25	78.65	4.83	100	100

*IUCN global red list

**Although the particular barracuda species was not recorded, it was assumed to be *S. sphyraena,* because it is also common in the NW Mediterranean

Supplementary Table SB3: List of vulnerable species caught as by-catch by small-scale (professional) and recreational fishing types together with the level of protection (international conventions for the protection of biodiversity), the areas where data is available and the bibliographic references.

	Species	Fishing type	International Conventions	Area	Reference
Mammals	*Tursiops truncatus*	gillnet trammel net drifting longline	Habitats Directive (Annex II and IV); Bern Convention (Annex II); Bonn Convention (Annex I and II); CITES (Annex II); VU (IUCN)	Sardinia, Algeria, Croatia, France, Greece, Israel, Italy, Malta, Morocco, Spain, Tunisia, Turkey	Díaz López, 2006; Bearzi *et al.,* 2008; Bearzi, 2002
	Delphinus delphis	gillnet driftnet	Habitats Directive (Annex IV); Barcelona Convention (Annex II); Bern Convention (Annex II); Bonn Convention (Annex II); CITES (Annex II); EN (IUCN)	Gibraltar Straits, Alboran Sea, Spanish and French Mediterranean	Silvani *et al.,* 1999; Bearzi *et al.,* 2003; Bearzi, 2002; Tudela *et al.,* 2005
	Stenella coeruleoalba	driftnet	Habitats Directive (Annex IV); Bern Convention (Annex II); Bonn Convention (Annex II); CITES (Annex II); VU (IUCN)	Gibraltar Straits, Alboran Sea	Silvani *et al.,* 1999; Tudela *et al.,* 2005
	Globicephala melas	driftnet	Habitats Directive (Annex IV); Bern Convention (Annex II); CITES (Annex II)	Ligurian Sea	Abend and Smith, 1999
	Grampus griseus	longline	Habitats Directive (Annex IV); Bern Convention (Annex II); CITES (Annex II); LC (IUCN)	Alboran Sea	Macías López *et al.,* 2012
	Physeter macrocephalus	longline	Habitats Directive (Annex IV); Bern Convention (Annex II); Bonn	Mediterranean Sea	Werner *et al*., 2015

			Convention (Annex I and II); CITES (Annex I); EN (IUCN)		
Reptiles	*Caretta caretta*	driftnet trammel net and gillnet drifting longlines demersal longlines	Habitats Directive (Annex II and IV; priority species); Barcelona Convention (Annex II); Bern Convention (Annex II); Bonn Convention (Annex I and II); CITES (Annex I); VU (IUCN)	Gibraltar Straits, Alboran Sea, Eastern Mediterranean	Silvani *et al.,* 1999; Tudela *et al.,* 2005; Casale, 2011; Carboneras, 2009; Carreras *et al.,* 2004
	Dermochelys coriacea	driftnet	Habitats Directive (Annex IV); Bern Convention (Annex II); Bonn Convention (Annex I and II); CITES (Annex I); VU (IUCN)	Spanish Mediterranean	Silvani *et al.,* 1999; Carreras *et al.,* 2004
	Chelonia mydas	set nets drifting longlines demersal longlines	Habitats Directive (Annex II and IV; priority species); Bern Convention (Annex II); Bonn Convention (Annex I and II); CITES (Annex I); EN (IUCN)	Eastern Mediterranean; Balearic Islands	Casale, 2011; Carreras *et al.,* 2004
Osteichthyes	*Coryphaena hippurus*	longlines	LC (IUCN)	Western Mediterranean Sea	Macias *et al.,* 2016
	Tetrapturus belone	Recreational boat fishing	LC (IUCN)	Spanish Mediterranean	Secretaria General de Pesca (pers.comm.)

Elasmobranchs	*Cetorhinus maximus*	trammel net gillnet driftnet longline	Barcelona Convention (Annex II); Bern Convention (Annex II); Bonn Convention (Annex I and II); CITES (Annex II) ; EN (IUCN)	Italy, Sardinia	Mancusi *et al.,* 2005; Storai *et al.,* 2011
	Isurus oxyrinchus	driftnet Longline Recreational boat fishing	Barcelona Convention (Annex III); Bern Convention (Annex III); Bonn Convention (Annex II); CR (IUCN)	Cádiz, Alboran Sea, Spanish Mediterranean, Sardinia	Font and Lloret, 2013; Silvani *et al.,* 1999; Tudela *et al.,* 2005; Storai *et al.,* 2011
	Sphyrna zygaena	pound net Longline	CITES (Annex II); CR (IUCN)	Cap de Creus Natural Park, Sardinia, Spanish Mediterranean	Lloret, 2011; Storai *et al.,* 2011, de la Serna et al. (2002)
	Dasyatis pastinaca	Recreational boat fishing	VU (IUCN)	Cerbère-Banyuls Cap d'Agde	Hartmann, 2009 Cimiterra, 2013
	Lamna nasus	Gillnet Longline Driftnet	Barcelona Convention (Annex III); Bern Convention (Annex III); Bonn Convention (Annex II); CITES (Annex II); CR (IUCN)	Adriatic Sea, Mediterranean	Scacco *et al.,* 2012; Cavanagh and Gibson, 2007
	Alopias vulpinus	Driftnet	Bonn Convention (Annex II);	Alboran Sea, Adriatic	Tudela *et al.,* 2005; Ferreti *et al.,*

		Longline	CITES (Annex II) ; EN (IUCN)	Sea, Sardinia	2008; Storai *et al.,* 2011
		Recreational boat fishing			
		Driftnet			
	Prionace glauca	Longline	Barcelona Convention (Annex III); Bern Convention (Annex III); CR (IUCN)	Spanish Mediterranean, Alboran Sea, Sardinia, Ligurian Sea	Silvani *et al.,* 1999; Tudela *et al.,* 2005; Storai *et al.,* 2011
		Recreational boat fishing			
	Galeorhinus galeus	longline	VU (IUCN)	Spanish Mediterranean	de la Serna *et al.,* 2002
	Mobula mobular	Longline	Barcelona Convention (Annex II); Bern Convention (Annex II); Bonn Convention (Annex I and II); EN (IUCN)	Sardinia, Mediterranean	Storai *et al.,* 2011; Cavanagh and Gibson, 2007
		Driftnet			
		Drifting longline			
		Longline			
	Calonectris diomedea	Gillnet	EU Birds Directive (Annex I); Barcelona Convention (Annex II); Bern Convention (Annex II); LC (IUCN global)	Spanish Mediterranean	Carboneras, 2009; García-Barcelona *et al.,* 2010; Belda and Sánchez, 2001
		Trammel net			
		Recreational boat and shore fishing			
	Puffinus yelkouan	Drifting longline	Barcelona and Bern Convention (Annex II); VU (IUCN global)	Spanish Mediterranean	Carboneras, 2009
		Longline			

Birds

Puffinus mauretanicus	Gillnet Trammel net Drifting longline Longline Gillnet Trammel net	EU Birds Directive (Annex I); Barcelona Convention (Annex II); Bern Convention (Annex II); CR (IUCN global)	Spanish Mediterranean	Carboneras, 2009
Larus audouinii	drifting longline Recreational boat and shore fishing Longline	EU Birds Directive (Annex I); Barcelona Convention (Annex II); Bern Convention (Annex II); LC (IUCN global)	Spanish Mediterranean	Carboneras, 2009; García-Barcelona *et al.,* 2010; Font and Lloret, 2013
Phalacrocorax aristotelis	Gillnet Trammel net Recreational boat and shore fishing	EU Birds Directive (Annex I); Barcelona Convention (Annex II); Bern Convention (Annex II); LC (IUCN global)	Spanish Mediterranean	Carboneras, 2009
Sterna spp.	Drifting longline	EU Birds Directive (Annex I); Barcelona Convention (Annex II); Bern Convention (Annex II)	Spanish Mediterranean	Carboneras, 2009

References

Abend, A.G. , and Smith, T.D. 1999. Review of Distribution of the Long-finned Pilot Whale (Globicephala melas) in the North Atlantic and Mediterranean. NOAA Technical Memorandum, NMFS-NE-117.

Bearzi, G. 2002. Interactions between cetacean and fisheries in the Mediterranean Sea. In: G. Notarbartolo di Sciara (Ed.), Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies. A report to the ACCOBAMS Secretariat, Monaco. Section 9, 20 pp.

Bearzi, G., Reeves, R.R., Notarbartolo di Sciara, G., Politi, E., Cañadas, A. Frantzis, A. and Mussi, B. 2003. Ecology, status and conservation of short-beaked common dolphins Delphinus delphis in the Mediterranean Sea. Mammal Review, 33(3): 224–252.

Bearzi, G., Fortuna, C. M. and Reeves R. R. 2008. Ecology and conservation of common bottlenose dolphins Tursiops truncatus in the Mediterranean Sea. Mammal Review, 39 (2): 92–123.

Belda, E.J. and Sánchez, A. 2001. Seabird mortality on longline fisheries in the western Mediterranean: factors affecting bycatch and proposed mitigating measures. Biological Conservation, 98: 357–363.

Carboneras, C. 2009. Guidelines for reducing bycatch of seabirds in the Mediterranean region. Contract RAC/SPA, N° 42, 54 pp. RAC/SPA, Tunis.

Carreras, C., Cardona, L., and Aguilar, A. 2004. Incidental catch of the loggerhead turtle Caretta caretta off the Balearic Islands (western Mediterranean). Biological Conservation 117: 321–329.

Casale, P. 2011. Sea turtle by-catch in the Mediterranean. Fish and Fisheries, 12: 299–316.

Cavanagh, R.D., and Gibson, C. 2007. El estado de conservación de los peces cartilaginosos (Condrictrios) del Mediterráneo. UICN, Gland, Suiza y Málaga, España.

Cimiterra, N., Blouet, S., Chéré, E., Dupuy de la Grandrive, R., and Monjol, J. 2013. Suivi de la pêche de loisir dans l'aire marine protégée agathoise. Année 2013 et bilan des suivis de 2011 à 2013. Site Natura 2000 « Posidonies du Cap d'Agde » FR-9101414. Mémoire Master 2 Université de Perpignan. Ville d'Agde publ. Fr. : 32pp.

De la Serna, J.M., Valeiras, J., Ortiz, J.M., and Macías, D. 2002. Large pelagic Sharks as By-catch in the Mediterranean Swordfish Longline Fishery: Some Biological Aspects. NAFO SCR Doc. 02/137, Serial No. N4759

Diaz-López, B. 2006. Interactions between Mediterranean bottlenose dolphins (Tursiops truncatus) and gillnets off Sardinia, Italy. ICES Journal of Marine Science, 63 (5): 946–951.

Font, T. and Lloret, J. 2013. Análisis de la pesca de recreo en las 10 Áreas LIC del proyecto LIFE+INDEMARES. Universidad de Girona – Ministerio de Agricultura, Alimentación y Medio Ambiente - Fundación Biodiversidad.

García-Barcelona, S., Ortiz De Urbina, J.M., De La Serna, J.M., Alot, E., and Macías, D. 2010, Seabird by-catch in Spanish Mediterranean large pelagic longline fisheries, 2000-2008. Aquatic Living Resources 23: 363-371

Lloret, J. 2011. Seguiment de la pesca artesanal al parc natural de Cap de Creus. Generalitat de Catalunya. 52pp.

Macías, D., Báez, J. C., García Barcelona, S., Saber, S., Camiñas, J. A. and Ortiz de Urbina, J. M. 2016. Malta 16-18 March 2016. GCP/INT/028/SPA - GCP/INT/006/EC.

CopeMed II Occasional Paper Nº 22.

Macías - Lopez, D., García Barcelona, S., Báez, J. C. De la Serna, M. and Ortiz de Urbina,and J. M. 2012. Marine mammal bycatch in Spanish Mediterranean large pelagic longline fisheries, with a focus on Risso's dolplhin (Grampus griseus). Aquatic Living Resources, 25: 321–331.

Mancusi, C., Clò, S., Affronte, M., Bradaï, M.N., Hemida, F., Serena, F., Soldo, A. and Vacchi, M. 2005. On the presence of basking shark (Cetorhinus maximus) in the Mediterranean Sea. Cybium, 29(4): 399–405.

Scacco, U., Consalvo, I., DiMuccio, S. and Tunesi, L. 2012. On the by-catch of two porbeagle sharks Lamna nasus in the central Adriatic Sea. Marine Biodiversity Records, page 1 of 5. Vol. 5; e61.

Silvani, L., Gazo, M., and Aguilar, A. 1999. Spanish driftnet fishing and incidental catches in the western Mediterranean. Biological Conservation, 90: 79–85.

Storai, T., Zinzula, L., Repetto, S., Zuffa, M., Morgan, A., and Mandelman, J. 2011. Bycatch of large elasmobranchs in the traditional tuna traps (tonnare) of Sardinia from 1990 to 2009. Fisheries Research, 109: 74–79.

Tudela, S., Kai Kai, A., Maynou, F., El Andalossi, M., and Guglielmi, P. 2005. Driftnet fishing and biodiversity conservation: the case study of the large-scale Moroccan driftnet fleet operating in the Alboran Sea (SW Mediterranean). Biological Conservation 121: 65–78.

Ungaro, N., Marano, G., De Zio, V., Pastorelli, A. M., and Rositani, L. 2005 Some information on offshore bottom longline fishery in the southern Adriatic Sea (GFCM Geographical Sub-Area 18). FAO-AdriaMed Technical Documents n°15 98-102.

Werner, T. B., Northridge, S., McClellan Press, K. and Young, N. 2015. Mitigating bycatch and depredation of marine mammals in longline fisheries. ICES Journal of Marine Science, 72(5), 1576–1586. doi:10.1093/icesjms/fsv092.