

The role played by citizen scientists in monitoring marine alien species in Greece

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Abstract: Environmental issues are best handled with the participation of all concerned citizens at the relevant level. Engaging citizen scientists to survey local biota and detect non-native marine species incursions is expected to result in the collection of significant data sets, which could potentially be used for an early-warning system *inter alia*. Our results suggest that such citizen support is beginning to develop in Greece, for invasive species such as the pufferfish *Lagocephalus sceleratus*; local newspapers often run a frontpage headline on the subject. Approximately 86 observations of 28 alien species (validated by taxonomic experts) were reported in 2012. Special mention is given to the following species, which until now had a very restricted distribution: *Atherinomorus forskalii*, *Callionymus filamentosus*, *Smaragdia souverbiana* and *Cylichnina girardi*. Concerned and informed citizens can participate personally in identifying incipient invaders and preventing them from spreading.

Résumé: Importance des scientifiques amateurs dans le suivi des espèces marines introduites en Grèce. Les problématiques environnementales sont mieux appréhendées grâce à la participation des citoyens concernés. Impliquer des scientifiques amateurs pour surveiller les milieux locaux et détecter l'arrivée d'espèces marines non natives permet l'acquisition d'importants jeux de données qui peuvent être potentiellement utilisées dans un dispositif d'alerte précoce. Nos résultats suggèrent qu'un tel support citoyen est en train de se développer en Grèce pour les espèces introduites telles que le poisson globe *Lagocephalus sceleratus*, les journaux locaux en faisant souvent un titre de une. Environ 86 observations de 28 espèces non natives (validées par des experts) ont été signalées en 2012. Une mention spéciale est faite pour les espèces suivantes, qui avaient jusqu'à maintenant une distribution très restreinte : *Atherinomorus forskalii*, *Callionymus filamentosus*, *Smaragdia souverbiana* et *Cylichnina girardi*. Des citoyens concernés et informés peuvent participer personnellement à l'identification d'espèces d'introduction récente et empêcher leur propagation.

Keywords: Citizen scientists • Invasive species • Greece

Introduction

The inventory of alien marine species in Greece, which is regularly updated (Pancucci et al., 2005; Zenetos et al., 2009a & 2011) is based on existing scientific and grey literature, including the HCMR database of Greek alien species (Ellenic Network of Aquatic Invasive Species: ELNAIS, 2013), technical reports, scientific congresses, academic dissertations, websites, and personal observations reported by citizens (divers, fishermen, tourists). As a matter of fact, 14 out of the approximately 240 alien species found in Greek waters (6%) were reported for the first time by citizen scientists.

The EU Marine Strategy Framework Directive (MSFD) (EU, 2008), aims at achieving Good environmental status (GES), and proposes indicators for assessing GES, such as “*Trends in abundance, temporal occurrence and spatial distribution in the wild of non-indigenous species, particularly invasive non-indigenous species, notably in risk areas, in relation to the main vectors and pathways of spreading of such species.*”

However, scientific surveys, involving scientists and research vessels, would be expensive and insufficient to ensure good spatial coverage in a country like Greece with approximately 17,000 km of coastline. In contrast, “citizen scientist” target groups can provide information that would otherwise be lost and thus ensure rapid data flow.

The occurrence and spread of marine alien species often goes unnoticed as only few people are able to observe incidents under water, including e.g. marine scientists and SCUBA divers. It is generally agreed that Citizen Science is a useful tool, which complement other Invasive alien species (IAS) monitoring activities.

The Mediterranean Science Commission (CIESM) *Jellywatch* programme, a citizen science initiative, launched in the summer of 2009, is a good example. This initiative produced valuable information on the spread of the comb jelly *Mnemiopsis leidyi* A. Agassiz, 1865 (Boero et al., 2009).

The aim of this work is to present a plethora of new information provided by “citizen scientists” in 2012, based on observations and accompanying photographs. These data confirm the spatial and temporal distribution of some IAS and are useful for the trend indicators proposed by the MSFD Directive.

Methodology

Recognizing the need for collaboration in research and management of aquatic alien species at both national and international level and in particular for data exchange, a network of experts was established in 2007 at HCMR

(Zenetos et al., 2009b). A web page addressing all aspects of research on aliens in Greek Seas, including visual distribution maps and photographs of alien species plays the role of an early warning system. The ELNAIS webpage has been advertised in newspapers and public means. An info page encourages the readers (scientists and citizen-scientist) to join ELNAIS by: (1) reporting on the occurrence of species which is after verification published in the news, (2) seeking external expert knowledge on species unknown to them, and (3) contributing new info by sending photos and environmental details of species they consider as new to the Greek biota. Based on the photos received, taxonomic experts of the ELNAIS experts network confirm the species observed; for Mollusca (A. Zenetos), Macroalgae (K. Tsiamis), Fish (M. Corsini-Foka, S. Kalogirou), Decapoda (MA Pancucci-Papadopoulou) and Cnidaria (I. Siokou). Divers, underwater photographers, amateur and professional shell collectors, fishermen and port authorities have been the main data providers for ELNAIS. Invasion stories of *Lagocephalus sceleratus* (Gmelin, 1789) are often front-page items in local newspapers.

Results

Table 1 shows all the records sent to ELNAIS in 2012, many of them referring to earlier observation dates. The locations of the visited sites are shown on Figure 1. The table lists 28 species and 86 observations, most of which are attributed to invasive species. These records are useful for detailed mapping of the geographic distribution of species well established in the Aegean Sea such as the molluscs *Aplysia dactylomela* Rang, 1828, *Brachidontes variabilis* (Krauss, 1848), *Melibe viridis* (Kelaart, 1858), *Pinctada imbricata radiata* (Leach, 1814); the fish *Fistularia commersonii* Rüppell, 1838, *Lagocephalus sceleratus* (Gmelin, 1789), *Siganus* spp., *Pempheris vanicolensis* Cuvier, 1831, *Pteragogus pelycus* Randall, 1981, *Stephanolepis diaspros* Fraser-Brunner, 1940, *Sphyræna chrysotaenia* Klunzinger, 1884; the crab *Pernon gibbesi* (H. Milne-Edwards, 1853); and the macrophytes *Caulerpa racemosa* var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, *Halophila stipulacea* (Forsskål) Ascherson, and *Stypopodium schimperi* (Kützinger) M. Verlaque & Boudouresque. All the aforementioned species are among those classified as the worst invasive in the Mediterranean and the eastern Mediterranean in particular (Streftaris & Zenetos, 2006). This compilation of citizen scientist input, validated by taxonomic experts, demonstrates the geographic expansion of more than twenty invasive species in Greece, while it provides information on four previously considered “casual” species known only from single records. These are the fish

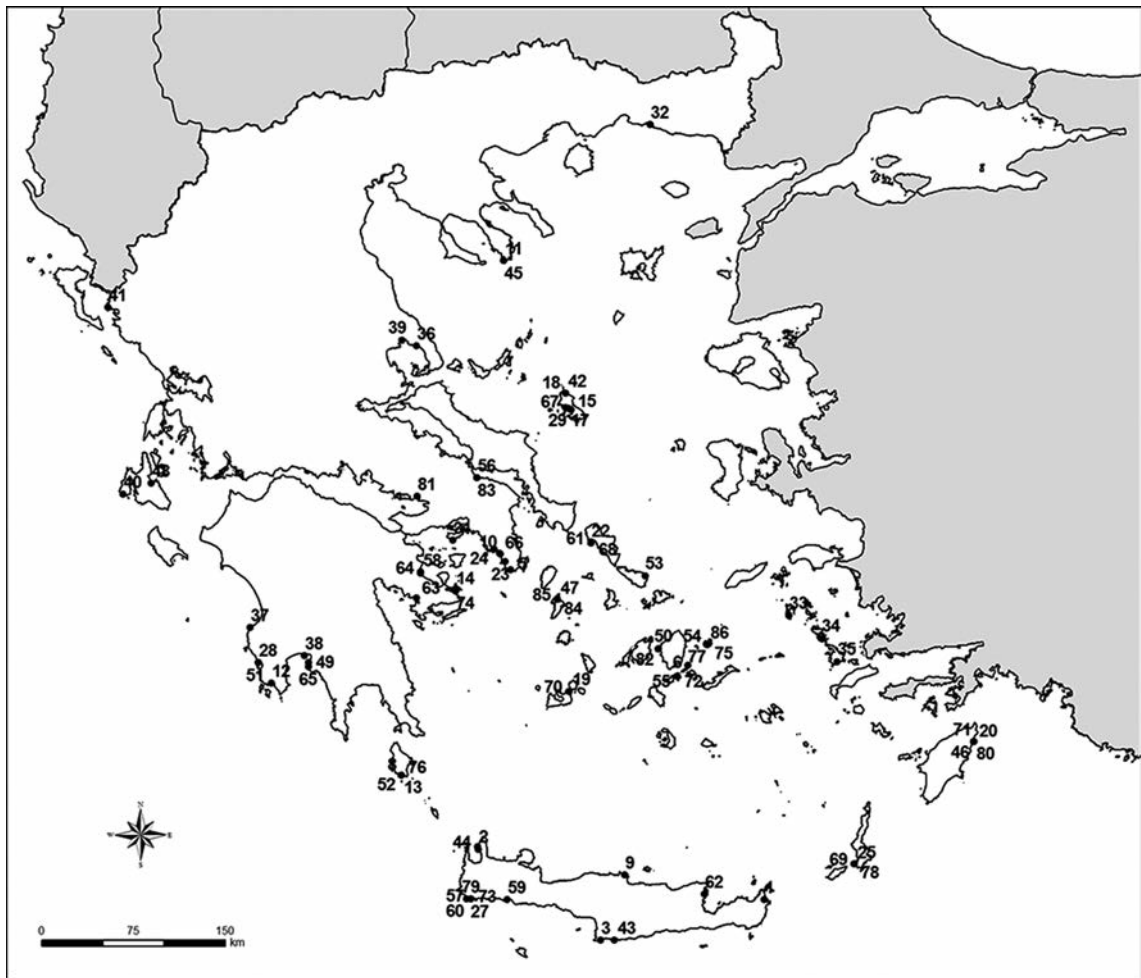


Figure 1. Location of reported sites. Numbers 1-86 correspond to sites reported in Table 1.

Atherinomorus forskalii (Ruppell, 1838) and *Callionymus filamentosus* Valenciennes, 1837, and the molluscs *Smaragdia souverbiana* (Montrouzier, 1863) and *Cylichnina girardi* (Audouin, 1826) (Fig. 2A-D). The observations of *Lagocephalus sceleratus* are of particular importance; range expansion attests to invasiveness in new zoogeographic areas.

Atherinomorus forskalii (Ruppell, 1838) (Fig. 2A)

The species, which is commercially exploited in the Levantine basin was until now known only from the Rhodes area (Pancucci-Papadopoulou et al., 2005). A school of approximately 30-40 individuals was observed in shallow waters (0.5 m deep), in a bay next to the port of Kythira, with calm waters and dense vegetation.

Callionymus filamentosus Valenciennes, 1837 (Fig. 2B)

A species commercially exploited in Egypt and Israel was

reported only from Rhodes isl (Corsini et al, 2005). Its finding in Finikounta Messinias, confirms its dispersion eastwards.

Cylichnina girardi (Audouin, 1826) (Fig. 2C)

In the Mediterranean, *Cylichnina girardi* has been found on shallow sandy bottoms among *Posidonia oceanica* meadows and in lagoons. It is common in the eastern Basin (Gofas & Zenetos, 2003). In Greece, there was only one record in 1994: Ierapetra, S. Kriti by Cosenza & Fasulo (1997).

Smaragdia souverbiana (Montrouzier, 1863) (Fig. 2D)

An Indo-Pacific species with many local records in the Levantine Sea (Gofas & Zenetos, 2003). Its westernmost occurrence was reported in Rhodes isl (Buzzurro & Greppi, 1994). Its finding in Kalamaki Korithias reveals further expansion northwards and eastwards.

Table 1. Records provided by citizen-scientists (PO: Panayotis Ovalis, DK: David Koutsogianopoulos, DP: Dimitris Poursanidis, Port auth.: Port Authorities).

Location id	Species	Area	Date	Colln
1	<i>Aplysia dactylomela</i>	Kouremenos, Siteia	18/8/2012	DP
2	<i>Aplysia dactylomela</i>	Kastelli, Chania	10/6/2010	DP
3	<i>Aplysia dactylomela</i>	Kaloi Limenes, S. Heraklion	8/8/2010	DK
4	<i>Aplysia dactylomela</i>	Palaiochora, Chania	26/8/2010	DK
5	<i>Aplysia dactylomela</i>	Legrena -Saronikos	18/12/2012	PO
6	<i>Aplysia dactylomela</i> :	Koufonisi	30/7/2005	DK
7	<i>Asparagopsis taxiformis</i>	Donousa isl- Kedros	18/6/2011	DK
8	<i>Atherinomorur forskalii</i>	Kythira isl- Kapsali	22/8/2012	DK
9	<i>Brachidontes pharaonis</i>	Agia Pelagia, Heraklion	20/1/2012	DP
10	<i>Brachidontes pharaonis</i>	Lagonisi, Saronikos	12/6/2010	PO
11	<i>Callinectes sapidus</i>	Peristera isl, Chalkidiki	10/7/2012	DK
12	<i>Callionymus filamentosus</i>	Finikounta, Messiniakos	9/9/2007	DK
13	<i>Callionymus filamentosus</i>	Kythira isl- Kapsali	25/8/2012	DK
14	<i>Cassiopea andromeda</i>	Poros isl - Paralia Monastiri	11/8/2012	DK
15	<i>Caulerpa racemosa var cylindracea</i>	Skyros isl. - Kalamitsa	10/9/2012	DP
16	<i>Caulerpa racemosa var cylindracea</i>	Skyros isl - Peukos	10/9/2012	DP
17	<i>Caulerpa racemosa var cylindracea</i>	Skyros isl. - Acherounes	12/9/2012	DP
18	<i>Caulerpa racemosa var cylindracea</i>	Skyros isl. - Palamari	13/9/2012	DP
19	<i>Caulerpa racemosa var cylindracea</i>	Milos isl. - Apollonia	13/8/2006	DK
20	<i>Caulerpa racemosa var cylindracea</i>	Rodos isl. - Kallithea	13/6/2007	DK
21	<i>Caulerpa racemosa var cylindracea</i>	Donousa isl.-Paralia Kedros	16/6/2011	DK
22	<i>Caulerpa racemosa var cylindracea</i>	Andros isl. - Gaurionisia	10/4/2012	DP
23	<i>Cylichnina girardi</i>	Anavyssos, Saronikos	15/5/2012	PO
24	<i>Dendostrea frons</i>	Agia Marina, Saronikos	8/6/2012	PO
25	<i>Fistularia commersoni</i>	Karpathos isl. - Diakoftis	3/8/2004	DK
26	<i>Fistularia commersonii</i>	Rodos isl.- Kallithea	11/6/2007	DK
27	<i>Fistularia commersonii</i>	Palaiochora, Chania	15/8/2010	DK
28	<i>Fistularia commersonii</i>	Gialova, Pylos	10/10/2011	DK
29	<i>Halophila stipulacea</i>	Skyros isl. - Kalamitsa	10/9/2012	DP
30	<i>Halophila stipulacea</i>	Rodos isl. - Kallithea	11/6/2007	DK
31	<i>Lagocephalus sceleratus</i>	Salamina isl.- Peristeria	7/12/2012	Port auth.
32	<i>Lagocephalus sceleratus</i>	Imeros, Thrakiko	8/9/2011	newspaper
33	<i>Lagocephalus sceleratus</i>	Patmos isl.	12/10/2012	newspaper
34	<i>Lagocephalus sceleratus</i>	Leros isl	6/5/2012	newspaper
35	<i>Lagocephalus sceleratus</i>	Kalymnos isl.	8/8/2012	newspaper
36	<i>Lagocephalus sceleratus</i>	Kato Gatztea, Larisa	23/10/2012	newspaper
37	<i>Lagocephalus sceleratus</i>	Agrili, Kyparissiakos	15/11/2012	newspaper
38	<i>Lagocephalus sceleratus</i>	Kalamata, Messiniakos	29/1/2013	newspaper
39	<i>Lagocephalus sceleratus</i>	Anayros, Pagasitikos	27/11/2012	Port auth.
40	<i>Lagocephalus sceleratus</i>	Kefallonia isl. -Vatsa	20/7/2012	AZ
41	<i>Lagocephalus sceleratus</i>	Igoumenitsa	15/8/2012	Port auth.
42	<i>Lophocladia lallemandii</i>	Skyros isl. - Palamari	13/9/2012	DP
43	<i>Lophocladia lallemandii</i>	Lentas, S. Heraklion	10/8/2010	DK
44	<i>Melibe viridis</i>	Kastelli, Chania	23/10/2012	DP
45	<i>Mnemiopsis leidyi</i>	Peristera isl, Chalkidiki	13/8/2008	DK
46	<i>Pempheris vanicolensis</i>	Rodos, Kallithea	10/6/2007	DK
47	<i>Percnon gibbesi</i>	Kythnos isl.- Loutro	25/5/2009	DK
48	<i>Percnon gibbesi</i>	Kefallonia isl.- Sami	27/8/2005	DK
49	<i>Percnon gibbesi</i>	Avia, Messiniakos	21/7/2008	DK
50	<i>Percnon gibbesi</i>	Naxos isl. - Agios Prokopis	15/9/2008	DK
51	<i>Percnon gibbesi</i>	Gialova, Pylos	9/10/2011	DK
52	<i>Percnon gibbesi</i>	Kythira isl. - Kapsali	19/8/2012	DK
53	<i>Percnon gibbesi</i>	Tinos isl. - Livadi	8/8/2011	DK
54	<i>Percnon gibbesi</i>	Donousa isl.- Kedros	15/6/2001	DK

55	<i>Percnon gibbesi</i>	Notia Sxoinoussa	7/8/2009	DK
56	<i>Percnon gibbesi</i>	Dilesi, Evvoikos	20/7/2011	DK
57	<i>Percnon gibbesi</i>	Palaiochora, Chania	28/8/2012	DK
58	<i>Percnon gibbesi</i>	Epidauros, Argolikos	Aug 2010	DK
59	<i>Percnon gibbesi</i>	Agia Roumeli, Chania	10/8/2012	DP
60	<i>Percnon gibbesi</i>	Palaiochora, Chania	15/6/2012	DP
61	<i>Pinctata imbricata radiata</i>	Andros isl. - Gaurionisia	10/4/2012	DP
62	<i>Pinctata imbricata radiata</i>	Elounda, Lasithi	20/11/2012	DP
63	<i>Pteragogus pelycus</i>	Salanti, Argolikos	1/6/2009	DK
64	<i>Pteragogus pelycus</i>	Epidauros, Argolikos	Aug 2010	DK
65	<i>Sargocenton rubrum</i>	Kitries, Mesiniakos	12/11/2012	Port auth.
66	<i>Septifer cumingii</i>	Lagonisi, Saronikos	12/6/2010	PO
67	<i>Siganus luridus</i>	Skyros isl. -Peukos	10/9/2012	DP
68	<i>Siganus luridus</i>	Andros isl.- Gaurionisia	10/4/2012	DP
69	<i>Siganus luridus</i>	Karpathos isl. - Diakoftis	11/8/2001	DK
70	<i>Siganus luridus</i>	Milos isl.- Apollonia	14/8/2006	DK
71	<i>Siganus luridus</i>	Rodos isl. - Kallithea	10/6/2007	DK
72	<i>Siganus luridus</i>	Notia Sxoinoussa	7/8/2009	DK
73	<i>Siganus luridus</i>	Palaiochora, Chania	25/8/2010	DK
74	<i>Siganus luridus</i>	Poros isl. - Paralia Monastiri	3/8/2012	DK
75	<i>Siganus luridus</i>	Donousa - Kedros	19/6/2011	DK
76	<i>Siganus luridus</i>	Kythira - Kapsali	21/8/2012	DK
77	<i>Siganus luridus</i>	Donousa isl.	19/6/2012	DK
78	<i>Siganus rivulatus</i>	Karpathos - Diakoftis	15/8/2004	DK
79	<i>Siganus rivulatus</i>	Palaiochora, Chania	10/8/2010	DK
80	<i>Siganus rivulatus</i>	Rodos isl. - Kallithea	12/6/2007	DK
81	<i>Smaragdia souverbiana</i>	Kalamaki, Korithiakos	1/11/2012	PO
82	<i>Sphyræna chrysotaenia</i>	Naxos isl. -Agios Prokopis	8/8/2006	DK
83	<i>Stephanolepis diaspros</i>	Dilesi, Evvoikos	20/7/2008	DK
84	<i>Stephanolepis diaspros</i>	Kythnos isl. -Loutro	26/5/2010	DK
85	<i>Stypopodium schimperi</i>	Kythnos isl. -Loutro	26/5/2010	DK
86	<i>Stypopodium schimperi</i>	Donousa isl. - Kedros	21/6/2012	DK

Lagocephalus sceleratus (Gmelin, 1789)

This is one of the most notorious introduced species occurring in abundance in the Levantine Sea and the South Ionian Sea. The current findings in the central and North Ionian Sea (Kefallonia, Igoumenitsa), confirm its geographic expansion northwards and establishment in the central Mediterranean. This is further confirmed by the presence of the species as north as the Adriatic Sea (Zenetos et al., 2012).

Discussion

Citizen science can be broadly defined as scientific research performed in part or in whole by volunteers who are not professional scientists. It provides an indispensable means of combining environmental research with environmental education and wildlife recording (Roy et al., 2012). Government efforts to monitor Invasive Alien Species cannot succeed without widespread support from citizens. The early warning system requires support from enthusiastic citizen-scientists complemented by reliable

systematic methodologies. The GB Non-native Species Information Portal (GBNNSIP) is an example of a structure established as a result of a policy need, which drives citizen science initiatives. Similar citizen scientist initiatives began in Alaska in 2008 (<http://www.alaskasealife.org/>). In the Mediterranean Sea Citizen science has proven an effective tool for monitoring gelatinous macroplankton (Boero et al., 2009).

The contribution of citizen scientists has been vital in understanding and monitoring the phenomenon of biological invasions in the Greek Seas. While scientific efforts keep discovering new alien species in Greek waters (Corsini-Foka et al., 2010; Simbhora, 2011; Tsiamis & Verlaque, 2011; Zenetos et al., 2011), reports by tourists, divers and fishermen add significant information. This is well demonstrated in the case of fishermen reporting to the Port authorities, who in their turn report to ELNAIS and/or the local newspapers. Amateur shell collectors are also an invaluable source of information (Crocetta & Russo, 2013).

Similarly, for other taxonomic groups, divers have provided considerable new knowledge: alien crustacean (Katsanevakis et al., 2012), Cnidaria (Navandi & Kikinger,

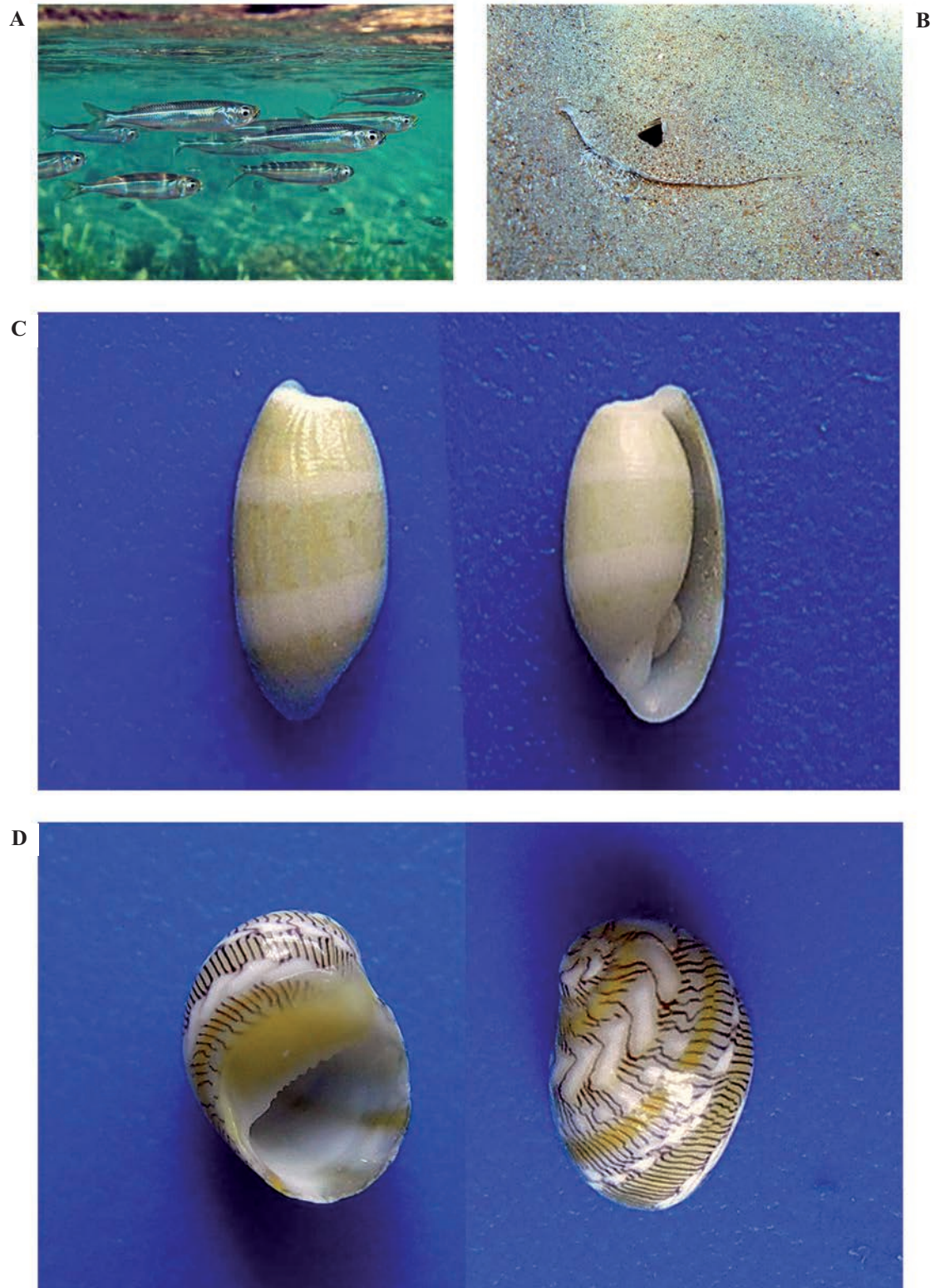


Figure 2. **A.** *Atherinomorus forskalii* (photo credit DK). **B.** *Callionymus filamentosus* (photo credit DK). **C.** *Cylichnina girardi*, size 3.5 mm (photo credit PO). **D.** *Smaragdina souverbiana*, size 4.49 mm (photo credit PO).

2007), Ascidia (Ramos-Espla et al. in Thessalou-Legaki et al., 2012), fish (Pirkenseer, 2012).

Citizen Science has the capability to involve communities and technologies, thus providing valuable data as long as the users of the data recognize the limitations inherent in data collected by volunteers. Better information and education, and improved public awareness of alien invasive issues by all sectors of society, is fundamental for preventing or reducing the risk of unintentional or unauthorised introductions, and establishing evaluation and authorisation procedures for proposed intentional introductions. Different groups should be targeted: the general public, school children and students, divers, fishermen, shell collectors, university students, and authorities, municipalities, teachers, managers, etc. The increasing use of mobile and Internet technologies and social networking systems (Robson, 2012) will further assist the coordination of efforts and collection of new data on alien species (Robson, 2012). However validation of the produced information through scientific expertise is a pre requisite to its use. It has been demonstrated that the accuracy of data collected by volunteers is affected by certain variables such as the volunteers' age and education (Delaney et al., 2008).

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