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Informing the general public on the threat status of the European spiny lobster, Palinurus elephas (Fabricius, 1787) through Citizen-Science and social media platforms. A case study from the Aegean Sea

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Informing the general public on the threat status of the European spiny lobster, *Palinurus elephas* (Fabricius, 1787) through Citizen-Science and social media platforms: A case study from the Aegean Sea

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Abstract

Research known as Citizen Science (CS) has been recognized as an important tool for both biodiversity restoration and fisheries management projects through the active involvement of citizens, with the aim of raising public environmental awareness. CS projects should be well designed and ask clear questions that will benefit both the research goals and the citizen scientists themselves. In January 2019, the "Red Fish Project" group was created on Facebook (FB) consisting of SCUBA divers and fishers and offering the main data source and the relevant digital material. The project's setup was based on previous personal experiences, and it was following specific protocols. Further information, such as the exact location and depth of the observation was provided by personal communications. By 21st October 2020, the FB group consisted of 464 members who recorded 348 European spiny lobster individuals from all sub-regions of the Aegean Sea. Based on the findings of the present study it became apparent that most of the citizens were unaware that the species is listed as "Vulnerable" in the International Union for Conservation of Nature (IUCN) Red List. Lastly, we discuss the importance of the spiny lobster in the country's culture. The species can be listed as a charismatic, flagship species for citizens to be ocean-literate since it has been shown, that it can raise the interest of recreational divers and increase their awareness.

Keywords: Ocean literacy; citizen-science; spiny lobster; threatened species; Aegean Sea, Mediterranean.

Introduction

Citizen science (CS) is defined as the active involvement of citizens with environmental awareness at research covering both the terrestrial and the marine environment. Considering the marine realm, it has been lately recognized that CS is an important tool for both biodiversity restoration and fisheries management projects (Fairclough *et al.*, 2014; Lloyd *et al.*, 2020). On a global scale, most marine CS projects consider marine litter, non-indigenous species, seabirds, marine mammals, and sea turtles (Krželj *et al.*, 2020). The use of social media is widely applied in CS projects, and it is documented that it is beneficial for both quick data and information sharing (Miyazaki *et al.*, 2016; Giovos *et al.*, 2019). Groups of people with relatively high environmental awareness, such as SCUBA divers, are amongst the most proper, usually being well-trained successfully used in CS projects, having the ability to provide results of excellent precision (Gerovasileiou *et al.*, 2016; Changeux *et al.*, 2019). Moreover, the fisher's Local Ecological Knowledge (LEK) is vital and very often used in CS projects. Relative examples of cooperative CS programmes, involving scientists, SCUBA divers, and fishers include the monitoring of endangered fish species (Andrews *et al.*, 2019), or the reassessment of the exploitation rate of the spiny lobster *Jasus frontalis* (H. Milne Edwards, 1837) (Eddy *et al.*, 2010). Though there are arguments, the data originating from such-like studies can be credible, especially in cases where the species or habitat of interest are relatively easily identifiable (e.g., Coralligenous formations - Gerovasileiou *et al.*, 2016; Sharks - Gibson *et al.*, 2019).

CS projects should be well-designed and ask clear questions, that will benefit both the research goals and the citizen scientists themselves (Steven *et al.*, 2019). Meaning that suchlike projects should aim to increase

ocean literacy among citizens, i.e., increase their knowledge about the ocean, their communication ability about it and the associated anthropogenic threats, and eventually their active participation in decision making (Fauville *et al*., 2015). It is strongly believed that when people understand in-depth issues relevant to the marine environment, their beliefs and actions may change towards its protection and sustainable use of its resources (Guest *et al.*, 2015; Mogias *et al.*, 2019; Kelly *et al.*, 2021).

There is no doubt that ocean-literate citizens are urgently needed, since the ocean's health, today more than ever, is threatened and declined by many anthropogenic activities. Climate change, marine pollution, and overharvesting of marine biological resources (amongst others) are variously impacting both the marine environment and humans. However, and despite the increased threats, the level of ocean literacy is rather low worldwide (Guest *et al.*, 2015) and the Mediterranean region is not an exemption (Mokos *et al.*, 2020). It is fundamental for human societies to understand that there is an amphidromous influence between them and the ocean and therefore it is necessary to follow the initiatives of the sustainable use of marine resources. This way, a continuous interaction among scientific experts, policymakers, and the public can be achieved (Fauville *et al.*, 2015; 2019). The United Nations (UN), through the Ocean Decade, is aiming to generate scientific data, information, and to transfer knowledge and experience at the public. The UN sets seven thematic pillars: (1) marine pollution, (2) healthy ecosystems via restoration and conservation, (3) sustainable food support via fisheries management, (4) understanding ocean via literacy, (5) promoting ocean safety to life and livelihoods by ocean associated hazards, (6) ocean open data via data sharing and (7) inspiring and directly engaging societies (UNESCO-IOC, 2021).Nowadays it is well recognised that ocean literacy could significantly contribute towards the Sustainable Development Goals of the United Nations and under the 2030 Agenda (Fritz *et al.*, 2019; Ferreira *et al.*, 2021).

Having in mind the significant gap on such like activities, regarding threatened taxa in Greece, the need to create a targeted project was identified and in December 2018, the "Red Fish Project" was established. Following initial efforts in January 2019, the "Red Fish Project" group was created on Facebook (FB). The project focused on four marine fishery resources in the Mediterranean Sea: the Dusky Grouper *Epinephelus marginatus* (Lowe, 1834), classified as "Endangered" in the IUCN Red List of Threatened Species, the Common dentex *Dentex dentex* (Linnaeus, 1758), classified as "Vulnerable", the Green Wrasse *Labrus viridis* Linnaeus, 1758, classified as "Vulnerable", and the European Spiny Lobster *Palinurus elephas* (Fabricius, 1787), also classified as "Vulnerable". Further information regarding the threat status of the species of interest was provided through the FB group narratively and referring to well-known examples both from the marine [e.g., the Mediterranean Monk Seal *Monachus monachus* Hermann, 1779 and the Loggerhead Sea Turtle *Caretta caretta* (Linnaeus, 1758)] and the terrestrial environment, that many people are familiar with their threat status. Also, in an effort to boost public participation and engagement, the relative information was shared in online articles in Greek media (https://www.grtimes.gr/diafora/perivallon/se-apeili-o-astakos-i-synagrida-kai-o), considering that diverse actions may trigger behavioural changes by the public towards their protection and conservation (McCauley *et al.*, 2019). In summary, the project's main research questions were: (a) Is the wider public aware that certain fisheries resources are threatened and listed in the IUCN Red List? (b) Can the project be used as an effective tool to trigger citizens and specific professional groups to obtain data on the species distribution, abundance, and habitat in the Mediterranean Sea? (c) Can the project be used as an effective tool on the relevant fisheries methods and techniques? (d) Is it possible to use such projects as a conservation and restoration initiative in the Mediterranean region?

The present paper aims to inform about the knowledge the general public has on the threat status of the European spiny lobster *P. elephas* based on the findings associated with the CS project "Red Fish Project" and provide additional information on the distribution, population density, habitat preference and use as well as depth range of the species based on records from the Aegean Sea.

Materials and Methods

The European spiny lobster *Palinurus elephas* (Fabricius, 1787), is a species that occurs and is harvested in the Mediterranean and in adjacent Atlantic waters from North Africa to Scotland, UK (Goñi & Latrouite, 2005). It is a data-limited species (Marengo *et al.*, 2020), especially at the population level and the relative fisheries data are scarce and usually local or regional (Goñi & Latrouite, 2005). It is the only spiny lobster species in the eastern Mediterranean Sea, dwelling in shallow waters up to 200 m, commonly found in hard substrates, though several individuals have been observed in coarse bottoms (i.e., "scuddy" grounds), sand beds, and mixed sediments. Existing data of the relevant fisheries are scarce and are usually local or regional, making it uncertain when fishermen began to fish beyond sustainable limits, though non-selective netting is negatively impacting population size (Kampouris *et al.*, 2020 and references therein).

P. elephas is a species that presents several advantages in CS projects, that minimize any potential misidentifications by the users, a key factor for any CS project's success (Gerovasileiou *et al.*, 2016). Namely, its external morphology is quite unique and is the only spiny lobster species occurring in the eastern Mediterranean waters (Groeneveld *et al.*, 2013), thus making it quite easy to be correctly identified by the public. Furthermore, the species is included at the IUCN Red List of Threatened Species and is popular among recreational divers. All participants of the "Red Fish Project" were asked to provide, apart from species records, additional data referring to abiotic factors such as depth and substrate type of the studied areas as well as the associated activity (e.g., fishing, diving) through which they have obtained their

records. The main data source was the FB group where citizen scientists could upload their observations along with digital material (photos and/or videos). Further information regarding the specific location (with coordinates), depth, and habitat was provided by personal communications (direct messages, e-mails, or phone calls).

The project's impact on public participation and engagement was assessed through the online system (FB group insights), provided by the social media platform itself. The engagement assessment was based on parameters such as group members, active involvement, gender, age groups, location (region, and city), etc. Currently, the FB group of the "Red Fish Project" covering all four marine fishery resources in the Mediterranean Sea counts 513 members (14 April 2021 status), and more than half are actively involved in the project. Noteworthy, the actual number of the people involved is higher, since several of them do not have a FB account and are communicating with the project managers directly or through e-mail (personal communications).

Finally, several records of spiny lobsters were obtained by fishers' Local Ecological Knowledge (LEK), mostly by professional and amateur fishers.

All records obtained were assigned to different habitat types according to the EU Habitats Directive 92/43. A brief description of Habitats types in which *P. elephas* individuls were recorded is as follows: Habitat type 1110_B: biocommunities of coarse-grained sandbanks with gravel, with strong bottom currents, presence of "maërl" (deeper waters – lower infralittoral and circalittoral zones, Habitat type 1170_A: biocommunities of rocky substrates of upper infralittoral zone, Habitat type 1170_B: biocommunities of rocky substrates of lower infralittoral zone and circalittoral zone and Habitat type 8330: Submerged or partially submerged sea caves.

Finally, all records obtained were mapped with the use of ArcGIS/ArcMap 10.5, on the layer maps and data from OpenStreetMap and OpenStreetMap Foundation (©OpenStreetMap contributors).

Results

By 21st October 2020, the FB group established in the framework of the "Red Fish Project", which provided most of the spiny lobster records, consisting of 464 members (307 men and 157 women). The age range for men was from 13-65+ years (average of 44 years) and the age range for women was 18-65+ years (average of 22.5 years). Young men between 25 and 44 years represented 33% of all participants, while women of the same age group represented 21% (Fig. 1). Most professional fishers were men, and one was a woman. All amateur fishers that participated were men. Moreover, though that most SCUBA divers ≈66% were men (Fig. 2).

The present study recorded 348 spiny lobster individuals obtained, mostly by professional fishers (83.91%) and to a lesser degree by SCUBA divers (15.23%) and

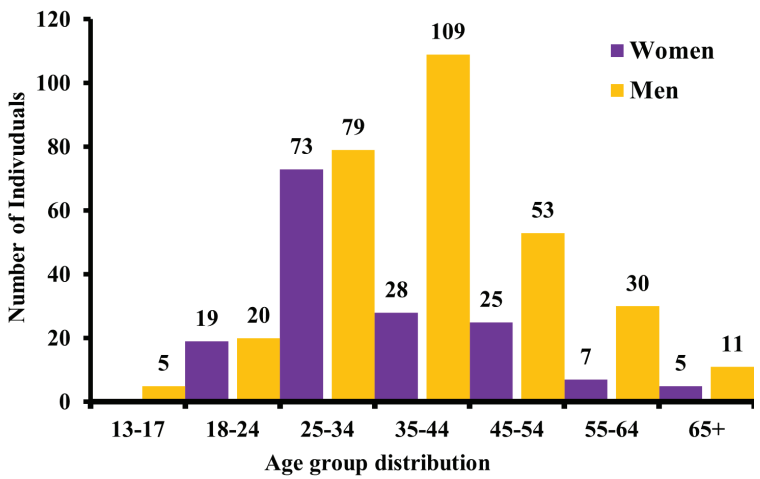

Fig. 1: The age range of the 'Red Fish Project' members at the Facebook group, as provided by the social media platform.

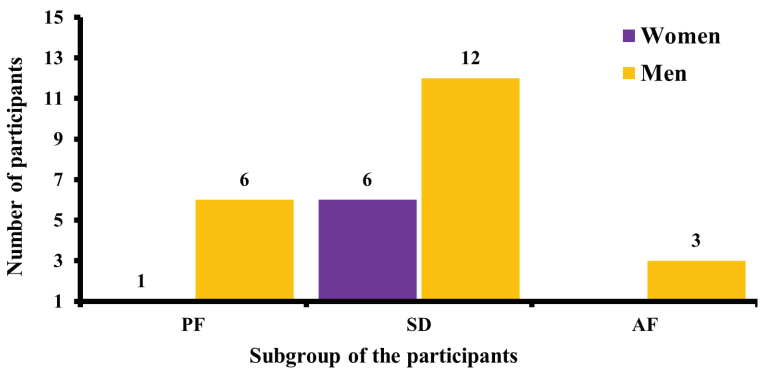

Fig. 2: The number and gender of Professional Fishers (PF), SCUBA divers (SD), and Amateur Fishers (AF) from all regions that provided the spiny lobster records of the study.

amateur fishers (0.86%), from different areas of the Aegean Sea: (a) the Cretan Sea, (b) Dodecanese Islands, (c) Peloponnese, (d) Saronic Gulf, (e) Cyclades Islands, (f) Lesvos Island, (g) Psara-Antipsara Islands, (h) Sporades Islands and (i) Chalkidiki Peninsula (Fig. 3). The areas with the highest records were Chalkidiki Peninsula, Sporades Islands, and the remote Psara-Antipsara Islands (Fig. 4). The spiny lobster records cover a wide range of depths from 1m (Sigri Bay, Lesvos Island) to 180 m (Psara-Antipsara islands), distributed in four ecological zones and four habitat types according to the EU Habitats Directive 92/43 (Table S1). The records from the Chalkidiki Peninsula cover all zones [(a) Upper Infralittoral, (b) Lower Infralittoral, (c) Upper Circalittoral and (d) Lower Circalittoral zones] and two Habitat types [(a) Habitat type1110_B and (b) Habitat type 1170_A] (Figs 5A, 5B). Also, the records from Sporades islands cover three ecological zones [(a) Lower Infralittoral, (b) Upper Circalittoral and (c) Lower Circalittoral zones] and three Habitat types [(a) Habitat type1110_B, (b) Habitat type1170_A and (c) Habitat type 8330]. (Figs 5A, 5B). Lastly, all records from Psara-Antipsara islands regard only one ecological zone (Lower Circalittoral zone) and one Habitat type (Habitat type 1170_B) (Fig. 5B). All available information on the spiny lobster records from the Aegean Sea is analytically presented in the supplementary material provided.

Discussion

One of the initial goals of the "Red Fish Project" was to inform the general public about the threat status of several fisheries resources such as the spiny lobster. Based on the findings of the present study it seems that most of the public was unaware that the species is included in the Red List of Threatened Species. Most of them were surprised, when the project's administrators and moderators informed them, by posts and direct messages, about the species' threat status. Their response, when approached to join the FB group and to contribute with posts and material was mixed. Many were eager while most of the SCUBA divers, professional fishers and anglers were actively and constantly participating. Though most of the group's members were recreational divers, most of the records were obtained by professional fishers. Others were willing to join the FB group, but they did not actively contribute, or their contribution was sporadic. Furthermore, some people were not just negative or sceptical towards the present project, but they were denying any provided evidence - regarding the threat status (the online factsheets of IUCN). The project was also beneficial for the participants themselves, converting their initial surprise to interest and to a better understanding of the fact that fisheries' resources occurring in the Mediterranean Sea and Greek seas in particular, may also include threatened species, such as the spiny lobster. The project provided the opportunity to communicate and clarify to the wider public the differences of the ecological terms "rare", "threatened" and "protected" species, therefore contributing towards a better understanding of several issues of the marine environment. Also, through direct dialog, the group's members were able to communicate with each other and discuss their viewpoints and/or areas of disagreement. The project contributed positively to the community of professional fishers who, although they

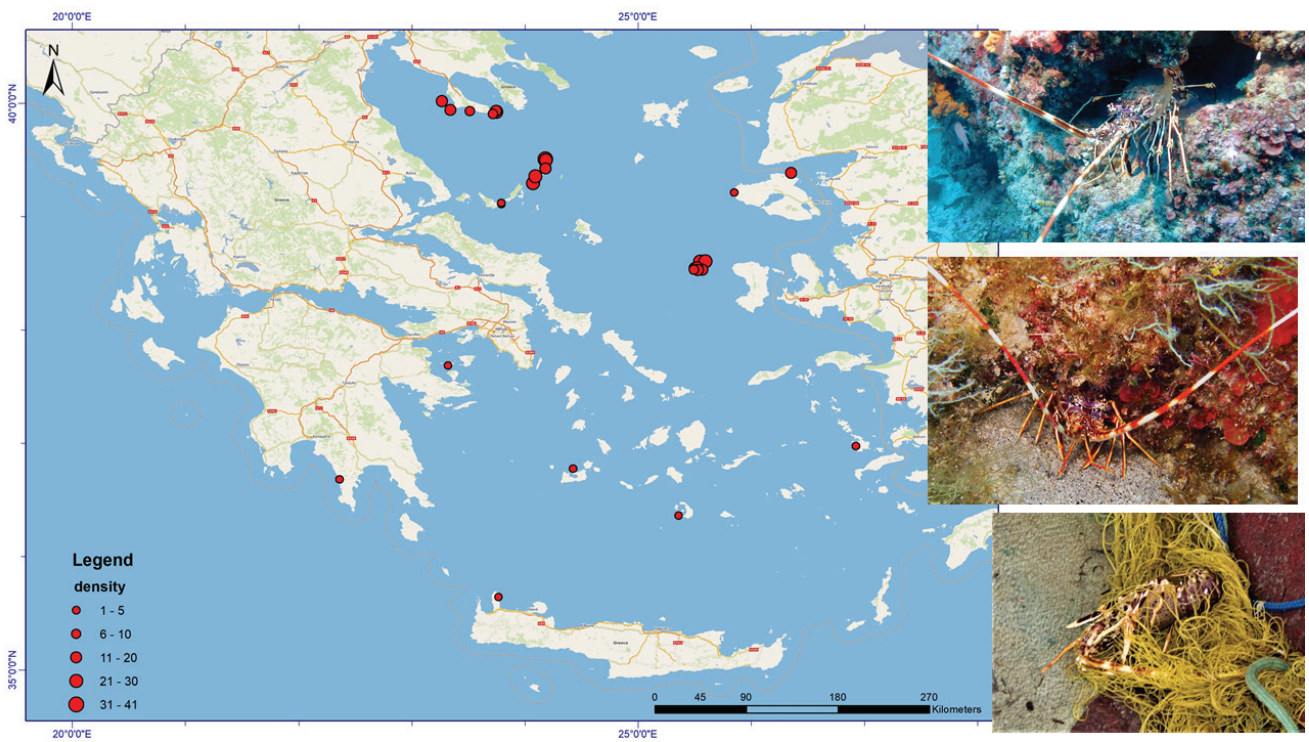

Fig. 3: The study areas from Greek waters. Marked with red circles. Inlaid photos (top to bottom) by: Milorad Mikota Djuknic, Christos Efthymiou and Dimitris Ganigiannis.

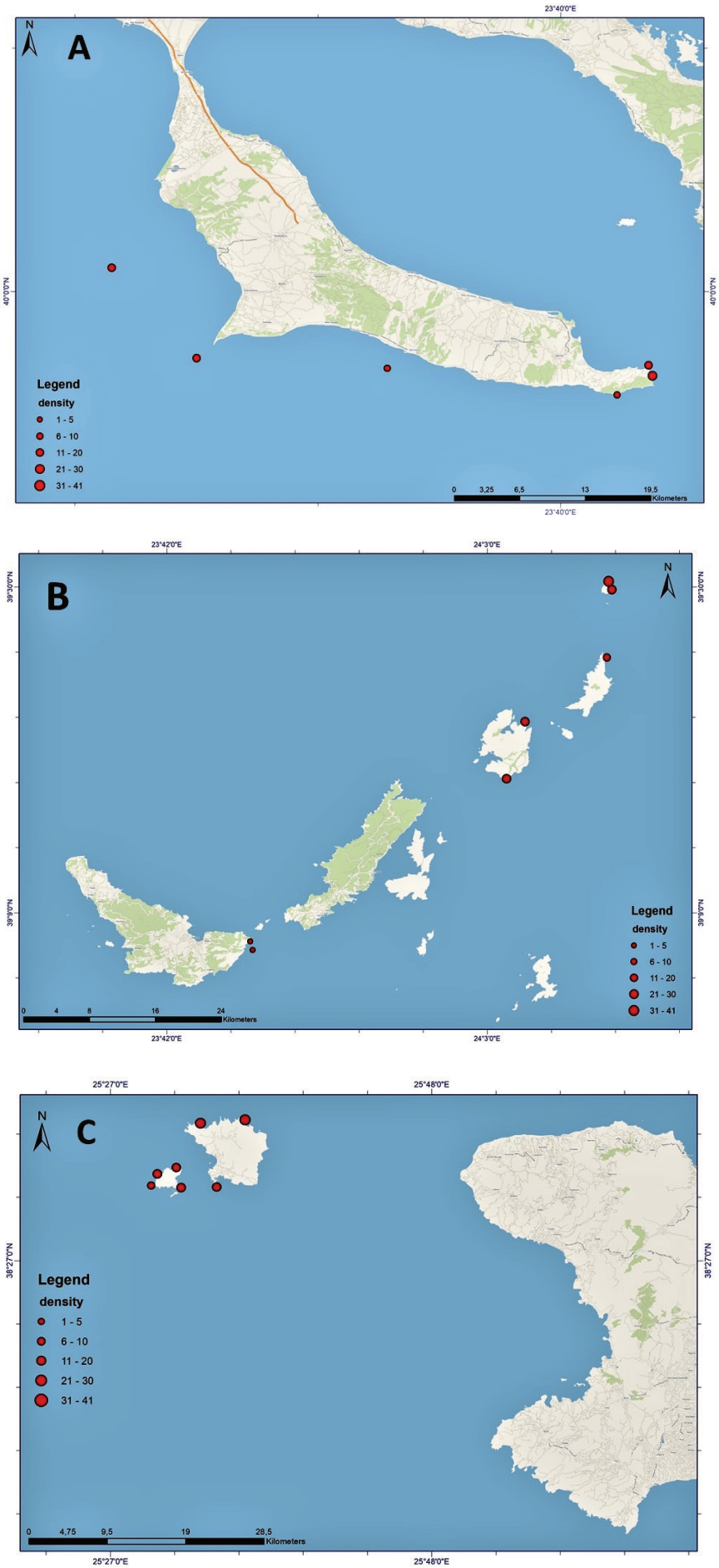

Fig. 4: The density of spiny lobster records from: (A) Chalkidiki Peninsula, (B) Sporades Islands, and (C) Psara-Antipsara Islands.

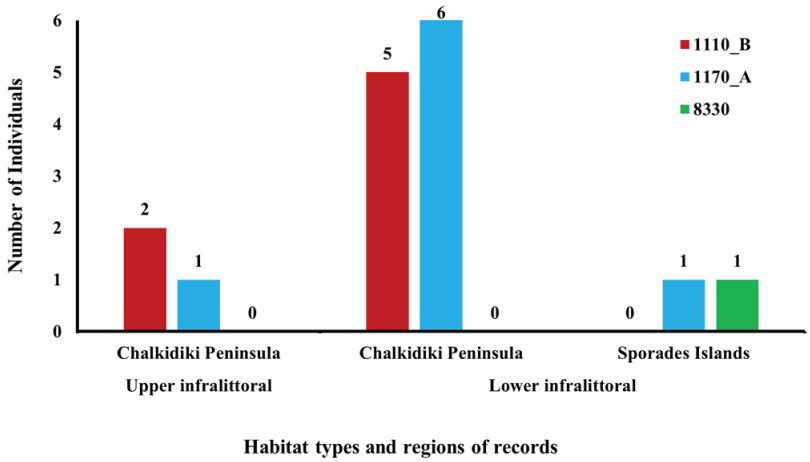

Fig. 5A: The number of spiny lobster individuals per habitat type and region. All records regard the Upper and Lower Infralittoral zones.

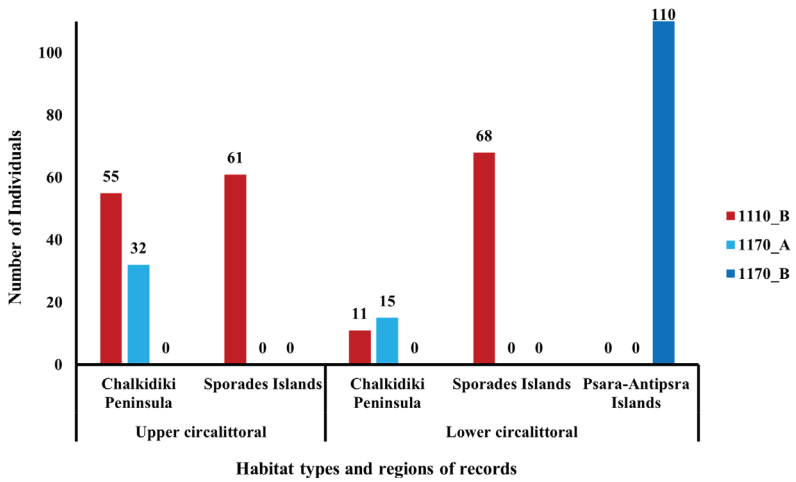

Fig. 5B: The number of spiny lobster individuals per habitat type and region. All records regard the Upper Circalittoral zone and the Lower Circalittoral zone

were aware of the national regulations and restrictions regarding the lobster fishery, almost all of them were unaware that *P. elephas* is a species listed at the Red Data List. It seems that the project and the dialog triggered their environmental responsibility, since they provided the vast majority of the individuals of the present study. Also, their profession and their continuous presence at the sea offers many opportunities for data collection. It is worth mentioning that, against common belief, a significant percentage of professional coastal fishers has proven to have an environmental concern, at least in the fishing areas of Chalkidiki Peninsula, since the release of undersized spiny lobster individuals has been recorded there in the past (Kampouris *et al.*, 2020). As mentioned above, most members that contributed were recreational SCUBA divers but certain limitations such as the diving depth, bottom time, and the frequency of diving can explain the lower number of spiny lobster records. We need to consider that the current study was conducted during the COVID-19 pandemic and the restrictions for social distancing limited their diving frequency and therefore potential encounters with spiny lobsters.

The findings of the current study can support the hypothesis that the species may prefer and utilize many different substrates and habitats, however, further experimental, evidence-based research is required. For instance, at Kanistro, a location in Chalkidiki Peninsula, most records were associated with heterogeneous substrata, most common hard bottoms mixed with sand, gravel, and "maërl". An important finding was the record from the Amfitriti sea cave, suggesting that the European spiny lobster can tolerate low-light conditions for extensive periods, a fact which has been documented from earlier studies from other Greek regions where this habitat extends (Gerovasileiou *et al.*, 2015). The participation of users with diverse backgrounds allowed records that cover most of the species' known depth range, and therefore robust data collection. The records obtained from SCUBA divers regard a narrower depth range, from 4-50m. The involvement of professional fishermen allowed to obtain records from most ecozones within a depth range from 30m to 180m. The upper circalittoral zone (40-80m) and the lower circalittoral zone (80-200m) seem to be important for the spiny lobster since most of the records were obtained within the borders of these zones (Figs 4A, 4B). Furthermore, the current records from Psara and Antipsara islands were obtained exclusively from professional fishers, and therefore they might be biased,

since records from other users like SCUBA or free divers are missing. A noteworthy finding of this study was the fact that all records from the islands of Psara and Antipsara were within a depth range between 140 and 180m, close to the maximum known depth that the species occurs (200m - Goñi & Latrouite, 2005). It seems that the spiny lobster stock in the region could be under important fishing pressure, but to support this hypothesis stronger evidence is required. Unfortunately, continuous and systematic monitoring is almost absent, as in most spiny lobster fishing grounds in the Greek seas (Kampouris *et al.*, 2020).

To the best of our knowledge, the Red Fish Project, an ongoing initiative which is mainly active through the Facebook group (https://www.facebook.com/groups/481084575908558), is the only one that focuses on the Vulnerable European spiny lobster and all the above demonstrate the project's novelty and potential. Though the spiny lobster records are patchy, they cover many major regions of the Aegean Sea (see Table S1) and reveals the importance of this crustacean species, not only for the economy but also for the Greek culture. The species seems to be among those that are very attractive for the SCUBA divers, and it could be included in the charismatic, flagship species list along with others (e.g., gorgonians, the dusky grouper) that may thrive in the rocky substrates and are known to raise the interest of recreational divers thus increasing their awareness for the habitat, and their willingness to invest time for data recording.

Many factors including overharvesting, climate change, and marine pollution are strongly impacting marine ecosystems and several marine species (Kelly *et al.*, 2020), and the Mediterranean Sea is not an exception. Enhancing the existing knowledge on the Mediterranean fisheries resources through targeted projects should be a must and the 'Red Fish Project' is contributing towards this direction. Based on the findings of the present research it can be said that Citizen scientists, especially SCUBA divers, can be powerful allies in endangered species monitoring projects. It is crucial to achieve continuity since continuous data flow in CS projects can be proven challenging (Arvanitidis *et al.*, 2011). Moreover, similar projects usually have a wide area of coverage, can be long lasting, offer limited surveying costs when compared to the traditional methodologies and are contributing to the Sustainability Development (SDGs) Goals of the United Nations since new indicators may be determined (Fritz *et al.*, 2019; Ferreira *et al.*, 2021). It is not a surprise that very recently, the European Commission has set specific guidelines on the best practices regarding citizen-science projects associated with environmental monitoring (EC, 2020).

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Supplementary Data

The following supplementary information is available online for the article:

Table S1. The full dataset regarding the spiny lobster records from the Red Fish Project. The provided data regard the region, area with coordinates, and depth of each record. Further data regarding the observer along with the habitat type, based on the National scheme, and the ecozone are also provided.