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Is shore-based recreational fishing in Greece an unregulated activity that increases catch uncertainty?

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ABSTRACT

In the current study, data on Greek marine recreational fisheries regarding the number of individual recreational fishing and vessel licenses issued until 2014 are given. Moreover, using information from a questionnaire-based survey, based on 52 responses, recreational catches in two localities in the Aegean Sea (GSA 22: Thermaikos Gulf and Alonissos Island) are presented. According to data from the Port Authorities (Hellenic Coast Guard), an average of 86835 individual and 36120 vessel licenses were issued/renewed in the country in 2014. Concerning recreational catches as recorded, in Thermaikos Gulf the mean number of fishing days per year was 81.4 and the yearly catch per fisher was estimated to be 78 kg. In Alonissos Island, recreational fishers spent more days at sea (104 days/year) and their catch was considerably higher (293 kg/fisher), something that could be attributed to the beneficial effects of the nearby marine reserve. Finally, 29 taxa were caught in both surveyed areas, with European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) exceeding 50% of the catches in Thermaikos Gulf, and white seabream (*Diplodus sargus*), bogue (*Boops boops*) and brown meagre (*Sciaena umbra*) contributing 45% of the total recreational catches in Alonissos Island.

1. Introduction

Catch data, as in '*the number or weight of fish caught by a fishery, either the total amount caught or only the amount landed*' (Froese and Pauly, 2018), are indicative of the abundance of fish in the oceans and therefore the health of fisheries (Pauly et al., 2013). One of the major shortcomings of the FAO global capture production database is that, in most cases, it does not include recreational catches and discards (Garibaldi, 2012). The term "recreational fishing" is generally defined as '*fishing for personal use, entertainment, sport and challenge*' (Froese and Pauly, 2018) and includes subsistence fisheries which are defined as '*the fishery conducted to supplement the diet*' (Moutopoulos et al., 2013). Other definitions of recreational fishing that may apply better to the Mediterranean Sea recreational fishing practices and particularly Greece, are those of the ICES "*the capture or attempted capture of living aquatic resources mainly for leisure and/or personal consumption that covers active fishing methods including line, spear, and hand–gathering and passive fishing methods including nets, traps, pots, and set–lines*" and the EU "*non-commercial fishing activities exploiting marine living aquatic resources such as for recreation, tourism or sport*" (Hyder et al., 2017, 2018).

Aquatic resources are under the pressure of overexploitation and mismanagement (Tsikliras, 2014) globally (Myers and Worm, 2003; Pauly et al., 2003) and in the Mediterranean Sea (Froese et al., 2018). More and more it is evident that the inclusion of all available information in the stock assessments and ecosystem modeling is a prerequisite for an integrated approach to fisheries management and conservation of the aquatic resources. Until recently, while reconstructing fisheries catches, recreational fisheries was disregarded and focus was restricted on commercial fishing (Pauly and Zeller, 2016). Yet, the assumed magnitude of recreational catches can be as high as 10%–50% of the total catch (Font and Lloret, 2014), or, on occasion, may reach and even exceed the small-scale fisheries catches (Khalfallah et al., 2017). The increasing extent of the activity made the inclusion of recreational fisheries in fisheries management and conservation a necessity.

Research referring to Marine Recreational Fisheries (MRF) has been increasing in the last years worldwide (e.g. Moutopoulos et al., 2013; Tunca et al., 2016; Cashion et al., 2018; Keramidas et al., 2018), mainly due to scientific efforts to fill-in the gap in fisheries statistics. With respect to MRF in Europe, a recent overview was produced, based on data compiled annually by the ICES Working Group on Recreational Fisheries Surveys (Hyder et al., 2018). Data included in the aforementioned overview regarding Greece, are based on a very limited number of available studies, as well as on estimates (on a "personal communication" basis) provided by the National Statistical Service of Greece, General Secretary of Fishery (Hyder et al., 2018).

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Moreover, in Greece, unlike other European Countries where legal frames exist (for an overview see Hyder et al., 2017), since 2014 (Anonymous, 2014a) there is no legal framework under which MRF would operate and that would allow the estimation of numbers in terms of catches, fishers and vessels engaged in MRF activities. Additionally, the composition of recreational catches, the abundance and biomass of the species removed from the sea has never been recorded officially (Moutopoulos et al., 2013), as there is no obligation of reporting catches, but only estimated since the 1950's as reconstructed catches (Moutopoulos et al., 2016). An estimate of recreational fishing vessels in Greece has only been recently provided (Keramidas et al., 2018). Thus, as a significant proportion of the biomass removed from the sea by recreational activities, which are inevitably turning into IUU (illegal, unreported and unregulated), still remains unknown, fisheries management of Greek stocks still remains problematic.

It is well acknowledged that fish and invertebrate stocks are overfished in Greek (Tsikliras et al., 2013) as well as Mediterranean waters (for officially assessed stocks see Colloca et al., 2013; for all stocks see Tsikliras et al., 2015; Froese et al., 2018). The data deficiency caused by the IUU activities is partly responsible for this current status, as it adds to the uncertainty of stock assessments biasing any results, that fail to depict the real status of the stocks, and thus making management measures ineffective to a large extent (Pauly and Zeller, 2016; Keramidas et al., 2018). Any study enriching our knowledge of the biomass removed from marine ecosystems per species, that would otherwise have been included in non-reported catches, is valuable. Such information is needed for the reconstruction of Greek and other Mediterranean countries' fisheries catches (Pauly et al., 2014; Moutopoulos et al., 2015). Towards that direction, within the European Union Data Collection Multi Annual Programme, previously referred to as Data Collection Framework (DCF), a pilot case study for the collection of information on MRF in Greece is planned for the period 2017–2019 (Hyder et al., 2017; Adamidou et al., 2018), in order to create a protocol for recording and monitoring MRF in the country.

The principal objective of the present study was to provide quantitative information on MRF' catches in the Greek Aegean Sea (GSA 22), thus contributing to the mitigation of the unreported catches, and to provide insighs towards future regulation perspectives. The total recreational catch was calculated using two different estimations of the number of fishers (one based on coastal population and another based on the number of recreational fishing licenses) and the catch rates reported by the fishers. Moreover, data from the Port Authorities (Hellenic Coast Guard), regarding licenses, in order to evaluate the magnitude of MRF in the Greek Aegean Sea, were collected and analyzed. Finally, data on MRF activities within a marine protected area, the National Park of Alonissos-Northern Sporades (NMPANS), are presented.

2. Material & methods

For the estimation of the MRF catches in the Greek Aegean Sea, the method used by Moutopoulos et al. (2013) was followed. Two coastal areas from different parts of Greece (Thermaikos Gulf and Alonissos Island in the northern Aegean Sea; Fig. 1) were surveyed, in 2016, based on personal interviews with 52 recreational fishers (36 shore based anglers in Thermaikos Gulf and 16 anglers fishing from shore and/or vessel in Alonissos Island; no spearfishers were included). For the needs of this study and the participation of fishers, at the time the survey was conducted, there was no legislation that required a review and/or approval by either the interviewee or by an ethics committee. The fishers were asked to declare, among other aspects: (a) the frequency of fishing trips throughout the year (fishing days per season), (b) daily fishing hours (hours of fishing per day and season, and time of activity), (c) species caught, and d) daily, monthly, seasonal or annual catch in weight (in terms of kilos per species) (for more details see Appendix Table A.1, and Dimarchopoulou et al., 2016).

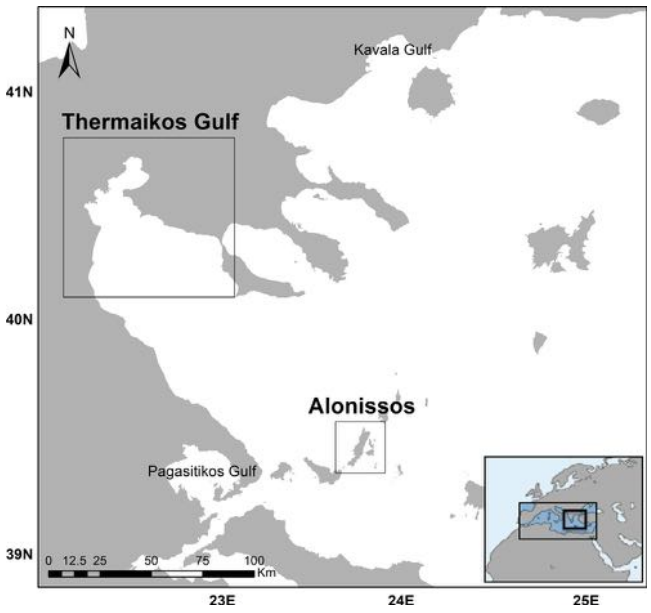

Fig. 1. Location of the questionnaire-based surveyed areas in the Aegean Sea.

In order to determine the number of recreational fishers, two methods were used; one based on the population of the Aegean coastline and one based on the number of licenses issued prior to 2014. In the frame of the first method, firstly the number of recreational fishers was estimated by deriving the resident population from the last census (2011) of the Hellenic Statistical Authority (HELSTAT, 2011; www.statistics.gr) conducted in each coastal prefecture of the Aegean Sea and multiplying by the ratio of recreational fishers to resident coastal population. For this ratio, previously estimated values for the Eastern Mediterranean were taken into consideration (Ünal and Franquesa, 2010; Ünal et al., 2010), and finally the conservative assumption of 1.5% of the coastal population made by Moutopoulos et al. (2013) was followed. For two prefectures with only a narrow coastline (i.e. Serres and Imathia) the ratio of 1% was used.

For the second method the number of recreational fishing licenses (individual and vessel) were collected from the 136 Port Authorities of the Aegean Sea. Communication was made (over the phone or by written requests) with every Central Port Authority, Port Authority and Port Station (Anonymous, 2014b) in the Greek part of the Aegean Sea (GSA 22). The information collected was the number of recreational licenses (individual fishers and vessels for recreational fishing) that has been recorded by each service until 2014 (for a detailed account see Dimarchopoulou et al., 2016). The total number of licenses in the Greek Seas were taken from the official license data by the Port Authorities and then, in order to exclude the Ionian Sea, it was assumed that 80% of those refer to the Aegean Sea (Keramidas et al., 2018). In addition, information on the number of licenses (issued and renewed) was collected from the Port Authorities (Ministry of Shipping and Island Policy, Hellenic Coast Guard), referring to the entire country, as they are the competent Greek authority for such official records. Official licensing data for the entire country were available only for the years 2010–2013 (for 2014 in part, as the licensing system was abolished then (Anonymous, 2014a)).

Using information collected by the fishers interviews (Thermaikos Gulf; Table 1) and data from literature (Pagasitikos and Kavala: Moutopoulos et al., 2013; Table 1), the mean annual catch per unit effort [CPUE (kg/fisher/day); averaged among the three

areas] and mean annual number of fishing days per fisher were estimated. In addition, the total annual fishing effort (in fishing days) was estimated by multiplying the mean number of fishing days per fisher multiplied by the number of fishers obtained both from the census of resident population and from the number of recreational licenses released by the Port Authority. Then, the overall MRF catch was calculated by multiplying the CPUE by the numbers of fishers as estimated by the two methods applied herein (i.e. the census of resident population and the number of recreational licenses); thus two estimates of overall MRF catch emerged.

Finally, the records of fishing activities within the jurisdiction of the NMPANS from the corresponding archives were also analyzed (2007–2014).

3. Results

The mean number of fishing days per year and the corresponding standard error was 81.4 ± 14 and 104 ± 25 and the average daily catch was 0.96 ± 0.19 and 2.82 ± 0.29 kg per fisher per day, in Thermaikos Gulf and Alonissos Island respectively (Table 1).

Table 1
Taxa composition (%) of recreational catches in Greek waters based on interviews in four coastal areas (for more details, see Materials and Methods section). The data from Pagasitikos and Kavala Gulfs are from Moutopoulos et al. (2013). Species common names are from FishBase (Froese and Pauly, 2018). CPUE: catch per unit effort.

Taxa	Species common name	Pagasitikos Gulf	Kavala Gulf	Thermaikos Gulf	Alonissos
Auxis thazard	Frigate tuna	0.60			
Belone belone	Garfish	0.62			
Boops boops	Bogue	0.64			13.37
Caranx spp.	Jacks	0.71		1.29	
Coryphaena spp.	Dolphinfishes	0.47		0.45	1.44
Dentex dentex	Common dentex	0.44	1.56		
Dentex gibbosus	Pink dentex	0.10	0.78		
Dicentrarchus labrax	European seabass	7.78	11.15	29.95	
Diplodus annularis	Annular seabream	11.26	18.25	8.04	2.09
Diplodus sargus	White seabream	4.46	3.51		18.68
Diplodus vulgaris	Common two-banded seabream	1.53	7.80		
Epinephelus aeneus	White grouper	0.10			
Epinephelus costae	Goldblotch grouper	0.10	0.78		
Epinephelus marginatus	Dusky grouper	0.10			
Euthynnus alletteratus	Little tunny	0.63			
Gobius spp.	Gobies	0.32			
Labridae	Wrasses	0.07			
Lichia amia	Leerfish	0.34			
Lithognathus mormyrus	Sand steenbras	2.24	4.68	16.11	
Merluccius merluccius	European hake	0.13			
Mugilidae	Grey mullets	18.32	19.50	2.08	0.29
Mullus barbatus	Red mullet	0.14			
Mullus surmuletus	Surmullet	0.10		0.05	
Oblada melanura	Saddled seabream	2.03			4.17
Osteichthyes	Other fishes	6.38	8.58		
Pagellus acarne	Axillary seabream	1.06			1.44
Pagellus bogaraveo	Blackspot seabream	1.89		0.04	2.53
Pagellus erythrinus	Common pandora	3.08		0.08	
Pagrus pagrus	Red porgy				9.88
Polyprion americanus	Wreckfish		0.39		
Pomatomus saltatrix	Bluefish	10.28		8.79	
Sarda sarda	Atlantic bonito	0.42			
Sarpa salpa	Salema	0.77		0.11	
Sciaena umbra	Brown meagre	0.20		6.39	13.00
Scomber colias	Atlantic chub mackerel	2.45	8.97	0.09	
Seriola dumerili	Greater amberjack		0.78		5.96
Serranus spp.	Other combers	0.07			0.11
Serranus cabrilla	Comber				0.90
Sparus aurata	Gilthead seabream	15.30	12.87	22.94	
Sphyraena sphyraena	European barracuda	0.21			2.00
Spicara flexuosa	Blotched picarel	2.91		0.68	
Spicara maena	Blotched picarel	1.06			
Spicara smaris	Picarel	0.07			
Spondyliosoma cantharus	Black seabream	0.17	1.17		7.58
Thunnus spp.	Tunas	0.14			
Trachinus spp.	Weevers	0.21			
Trachurus mediterraneus	Mediterranean horse mackerel	2.09	7.80		
Trachurus spp.	Horse mackerels			1.05	0.67
Umbrina cirrosa	Shi drum	0.07			
Cephalopods					
Loliginidae, Ommastrepidae		1.08			
Loligo vulgaris	European squid	1.06		0.59	12.64
Octopus vulgaris	Common octopus	1.83		0.06	3.25
Sepia officinalis	Common cuttlefish	0.35		1.22	
Mean annual number of fishing days		**191.0**	**180.0**	**81.4**	**104.0**
CPUE (kg/fisher/day)		**0.80**	**0.71**	**0.96**	**2.82**
Yearly catch/fisher		**154**	**128**	**78**	**293**

Table 2
Yearly recreational catch per Greek coastal prefecture of the Aegean Sea (for details see Material and Methods).

Prefecture	Resident population	Fishers	t/year
Argolida	97 044	1 456	175
Arkadia	86 685	1 300	156
Attiki	3 828 434	57 427	6 891
Voiotia	117 920	1 769	212
Dodekanisos	186 272	2 794	335
Evros	147 947	2 219	266
Evia	210 815	3 162	379
Imathia[a]	140 611	1 406	169
Thessaloniki	1 882 108	28 232	3 388
Kavala	124 917	1 874	225
Korinthia	145 082	2 176	261
Kyklades	121 335	1 820	218
Lakonia	89 138	1 337	160
Larisa	284 325	4 265	512
Lesvos	86 436	1 297	156
Magnisia	190 011	2 850	342
Mount Athos	1 811	27	3
Xanthi	111 222	1 668	200
Pieria	126 698	1 900	228
Rodopi	126 692	1 900	228
Samos	32 977	495	59
Serres[a]	176 430	1 764	212
Fthiotida	158 231	2 373	285
Chalkidiki	105 908	1 589	191
Chios	52 674	790	95
Total	**8 631 723**	**127 891**	**15 347**

[a]Exception: No. of fishers calculated as 1% of 2011's resident population, instead of 1.5%.

Table 3
Number of individual recreational fishing licenses (fishers) per prefecture as stated by the Greek Port Authorities of the Aegean Sea; number of active fishers (80% of the stated numbers); catch per year in tonnes (described in Materials and Methods).

Prefecture	Fishers	Active fishers	t/year
Argolida	1 186	949	114
Arkadia	540	432	52
Attiki	37 268	29 814	3578
Dodekanissos	2 228	1 782	214
Evros	780	624	75
Evia	2 019	1 616	194
Thessaloniki	9 021	7 216	866
Kavala	2 443	1 954	235
Korinthia	617	494	59
Kyklades	3 890	3 112	373
Larissa	154	124	15
Lesvos	1 005	804	96
Magnissia	2 583	2 067	248
Xanthi	731	585	70
Pieria	1 713	1 370	164
Samos	940	752	90
Fthiotida	2 196	1 757	211
Chalkidiki	601	481	58
Chios	84	67	8
Total	**69 999**	**56 000**	**6720**

Table 4
Number of vessel and individual recreational fishing licenses in Greece (data: Port Authorities).

Year	Vessel			Individual		
	Issued	Renewed	Total	Issued	Renewed	Total
	Number of licenses					
2010	14 486	23 892	38 378	42 898	46 426	89 324
2011	12 803	15 591	28 394	37 363	49 272	86 635
2012	11 529	27 246	38 775	34 643	49 086	83 729
2013	11 122	27 809	38 931	34 780	52 871	87 651
Average	12 485	23 635	36 120	37 421	49 414	86 835

For the two surveyed areas combined, 29 taxa contributed to the total catches, four of which (European seabass *Dicentrarchus labrax*, gilthead seabream *Sparus aurata*, brown meagre *Sciaena umbra* and white seabream *Diplodus sargus*) made up about 50% of the total recreational catches (Table 1). The species dominating the catches varied with studied area. In Thermaikos Gulf, two fish species (European seabass and gilthead seabream) made up more than half of the total catches and in Alonissos three fish species (white seabream, bogue *Boops boops* and brown meagre) contributed 45% of the total recreational catches (Table 1).

As calculated from the proportion of resident population (1.5% for all coastal regions and 1% for Imathia and Serres), the highest yearly recreational catch was encountered in the two largest prefectures in Greece, namely Attiki (6891 t/year) and Thessaloniki (3388 t/year) (locations indicated in Fig. 2) (Table 2). The total biomass of fish and invertebrates (MRF catch) removed from the Aegean Sea based on the coastal population estimation was calculated at 15347 t/year (Table 2).

As far as the data on recreational fishing collected from the Port Authorities of the Aegean Sea are concerned, these were provided by 136 Port Authorities (Fig. 2). The Central Port Authorities of Pireas (Attiki), Thessaloniki, Cyclades, and Volos (Magnisia) have issued the highest number of individual recreational fishing licenses, whereas the Central Port Authorities of Pireas, Thessaloniki, and Volos have issued the highest number of recreational fishing vessel licenses (Fig. 2).

Based on the recreational licenses issued by the Greek Port Authorities, the areas with the highest numbers of active recreational fishers were encountered in the two largest Greek prefectures, namely Attiki (29814) and Thessaloniki (7216), with the highest recreational yearly catch (3578 and 866 t/year, respectively) (Table 3). In Chios, there were the fewest active fishers (67) and therefore the lowest catch (8 t/year) (Table 3). Thus, the total biomass of fish and invertebrates removed from the Aegean Sea based on the number of licenses was estimated to be 6720 t/year (Table 3).

The relation between the numbers of recreational fishers calculated with different methods is shown in Fig. 3. In all areas, the three methods display similarly patterned results with the exception of Attiki and Thessaloniki, where the "1.5% census" fishers were more than the "active" ones (Fig. 3). Based on the data provided by the Port Authorities, the mean annual number of licenses for the entire country (2010–2013) was 36120 (range: 28394–38931) for vessels and 86835 (range: 83729–89324) for individuals (Table 4).

Finally, for the area of Alonissos in particular, the management body of the NMPANS and the Port Authority of Alonissos have recorded the recreational vessels entering the park area or mooring at the central port of the island, the cases of recreational fishing activity (including illegal ones) and its different types (Fig. 4). In 2014, 1438 recreational vessels moored at the main port of Alonissos and 179 were recorded during the 117 NMPANS boat patrols (Fig. 4a). During these 117 patrols, 15 cases of sport fishing activity were recorded, 7 of which were illegal (Fig. 4b). The highest proportion of the recreational fishing activity in the area of Alonissos was angling (39.52%), followed by spearfishing (34.68%) (Fig. 4c).

4. Discussion

In recent years, effort has been put towards estimating the magnitude of the catches of recreational fisheries (Cooke and Cowx, 2004; Moutopoulos et al., 2013, 2015) as well as their

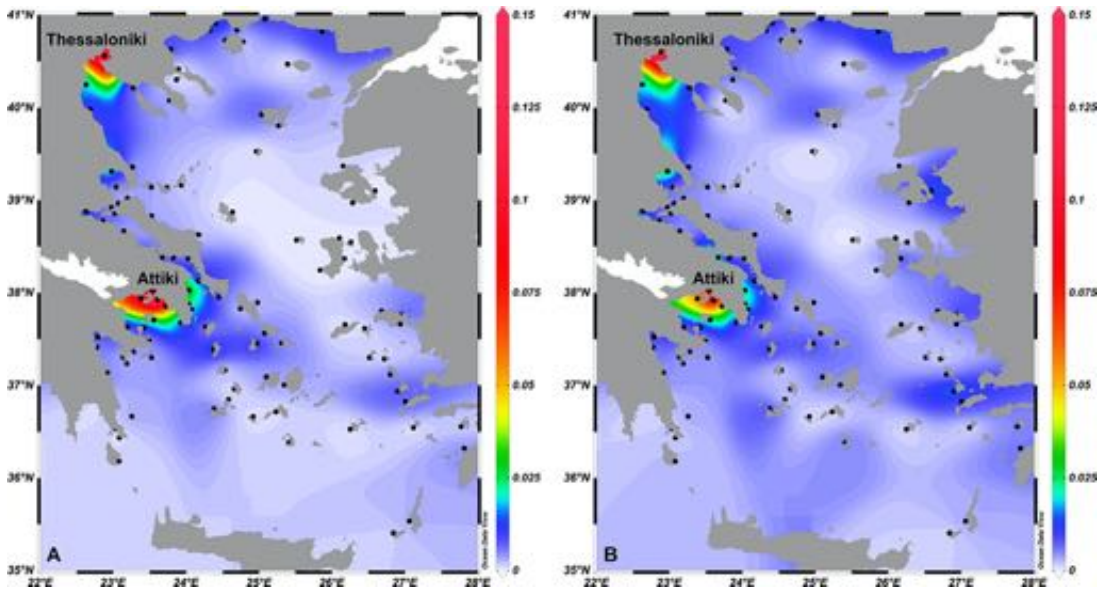

Fig. 2. The studied Greek Port Authorities of the Aegean Sea (black dots) and the percentage of recreational fishers (left panel) and vessels (right panel) to the total of the Aegean Sea (100% expressed as unity). *Map created with Ocean Data View software.

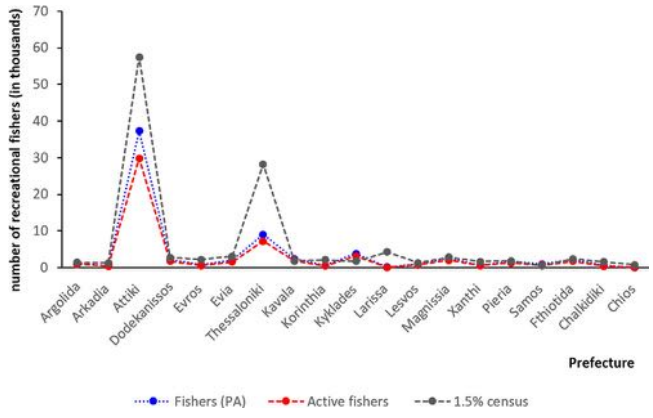

Fig. 3. Number of: recreational fishers as stated by the Greek Port Authorities (Fishers PAs); active recreational fishers; recreational fishers calculated as a proportion of the resident population (1.5% census).

impacts on fish stocks and the aquatic environment (Lewin et al., 2006; Lloret et al., 2008a,b). Today, researchers are even using satellite data and social media, to record information on fishing effort (Keramidas et al., 2018) and recreational catches (Belhabib et al., 2016; Giovos et al., 2018).

Based on a questionnaire survey in two areas of high fisheries interest (Thermaikos Gulf, that is highly populated and is a high-effort area of commercial fishing; and Alonissos where the largest Marine Protected Area of the Aegean Sea is located), it was revealed that recreational fishers mainly target a limited number of species. Only the catch rates per fisher from Thermaikos Gulf were used from the present work because the high catch rates in Alonissos Island are possibly determined by the protection regime of the marine park (NMPANS) (Anonymous, 2003). The catch rates for two other areas of Greece (Kavala Gulf in the northern Aegean Sea and Pagasitikos Gulf in the central Aegean Sea) collected by Moutopoulos et al. (2013) are also presented for comparison and were used for data extrapolation. Given the local character of the survey presented herein, the limited number of questionnaires focusing on shore-based fishers and the short time frame, the species composition and the catch per species should not be considered representative of the entire Aegean Sea.

Comparison of our results with previous studies show that these species are also targeted in other areas of the country. According to Moutopoulos et al. (2013), in Pagasitikos Gulf, six fish species contributed 64.8% of the total catches, with gilthead seabream, grey mullets (Mugilidae) and annular seabream (*Diplodus annularis*) being the most dominant taxa. In Kavala Gulf, eight species contributed more than 90% of the total catches, with Mugilidae and annular seabream representing 37.8% of the total catches (Table 1). Similarly, in Saronikos Gulf (Kyriakidis et al., 2018), sparids (Sparidae) were the target-species, yet no detailed information on their contribution in the catch was available. Using the social media (YouTube shared videos), Giovos et al. (2018) found that 70 species are caught in Greece, with common pandora (*Pagellus erythrinus*), common two-banded seabream (*Diplodus vulgaris*), white seabream, gilthead seabream and European seabass being the most numerically abundant (>40%). Yet, as the authors also state in the paper, there might be a potential underestimate of the number of species and the frequency of the appearance of a species in a post, as there is a tendency towards sharing the most impressive and eye-catchy fish and fishing techniques (Giovos et al., 2018). This set of species also appears in questionnaire-based surveys (Moutopoulos et al., 2013; Kyriakidis et al., 2018; present study), clearly depicting the evident preference of recreational fishers towards sparids, European seabass and grey mullets. This could be attributed to the fact that these species, found in relatively shallow/coastal waters (Froese and Pauly, 2018), can be easily caught with shore-angling and long-lines, fishing gears that are very commonly used by recreational fishers in Greece (Hyder et al., 2017). It is worth noting that the main target species of MRF are also targeted by the commercial small-scale coastal fleet. Therefore, given that recreational fishers tend to use the same resources as commercial small-scale fishers and there is an overlap on the strategies and gears used (Tzanatos et al., 2005), and the recreational fleet is double the size of the small-scale one in terms of vessel numbers

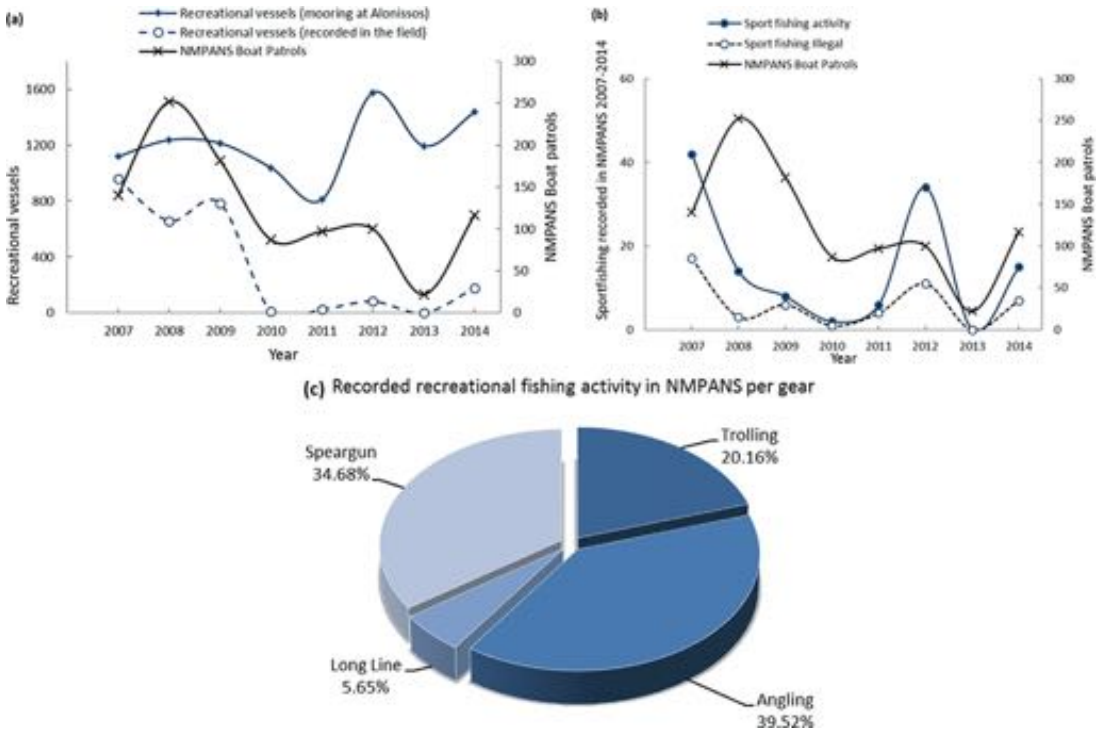

Fig. 4. (a) Recreational vessels (mooring at the main Port of Alonissos, Patitiri) (Source: Alonissos Port Authority), recreational vessels in the field (Source: National Marine Park of Alonissos Northern Sporades NMPANS) and annual NMPANS boat patrols; (b) Legal vs. illegal sport fishing; (c) Recreational fishing activity in NMPANS per fishing gear.

(Keramidas et al., 2018), the conflicts between the two sectors could be amplified. According to the most recent official fisheries statistics, the total catch of small-scale coastal fisheries in the Aegean Sea is around 25000 tn per year (HELSTAT, 2018) and based on our estimates, MRF in the same area may reach 15000 tn if the number of fishers is calculated based on the population along the coast (Table 2).

According to Moutopoulos et al. (2013), the mean number of fishing days per year for Pagasitikos and Kavala Gulf was 191 and 180 days per year and the average daily catch was 0.80 and 0.71 kg per fisher per day, respectively (Table 1). In the present study, it was found that in Thermaikos Gulf and in Alonissos, even though the number of fishing days are almost half (81.4 and 104.0, respectively), the daily catch was either similar (Thermaikos: 0.96 kg/fisher/day) or notably higher (Alonissos: 2.82 kg/fisher/day) compared to Pagasitikos and Kavala Gulfs (Table 1). In the case of Thermaikos Gulf, a plausible explanation for the high yield with the minimum effort, could be attributed to the fact that the questionnaires conducted in the present study were restricted in the Bay of Thessaloniki, the inner part of the area (for a full description of Thermaikos Gulf see supplementary material in Dimarchopoulou et al., 2018). Thermaikos Gulf is characterized by high productivity (Stergiou et al., 1997; Pagou, 2005; Gotsis-Skretas and Ignatiades, 2007) and is one of the richest fishing grounds in Greece (Stergiou et al., 1997; Papaconstantinou, 2005; Dimarchopoulou et al., 2018). Moreover, in the nearby area of Angelochori, a small lagoon is located that serves as a farming area for gilthead seabream. Fishers in the area report that very often the catches of gilthead seabream are rather high, due to escapees from the lagoon. This is also shown by the reported catches of this species in the area in the present study that reached up to 23% (Table 1).

Alonissos Island, on the other hand, is located in the Marine Protected Area (MPA) of Northern Sporades, and fisheries of all kind are under special restrictions (Anonymous, 2003). The park, apart from the no-take zone, is divided in two more zones (A and B), and those are further subdivided in nine (A1–A9) and four (B1–B4) subzones respectively (Anonymous, 2003). As far as recreational fishing is concerned this is prohibited in ten out of the fourteen zones, including of course the no-take zone of the MPA [core of zone A1: Piperi islet and the marine area within three nautical miles around its coast (total area of 70 km^2)]. The management body of the NMPANS and the Port Authority of Alonissos Island have recorded the recreational vessels entering the park area or mooring at the central port of the island, the cases of recreational fishing activity (including illegal ones) and the different types of illegal activity (e.g. fishing with illegal gear, in forbidden areas, and without a permit). Moreover, the entire area has been under strong protection by the Underwater Archaeological Service (Anonymous, 1997). Thus, low fishing effort, both commercial and recreational, would be anticipated. In addition, despite the fact that many recreational vessels are recorded yearly in the port of Alonissos (1438 vessels for 2014: current study) and the general area of Sporades and Eastern Evvoia Island (1221: Keramidas et al., 2018) only few actually show fishing activity. The most alarming issue, nonetheless, it that half of these fishing operations, based on the NMPANS records are illegal, despite the efforts of the management body to control and clamp down IUU in the park. Indeed, as clearly stated in the legal frame regarding recreational fishing in the NMPANS (Anonymous, 2003), only trolling and angling is permitted. Nevertheless, 40% of the recreational fishing activity is performed with spearguns and to a lesser extend with longlines (Fig. 4), constituting a large percentage of IUU in the MPA. The inadequacy of the authorities

to control illegal fishing in the area, has been identified a decade ago by Sala et al. (2012) who recorded extremely low biomasses and stray fishing gears inside the core of the MPA, Piperi Islet. Yet, the high daily catch in the area, of species that are targeted by small-scale fisheries and are of high commercial value (e.g. white seabream, common seabream, meagre), indicate that the fishing restrictions since the MPA establishment have improved the status of the fish stocks in the area by sustaining the biomass and size structure (Tsikliras et al., 2018). NMPANS, unfortunately, is not the only MPA in Greece where IUU is being identified. In a recent work of Moutopoulos et al. (2017), high rates of IUU were also recorded in the Mesolonghi-Etolikon lagoons (Ionian Sea, Greece) MPA. In any case, unmonitored and unregulated fishing activities such as recreational fishing in Greece since 2014, not only contribute to the IUU catch but may also lead to strong underestimation of the biomass removal from the sea for specific stocks and bias stock assessments and therefore fisheries management. IUU catch that is sold through the black market may also cause economic damage to professional fishers, especially the small-scale coastal ones.

In their analyses Keramidas et al. (2018) estimated the recreational fleet to account for 31 635 vessels. This number is very close to the annual mean vessel licenses presented here, indicating that satellite images can provide quite accurate estimates of the size and location of the fleet. This successful use of technological applications and the relatively high accuracy of data they provide could act as a powerful tool in recording, monitoring and controlling fishing activities. It has been argued that it is very difficult to locate, estimate and monitor vessels that are not equipped with monitoring systems (such as vessel monitoring system VMS, automatic identification system AIS, etc.), namely small-scale professional fishing vessels and recreational ones. Yet, the study of Keramidas et al. (2018) and the ground-truthing results of the present study show that quite good estimates can be attained, even when official or other data are missing. However, as the records refer to total numbers of vessels and not actually "active vessels", as Keramidas et al. (2018) also suggest, further research is required in order to identify the actual number of recreational vessels engaged in MRF activities.

In terms of human-power, recreational fisheries in Europe account for approximately 2.8 million people (Hyder et al., 2017), a number that in Greece, including boat, shore and spearfishers, is as high as 300 000 (i.e. 2.75% of the Greek population; Hyder et al., 2017). This estimate is more than three times higher than the individual licenses presented here. The difference in the numbers, as here only data according to the licenses are presented, could be attributed to two main reasons: (a) according to the abolished law (Anonymous, 1985) only recreational fishers fishing by boat were obliged to have a valid personal license, as for all the remaining ones, the obligation was not so clearly stated, and (b) shore-based fishing is the most popular in the country (Hyder et al., 2017).

In conclusion, recreational fishing, which is completely unregulated since 2014 and often practiced illegally, is generally concentrated in highly populated coastal areas and islands, with species composition and catches varying regionally. Although the biomass removed by recreational fishing in Greek waters is a significant proportion of the total catch, it still remains unrecorded thus increasing uncertainty in catch statistics. The significance of recreational fishing in stock assessments and fisheries management requires an integrated licensing system, which should be re-enforced serving both science and society. In parallel, official data collection of MRF will minimize data deficiency, provide better estimates of the biomass extracted, and mitigate IUU.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Paraskevi K. Karachle: Funding acquisition, Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Donna Dimarchopoulou:** Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization. **Athanassios C. Tsikliras:** Conceptualization, Methodology, Formal analysis, Resources, Writing - review & editing.

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Appendix

See Table A.1.

Table A.1
General description of the questionnaire used in the frame of the current study. For the detailed presentation of the questionnaire (in Greek), see Dimarchopoulou et al. (2016).

General category	Type of information
Fishing activity	• frequency of fishing operations throughout the year (fishing days per season) • daily fishing hours (hours of fishing per day and season, and time of activity) • average daily catch per season (in weight) • percentage of catch for personal consumption
Trends	• residents in the area that recreationally fish • views on the abolishment of recreational fishing licencing system • views on existing legislation regarding recreational fishing • overfishing and probable causes
Typology	• catch composition • monthly, seasonal or annual catch in weight (in terms of kilos per species)

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