J. Black Sea/Mediterranean Environment
Vol. 26, No. 1: 59-83 (2020)

RESEARCH ARTICLE

Sea turtles and sharks bycatch in Greece: Fishers' and stakeholders' knowledge

Eleana Touloupaki[1], Nikolaos Doumpas[2], Dimitrios Bouziotis[1], Vicky Rae[1], Dimitrios K. Moutopoulos[3], Ioannis Giovos[2*]

[1] MEDASSET-Mediterranean Association to Save the Sea Turtles, Athens, GREECE
[2] iSea, Environmental Organisation for the Preservation of the Aquatic Systems, Thessaloniki, GREECE
[3] Department of Animal Production, Fisheries & Aquaculture, University of Patras, Mesolonghi, GREECE

ORCID IDs: E.T. 0000-0002-4020-4900; N.D. 0000-0002-6713-325X; D.B. 0000-0002-9250-2133; V.R. 0000-0002-6248-1749; D.K.M. 0000-0001-5873-9893; I.G. 0000-0001-5733-0092

***Corresponding author:** ioannis.giovos@isea.com.gr

Abstract

One of the biggest threats facing vulnerable marine megafauna is their interaction with fisheries. Numerous studies have typically been confined to single taxa, however, the risk applies mutually to the majority of vulnerable marine megafauna. Using a bottom-up approach to utilize fishers and fisheries stakeholders' knowledge and perceptions of incidental capture for two vulnerable megafauna taxa, sea turtles and sharks, five important ports of Greece accounting 65% of the country's fishing fleet were surveyed. All respondents interacted with at least one of the megafauna species (dolphins, monk seals, sea turtles, elasmobranchs and sea birds), declared that they commonly bycatch them and were well-aware only of sea turtles conservation, knowledge and handling releasing techniques as opposed to sharks. The statements provided by the administration authorities revealed that a great number of employees were familiar with the species under protection, the biodiversity sustainability and the in-force legislation, whereas a vast majority of them were not aware of bycatch incidents, a fact that strongly indicated the lack of mutual communication among professionals and stakeholders.

Keywords: Marine megafauna, fisheries interaction, Mediterranean

Received: 07.02.2020, **Accepted:** 12.04.2020

Introduction

Greek seas serve as a biodiversity hotspot inhabited by a significant number of megafauna species such as sea turtles, sharks, rays, marine mammals, seabirds and others (Coll *et al*. 2011). About 36 species of sharks and the three species of

sea turtles are found within the Greek Exclusive Economic Zone (Casale and Margaritoulis 2010; Papaconstantinou 2014). The Mediterranean subpopulation of loggerhead sea turtle (*Caretta caretta*) (Wallace *et al*. 2010) is listed as Least Concern with the emphasis as 'Conservation Dependent' from the revised status of Vulnerable after successful conservation programs (Casale *et al.* 2018) and the green sea turtle (*Chelonia mydas*) is listed as Endangered and the leatherback sea turtle (*Dermochelys coriacea*) as Vulnerable. Greek waters also host the largest breeding population of *C. caretta* (Linnaeus, 1758) that is protected by the EU Habitats Directive, with over 60% of all nesting occurring in Greece (Margaritoulis 2005). The majority of the Mediterranean population of shark species are listed as threatened in the IUCN Red List of Threatened Species (Dulvy *et al*. 2016), but our knowledge regarding their distribution within Greek waters is scarce, with some areas, like the northern Aegean, central Ionian, Cretan, and Levantine Seas, identified as potentially important areas for some species (Megalofonou *et al*. 2009; Damalas and Megalofonou 2010; Maravelias *et al*. 2012; Tserpes *et al*. 2013).

Among different anthropogenic threats that affect sharks and sea turtles, the issue of incidental capture (referred to in this paper as bycatch) of the non-target and non-retained species is classified as one of the most critical (sea turtles: Lucchetti and Sala 2010; sharks: Dulvy *et al*. 2016). The issue is particularly important for the Mediterranean fisheries that are characterized as highly complex, due to a wide variety of fishing techniques targeting a diversity of species in variable fishing grounds (Moutopoulos *et al*. 2013 and references within). Although conservation measures apply for all three sea turtle species (Mazaris *et al.* 2009) and 20 out of the 36 species of sharks (Giovos *et al*. 2019 and references within), information on the bycatch rates and the frequency of this interaction with fisheries needs to be addressed (Casale 2015). The problem for setting a reliable threshold on sharks and sea turtles bycatch is getting more complex when considering it at the European level, as all bycatch estimates derive from the Data Collection Framework monitoring programs. These are under-estimated biased data (ICES 2018) because they are collected through scientific surveys focused on sampling with special demersal towed fishing gears (i.e., trawls and purse seines) and therefore, they do not include estimates for the small scale fishing fleet, which is the largest in the Mediterranean (CFR 2018). Moreover, the Data Collection Framework monitoring programs fall under the Common Fisheries Policy of the European Commission paying significant attention to the data collection on the commercial fish stocks rather than the species protected under the Environmental European Legislation (Council Directive 92/43/EEC) and other international conventions like CITES and the Barcelona Convention.

To fill in knowledge gaps regarding bycatch of sea turtles and sharks with a multi-taxa/gear approach, the present study was designed with a bottom-up approach making it the first effort in the Mediterranean Sea. Fishers' and

stakeholders' awareness of conservation issues is of vital importance for fishery-dependent area communities, such as most of the Greek ones (Tzanatos *et al*. 2005) and might have a positive domino effect among the above-mentioned users' towards sustainability. Thus, we tried to define the degree of interaction between fishing activities and the marine megafauna, while we further investigated the opinion of the fishers and stakeholders on major problems they faced from this interaction with the species studied.

Within this context, relevant studies on sea turtle bycatch quantification were conducted for the major fisheries operating in the Mediterranean; bottom trawlers (Margaritoulis and Arapis 1990; Margaritoulis *et al*. 1992), surface longlines (Laurent *et al*. 2001; Panou *et al*. 1992, 1999) and gillnets (Suggett and Houghton 1998) and for all fishing gear combined (Lucchetti and Sala 2010). Concerning sharks, bycatch studies were conducted for bottom trawlers (Damalas and Vasilopoulou 2011; Tsagarakis *et al*. 2018) and on surface longlines (Megalofonou *et al*., 2009; Damalas and Megalofonou 2010).

Unreliable catch data, such as the unreported and underestimated quantities for sharks (Cashion *et al*. 2019) and biased fishing mortality estimates pose difficulties in evaluating the fishing pressure on these groups. Hence, unconventional sources of information, such as Fishers' Local Ecological Knowledge (FLEK) are increasingly being used to enhance our baseline knowledge (Eckert *et al*. 2018; Giovos *et al*. 2019). Despite its potential biases (Thurstan *et al*. 2016), FLEK represents a lifetime of accumulated ecological observations and it can be an effective tool for understanding the interaction of fisheries with marine fauna by setting a basis for future conservation actions. Up to date, several studies utilized FLEK for investigating the interaction between fisheries and marine megafauna (e.g. Moore *et al*. 2010; Gonzalvo *et al*. 2015; Panagopoulou *et al*. 2017; Ayala *et al*. 2018). This information should enable fisheries managers to identify fishing types that require further monitoring and those where mitigation measures are most urgently required.

In this work, we aim at collecting baseline information regarding sea turtle and shark bycatch in Greece, focusing our efforts in five ports where the majority of the landings exist. Hence, the main goal of this study is to quantify the impact of the fishery on vulnerable shark and sea turtle species, for which very little information has been available to date, using local fishers knowledge. Our work aims to steer future efforts that aim to mitigate the issue of bycatch within the Greek waters.

Materials and Methods

Study area

In situ information was collected at the fishing ports of Alexandroupoli, Kavala, Michaniona, Piraeus and Patra (Figure 1), which combined account for 6% of the total Greek fishing fleet reported in the Common Fisheries Register (CFR

2018), but for almost 65% of the total Greek fisheries landings (Hellenic Statistical Authority-HELSTAT 2018). According to the 2018 records, the small-scale fishery represents the vast majority of the professional fishing vessels (almost 85% of the total Greek fleet), followed by trawlers and purse seiners (8.3% and 5.8%, respectively) and beach seiners (less than 1%). CFR is the official record of all community fishing vessels based on the national registers of the EC Member States since 1991 (EC 1998).

Figure 1. Five ports visited for the study in Greece

Surveys

An on-the-spot questionnaire survey was conducted by two independent researchers from 21 May to 1 June 2018 among professional fishers in the aforementioned ports (Figure 1). Given the large size of the questionnaire (63 questions) and to avoid brief and/or unrealistic answers, the fishers were surveyed around their mooring/landing sites, once returning from the sea to mend their nets. This assisted to create a relaxed atmosphere and increased their confidence (Gonzalvo *et al*. 2015). Fishers that were in a hurry (for example to transfer their catch to market) were avoided (Snape 2017). An attempt was made to include fishers of all age groups and from all types of fishing vessels. Before visiting the ports, the local fishing cooperatives were informed and were asked to reinforce their members to participate in the study. To avoid biases resulting from different presentations of the questionnaire, researchers were provided with instructions on how to approach the fishers and conduct the surveys. Questionnaires were carried in one-to-one sessions, for preventing influences by others, especially by the fisher's colleagues. To avoid pseudoreplication, the responders were exclusively owners of fishing vessels or

captains and no more than one questionnaire per fishing vessel took place. Researchers surveyed fishers using a tablet to record their responses, to test the practicality of this tool for collecting data for port-questionnaires.

An additional questionnaire survey was conducted from 6 June to 6 July 2018 among relevant fisheries authorities. The survey was disseminated via e-mail to the Directorate General of Fisheries of the Greek Ministry, and the Fisheries Departments of the Regions, the Port Authorities of the five ports and neighboring port authorities.

Questionnaires

To make a customized collection of information aimed at a holistic approach to the problem, two questionnaires were prepared, one distributed to professional fishers (Questionnaire for Fishers; Appendix 1) and one to control authorities (Questionnaire for Authorities). The first was developed based on Snape (2017) and Gonzalvo *et al*. (2015) and included a total of 63 questions, which consisted of closed-ended dichotomous; Yes-No, Positive-Negative, Opinion-Calibration Questions, Ranking (Priority 1 to 5) and Multiple-Choice Questions. Included was an effort to estimate the seasonality of incidental capture of sea turtles and sharks concerning the seasonality of fishing effort (months that fishers are active). The questionnaire was divided into three parts. Part 1 focused on demographic features, vessel technical characteristics and applied fishing strategies, including a map for indicating the main fishing grounds. Part 2 focused on incidental captures of both taxa, including handling methods on ST (Part 2a) and on sharks (Part 2b), in which additional questions relating to the individual taxa were asked, for sea turtle mitigation measures and the shark economic value. Part 3 focused on collecting information for other vulnerable marine megafauna that possibly interact with them. Lastly, an open field question was also included for the researchers conducting the surveys regarding qualitative information on issues such as the fisher's attitude, reliability of their responses and if the fishers mentioned other important information regarding the two taxa.

The Questionnaire for Authorities focuses on whether authorities' staff are aware of the legal framework for protecting the two taxonomic groups, if they receive reports and updates of incidental catches and if they are willing to cooperate with environmental NGOs to achieve as much as possible integrated protection for sea turtles and sharks. Initially, the contact department was asked to provide basic contact information, as well as whether it has previously participated in other related surveys. The main body of the questionnaire was divided into two parts. Part 1 explored the knowledge of the protection status for the two taxonomic groups with closed-ended questions (YES-NO). Part 2 with closed-ended questions (YES-NO) on whether and how fisheries affect the endangered species of the two taxonomic groups.

Data analysis

Descriptive statistics (i.e., estimation of means and standard deviations) and frequency of occurrence (%) was applied to all statements. The non-parametric chi-square test (χ^2-test) was used to examine whether there is a possible association and if so the degree of association between each of the participants' demographic characteristics (i.e., age, years of experience, education level). We chose this test among others (logit relation) because we aimed to describe the strength of a relationship between a categorical variable and demographic features and not to model the determinants of and predict the likelihood of an outcome (Zar 1999). All statistical analyses were carried out using the statistical package IBM SPSS statistics v 24.0.

Results

Concerning the Questionnaire for Authorities that were sent electronically, eight authorities responded positively, specifically, the port authorities of Kavala, Alexandroupoli and Patras. The contribution of the Port Authority of Corinth due to the utmost importance of the Corinthian Gulf is considered to be very positive. Other responses were also received by, the Directorate of the Attica Region, the Department of Fisheries of the Region of Kavala, the Department of Fisheries of the Region of Western Greece and the Directorate General of Fisheries of the Greek Ministry.

Concerning the Questionnaire for fishers, five ports were visited (Figure 1) 56 questionnaires were filled and approximately 5% of the total number of registered vessels was sampled, dependent on the port and fishing gear. Table 1 showed the demographic features of the surveyed fishers (age and years of experience) and the length of their vessels. In fact, most of the fishers exhibited a systematic fishing activity with more than 16 fishing days per month (Table 1) independently of the fishing gear they use. The majority of the stakeholders (62.5% and 87.5%) stated that they did not receive any incidental capture reports of sea turtles and sharks, respectively, although they are aware that sea turtle strandings should be reported to them. They were also aware that sea turtles and sharks are incidentally caught in the fishing gear and they acknowledged the releasing techniques legislation and which bodies to contact in this event.

The majority of the surveyed fishers (65%) stated that they had at least one sea turtle incidental capture and/or shark species during the last year (Figure 2A), declaring for the latter that they do not target sharks. Netters (GNS= Set Gillnets (anchored), GTN= Combined gillnets-trammel nets, GTR= Trammel nets) and bottom trawlers (OTB) mostly interacted with sea turtles (Figure 2B), whereas for sharks, the responses were more diverse, which is indicative to the great variety of species of this taxon, exhibiting different life history, biological and ecological strategy. Responses for what action fishers take if they incidentally caught a shark revealed that 80% of bottom trawlers market shark

individuals as opposed to releasing (20%), followed by longliners (50% are marketing sharks and 50% are releasing them, depending on the species). Most of the fishers using nets stated that they sold sharks (42%), whereas the rest of them are disposing of them because there is no market value (31%), or they self-consume shark captures (15%), with only 12% releasing them. All of the fishers using purse seines (100%) stated that they were releasing sharks. Independently from the gear used, all fishers also stated that the economic efficiency from shark fishing is minor. Seasonally, fishers stated that the highest frequency of sea turtle bycatch is from April to August, whereas for sharks from March to August (Figure 2C), with responses not significantly (χ^2-test; df50; P>0.05) varying between fishing gears. To gain insight into shark and sea turtle historical bycatch rate the fishers experience was utilized, given their relatively larger age and high experience (Table 1) and were asked if they perceived that their bycatch rates for each taxa is higher now than in the past. All of the fishers stated that they were catching fewer sharks now than in the past, with the majority of them stating the same for sea turtle bycatch (90.1%).

Table 1. Demographic features and fleet characteristics based on the 56 questionnaires collected from the five studied ports (see Figure 1)

Ports	**Average age (years)**	**Average experience (years)**	**Average vessel size (m)**	**Number of monthly fishing days**
Alexandroupoli	52.8	30.9	14.3	11-15 (32%)/ 16-20 (26%)
Kavala	50.4	25.3	8.0	21-25 (50%)/ 16-20 (36%)
Nea Michaniona (Thessaloniki)	53.2	34.3	21.2	21-25 (50%)/ 11-20 (35%)
Piraeus	53.0	28.3	18.5	26-30 (100%)
Patra	48.5	22.8	18.0	26-30 (75%)/ 21-25 (25%)
Total	**51.6**	**28.3**	**13.1**	

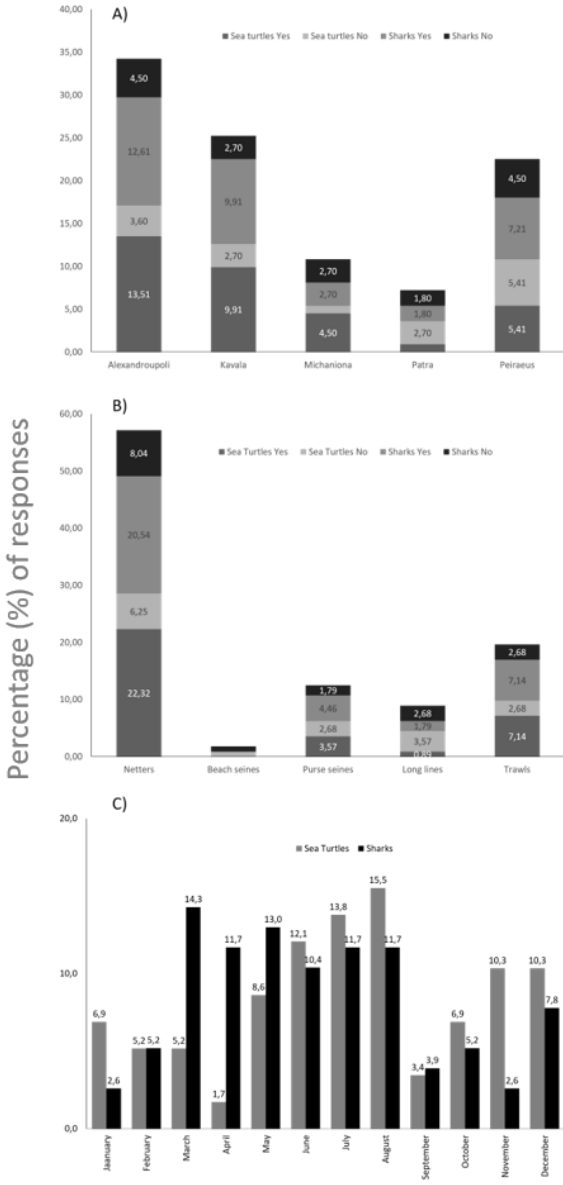

Figure 2. Percentage of responses to the questionnaire survey
(In all cases, values below 1 are not visible.)
(A) the annual incidental captures of sea turtles and shark species per port (Yes= yes the fisher had an incidental capture; No=no the fisher did not experience any incidental capture), (B) the annual incidental captures of sea turtle and shark species per fishing equipment (Yes= yes the fisher had an incidental capture; No=no the fisher did not experience any incidental capture), (C) seasonality of the interaction.

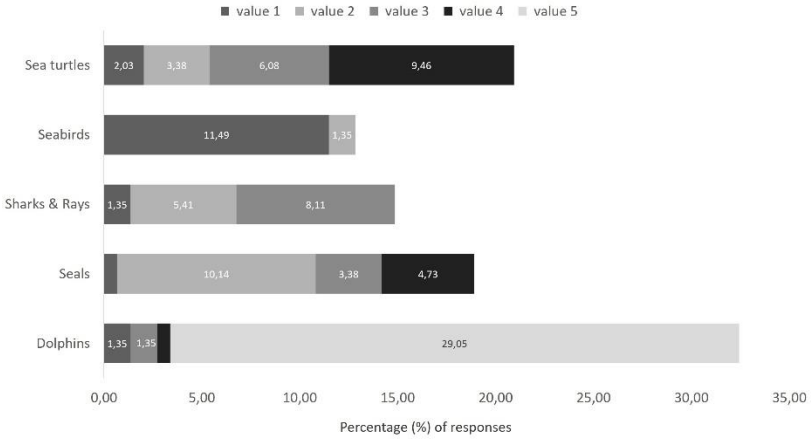

Figure 3. The most detrimental marine animal as stated by the fishers. The question was based on a 5 level Likert scale (value 1=completely no detrimental-value 5= very detrimental). In all cases, values below 1 are not visible.

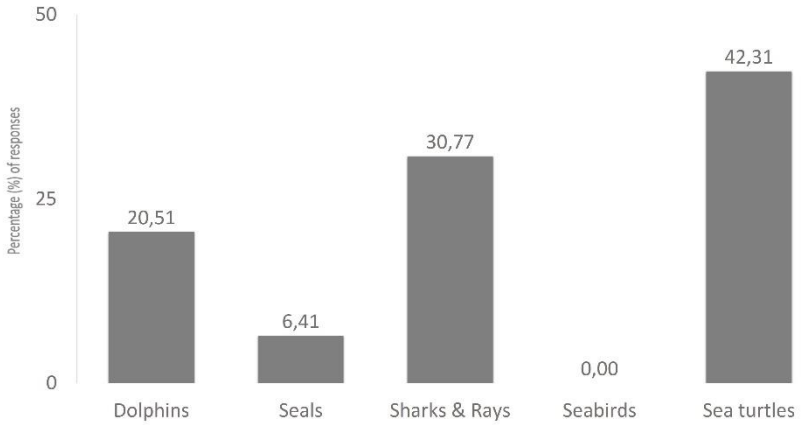

Figure 4. The most frequently entangled marine animal based on the responses of the fishers

Despite the limited number of interviews, a relatively good number of fishers from all different fishing techniques was interviewed (Table 2). For sharks, the vast majority of the fishers in all ports stated that they were not aware of releasing techniques (in all cases >70%) independently of the port. Spatially, when fishers were asked if they are willing to learn releasing techniques, fishers from Piraeus and Patra responded at 100% and in Alexandroupoli at 65% responded positively, while in Michaniona all fishers and in Kavala 64.7% did not want to learn releasing techniques. The percentages were similar for sea turtles (Piraeus 100%, Alexandroupoli 63% wanted to ascertain new techniques,

while in Michaniona only 20% and in Kavala 29%). For sea turtles, fishers were asked if they were willing to modify their equipment for reducing the incidental captures, with most of them from the ports of Piraeus (100%) and Michaniona (50%) responding positively, whereas fewer positive responses were received from fishers of Kavala and Alexandroupoli (17% and 29%, respectively). From those providing a negative response for modifying the equipment, the vast majority of them did not perceive bycatch to be an issue for sea turtles; 'There are too many [sea turtles]'; [They are] no longer caught'; '[They are] rarely caught'. Moreover, a high number of fishers (67%) failed to recognize, with the aid of a guide, all the protected species of sharks based on the national and international legislation applied in Greece.

Table 2. Number of sea turtles (ST) and shark (SK) bycaught per year per fishing gear based on the responses of the fishers
(GNS= Set gillnets (anchored), GTN= Combined gillnets-trammel nets, GTR= Trammel nets, PS=Purse seines, LL=Longlines, OTB= Bottom trawlers)

Sea Turtles		**Sharks**	
GNS, GTN		**GNS, GTN**	
0	28.6%	0	31.0%
1-5	67.8%	1-5	37.6%
6-10	3.6%	6-10	5.3%
>10	0.0%	>10	26.1%
PS		**PS**	
0	0.0%	0	0.0%
1-5	100.0%	1-5	100.0%
6-10	0.0%	6-10	0.0%
>10	0.0%	>10	0.0%
LL		**LL**	
0	33.3%	0	0.0%
1-5	66.7%	1-5	100.0%
6-10	0.0%	6-10	0.0%
>10	0.0%	>10	0.0%
OTB		**OTB**	
0	12.5%	0	0.0%
1-5	62.5%	1-5	85.7%
6-10	12.5%	6-10	0.0%
>10	12.5%	>10	14.3

Concerning other vulnerable megafauna taxa, fishers reported dolphins as causing the highest economic damage to fishing gears followed by sea turtles, monk seals, elasmobranchs and sea birds (Figure 3). Of these taxa, the most frequently entangled marine megafauna animal (stated by almost half of the fishers participating in the survey) was sea turtles, followed by elasmobranchs (batoids), dolphins, and seals (Figure 4).

Finally, the willingness of the fishers to participate in future projects for mitigating the issue of bycatch was investigated. For this, fishers were asked if in the past they had participated in any fisheries and/or conservation project(s). In Alexandroupoli, Michaniona and Kavala, the majority of the fishers declared that they had participated (75%, 60% and 35.3%, respectively), while in Piraeus 64.7% and in Patra 50% of the fishers stated that they had never participated in similar projects. Subsequently, fishers were asked if they are aware of safe releasing techniques for sea turtles and sharks, with fishers from Michaniona, Kavala and Alexandroupoli stating they were aware (75%, 81.3%, and 63.3%, respectively), in Piraeus only 7.7% and in Patra 75%.

Discussion

Reliable fisheries data are of high importance for fishery management, which gradually incorporates across years a multi-disciplinary range of information, such as the monitoring of marine protected species and the degree of interaction between fishers and marine fauna. The quantification of this interaction is of high importance for the successful implementation of protection and conservation measures. In this framework, the use of unconventional sources of information, in cases where the official statistics and national monitoring system are absent or lack efficiency, sheds light on important issues of the management of protected species and enable us to set a baseline to target future research and conservation priorities. This is the first study that provided quantification on the incidental capture of charismatic megafauna species with a special focus on sea turtles and sharks in the Greek waters to trigger a more integrating actions. For enhancing the validity of the results, key respondents were chosen for their high level of experience, being entirely dependent on fishing and exclusively operating within the study areas.

It is important to note that fishers were well-aware of sea turtle conservation, knowledge and handling/releasing techniques as opposed to sharks. This can be partly explained by the fact that the former consists of fewer species within the taxa and that the Greek coastline has been long recognized for its importance for the flagship species *C. caretta*. As a result, conservation campaigns and actions have been implemented over decades and highly successful in presenting sea turtle issues related to marine conservation (Liordos *et al*. 2017). Although a small minority of the respondents expressed their dissatisfaction when these species were entangled in their fishing gear, (second most frequently caught after dolphins), fishers positively reacted to the training of release techniques, despite that half of them stated that are aware of such techniques.

Of particular interest is the response of fishers to the question regarding the frequency of a gear in which they accidentally caught sea turtles. Based on earlier studies in the Greek waters (mostly in the Ionian Sea: Teneketzis *et al*. 2003), the most common fishing gear that incidentally captures sea turtles was

reported as small scale gears (nets: 42%; and surface longlines: from 0.5% to 16%: Kapantagakis and Lioudakis 2001), followed by beach seines (34%) and trawlers (21%). In contrast to the present study, surface longlines did not show similar high rates of sea turtle bycatch. Another issue that increases the uncertainty of sea turtle bycatch estimation is that reasons against implementing a modification to their gear to reduce sea turtle bycatch were presented as '*rarely caught'* or '*no longer caught'*. This indicates that even though fishers incidentally catch sea turtles, they do not perceive it as an issue, as the occurrence is not very high per fisher. For any further research, fishers must be included in the process, not only in the data collection process but the feedback with the results and conclusions. This can provide fishers with a comprehensive overview of the entire issue and assist in fostering more positive responses to any conservation measures proposed.

Regarding bycatch of sharks, it is evident that a shark fishery does not exist in the study area and that sharks are valuable bycatch and/or discarded in large proportions, with landings mostly derive from bottom trawlers (Damalas and Vasilopoulou 2011) and drifting longlines (Megalofonou *et al*. 2009; Damalas and Megalofonou 2010). Yet studies on net fishing are scarce and no estimation or quantification can be made. In contradiction, about 1/3 of the total Greek sharks' landings are caught in the studied areas (i.e., Alexandroupoli and Kavala; Thessaloniki; Piraeus; and Patra), according to the reports from HELSTAT, from bottom trawlers, purse seiners and small-scales (HELSTAT 2018). This is likely attributed to the fact that HELSTAT does not directly monitor fisheries landings, but is based on a register of fishing vessels for estimating the total landings data per subarea from the landings data of the expected mean annual landings per each fishing vessel (Moutopoulos and Koutsikopoulos 2014). However, it has been shown that HELSTAT numbers of purse seines and small-scale vessels were significantly different when compared with the ones reported in Common Fisheries Register (Moutopoulos and Koutsikopoulos 2014). These misreporting estimates can potentially be caused by the multiple licensing systems allowing fishers to overcome the temporal and/or local (i.e. especially in enclosed gulfs) closures (Moutopoulos *et al*. 2016).

During the survey it was revealed that there was confusion between researchers and fishers of the term "shark" (in Greek "Karcharias"). According to fishers this term was related only to big sharks like *Alopias vulpinus* (Bonnaterre, 1788) and *Cetorhinus maximus* (Gunnerus, 1765), while for the small-size species like *Scyliorhinus canicula* (Linnaeus, 1758) and *Mustelus mustelus* (Linnaeus, 1758) fishers use the term "dogfish" (in Greek "Skilopsaro"). Additionally, the term "Galeos", which according to the Ministerial Decision No 1750/32219/2015 (about the Union's provisions about Common Market Organisation of fisheries' and aquaculture's products and Community Fishery Control System) refers to *Mustelus* sp., in retailers genuinely refers to all shark species (Giovos *et al*.

2020). Both *S. canicula* and *M. mustelus* are commonly caught and sold in all local markets of northern Greece (Giovos *et al*. 2019, 2020) and therefore fishers do not consider them as bycatch, explaining the low numbers in the bycatch rate they declared (Table 2). The low bycatch rates declared seem highly unlikely to be accurate due to the fact that Northern Aegean Sea, where the majority of the respondents were derived, is a hotspot for several elasmobranch species (Maravelias *et al*. 2012; Tserpes *et al*. 2013).

Questionnaires also revealed a lack of knowledge regarding the applied legislation for the protection of sharks. The in-force legislation is highly complicated creating confusion both to the fishers and the competent authorities (Moutopoulos *et al*. 2016), resulting in erroneous mislabeling in some cases of protected species (Giovos *et al*. 2019). This might be an additional reason why fishers might have been hesitant in providing more accurate numbers regarding the bycatch rate of sharks. In this context, the statements provided by the administration authorities showed that a great number of stakeholders were familiar with the species under protection, biodiversity sustainability, and the in-force legislation. The most revealing issue, in contrarily, was that a vast majority of them stated that they were not aware of bycatch incidents for both studied species, a fact that strongly hightlighted the lack of mutual communication among fishers, administration, researchers and control authorities that highlight a lack of participatory management.

Potentially augmenting this issue, the lack of expertise by the patrol authorities (Port Police, Hellenic Coastguard) and the training and awareness of the professional fishers to enforce and abide by the current legislation regarding marine protected species are a tough reality. A promising sign could be the fact that the patrol authorities were gradually becoming accustomed to the new regulations and the pressure forced by the interested public on issues related to the protection of threatened species (Moutopoulos *et al*. 2016). In this context, more emphasis should be given to the role of control and implementation of protection policies for threatened species. The social part and the involvement of the fishing community in management strategies for traditional fisheries (for review see: Pomeroy 2016) must be also incorporated. Appropriate rewarding schemes for those fishers incorporating mitigation devices may stimulate other professionals towards the reduction of the amount of bycatch. Surveillance would be enforced to avoid landings of unmonitored bycatch. According to the EU policy, fishers are the guardians of the Sea that can offer valuable insights, important for fisheries and ecosystems management (Stephenson *et al*. 2016). The contribution of fishers to better understand the issue bycatch is one of the most persistent issues of the oceans, especially for megafauna species like sharks and sea turtles (Lewinson *et al*. 2004). By understanding the fishers' perceptions future management steps can be better designed as this influences their sustainable fishing practices (Karnad *et al.* 2013) and their willingness to implement and comply with mitigation measures.

The results of the present study should be interpreted with caution taking into consideration of certain limitations. The sampled number is small compared with the spatial expansion of the study and the multi-gear context of the fisheries. Nevertheless, the present study is the first providing information about fisheries typology of interactions between fishing activities and top predators and dealing with the sustainability of top marine megafauna and the incidental capture in fishing gears. The species implicated per métier were also not, on purpose, presented, although provided by the fishers, due to a large number of species, the fact that several species are very similar and impossible for fishers to distinguish them. Further research should be also carried out to reinforce our findings and to clarify issues that are critical in identifying the actual perceptions of species bycatch.

It is worth noting that all interviewed fishers stated that they interact with at least one of the following megafauna species (dolphins, monk seals, sea turtles, elasmobranchs and sea birds) and commonly bycatch them. Determining potential hotspot areas for sea turtles and sharks distribution and combining these results with available data on other anthropogenic activities (i.e., tourism, shipping) might pinpoint areas with a high risk of conflict and could place bycatch effect into an ecosystem perspective.

Acknowledgements

We would like to thank the Green Fund for funding and supporting the project "Fishers, Sea turtles and Sharks: Alliance for Survival" under the Programme "Natural Environment and Innovative Actions", Strand "Natural Environment Management Actions", Measure "Innovative Actions with Citizens". In addition, we would like to warmly thank all the fishers and authorities that contributed meaningfully for this work and shared with us all their experience.

References

Ayala, L., Ortiz, M., Gelcich, S. (2018) Exploring the role of fishermen' knowledge in assessing marine megafauna bycatch: insights from the Peruvian longline artisanal fishery. *Anim Conserv* 22(3): 251-261.

Casale, P. (2015) *Caretta caretta* (Mediterranean subpopulation). The IUCN Red List of Threatened Species 2015: e.T83644804A83646294. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T83644804A83646294.en.

Casale, P., Broderick, A.C., Camiñas, J.A., Cardona, L., Carreras, C., Demetropoulos, A., Fuller, W.J., Godley, B.J., Hochscheid, S., Kaska, Y., Lazar, B., Margaritoulis, D., Panagopoulou, A., Rees, A.F., Tomás, J., Türkozan, O. (2018) Mediterranean Sea turtles: current knowledge and priorities for conservation and research. *Endanger Species Res* 36: 229-267.

Casale, P., Margaritoulis, D. (2010) Sea Turtles in the Mediterranean: Distribution, Threats and Conservation Priorities. Gland, Switzerland: IUCN. p. 85.

Cashion, M.S., Bailly, N., Pauly, D. (2019) Official catch data underrepresent shark and ray taxa caught in Mediterranean and Black Sea fisheries. *Mar Pol* 105: 1-9.

CFR (2018) European Commission, Common Fisheries Policy 2018.

Coll, M., Piroddi, C., Albouy, C., Ben Rais Lasram, F., Cheung, W. W. L., Christensen, V., Pauly, D. (2011) The Mediterranean Sea under siege: spatial overlap between marine biodiversity, cumulative threats and marine reserves. *Global Ecol Biogeogr* 21(4): 465-480.

Damalas, D., Megalofonou, P. (2010) Environmental effects on blue shark (*Prionace glauca*) and oilfish (*Ruvettus pretiosus*) distribution based on fishery-dependent data from the eastern Mediterranean Sea. *J Mar Biol Assoc UK* 90(03): 467.

Damalas, D., Vassilopoulou, V. (2011) Chondrichthyan bycatch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). *Fish Res* 108(1): 142–152.

Dulvy, N.K., Allen, D.J., Ralph, G.M., Walls, R.H.L. (2016) The Conservation Status of Sharks, Rays and Chimaeras in the Mediterranean Sea [Brochure]. IUCN, Malaga, Spain.

Eckert, L.E., Ban, N.C., Frid, A., McGeer, M. (2018) Diving back in time: extending historical baselines for yelloweye rockfish with Indigenous knowledge. *Aquat Conserv* 28(1): 158-166.

HELSTAT (2018) Hellenic Statistical Authority (HELSTAT). Results of the sea fishery survey by motor boats (for the years 1982-2017). Athens, Greece: Hellenic Statistical Authority of Greece, 1965–2018.

Giovos, I., Arculeo, M., Doumpas, N., Katsada, D., Mitsou, E., Aga-Spyridopoulou, R.N., Stoilas, V.-O., Tiralongo, F., Tsamadias, I., Vecchioni, L., Moutopoulos, D.K. (2020) Assessing miltiple sources of data to detect illegal fishing, trade and misladelling of elasmobranchs in Greek markets. *Mar Pol* 112: 103730.

Giovos, I., Stoilas, V.S., Al Mabruk, S.A.A., Doumpas, N., Marakis, P., Maximiadi, M., Moutopoulos, M., Kleitou, P., Tiralongo, F., de Maddalena, A. (2019) Integrating local ecological knowledge, citizen science and long-term

historical data for endangered species conservation: New records of Angel Sharks (Chondrichthyes: Squatinidae) in the Mediterranean Sea. *Aquat Conserv* 29(6): 881-890.

Gonzalvo, J., Giovos, I., Moutopoulos, D.K. (2015) Fishermen's perception on the sustainability of small-scale fisheries and dolphin–fisheries interactions in two increasingly fragile coastal ecosystems in western Greece. *Aquat Conserv* 25: 91-106.

ICES (2018) Report from the Working Group on Bycatch and Protected Species (WGBYC), 1-4 May 2018, Reykjavik, Iceland. ICES CM 2018/ACOM: 25, 128 pp.

Kapantagakis, A., Lioudakis, L. (2001) Estimation of marine turtle bycatch in the long line fishery. Proceedings of 10th Panhellenic Conference of Ichthyologists.

Karnad, D., Ganagal, M., Karanth, K.K. (2013) Perceptions matter: how fishermen's perceptions affect trends of suatainability in Indian fisheries. Fauna & Flora International. *Oryx* 48(2): 218-227.

Laurent, L., Camiñas, J.A., Casale, P., Deflorio, M., De Metrio, G., Kapantagakis, A., Margaritoulis, D., Politou, C.Y., Valeiras, J. (2001) Assessing marine turtle bycatch in European drifting longline and trawl fisheries for identifying fishing regulations. Project-EC-DG Fisheries 98-008, Final Report. Joint project of BIOinsight, IEO, IMBC STPS and University of Bari. Villeurbanne, France. 267.

Lewison, R.L., Crowder, L.B., Read, A.J., Freeman, S.A. (2004) Understanding impacts of fisheries bycatch on marine megafauna. *Trends Ecol Evol*, 19(11): 598-604.

Liordos, V., Knotsiotis, V.J., Anastasiadou, M., Karavasias, E. (2017) Effects of attitudes and demography on public support for endangered species conservation. *Sci Total Environ* 595: 25-34.

Lucchetti, A., Sala, A. (2010) An overview of loggerhead sea turtle (*Caretta caretta*) bycatch and technical mitigation measures in the Mediterranean Sea. *Rev Fish Biol Fisher* 20: 141-161.

Maravelias, C.D., Tserpes, G., Pantazi, M., Peristeraki, P. (2012) Habitat selection and temporal abundance fluctuations of demersal cartilaginous species in the Aegean Sea (eastern Mediterranean). *PLoS ONE* 7(4): e35474.

Margaritoulis, D. (2005) Nesting activity and reproductive output of loggerhead sea turtles, *Caretta caretta*, over 19 seasons (1984 – 2002) at Laganas Bay, Zakynthos, Greece: The largest rookery in the Mediterranean. *Chelonian Conserv Biol* 4(4): 916-929.

Margaritoulis, D., Arapis, T. (1990) Monitoring and Conservation of the Loggerhead ST *Caretta caretta* in Greece. Final report to WWF on project 3825. Athens, ST Protection Society of Greece.

Margaritoulis, D., Kousias, N., Nicolopoulou, G., Teneketzis, K. (1992) Incidental catch of ST in Greece: the case of Lakonikos Bay. Proc. Eleventh Annual Workshop on ST Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-302, pp. 168-170.

Mazaris, A.D., Kramer-Schadt S., Tzanopoulos, J., Johst, K., Matsinos, Y.G., Pantis, J.D. (2009) Assessing the relative importance of conservation measures applied on sea turtles: Comparison of measures focusing on nesting success and hatching recruitment success. *Amphibia-Reptilia* 30(2): 221-231.

Megalofonou, P., Damalas, D., Deflorio, M., De Metrio, G. (2009) Modeling environmental, spatial, temporal, and operational effects on blue shark bycatches in the Mediterranean long-line fishery. *J Appl Ichthyol* 25: 47-55.

Moore, J.E., Cox, T.M., Lewison, R.L., Read, A.J., Bjorkland, R., McDonald, S.L., Kiszka, J. (2010) An interview-based approach to assess marine mammal and ST captures in artisanal fisheries. *Biol Conserv* 143(3): 795-805.

Moutopoulos, D.K., Koutsikopoulos, C. (2014). Fishing strange data in national fisheries statistics of Greece. *Mar Pol* 28: 114-122.

Moutopoulos, D.K., Libralato, S., Solidoro, C., Stergiou, K.I. (2013) Toward an ecosystem approach to fisheries in the Mediterranean Sea: Multi-gear/multi-species implications from an ecosystem model of the Greek Ionian Sea. *J Mar Syst* 113-114: 13-28.

Moutopoulos, D.K., Prodromitis, G., Mantzouni, I., Koutsikopoulos, C. (2016) Quantifying the implementation of common fisheries policy: patterns of fisheries violations and penalties imposed in Greek waters. *Mar Pol* 70: 65-76.

Panagopoulou, A., Meletis, Z.A., Margaritoulis, D., Spotila, J.R. (2017) Caught in the same net? small-scale fishermen's perceptions of fisheries interactions with ST and other protected species. *Front Mar Sci* 4: 180.

Panou, A., Antypas, G., Giannopoulos, Y., Moschonas, S., Mourelatos, D.G., Mourelatos, C. H., Toumazatos, P., Tselentis, L., Voutsinas, N., Voutsinas, V. (1992) Incidental catches of loggerhead turtles, *Caretta caretta*, in swordfish longlines in the Ionian Sea, Greece. *Testudo* 3(4): 46-57.

Panou, A., Tselentis, L., Voutsinas, N., Mourelatus, C.H., Kaloupi, S., Voutsinas, V., Moschonas, S. (1999) Incidental catches of marine turtles in surface longline fishery in the Ionian Sea (Greece). *Contrib Zoogeogr Ecol East Medit Region* 1: 435-445.

Papaconstantinou, C. (2014) Fauna Graeciae. An updated checklist of the fishes in the Hellenic Seas, Monographs on Marine Sciences, 7, Athens 2014, HCMR, 340 pp.

Pomeroy, R. (2016) A research framework for traditional fisheries: Revisited. *Mar Pol* 70: 153-163.

Snape, R. (2017) Summary Report "Data Collection and Reporting Tools for Incidental Catches of sea turtles in Mediterranean Fisheries". Mediterranean Association to Save the Sea Turtles.

Stephenson, R.L., Paul, S., Pastoors, M.A., Kraan, M., Holm, P., Wiber, M., Mackinson, S., Dankel, D.J., Brooks, K., Benson, A. (2016) Integrating fishermen' knowledge research in science and management. *ICES J Mar Sci* 73(6): 1459-1465.

Suggett, D.J., Houghton, J.D.R. (1998) Possible link between sea turtles bycatch and flipper tagging in Greece. *Mar Turtle Newsl* 81: 10-11.

Teneketzis, K., Spinos, E., Margaritoulis, D. (2003) Impact of fisheries in the population of ST Caretta caretta in Kyparissia Bay, Greece. Proceedings of 11th Panhellenic Conference of Ichthyologists.

Thurstan, R.H., Buckley, S.M., Pandolfi, J.M. (2016) Oral Histories: Informing Natural Resource Management Using Perceptions of the Past. In: Perspectives on Oceans Past. (eds., Schwerdtner Máñez, K., Poulsen, B.) Springer, Dordrecht.

Tsagarakis, K., Nikolioudakis, N., Papandroulakis, N., Vassilopoulou, V., Machias, A. (2018) Preliminary assessment of discards survival in a multi-species Mediterranean bottom trawl fishery. *J Appl Ichthyol* 34(4): 842-849.

Tserpes, G., Maravelias, C.D., Pantazi, M., Peristeraki, P. (2013) Distribution of relatively rare demersal elasmobranchs in the eastern Mediterranean. *Estuar Coast Shelf S* 117: 48-53.

Tzanatos, E., Dimitriou, E., Katselis, G., Georgiadis, M., Koutsikopoulos, C. (2005) Composition, temporal dynamics and regional characteristics of small-scale fisheries in Greece. *Fish Res* 73: 147–158.

Wallace, B.P., DiMatteo, A.D., Hurley, B.J., Finkbeiner, E.M., Bolten A.B., Chaloupka, M.Y., Hutchinson, B.J., Abreu-Grobois, A., Amorocho, D., Bjorndal, K.A., Bourjea, J., Bowen, B.W., Briseño Dueñas, R., Casale, P., Choudhury, B.C., Costa, A., Dutton, P.H., Fallabrino, A., Girard, A., Girondot, M., Godfrey, M.H., Hamann, M., López-Mendilaharsu, M., Marcovaldi, M.A., Mortimer, J.A., Musick, J.A., Nel, R., Pilcher, N.J., Seminoff, J.A., Troëng, S., Witherington, B., Mast, R.B. (2010) Regional management units for marine turtles: a novel framework for prioritizing conservation and research across multiple scales. *PloS ONE* 5(12): e15465.

Zar, J.H. (1999) Biostatistical analysis (4th ed.). Englewood Cliffs, NJ: Prentice Hall. 929 pp.

APPENDIX I

QUESTIONNAIRE FOR FISHERS (PART A)

General Info	
Port	
Date	
Researcher	
Interviewee	
Have you taken part in a survey before?	☐YES ☐NO
If so, when?	
What was it about?	☐Fisheries ☐Sharks ☐Sea turtles ☐Dolphins ☐Monkseals ☐None of the above
Age	
How many years have you been fishing?	
Is it your main source of income?	☐YES ☐NO
Is it your only source of income?	☐YES ☐NO
Do you own a vessel?	☐YES ☐NO

Fishing vessel specs	
Name of vessel	
Length of vessel	
Fishing gear you are using now	☐ Nets (GNS, GTN) ☐ Trawl ☐ Longline ☐ Purse seine ☐ Pelagic seine net
Do you use any extra gear during the year? If yes, what is it?	☐ Nets (GNS, GTN) ☐ Trawl ☐ Longline ☐ Purse seine ☐ Pelagic seine net

Fishing Gear			
Nets		**Trawl**	
Set nets Encircling gillnets Trammel nets: Combined gillnets-trammel nets: Mesh size Number of nets Total length of nets Depth / width of net	☐ ☐ ☐ ☐	Mesh size Mouth size Average speed during fishing trip	
Longline		**Purse seine**	

Static Drifting Handlines and pole-lines: Op by hand Op by machine Hook size Number of longlines Number of hooks per line Length of line	☐ ☐ ☐ ☐ ☐	Mesh size Total length of size Depth / width of net	
Pelagic seine net		**Other**	
Mesh size Total length of size Depth / width of net Distance from coast			

Fishing trips		
Number of fishing trips per month	0-5	☐
	6-10	☐
	11-15	☐
	16-20	☐
	21-25	☐
	26-30	☐
Duration per fishing trip	0-10 hours	☐
	10-24 hours	☐
	1-2 days	☐
	3-5 days	☐
	>5 days	☐

How many times do you deploy and haul your gear per trip?	
Which areas do you usually fish in? Show in the map.	
Are there any areas where fishing activities are prohibited?	
Average distance from the coast?	
How does the distance and the fishing area change during the season?	
What time of day do you deploy you gear?	
What time of day do you haul your gear?	
What depth do you deploy *(m)?	

What months do you fish?	☐ January ☐ February ☐ March ☐ April ☐ May ☐ June ☐ July ☐ August ☐ September ☐ October ☐ November ☐ December
During which season do you have the most fishing effort?	☐ Spring ☐ Summer ☐ Autumn ☐ Winter

Part B: Incidental Catches	
1. Sea turtles	
Do you incidentally catch sea turtles?	☐YES ☐NO
If yes, how many on average per month?	☐<1 ☐1-5 ☐6-10 ☐>10
How many individuals did you catch during the last year?	☐0 ☐<1 ☐1-5 ☐6-10 ☐>10
During which months do you usually catch them?	☐ January ☐ February ☐ March ☐ April ☐ May ☐ June ☐ July ☐ August ☐ September ☐ October ☐ November ☐ December

If you are using more than one fishing gear, which one do you more frequently bycatch sea turtles in?	☐ Nets (GNS, GTN) ☐ Trawl ☐ Longline ☐ Purse seine ☐ Pelagic seine net
Which areas do you usually you bycatch them (distance from the coast)? (Shows map)	
If you incidentally catch a sea turtle, what procedures do you follow?	
Do you incidentally catch more sea turtles than before?	☐YES ☐NO
Would you be willing to modify your fishing gear in order to reduce sea turtle bycatch?	☐YES ☐NO
If no, why?	
How much would you estimate the economic loss/ damage that sea turtles cause to your fishing gear per year?	
Do you know handling methods for releasing sea turtles from fishing gears?	☐YES ☐NO
Would you like to be trained in handling methods?	☐YES ☐NO
Have you ever heard of trade or consumption of sea turtles?	☐YES ☐NO
If yes, any comment?	

2. Sharks	
Do you target sharks?	☐YES ☐NO
Do you catch sharks?	☐YES ☐NO
If yes, how many individuals average per month?	
How much would you estimate your profit from selling sharks?	
Which species do you usually catch? (shows in the guide)	

During which months do you usually catch them?	☐ January ☐ February ☐ March ☐ April ☐ May ☐ June ☐ July ☐ August ☐ September ☐ October ☐ November ☐ December
If you are using more than one fishing gear, which one do you more frequently bycatch sharks in?	☐ Nets (GNS, GTN) ☐ Trawl ☐ Longline ☐ Purse seine ☐ Pelagic seine net
Which areas do you usually you bycatch them (distance from the coast)? (Shows map)	
If you incidentally catch a shark, what procedures do you follow?	
Do you incidentally catch more sharks than before?	☐YES ☐NO
Have you ever released a shark?	☐YES ☐NO
Do you know handling methods for releasing sharks from fishing gears?	☐YES ☐NO
Would you like to be trained in handling methods?	☐YES ☐NO
Do you know the protected species? (Shows in the guide)	☐YES ☐NO
Have you recently caught an angel shark?	☐YES ☐NO
If yes, in which area?	
If yes, how often do you catch an angel shark?	
COMMON QUESTIONS	
Which of the following are usually caught in your fishing gear?	☐Dolphins ☐Monk seals ☐Sharks and rays ☐Seabirds ☐Sea turtles

Could you rank the following from the most harmful to your fishing gear and downwards?	☐Dolphins ☐Monk seals ☐Sharks and rays ☐Seabirds ☐Sea turtles

Lost Fishing Gear	
Have you ever heard of ghost nets and ghost fishing?	☐YES ☐NO
Do you recycle your fishing gears?	☐YES ☐NO

FOR THE RESEARCHER	
Any suggestions to amend the questions of this survey?	
Please comment on the reliability of the fishers as per their responses, e.g. Where they willing and in a relaxed mood to answer? Were they honest?	
If not in a relaxed mood, this happened to which questions?	