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## ELNAIS meets EASIN: distribution of marine alien species in Greece using EASIN mapping services and ELNAIS spatial data

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### Abstract

The European Alien Species Information Network (EASIN) was created with the aim to provide easy access to accurate information on alien species in Europe. EASIN allows the retrieval of spatial information from existing online data providers in order to produce integrated georeferenced distribution maps of alien species in Europe. In November 2012, a new data provider, the Hellenic Network on Aquatic Invasive Species (ELNAIS), joined EASIN; this has significantly increased the available georeferenced information on marine/estuarine alien species in Greece. Here, we use maps created by EASIN to show differences in patterns of distribution in the Greek Seas for the most abundant Phyla of marine alien species - Mollusca, Arthropoda, Chordata and Annelida. We also show that the two main pathways of introduction of marine alien species (Lessepsian migration and shipping) are related to different patterns of species spatial distribution in Greece. Overall, the tools provided by EASIN can greatly aid scientists and policy makers in obtaining high quality information on marine alien species in Greece, especially after the association with ELNAIS.

**Keywords:** marine alien species, Greece, pathways.

### Introduction

The European Alien Species Information Network (EASIN; <http://easin.jrc.ec.europa.eu>) aims to facilitate the study of information on alien species from various sources through a network of interoperable web services, and to assist the implementation of European policies focusing on biological invasions. EASIN allows extraction of alien species information from existing online information systems for all species included in the EASIN catalogue. This catalogue, which is at the core of the system, includes information on species taxonomic classification, synonyms, common names, pathways of introduction, native range in Europe, and impact (Katsanevakis *et al.*, 2012). The current version of the EASIN catalogue (v2.3) includes 1369 marine or estuarine alien species in European Seas. Greece is among the EU countries with the highest number of reported marine alien species (Katsanevakis *et al.*, 2013).

EASIN provides a number of services powered by a widget framework, including efficient search and mapping tools. Georeferenced distribution maps of selected alien species in Europe can be produced dynamically and

downloaded by the user. These maps are built by retrieving and aggregating information from multiple online data providers with which EASIN has established partnerships. As of October 2012, these providers were GBIF (Global Biodiversity Information Facility; <http://www.gbif.org>), GISIN (Global Invasive Species Information Network; <http://www.gisin.org>) and REABIC (Regional Euro-Asian Biological Invasions Centre; <http://www.reabic.net>).

Recognising the need for national/international co-operation 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: <https://services.ath.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 have been carrying out research related to aquatic alien species. Presently, the registry of experts includes 56 Greek experts from 11 Research Institutes/Universities. ELNAIS is an information platform aiming to collect information on the distribution and establishment success of alien

species in Greek waters. It covers freshwater, marine and estuarine species, including not only established aliens but also casual records and cryptogenic species. Besides the ELNAIS experts, divers, students, and NGOs contribute to the Network by providing information on new findings of alien species, photos of suspects, and habitat details. A total of 327 aquatic species (235 marine, 86 freshwater and/or brackish, 6 range expansion/vagrant) have been reported by ELNAIS (as of December 2012) to be present in Greek waters.

Since November 2012, ELNAIS joined EASIN as a new spatial data provider, supplying information on alien species for Greek waters. Herein, we present some immediate outputs of this collaboration and provide examples of how the EASIN services can assist scientific research on marine alien species in Greece. The maps included here have been exported from EASIN to ArcGIS (ESRI) for additional formatting.

### Overall contribution of ELNAIS

ELNAIS has provided georeferenced data for 133 marine alien species in Greece, being currently the most important data provider for this country (Fig. 1). By including ELNAIS, EASIN now has georeferenced records for a total of 177 marine alien species in Greece; apart from ELNAIS, data for 55 species come from GBIF, for 3 species from GISIN, and for 1 species from REABIC. ELNAIS has substantially contributed to increasing the available information on species occurrences in Greek waters (Fig. 1).

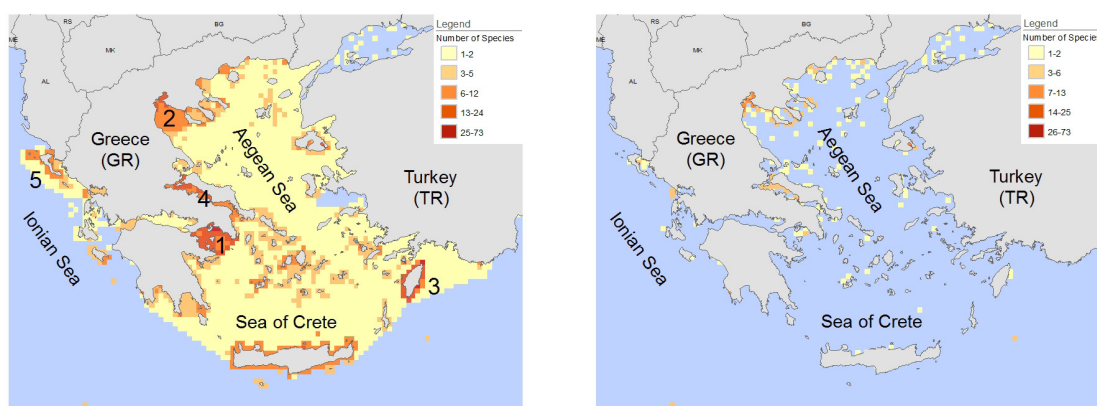
### Spatial patterns by taxa or by pathway of introduction

The ‘combined criteria search’ widget available at EASIN (<http://easin.jrc.ec.europa.eu/use-easin/species->

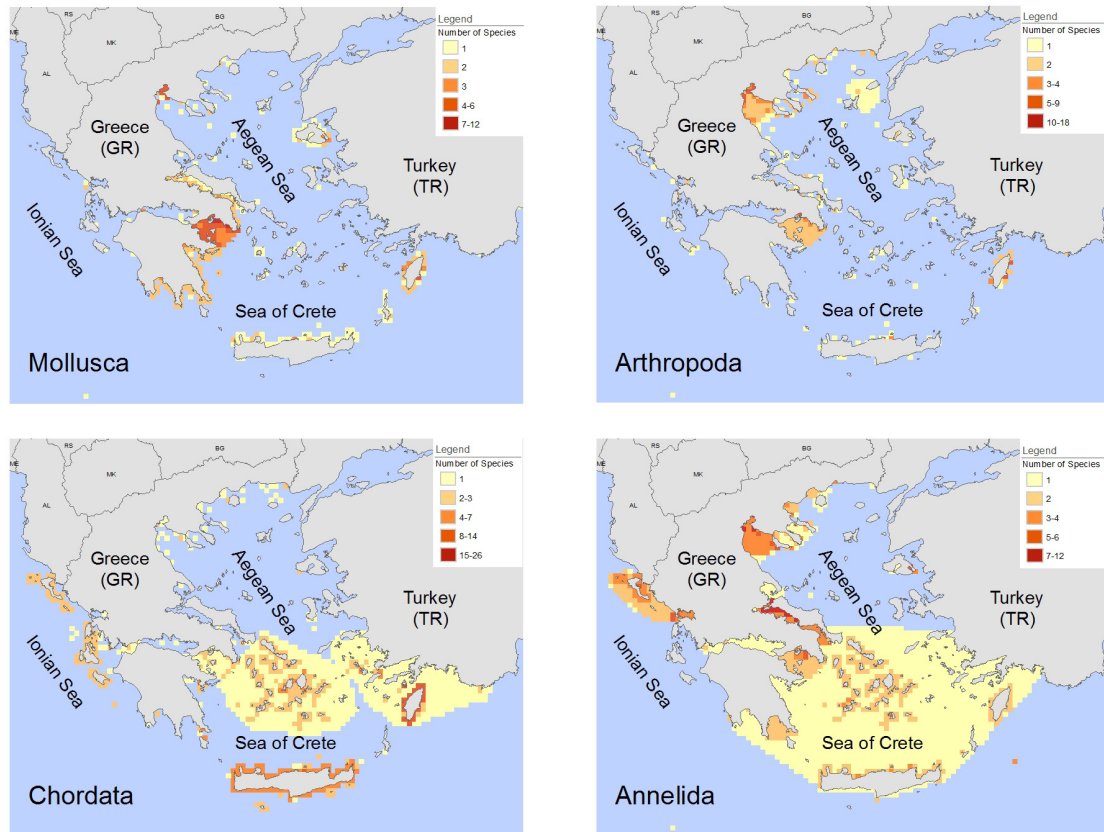
search/combined-criteria-search) makes it easy to produce distribution maps for different aggregations of alien species. It is possible to retrieve spatial data on species aggregated by taxonomic group (from Kingdom to Family level) or by pathway of introduction. Herein we present distribution maps of Greece with the four most numerous Phyla of marine alien species in Europe (i.e. in descending order: Mollusca, Arthropoda, Chordata, and Annelida, according to Katsanevakis *et al.*, 2013) (Fig. 2) and the two most important pathways of initial introduction of marine alien species in Greece (i.e. Corridors/Lessepsian and Stowaway/Shipping; Zenetos *et al.*, 2009b, 2011) (Fig. 3).

There are clear differences in the spatial invasion patterns of the different taxonomic groups (Fig. 2). The Saronikos and Thermaikos Gulfs are hotspots for alien Mollusca, Arthropoda, and Annelida, but not for Chordata (mostly fish). The Evvoikos Gulf appears to be a hotspot for Annelida, but not for any other taxonomic group. Alien Annelida are also abundant in the northern Greek Ionian Sea. A hotspot for alien Chordata is observed in Rhodes Island; they are abundant mainly in the southern Aegean Sea, the Ionian Sea, and in Crete, while there are very few species in the northern (and colder) Aegean Sea. Rhodes Island is also a hotspot for Arthropoda and Mollusca.

Different pathways of introduction are related to different patterns of species spatial distribution (Fig. 3). Lessepsian species thrive in the southern Aegean Sea, Crete, and the Ionian Sea, the Saronikos Gulf and Rhodes Island being hotspots (in agreement with Zenetos *et al.*, 2011; Pancucci-Papadopoulou *et al.*, 2012), but they are generally absent from the northern Aegean Sea. As these species are thermophilic, the lower temperatures of the northern Aegean Sea in most cases constitute a barrier to their establishment. On the contrary, species introduced by shipping have invaded areas throughout the Aegean



**Fig. 1:** The distribution of marine alien species in Greece on a standard 10x10 km grid, as extracted from EASIN (v2.3 of the EASIN Catalogue; accessed on 14 December 2012). The colour gradient indicates the number of marine alien species reported to be present at each cell of the grid. The map on the left has utilized data from all data providers (ELNAIS, GBIF, GISIN, REABIC), while the map on the right was created excluding ELNAIS data. 1: Saronikos Gulf; 2: Thermaikos Gulf; 3: Rhodes Island; 4: Evvoikos Gulf; 5: northern Greek Ionian Sea.

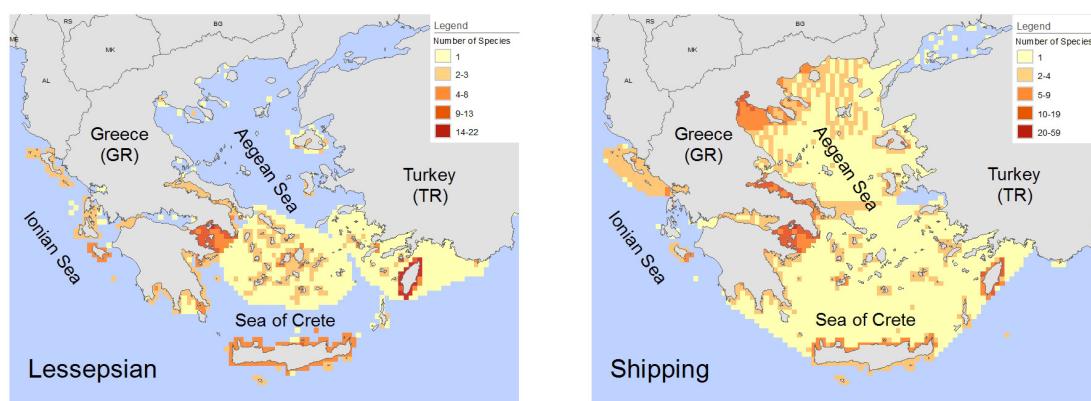


**Fig. 2:** Spatial distribution of the four most numerous Phyla of marine alien species - Mollusca, Arthropoda, Chordata, and Annelida -in the Seas surrounding Greece.

Sea; the Saronikos, Thermaikos, and Evvoikos Gulfs and Rhodes Island are hotspots for these ship-mediated species (Fig. 3).

In an attempt to show the different impact of other sources of pollution versus biopollution, Pancucci-Papadopoulou *et al.* (2009) applied the biopollution level (BPL) index proposed by Olenin *et al.* (2007) to data from the two major Greek Gulfs (Saronikos and Thermaikos), which have been affected by human pressure and high levels of pollution (mostly moderate ecologi-

cal status according to the assessments made for the Water Framework Directive - WFD), and to data from Rhodes Island, where there are no pollution sources (high ecological quality, according to WFD criteria). Results showed that biopollution was higher in Rhodes, while its values decreased northward showing a divergence among WFD ecological status and biopollution levels in the areas studied. This high biopollution level in Rhodes is largely associated with the presence of Lessepsian species. This work reinforces the observation that biopol-



**Fig. 3:** Spatial distribution of marine alien species introduced via the Suez Canal (Lessepsian) and by shipping, in the Seas surrounding Greece.



lution hotspots associated with Lessepsian introductions may diverge from pollution hotspots. On the other hand, pollution hotspots (Saronikos and Thermaikos) are also biopollution hotspots, mainly due to ship-mediated introductions.

The spatial patterns presented might also be due partly to a non-uniform distribution of monitoring efforts. This factor should always be taken into account when interpreting such distribution patterns. Nevertheless, with increasing monitoring and reporting efforts and with the collaboration of many initiatives into a common network such as EASIN, such biases will very likely decrease and higher quality information will be available to scientists and policy makers. The EASIN-ELNAIS collaboration also provides valuable tools for the environmental assessment of the MSFD Descriptor 2 (Non Indigenous Species - NIS), specifically for assessing the trends in abundance, temporal occurrence, and spatial distribution of NIS in relation to the main vectors and pathways of spreading (indicator 2.1.1; EC, 2008; Cardoso *et al.*, 2010).

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