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Citizen scientists monitoring the establishment and expansion of *Pterois miles* (Bennett, 1828) in the Aegean Sea, Greece

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Abstract: The introduction of the lionfish in the western Atlantic has been considered as one of the world's most detrimental invasions. However, in the Mediterranean Sea, the devil firefish *Pterois miles* (Bennett, 1828) long after its first record in 1991, has only recently shown a rapid expansion. Citizen scientists have played a significant role in reporting the presence and monitoring the expansion of several invasive species around the world. In 2016 the environmental non-governmental Greek organisation "iSea", initiated the citizen science project "Is it alien to you…Share it", for the monitoring of alien species in the Greek waters. Between May 2016-Septeber 2017, 37 records of the devil firefish have been reported, documenting the establishment and a northward expansion of the species in the Mediterranean. We discuss the importance of citizen scientists in the collection of information regarding invasive species and the potential of suggested conservation measures.

Résumé : *Scientifiques citoyens surveillant l'établissement et l'expansion de* Pterois miles *(Bennett, 1828) en Mer Egée, Grèce*. L'introduction du poisson-lion dans l'Atlantique Ouest est considérée comme l'une des invasions les plus préjudiciables au monde. Cependant, en Mer Méditerranée, le poisson-lion *Pterois miles* (Bennett, 1828) longtemps après son premier signalement en 1991, a récemment montré une rapide expansion. Les citoyens scientifiques ont joué un rôle important en signalant sa présence et en surveillant l'expansion de plusieurs espèces invasives à travers le monde. En 2016, l'organisation environnementale grecque non-gouvernementale "iSea" a initié le projet de science citoyenne : "est-ce que cela est étranger…. Partagez-le", pour la surveillance des espèces invasives dans les eaux grecques. Entre mai 2016 et septembre 2017, 37 signalements poisson-feu diable ont été rapportés, documentant ainsi l'établissement et l'expansion de l'espèce vers le nord de la Méditerranée. Nous discutons de l'importance des scientifiques citoyens dans la collecte d'informations sur les espèces invasives et le potential des mesures de conservation suggérées.

Key words: Lionfish ● Devil firefish ● Greece ● Aegean Sea ● Mediterranean Sea ● *Pterois miles*

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Introduction

In the western Atlantic, the Indo-Pacific lionfish *Pterois miles* (Bennett, 1828) and its congeneric *Pterois volitans* (Linnaeus, 1758) have been recognised amongst the most ecologically harmful marine fish invasions (Whitfield et al., 2007; Albins & Hixon, 2013). In the Mediterranean, *P. miles* was first recorded in 1991 off the Israeli coast (Golani & Sonin, 1992) and since then several records have been reported from Lebanon (Bariche et al., 2013; Azzuro et al., 2017), South Turkey (Turan & Ergüden, 2014), Cyprus (Kletou et al., 2016), Southern Greece (Corsini-Foka & Kondylatos, 2015; Sterioti, 2016; Poursanidis & Marakis, 2016), Tunisia (Azurro et al., 2017) and Italy (Azzuro et al., 2017), indicating an establishment of the lionfish at the eastern basin, thus raising concerns among conservationists.

In Greece, the first observation of *P. miles* was reported in 2015, in Kallithea, Rhodes Island (Corsini-Foka & Kondylatos, 2015) followed by observations in Crete (Sterioti, 2016) and Karpathos Island (Poursanidis & Marakis, 2016). Most of these sightings were collected by citizen scientists (divers, naturalists, fishermen, etc.) who can play a decisive role in the documentation of marine alien species presence and distribution worldwide (Zenetos et al., 2013; Scyphers et al., 2015). Citizen science is defined as research techniques that enlist the help of members of the public to collect scientific data (Bonney et al., 2009) that along with local ecological knowledge can significantly improve research and data collection (Huntington, 2000).

Several portals and applications have been proven valuable tools and used to assist and involve the public (Ruttenberg et al., 2012). In May 2016, iSea launched the citizen science project "*Is it alien to you…Share it*" aiming to record information on the occurrence, distribution and expansion of marine alien species in Greek waters and the contiguous seas. Up to date, the project has collected (*inter alia)* significant information on the presence of *P. miles* in the Greek seas, indicating its northward expansion and establishment.

Materials and Methods

In 2016, iSea established an online data repository, where each interested citizen could easily upload information along with a clear picture of the reported alien species. A Google Form and a Group on Facebook have been set up for facilitating the reports of alien species observations. The project's group on Facebook numbers 1798 members up to date, with 320 actively engaged, 100 of those on a daily basis. Furthermore, 9 articles and 2 press releases have been published in local and national press for promoting the project and educating the public, accompanied by a social media campaign on the iSea's social media platforms and pages.

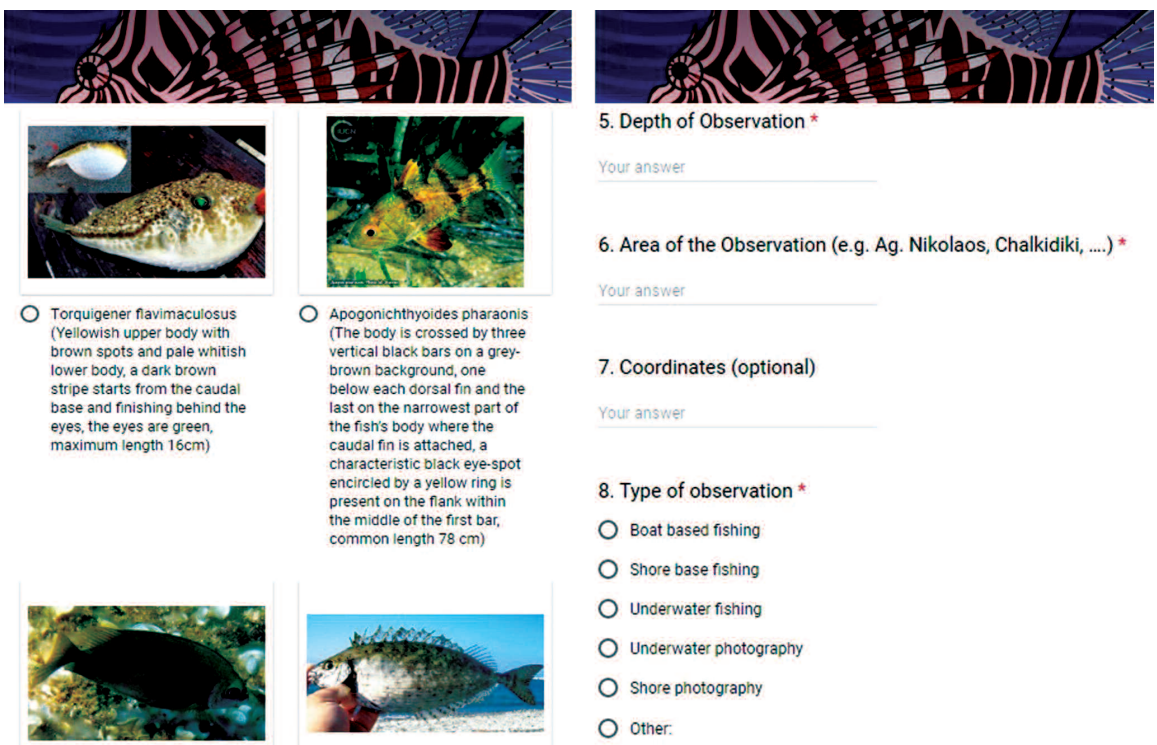

Figure 1. *Pterois miles*. iSea´s Alien Species Observation Form. The form is used for facilitating reports of alien species without photographic evidences to the project "Is it Alien to you…Share it!!!.

Table 1. *Pterois miles*. Specimens reported to the project

No	Length (cm)	Depth (m)	Coordinates	Area	Region	Date	Observer
1		15	36.097250-28.091399	Lindos. Rhodes	Dodecanese Islands	2016	Recreational fisher
2			36.095768-28.090451	Lindos. Rhodes	Dodecanese Islands	07/2016	Recreational fisher
3			35.469379-27.195089	Castelia. Karpathos	Dodecanese Islands	21/08/2016	Underwater Photographer
4		4	36.061653-28.050106	Peukoi. Rhodes	Dodecanese Islands	28/08/2016	Spearfisherman
5		4	36.042562-27.970541	Kiotari. Rhodes	Dodecanese Islands	05/03/2017	Spearfisherman
6	20		35.164958-24.415054	Schinaria Beach	Crete Island	11/03/2017	Scuba diver
7				Nysiros	Dodecanese Islands	03/04/2017	Professional fisherman
8		24	36.811629-27.182363	Lakos. Kardamena. Kos	Dodecanese Islands	22/04/2017	Spearfisherman
9	24	8	36.720066-26.983918	Kefalos. Kos	Dodecanese Islands	24/04/2017	Professional fisherman
10			35.006451-26.141408	Athrinolakos. Siteia	Crete Island	5/2017	Professional fisherman
11			35.179617-24.395664	Plakias Beach	Crete Island	04/06/2017	Scuba diver
12			36.378871-28.241711	Kalithea. Rhodes	Dodecanese Islands	09/06/2017	Spearfisherman
13	4-6	9	35.469379-27.195089	Castelia. Karpathos	Dodecanese Islands	09/06/2017	Scuba diver
14	30		35.006451-26.141408	Atherinolakkos. Siteia	Crete Island	15/06/2017	Spearfisherman
15	10	7	36.428333-28.240278	Zefiros Beach. Rodos	Dodecanese Islands	17/06/2017	Scuba diver
16	15	8	35.176425-24.392863	Plakias Beach	Crete Island	18/06/2017	Vet
17			37.012940-26.918120	Telendos. Kalymnos	Dodecanese Islands	22/06/2017	Scuba diver
18		20	34.997229-25.581359	Nea Myrtos. Ierapetra	Crete Island	25/06/2017	Recreational fisher
19	11	5	36.318979-28.206942	Ladiko. Rhodes	Dodecanese Islands	19/07/2017	Underwater Photographer
20	22.5	6	36.319205-28.208332	Ladiko. Rhodes	Dodecanese Islands	19/07/2017	Underwater Photographer
21			35.179752-24.227789	Fragokastelo. Sfakia	Crete Island	23/07/2017	Spearfisherman
22	23.5	12.5	36.890295-27.331688	Psalidi. Kos	Dodecanese Islands	25/07/2017	Scuba diver
23		2	35.604653-27.160267	Apella Beach. Karpathos	Dodecanese Islands	27/07/2017	Underwater Photographer
24		4	36.379768-28.238998	Kalithea. Rhodes	Dodecanese Islands	31/07/2017	Spearfisherman
25	27.5	5	35.171868-24.401393	Kalypso Bay. Southern Crete	Crete Island	04/08/2017	Scuba diver
26	27.5	20	36.406175-27.452644	Tilos	Dodecanese Islands	05/08/2017	Scuba diver
27	22.5	10	36.227947-27.625076	Chalki	Dodecanese Islands	05/08/2017	Scuba diver
28			35.191942-24.143457	Ammoudi beach	Crete Island	06/08/2017	Recreational fisher
29		4	35.187085-24.390978	Plakias Beach	Crete Island	08/08/2017	Underwater Photographer
30	20	4	36.087409-28.088405	Lindos. Rhodes	Dodecanese Islands	12/08/2017	Spearfisherman
31	20	2	34.930485-24.802379	Kala Limania Beach	Crete Island	12/08/2017	Spearfisherman
32	10	4	36.070524-28.047214	Peukoi. Rhodes	Dodecanese Islands	13/08/2017	Spearfisherman
33	15	3	6.173128-28.105036	Agathi Beach. Rhodes	Dodecanese Islands	18/08/2017	Recreational fisher
34	15	3	35.407490-27.153068	Diakofti Beach. Karpathos	Dodecanese Islands	20/08/2017	Underwater Photographer
35	7.5	4	36.379719-28.239012	Kalithea. Rhodes	Dodecanese Islands	03/09/2017	Spearfisherman
36			34.924020-26.128635	Koufonisi Siteias	Crete Island	08/09/2017	Spearfisherman
37	6	4	34.953254-25.137108	Treis Ekklisies	Crete Island	09/09/2017	Spearfisherman
38		25	36.320292-28.207243	Ladiko. Rhodes	Dodecanese Islands	19/09/2017	Scuba diver

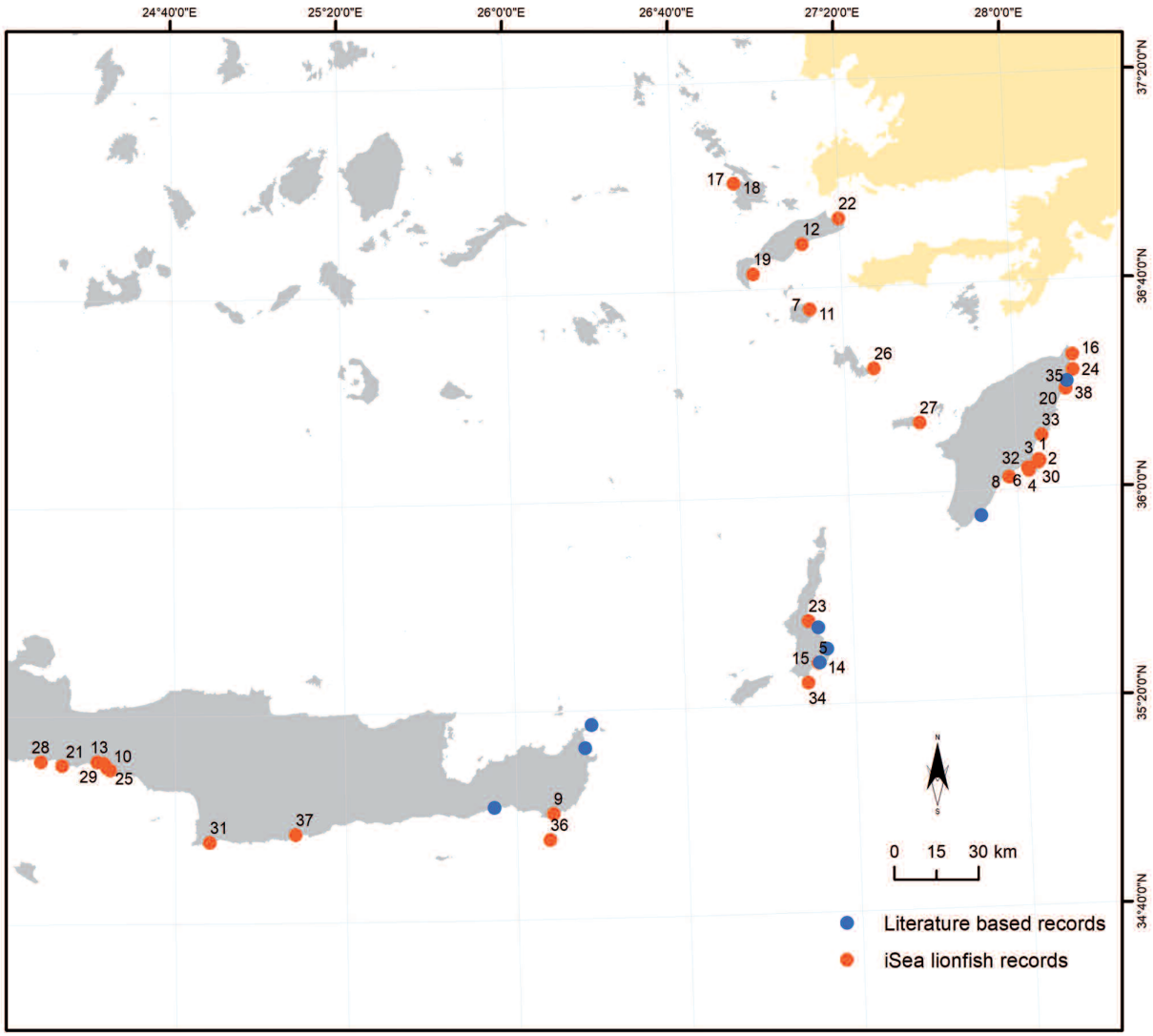

Figure 2. *Pterois miles*. Records in Greece, reported to the project "Is it Alien to you…Share it!!! (red) and previous published observations (blue)

iSea's project "Is it alien to you…Share it" utilizes a verified citizen science model as the most cost effective and accurate citizen science model (Gardiner et al., 2012). Observers are requested to provide the photo of the specimen and information on the size (length and/or weight), the depth, the number of observed specimens, the exact location, the date and the type of observation (Fig. 1 & Table 1). Only photo-identified observations are recorded in the database.

Results and Discussion

In total, 38 records of different *P. miles* individuals are recorded in the database with 37 reported by citizen-scientists and 1 record retrieved from a media network channel post (Figs 2 & 3). Most of these records involved spear-gun fishermen (n = 13, 35.14%), followed by scuba divers (n = 10, 27.03%), underwater photographers (n = 6, 16.22%), other types of recreational fishers, (n = 5, 13.51%), professional fishermen (n = 2, 5.41%) and a vet (n = 1, 2,70%). Some of the lionfish sightings were located within the known distribution of the species in Greece (i.e. near Rhodes, Karpathos and Crete islands) (Table 1). However, the majority confirm the expansion of the species distribution in the Greek waters. Specifically, specimens 6, 10, 11, 14, 16, 18, 21, 25, 28, 29, 31, 36 and 37 (Table 1) constitute the first records of the species from South Crete, while records 7, 8, 9, 17, 23, 26 and 27 indicate its distribution expansion towards northern parts of the

Figure 3. *Pterois miles*. Some of the pictures accompanied the report of P. miles in the database of the project.

Southern Aegean Sea, with record 17 (in Kalymnos island) being the northernmost Mediterranean lionfish encounter up to date. It should be noted that, the expansion data presented within this study, closely follow the predictions of Poursanidis (2015), as these were described as potential suitable areas for the species in the Mediterranean Sea through ecological niche modelling.

Taking into account the rapid and detrimental expansion of the lionfish in the Caribbean Sea (Albins & Hixon, 2008 & 2013), it is possible that *P. miles* may bring similar negative results and consequences through its rapid establishment in the eastern Mediterranean basin. The latter is highlighted by the fact that in only 3 to 5 years after its reappearance in the Mediterranean, the lionfish was able to fully establish its populations in several countries of the eastern Mediterranean basin including Cyprus (Kletou et al., 2016), Lebanon (Bariche et al., 2013) and Turkey (Özbek et al., 2017) as well as far to the Central Mediterranean Sea (Azzuro et al., 2017). The findings of this study provide the first robust evidence of its expansion and establishment towards northern parts of the Eastern Mediterranean Sea, presenting the patterns followed by most Lessepsian immigrants (Katsanevakis et al., 2013). The on-going climate change in the eastern Mediterranean basin (Occhipinti-Ambrogi, 2007; Raitsos et al., 2010) indicate that its rapid increase and establishment favoured by the overall environmental conditions and no obstacle exist to its further dispersal. In order to mitigate the potentially serious negative consequences of the permanent establishment of an introduced IAS, as the lionfish, early detection and rapid eradication measures are crucial to be taken immediately, by the scientific community and the competent authorities. Such measures have been also identified as necessary to mitigate IAS by the recent EU Regulation ((EU) No 1143/2014). Apart from the latter, conservation approaches, increased and wide spread public awareness activities to marine users and all involved stakeholders are also necessary to be carried out, to inform

on the potential impact of the fish in human health, to ameliorate possible ecosystem effects of the lionfish invasion in the Mediterranean Sea and to assure that the species are properly identified as an IAS.

Similar activities are included in a recently approved EU LIFE project (RELIONMED - LIFE16 NAT/CY/000832), which aims to set the basis for prevention of lionfish expansion through early response and targeted removal efforts by scientists. RELIONMED project was formally initiated on September 2017, and will encompass several activities strongly relying on citizen scientists' and stakeholder's participation. Amongst other, the project plans to undertake risk analysis and risk assessment of lionfish presence in the Mediterranean Sea, develop and operate a lionfish surveillance and early detection system, increase awareness and develop best guides and tools for managers. The demonstration activities of the project will take place in Cyprus and the best practices, will be transferred to Greece and replicated by iSea. Such initiatives are crucial and should be further promoted in addition to complementary research activities for unravelling interactions between the lionfish and the Mediterranean ecosystems are of paramount importance towards their better understanding and mitigation.

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