Fisheries Research 208 (2018) 1–6

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Estimating recreational fishing fleet using satellite data in the Aegean and Ionian Seas (Mediterranean Sea)

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ARTICLE INFO

Handled by B. Morales-Nin

Keywords:
Unreported effort
Fisheries management
Fishing effort
Google Earth

ABSTRACT

In the Mediterranean Sea, recreational fishing is part of the local culture and has been practiced for centuries using various techniques and gears. Yet, recreational fishing effort and catches are not officially recorded in most Mediterranean countries, Greece included. The objective of this work was to estimate the number of vessels fishing for recreational purposes in the Aegean and Ionian Seas (Greece) using two independent sources of data. Firstly, we physically visited 42 ports and marinas across the Greek Aegean Sea coastline and counted the recreational vessels. Secondly, we used satellite image frames (from Google Earth) to count the recreational vessels at the same and in additional 620 ports and marinas of the entire Aegean (420 ports) and Ionian (200 ports) coastlines, including the inhabited islands. The agreement between the *in situ* visits and the satellite data was very high (correlation coefficient $r = 0.96$, $P < 0.001$), indicating that Google Earth is a valuable and low cost tool that provides useful information for fisheries management. According to the satellite data, the total number of recreational fishing vessels was about 24,650 in the 462 ports of the Aegean Sea and 7000 in the 200 ports of the Ionian Sea; this adds up to a total number of around 31,650 recreational fishing vessels in Greek waters, which agrees with the number of recreational fishing licenses issued in 2014 but is lower compared to previous estimates. Most vessels were recorded near large cities, where the majority of inhabitants are concentrated and in islands, where the majority of tourists spend their time.

1. Introduction

In many coastal areas of the world, including the entire Mediterranean Sea, recreational fishing is part of the local culture and has been practiced for centuries, from shore, onboard or underwater using various techniques and gears (Arlinghaus et al., 2015). Besides the benefits of being a sport or a hobby practiced in nature, recreational fishing may also subsidize dietary needs or be a source of income when part of the catch is sold in the black market (Ünal et al., 2010; Tunca et al., 2016). The rapid expansion of recreational fishing in the Mediterranean Sea (Lloret and Font, 2013; Morales-Nin et al., 2015) and Greece in particular (Moutopoulos et al., 2013), as well as the continuous increase of recreational catches (Moutopoulos et al., 2016a,b) raises concerns regarding the effect it may have on fish stocks and marine ecosystems (Lewin et al., 2006; Lloret et al., 2008). Also, its interaction, overlap and conflict with commercial fisheries and fishers may be extensive, especially with small-scale coastal fisheries that often target the same species and operate at the same coastal areas where recreational fishing is concentrated (Gaudin and De Young, 2007; Lloret et al., 2008; Ünal et al., 2010; Tsikliras, 2015; Silvestri et al., 2016; Tunca et al., 2016).

Fisheries research has been traditionally focused on the effects of commercial fishing on the biomass and life history of exploited populations (Froese et al., 2018), the loss of marine habitats (Pawson et al., 2008), and changes in the ecosystem structure and function (Pauly et al., 1998). Before the reconstruction of global catches that revealed that a large proportion of the unreported catch is derived from recreational fishing (Pauly and Zeller, 2016), recreational fishing was rarely part of this picture and its effect on marine populations was rather overlooked. In addition, the misconception that recreational fishing is not driven by the same socio-economic drivers as commercial fisheries, has led to an underestimation of its impact on fish stocks (Lloret and Font, 2013) and created the perception that it does not contribute to global fish stock overexploitation (Ünal et al., 2010).

Today, recreational fishing is gaining attention because, in many areas, it constitutes a black box for fisheries management and a major component of illegal, unreported and unregulated catches (Moutopoulos et al., 2013). Thus, total marine catches and fishing effort are underreported, stock assessments are biased because they exclude a proportion of the total biomass removed by fishing, and fisheries

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https://doi.org/10.1016/j.fishres.2018.07.001
Received 16 April 2018; Received in revised form 13 June 2018; Accepted 6 July 2018

management is hampered (Lloret et al., 2008; Pauly and Zeller, 2016). Assessing the potential impacts of recreational fishing on marine populations is also impaired by the absence of long-term monitoring programs of recreational fisheries, the dispersity of recreational fishing activities and the complexity of fishing techniques, as well as the lack of time-series on the evolution and catches of recreational fisheries (Lewin et al., 2006; Ünal et al., 2010).

In Europe, studies on recreational fisheries are sparse and only a few stock assessments include mortality data from this activity (Ryan et al., 2016), while in the Mediterranean Sea research on recreational fisheries is quite recent (Morales-Nin et al., 2005; Lloret et al., 2008; GFCM, 2010; Morales-Nin et al., 2015; Silvestri et al., 2016; Tunca et al., 2016), with only a few studies for Greek waters, most published in the grey literature (Anagnopoulos et al., 2000; Koutsikopoulos et al., 2009; Moutopoulos et al., 2013; Tsikliras, 2015). As the process of issuing recreational fishing licenses has not been continuous and consistent in Greece and the recording system does not distinguish between active and inactive vessels and fishers, an up-to-date assessment of recreational fisheries (vessels and fishers), which can be potentially used in fisheries management, is challenging and requires alternative approaches (Holdsworth et al., 2018; van Poorten and Brydle, 2018). In fact, since 2014 the Greek Port Police no longer issue licenses for recreational fishing, which practically means that the activity is completely unregulated and the number of recreational fishers and vessels not monitored (unpublished data).

Thus, the objective of the present work was to determine the recreational fishing fleet of the Greek part of the Aegean and Ionian Seas using two independent sources of data (*in situ* monitoring and satellite data); also to highlight the importance, in terms of reliability and cost, of satellite imagery tools in fisheries research and management, especially for remote and isolated areas such as the Greek islands and data-poor areas such as the eastern Mediterranean Sea (Dimarchopoulou et al., 2017). Satellite images are a recent tool in fisheries science and have been used to estimate the boating activity (number and distribution of vessels) in inland waters (Bacela-Spychalska et al., 2013), to count coastal fishing weirs (Al-Abdulrazzak and Pauly, 2014) but also the numbers of fish farm cages across the Mediterranean Sea (Trujillo et al., 2012).

2. Materials and methods

2.1. Study area

The Aegean Sea (GSA 22), together with Cretan Sea (GSA 23), occupy an area of 213,000 km^2 and contain several thousand islands (Fig. 1), around 200 of which are inhabited and attract millions of tourists each summer. The Ionian Sea (GSA 20) occupies an area of 169,000 km^2 and contains seven main islands, that are also attracting millions of tourists, and several smaller ones (Fig. 1). The majority of the Greek population inhabit the Greek coastline, where a lot of fishing, touristic and building activities are concentrated (Moutopoulos et al., 2013).

The Aegean Sea, especially the northern part, is among the most productive areas in the Eastern Mediterranean, in terms of fisheries catches because of the inflow of the nutrient rich, low salinity, Black Sea water, the river flows that enhance the productivity of the coastal zone, and the extended continental shelf (Koutrakis et al., 2004; Tsikliras et al., 2013). The Ionian Sea includes the deepest area of the Mediterranean Sea and serves as an important ground for deep-water fisheries. Its coastal areas, with a large number of lagoons are also productive and support the small-scale coastal fisheries of western Greece (Piroddi et al., 2010).

Several areas of the Aegean and Ionian Seas have been identified as important spawning and nursery habitats for a number of small pelagic and demersal fishes (Tsikliras et al., 2010). Small pelagic fish (European anchovy *Engraulis encrasicolus* and European pilchard *Sardina pilchardus*) dominate the catches of both areas but over 100 fish and invertebrate stocks are being exploited by the coastal vessels, purse-seiners and trawlers (Tsikliras et al., 2013; Stergiou et al., 2016), most of which are understudied (Dimarchopoulou et al., 2017). A large number of species are also targeted by the recreational fisheries but the distribution and quantities of the catch vary regionally (Moutopoulos et al., 2013; Tsikliras, 2015). Most fish and invertebrate stocks of the Aegean and Ionian Seas are considered fully exploited or overfished (Tsikliras et al., 2013), while the probability of the ecosystem being sustainably fished is low (Froese et al., 2018). Total catch has been relatively constant over the recent years following a rapid decline since 1995 in both areas (Tsikliras et al., 2015).

2.2. Survey and data analysis

Two independent methods were used for estimating the recreational fishing fleet of the Greek part of the Aegean (western and northern coastlines and islands, including Crete) and Ionian (southeastern coastline and Greek islands) Seas. Firstly, the recreational fleet was counted by physically surveying 42 ports and marinas of the Aegean coastline and visually counting and photographing the recreational fishing vessels (Fig. 1). Professional small-scale coastal vessels and sailing/motor yachts were identified *in situ* and excluded from the analysis. The survey took place during the summer months (July and August 2016), when the vast majority of recreational vessels are at sea (Keramidas, 2017). The purpose of this survey was to validate the extensive recreational fishing counting using satellite snapshots from Google Earth.

According to the second method, the number of recreational vessels was recorded at the same 42 ports and marinas through satellite snapshots from Google Earth for comparing the two methods and for validating the satellite observations. The entire Aegean and Ionian coastlines and islands were scanned and an additional number of 420 ports and marinas were identified in the Aegean and 200 in the Ionian Sea (Fig. 1). These were also surveyed using Google Earth in order to count the total number of recreational fishing vessels in the area. Only recent snapshots (spanning over the last four years) were selected that were taken during the summer months (July and August) to ensure comparability with the first method. The precision of the snapshots ranged from 15 m to 30 cm. The recreational vessels were counted, whereas professional small-scale coastal vessels and sailing/motor yachts were identified and excluded.

The results for the same ports and marinas using the two independent methods were correlated to validate the satellite data and ensure that it can be used to count the recreational fishing vessels of the area. In order to evaluate the potential conflict of recreational fisheries with the professional small-scale coastal fisheries and identify the hotspots of fleet competition in the Aegean Sea, we also collected the number of the professional small-scale coastal fishing vessels for each fishing subarea as defined by the Hellenic Statistical Authority (Fig. 1).

3. Results

According to the *in situ* recording in 42 ports and marinas of the Aegean Sea coastline, the number of recreational vessels counted was 3290 and ranged between 7 (Myloi in Peloponnese) and 313 (Thessaloniki), while according to the satellite snapshots at the same 42 ports and marinas, the number of recreational vessels counted was 3330 and ranged between 9 (Myloi in Peloponnese) and 369 (Thessaloniki). The two sources of data were strongly positively and linearly correlated (correlation coefficient = 0.96, $P < 0.001$; Fig. 2) indicating that the satellite snapshots are a reliable source of information and can be used to count the number of recreational fishing vessels in the Greek seas. Following the strong correlation between the two sources of data that validates the use of satellite snapshots, satellite snapshots were extracted from Google Earth for 420 additional ports and marinas across

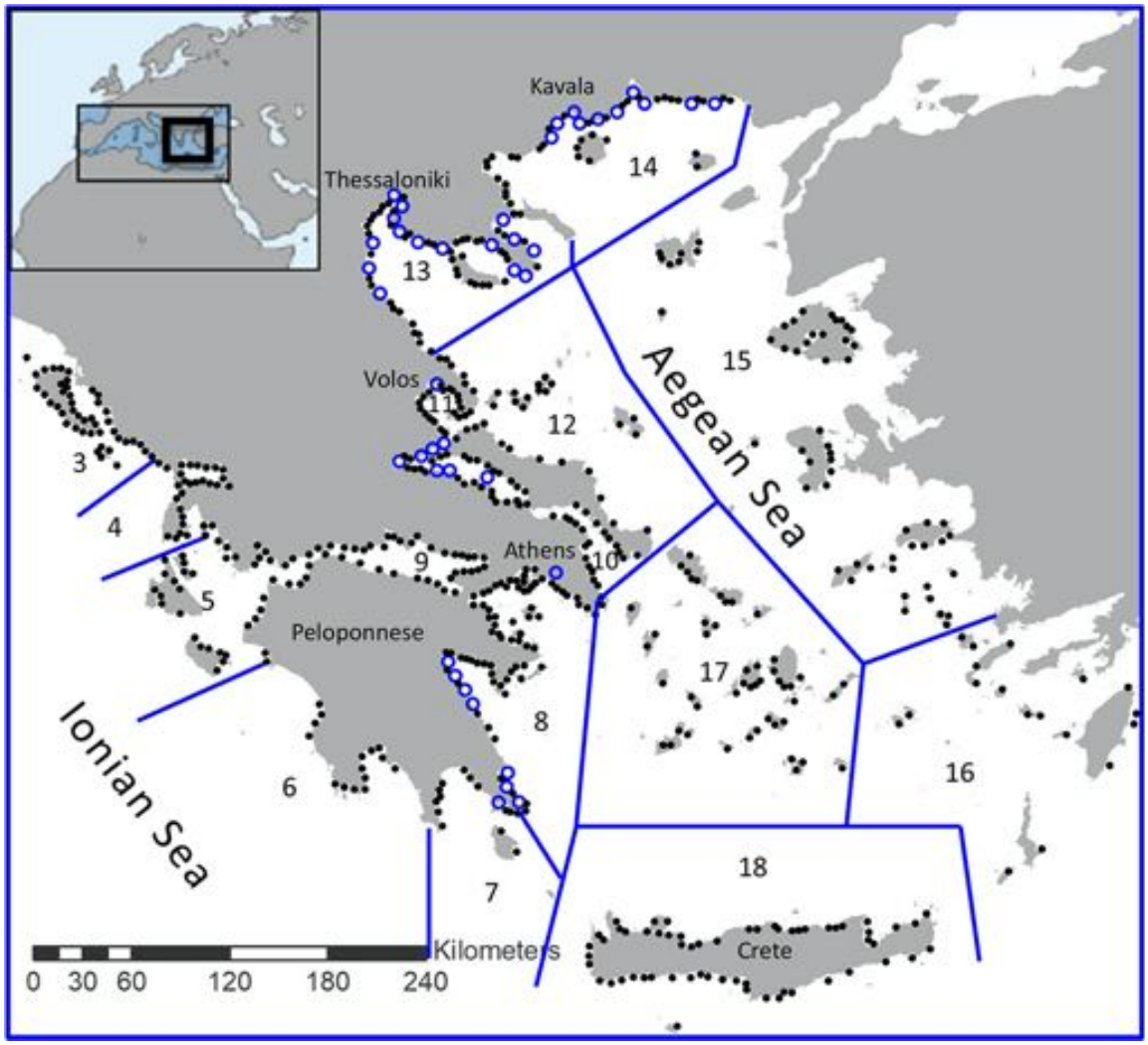

Fig. 1. Map of the Aegean and Ionian Seas showing the visited (open blue circles) and satellite (solid black circles) sampled ports and marinas. The 16 fishing subareas of the Greek waters are shown with their official codes (3: Coasts of Epirus and Corfu; 4: Amvrakikos Gulf and coasts of Lefkada Island; 5: Patraikos Gulf and coasts of Kefalonia and Zakynthos islands; 6: Kyparissiakos and Messiniakos Gulfs; 7: Lakonikos Gulf; 8: Argolikos and Saronikos Gulfs; 9: Korinthiakos Gulf; 10: Maliakos and Evoikos Gulfs; 11: Pagassitikos Gulf; 12: Eastern coasts of Evia and Sporades islands; 13: Thermaikos and Chalkidiki Gulfs; 14: Strymonikos and Kavala Gulfs and Thracian Sea; 15: eastern Aegean Islands; 16: Dodecanese Islands; 17: Cyclades Islands; 18: Crete). Note that subareas (1) and (2) refer to Atlantic Ocean and north African coasts, respectively. The main cities, ports and/or areas mentioned in the text are also indicated. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article).

the Aegean Sea and 200 across the Ionian Sea, including the inhabited islands. According to these counts, the total number of recreational fishing vessels in the Aegean Sea was estimated at around 24,650. Marina Zeas (near Athens) was the place with the most vessels (n = 464) followed by another marina near Athens (Glyfada) and Thessaloniki. In the Ionian Sea the total number of recreational fishing vessels was estimated at around 7000. Xilokastro (subarea 9 of Fig. 1) was the place with the most vessels (n = 210) followed by Preveza (subarea 4) with 179 vessels.

Although some large motor yachts and sailing boats are rarely used for recreational fishing, these two types of vessels (that amounted to around 4750 vessels in the Aegean and around 5000 in the Ionian, *i.e.* a total of around 10,000 vessels; according to the Hellenic Chamber of Shipping the official total number of yachts in Greece was 17,700; HCS, 2012) were excluded from the analysis. Based on those numbers, around 75% of all recreational vessels in Greece are used for fishing. Our analysis also excluded recreational vessels that were at sea at the time the image was taken or those that are kept ashore in yards and garages. Based on our empirical knowledge, previous anecdotal data and the total capacity of all ports and marinas in Greece, we assume that the error on our total estimate regarding vessels at sea should not exceed 10%. The exact number of vessels kept ashore is harder to estimate but it generally refers to small vessels that are used less than twice a week and mostly during the summer months.

According to the fleet register (data for 2016), the number of professional small-scale coastal vessels was 11,716 vessels in the Aegean Sea including the islands and Crete and 3438 vessels in the Ionian Sea including the islands, *i.e.* a total of 15,154 professional small-scale coastal vessels operate in Greek waters (Table 1). However, some of these vessels are inactive and some are semi-professional in the sense that the owner is a part-time fisher and has a second job. The cumulative percentage of inactive and semi-professional boats is estimated at around 30% (unpublished data).

Among the major fishing subareas of the Aegean Sea, Argosaronikos (Argolikos and Saronikos, subarea 8) and Evoikos Gulfs (subarea 10) in the southern Aegean, and Thermaikos Gulf (subarea 13) and Thracian Sea (subarea 14) in the northern part, concentrate the majority of recreational fishing vessels (Table 1, Fig. 3). The number of recreational vessels is also high in island complexes (Cyclades, eastern Aegean and Dodecanese). In the Ionian Sea, most recreational vessels are

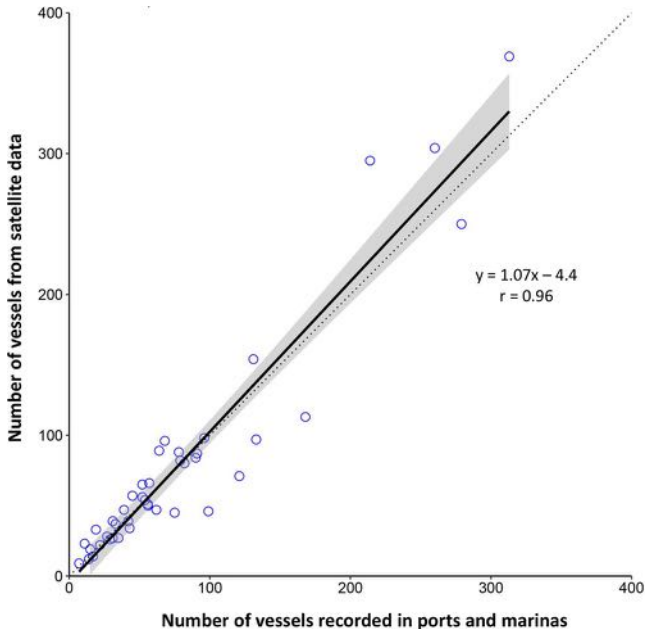

Fig. 2. The correlation between the number of recreational fishing vessels in the ports and marinas that were visited and those sampled using satellite images (n = 42), with the 95% confidence intervals (shaded area). The dotted line indicates the 1:1 ratio.

Table 1
The numbers of recreational vessels (as recorded *via* Google Earth in the present study) and registered professional small-scale coastal vessels (from the fleet register, data for 2016) per main fishing subarea of the Aegean and Ionian Seas (see Fig. 1 for details). In Fig. 3, subareas 8 & 10 and 11 & 12 were combined for visibility purposes.

Code	Area	Number of vessels		Ratio
		Recreational	Coastal	
3	Coasts of Epirus and Corfu	1972	660	2.99
4	Amvrakikos Gulf and Lefkada Island	950	795	1.19
5	Patraikos Gulf, Zakynthos and Kefallonia	1596	1058	1.51
6	Kyparisiakos and Mesiniakos Gulfs	436	275	1.59
7	Lakonikos Gulf	170	163	1.04
8	Argolikos and Saronikos Gulfs	5678	2133	2.66
9	Korinthiakos Gulf	1872	487	3.84
10	Maliakos and Evoikos Gulfs	3638	1449	2.51
11	Pagasitikos Gulf	582	473	1.23
12	Eastern coasts of Evia and Sporades islands	1221	427	2.86
13	Thermaikos and Chalkidiki Gulfs	1517	1479	1.03
14	Strymonikos and Kavala Gulfs and Thracian Sea	1636	973	1.68
15	Eastern Aegean Islands	2799	1953	1.43
16	Dodecanese Islands	2257	1122	2.01
17	Cyclades Islands	3323	881	3.77
18	Crete	1988	826	2.41
	Total	**31,635**	**15,154**	**2.06**

concentrated in Korintiakos (area 9) and Amvrakikos (area 4) Gulfs and in the large islands (Table 1, Fig. 3). The same fishing subareas concentrate the majority of the professional small-scale coastal vessels (Table 1, Fig. 3) since the ratio of recreational to professional coastal fishing vessels exceeds 2 and near Athens (Argolikos, Saronikos and Evoikos and Korinthiakos Gulfs) where half of the population of Greece lives (Table 1, Fig. 3).

4. Discussion

Although recreational fishing poses an increasingly popular activity in the Mediterranean yielding considerable amount of catches that add up to the biomass extracted by professional fisheries from the ecosystem (GFCM, 2010; Lloret and Font, 2013), its magnitude is rarely accurately assessed since the size of the recreational fishing fleet and its catches are incompletely recorded or even omitted from official catch statistics on a global scale (Pauly and Zeller, 2016). The same situation holds for Greek waters in which the recreational and subsistence fisheries may exceed 15% of the official landings (Moutopoulos et al., 2013, 2016a,b).

Regarding the estimation of the recreational fishing fleet, several methods have been applied such as utilizing information from fishing licenses, performing telephone surveys and *in situ* interviews with questionnaires (Morales-Nin et al., 2005), which can, however, at times be inaccurate or time consuming and costly. Therefore, alternative methods, as is the use of satellite images that are considered reliable, could potentially be employed as efficient complementary sources of data (Bacela-Spychalska et al., 2013). Google Earth, a freely available software that offers 3D representation of the earth based on satellite imagery, aerial photography and GIS data (https://www.google.com/earth/), makes even the most remote locations accessible to scientific research and offers a plethora of data to scientists. It has been previously used on testing ecological theories (Madin et al., 2011), estimating forest biomass (Ploton et al., 2012), counting the number of cages in aquaculture units (Trujillo et al., 2012), as well as measuring fishing effort in areas not easily accessible (Al-Abdulrazzak and Pauly, 2014). In the present work, data from Google Earth was very highly correlated to *in situ* observations in randomly selected ports and marinas and was therefore used to extend the estimation of the number of recreational fishing vessels throughout the Aegean and Ionian Seas, with a very low (< 10%) probability of error. The error is in fact a potential underestimation of the recreational fishing fleet owing to the number of vessels kept ashore at the time of sampling and to the yachts that may be occasionally (estimated to be less than 5% for yachts exceeding 10 m in length: HCS, 2012) used for recreational fishing but were excluded from the analysis.

Research on recreational fisheries, apart from improving the knowledge on the actual fishing pressure on stocks, also identifies the potential competition with professional fisheries, especially with small-scale coastal fisheries, which is stronger in the Mediterranean Sea (Lloret et al., 2008; Lloret and Font, 2013; Silvestri et al., 2016). It has been reported that recreational fisheries largely overlap with small-scale coastal fisheries in terms of targeted species resulting in considerable conflict between the two activities (Ünal et al., 2010; Tunca et al., 2016) especially since some fishers are semi-professional or semi-recreational. In Greece, the conflict is even stronger because in some coastal areas and across the islands recreational fishing vessels outnumber professional ones by a factor of two (Table 1, Fig. 3) and also because recreational fishing is also conducted from shore, from vessels and underwater (Moutopoulos et al., 2013). According to a study on recreational fisheries of Greece, in the late 1990s, a total of 70,000 recreational fishing vessels were registered across the Greek waters, *i.e.* Aegean and Ionian Seas combined (Anagnopoulos et al., 2000). At that time the professional fishing vessels were largely outnumbered (then around 16,000 across the Greek waters). Based on the records of the Port Police (Department of Fisheries Control, data available online at http://www.hcg.gr/alieia/statistika/statistika.php), in 2013 (last year with the state obligation to issue fishing licenses), 11,110 new recreational fishing vessel licenses were issued and 27,810 were renewed by the Greek Port Police resulting to a total of 39,000 recreational vessels licensed for fishing in Greek waters. The corresponding number of individual fishing licenses for 2013 was 87,550 (34,780 issued and 52,870 renewed). Considering that some of the sailing yachts that are chartered during the summer do have a fishing license but were excluded from our analysis, the records of the Port Police closely agree with the number of vessels we counted using satellite data.

It should be noted here that some recreational fishers sell their catch

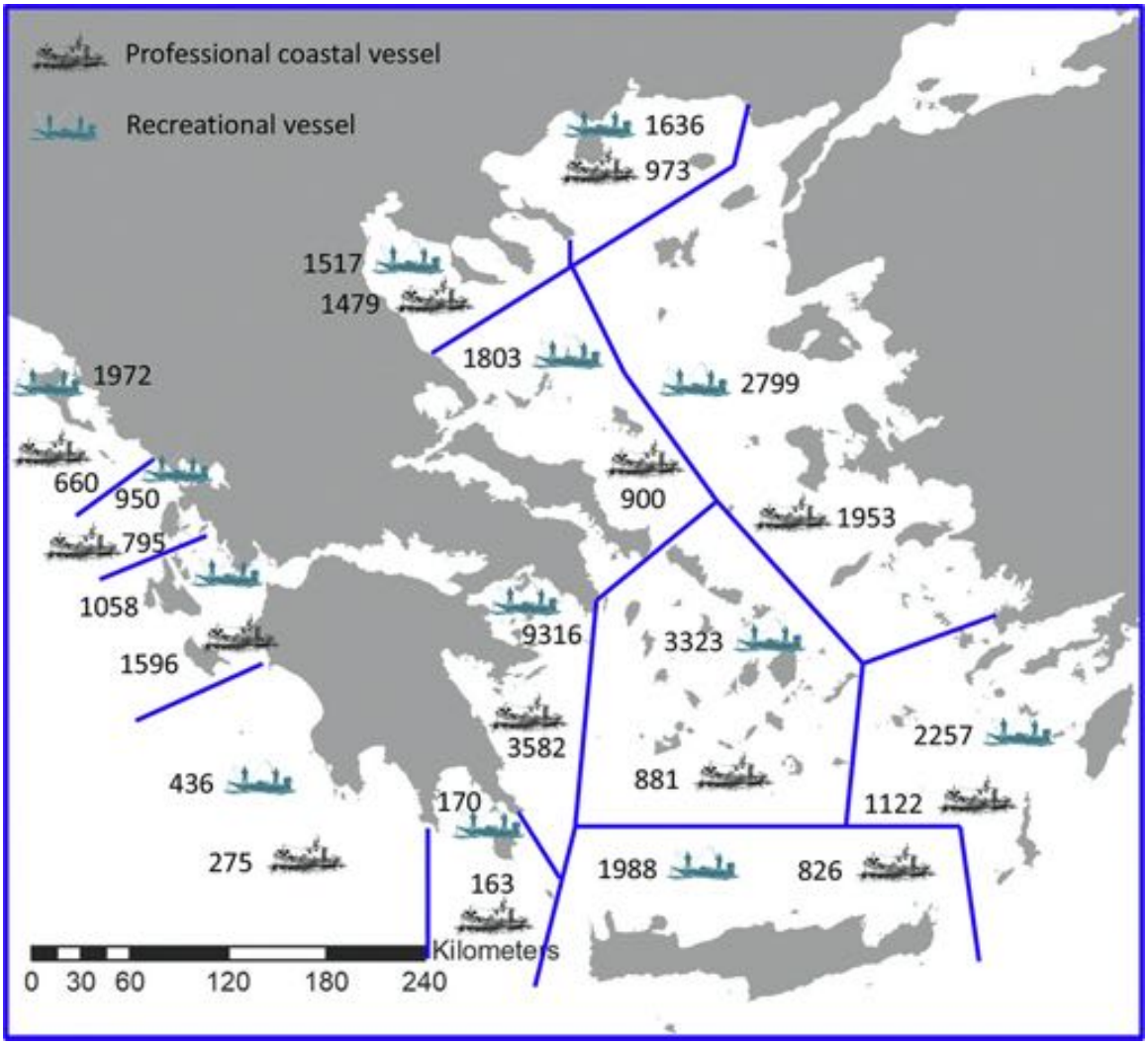

Fig. 3. Map of the Aegean and Ionian Seas showing the distribution and numbers of recreational vessels (as recorded *via* Google Earth in the present study) and registered small-scale professional vessels (from the fleet register) per main fishing subarea (see Table 1 for details).

to tavernas and restaurants and in the black market, a practice that is unofficially known but has never been evaluated in Greece. Apart from targeting the same stocks, this practice creates financial conflict with the professional small-scale coastal fisheries that operate in the same areas and are also selling directly to tavernas and restaurants. Both professional and recreational fishing constitute an integral part of the economy and society in many coastal and island communities (Ünal et al., 2010; Tunca et al., 2016). Professional fishing, and all the related activities, is characterized by a particularly dynamic economy, even though it employs only a small part of the population in Greece and, on the other hand, recreational fishing adds to local financial income through attracting interested tourists. Nevertheless, the excessive recreational fishing along with the lack of official catch reporting hinders any attempt of designing and implementing realistic and effective management plans (Lloret et al., 2008; Koutsikopoulos et al., 2009) and, at the same time, can have negative effects on the marine environment (Cooke and Cowx, 2004) by disturbing biodiversity and habitats (Gaudin and De Young, 2007).

In conclusion, the results of the present work highlight the importance, in terms of high reliability and low cost, of satellite imagery tools in fisheries research and management but also the need to adequately estimate the excessive fishing effort applied on the stocks in remote island areas where fishing activity (professional and recreational) is rarely monitored. It also provides a method of counting the recreational fishing fleet, the size of which may have wider implications concerning the impact of discharged motor pollutants and noise disturbance on the ecosystem, fish, seabirds, and marine mammals as well as mechanical damage caused on seagrass meadows (Lloret et al., 2008). These effects that have also been recorded in areas outside the Mediterranean highly depend on the size and activity of the recreational fleet (Widmer and Underwood, 2003). Future research should be focused on the actual activity of the recreational fishing vessels in terms of days at sea, the quantity and composition of catches as well as the baits that are used.

References

Al-Abdulrazzak, D., Pauly, D., 2014. Managing fisheries from space: Google Earth improves estimates of distant fish catches. ICES J. Mar. Sci. 71, 450–454.
Anagnopoulos, N., Papaconstantinou, C., Oikonomou, A., Papaharisis, L., Frangoudes, K., 2000. Sport fisheries in eastern Mediterranean (Greece and Italy): parameter estimates, linkages and conflict with professional fisheries. Proceed. Hell. Conf. Ichthyol., vol. 9, 295–299.
Arlinghaus, R., Tillner, R., Bork, M., 2015. Explaining participation rates in recreational fishing across industrialised countries. Fish. Manag. Ecol. 22, 45–55.
Bacela-Spychalska, K., Grabowski, M., Rewicz, T., Konopacka, A., Wattier, R., 2013. The 'killer shrimp' *Dikerogammarus villosus* (Crustacea, Amphipoda) invading Alpine lakes: overland transport by recreational boats and scuba-diving gear as potential entry vectors? Aquat. Conserv. Mar. Fresw. Ecosyst. 23, 606–618.
Cooke, S.J., Cowx, I.G., 2004. The role of recreational fishing in global fish crises. Bioscience 54, 857–859.
Dimarchopoulou, D., Stergiou, K.I., Tsikliras, A.C., 2017. Gap analysis on the biology of

Mediterranean marine fishes. PLoS One 12, e0175949.
Froese, R., Winker, H., Coro, G., Demirel, N., Tsikliras, A.C., Dimarchopoulou, D., Scarcella, G., Quaas, M., Matz-Lück, N., 2018. Status and rebuilding of European fisheries. Mar. Pol. 93, 159–170.
Gaudin, C., De Young, C., 2007. Recreational Fisheries in the Mediterranean Countries: A Review of Existing Legal Frameworks. Studies and Reviews, vol. 81. General Fisheries Commission for the Mediterranean, pp. 1–85.
GFCM, 2010. Report of the Transversal Workshop on the Monitoring of Recreational Fisheries in the GFCM Area. Scientific Advisory Committee (SAC), General Fisheries Commission for the Mediterranean, Palma de Majorca, Spain 20–22 October 2010, p. 31.
HCS, 2012. Study on the Importance of Yachting in Marine Tourism and National Economy. Hellenic Chamber of Shipping, Greece p. 199.
Holdsworth, J.C., Hartill, B.W., Heinemann, A., Wynne-Jones, J., 2018. Integrated survey methods to estimate harvest by marine recreational fishers in New Zealand. Fish. Res. 204, 424–432.
Keramidas, I., 2017. Counting the Greek Recreational Fishing Fleet from Space. Master Thesis. School of Biology, Aristotle University of Thessaloniki, Greece.
Koutrakis, E.T., Kallianiotis, A.A., Tsikliras, A.C., 2004. Temporal patterns of larval fish distribution and abundance in a coastal area of northern Greece. Sci. Mar. 68, 585–595.
Koutsikopoulos, K., Poulos, K., Christodoulou, B., 2009. Comparison of basic fisheries data from various sources of information. Proceed. Hell. Symp. Oceanogr. Fisher., vol. 9, 1–4.
Lewin, W.-C., Arlinghaus, R., Mehner, T., 2006. Documented and potential biological impacts of recreational fishing: insights for management and conservation. Rev. Fish. Sci. 14, 305–367.
Lloret, J., Font, T., 2013. A comparative analysis between recreational and artisanal fisheries in a Mediterranean coastal area. Fish. Manag. Ecol. 20, 148–160.
Lloret, J., Zaragoza, N., Caballero, D., Riera, V., 2008. Biological and socioeconomic implications of recreational boat fishing for the management of fishery resources in the marine reserve of Cap de Creus (NW Mediterranean). Fish. Res. 91, 252–259.
Madin, E.M.P., Madin, J.S., Booth, D.J., 2011. Landscape of fear visible from space. Sci. Rep. 1, 14.
Morales-Nin, B., Moranta, J., Garcia, C., Tugores, M.P., Grau, A.M., Riera, F., Cerda, M., 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. ICES J. Mar. Sci. 62, 727–739.
Morales-Nin, B., Cardona-Pons, F., Maynou, F., Grau, A.M., 2015. How relevant are recreational fisheries? Motivation and activity of resident and tourist anglers in Majorca. Fish. Res. 164, 45–49.
Moutopoulos, D.K., Katselis, G., Kios, K., Tsotskou, A., Tsikliras, A.C., Stergiou, K.I., 2013. Estimation and reconstruction of shore-based recreational angling fisheries catches in the Greek Seas (1950-2010). J. Biol. Res. 20, 376–381.
Moutopoulos, D.K., Bailly, N., Tsikliras, A.C., Stergiou, K.I., 2016a. Greece (Crete). In: Pauly, D., Zeller, D. (Eds.), Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts. Island University Press, Washington DC p. 279.
Moutopoulos, D.K., Tsikliras, A.C., Stergiou, K.I., 2016b. Greece (excluding Crete). In: Pauly, D., Zeller, D. (Eds.), Global Atlas of Marine Fisheries: a Critical Appraisal of Catches and Ecosystem Impacts. Island University Press, Washington DC p. 278.
Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., Torres, F.Jr., 1998. Fishing down marine food webs. Science 279, 860–863.
Pauly, D., Zeller, D., 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. Nat. Commun. 7, 10244.
Pawson, M.G., Glenn, H., Padda, G., 2008. The definition of marine recreational fishing in Europe. Mar. Pol. 32, 339–350.
Piroddi, C., Bearzi, G., Christensen, V., 2010. Effects of local fisheries and ocean productivity on the northeastern Ionian Sea ecosystem. Ecol. Model. 221, 1526–1544.
Ploton, P., Pelissier, R., Proisy, C., Flavenot, T., Barbier, N., Rai, S.N., Couteron, P., 2012. Assessing aboveground tropical forest biomass using Google Earth canopy images. Ecol. Appl. 22, 993–1003.
Ryan, K.L., Trinnie, F.I., Jones, R., Hart, A.M., Wise, B.S., 2016. Recreational fisheries data requirements for monitoring catch shares. Fish. Manag. Ecol. 23, 218–233.
Silvestri, R., Colella, S., De Rabieri, S., Mannini, P., 2016. Italian marine recreational fishery: state of the art and interactions with artisanal fishery. Biol. Mar. Mediterr. 23, 30–36.
Stergiou, K.I., Somarakis, S., Triantafyllou, G., Tsiaras, K.P., Giannoulaki, M., Petihakis, G., Machias, A., Tsikliras, A.C., 2016. Trends in productivity and biomass yields in the Mediterranean Sea large marine ecosystem during climate change. Environ. Dev. 17 (Suppl. 1), 57–74.
Trujillo, P., Piroddi, C., Jacquet, J., 2012. Fish farms at Sea: the ground truth from Google Earth. PLoS One 7, e0134745.
Tsikliras, A., 2015. Social networks reveal composition of unreported catches: “checking-in” on spearfishing. Proceed. Hell. Symp. Oceanogr. Fisher. Vol. 11, 213–216.
Tsikliras, A.C., Antonopoulou, E., Stergiou, K.I., 2010. Spawning period of Mediterranean marine fishes. Rev. Fish Biol. Fish. 20, 499–538.
Tsikliras, A.C., Tsiros, V.-Z., Stergiou, K.I., 2013. Assessing the state of Greek marine fisheries resources. Fish. Manag. Ecol. 20, 34–41.
Tsikliras, A.C., Dinouli, A., Tsiros, V.-Z., Tsalkou, E., 2015. The Mediterranean and Black Sea fisheries at risk from overexploitation. PLoS One 10, e0121188.
Tunca, S., Ünal, V., Miran, B., Güçlüsoy, H., Gordoa, A., 2016. Biosocioeconomic analysis of marine recreational fisheries: a comparative case study from the Eastern Mediterranean, Turkey. Fish. Res. 174, 270–279.
Ünal, V., Acarli, D., Gordoa, A., 2010. Characteristics of marine recreational fishing in the Çanakkale Strait (Turkey). Mediterr. Mar. Sci. 11, 315–330.
van Poorten, B.T., Brydle, S., 2018. Estimating fishing effort from remote traffic counters: opportunities and challenges. Fish. Res. 204, 231–238.
Widmer, W.M., Underwood, A.J., 2003. Factors affecting traffic and anchoring patterns of recreational boats in Sydney Harbour, Australia. Landsc. Urban Plan. 66, 173–183.