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Research Article

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Does by-catch pose a threat for the conservation of seabird populations in the southern Ionian Sea (eastern Mediterranean)? A questionnaire-based survey of local fisheries

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Abstract

A significant number of studies worldwide have shown that incidental catches (by-catch) of seabirds in fishing gear might pose a considerable risk for the conservation of their populations. Nevertheless, reliable data on by-catch rates of seabirds in European marine ecosystems are patchy and need to be improved. This study constitutes a first attempt at the evaluation of by-catch rates in the southern Ionian Sea. Data were obtained by distributing a specific questionnaire to the fishers of Zakynthos Island. 150 professional fishers (representing 90% of the local fishing fleet) participated in the survey, and were interviewed during July-December 2010. The information collected showed that commercial longline and (to a lesser extent) gillnet fishery gears caused incidental catches mostly of Scopoli's Shearwater and Mediterranean Shag. The temporal analysis of incidental bird mortality showed that seabirds were more susceptible to be trapped in fishery gears set around sunrise during spring and summer whereas spatial analysis of by-catch data indicated variations in the number of seabirds caught in different fishery areas.

Keywords: incidental catch, longline, gillnet, Scopoli's Shearwater, Mediterranean Shag.

Introduction

Fisheries-seabird interactions include both negative (e.g. prey depletion) and positive (e.g. food provision via fisheries discards) effects on the population of marine birds (Tasker *et al.*, 2000; Montevecchi, 2002; Louzao *et al.*, 2011). Entrapment of seabirds in fishing gear constitutes one of the most significant direct negative effects of the fisheries industry. On the other hand, numerous studies worldwide have demonstrated that incidental catches (by-catch) of seabirds in fishing gear potentially pose a considerable risk to their populations (Weimerskirch & Jouventin, 1987; Brothers *et al*., 1999). The problem of seabird by-catch in commercial (mostly longline and gillnet) fisheries has been particularly severe in the southern oceans and has mainly affected various species of albatrosses and petrels (Brothers, 1991; Favero *et al.,* 2003). At the same time, incidental catches of seabirds reduce the effectiveness of fishery activities due to bait loss and associated decreased fish catches since it is observed that hooked seabirds in longline sets may remove the line from the desired fishing zone or cause the breaking of the line when trying to release the bait from the hook (Sánchez & Belda, 2003). As a consequence, by-catch may lead to considerable economic losses for fishing companies (Gandini & Frere, 2012).

However, available data on seabird by-catch mortality are scarce for European Union marine ecosystems, particularly in the eastern Mediterranean where such information is still patchy and insufficient to determine the rates of seabird by-catch and consequent impact on seabird populations.

In the Mediterranean, species known to be implicated in incidental by-catch on fishing gears are Scopoli's (*Calonectris diomedea*), Balearic (*Puffinus mauretanicus*) and Yelkouan (*Puffinus yelkouan*) Shearwaters, Mediterranean Shag (*Phalacrocorax aristotelis desmarestii*), and Audouin's (*Larus audouinii*) and Yellow-legged (*Larus michahellis*) gulls (ICES, 2008; Dimech *et al.,* 2009; Barcelona *et al.,* 2010). Some of these species are long lived and characterized by naturally high levels of adult survival, late onset of breeding, a low reproductive rate and a long breeding cycle. Increased adult mortality in species with these life history traits may undermine the stability of their regional population in the long term (FAO, 2008). Therefore, there is an urgent need to assess the magnitude of the by-catch problem in the region and to promote adequate conservation measures to reduce the negative impacts on seabird species.

This study was carried out as part of the LIFE07/NAT/GR/000285 project "Concrete conservation actions for Mediterranean Shag and Audouin's Gull in Greece including the inventory of relevant Marine IBAs" and attempts to improve

understanding of the patterns of seabird by-catch in the Ionian Sea and more specifically in the wider marine area of the Prefecture of Zakynthos Island, as well as to identify the main types of fishing gear responsible for by-catch, and to estimate the impact on local populations of seabird species listed in Annex I of the 'Birds Directive' 2009/147/EC (EU, 2009).

Materials and Methods

The data were collected through a questionnaire-based survey, which was conducted in collaboration with the Fishery Department of the Prefecture of Zakynthos during the period July to December 2010. The questionnaire was distributed to local fishers and consisted of closed and open-ended questions. The method used was based on personal interviews with fishers and the data obtained were analysed in order to identify possible temporal and spatial trends. The collected fishery data included fishery characteristics, types of fishing gear used, fishing months per gear type, marine fishing areas targeted, average fishing days per month, and average daily fishing effort (number of hooks per day for longlines, and metres of net deployed for nets). The data related to seabird by-catch included main by-catch seasons, marine areas targeted and average annual number of seabirds caught per seabird species and per type of fishing gear. The questions relating to specific species incidentally captured were accompanied by images of the birds to facilitate correct identification of the species by the interviewees.

The annual fishing effort for each fishery gear type was estimated from the identified fishing months, average fishing days per month and mean daily fishing effort. For fisheries using more than one type of gear during a particular month, the proportion of fishing days was equally weighted for each type of gear (i.e. if a particular fishery uses both nets and bottom longlines during a particular month and the average number of fishing days is 20, then 10 fishing days were attributed to nets and 10 to bottom longlines). Seasonal fishing effort was estimated by adding up the monthly fishing effort for the respective months. Fishing areas for each fishery were identified on maps using 10x10 nautical miles grid, created in GIS, Hellenic Geodetic Reference System 1987 (GGRS87).

The average number of birds incidentally caught per unit effort (per 1,000 hooks for longlines and km of net for nets) was initially estimated by dividing the annual by-catch with the annual fishing effort. To analyze differences between by-catch incidents among seasons, seasonal rates were estimated for each species. Data about seasonal fishing effort and incidental mortality per fishing gear were used in order to acquire a rough estimate of seasonal by-catch rates per fishing gear. It was assumed that, for each fishery, by-catch rates were the same during all seasons when incidental catches occur. In this way, estimation of by-catch rates takes into account the variations in fishing efforts and fishing areas among fisheries.

Estimates of seasonal by-catch rates per species and per fishing type were made by averaging the seasonal by-catch rates over all fisheries. The accuracy of the estimate is limited by the fact that fishers could not provide information on the total number of seabirds caught per season.

The data from the questionnaires were stored in an MS Access data-base and were further spatially examined with ArcGIS 9.3 software. The produced distribution maps represent the core fishing areas used by the local professional fishing fleet as well as the main marine areas of the southern Ionian Sea where by-catch mortality of seabirds occurs.

Results

Fishing effort

Information on the actual fishing effort was of crucial importance so as to relate it to the by-catch mortality of seabirds. Even if incidental catches of seabirds may occur in several types of fisheries (Davoren, 2007; Karpouzi *et al*., 2007), the effort was focused on the longline and gillnet fisheries since these fishing gears were the main local fishing methods used.

According to the EU Fleet Register, there were 189 fishing licenses issued in Zakynthos at the time of the current research. This questionnaire study covered almost 79% of the local registered fishing fleet (150). The main fishing gears used by the fisheries surveyed were nets, bottom longlines (BLL) and surface longlines (SLL) with an estimated overall annual fishing effort of i) 31,420,897 m of nets (total annual average length of nets per fishery operation: 225,312 m), ii) 5,902,030 BLL hooks (annual average number of hooks per fishery operation: 42,158 hooks) and iii) 602,048 SLL hooks (annual average number of hooks per fishery operation: 13,088 hooks). The average number of fishing days per month was 15.3 days. The main fishing areas were located primarily in the coastal regions of Zakynthos Island and nearby islands (Kefalonia, Echinades, Ithaki, Strofadia) (Fig. 1, 2, 3 & 4). The estimation of fishing effort per fishing gear revealed no differences between seasons with the exception of SLL where 70% of hooks are deployed during spring and summer (Table 1).

By-catch rates

Incidental catches of seabirds occurred mainly in the coastal regions of Zakynthos Island, the southern coastal area of Kefalonia Island and the marine area around the Strofades island complex (Fig. 5, 6, 7 & 8).The initial estimation of by-catch rates was based on total annual fishing effort and total number of accidentally trapped birds per type of fishing gear and per species.

The results (Table 2) indicate that Scopoli's Shearwaters are mostly susceptible to incidental mortality, primarily in BLL (by-catch rate 0.0626 birds/1,000 hooks) and SLL (by-catch rate 0.06976 birds/1,000 hooks). Mediterranean Shags have also been reported to be caught in BLL (by-catch rate 0.00071 birds/1,000 hooks) and gillnets (by-catch rate

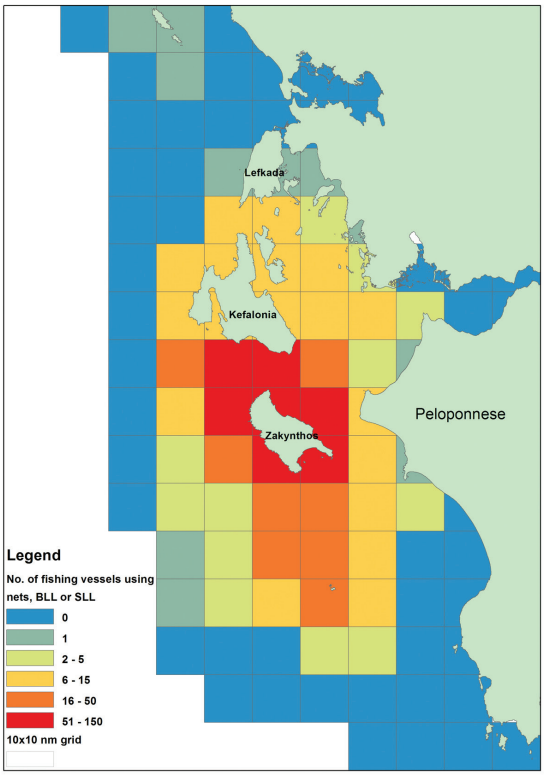

Fig. 1: Number of professional fishing vessels from Zakynthos using any type of fishing gear, i.e. nets, Bottom Long Lines (BLL) or Surface Long Lines (SLL), represented on a 10x10 nautical mile grid.

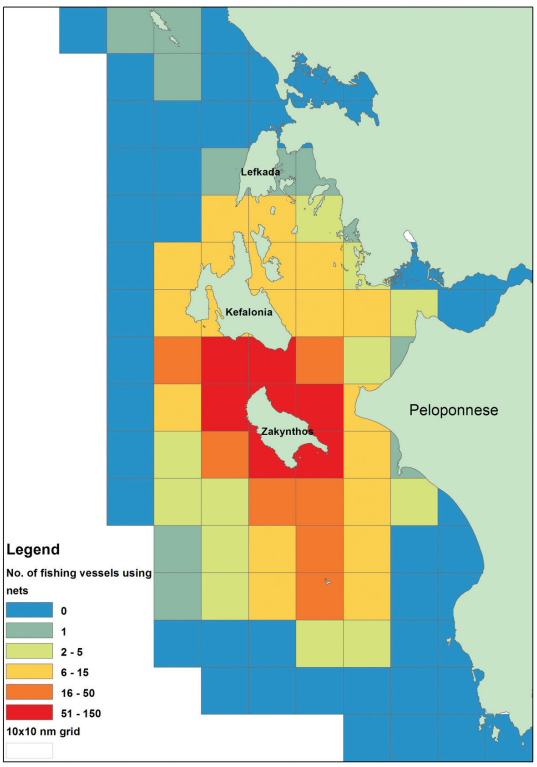

Fig. 2: Number of professional fishing vessels from Zakynthos using nets, represented on a 10x10 nautical mile grid.

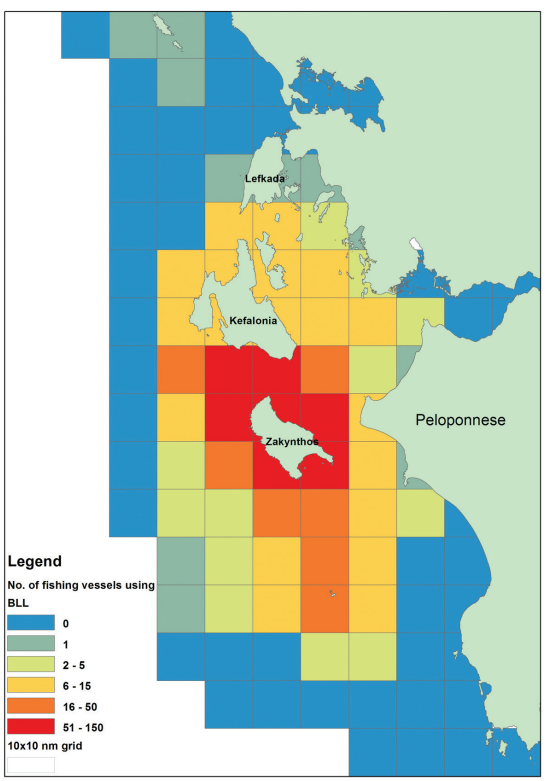

Fig. 3: Number of professional fishing vessels from Zakynthos using Bottom Long Lines (BLL), represented on a 10x10 nautical mile grid.

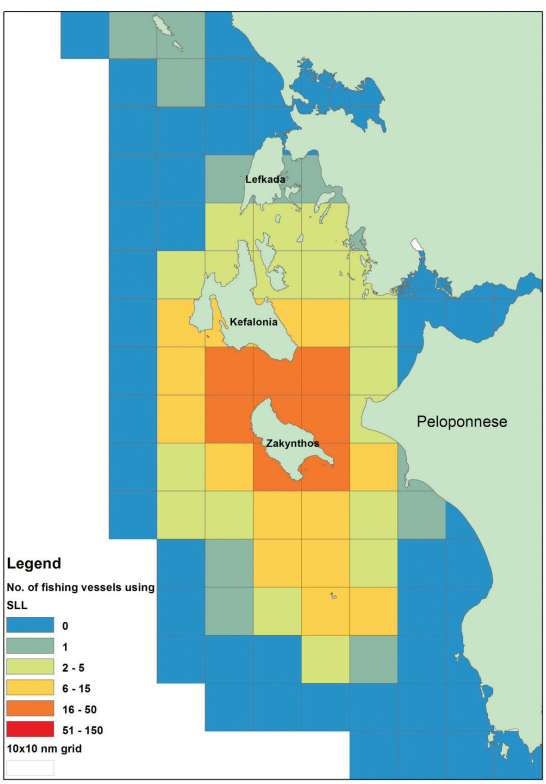

Fig. 4: Number of professional fishing vessels from Zakynthos using Surface Long Lines (SLL), represented on a 10x10 nautical mile grid.

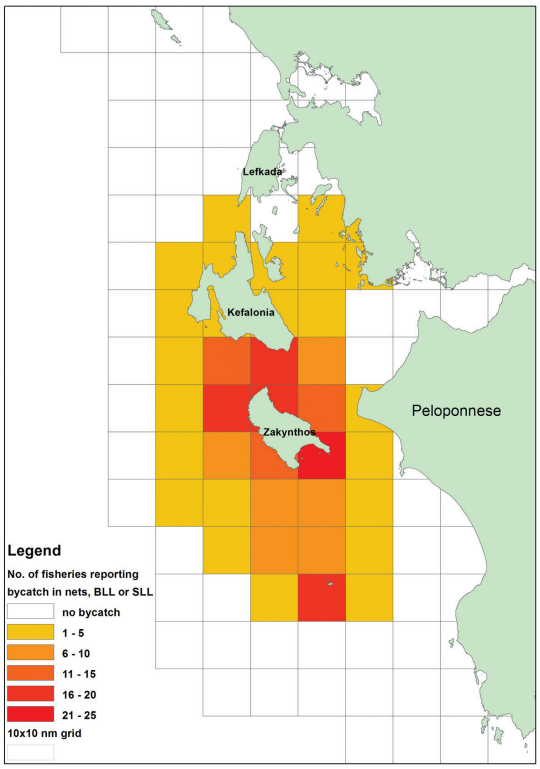

Fig. 5: Number of professional fishing vessels from Zakynthos reporting seabird by-catch in any type of fishing, i.e. nets, Bottom Long Lines (BLL) or Surface Long Lines (SLL), represented on a 10x10 nautical mile grid.

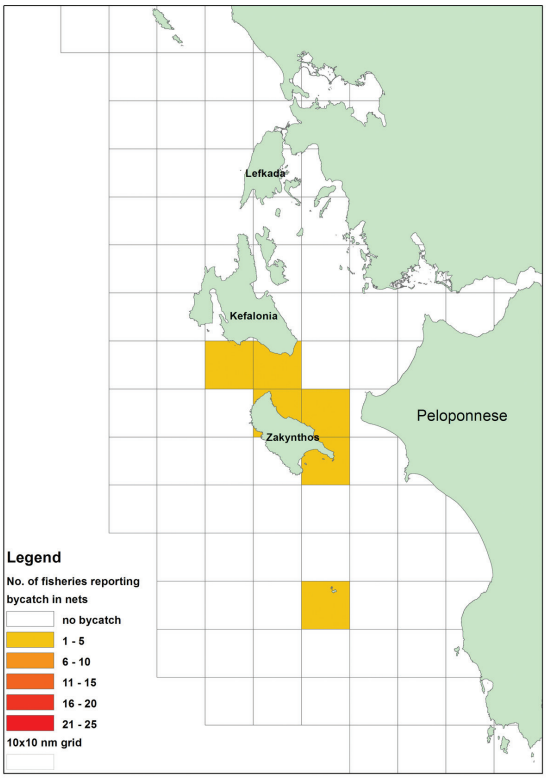

Fig. 6: Number of professional fishing vessels from Zakynthos reporting seabird by-catch in nets, represented on a 10x10 nautical mile grid.

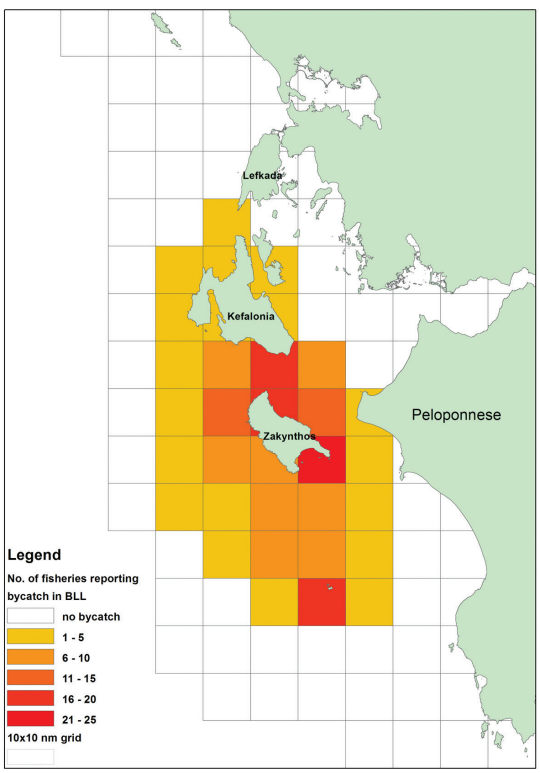

Fig. 7: Number of professional fishing vessels from Zakynthos reporting seabird by-catch in Bottom Long Lines (BLL), represented on a 10x10 nautical mile grid.

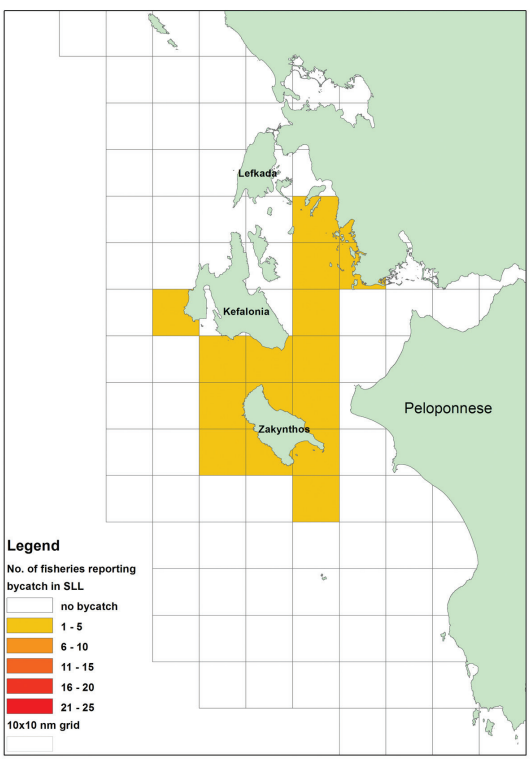

Fig. 8: Number of professional fishing vessels from Zakynthos reporting seabird by-catch in Surface Long Lines (SLL), represented on a 10x10 nautical mile grid.

Table 1. Estimated annual fishing effort.

Season	Nets [m]	No. of fishers	Bottom longlines [hooks]	No. of fishers	Surface longlines [hooks]	No. of fishers
Spring	7,552,441	137	1,462,196	124	196,368	38
Summer	6,985,941	135	1,597,282	124	225,875	40
Autumn	8,264,297	135	1,421,276	105	110,380	30
Winter	8,618,218	117	1,421,276	70	69,425	8
Annually	31,420,897	139	5,902,030	133	602,048	48

Table 2. Estimated annual by-catch rates.

Season	Nets [ind/1000m]	Total no. of inds.	BLL [ind/1000hooks]	Total no. of inds.	SLL [ind/1000hooks]	Total no. of inds.
Audouin's Gull	0	0	0	0	0	0
Mediterranean Shag	0.00003	1	0.00071	4	0	0
Scopoli's Shearwater	0	0	0.0626	351	0.06976	42
Yelkouan Shearwater	0	0	0	0	0	0

Table 3. Annual and seasonal seabird by-catch per species and per km of nets for the sample analyzed (N=139).

Species	Total no. of inds.	Mean ± SD	Annual	Spring	Summer	Autumn	Winter
Audouin's Gull	0	0	0	0	0	0	0
Mediterranean Shag	1	0.007 ± 0.08	0.00001	0.00003	0.00003	0	0
Scopoli's Shearwater	0	0	0	0	0	0	0
Yelkouan Shearwater	0	0	0	0	0	0	0

Table 4. Annual and seasonal seabird by-catch per species and per 1,000 bottom longline hooks for the sample analyzed (N=133).

Species	Total no. of inds.	Mean ± SD	Annual	Spring	Summer	Autumn	Winter
Audouin's Gull	0	0	0	0	0	0	0
Mediterranean Shag	4	0.03 ± 0.27	0.00091	0.00017	0.0042	0	0
Scopoli's Shearwater	351	2.64 ± 5.55	0.05749	0.06175	0.15307	0.00405	0.00078
Yelkouan Shearwater	0	0	0	0	0	0	0

Table 5. Annual and seasonal seabird by-catch per species and per 1,000 surface longline hooks for the sample analyzed (N=48).

Species	Total no. of inds.	Mean ± SD	Annual	Spring	Summer	Autumn	Winter
Audouin's Gull	0	0	0	0	0	0	0
Mediterranean Shag	0	0	0	0	0	0	0
Scopoli's Shearwater	42	0.88 ± 1.75	0.04163	0.03655	0.375	0	0
Yelkouan Shearwater	0	0	0	0	0	0	0

0.00003 birds/km of nets) set near coastal areas, which host small colonies. On the other hand, Audouin's Gulls as well as Yelkouan Shearwaters were not reported to be implicated in incidental catches in the southern Ionian Sea.

By-catch patterns were further elaborated by estimation of seasonal by-catch rates per species and per gear type. Only the Mediterranean Shag has been recorded to be caught in nets. Low numbers of caught birds resulted in low seasonal by-catch rates varying between 0.00001 and 0.00003 birds/km of nets. By-catch in nets has been recorded to occur during spring and summer (Table 3).

BLL have been identified as a main type of fishing gear responsible for seabird by-catch. It is estimated that 351 Scopoli's Shearwaters are caught annually by the surveyed fisheries. The main by-catch seasons are spring and summer with by-catch rates up to 0.061 and 0.153 birds/1,000hooks respectively; however, by-catch also occurs during the autumn and winter months. In addition, Mediterranean Shags are caught in BLL during spring and summer with by-catch rates ranging from 0.00017 to 0.0042 birds/1,000hooks, respectively (Table 4).

Of all seabird species, only Scopoli's Shearwater (42 inds per year) has been recorded to be caught in SLL. By-catch primarily occurs in summer (0.375 birds/1,000 hooks) and to a lesser extent during spring (0.0365 birds/1,000 hooks) (Table 5).

Discussion

Entrapment in fishing gear constitutes a significant direct influence of fisheries on marine birds at global level (Tasker *et al.*, 2000). Anderson *et al.* (2011) have roughly estimated that 160,000 to 320,000 seabirds are killed annually in global longline fishery operations. Onboard observations, information from wildlife rehabilitation institutions as well as questionnaires have proven to be useful complementary tools for the assessment of seabird by-catch (Belda & Sánchez, 2001; Dimech *et al*., 2009). Therefore, in order to assess the overall impact of the Zakynthos fishing fleet on seabird populations, studies such as this questionnaire-based survey can contribute substantially to recent findings of onboard observations in the Ionian Sea (Karris *et al*., 2010).

There are five seabird species present in the southern Ionian Sea, namely Scopoli's Shearwater that was recently recognized as a monotypic species (Sangster *et al*., 2012), Mediterranean Shag, Yellow-legged Gull, Audouin's Gull and Yelkouan Shearwater. All these species have been identified to be implicated in incidental catches by fishing gear in the eastern Mediterranean (ICES, 2008); however, only the first two species have been recorded to be caught in significant numbers in the southern Ionian Sea according to the current study, corresponding to their greater abundance in the study area.

Longlines, mainly BLL but also SLL, have been identified as the main types of fishing gear causing seabird by-catch mortality in the study area. In general, the seabird species that are more susceptible to longline by-catch are attracted to fishing vessels as a result of food provisioning via fishery discards and forage near the sea surface, scavenging and stealing bait from hooks (Montevecchi, 2002). This fact can explain the high rate of Scopoli's Shearwater mortality on longlines, which is in accordance with previous by-catch studies in the Mediterranean basin where the majority of individuals implicated in incidental by-catch belonged to this long-lived colonial pelagic species (Belda & Sánchez, 2001; Cooper *et al*., 2003; Sánchez & Belda, 2003; Dimech *et al*., 2009). In addition, incidental catches primarily occurred around sunrise and late afternoon, mainly Scopoli's Shearwaters and to a lesser extent Mediterranean Shags, which were waiting for the baited hooks to be deployed, and then attempted to eat the bait (usually sardines or squid).

At the species level and by extrapolating the by-catch rates to all 189 fishers registered in Zakynthos Prefecture, the estimated annual incidental mortality of 6.3 Mediterranean Shags in bottom longlines and nets represents approximately 3.0-5.1% of the 31-53 pairs breeding in the southern and central Ionian Sea (Fric *et al*., 2012). It is worthwhile mentioning that gillnets have less negative effects than bottom longline hooks even if a recent study showed that the former could pose a more significant threat for a coastal diving species such as the Mediterranean Shag (Muntaner-Yangüela, 2004). The impact of the incidental mortality caused by by-catch on the populations of Mediterranean Shags in the southern Ionian Sea is estimated to be low because the species breeding productivity is considered to be sufficient to compensate for the by-catch losses. On the other hand, the Greek population of this Cormorant species is estimated at 1,000-1,200 breeding pairs (BirdLife International, 2004) and the impact on the national population due to incidental catches should be further investigated.

Similarly, by extrapolating the by-catch rates to the total fishing fleet registered in the study area, 495 Scopoli's Shearwaters were estimated to be caught in longlines, which represents 1.7-2.0% of the local population since the Strofades island complex hosts about 5,000-6,000 breeding pairs (Karris *et al*., 2009). Although by-catch of this procellariiform species during the pre-breeding period in early May affects birds that migrate via the southern Ionian Sea to the Aegean Sea, the highest by-catch rates occur during the summer months, when it can be assumed that the caught birds originated from the colonies in the southern Ionian Sea. It is evident that by-catch mortality of Scopoli's Shearwaters could be considered as a potential risk for the local colonies because this marine top predator shows a long-term mate fidelity as well as biparental care during the incubation of the single egg per nest and the consequent chick rearing duties. Additionally, the significant mortality of Scopoli's Shearwater in the southern Ionian Sea underlines the need for transnational by-catch mitigation measures, since the species numbers about 50,000 pairs and is considered as vulnerable as a result of continuous population decline during the last decades (BirdLife International, 2004).

It is worthwhile mentioning that this study was based on non-direct data through distributed questionnaires and that our results have to be considered with caution. Furthermore, the results of the current study point out the urgent need to evaluate the total magnitude of the seabird by-catch problem in Greece. The assessment of incidental catch mortality at national level constitutes a prerequisite for the preparation and implementation of an effective Plan of Action with relevant mitigation measures. A comprehensive approach including data collection from stakeholders, and data obtained from the establishment and elaboration of a monitoring scheme aimed at quantifying seabird by-catch mortality, could constitute the basis for systematic assessment and mitigation of this threat for seabirds in Greek marine ecosystems.

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