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Aquatic alien species in Greece (2009): tracking sources, patterns and effects on the ecosystem

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More than 270 Aquatic Alien Species (AAS) are reported from Greece. Besides the introductions via the Suez Canal, the most important vectors of introduction are imports for aquaculture purposes and trade. Most marine biota has spread in the south Aegean, while freshwater biota occur mostly in northern Greece. Prime source regions are the Indo-Pacific and America. For all source regions and taxonomic groups considered, the invasion rate has been increasing since the end of the last century, a trend indirectly related to the "tropicalization" of the Mediterranean Sea. Although the impact of AAS has been poorly documented, a literature review reveals many cases of formerly considered tropical species (such as the ciguatera causing genus *Gambierdiscus*) in the Mediterranean Sea and specifically in Greek waters, the presence of which might not only affect the ecosystems, but also human health and economic activities, such as fisheries, aquaculture and tourism. International as well as EU regulations are implemented in theory but not adequately enforced or need to be updated based on recent advances of AAS. A targeted public awareness campaign aimed particularly at resource users and site-based monitoring is suggested.

Key words: check-list, introduced species, invasive species, marine, freshwater, Greece.

INTRODUCTION

There is a consensus today that human mediated introduction of species outside their natural range, the so-called biological pollution (Elliot, 2003), is one of the main threats to biodiversity. The rate of new alien species establishment in terrestrial and freshwater ecosystems has been considered as constant during the last 100 years, while there is a significant increase during the last 50 years as regards marine/estuarine species (EEA/SEBI2010, 2007). An increasing trend towards aquatic invasions has been documented for all European Large Marine Ecosystems but it is most pronounced in the Mediterranean Sea (Streftaris *et al.*, 2005; EEA, 2007). This accelerating trend in alien species establishment indicates that the situation is far from being under control, with impacts on biodiversity expected to be increased because of the growing number of species involved and an increasing vulnerability of ecosystems to invasions (which results from habitat degradation, fragmentation and climate change).

The eastern Mediterranean Sea is especially susceptible to biological invasions because it is a crossroad between the Ponto-Caspian and the Indian Sea/

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Red Sea regions, the maritime traffic from the Indian Ocean and the widespread occurrence of fish and shellfish farms (CIESM, 2007). Hence, Greek waters may function as a gateway to the dispersal of marine alien species, either from the Levantine to the Adriatic and/or to the western Mediterranean or from the Black Sea to the eastern Mediterranean. Pancucci-Papadopoulou *et al.* (2005a) reported that among the Greek Seas, the Aegean, and in particular its southern part, is the area where the majority of the alien marine species is distributed, mainly due to its vicinity to the Levantine Basin. Indeed, the influx of the Levantine Intermediate Water (Kontoyiannis *et al.*, 2005) supplies the southern Aegean with elements of Indo-Pacific origin (Zenetos *et al.*, 2005a). It might be expected that planktonic larvae of alien species established in the Levantine would disperse into the Aegean, and also that larvae of species established in the Black Sea should be able to disperse into this area. Furthermore, shipping traffic through the Dardanelles Strait, Gibraltar and Suez Canal is very heavy, which should increase the likelihood of alien species introductions.

Following a series of scattered publications dealing with single species or groups (Papaconstantinou, 1990; Corsini *et al.*, 2002, 2005; Corsini-Foka *et al.*, 2004; Simboura & Zenetos, 2005; Zenetos *et al.*, 2005a), a summary of marine alien biota in Greek waters was reported by Pancucci-Papadopoulou *et al.* (2005) and updated by Pancucci-Papadopoulou *et al.* (2005b). Zenetos *et al.* (2007) provided some additions to the alien fauna and Corsini-Foka & Economidis (2007) focused on the marine and estuarine fish fauna. Tsiamis *et al.* (2008) have reviewed the alien marine macrophytes, while information regarding marine microalgae (comprising some species formerly known as tropical) is increasing (Aligizaki *et al.*, 2004, 2008a, 2009a; Aligizaki & Nikolaidis, 2006, 2008).

With regard to the freshwater fish fauna of Greece, reviews and checklists produced by Stephanidis (1939), Economidis (1973, 1991), Economidis *et al.* (2001) and Economou *et al.* (2007a) indicate an increasing rate of occurrence of non-native fish. An overview of the introduced fish species to the inland waters of Greece published by Economidis *et al.* (2000a) contains comprehensive information for each species listed. Recently, more data on the introduced species in individual drainages have been provided by numerous authors, i.e. Kokkinakis *et al.* (1999), Economou *et al.* (2004), Kokkinakis (2006) and Leonardos *et al.* (2007).

Despite periodical reviews, site-based inventory and monitoring of species and assemblage distributions is poorly developed and coordinated in Greece. This is epitomized in the remarkable lack of attention to and monitoring of non-vertebrates and aquatic plants from inland waters. Field surveys rarely target alien species distributions or impacts in Greece, as there is a traditional priority placed on identifying range-restricted or endemic terrestrial species (Legakis, 1992, 2004). Unfortunately, the grey literature or even the published bibliography is often susceptible to misidentifications or taxonomic problems since the number of taxonomists interested in alien species has been, until recently, very low. The freshwater invertebrate fauna of Greece is one of the least studied (Mantziou *et al.*, 1999) and therefore many alien species may go unnoticed or unrecorded (Legakis, 2004). Although the flora is better studied (Arianoutsou *et al.*, 2007), there is a lack of work, especially on aquatic macrophytes and wetland flora (e.g. Raus & Raabe, 2002). A recent EU initiative focusing on alien flora is the DAISIE project (The Delivering Alien Invasive Species Inventory for Europe), compiled the first comprehensive checklist of alien species of vascular plants in Greece (Lambdon *et al.*, 2008). Coordinating, communicating and promoting all-taxa distribution and status information is one of the most critical needs in managing the issue of alien invasions.

Here, we conducted an extensive update of alien species distributions and their dispersal history in order to produce an inventory dealing with all major taxa within the aquatic ecosystems of inland and marine waters. We aim at producing a baseline for identifying the establishment success of these species in Greece, and the times and modes of introduction. Finally, we analyze the all-taxa dataset to extract generalizations that may allow suggestions about the approach required for managing alien species in Greece.

MATERIALS AND METHODS

The list has been compiled gathering the information available to date from the scientific literature and processing it after careful verification and reference cross-checking. Here we analyze species introduced by humans and those of possible natural dispersal (potentially assisted by anthropogenic means).

For marine biota, the basis of the present work is the checklist of alien species reported by Pancucci-Papadopoulou *et al.* (2005b). Additional records of species found in the period January 2006-June 2009,

published or recorded in the grey literature, as well as species belonging to taxonomic groups not considered previously and unpublished records are included. Grey literature includes HCMR and EU technical reports, scientific congresses, personal communications by specialists and websites (e.g. SEASLUG forum, ALGAEBASE, FISHBASE, FAO's DIAS, IUCN/ISSG). Another data set of aquatic invaders, which contains more comprehensive information for each species listed, is archived in the HCMR data base and detailed distribution maps for each species can be found on the ELNAIS website (http://elnais.ath.hcmr.gr).

For the freshwater fish of Greece, we employed as a baseline the review by Economidis *et al.* (2000a) and a detailed survey that produced a hydrographic basin based inventory and codification of available data (Economou *et al.*, 2004, 2007a). Euryhaline species stocked in inland waters but not able to reproduce in freshwater (e.g. Bobori *et al.*, 1998) and alien species reported in transboundary water bodies (Stefanof, 2007; Uzunova & Zlatanova, 2007) but not yet found in Greek sections have been excluded. Alien fish/shellfish species used in aquaculture with uncertain presence in the field are reported as questionable.

For the macrophyte species of inland waters (lakes, rivers and ponds) and of some wetland habitats in Greece, the basis of the present work is the published papers and Ph.D. theses of Greek and other experts (e.g. Koumpli-Sovantzi, 1983, 1989, 2008; Papastergiadou, 1990; Raus, 1991; Yannitsaros, 1991; Papastergiadou & Babalonas 1993; Sarika-Hatzinikolaou, 1999; Raus & Raabe, 2002; Sarika, 2005; Sarika *et al.*, 2005; Zotos *et al.*, 2006), Mediterranean Check Lists (Greuter & Raus, 1982, 2001, 2002, 2006), as well as further investigation and cross checking of reports, conference proceedings and databases (e.g. IUCN, DAISIE). Due to difficulties in distinguishing between terrestrial and amphibious plants and misunderstanding of taxonomic rules we followed the proposed synthetic ecological classification system by Hutchinson (1975), based on life forms and growth forms for aquatic macrophytes. For the purposes of this work we exclude alien ruderal and nitrophilous species (for example *Cotula coronopifolia*, *Xanthium strumarium*, etc) growing on the banks of bodies of water or on wet habitats, which will be included in a future publication (Papastergiadou *et al.*, in preparation).

According to their establishment success alien species have been grouped into four broad categories namely "established" (permanent, self-maintaining populations including invasive), "casual" (recorded only once or twice), "questionable" (insufficient information, highly probable records requiring confirmation), and "cryptogenic" (species of inconclusive origin). Uncertainties in systematic identifications could result in unsound hypotheses or incorrect conclusions about the evolutionary and invasion history of populations. In such cases we have used the term "cryptogenic/questionable".

The date of the discovery of the first population is of significance when studying patterns and processes of invasion (Ruiz *et al.*, 2000). Thus, the year of the first sighting or report for each taxon as well as corresponding references are given. For some of the species, the exact dates of introductions are unknown and are indicated by the decade when the introduction occurred. When the year of the first record is missing, we consider the date of publication. However, in many, if not most, cases, comprehending the patterns of the spread of aliens is hampered by our ignorance of the species arrival date and the location of first arrival.

Regarding origin of species, both origin and donor area are given in cases of secondary introductions (species imported or invasive in neighbouring Seas that have progressively penetrated into the Mediterranean). In such cases, our considerations on origin refer to the donor area.

RESULTS AND DISCUSSION

A total of 275 alien taxa reported from Greek waters are considered in this overview, i.e. the coasts of the Aegean and Ionian Seas (193 species) and the inland and estuarine waters (87) within the national borders of Greece (Annex). Five of them were found both in fluvial and estuarine areas (see Annex). Most alien species are invertebrates, followed by plants and vertebrates (Table 1). Of the zoobenthic species, the majority belongs to mollusca and crustacea (Fig. 1). A biogeographic study of marine aliens showed that they are present in their majority in the southeastern Aegean (Pancucci-Papadopoulou *et al.*, 2005a). In contrast, most freshwater alien fish species have been recorded in northern Greece (Economidis *et al.*, 2000a).

Trends in establishment success

Overall trends for marine and freshwater environments are presented in Fig. 2. In the marine environment it is widely perceived that the littoral and in-

TABLE 1. Who is who per ecofunctional/taxonomic group. NA: Non available data

		Total	Marine/estuarine	Freshwater/estuarine
VERTEBRATES	fish	66	42	28
(74 species)	mammals	2	–	2
	other	6	1	5
INVERTEBRATES	zooplankton	9	9	NA
(110 species)	zoobenthos	99	91	8
	parasites/pathogens	3	2	2
PLANTS	planktonic microalgae	8	8	NA
(90 species)	benthic microalgae	9	9	NA
	macrophytes (hydrophytes)	10	1	9
	macrophytes (helophytes and amphibious species)	33	–	33
	phytobenthos	30	30	–
TOTAL		275	193	87

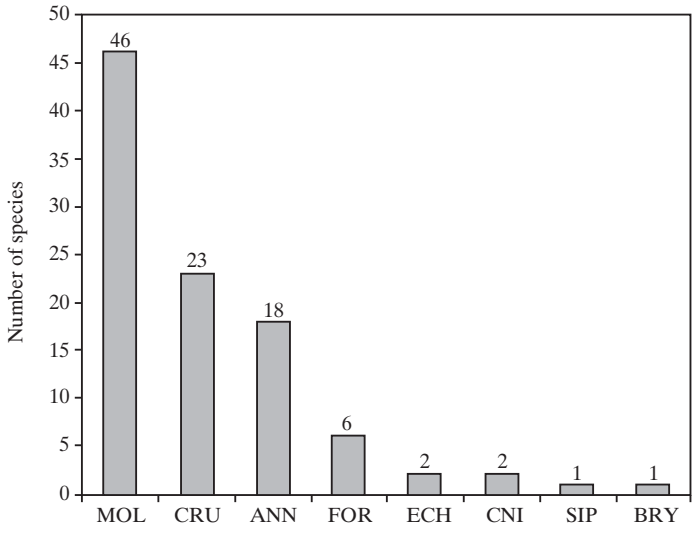

FIG. 1. Breakdown of zoobenthic alien species per taxonomic group (MOL = Mollusca, CRU = Crustacea, ANN = Annelida, FOR = Foraminifera, ECH = Echinodermata, CNI = Cnidaria, SIP = Sipuncula, BRY = Bryozoa).

fralittoral biota has been undergoing a rapid and profound change. An increasing trend in the occurrence of marine aliens (Fig. 2A) that started in the decade 1980-1990 coincides with the revival of Greek taxonomists, mainly in zooplanktonic and zoobenthic groups. This trend continues in the following decade, when the world scientific interest in aliens increased, and culminates in the present decade. It is worth noticing that intensive research during the last nine years has revealed 65 new entries (Fig. 2A).

The introduction of freshwater alien species in Greece is also rising (Fig. 2B). We suspect that some of the fish introductions reported in the 1990s had occurred at an earlier time but went unrecorded. 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). In

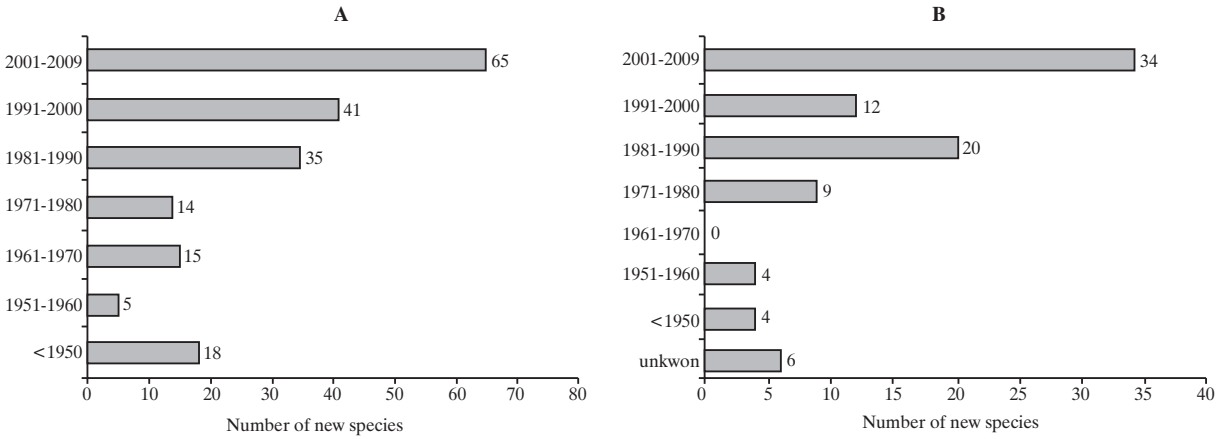

FIG. 2. Number of A) marine and B) freshwater species introductions into Greek waters for 10 year intervals after 1950.

addition, global warming and the tropicalization scenario (Occhipinti-Ambrogi, 2007) cannot be ruled out as contributing factors enhancing the opportunities for introduced aliens to establish viable populations. Thus, although water warming cannot explain totally the aliens success, it may accelerate the northward expansion and biomass increase of thermophilic species, including non-indigenous tropical and subtropical species (Boudouresque, 2005; Bianchi, 2007; Fraga, 2007); this seems to be the case for the toxigenic tropical dinoflagellate genus *Gambierdiscus*, which was recorded for the first time in the Mediterranean Sea in Crete Island (Aligizaki & Nikolaidis, 2008; Aligizaki *et al*., 2008a), but very recent data indicate its further northward expand at Saronikos Gulf (Aligizaki *et al.*, 2009b). Details on the history of introduction per ecofunctional/taxonomic group are provided below.

VERTEBRATES: Fish

A review of the alien ichthyofauna occurring in the marine and estuarine waters presented in Corsini-Foka & Economidis (2007) includes 41 species. Among them, six species fall into the category of introduced for aquaculture and their presence in nature is based on observation of free swimming specimens, strongly suggesting unintentional release or escape from fish farms.

Corsini & Economidis (1999) reported that several Indo-Pacific species were reported in the Dodecanese (SE Aegean) almost simultaneously as on the coasts of Israel. Such are the cases of *Siganus rivulatus*, *Upeneus moluccensis*, *Sargocentron rubrum*, *Pteragogus pelycus* and *Fistularia commersonii.* The trend in fish species introduction and establishment success is increasing; *Scomberomorus commerson* was recorded in 2007 (Corsini-Foka & Kalogirou, 2008), *Lagocephalus sceleratus* spread rapidly in the Aegean (Peristeraki, 2007); *Upeneus pori, Scomberomorus commerson* and *Torquigener flavimaculosus* are recorded more and more often (Corsini-Foka, personal communication).

Of the 28 alien freshwater fish species in Greece, only 10 have established themselves through natural reproduction. Among the intentionally introduced aliens with established populations, the most widespread is the mosquito fish *Gambusia holbrooki* followed by the common carp *Cyprinus carpio.* Of the intentionally introduced species, the most commercially important are *Oncorhynchus mykiss*, *Ctenopharyngodon idella* (grass carp) and *Hypophthalmichthys molitrix* (silver carp). Of the unintentionally introduced species with well-established populations, *Carassius gibelio* is particularly widespread and has entered water bodies following carp introductions. *Lepomis gibbosus* and *Pseudorasbora parva* are two other aliens unintentionally introduced, which are spreading quite rapidly. *Lepomis gibbosus*, *Pseudorasbora parva*, *Carassius gibelio* and *Gambusia holbrooki* have been adapted very successfully and established thriving populations in many water bodies. These four species are spreading rapidly and are regarded as invasive. Others, such as *Salmo trutta* and *Acipenser naccarii*, can potentially breed but the rarity of individuals in the wild indicates either low reproductive success or poor survival. Such species are considered

as non-acclimatised and their occurrence in the field depends on stockings and/or aquaculture escapes.

The available data indicate conclusively rising trends in introductions and establishments of alien fish species during the 20th century. Improvements in experimental fishing techniques (e.g. electrofishing) and data collection systems have facilitated the detection of rare species in the last decades.

VERTEBRATES: Mammals

Few semi-aquatic mammals have been released in Greece. *Myocastor coypus* (coypu), raised in captivity, has been observed in the wild between 1948 and 1966 in a variety of habitats (Aliev, 1967). There are currently wild populations in the northen part of Greece (Mitchell-Jones *et al.*, 1999). The status of some other species remains questionable such as the distribution of *Ondatra zibethicus* (Mitchell-Jones *et al.*, 1999) which may have been introduced through fur farming, although no evidence of establishment has been confirmed.

VERTEBRATES: Amphibians/Reptiles

There are very few incidences of reptile or amphibian introductions, e.g. the released pond slider, *Trachemys scripta*, occurs in Crete, Kos, Zakynthos and Corfu islands (Bruekers *et al.*, 2006). The American bullfrog *Lithobates catesbeianus* has been introduced into Crete (Mantziou *et al.*, 1999). An incidental sighting of the tropical sea serpent *Laticauda colubrina* in Corfu (Steinicke & Trutnau, 1993) is classified as questionable on the grounds that it is highly unlikely that the species would occur in Greek seas.

VERTEBRATES: Birds

Officially only one alien aquatic waterfowl population is established in Greece, although several ornamental waterbirds have been released or have unintentionally escaped from captivity. The mute swan, *Cygnus olor*, although a native localized breeding species and winter visitor to Greece, has been intentionally introduced to lakes in northern Greece where these resident alien populations have survived in a wild state. These small alien populations in Lakes Agra and Orestiada (N. Greece) have resulted from introductions of specimens brought from northwestern Europe in the 1960s (Handrinos & Akriotis, 1997).

There is no documented evidence of other alien established waterbird populations. Free-flying escapes from zoos or private collections are rather frequent but these species usually do not survive for long periods in the wild; *Pelecanus rufesens* was recorded in one western Greek wetland at the same time as an individual escaped from the Attika Zoological Park (Zogaris *et al.*, 2003). Several species of ornamental ducks and other waterfowl are frequently seen in the wild and especially in or near urban parks including *Aix galericulata*, *Aix sponsa*, *Alopochen aegyptiacus*, *Branta leucopsis*, *Branta canadensis*, *Cygnus atratus*, and *Phoenicopterus minor* (Hellenic Ornithological Society, 2007). Some of these, such as *Aix sponsa* are already taking advantage of artificial reservoirs (e.g. in Crete) and they may be able to breed there in the future.

An interesting potential addition to the Greek avifauna is the sacred ibis (*Threskiornis aethiopicus*), a wading bird, which breeds in sub-Saharan Africa, southeastern Iraq, and formerly in Egypt, where it was venerated and often mummified as a symbol of the god Thoth. The species was first observed in Greece in December 2008 and two sub-adult birds were present at Schinias Wetland in Attika throughout the spring of 2009 (S. Zogaris, A. Vidalis, A. Papadaki & L. Katerinopoulos, personal observation). These birds may be escapees or may possibly have dispersed from established breeding colonies in the Western Mediterranean; the number of individuals of this alien species has been rapidly increased in France while *T. aethiopicus* populations have been established in Italy and other European countries (Yésou & Clergeau, 2005).

INVERTEBRATES: Molluscs

To date there are 40 alien marine molluscs in Greece (Zenetos *et al.*, 2005a, 2007, 2008a, 2009b; Ovalis & Zenetos, 2007; Mollo *et al.*, 2008; ELNAIS website). The latest records mostly concern establishment of recently introduced nudibranchia, such as *Aplysia dactylomela* and *Haminoea cyanomarginata* (Zenetos *et al.*, 2007), or bivalvia (*Petricola pholadiformis*; Zenetos *et al.*, 2009a) and new findings such as *Syphonota geographica* (Mollo *et al.*, 2008), *Chama aspersa* and *Chama asperella* (Ovalis & Zenetos, 2007), *Ergalatax junionae* (Zenetos *et al.*, 2008a), *Cerithium scabridum* (Zenetos *et al.*, 2009b) and *Sepioteuthis lessoniana* (Lefkaditou *et al.*, 2009). The occurrence of freshwater alien molluscs seems to be restricted to certain sites, and this may represent inadequate sampling and inventory. Taxonomic problems with the local

fauna have not been totally resolved (Bank, 2006). A dreissenid invasion of unknown origin (true zebra mussel or autochthonous Balkan dreissenid) was reported from Greek reservoirs (especially Tavropos, Kremasta and Kastraki), where invaders were identified as *Dreissena polymorpha* (Economou *et al.*, 1991; Petridis & Sinis, 1993; Conides *et al.*, 1995). The New Zealand mud snail, *Potamopyrgus antipodarum,* one of the most invasive species in Europe (EEA/SEBI2010, 2007) is established in Lake Trichonis (W. Greece) (Radea *et al.*, 2008).

INVERTEBRATES: Crustacea

As opposed to freshwater crustacea, marine species are fairly well studied and, among them, 23 alien benthic species are registered, thirteen of which are well-established. One third of these species were recorded for the first time after 2000. *Callinectes sapidus* was the first alien crab collected in northeastern Greece in 1947 (Serbetis, 1959) also reported in the marine area of Rhodes island by 1976 (Lewinshon, 1976). One of the latest alien species reported for Greece (*Sirpus monodi*: Pancucci-Papadopoulou & Naletaki, 2007) is also a first record for the Mediterranean Sea while the finding of *Carupa tenuipes* (Pancucci-Papadopoulou *et al.*, 2009a) confirms the successful establishment of the species in the Eastern Mediterranean after Israel and Turkey (Yokes *et al*., 2007). One of the most invasive species is *Percnon gibbesi* (Thessalou-Legaki *et al.,* 2006), which is widely distributed along the south Aegean coasts.

Published work on freshwater crustacean distribution in Greece is scarce. Moreover, unidentified and misidentified animals by some authors complicate the situation. Previous papers on pan-European crayfish distribution provide a description of crayfish distribution up to 1996, but only in northern Greece (Machino & Holdich, 2006). *Pacifastacus leniusculus* was imported, at least in two cases, from Sweden and Germany during the early and late 1980s, respectively. It was introduced into Lake Agra, near Edessa (N. Greece) in 1987, imported from Germany after a mass mortality incidence during 1976-1977 that eliminated the native population in the lake (Evaggelidis, 2001). Today this is the only known established population of the species in Greece (Koutrakis *et al.*, 2007; Perdikaris *et al.*, 2007). Research pertaining to freshwater planktonic crustaceans (Copepoda, Cladocera) in Greece does not exist.

INVERTEBRATES: Annelida: Polychaetes/Oligochaetes

Simboura & Zenetos (2005) report six alien species occurring in Greek waters that have more or less passively entered through the Suez Canal. Some of these species, such as *Metasychis gotoi*, have established viable populations and are widely distributed while others, such as *Notomastus aberans* and *Spirobranchus tetraceros* have a very restricted distribution in the Aegean Sea. Pancucci-Papadopoulou *et al.* (2005b) have revised previous lists, following the Mediterranean Annotated List of Alien Biota (Zenetos *et al.*, 2005b) inventorying twelve species, two of them as questionable (*Cossura coasta* and *Lysidice collaris).* The present work adds 5 more species, namely *Hydroides diramphus*, *Glycinde bonhourei* and *Polydora cornuta* as casual records (Nicolaidou & Pitta, 1986; Simboura, 2008; Simboura *et al.*, 2008), and *Branchiomma luctuosum* and *Pseudonereis anomala* as established (Zenetos *et al.*, 2007). Fifty six (56) individuals of the freshwater oligochaete *Branchiura sowerbyi* were found in 2008 in Strymonas River, N. Greece (Grabowski & Jabłońska, 2009).

INVERTEBRATES: Other

The Indo-Pacific holothurian, *Synaptula reciprocans*, which has entered the Mediterranean Sea through the Suez Canal and has spread along the Levantine coast was first noted in Rhodes island in 2004 (Pancucci *et al*., 2006). A recent survey reports the finding of flourishing populations off the Dodecanese and Kyklades islands, southeastern Aegean Sea (Antoniadou & Vafidis, 2009). Similarily, the scleractinian coral *Oculina patagonica* first reported in 2005 (Salomidi *et al*., 2006) has become one of the most invasive species in the Saronikos Gulf by 2009 (M. Salomidi, personal communication).

PLANTS: Planktonic and benthic microalgae

Seventeen marine microalgal species have been recorded totally, nine of which are benthic dinoflagellates. While the planktonic forms were mostly reported in the 1980s, the benthic ones are being detected mainly after 2002. The records of taxa, such as *Prorocentrum borbonicum*, *Sinophysis canaliculata* and *Gambierdiscus* sp. in Greek waters indicate the northward expansion of previously considered tropical species (Aligizaki & Nikolaidis, 2008; Aligizaki *et al*., 2008a, 2009a), strengthening the discussions on the "tropi-

calization" of the Mediterranean Sea (Bianchi, 2007).

An ambiguous case is that of *Prorocentrum rhathymum*, a benthic/ticoplanktonic dinoflagellate, and *P. mexicanum*, a planktonic species; these taxa were erroneously considered as synonyms for more than 20 years (Steidinger, 1983; Cortés-Altamirano & Sierra-Beltrán, 2003) and this confusion led to a high number of inaccurate records of *P. mexicanum* worldwide. *Prorocentrum mexicanum* was reported from Greek waters in 1991 (HCMR, 1992), while *P. rhathymum* was recorded and identified according to its original and its emended description (Loeblich *et al.*, 1979; Cortés-Altamirano & Sierra-Beltrán, 2003) in 2003 (Aligizaki & Nikolaidis, 2006). Based on similar records from the Mediterranean Sea (e.g. Vila *et al*., 2001), and the fact that *P. mexicanum* has a very narrow distribution in the South Pacific (Cortés-Altamirano & Sierra-Beltrán, 2003) and has not been detected in Greek waters after 1991, is most possible that this record represents a misidentification of *P. rhathymum*. The aforementioned situation is indicative of the difficulties that arise regarding detection of alien microalgae, where precise morphological and molecular identification should be addressed.

To our knowledge, there is no data on alien freshwater microalgae, a fact most probably attributed to the absence of research on this issue.

PLANTS: Macroalgae

During recent decades, there has been an increasing rate of marine macroalgae introduction in all parts of the world, but especially in the Atlantic Ocean and the Mediterranean Sea (Wallentinus, 2002). Alien marine macroalgae, such as *Hypnea cornuta*, have been reported in Greece since the late 19th century (Reinbold, 1898). However, their occurrence on the Greek coasts was restricted, and until the 1970s their rate of introduction was extremely low (~ 1 alien algal species per decade). Since then, the rate of introduction has clearly increased. From today's total of alien macroalgae in Greek waters, approximately 65% has been reported during the last 30 years. To a large extent, this is due to confusion in nomenclature and literature. Genetic and morphological studies will help solve many difficulties, e.g. genetic studies in *Asparagopsis taxiformis* have demonstrated that several strains co-occur in the Mediterranean and one of them is definitely introduced (Andreakis *et al.*, 2004).

Among the introduced marine macrophytes in Greece, five have invasive behaviour: *Asparagopsis taxiformis*, *Caulerpa racemosa* var. c*ylindracea*, *Codium fragile fragile*, *Womersleyella setacea* and *Halophila stipulacea*; these are among the 9 most invasive marine macrophytes listed for the Mediterranean Sea (Boudouresque & Verlaque, 2005). Most alien marine macroalgae are found in the south Aegean, while the fewest are found in the Ionian Sea. *Caulerpa racemosa* var. *cylindracea*, *Asparagopsis taxiformis*, *Codium fragile fragile* and *Womersleyella setacea* are considered as invasive on several Greek coasts (Tsiamis *et al.*, 2008). By July 2009, the total number of alien marine macroalgae recorded on Greek coasts (30 taxa) remains unchanged when compared to Tsiamis *et al.* (2008); however, the proportion of each category differs with 12 established, 6 casual and 12 questionable species (Tsiamis *et al*., in press). *Neosiphonia harveyi* (J. Bailey) M.-S. Kim, H.-G. Choi, Guiry & G.W. Saunders has been added to the list, while *Chorda filum* (Linnaeus) Stackhouse has been excluded as according to Athanasiadis (1987), the record of *Chorda filum* from the N. Aegean Sea (Candargy, 1899) is probably based on a misidentification (Tsiamis *et al*., in press).

PLANTS: Macrophytes

The marine flowering plant *Halophila stipulacea* is one of the first alien species reported in the Mediterranean and was noted in Greece in the late 19th century (Fritsch, 1895). The species is presently widely spread along Greek coasts (Tsiamis *et al.*, 2008).

The alien freshwater flora of Greece is poorly studied, since several regions and habitats likely to host such species are under-sampled. Recent inventory and compilation work has been promoted through the DAISIE project; the database currently concerns 325 taxa, with comparatively few truly aquatic species (hydrophytes). Most of the alien taxa grow in disturbed and man-made habitats, such as cultivations, paddy fields, fallow lands, roadsides and wastelands, around and within inhabited areas (Greuter & Raus, 2002, 2006; Bazos *et al.*, 2009). It is remarkable that certain widespread aquatic aliens have been recorded only locally or remain unrecorded in Greece; more intense field research will eventually increase their numbers (Raabe & Koumpli-Sovantzi, 2002; Raus & Raabe, 2002; Sarika, 2005; Zotos *et al.*, 2006). Most alien macrophytes have been found recently in the paddy fields of northern and western Greece (Raus & Raabe, 2002; Koumpli-Sovantzi, 2008) and some others have escaped from aquaria or botanical gardens.

Semi-terrestrial riparian areas and humid wetland fringes seem to be a hotspot for certain invasive species and larger woody species which are widespread and influence riverine and lacustrine shores. These alien woody species include *Robinia pseudacacia*, *Ailanthus altissima*, *Amorpha fruticosa*, *Eucalyptus camaldulensis* and locally *Acacia cyanophylla* (DAISIE; Zogaris pers. obs.). *Arundo donax* is a reed-cane which was presumably introduced by man before classical times but the species has become naturalized and exhibits very 'invasive' behaviour in lowland riparian areas, as it does in the western Mediterranean and in California (Bell, 1997). Another non riparian species of *Arundo*, growing close to river banks but at a higher elevation, *Arundo mediterranea* Danin (synonym *A. mauritanica* Desf, originating in Algeria) has recently been reported from many areas of Greece, Cyprus and east Mediterranean countries (Greuter & Raus, 2006).

Parasites/Pathogens

Aphanomyces astaci is a fungus endemic to North America, carried by North American species, i.e. signal crayfish *Pacifastacus leniusculus*, *Procambarus clarkii* and *Orconectes limosus*. In Greece, crayfish plague was first noted in 1982 (Thyamis River) after 1,000 individuals of *Pacifastacus leniusculus* were released from a Swedish stock. Mass deaths of local species occurred also later in the Louros River (W. Greece). The parasitic swimbladder nematode, *Anguillicola crassus*, originally native to East Asia, has transferred from its native host, the Japanese eel, *Anguilla japonica*, to the European eel, *Anguilla anguilla. Anguillicola crassus* is a very successful colonizer and is known to occur in four continents (Asia, Europe, Africa and America). Its unintentional spread into Greece took place in the 1980s (Moravec, 1992). The introduction and the rapid expansion of this nematode in Europe since the early 1980s is considered one of the causes for the decrease in European eel populations. The nematode can severely impair swimbladder function and has caused mortalities in both farmed and wild populations in the presence of other stressors. No recent widespread survey of this or other potentially threatening parasites has been undertaken.

Origin/Donor area

The origin of the Greek populations of an alien species is deduced from the species known distribution. However, the true source population may be either its populations in the Pacific/Indian/Atlantic, or secondarily from other established populations in another region e.g. the Levantine, east Atlantic or the Black Sea. The source populations or means of introduction of alien species in Greece have not yet been successfully ascertained by molecular means and as such are often questioned. One such example is the invasive species *Caulerpa racemosa*. Panayotidis (2006) argues for the cryptogenic origin of *C. racemosa* supporting a differentiation of pre-existing Mediterranean Sea varieties of *Caulerpa racemosa* triggered by the extremely hot summers observed frequently in the Mediterranean Sea since the last decade of the 20th century. In other cases the use of molecular techniques has tried to elucidate the origin. For example, the morphological evidence and the molecular data led to the conclusion that the alien species reported in the Adriatic Sea, Greece and Turkey as *Anadara demiri* is an allochthonous population of *Anadara transversa* (Albano *et al*., 2009). Morphological comparison may suggest the origin of the Mediterranean population is from the southern part of the range of *Anadara transversa*, e.g. Gulf of Mexico coasts of Florida (Albano *et al.*, 2009)

In aquaculture introductions, the origin of the donor population is not always reported and when hatchery-reared young are introduced, the previous breeding history of the hatchery brood stock is seldom known or indicated. Furthermore, there is some degree of uncertainty as to the origin of the donor stock due to the confounding effect of multiple stockings for fishery exploitation and unrecorded private transfers by anglers.

The origin of marine alien species (Fig. 3A) 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%). Few species, such as the molluscs *Strombus persicus* and *Chromodoris annulata* are endemic to the Red Sea or the Persian Gulf. However, the number of Atlantic species, either of Senegalese or West Atlantic origin, is non-negligible. Four species, namely *Rapana venosa*, *Liza haematocheila*, *Beroe ovata* and *Mnemiopsis leidyi* well-established in the Black Sea, have progressively penetrated through the Dardanelles Straits.

Most introduced freshwater species (Fig. 3B) 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/

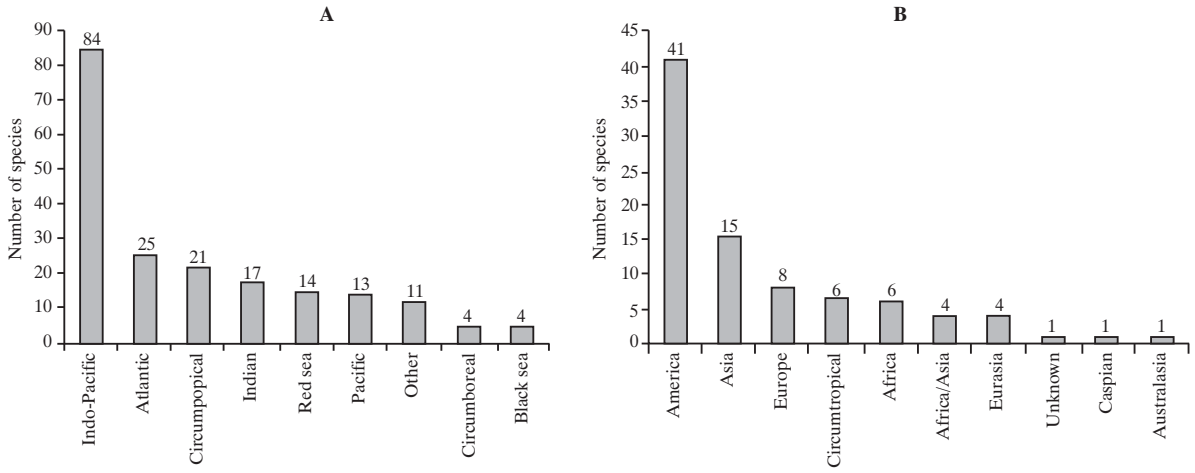

FIG. 3. Origin of A) marine B) freshwater alien species in Greek waters.

Asian (4.6%) Eurasian (4.6%), Circumtropical (6.9%), Australasian (1.1%) and Ponto-Caspian (1.1%).

Mode of introduction of AAS in Greece

Introductions of marine species in Greece have often been multiple and through different pathways (see Annex). Thus, multiple vectors have been considered as different entries when calculating the mode of introduction of an alien species. The most important pathway for marine species introduction appears to be the canals (Fig. 4A). The Suez Canal accounts for 44-54%, introduction via Gibraltar is also significant (6%) while that from the Black Sea is very limited (3%). Shipping is considered to be the second most important vector of the primary as well as the secondary spread of alien species (23-33%) (see also Pancucci-Papadopoulou *et al.*, 2006). *Callinectes sapidus* is one of the vessel-transported alien species, recorded in the North Aegean Sea in the 1940s, and it is now widely spread, ranging from Spain to the Levantine. Finally, aquaculture plays a minor role in the introduction of estuarine and marine species. The mode of introduction is somewhat different among the various taxonomic groups.

Molluscs are one of the 'leading' groups of the Lessepsian migration (progressive penetration via the Suez Canal: Por, 1978), together with decapod crustaceans and fish (Por & Dimentman, 1989). Many of the Indo-Pacific species, either well-established in the eastern Mediterranean (*Cylichna girardi*, *Bursatella leachii*, *Brachidontes pharaonis*, *Malfuvundus regulus*, *Gastrochaena cymbium*, *Cellana rota*, *Cerithium scabridum*, *Trochus erithreus*), or casual (*Murex forskoehli*, *Pseudochama corbieri*) occur in the Suez Canal and therefore their occurrence on the Greek coasts should be attributed to Lessepsian migration. However, the exclusive occurrence of many molluscan alien species in or near major port areas leads to the assumption that shipping is playing an equally important role in their transport.

Similarly, Lessepsian fish dominate among marine alien ichthyofauna. The spread and establishment of Lessepsian fish varies. Some species have spread rapidly, such as the recent invader *Lagocephalus sceleratus*, whereas others, such as *Sphyraena chrysotaenia*, *Apogon pharaonis, Etrumeus teres*, advanced slowly along the Anatolian coasts and reached the Dodecanesos area (SE Greece) after a relatively long time, depending on biotic and abiotic factors (Corsini-Foka & Economidis, 2007). *Siganus luridus* has established a permanent population in the Ionian Sea, while the recent colonizer *Fistularia commersonii,* thriving in the Dodecanese (Kalogirou *et al.*, 2007), has spread to the Ionian Sea (Bardamaskos *et al.*, 2008). There is widespread discussion regarding the exact number of Atlantic vagrant and new colonizer fish species in the Mediterranean (Quignard & Tomasini, 2000). Some of them, particularly *Sphoeroides pachygaster*, *Seriola fasciata* and *Seriola carpenteri*, have achieved significant biomass (Andaloro *et al.*, 2005). Five species have been recorded in the Aegean Sea: *Sphoeroides pachygaster*, a species well-established throughout the Mediterranean, *Enchelycore anatina, Seriola fasciata*, and *Gaidropsarus granti* as casual records, while the record of *Alopias superliciosus* as alien is considered as questionable (Corsini-Foka &

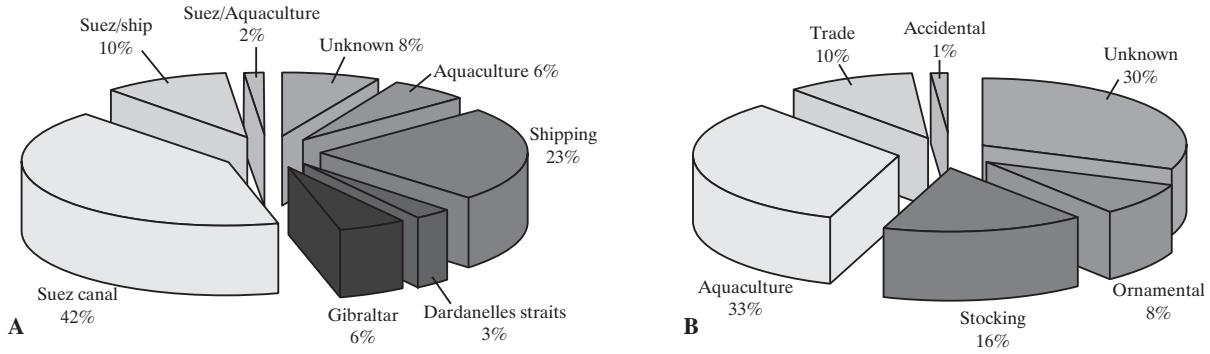

FIG. 4. Introduction vectors of A) marine B) freshwater alien species in Greek waters.

Sioulas, 2008; Zenetos *et al.*, 2008b). Shipping is suspected as a secondary vector of Indo-Pacific species introduction, such as the cases of *Stephanolepis diaspros* and *Alepes djedaba* (Galil *et al*., 2008). The Atlantic muraenid *Enchelycore anatina* spread from the Atlantic to the Mediterranean, where there are only two records one of which being from Elafonissos (S. Aegean Sea) could be explained by passive dissemination of the leptocephali larvae and/or via transport in ship ballast (Golani *et al.*, 2006).

In contrast to fish and zoobenthos, alien marine macrophytic taxa have been introduced mostly through shipping (48%) and via the Suez Canal (33%), while aquaculture has played a rather minor role (16%) (Tsiamis *et al.*, 2008). The modes of invasion have not been studied thoroughly in the case of microalgae in Greek waters. However, shipping and aquaculture products seem to be the common means of microalgal dispersion, especially in the form of resting cysts (Hallegraeff & Gollach, 2006). Although, cyst formation is extensively studied (Steindinger & Garcés, 2006) for planktonic microalgae, the information regarding benthic microalgae is limited (Pearce *et al.*, 2001; Aligizaki & Nikolaidis, 2006). Nevertheless, benthic dinoflagellates have the advantage of being able to "travel" attached on floating material, e.g. macroalgae or even plastic debris (Bomber *et al.*, 1988; Masó *et al.*, 2003). Thus, it is possible that some benthic dinoflagellates may have invaded the Mediterranean Sea along with "alien" macroalgae, which are increasing in Mediterranean waters lately (Tsiamis *et al*., 2008).

In some cases we suspect a different form of transport from the one assumed for the alien species in the Mediterranean Sea. For instance, the pearl oyster *Pinctada radiata*, established in the Mediterranean prior to 1900, widely recognized as one of the first Lessepsian species, was introduced deliberately into Greece for mariculture purposes (Serbetis, 1963), and has since established thriving populations in the sites where it was first imported for aquaculture (i.e. Lesvos island, the Evoikos Gulf, the Saronikos Gulf) (Zenetos *et al.*, 2005a). However, its recent finding in Rhodes Island and the Lakonikos Gulf (S. Aegean Sea), where aquaculture activities are absent, also supports a Lessepsian mode of introduction. *Rapana venosa*, a gastropod native to the Sea of Japan, was accidentally introduced into the Black Sea in the 1940s and independently in the Adriatic in the 1970s, also related to aquaculture activities (Ghisotti, 1974). Its discovery in the bay of Thessaloniki (a major port in the N. Aegean Sea) in 1998 (Koutsoubas & Voultsiadou-Koukoura, 1991) is most possibly related to shipping; however, transfer via the Dardanelles Straits should not be excluded. *Codium fragile fragile* has been introduced into the Mediterranean Sea through shipping and aquaculture (Boudouresque & Verlaque, 2002). Its occurrence in Greece is attributed mostly to shipping (Tsiamis & Panayotidis, 2007b).

The exact pathways of transfer for freshwater species are also not always known. Most introductions were intentional and in many cases they have been carried out with more than one purpose. Introductions made by stocking, primarily for fishery enhancement or angling, have been the most numerous. The common carp, *Cyprinus carpio*, was originally introduced into western Greece in the 1920s with the purpose of improving fisheries (though aquaculture activities subsequently provided another way for introduction). Today there are stable populations in most Greek lakes and the commercial catches of this species have replaced the catches of all other native species (Economou *et al.*, 2001). Various other species, e.g. *Salvelinus fontinalis* and *Oncorhynchus mykiss*, have

also been introduced for commercial or sport fisheries. Four species, *Gambusia holbrooki*, *Ctenopharyngodon idella*, *Hypophthalmichthys nobilis* and *Hypophthalmichthys molitrix*, have been introduced as biocontrol agents. Unintentional introductions have been less frequent than the intentional ones and they seem to be connected with accidental transfers during stocking operations, aquaculture practices or ornamental trade. A classic example of accidental transfer is the one of *Pseudorasbora parva*. This small cyprinid is a common contaminant of grass carp shipments and most probably spread around the country among stocking material. Escapes of fish transferred for aquaculture purposes, e.g. *Oncorhynchus mykiss*, is suspected to be responsible for introductions in some water bodies. It is difficult to ascertain the scope and pathway of transfer of *Carassius gibelio*. While it is possible that this species has been intentionally introduced into some water bodies due to ignorance of the catastrophic consequences (e.g. Lake Amvrakia, NW Greece), most introductions seem to have taken place during transfers of other fish. In the case of ornamental fish, it is not always clear if the introduction was really unintentional (fish having escaped into the wild) or intentional (fish were deliberately released by aquarium owners). Ornamental trade accounts for a limited but steadily growing proportion of fish introductions to Greek freshwaters. The goldfish (*Carassius auratus*) is a favourite species for aquaria and garden or park ponds, and its introduction may be due either to escapes or to releases. *Poecilia latipinna* is an aquarium fish but it is also used for mosquito control. Its introduction into Lake Vouliagmeni (Attica, C. Greece) is most likely linked to its ornamental use. *Lepomis gibbosus* is another aquarium fish with an unclear pathway of transfer. It seems likely that originally this fish found its way to natural water through accidental or deliberate releases by aquaria owners. However, *Lepomis gibbosus* is highly adaptable to different habitats, and hence invasive, and its range is expanding, presumably through fish transfers among basins.

The freshwater oligochaete *Branchiura sowerbyi* has already been known for a long time from the Struma River in Bulgaria (Uzunov, 1976). The Strymonas River (N. Greece) is the downstream section of Struma River flowing to the Aegean Sea. The sampling site was located just some 15 km below Bulgarian-Greek border. Thus, it is likely that *Branchiura sowerbyi* has reached Greece with the river flow from Bulgarian territory and then spread throughout the country (Grabowski & Jabłońska, 2009).

Although the invasion mode of the gastropod *Potamopyrgus antipodarum* in the wider area of Lake Trichonis (W. Greece) still remains unknown, it is suggested that it has possibly been transported from other parts of Europe and/or Asia Minor by migrating and/or wintering shorebirds (Radea *et al.*, 2008).

Why does it matter?

VERTEBRATES

Despite some positive influences (contribution to fishery production, aquaculture development, mosquito control and reduction of heavy algal blooms; see Economidis 1986, 2000), fish introductions have strongly negative ecological, socio-economic and genetic impacts, particularly in regard to fish population interactions, environmental degradation, habitat modification, new diseases and deterioration of fishing opportunities.

Certain alien species have a strongly adverse effect on ecosystems. For example, the introduction of herbivorous carp into some Greek lakes has led to the decline of submerged macrophytes, and thus to loss of habitat complexity (Kagalou & Leonardos, 2009). The introduction of *Carassius gibelio* has caused severe problems to fisheries in several lakes, both because of altered community structure and because of the frequent 'clogging' of gill-nets. Stocking of a number of streams with *Oncorhynchus mykiss* has resulted in the decline or even local extinction of native salmonids. Also, the introduction of *Salmo trutta* and *Salmo letnica* to Greek freshwaters (where different *Salmo* species exist) has resulted in harmful hybridizations that may prove detrimental to the native trout species in the long term (Crivelli *et al.*, 1997; Economou *et al.*, 2007b).

One of the highest potential risks concerns fish introductions into reservoirs and lakes for angling interests. Although the popularity of angling in Greece is steadily growing, fortunately it has not yet led to widespread introductions of invasive aliens, in contrast to other Mediterranean European countries where angling in inland waters is more popular and live bait is widely used. Therefore, Greece does not have a problem –yet– with highly sought-after piscivorous species such as the American bigmouth bass *Micropterus salmoides*. It should be made clear that the threat of alien predatory fish introductions remains

extremely high. This is due to a combination of a recently increasing interest in amateur angling, low public awareness about alien fish impacts, and a poor means of enforcing bans on alien introductions –even within protected natural areas. Furthermore, in some cases, transnational rivers (such as the three rivers entering Greece from Bulgaria) have effectively facilitated the introduction of certain alien fish into Greece.

Alien species often negatively affect the survival of native fish or interfere with ecosystem function through competition and predation. Some small-sized alien species, particularly *Gambusia holbrooki* and *Lepomis gibbosus*, are reported to feed on the eggs and fry of other species (García-Berthou & Moreno-Amich, 2000; Wittenberg, 2005). Introduced fish can also reduce the amount of natural feed available to native species through a dietary overlap. For instance, *Pseudorasbora parva* can potentially compete with three native species in Lake Prespa, NW Greece (Rosecchi *et al.*, 1993), while *Carassius gibelio* is a very effective competitor of carp and other cyprinids; where the latter species was introduced, it formed huge populations replacing native fish species (Paschos *et al.*, 2004). *Gambusia holbrooki* has been implicated in the decline of the critically endangered endemic fish *Valencia letaourneuxi* through competition for food (Bianco & Miller, 1989). The numerous introductions of alien species and the extensive stocking efforts made in Lake Pamvotis (NW Greece) have been blamed for the severe decline, almost extinction, of the local endemic *Pelasgus epiroticus*, though the specific determinant of its decline is not yet fully understood (Perdikaris *et al.*, 2005).

However, the negative impacts of fish introductions reported so far have not been well documented and rely on incidental observations or scattered empirical evidence. No research has been undertaken to examine how alien species may affect the survival of native species, the structure of the local fish communities or ecosystem function. The fish fauna in some lakes and reservoirs is comprised mainly of alien species. For example, Lake Pamvotis contains 24 species of which only four are native and 20 have been introduced to this system (Leonardos *et al.*, 2007). Likewise, the fish fauna of the Tavropos reservoir (N Greece) is composed of 15 species, five of which are native and 10 have been introduced (Tsekos *et al.*, 1992).

Although some introductions do not entail visible negative ecological or socio-economic consequences, they may have a considerable impact on the genetic composition and quality of endemic fish. This kind of problem is expected when the introduced species interbreed with closely-related native forms and hybrids are produced. Since the 1960s stocking operations have been carried out on a regular or *ad hoc* basis, involving releases of hatchery-reared fingerlings in several lakes and rivers and also interbasin transfers of juveniles. Without appropriate genetic research, this kind of impact is difficult to quantify. Aquaculture escapes and deliberate releases of *Salmo trutta* imported from abroad into the Aroaneios River (S. Greece) may have been detrimental to the local trout species *Salmo farioides*, which has been extirpated from this river (Economou *et al.*, 2007b). However, aquaculture escapes and stocking of the Aroaneios River with the rainbow trout *Oncorhynchus mykiss* have also occurred, thus confounding interpretations about the possible causes of the extirpation. Fortunately, there are still river reaches in the Ladon and Erymanthos basins (S. Greece) where unaffected remnant trout stocks of the native trout species can still be found; these stocks can be used as an egg source for rehabilitation projects.

The spreading of new diseases and parasites is one of the most important and persistent environmental risks inherent to fish introductions. This is still a poorly-explored issue in Greece. There are a few reports of pathogen introduction associated with the culture of imported trout and sturgeon (Athanassopoulou *et al.*, 2004) but the extent of the problem is unknown and many more instances of disease remain unreported.

Among the established marine fish species listed in the Annex, some species, successfully established, are common and have acquired a commercial importance, i.e. *Siganus luridus*, *Siganus rivulatus* and *Sphyraena chrysotaenia* (Corsini-Foka & Economidis, 2007). The rapidly increasing population of the recent colonizer *Etrumeus teres* is already contributing to enriching fishery resources in the Dodecanese and Kyklades islands (Kallianiotis & Lekkas, 2005) and Crete (Kasapidis *et al.*, 2007); it has also been observed in Israel, Cyprus and Turkish Mediterranean waters (Golani *et al.*, 2006). Local indigenous fish, especially the small sized and fry, are subject to a remarkable predation pressure. Consequently, the impact on the local fish populations by Lessepsian immigrants seems to be serious and accelerated in some cases. In several cases successful breeding in combination with food availability and other favourable environmental factors has very often led to a population explosion. Such a case of population explosion was observed in

the area during the 1940s for *Upeneus moluccensis* (Laskaridis, 1948b), followed by an incomprehensible dramatic fall shortly after, so that nowadays this species is rather rare in the area (Corsini & Economidis, 1999).

In terms of impact, the blue cornetfish, *Fistularia commersonii*, caught normally by trawl-nets up to a 50-60 m depth, has developed an important population and it is considered at the moment as one of the most invasive species in the Mediterranean Sea (Streftaris & Zenetos, 2006). This species exhibits a rapid expansion along the coasts of the Levantine Basin, to the northern coasts of Crete and westward to the Central Mediterranean and Tyrrhenian Sea (Golani *et al.*, 2006). The phenomenon is alarming because this fish reproduces and grows very rapidly, reaching a remarkably large size (160 cm TL: Fritzsche & Schneider, 1995). Since its first appearance in 2001 in the Rhodes island marine area, the blue cornetfish has actually occurred at a number of 5 to 20 specimens in a catch of any trawl net operation, mainly at 20-25 m depth (Kalogirou *et al.*, 2007). Among these last invaders, the population of the the silver stripe blaasop *Lagocephalus sceleratus* is increasing rapidly (Kasapidis *et al.*, 2007; Peristeraki, 2007) and this poses severe health hazards (Corsini-Foka & Economidis, 2007). The blaasop's internal organs, and in particular the gonads, contain a strong paralytic neurotoxin called tetrodotoxin (TTX) that has a potential risk to humans (Katikou *et al*., 2009). Thirteen cases of poisoning have been reported from Israel (Bentur *et al*., 2008).

The pond slider *Trachemys scripta* is native to the eastern and central United States of America. In some places they are considered to represent a threat to the local turtle species (through competition) and to the ecosystem (competition, predation) (Cadi & Joly, 2003). The species is included in the IUCN/ISSC Invasive Species Specialist Group 100 Worst Invasives List. The American bullfrog *Lithobates catesbeianus* introduced into Crete (Mantziou *et al.,* 1999), is a potential predator of native species and a possible vector of pathogens (Barrasso *et al*., 2009). The nutria, (*Myocastor coypus*) has been introduced to every continent except Antarctica and Australia, primarily for use as a furbearer (Carter & Leonard, 2002). While perceived in some regions as a valuable resource, in most regions the species is considered as a pest. Coypus have caused damage to water control structures, crops and marsh systems and are considered as a disease host (Carter & Leonard, 2002).

INVERTEBRATES

Although there is no documentation of direct competition between alien and indigenous invertebrate species, there are many instances of sudden changes in abundance where competition is suspected. Among the most invasive species worth noting are the molluscan *Strombus persicus* and *Pinctada radiata;* the grapsid crab *Percnon gibbesi* and the scleractinian coral *Oculina patagonica.* Besides the adaptation of *Pinctada radiata* to the subtropical environment of the south-eastern Mediterranean Sea, its tolerance to chemical contamination has enhanced its expansion in enclosed polluted ecosystems all over Greece. *Strombus persicus* has become locally invasive in the south-eastern Mediterranean Sea including several Greek localities such as Rhodes, the south Peloponnesos coast, the Argolikos Gulf and along the Attiki coast of the Saronikos Gulf from Cape Sounion to Agia Marina (Zenetos *et al.*, 2007). The grapsid crab, *Percnon gibbesi*, is the most invasive decapod species to enter the Mediterranean (Streftaris & Zenetos, 2006). Thus, if the present rate of introduction persists, a modification of the composition and structure of the fauna is entirely possible.

PLANTS

Reports on potentially toxic epiphytic dinoflagellates of the genera *Ostreopsis*, *Coolia* and *Prorocentrum* in the Mediterranean Sea, including Greece, are rising during the last decade (Penna *et al.*, 2005; Aligizaki & Nikolaidis, 2006; Monti *et al.*, 2007; Aligizaki *et al.*, 2008a, 2009a; Dolapsakis *et al.*, 2008). This fact possibly represents the global trend towards increase of harmful algal blooms in frequency, intensity and geographic distribution (Hallegraeff *et al.*, 2003). However, the possibility that increased records of potentially harmful microalgae might be partially attriduted to the intensification of research towards this field should not be overlooked.

The main harmful dinoflagellates, which have so far caused the greatest economic losses in Greece, due to diarrhetic shellfish intoxication (Mouratidou *et al.*, 2006), belonged to the genus *Dinophysis* (Koukaras & Nikolaidis, 2004; Nikolaidis *et al.*, 2005). However, the documented presence of additional potentially toxic and/or toxic species of the genera *Ostreopsis*, *Prorocentrum* and *Gambierdiscus* (Aligizaki & Nikolaidis, 2006, 2008; Aligizaki *et al.*, 2008a, 2009a) indicate the potential increase in different kinds of fish and shellfish intoxication, following the already

documented shellfish contamination by palytoxin-like compounds from *Ostreopsis* species (Aligizaki *et al.*, 2008b, 2009b).

The most serious impact caused by invasive alien freshwater macrophytes comes from aquatic plants which have escaped from aquaria, water gardens, or ricefield cultivations. These plants often reproduce rapidly by vegetative means and can rapidly colonise large areas (e.g. *Azolla filiculoides*, *Azolla caroliniana*). *Ludwigia peploides* subsp. *montevidensis*, *Paspalum distichum*, *Paspalum dilatatum*, *Paspalum paspalodes* expand very quickly and disrupt channel flow and stagnation, and eventually compete with indigenous species for resources (Yannitsaros, 1991; Zotos *et al.*, 2006). They may pose a threat to native plants and animals and ecosystems, and are likely to increase as a consequence of climate change and increasing water temperature.

The direct impact of the invasive macrophytes on the native biota has not yet been documented off the Greek coasts. The green alga *Caulerpa racemosa* var. *cylindracea* has been spreading extremely rapidly along Greek coasts since 1993 (Panayotidis & Montesanto, 1994), occupying diverse substrata, various depths, polluted and unpolluted areas, revealing thus a strong invasive behaviour (Tsirika & Haritonidis, 2005) and it is presently found in all Greek seas. Populations of the green alga *Codium fragile fragile* have been present in Greece at least since the last decade of the 20th century, and today it can be found in several locations in the Central and North Aegean Seas (Tsiamis & Panayotidis, 2007b). Its spread seems to be still in progress along Greek coasts, presenting some sporadic blooms. The seagrass *Halophila stipulacea* was first reported in the Mediterranean in Rhodes Island (SE Aegean) by Fritsch (1895). Since then, it has been reported from numerous Greek coasts, revealing a strong invasive behaviour in both the Aegean and Ionian Seas (Haritonidis & Diapoulis, 1990). Invasive behaviour was observed for *Asparagopsis taxiformis* on Andros Island (Central Aegean Sea) in June 2008. More specifically, numerous gametophytes of *Asparagopsis taxiformis* were found on rocky substrate, monopolizing the indigenous phytocommunity along with tetrasporophytes ("*Falkenbergia"* stage) as turfs or epiphytes at the upper sublittoral zone (0-2 m depth), in the same area (Tsiamis *et al.*, 2009).

What do we do?

Marine alien fish species are not monitored specifically, but fish populations are monitored on a regular basis for the needs of the European Community Regulation (EC) No 1543/2000 and data are recorded in the Hellenic Fish Information System (IMAS-Fish 2007) based at HCMR. Based on the increasing records of marine alien species, which may have been the result of intense research in this field, it could be suggested that the gradual increase in sea surface water temperature (EEA, 2006; Zervakis *et al.*, 2007) has facilitated the acclimatisation and settlement of tropical species in the Greek Seas.

The presence of the genus *Gambierdiscus* in the Mediterranean Sea constitutes the prerequisite for the onset of ciguatera disease in this area; ciguatera is the most frequently reported marine toxin-derived disease resulting in the illness of more than 50,000 people each year worldwide and also affecting the fish industry with consequent economic losses (Lewis, 2001). The fact that *Gambierdiscus* detection in the Canary Islands (Fraga *et al.*, 2004) was followed by ciguatera incidents in the same area (Pérez-Arellano *et al.*, 2005), indicates the potential hazard for a future occurrence of ciguatera inside the Mediterranean Sea, since *Gambierdiscus* is a Mediterranean inhabitant for at least 6 years (Aligizaki & Nikolaidis, 2008). The only data that stands against this possibility is the fact that the preliminary results from the first examined *Gambierdiscus* strains from the Mediterranean Sea have shown low toxicity (Aligizaki *et al*., 2009b; Caillaud *et al*., 2009).

It is surprising that many alien woody plants have not spread widely in Greek inland waters and seem to be quite localized; this is evident even in aliens in riparian vegetation in montane streams (Zogaris *et al.*, 2008), a fact that could be attributed to the relatively small size and geographical isolation of most river basins especially in southern and western Greece. Invasion of one isolated basin means the species has to somehow cross a watershed barrier in order to spread; this is one reason for maintenance of a slower spread of some freshwater species within Greece.

In this way, freshwater species may spread through unintentional or negligent human releases and unfortunately these introductions and associated impacts may go unnoticed for years. An example of pet-trade introductions is the turtle *Trachemys scripta*, an opportunistic inhabitant of freshwater habitats, generally in close proximity to human habitation and/or recreation areas. European populations are either tolerated or their elimination is desired. The European Union has banned the import of *Trachemys scripta* on the basis of it being an invasive species, but other sub-

species are being imported instead. For some of the vertebrate aliens there is a surprising lack of published information or public interest. Nutria *Myocastor coypu*, for example, has large populations in some wetland localities such as Axios River (N. Greece) and Kalamas River (W Greece) (S. Zogaris, personal observation), but specific impacts and potential habitat degradation caused by this herbivore have never been assessed. It is not therefore possible to suggest any kind of management before baseline studies assess current impacts of these alien populations (Carter & Leonard, 2002).

In Greece, national regulations concerning alien introductions are poorly enforced and public interest or awareness of the environmental risks is nearly nonexistent. The International Maritime Organization (IMO) was involved in the establishment of an International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention 2004) which focuses on minimizing risks and side effects to the environment and human health arising from the transfer of species in ship ballast water and sediments. The Commission has concluded a cooperation agreement with the IMO, and the EU has passed legislation to implement IMO decisions. However, by May 2009, the IMO Convention has been ratified by only 18 countries (Greece excluded).

With regard to freshwater biota, EU regulations such as the Council Regulation (EC) No 708/2007, are implemented in policy manuscripts, but rarely in practice. Fish controls and the enforcement of discipline in lowland areas fall under the authority of the police, while in upland areas they fall under the authority of the Forestry Service. In theory, any introduction or translocation should follow certain rules, but in practice the existing rules are insufficient and not adequately enforced. Greek governmental authorities have no mechanism for systematically recording information concerning alien species in aquatic environments and very little information is present in the literature (apart from area species lists and biota survey reports).

In Greece, alien species have been primarily reported through publication in a relatively few peer-reviewed journals, conference abstracts and reports. Although a small number of Greek scientists have extensive experience in the systematic recording of alien species and their impacts, recently some isolated initiatives have been taken. Examples of recent initiatives include the University of Athens involvement in the DAISIE Project and the Hellenic Centre for Marine Research (HCMR) marine and inland waters biota surveys. Recognising world scientific interest in alien species, a Greek national network of experts on aquatic alien species was brought together by HCMR and hence the Ellenic Network on Aquatic Invasive Species (ELNAIS) was initiated in 2007, structured according to the same pattern as that of the European Research Network on Aquatic Invasive Species (ERNAIS).

Recently, a debate has been opened regarding alien species and the assessment of ecological status under the Water Framework Directive (WFD). Following ECOSTAT workgroup resolutions, a workshop held in Ispra (Italy) hosting representatives from 10 European countries, tried to unify the way different countries construct lists of alien species for use under the WFD and how levels of impact are assessed. Furthermore, it was discussed how information on alien species is being used in the classification of ecological status. Considering the peculiarity of E Mediterranean countries, Greek representatives (Pancucci-Papadopoulou *et al*., 2009b) suggested that alien species presence and impact must be assessed as a separate risk analysis alongside the classification of WFD, otherwise a significant number of good or high status EcoQ areas, but affected by high biopollution levels, would risk to be severely downgraded due to vicinity with Alien Species pathways-gateways (e.g. Suez Canal) or vectors' incidence (e.g. navigation routes) that is practically impossible to deal with.

One of the most important requirements needed to stem the spread of aquatic aliens is a targeted public awareness campaign aimed particularly at resource users. Special interest groups such as anglers, fishermen, port authorities, tourism development stakeholders and Ministries may play an important role in guarding against intentional and unintentional species introductions. Governmental authorities must also be given greater incentives to become involved in monitoring and enforcement activities, particularly within protected areas where they have increased jurisdiction to act and prevent introductions. Therefore, we suggest promotion of educational programmes to reduce the risk of new introductions and translocations from established populations.

Finally, the scientific community must intensify actions towards inventorying and monitoring alien species distributions and impact assessments. Careful site-based monitoring is necessary for the early detection and management of newly established populations. In order to achieve such a goal, it is critically

important that baseline inventorying and monitoring is supported by long-term funding.

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DIAS: The Database on Introductions of Aquatic Species (DIAS): http://www.fao.org/fishery/dias/en/

ELNAIS: Hellenic Network on Aquatic Alien Species: http://www.elnais.ath.hcmr.com

ERNAIS: European Research and Stakeholder Network on Aquatic Invasive Species: http://www.zin.ru/rbic/projects/ernais/

FISHBASE: A Global Information System on Fishes: http://www.fishbase.org

MedOBIS: Mediterranean Ocean Biogeographic Information System. http://www.medobis.org

SEASLUG: The seaslug Forum: http://www.seaslugforum.net/

IUCN: International Union for the Conservation of Nature: http://www.iucn.org

ISSG: Invasive Species Specialist Group (IUCN): http://www.issg.org

ANNEX follows, see pages 163-172

ANNEX

Species Name	Marine/ estuarine	Fresh-water	Origin / donor area	Pathway	Establishment success	Source
PLANKTONIC MICROALGAE						
Alexandrium insuetum Balech, 1985	2003		Pacific	unknown	established	Nikolaidis *et al.,* 2005
Alexandrium taylori Balech, 1994	2001		circumtropical	shipping/ballast	established	Gotsis-Skretas *et al.,* 2003
Gymnodinium catenatum L.W. Graham, 1943	2001		circumtropical	shipping/ballast	cryptogenic/ established	Giannakourou *et al.,* 2005
Karenia brevis C.C. Davis, 1948	1978		Atlantic	shipping/ballast	established	Satsmadjis & Friligos, 1988
Karenia mikimotoi Miyake & Kominami ex Oda, 1935	1989		unknown	shipping/ballast	cryptogenic/ established	NCMR, 1992
Histioneis detonii Rampi, 1947	1984		Indo-Pacific	via Suez	casual	Ignatiades, 1987
Phaeocystis pouchettii Lagerheim, 1896	1983		cosmopolitan	via Dardanelles	cryptogenic/ established	Ignatiades, 1987
Proboscia indica (Peragallo) Hernández-Becerril, 1995	1983		Indo-Pacific	via Suez	cryptogenic/ established	Ignatiades, 1987
BENTHIC MICROALGAE						
Coolia monotis Meunier, 1919	2002		boreal	shipping/ballast	established	Dolapsakis *et al.,* 2006
Gambierdiscus sp.	2003		Indo-Pacific	via Suez	established	Aligizaki *et al.,* 2008a Aligizaki & Nikolaidis, 2008
Ostreopsis ovata Fukuyo, 1981	2003		Indo-Pacific	via Suez	established	Aligizaki & Nikolaidis, 2006
Ostreopsis cf. *siamensis* Schmidt, 1901	2003		Indo-Pacific	via Suez	established	Aligizaki & Nikolaidis, 2006
Prorocentrum borbonicum Ten-Hage, Turquet, Quod, Puiseux-Dao et Couté, 2000	2004		Indian	unknown	established	Aligizaki *et al.,* 2009a
Prorocentrum emarginatum Fukuyo, 1981	2003		circumtropical	unknown	established	Aligizaki & Nikolaidis, 2006
Prorocentrum levis Faust, Kibler, Vandersea, Tester et Litaker, 2008	2004		Caribbean Sea	unknown	established	Aligizaki *et al.,* 2009a
Prorocentrum rhathymum Loeblich III, Sherley & Schmidt 1979	(1991?) 2003		Caribbean Sea	unknown	established	NCMR,1992; Aligizaki & Nikolaidis, 2006
Sinophysis caniculata Quod, Ten-Hage, Turque, Mascarell, Couté, 1999	2003		Indo-Pacific	via Suez	established	Aligizaki & Nikolaidis, 2008
MACROPHYTES						
Azolla filiculoides Lamarck		1973-81	S America	Ornamental/ uknown	established	Koumpli-Sovantzi, 1983
Azolla caroliniana Wild.		1981	America	Aquarium trade	established	Greuter & Raus, 1982
Azolla mexicana C. Presl.		??	S America	Ornamental/ uknown	established	DAISIE
Halophila stipulacea Forsskål, 1775	1894		Red Sea	via Suez	established	Fritsch, 1895
Lemna aequinoctialis Welw.		2004	Asia, S & N America	unknown	unknown	Koumpli-Sovantzi, 2008
Lemna minuscula Herter		1988	America	unknown	established	Raus, 1991
Najas gracillima Magnus		1988	Asia (Japan)	unknown	established	Papastergiadou, 1990 Papastergiadou 1990
Najas graminea Delile		1989	Subtropical, tropical	unknown	unknown	Raus & Raabe, 2002
Najas orientalis Triest & Uotila		2001	E Asia	unknown	unknown	Raus & Raabe, 2002
Utricularia gibba Linnaeus		1989-95	America	ornamental/ botanical gardens	established	Sarika-Hatzinikolaou, 1999

Species Name	Marine/ estuarine	Fresh-water	Origin / donor area	Pathway	Establishment success	Source
Helophytes and some amphibian wetland species						
Ammania auriculata Willd.		2004	America, Asia, Africa, Australia	unknown (Paddy fields)	established	Koumpli-Sovantzi, 2008
Ammania baccifera Linnaeus.		2002	Tropical & subtropical Africa, Asia	unknown (Paddy fields)	established	Greuter & Raus, 2002
Ammania coccinea Roth		2001	America, Brazil	unknown (Paddy fields)	established	Raus & Raabe, 2002
Ammania senegalensis Lam.		2002	Tropical & subtropical Africa, Asia	unknown (Paddy fields)	established	Greuter & Raus, 2002
Arundo donax Linnaeus		1973-81	Asia	unknown	established	Koumpli-Sovantzi, 1983
Arundo mediterranea Danin		2005	Africa	unknown	established	Greuter & Raus, 2006
Bacopa rotundifolia (Michaux) Wettst.		2001	N America	unknown (Paddy fields)	established	Raus & Raabe, 2002
Bergia capensis Linnaeus		2001	Tropical & subtropical Africa, Asia	unknown (Paddy fields)	established	Greuter & Raus, 2001
Cyperus alternifolius Linnaeus		??	Africa	unknown/ornament	established	DAISIE Chilton & Turland, 1997
Cyperus esculentus Linnaeus		1990	America	unknown	established	Yannitsaros, 1991
Cyperus laevigatus Linnaeus. subsp. *laevigatus* L.		1989-92	subcosmop/tropic	unknown	unknown	Sarika *et al.,* 2005
Diplachne fusca (Linnaeus) Beauv.		2002	Tropical Africa, SE Asia, Australia	unknown (Paddy fields)	established	Greuter & Raus, 2002
Echinochloa colona (Linnaeus.) Link		1976	tropical subtropical	unknown	established	Yannitsaros, 1991
Echinochloa crus-galli subsp. *hispidula* (Retz) Honda		2002	Asian Pacific	unknown (Paddy fields)	established	Greuter & Raus, 2002
Echinochloa oryzoides (Ard) Fritsch		2002	Uncertain origin, homeless weed	unknown (Paddy fields)	established	Raus & Raabe, 2002
Eclipta prostrata Linnaeus		2001	Tropical & warm temperate America	unknown (Paddy fields)	established	Raus & Raabe, 2002
Eleocharis parvula (Roem & Schult) Bluff & al.		2002	subcosmop	unknown (Paddy fields)	unknown	Greuter & Raus, 2002
Epilobium adenocaulon Hausskn		2001	America	unknown	unknown	Greuter & Raus, 2006
Eragrostis pectinacea (Michx.) Nees		??	America	unknown	established	DAISIE
Heteranthera limosa (Sw) Willd.		2001	America	unknown (Paddy fields)	established	Greuter & Raus, 2001
Heteranthera reniformis Ruiz & Pavon		2001	America	unknown (Paddy fields)	established	Raus & Raabe, 2002
Heteranthera rotundifolia (Kunth) Griseb.		2002	America	unknown (Paddy fields)	established	Greuter & Raus, 2002
Hemarthria altissima (Poir) Stapf & Hubbard		1974	African	unknown	unknown	Yannitsaros, 1991
Lindernia dubia (L) Pennell		1988	N American	unknown	established	Raus, 1991
Littorella uniflora (Linnaeus) Asch (synonyms *L. americana, Plantago uniflora*)		??	America	unknown	unknown	DAISIE (Dirk Albach, Germany)

Species Name	Marine/ estuarine	Fresh-water	Origin / donor area	Pathway	Establishment success	Source
Ludwigia peploides (Kunth) Raven subsp. *montevidensis* (Spreng) Raven		2001	S America	unknown	established	Zotos *et al*., 2006
Oenothera indecora Cambess subsp. *indecora*		2002	S America	unknown	established	Greuter & Raus, 2006
Oenothera laciniata Hill		2006	N America	unknown	established	Greuter & Raus, 2006
Aspalum dilatatum Poiret (synonym *P. distachyon*)		1976	S. America	Ornamental/ Botanical gardens	established	Yannitsaros, 1977
Paspalum notatum Flgg.		2002	America	unknown	unknown	Greuter & Raus, 2002
Paspalum paspalodes (Michx) Scribner (synonym *Paspalum distichum* (Linnaeus)		1973-81	neotrop America	unknown	established	Koumpli-Sovantzi, 1983
Polygonum lapathifolium Linnaeus		1990	N Africa, SW Asia	unknown	established	Yannitsaros, 1991
Rotala ramosior (Linnaeus) Koehne		2002	America	unknown (paddy fields)	established	Greuter & Raus, 2002
Macroalgae						
Phaeophyceae						
Colpomenia peregrina Sauvageau, 1927	1986		Indo-Pacific	shipping/fouling	established	Orfanidis, 1992
Padina boryana Thivy in W.R.Taylor, 1966	1981		Indo-Pacific	via Suez	casual	Nizamuddin, 1981
Pylaiella littoralis (Linnaeus) Kjellman, 1872	1968		circumboreal	unknown	cryptogenic/ questionable	Anagnostidis, 1968
Stypopodium schimperi Verlaque & Boudouresque, 1991	1994		Red Sea	via Suez	established	Panayotidis, 1994
Rhodophyceae						
Acanthophora nayadiformis (Delile) Papenfuss, 1968	1861		Indo-Pacific	via Suez	cryptogenic/ questionable	Grunow, 1861
Antihamnionella elegans (Berthold) J.H. Price & D.M. John	1981		Indo-Pacific	shipping	established	Schnetter & Schnetter, 1981
Antihamnionella spirographidis (Schiffner) E.M. Wollaston, 1968	1983		Indo-Pacific	shipping/fouling	cryptogenic/ questionable	Diapoulis & Haritonidis, 1987
Asparagopsis armata (Harvey, 1855)	1972		Pacific (Australia)	shipping/fouling	established	Koussouris *et al.,* 1973
Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845	2006		circumtropical	via Suez, shipping/ fouling	established	Tsiamis & Panayotidis, 2007a
Bonnemaisonia hamifera Hariot, 1891	1997		Pacific	via Gibraltar/ shipping	casual	Skoufas & Tsirika, 2006
Ceramium bisporum D.L. Ballantine, 1990	1980		W Atlantic	shipping/fouling	questionable	Sartoni & Boddi, 2002
Ceramium strobiliforme G.W. Lawson & D.M. John, 1982	2001		Atlantic	shipping/fouling	casual	Tsirika & Haritonidis, 2005
Chondria coerulescens (J. Agardh) Falkenberg, 1901	1982		Atlantic	unknown	questionable	Athanasiadis, 1987
Chondria curvilineata F.S Collins & Hervey	1980		Indian	via Suez	casual	Athanasiadis, 1987
Ganonema farinosum (J.V. Lamouroux) K.C. Fan & Yung C. Wang, 1974	1931		Indian	via Suez	cryptogenic/ questionable	Hamel, 1931
Hypnea cornuta (Kützing) J. Agardh, 1851	1894		Red Sea	via Suez	casual	Reinbold, 1898
Hypnea spinella (C. Agardh) Kützing, 1847	1928		circumtropical	shipping/fouling	established	Forti, 1928
Hypnea valentiae (Turner) Montagne, 1841	1983		Red Sea	aquaculture/via Suez	casual	Bogdanos & Diapoulis, 1984
Laurencia caduciramulosa Masuda & Kawaguchi, 1997	2001		Pacific	shipping	casual	Tsirika & Haritonidis, 2005
Lophocladia lallemandii (Montagne) Schmitz, 1893	1908		Indo-Pacific	via Suez/shipping/ fouling	established	Petersen, 1918
Neosiphonia harveyi (J. Bailey) M.S. Kim, H.G. Choi & G.W. Saunders	1991		Pacific	Shipping/aquaculture	Casual	Tsiamis *et al.*, in press

Species Name	Marine/ estuarine	Fresh-water	Origin / donor area	Pathway	Establishment success	Source
Neosiphonia sphaerocarpa Børgesen, 1918	1990		circumtropical	shipping/fouling	established	Lazaridou, 1994
Polysiphonia atlantica Kapraun & J.N. Norris, 1982	1988		Atlantic, Indo-Pacific	shipping	Questionable	Lazaridou, 1994
Polysiphonia fucoides (Hudson) Greville, 1824	1968		Atlantic	unknown	Questionable	Anagnostidis, 1968
Sarconema scinaioides Børgesen, 1934	1980		Indian	via Suez	established	Diapoulis *et al.,* 1985
Womersleyella setacea R.E. Norris, 1992	1988		circumtropical	shipping/fouling	established	Lazaridou, 1994
Chlorophyceae						
Caulerpa racemosa var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque, 2003	1993		Pacific?	shipping	cryptogenic/ established	Panayiotidis & Montesanto, 1994
Caulerpa racemosa var. *lamourouxi* (Montagne) Weber van Bosse	1956		cosmopolitan	via Suez	established	Huvé, 1957
Codium fragile fragile (Suringar) Hariot	1992		Pacific	shipping	established	Tsiamis & Panayiotidis, 2007b
Ulva fasciata Delile, 1813	1832		cosmopolitan	shipping	Questionable	Fauché *et al.,* 1832–1833
ZOOPLANKTON						
Ctenophora						
Beroe ovata Mayer, 1912	2004		Atlantic/Black Sea	via Dardanelles	casual	Shiganova *et al.,* 2007
Mnemiopsis leidyi (Agassiz, 1865)	1990		Atlantic/Black Sea	via Dardanelles	established	Shiganova *et al.,* 2001
Crustacea						
Arietellus pavoninus (G. O. Sars, 1905)	1967		circumtropical	via Suez/shipping	established	Moraitou-Apostolopoulou, 1969
Calanopia elliptica (Dana, 1846)	1988		Indo-Pacific	via Suez	casual	Siokou-Frangou *et al.,* 1999
Centropages furcatus (Dana, 1852)	1988		Indo-Pacific	via Suez	casual	Siokou-Frangou *et al.,* 1999
Paracartia grani (G. O. Sars, 1904)	1988		circumboreal	shipping/ballast	established	Siokou-Frangou, 1999
Pseudocalanus elongatus (Boeck, 1865)	1982		circumboreal	via Dardanelles	established	Siokou-Frangou, 1985
Cnidaria						
Rhopilema nomadica Galil, 1990	2006		Red Sea	via Suez	casual	Siokou-Frangou *et al.,* 2006
Phylloriza punctata von Lendenfeld, 1884	2005		Pacific	via Suez/shipping	established	Abed-Navandi & Kikinger, 2007
MACROZOOBENTHOS						
Bivalvia						
Anadara transversa (Say, 1822)	1993		W. Atlantic	shipping/fouling	established	Zenetos, 1994
Anadara granosa (Linnaeus, 1758)	2006		Indo W Pacific	shipping	casual	Young *et al.,* 2007
Brachidontes pharaonis (Fischer P., 1870)	1975		Indian	via Suez/shipping	established	Koroneos, 1979
Chama asperella Lamarck, 1819	2007		Red Sea	via Suez/shipping	established	Ovalis & Zenetos, 2007
Chama aspersa Reeve, 1846	2007		Red Sea	via Suez/shipping	established	Ovalis & Zenetos, 2007
Circe scripta (Linnaeus, 1758)	2007		Indo W Pacific	shipping	casual	Young *et al.,* 2007
Crassostrea gigas (Thunberg, 1793)	1989		Pacific	aquaculture	established	Dimitrakis, 1989
Dreissena polymorpha (Pallas, 1771)		unknown	Ponto Caspian?	unknown	cryptogenic/ established	Albrecht *et al.,* 2007
Fulvia fragilis (Forsskål in Niebuhr, 1775)	1998		Indian	via Suez/shipping	established	Vardala-Theodorou, 1999

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Gastrochaena cymbium (Spengler, 1783)	1974		Indo-Pacific	via Suez	casual	Tenekides, 1989
Malvufundus regulus (Forskål, 1775)	1999		Indo-Pacific	via Suez	casual	Giannuzzi-Savelli *et al.,* 2001
Mya arenaria Linnaeus, 1758	1984		Atlantic	shipping	casual	Zenetos *et al.,* 2004
Petricola pholadiformis Lamarck, 1818	1985		Atlantic	Suez/shipping	established	Delamotte & Vardala-Theodorou, 1994
Pinctada radiata (Leach, 1814)	1963		Indo-Pacific	via Suez/aquaculture	established	Serbetis, 1963
Pseudochama corbieri (Jonas, 1846)	1939		Indo-Pacific	via Suez	casual	Ralli-Tzelepi, 1946
Sinanodonta woodiana (Lea, 1834)		2000s	E Asia	unknown	established	Albrecht *et al.,* 2006
Gastropoda						
Opistobranchia						
Acteocina mucronata (Philippi, 1849)	1991		Red Sea	via Suez	casual	Storsberg, 1997
Aplysia dactylomela (Rang, 1828)	2005		circumtropical	via Suez/shipping	established	Sterniuk-Gronek, 2005
Bulla ampulla (Linnaeus, 1758)	1998		Indo-Pacific	via Suez/shipping	established	Vardala-Theodorou, 1999
Bursatella leachii (De Blainville, 1817)	1975		circumtropical	via Suez/shipping	established	Barash & Danin, 1986
Chromodoris annulata (Eliot, 1904)	2004		Indian (Persian Gulf)	shipping	casual	Daskos & Zenetos, 2007
Cylichnina girardi (Audouin, 1826)	1994		Indo-Pacific	via Suez	casual	Cosenza & Fasulo, 1997
Haminoea cyanomarginata Heller & Thompson, 1983	2001		Red Sea	via Suez	established	Zenetos *et al.,* 2004
Melibe viridis (Kelaart, 1858)	1970		Indo-Pacific	shipping/ballast	established	Moosleitner, 1986
Polycerella emertoni Verrill, 1881	1995		Atlantic	shipping/fouling	casual	Koutsoubas *et al.,* 2000
Syphonota geographica (Adams & Reeve, 1850)	2002		circumtropical	unknown	established	Mollo *et al.,* 2008
Prosobranchia						
Cellana rota (Gmelin, 1791)	1989		Indo-Pacific	via Suez	casual	Fountoulakis & Sabelli, 1999
Cerithium literatum (Born, 1778)	1978		Atlantic	via Gibraltar/ shipping	casual	Garilli & Vardala-Thedorou, 2005
Cerithium scabridum Philippi, 1848	2007		Indo-Pacific	via Suez	established	Zenetos *et al.*, 2009b
Coralliobia madreporarum (Sowerby, 1832)	1978		Indo-Pacific	unknown	casual	Delamotte & Vardala-Theodorou, 1994
Conus inscriptus Reeve, 1843	2007		Indian	shipping	casual	Young *et al.,* 2007
Crepidula fornicata (Linnaeus, 1758)	1994		Atlantic	via Gibraltar/ shipping	established	Delamotte & Vardala-Theodorou, 1994
Ergalatax junionae Houart, 2008	2007		Indian (Persian Gulf)	via Suez/shipping	established	Zenetos *et al.,* 2008a
Ferrissia wautieri (Mirolli, 1960)		1981	N America	ornamental	cryptogenic	Reischutz, 1981
Helisoma anceps (Menke, 1830)		2005	N America	unknown	established	Eross *et al.,* 2005
Murex forskoehli Roeding, 1798	1966		Indian (Persian Gulf)	via Suez	Questionable	Settepassi, 1967
Nassarius stolatus (Gmelin, 1791)	2006		Indo-Pacific	shipping	casual	Young *et al.,* 2007
Nerita sanguinolenta Menke, 1829	1968		Red Sea	via Suez/shipping	casual	Nordsieck, 1973
Potamopyrgus antipodarum (Gray, 1843)		1996	New Zealand/Europe	unkwown	established	Radea *et al.,* 2008
Pseudosuccinea columella (Say, 1817)		2000s	N America	unknown	established	Reischutz & Reischutz, 2004
Rapana rapiformis (Von Born, 1778)	1970		Indo-Pacific	via Suez	Questionable	Barash & Danin, 1988/89

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Rapana venosa (Valenciennes, 1846)	1988		Pacific/Black Sea	via Dardanelles/ shipping	casual	Koutsoubas & Voultsiadou-Koukoura, 1991
Smaragdia souverbiana (Montrouzier, 1863)	1993		Indo-Pacific	via Suez	Questionable	Buzzurro & Greppi, 1994
Strombus persicus Swainson, 1821 (Roeding, 1798)	1986		Indian (Persian Gulf)	via Suez/shipping	established	Nicolay, 1986
Trochus erithreus Brocchi, 1821	1994		Indian (Persian Gulf)	via Suez	established	Cosenza & Fasulo, 1997
Cephalopoda						
Sepioteuthis lessoniana Lesson, 1830	2009		Indo-Pacific	Via Suez	casual	Lefkaditou *et al.,* 2009
Foraminifera						
Amphistegina lessonii D' Orbigny, 1826	1997		Indo-Pacific	via Suez	established	Hollaus & Hottinger, 1997
Amphistegina lobifera Larsen, 1976	1967		Indo-Pacific	via Suez	established	Cherif, 1970
Heterocyclina tuberculata (Mobius)	1993		Indo-Pacific	via Suez	casual	Debenay *et al.*, 2005
Heterostegina depressa D' Orbigny	1988		Indo-Pacific	via Suez	established	Morariu & Hottinger, 1988
Sorites orbiculus Ehrenberg (Forskål, 1775)	1967		Indo-Pacific	via Suez	established	Cherif, 1970
Spiroculina antillarum D'Orbigny	1993		Indo-Pacific	via Suez	established	Debenay *et al.,* 2005
Crustacea						
Alpheus rapacida (de Man, 1908)	1998		Indo W Pacific	via Suez	casual	Pancucci-Papadopoulou *et al.,* 2005a
Balanus trigonus Darwin, 1854	2001		circumtropical	shipping/fouling	established	MEDOBIS
Calappa pelii Herklots, 1851	2005		Atlantic	via Gibraltar/ unknown	casual	Pancucci-Papadopoulou *et al.,* 2005b
Callinectes sapidus Rathbun, 1896	1947		Atlantic	via Gibraltar/ shipping	established	Serbetis, 1959
Caprella scaura Templeton, 1836	2002		Indo-Pacific	unknown	casual	Krapp *et al.,* 2006
Carupa tenuipes Dana, 1851	2009		Indo-Pacific	via Suez	casuas	Pancucci-Papadopoulou *et al.,* 2009a
Charybdis hellerii (A. Milne-Edwards, 1867)	2004		Indo W Pacific	via Suez/shipping	established	Kirmitzoglou *et al.,* 2006
Charybdis longicollis Leene, 1938	1996		Indian (Persian Gulf)	via Suez	established	Galil & Kevrekides, 2002
Erugosquilla massavensis (Kossmann, 1880)	1963		Indian (Persian Gulf)	via Suez	established	Dounas & Steudel, 1994 Corsini & Kondilatos, 2006
Ixa monodi Holthuis and Gottlieb, 1956	1999		Red Sea	via Suez	casual	Galil & Kevrekides, 2002
Leucosia signata Paulson, 1875	2005		Indo -Pacific	via Suez	casual	Corsini-Foka *et al.,* 2006a
Marsupenaeus japonicus (Bate, 1888)	1995		Indo-Pacific	via Suez, aquaculture	established	Kevrekidis & Kevrekidis, 1996
Megabalanus tintinnabulum (Linnaeus, 1758)	1996		circumtropical	shipping/fouling	Questionable	NCMR, 1997a
Metapenaeopsis aegyptia Galil & Golani, 1990	1996		Indo-Pacific	via Suez	established	Kevrekidis *et al.,* 1998
Metapenaeopsis mogiensis consobrina (Nobili, 1904)	1995		Indo W Pacific	via Suez	established	Kevrekidis *et al.,* 1998
Myra subgranulata Galil & Golani, 1990	2004		Indian	via Suez	casual	Corsini- & Kondilatos, 2006
Pacifastacus leniusculus (Dana, 1852)		1987	N America	trade	established	Koutrakis *et al.,* 2007
Percnon gibbesi (H. Milne Edwards, 1853)	2004		Atlantic	via Gibraltar	established	Thessalou-Legaki *et al.,* 2006
Portunus pelagicus (Linnaeus, 1758)	1991		Indo-Pacific	via Suez	established	Corsini-Foka *et al.,* 2004

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Sirpus monodi Gordon, 1953	2002		Atlantic	via Gibraltar/ shipping	casual	Pancucci-Papadopoulou & Naletaki, 2007
Stenothoe gallensis Walker, 1904	1970s		circumtropical	shipping	established	Stefanidou, 1996
Thalamita poissonii (Audouin, 1826)	1983		circumtropical	unknown	cryptogenic/ questionable	Kalopissis & Kalopissis, 1984
Trachysalambria palaestinensis (Steinitz, 1932)	1995		Red Sea	via Suez	established	Kevrekidis *et al.,* 1998
Sipuncula						
Aspidoshiphon mexicanus (Murina, 1967)	1991		circumtropical	unknown	casual	Pancucci-Papadopoulou *et al.,* 1999
Polychaeta						
Branchiomma luctuosum (Grube 1869)	1991		Indo-Pacific	via Suez/shipping	established	Arvanitidis, 2000
Cossura coasta Litamori, 1960	1975		unknown	via Suez	cryptogenic/ established	Bogdanos & Fredj, 1983
Desdemona ornata Banse, 1957	1986		Indo-Pacific	via Suez/shipping	established	Panagopoulos & Nicolaidou, 1989-90
Ficopomatus enigmaticus (Fauvel, 1923)	1959		Subtropical	shipping/fouling	established	Marinov, 1959
Glycinde bonhourei Gravier, 1904	2007		Red Sea	via Suez	casual	Simboura, 2008
Hydroides dianthus (Verrill, 1873)	1981		Atlantic	Accid/aquaculture	established	Nicolaidou & Pitta, 1986
Hydroides diramphus Mörch, 1863	1981		circumtropical	Accid/aquaculture	casual	Nicolaidou & Pitta, 1986
Hydroides elegans (Haswell, 1883)	1990		circumtropical	shipping/fouling	established	Arvanitidis, 2000
Lysidice collaris Grube, 1870	1975		Pacific	via Suez	Questionable	Koukouras *et al.,* 1985
Metasychis gotoi (Izuka, 1902)	1955		Indo-Pacific	via Suez	established	Peres, 1959
Notomastus aberans Day, 1957	1964		Indo-Pacific	via Suez	casual	Harmelin, 1969
Paradyte cf. *crinoidicola* (Potts, 1910)	1964		Indo-Pacific	via Suez	casual	Barnich & Fiege, 2003
Polydora cornuta Bosc, 1802	2008		Atlantic/Pacific	shipping	casual	Simboura *et al.*, 2008
Prionospio pulchra Imajima, 1990	2000		Atlantic/Pacific	unknown	casual	Pancucci-Papadopoulou *et al.,* 2005a
Pseudonereis anomala (Gravier, 1900)	2003		Indo-Pacific	via Suez/shipping	established	Kambouroglou & Nicolaidou, 2006
Spirobranchus tetraceros (Schmarda, 1861)	1970		Indo-Pacific	via Suez	established	Ben Eliahu, 1972
Spirorbis marioni Caullery & Mesnil, 1897	1997		Pacific	shipping/fouling	established	NCMR, 1997b
Oligochaeta						
Brachiura sowerby Beddard, 1892		2008	Australasia	other	Established	Grabowski & Jabłońska, 2009
Cnidaria						
Cassiopeia andromeda (Forsskål, 1775)	1955		Indo-Pacific	via Suez	casual	Zibrowius, 1992
Oculina patagonica (De Angelis, 1908)	2005		Atlantic	via Gibraltar/ shipping	established	Salomidi *et al.,* 2006
Bryozoa						
Hippopodina feegeensis (Busk, 1884)	1996		Indo-Pacific	via Suez	established	Morri *et al.,* 1999

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Echinodermata						
Ophiactis savignyi (Müller and Troschel, 1842)	1993		circumtropical	via Suez	casual	Pancucci-Papadopoulou, 1994
Synaptula reciprocans (Forsskål, 1775)	2004		Indo-Pacific	via Suez	established	Pancucci-Papadopoulou *et al.,* 2005b
FISHES						
Acipenser baeri Brandt, 1869	1990s	1990s	Asia	stocking	casual	Economidis *et al.,* 2000b
Acipenser gueldenstaedtii Brandt & Ratzeburg, 1833	1990s	1990s	Eurasia	stocking/aquaculture	casual	Economidis *et al.,* 2000b
Acipenser naccarii Bonaparte, 1836		2000	Europe	stocking	questionable	Paschos *et al.,* 2001
Acipenser ruthenus Linnaeus, 1758		1990s	Eurasia	stocking	casual	Economidis *et al.,* 2000a,b
Alepes djedaba (Forsskål, 1775)	1916		Indo-Pacific	via Suez/shipping	casual	Panagiotopoulos, 1916
Alopias superciliosus (Lowe, 1841)	1952		circumtropical	unknown	questionable	Corsini-Foka & Sioulas, 2008
Anguilla japonica Temminck & Schlegel, 1847	2006		Pacific	aquaculture	Questionable	Corsini-Foka & Economidis, 2007
Apogon pharaonis (Bellotti, 1874)	2002		Indo-Pacific	via Suez	established	Corsini-Foka *et al.,* 2004
Atherinomorus lacunosus (Forster, 1801)	1986		Indo-Pacific	via Suez	casual	Quignard & Pras, 1986
Callionymus filamentosus Valenciennes, 1837	2003		Indo-Pacific	via Suez	casual	Corsini *et al.,* 2005
Carassius auratus (Linnaeus, 1758)		1990s	Asia	trade	established	Economidis *et al.,* 2000a
Carassius gibelio (Bloch, 1782)		1958	Eurasia	stocking	questionable/ established	Karvounaris, 1973
Clarias gariepinus (Burchell, 1822)		1993	Africa	aquaculture	Questionable	Economidis *et al.,* 2000a
Coregonus lavaretus (Linnaeus, 1758)		1950s	Europe	aquaculture	established	Sinis & Petridis, 1993
Ctenopharyngodon idella Valenciennes, 1844		1980s	Asia	stocking	casual	Economidis, 1991
Cyprinus carpio Linnaeus, 1758		1920	Eurasian	stocking	cryptogenic/ established	Athanassopoulos, 1935
Enchelycore anatina (Lowe, 1839)	2002		Atlantic	via Gibraltar/ shipping	casual	Golani *et al.,* 2002
Etrumeus teres (DeKay, 1848)	2003		Indo-Pacific	via Suez	established	Kallianiotis & Lekkas, 2005
Fistularia commersonii (Rüppell, 1835)	2001		Indo-Pacific	via Suez	established	Corsini *et al.,* 2002
Gaidropsarus granti (Regan, 1903)	1988		Atlantic	via Gibraltar	casual	Zachariou-Mamalinga, 1999
Gambusia holbrooki Girard, 1859		1927	America	stocking	established	Livadas & Sphangos, 1941
Hemiramphus far (Forsskål, 1775	1943		Indo-Pacific	via Suez	established	Tortonese, 1946
Huso huso (Linnaeus, 1758)	2006	2006	Europe	stocking	casual	Koutrakis & Economidis, 2006
Hypophthalmichthys molitrix (Valenciennes, 1844)		1970s	Asia	stocking	casual	Economidis, 1991
Hypophthalmichthys nobilis (Richardson, 1845)		1980s	Asia	aquaculture	casual	Economidis, 1991
Ictalurus punctatus (Rafinesque, 1818)		2000s	N America	aquaculture	Questionable	Economou *et al.,* 2007a
Iniistius pavo Valenciennes, 1840	2004		Indo-Pacific	via Suez	casual	Corsini *et al.,* 2006
Lagocephalus sceleratus (Gmelin, 1788)	2005		Indo-Pacific	via Suez	established	Corsini *et al.,* 2005
Lagocephalus spadiceus (Richardson, 1844)	1930		Indo-Pacific	via Suez	established	Ananiadis, 1952

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Lagocephalus suezensis Clark & Gohar, 1953	2003		Red Sea	via Suez	established	Corsini *et al.,* 2005
Leiognathus klunzingeri (Steindachner, 1898)	1937		Indo-Pacific	via Suez	established	Kosswig, 1950
Lepomis gibbosus (Linnaeus, 1758)		1981	America	trade	established	Economidis *et al.,* 1981
Liza carinata (Valenciennes, 1836)	2006		Indian	aquaculture	Questionable	Corsini-Foka & Economidis, 2007
Liza haematocheila (Temminck & Schlegel, 1845)	1995		Black Sea	via Dardanelles	established	Koutrakis & Economidis, 2000
Micropterus salmoides (Lacepède, 1802)	2003	2003	America	aquaculture	casual	Corsini-Foka & Economidis, 2007
Oncorhynchus kisutch (Walbaum, 1792)		1980s	America	aquaculture	casual	Tsekos *et al.,* 1992
Oncorhynchus mykiss (Walbaum, 1792)		1951	America	aquaculture	casual	Economidis, 1974
Oreochromis niloticus niloticus Linnaeus 1758		1990s	Africa	aquaculture	casual	Katsaros & Fousekis, 1997
Pagrus major (Temminck & Schlegel, 1843)	2006		Pacific	aquaculture	casual	Corsini-Foka & Economidis, 2007
Parabramis pekinensis (Basilewski, 1855)		1959	Asia	aquaculture	casual	Rosecchi *et al.,* 1993
Parexocoetus mento (Valenciennes, 1846)	1937		Indo-Pacific	via Suez	established	Kosswig, 1950
Pempheris vanicolensis Cuvier, 1831	1985		Indo-Pacific	via Suez	established	Papaconstantinou & Caragitsou, 1987
Petroscirtes ancylodon Rüppell, 1838	2004		Indo-Pacific	via Suez	established	Corsini *et al.,* 2005
Poecilia latipinna Lesuer, 1821		2005	America	trade	established	Koutsikos *et al* (in preparation)
Polyodon spathula (Walbaum 1792)		1990s	America	stocking	casual	Leonardos *et al.,* 2007
Pseudorasbora parva (Temminck & Schlegel, 1846)		1970s	Asia	Accidental	established	Bianco, 1988
Pteragogus pelycus Randall, 1981	1992		Indo-Pacific	via Suez	established	Corsini & Economidis, 1999
Salmo letnica (Karaman, 1924)		1970s	Europe	stocking	established	Crivelli *et al.,* 1997
Salmo salar Linnaeus, 1758		1984	Europe	aquaculture	casual	Economidis *et al.*, 2000a
Salmo trutta Linnaeus, 1758		2004	Europe	aquaculture	established	Economou *et al.,* 2007
Salvelinus fontinalis (Mitchill, 1814)		1980s	America	aquaculture	casual	Tsekos *et al.,* 1992
Sargocentron rubrum (Forsskål, 1775)	1947		Indo-Pacific	via Suez	established	Laskaridis, 1948a
Saurida undosquamis (Richardson, 1848)	1971		Indo-Pacific	via Suez	established	Ondrias, 1971
Scomberomorus commerson Lacepède, 1800	2008		Indo-Pacific	via Suez	establihsed	Corsini-Foka & Kalogirou, 2008
Seriola fasciata (Bloch, 1793)	2004		Atlantic	via Gibraltar	establihsed	Corsini *et al.,* 2006
Siganus luridus (Rüppell, 1829)	1964		Indo-Pacific	via Suez	established	Kavallakis, 1968
Siganus rivulatus Forsskål, 1775	1932		Indo-Pacific	via Suez	established	Brunelli & Bini, 1934
Sphoeroides pachygaster (Müller & Troschel, 1848)	1992		Atlantic	via Gibraltar	established	Zachariou-Mamalinga & Corsini, 1994
Sphyraena chrysotaenia Klunzinger, 1884	1995		Indo-Pacific	via Suez	established	Corsini & Economidis, 1999
Sphyraena flavicauda Rüppell, 1838	2003		Indo-Pacific	via Suez	casual	Corsini *et al.,* 2005
Stephanolepis diaspros Fraser-Brunner, 1940	1943		Indo-Pacific	via Suez/shipping	established	Tortonese, 1946
Torquigener flavimaculosus Hardy & Randall, 1983	2006		Indo-Pacific	via Suez	established	Corsini-Foka *et al.,* 2006b
Tylerius spinosissimus (Regan, 1908)	2004		Indo-Pacific	via Suez	casual	Corsini *et al.,* 2005

Species Name	Marine/ estuarine	Fresh-water	Origin / donor area	Pathway	Establishment success	Source
Tylosurus crocodilus Péron & Lesueur, 1821	2003		Indo-Pacific	via Suez	casual	Sinis, 2005
Upeneus moluccensis (Bleeker, 1855)	1947		Indo-Pacific	via Suez	established	Serbetis, 1947
Upeneus pori Ben-Tuvia & Golani, 1989	2003		Indo-Pacific	via Suez	established	Corsini *et al.,* 2005
Parasites/Pathogens						
Anguillicola crassus Kuwahara, Niimi & Itagaki, 1974	1988	1988	East Asia	aquaculture	established	Moravec, 1992
Aphanomyces astaci Schikora		1982	N America	aquaculture	questionable	Theocharis, 1986
Photobacterium damsella	1995		unknown	aquaculture	established	Bakopoulos *et al.,* 1995
(Arthropoda/Diptera)						
Aedes albopictus (Skuse, 1895)		2000s	East Asia	unknown	established	Patsoula *et al.,* 2006
Amphibians						
Lithobates catesbeianus (Shaw, 1802)		1994	N America	trade	established	Mantziou *et al.,* 1999
Reptilia						
Trachemys scripta (Schoepff, 1792)		1980s	N America	trade	established	Bruekers, 1993
Laticauda colubrina Schneider, 1799	1985		Indo-Pacific	unknown	questionable	Steinicke & Trutnau, 1993
Aves						
Cygnus olor (Gmelin, 1789)		1960s	Europe	ornamental	established	Handrinos & Akriotis, 1997
Threskiornis aethiopicus (Latham, 1790)		2008	Africa	other	casual	Zogaris & collaborators pers. comm
Mammalia						
Ondatra zibethicus (Linnaeus, 1766)		unknown	N America	trade	casual	Mitchell-Jones *et al.,* 1999
Myocastor coypus (Molina, 1782)		1948	S America	trade	established	Aliev, 1967