

ELNAIS: A collaborative network on Aquatic Alien Species in Hellas (Greece)

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Abstract

ELNAIS is a dynamic online information platform aiming to collect and report spatial information on Aquatic Alien Species in Greek waters. It covers freshwater, marine and estuarine waters, including not only established aliens but also casual records and cryptogenic species. The ELNAIS system includes: News, List of Greek experts, Literature of findings in Greece, List of species with information on their first introduction date and source as well as photos and distribution maps. Data providers are the scientific community (publications, grey literature, and databases) as well as citizen scientists. ELNAIS provides a useful tool towards national obligations and commitments under both the European and global frameworks in respect to Non Indigenous Species (CBD, WFD, MSFD).

Key words: aquatic aliens, Greece, list, mapping, online information platform

Introduction

EU member States have obligations and commitments under both the European and global frameworks in respect to Non Indigenous Species [Marine Strategy Framework Directive MSFD (EU 2008); EU Biodiversity Strategy (EU 2011)]. These include prioritizing pathways for prevention, identifying the most harmful species for responses, enforcing effective early warning and rapid response mechanisms, developing indicators of trends and responses, and other

management strategies (Katsanevakis et al. 2013a; EU 2014).

Recognizing the need for national/international cooperation in research scientific information exchange and management of marine alien species in Greece, a network of experts was developed in 2007, the Hellenic Network on Aquatic Invasive Species (ELNAIS: <http://elnais.hcmr.gr/>), based at the Hellenic Centre for Marine Research (HCMR) (Zenetos et al. 2009a). ELNAIS initially included nine Research Institutes/Universities and more than 34 Greek scientists who carry out research

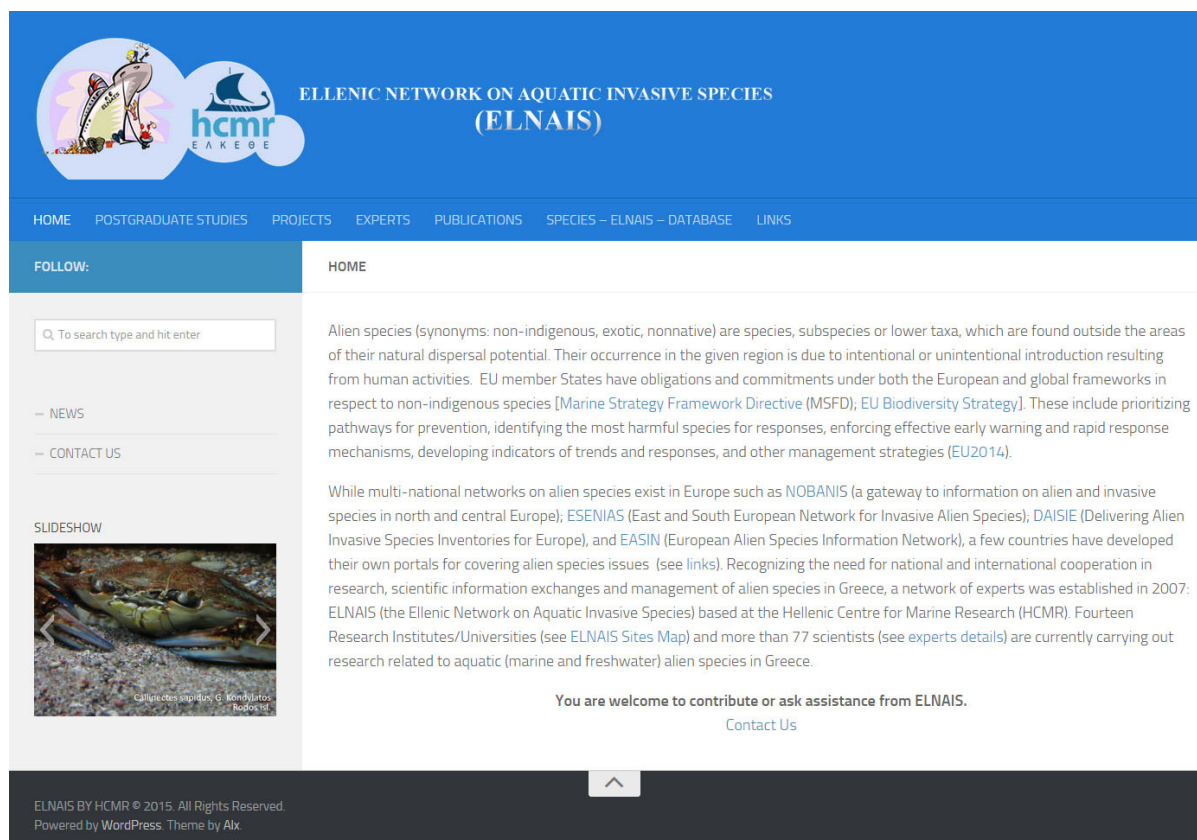


Figure 1. Homepage of ELNAIS (<http://elnais.hcmr.gr>).

relating to aquatic alien species. Presently, the experts' registry counts 77 experts (see experts details: <http://elnais.hcmr.gr/experts/>) from 14 Research Institutes/Universities/NGOs (see ELNAIS Sites Map: <http://elnais.hcmr.gr/map.jpg>). The ELNAIS on-line information system on aquatic alien species is freely accessible to all including policy makers and scientists who can download the latest publications, programs and results.

ELNAIS website

The new ELNAIS site is developed in the free open source WordPress web software. For the species' data, MySQL is used. MySQL is a relational database management system data (RDBMS).

ELNAIS is an information platform aiming to collect spatial information on the distribution of alien species in Greek waters. It covers freshwater, marine and estuarine waters, including not only established aliens but also casual records and cryptogenic species. Invasive species are also

noted. Besides the species list, information is provided on: ELNAIS experts and their field of expertise; postgraduate studies; projects; publications and overall NEWS (Figure 1). The dataflow and output of marine species within ELNAIS is shown schematically in Figure 2. The system (ELNAIS news, List of species, distribution maps) is continually updated thanks to the ELNAIS site that welcomes input by the wider public. In addition to the ELNAIS members, other Network contributors include divers, students and NGOs who provide us with information on new findings of alien species, photos of suspects, and habitat details.

DATA providers

The main data provider is the scientific community. To be more specific, data archived in ELNAIS are based on: Published literature: Marine alien species were encountered among soft bottom zoobenthos (Pancucci-Papadopoulou et al. 2005;

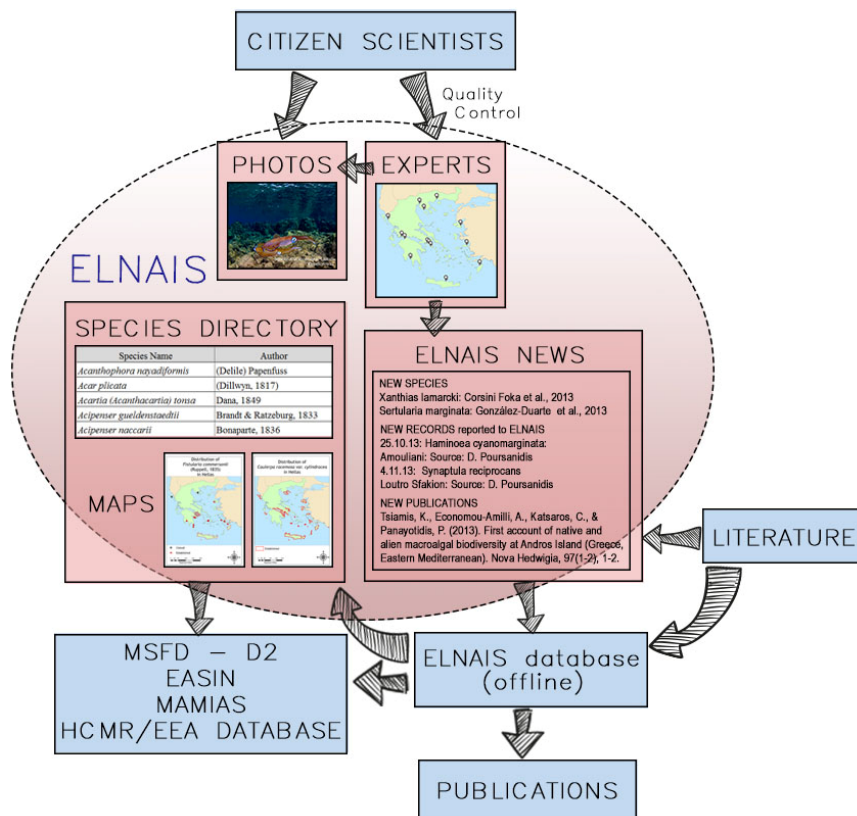


Figure 2. Data flow on marine NIS within ELNAIS. For ELNAIS database offline details see Figure 4.

Zenetos et al. 2008; 2009b; 2011; Simboura and Zenetos 2005; Simboura et al. 2010); hard bottom zoobenthos (Salomidi et al. 2006; Ovalis and Zenetos 2007; Pancucci-Papadopoulou et al. 2009; 2010; Polychronidis et al. 2013; Zenetos et al. 2013a); foraminifera (Triantaphyllou et al. 2009; Koukousioura et al. 2010); fish (Papaconstantinou 1987, 2014; Peristeraki et al. 2006; Corsini-Foka and Economidis 2007; Corsini-Foka 2010; Lefkaditou et al. 2010), phytobenthos (Tsiamis et al. 2008, 2010), and zooplankton (Siokou et al. 1999). For freshwater plants the data recorded are based on the investigation of mainly original articles and also include standard floras and checklists, such as Flora Hellenica (Strid and Tan 1997; 2002), Flora Europaea (Tutin et al. 1964–1980; 1993) and Med-Checklist (Greuter et al. 1984–1989; Greuter and von Raab-Straube 2008). The basis of the freshwater fish is Greece’s recently annotated inventory of freshwater fishes per hydrographic basin (Economou et al. 2007), along with its 2012 supplement (Koutsikos et al. 2012). Another annotated national species checklist (Barbieri et al. 2015), providing a

complete list of freshwater fishes inhabiting Greek inland waters, was used in order to provide careful verification and reference cross-checking.

Unpublished data used for ELNAIS was produced in the framework of monitoring projects such as: the Saronikos Gulf and the Larymna area in N Evvoikos (monitored regularly since 1985); the National Monitoring Program for the Assessment and Control of Marine Pollution in the Mediterranean (MED-POL) MAP/UNEP for plankton and heavy metals and sporadically for zoobenthos; surveying and monitoring of the marine NATURA 2000 network in Greece; and datasets from Water Framework Directive monitoring surveys.

Greek databases such as “IMAS-Fish” (Kavadas et al. 2013), which include data on marine biological resources (fish, crustacean, cephalopoda) collected during the MEDITS Trawling Surveys running in Greek Seas since 1998 were also used.

A **desktop application** in MS Access ‘Alien’ dealing with freshwater plant species has been in place since 2005 at the Faculty of Biology of the

University of Athens (see Arianoutsou et al. 2010). The 'Alien' database is an upgraded version of the database compiled for the DAISIE project (Pyšek et al. 2009; <http://www.europe-aliens.org>), enriched with additional and updated information on terrestrial alien plants. The database includes tables with multiple records regarding the status, distribution, introduction and ecological traits of each plant. Internet databases, such as the International Plant Names Index, and unpublished relevant vegetation databases (available to the authors) are also used.

All species are archived in a desktop application in MS Access 'ELNAIS db' see description below.

Circumstantial field observations and expert opinion provided by our research team are also used.

There are also significant contributions from **citizen scientists**. It is worth mentioning that the first recordings of 14 species among marine NIS in Greek waters (6%) are attributed to citizen scientists (Zenetos et al. 2013a, b). The ELNAIS webpage has been advertised in newspapers and public means. Based on the photos received, taxonomic experts among the ELNAIS marine experts network confirm the species observed; for Mollusca (A. Zenetos), Polychaeta (N. Simboura), Macroalgae (K. Tsiamis), fish (M. Corsini-Foka, S. Kalogirou), Decapoda (MA Pancucci-Papadopoulou, K. Kaporis), Foraminifera (M. Triantaphyllou) and Cnidaria (I. Siokou). Divers, underwater photographers, amateur and professional shell collectors, fishermen and port authorities have been data providers for ELNAIS. The contribution of citizen scientists has proven of paramount importance in monitoring biological invasion in its whole and alerting on invasive species such as *Lagocephalus sceleratus* (Gmelin, 1789). Reports on *L. sceleratus* findings are often front-page items in local newspapers (Figure 3).

ELNAIS species list

A total of 322 aquatic species 239 marine, and 83 freshwater and/or brackish) have been reported by ELNAIS (as of September 2014) to be present in Greek waters (see <http://elnais.hcmr.gr/elnais-database-2>). Of these, 194 are classified as established (including 20 invasive); 69 as casual records (1-2 findings); 28 as cryptogenic. The establishment status is questionable or unknown for 31 species. Nomenclature of marine species is based on WoRMS (WoRMS Editorial Board 2014). For Vascular Plants nomenclature is based on

Dimopoulos et al. (2013); the Euro+Med Plantbase and The Plant List (2013). By following the latest nomenclature and publications, 18 freshwater species listed previously in ELNAIS (Zenetos et al. 2009b) have been removed and nine species have been added.

Photos (if available) and distribution maps can be downloaded from the species list widget.

'ELNAIS db'

A database on the marine alien species in Greece has been developed based at HCMR. The database is structured in MS Access but it is also geo-referenced so that distribution maps for each species are easily/timely produced which in turn feedback distribution maps in ELNAIS list. For each species, information stored includes its taxonomy, habitat details, origin, known or suspected mode of introduction, first sighting date and sources of information. The area of occurrence is archived in hierarchical levels (**Sea**: North Aegean, South Aegean, Ionian; **Gulf**: for the main gulfs; **island complex**: Dodecanesa, Sporades, Kyklades) so as to be retrieved accordingly (Figure 4).

ELNAIS Geodatabase

Considering the necessity for geocoded data in the era of digital information and the need for accurate distribution data for the alien species, the available information data on the distribution of the species have been turned into spatial data within the framework of an offline personal geodatabase (ESRI 2010). After the indexing of the relevant literature (scientific literature and technical reports) in the aforementioned ELNAIS database (MS Access), the data have been exported into tables in order to assign coordinates to the location that is given by the literature. Geocoordinates have been extracted by interpreting georeferenced military maps, geographic gazetteers (Chapman and Wiczorek 2006) and the Google Earth application (Google Inc. 2014). Publications of the last decade include coordinates and thus these have been used. In the previous years, in many publications, only the location was reported.

For the species that have punctual presence, the exact locality is stored in the geodatabase in the form of point shapefiles. For the species that the distribution is given in the form "from this location up to this location" or "in this area" but with no exact locations, the data are stored in

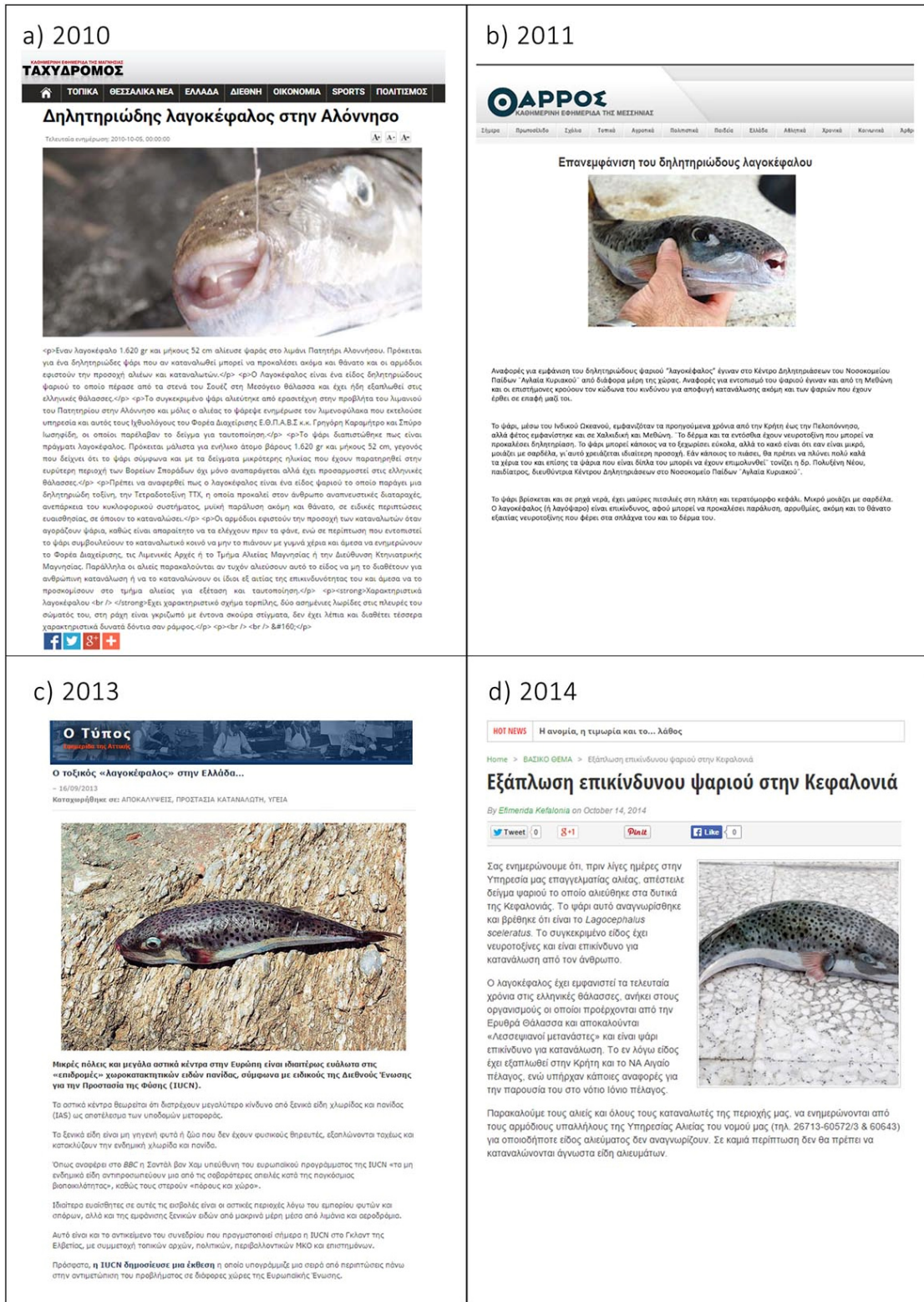


Figure 3. *Lagocephalus sceleratus* from local and regional newspapers: a) 2010: The Postman of Magnisia (regional); b) 2011: To Tharos, Messinia (local); c) 2013: The Press : Newspaper of Attica (regional); d) 2014: Kefallonia (local).

Form Species Distribution Data entry

Species ID	LOP-LAL	Establishment	Established	Donor Area	fouling/ natural dispersal	Vector Records	
Species Name	Lophocladia lallemandii	Biotope	Marine	Impact	Generally invasive	Vector_Name	
Author	(Montagne) Schmitz, 1893	Origin	Indo-Pacific, Red Se	Notes	via Suez/shipping		
Ecofunctional	Phytobenthos	First Record	1908				
Taxon	Rhodophyta	First Citation	Petersen, 1918				
Subgroup	Rhodophyta	Modification Date 13/10/2014 12:41:08					

Distribution ID	Species Name	Area	Subarea	First Record	Success	Biotope Details	Reference
LOP-LAL-02	Lophocladia lallemandii	South Aegean	Dodecanesa	2006	Established	Rodos	Athanasiadis pers. Comm. Tsiamis et al 2008
LOP-LAL-03	Lophocladia lallemandii	Ionian Sea	Ionian islands	2001	Established	3m, Zakynthos (Laganas, Keri)	Tsirika & Haritonidis, 2005: Botanica Marina 48 (2005): 38-45
LOP-LAL-01	Lophocladia lallemandii	South Aegean	Saronikos Gul	1908	Established	Salamina	Petersen, 1918
LOP-LAL-04	Lophocladia lallemandii	South Aegean	Kriti	2008	Established	Istron, Crete Isl.	Tsiamis et al 2010 MMS
LOP-LAL-05	Lophocladia lallemandii	South Aegean	Kyklades	2007	Established	Tsigrado, Milos Isl.	Tsiamis et al 2010 MMS

Record: 1 of 7 | Unfiltered | Search

Figure 4. Extract from a data entry form in ELNAIS db off line.

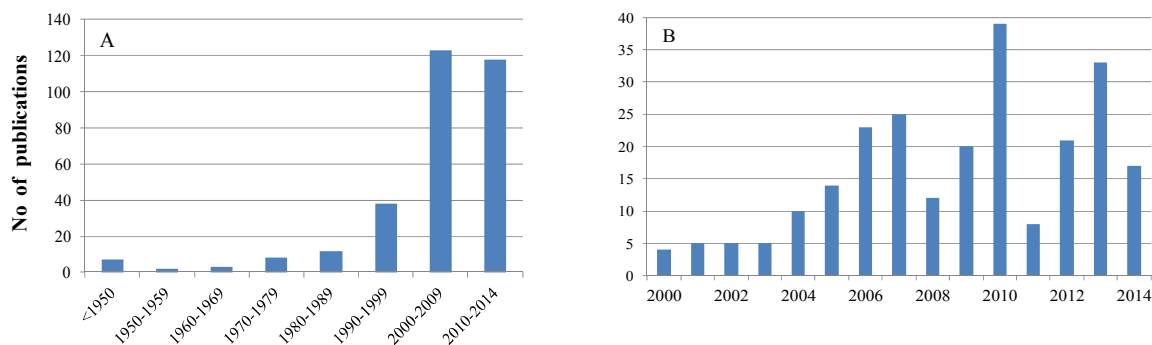


Figure 5. Number of publications: A - by decade; B - during the last 15 years.

form of line shapefiles when the species occurs in the coastal zone and in form of polygon shapefiles, when the species occurs both in the coastal and pelagic zone. The geodatabase has been organized by using feature datasets, one for each taxonomic group, in which the distribution data are stored in order to manage more accurate the updated information for each species.

For each species that is included in the ELNAIS geodatabase, a relevant map is designed for further use in the ELNAIS website, for technical reports, and for scientific publications. Such maps are also used as information material for the citizen scientists; their feedback greatly supports the update of the data (Zenetos et al. 2013b).

ELNAIS literature

A total of 315 publications focusing on alien species are reported in ELNAIS, from 1934 to date. A “step by step” increase is observed from the first alien sighting until 1980, while a first peak appears in 1990, followed by a huge increase during the last one and half decades (Figure 5a). Zooming in on the last 15 years, the number of publications dealing with new alien entries shows its maximum in 2010 (39 publications) and minimum in 2011 (8), this is probably a consequence of the previous publication “explosion” (Figure 5b).

A total of 559 scientists have contributed to the cited literature, with a varied number of publications.

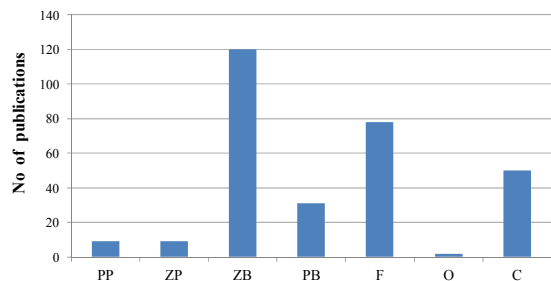


Figure 6. Number of publications for each taxonomic group (PP = Phytoplankton, ZP = Zooplankton, ZB = Zoobenthos, PB = Phytobenthos, F= Fish, O = Others, C= Collective, Comprehensive).

The vast majority of scientists (379) have published only once, 84 twice, while 15 published more than 10 papers, with a maximum of 52 (1 author). This can be attributed to the participation of numerous scientists to one single collective paper, apart from specific taxonomic records. The bulk of publications are dealing with marine alien species (only 15 exclusively dedicated to fresh water). Regarding marine taxonomic groups (Figure 6), zoobenthos contributes to 120 specific papers, followed by fish (78) and phytobenthos (31). It is however worth mentioning that 50 papers are comprised of more than one taxa (collective), with some including all groups (comprehensive).

Overall contribution of ELNAIS

ELNAIS has substantially contributed to increasing the available information on species occurrences in Greek waters. ELNAIS includes geo-referenced data for most marine alien species in Greece, being currently the most important data provider for the country. Since November 2012, ELNAIS joined EASIN (European Alien Species Information Network; Katsanevakis et al. 2012) as a new spatial data provider, supplying information on alien species for Greek waters (Katsanevakis et al. 2013b). EASIN was created by the European Commission to support the European policies on alien species, in particular the new Regulation on the prevention and management of the introduction and spread of invasive alien species (EU 2014). The linkage between ELNAIS and EASIN has significantly increased the available, through EASIN, georeferenced information on marine/estuarine alien species in Greece.

ELNAIS data base offers a tool for the assessment of the status of Descriptor 2 of MSFD in Greece (<http://marinestrategy.opengov.gr/>). Indeed,

the increasing trends in the abundance and frequency of occurrence of the non-indigenous species, especially so of the invasive ones, is considered as indicator for the Descriptor 2 "Non-indigenous species" (NIS) within the MSFD (EU 2010).

It also helps the interpretation and connection of alien data among scientists from different fields, providing valuable data for monitoring the ecosystems environmental status.

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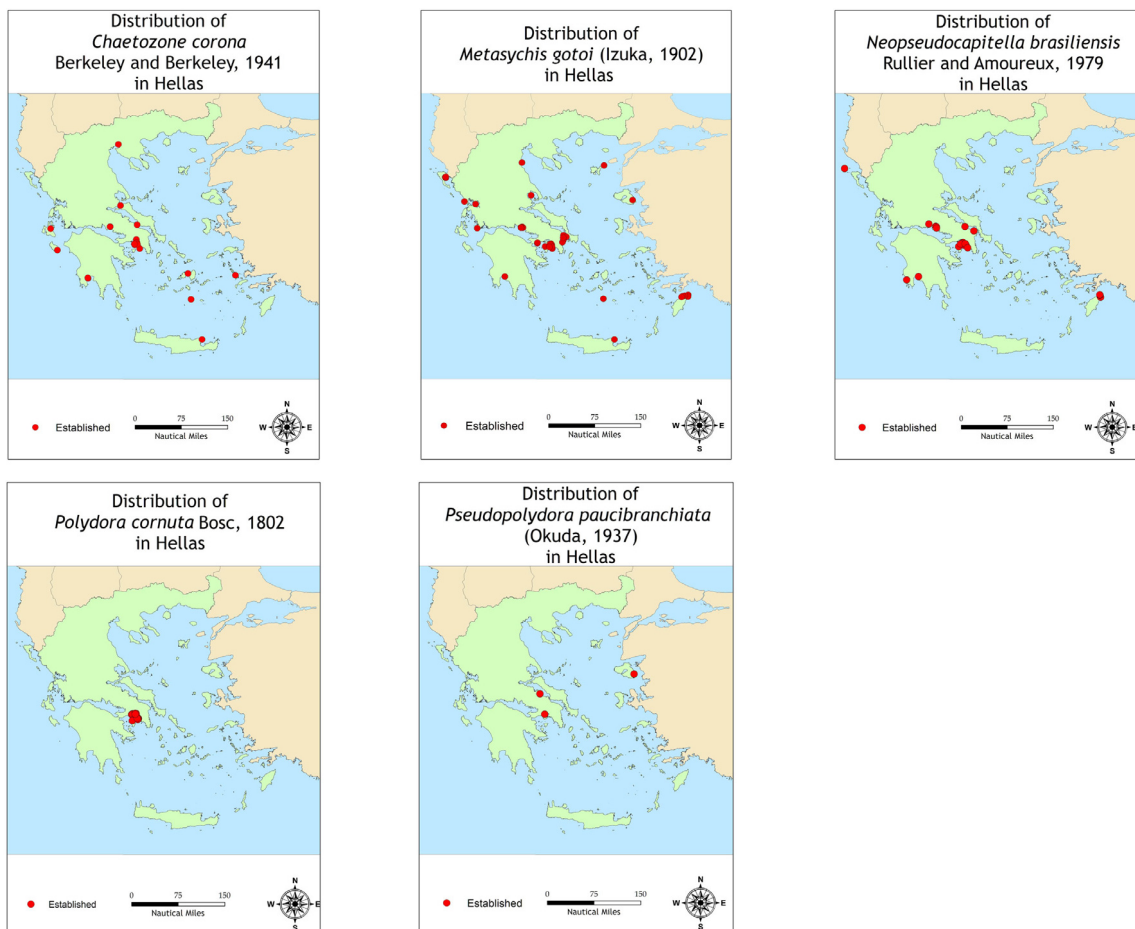
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The following supplementary material is available for this article:

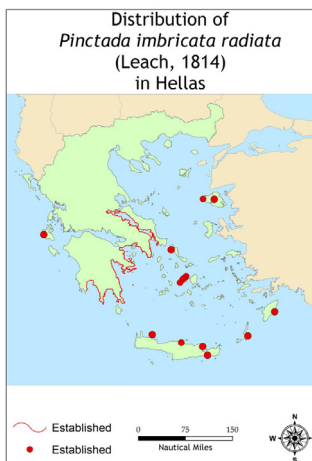
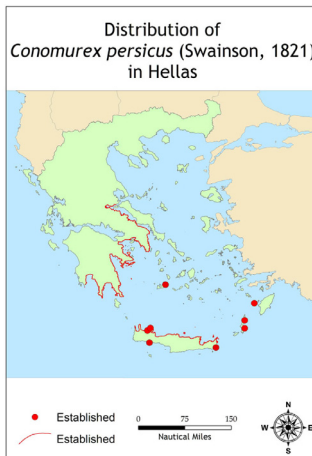
Appendix 1. Distribution maps for selected non-native species available in ELNAIS database (generated on 7 September 2014).

Polychaeta



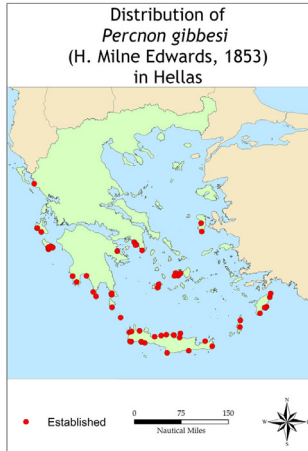
Appendix 1 (continued).

Mollusca

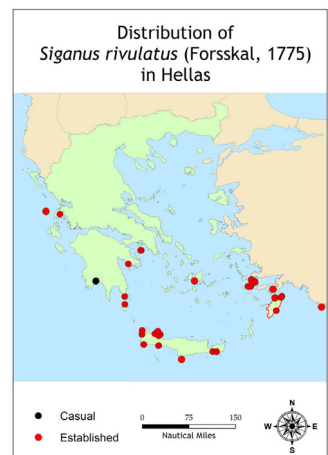
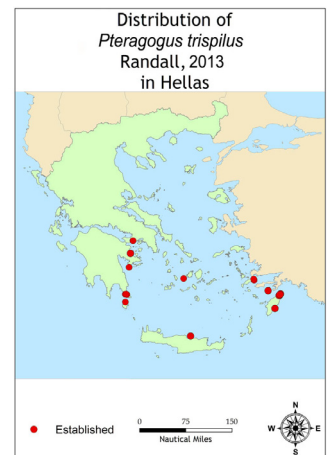
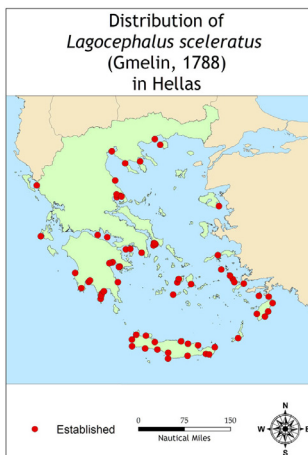
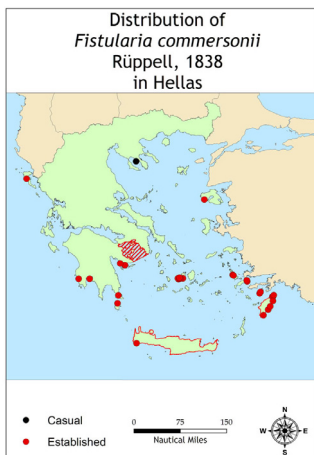


Appendix 1 (continued).

Crustacea

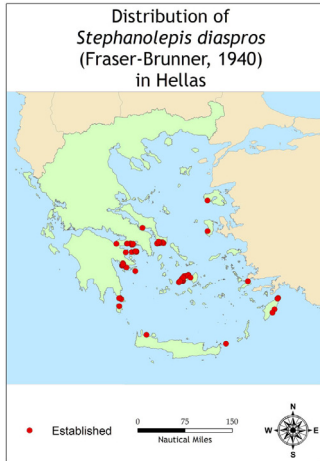


Fish



Appendix 1 (continued).

Fish (continued)



Phytobenthos

