

Country reports

Overview of Non-indigenous Species in Greece (2013)

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Abstract

The state of the art on activities related to non-indigenous species (NIS) in Greece is presented. These include scientific networks, databases, engagement of citizen scientists, and policies. The trends in the introduction of NIS per habitat (terrestrial, freshwater, marine) and per taxon (vertebrates, invertebrates, primary producers) as a state indicator, revealed a significant increase in marine biota (all taxa), and low increase in freshwater biota (vertebrates: fish). The trend in terrestrial introductions was not evaluated, whereas lack of information on freshwater macrophytes was highlighted. The number and list of invasive species as a pressure indicator is provided per habitat (marine: 40 species; freshwater: 22 species; terrestrial: 17 species). Finally, the list of potential invasive species in Greece is provided as an early warning system.

Keywords

Alien species, invasive, Greece

Introduction

The first comprehensive checklist of terrestrial non-indigenous species (NIS) or alien species in Greece was produced upon completion of the DAI-SIE project in 2008 (<http://www.europe-aliens.org>). The results were published in Lambdon et al. (2008); Bazos et al. (2009); and Arianoutsou et al. (2007, 2010a, b). With regards to freshwater NIS, vertebrates are fairly well studied (Economidis et al. 2000; Economou et al. 2007a). In contrast, the freshwater invertebrate fauna of Greece is one of the least studied and therefore many alien species may go unnoticed or unrecorded (Legakis 2004). Although terrestrial flora has been studied to a fair extent (Arianoutsou et al. 2007, 2010a, b), there is a lack of work on aquatic macrophytes. The most recent overview with comprehensive information on freshwater species was carried out by Zenetos et al. (2009b), and amended by Koutsikos et al. (2012). The first inventory of marine alien species in Greece was compiled in 2004 (Pancucci-Papadopoulou et al. 2005a) and has been regularly updated (Pancucci-Papadopoulou et al. 2005b; Zenetos et al. 2007; 2009a, 2011).

State of the Art

Terrestrial NIS

The number of terrestrial non-indigenous plant species reported so far has been nearly 350 (Arianoutsou et al. 2010b), of which only 49 were introduced before 1500 AD. A high percentage of the alien flora (approximately 40%) is naturalised, i.e. the populations reproduce without human intervention and far from their original introduction site, while the remaining alien plants are casual or of unknown status. Of the naturalised taxa, 50 are considered as having potential invasive behaviour. *Opuntia ficus-barbarica*, *Ailanthus altissima*, *Oxalis pes-caprae*, *Erigeron bonariensis*, *Amaranthus albus*, and *Symphyotrichum squamatum* are considered as the most invasive (Arianoutsou et al. 2010b). The majority of the alien plant taxa occurring in Greece is of American origin (46%),

followed by those of Asiatic (15%), and African origin (10%) (Arianoutsou et al. 2010a, b).

Most naturalised alien plant species occur in disturbed or man-made habitats, such as industrial sites, waste deposits and cultivated areas, while far less have invaded natural habitats. Terrestrial invertebrates are the second most numerous category of invasive alien species (approximately 170 species recorded to date), while vertebrates rank third, with approximately 20 species recorded (<http://www.europe-aliens.org>; Legakis and Maragou 2009; Legakis unpublished data).

Freshwater NIS

A total of 89 alien species, belonging mainly to macrophytes and fish, have been reported in the inland and estuarine waters within the national borders of Greece. Five of the fish species have been found in both fluvial and estuarine areas. A biogeographic study showed that most freshwater alien fish species have been recorded in northern Greece (Economidis et al. 2000).

Most of the freshwater species originate in the temperate areas of the Northern Hemisphere and are characterised according to their native distributional ranges as American (47.1%), Asian (17.2%), European (9.2%), African (6.9%), African/Asian (4.6%), Eurasian (4.6%), Circumtropical (6.9%), Australasian (1.1%), and Ponto-Caspian (1.1%).

Marine NIS

A total of 236 marine alien species (including unicellular algae) have been reported in the Greek Seas. The majority of alien species belongs to Mollusca (48 species: 20.4%), followed by fish (39 species: 16.5%), polychaetes (39 species: 16.5%), macroalgae (37 species: 15.7%), and crustaceans (30 species: 12.7%). The highest number (approximately 100 species) has been reported in the Dodekanisos area, SE Aegean, which testifies to the importance of the area as the entrance point of Lessepsian immigrants spreading to the Aegean Sea. Particular notice should be given to the

more than 90 species reported in the wider area of the Saronikos Gulf, a hotspot area for biological invasions in the Greek waters, closely related to the route of ships traveling to Piraeus, the largest port in Greece. The number of alien species found in the Thermaikos Gulf (due to the port of Thessaloniki) is also relatively high (approximately 40 species).

The origin of marine alien species shows that ca. 11% have a circumtropical distribution, while most species originate in the tropical Indo-Pacific or parts thereof (Indo-Pacific 43%, Indian Ocean 9%, Red Sea 7%) (Zenetos et al. 2009a).

Networks-Databases

Recognising the need for collaboration in the research and management of aquatic alien species at both national and international levels, and in particular for data exchange, a network of experts was established in 2007 at HCMR (Hellenic Network on Aquatic Invasive species: ELNAIS: www.services.ath.hcmr.gr/) (Zenetos et al. 2009b). A web page addressing all aspects of research on aliens in the Greek Seas, including visual distribution maps and photographs of alien species plays the role of an early warning system. In November 2012 ELNAIS joined the European Alien Species Information Network (EASIN) and has provided georeferenced information on marine/ estuarine alien species in Greece. This association can greatly aid scientists and policy makers in obtaining high quality information on marine alien species in Greece by making use of the tools provided by EASIN (Katsanevakis et al. 2013)

With regards to the terrestrial plant species, a desktop application in Microsoft Access 'Alien' has been in place since 2005 at the School of Biology (University of Athens). 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. The data recorded are based on the investiga-

tion of original articles mainly and standard floras and checklists, such as Flora Hellenica (Strid and Tan 1997, 2002), Flora Europaea (Tutin et al. 1968–1980, 1993) and Med-Checklist (Greuter et al. 1984–1989; Greuter and von Raab-Straube 2008). Internet databases, such as the International Plant Names Index, and unpublished relevant vegetation databases (available to the authors) are also used. Circumstantial field observations and expert opinion provided by our research team are also used. The bulk of the sources consists of research results published from the 1980s onwards.

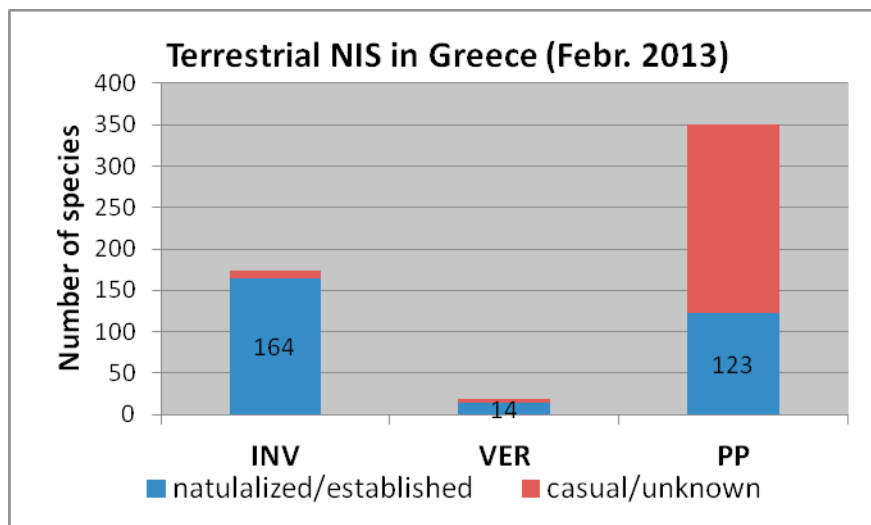
Indicators

The Invasive alien species indicator is included among the descriptors required for assessing Good Environmental Status (GES) in the MSFD. This is best represented by the cumulative number of WIAS (Worst Invasive Alien Species). However, when there is a lack of data on the most invasive species, trends in all NISs are used as a proxy. The trends in the NIS indicator for Greece are the cumulative number of all alien species (primary producers (PP), invertebrates (INV) and vertebrates (VER) that have been recorded in Greece since 1950. Three sub-indicators have been developed for this topic: one for the terrestrial environment, one for the marine environment and one for the inland freshwaters (EEA 2007). A fourth sub-indicator (*worst invasive alien species*) represents the sum of all *highly* invasive alien species (terrestrial, marine, freshwater) recorded in the country.

1st Indicator: Trends in terrestrial NIS

Detection of trends in the numbers of terrestrial species (increasing, decreasing or stable) is not yet possible. More than half (60%) of the terrestrial aliens are primary producers, 38% are invertebrates and only 2% are vertebrates (Fig. 1). Due to the close relationship between the total number of naturalised plant species and that of pests, it is expected that an increase in the number of alien plant species in the near future

Fig. 1. Number of alien taxa occurring in terrestrial habitats in Greece. Data on invertebrates and vertebrates are obtained from the DAISIE database (2008), while data on plants are from the updated 'Alien' database held at School of Biology, University of Athens (2013).



will be translated into more impacts on biodiversity, human health and/or the economy.

2nd Indicator: Trends in inland/ freshwater NIS

Fig. 2 shows that the introduction of freshwater alien species in Greece is increasing. It is suspected that some of the fish introductions reported in the 1990s had occurred at an earlier date but went unrecorded (Zenetos et al. 2009a). The increasing rate at which invasions are reported in Greece may be due to a multiplicity of interactions, such as intensive research into marine biota and increased anthropogenic activities over the last decades (e.g. aquaculture, international trade and tourism favour the unintentional introduction of aliens).

3rd Indicator: Trends in marine NIS

In the marine environment, an increasing trend in the occurrence of marine NIS (Fig. 3), which started in the decade 1980-1990, coincides with the revival of the Greek taxonomists, mainly in zooplanktonic and zoobenthic groups. This trend continued in the following

decades, when the scientific interest in aliens increased, and has continued to increase in the present decade. It is worth noting that the intensive research since 2001 has increased the number of marine NIS by 87 species (as of February 2013).

4th Indicator: Invasive species

Invasive Alien species (IAS) are those introduced alien species that establish themselves, spread rapidly and can threaten biological diversity in various ways (from reducing genetic variation and eroding gene pools to causing the extinction of endemic species, and by altering habitat and ecosystem functioning); in addition, they may have negative consequences for human activities, health and/or economic interests.

A list of the worst invasive alien species (WIAS) threatening biodiversity in Europe across environments and taxonomic groups has been compiled by the SEBI2010 expert group. In 2006, after consultation with the DAISIE, NOBANIS, Bern Convention experts and IUCN/GISP, a final list including 163 species was made available. In 2008, 18 of the 100 WIAS species threatening biodiversity in Europe (according to the DAISIE database <http://www.europe-aliens.org>) were

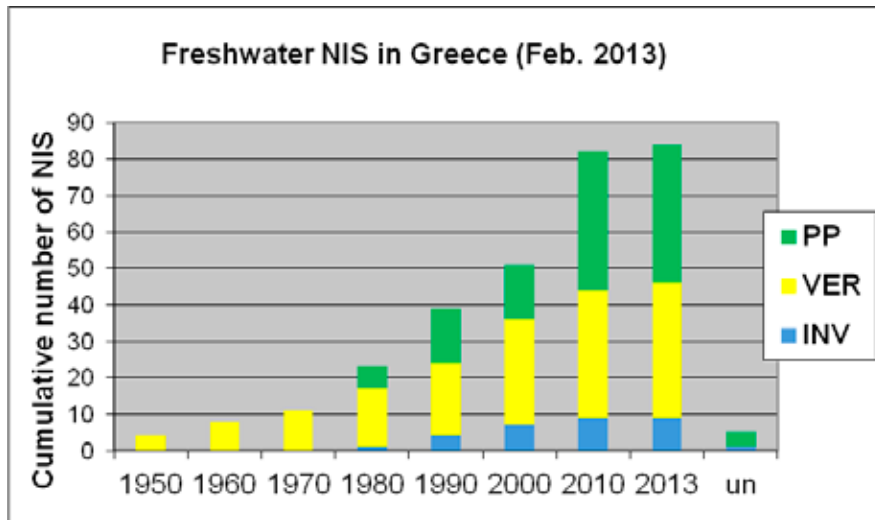


Fig. 2. Cumulative number of alien species established in the inland freshwaters, Greece, 2009.

Source: based on Zenetos et al. (2009a) and Koutsikos et al. (2012).

established in the terrestrial environment of Greece (6 primary producers, 7 invertebrates, 5 vertebrates).

In 2009, the Greek waters (inland, coastal and marine) hosted a total of 60 species of the worst invasive alien species threatening biodiversity in the Mediterranean (i.e. species that are highly invasive and have negative impact on native ecosystems, human health and the economy), showing a 20% increase (11 additional species) since 2000. The observed increase is a serious cause of concern, although it may be par-

tially related to the lower level of detail in screening alien species in earlier years. Of the 60 highly invasive species recorded, the majority (42%) is vertebrates followed by invertebrates (38%); primary producers account for 20%.

Specifically, 40 WIAS have been established in the marine environment (19 invertebrates, 11 primary producers, and 10 vertebrates); compared to the 29 species recorded up until 2000, they represent a 28% increase. 22 WIAS (14 vertebrates, 6 invertebrates

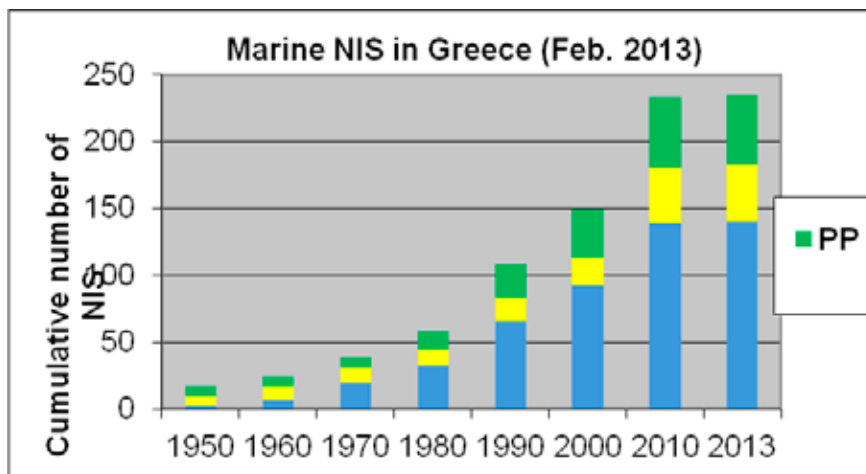


Fig. 3. Cumulative number of alien species established in the marine environment, Greece, 2013. Source: based on Zenetos et al. (2011) and ELNAIS (2013).

and 2 primary producers) have been recorded in the inland freshwaters, but only 2 of those were recorded after 2000 (10% increase).

Considering the high rate of biological introductions, which is particularly evident in the marine environment (Zenetos et al. 2011), new alien species has entered the ecosystem and some of them should

be added to the WIAS list. Table 1 lists the WIAS in Greece present to date. In addition to those present in Greece that have already exhibited an invasive behaviour, species with limited distribution and not documented by studies to date as invasive, are also presented in Table 1 as potential WIAS. The list of potential WIAS is intended as an early warning system.

Table 1. The worst invasive alien species (WIAS) reported in Greece based on SEBI 2010 and DAISIE compilation of WIAS in Europe (DAISIE, EEA 2007), and updated information for terrestrial plants reported in Arianoutsou et al. (2010a, b). Recent expert opinion was also considered. Purple shaded species are classified as potentially invasive (based on their traits).

Primary Producers	Invertebrates	Vertebrates	Environment
<i>Alexandrium taylori</i>	<i>Amphistegina lobifera</i>	<i>Fistularia commersonii</i>	Marine
<i>Asparagopsis armata</i>	<i>Brachidontes pharaonis</i>	<i>Lagocephalus scleratus</i>	Marine
<i>Asparagopsis taxiformis</i>	<i>Branchiommma luctuosum</i>	<i>Saurida lessepsianus</i>	Marine
<i>Caulerpa cylindracea</i>	<i>Bursatella leachii</i>	<i>Scomberomorus commerson</i>	Marine
<i>Codium fragile</i>	<i>Callinectes sapidus</i>	<i>Siganus luridus</i>	Marine
<i>Colpomenia peregrina</i>	<i>Crassostrea gigas</i>	<i>Siganus rivulatus</i>	Marine
<i>Halophila stipulacea</i>	<i>Crepidula fornicata</i>		Marine
<i>Ostreopsis ovata</i>	<i>Ficopomatus enigmaticus</i>		Marine
<i>Phaeocystis pouchettii</i>	<i>Hydroides dianthus</i>		Marine
<i>Styopodium schimperi</i>	<i>Hydroides elegans</i>		Marine
<i>Womersleyella setacea</i>	<i>Penaeus pulchricaudatus</i>		Marine
	<i>Mnemiopsis leidyi</i>		Marine
	<i>Percnon gibbesi</i>		Marine
	<i>Petricola pholadiformis</i>		Marine
	<i>Pinctada radiata</i>		Marine
	<i>Portunus segnis</i>		Marine
	<i>Rapana venosa</i>		Marine
	<i>Rhopilema nomadica</i>		Marine
	<i>Spirorbis marioni</i>		Marine
		<i>Gambusia affinis</i>	Freshwater/brackish
		<i>Micropterus salmoides</i>	Freshwater/brackish
		<i>Liza haematocheila</i>	Freshwater/brackish
<i>Azolla filiculoides</i>	<i>Anguillicoloides crassus</i>	<i>Carassius gibelio</i>	Freshwater
<i>Ludwigia peploides montevidensis</i>	<i>Anodonta woodiana</i>	<i>Cyprinus carpio carpio</i>	Freshwater

Primary Producers	Invertebrates	Vertebrates	Environment
	<i>Aphanomyces astaci</i>	<i>Gambusia holbrooki</i>	Freshwater
	<i>Dreissena polymorpha</i>	<i>Lepomis gibbosus</i>	Freshwater
	<i>Pacifastacus leniusculus</i>	<i>Oncorhynchus mykiss</i>	Freshwater
	<i>Potamopyrgus antipodarum</i>	<i>Ondatra zibethicus</i>	Freshwater
		<i>Pseudorasbora parva</i>	Freshwater
		<i>Salmo salar</i>	Freshwater
		<i>Salvelinus fontinalis</i>	Freshwater
		<i>Trachemys scripta</i>	Freshwater/terrestrial
<i>Paspalum paspaloides</i>		<i>Myocastor coypus</i>	Freshwater/terrestrial
		<i>Lithobates catesbeianus</i>	Freshwater/terrestrial
<i>Acer negundo</i>	<i>Aphis gossypii</i>	<i>Psittacula krameri</i>	Terrestrial
<i>Ailanthus altissima</i>	<i>Bemisia tabaci</i>	<i>Rattus norvegicus</i>	Terrestrial
<i>Carpobrotus edulis</i> & C. spp	<i>Cameraria ohridella</i>		Terrestrial
<i>Opuntia ficus- indica</i>	<i>Frankliniella occidentalis</i>		Terrestrial
<i>Opuntia</i> spp.	<i>Harmonia axyridis</i>		Terrestrial
<i>Oxalis pes-caprae</i>	<i>Leptinotarsa decemlineata</i>		Terrestrial
<i>Robinia pseudoacacia</i>	<i>Liriomyza huidobrensis</i> <i>Aedes albopictus</i>		Terrestrial
<i>Acer negundo</i>			Terrestrial
<i>Erigeron bonariensis</i>			Terrestrial
<i>Erigeron canadensis</i>			Terrestrial
<i>Erigeron sumatrensis</i>			Terrestrial
<i>Euphorbia maculata</i>			Terrestrial
<i>Euphorbia prostrata</i>			Terrestrial
<i>Heliotropium curassavicum</i>			Terrestrial
<i>Malephorra purpuro-crocea</i>			Terrestrial
<i>Medicago sativa</i> subsp. <i>sativa</i>			Terrestrial
<i>Nicotiana glauca</i>			Terrestrial
<i>Paspalum dilatatum</i>			Freshwater/terrestrial
<i>Paspalum distichum</i>			Freshwater/terrestrial
<i>Phytolaca americana</i>			Terrestrial
<i>Ricinus communis</i>			Terrestrial
<i>Salix fragilis</i>			Terrestrial
<i>Stearia adhaerens</i>			Terrestrial

Raising Awareness

Systematic monitoring of alien species and its continuation is of high importance. Priority should be given to the prevention of the establishment of aliens, through an improvement of the existing international legal framework, better coordination of international cooperation and the immediate elaboration of a targeted national strategy, which will improve the control of pathways of introduction and will establish an effective early warning system.

To date there have been 2 cases of invasive species for which there was nationwide public awareness: that of the deleterious puffer fish *Lagocephalus sceleratus* and that of the Asian tiger mosquito *Aedes albopictus*, carrier of the West Nile virus (WNV). In July 2012, Greece's Centre for Disease Control and Prevention, KEELPNO, confirmed that the number of cases of West Nile virus infection in Greece had risen to 14 (<http://digitaljournal.com/article/329388#ixz-z2LKt8lOsp>).

Citizen Science

The contribution of citizen scientists has been vital in understanding and monitoring the phenomenon of biological invasions in the Greek Seas. This is well demonstrated in the case of fishermen reporting to the Port authorities, who in turn report to ELNAIS and/or the local newspapers. Amateur shell collectors are also an invaluable source of information. Recent results suggest that citizen support, especially related to the marine invasive species, such as the pufferfish *Lagocephalus sceleratus*, is beginning to develop in Greece; local newspapers often run a front page headline on the subject. Approximately 86 observations of 28 alien species (validated by taxonomic experts) were reported in 2012 (Zenetos et al. 2013).

Legal Framework/ Policies Relevant to IAS in Greece

- Law No 3937/ 31.03.2011 on Biodiversity Conservation makes provisions on alien species. Article 12, in particular, includes specific regulations for invasive alien species such as: preparation of an inventory of all species classified according to their potential risk for ecosystem functioning; preparation of management plans according to their risk assessment; and issuance of leaflets with the most invasive species for the public. In the same law, Article 17 in particular, there are provisions for the establishment of a National Biodiversity Strategy and Action Plan (NBSAP) for Greece. According to the draft NBSAP, Biodiversity Protection from invasive alien species is one of its specific targets.
- Law 3983/2011 “National Strategy for the protection and management of the marine environment” - transposition of the Directive 2008/56 of the European Parliament and of the Council of 17 June 2008, establishing a framework for community action in the field of environmental (Marine Strategy Framework Directive) protection in marine waters across Europe; Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version of Directive 79/409/EEC as amended).
- Law 3199/2003 – transposition of Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy (EU Water Framework Directive or WFD) sets a framework for comprehensive management of water resources in the European Community, within a common approach and with common objectives, principles and basic measures.
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of

- wild fauna and flora.
- Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture as amended with Regulation (EE) 304/2011.
- Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions towards an EU Strategy on Invasive species of 3.12.2008 (COM (2008) 789) and the dedicated European legislative instrument on Invasive Alien Species, which is due to be adopted in 2013. This is one of six key objectives of the new EU 2020 Biodiversity Strategy adopted in May 2011 (<http://ec.europa.eu/environment/nature/invasivealien>).
- The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM 2004) of the International Maritime Organization (not ratified by Greece yet).
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Ratification by Law 2055/1992).
- The United Nations Convention on Biological Diversity (CBD) (Ratification by Law 2204/1994) and its Strategic Plan for Biodiversity 2011-2020 adopted in October 2010, with a target on invasive alien species.

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ANNEX

Research

Kalogirou S 2011. Alien fish species in the Eastern Mediterranean Sea: Invasion biology in coastal ecosystems. PhD Thesis, Department of Marine Ecology, University of Gothenburg, Sweden; <http://hdl.handle.net/2077/24869> ISBN: 91-89677-47-1

Tsiamis K 2012. Alien macroalgae in the sublittoral zone of the Greek coasts. PhD Thesis, Department of Biology, University of Athens

Kambouroglou V 2011. Introduction of allochthonous species in Greek Ports via Shipping and impact on local ecosystems. PhD Thesis, Department of Biology, University of Athens

Dissemination of information

A number of 10-15 publications per year reporting either new species in the Greek Seas or dispersion of established species. For new publications in aquatic environment every year see ELNAIS NEWS.