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Marine alien species in Greek Seas: Additions and amendments by 2010

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Abstract

An update of the inventory of alien marine species from the coastal and offshore waters of Greece is presented. Records were compiled based on the existing scientific and grey literature, including the HCMR database of Greek alien species (ELNAIS), technical reports, scientific congresses, academic dissertations, websites, and unpublished/personal observations. 47 species were added to the inventory, including 34 invertebrates, one vertebrate (fish), three plants, eight protozoa, and one cyanobacterium. With the new records, the inventory of alien marine species of Greece now includes a total of 237 species (33 macrophytes, 131 invertebrates, 42 vertebrates, two bacteria and 29 protozoans). Among these, the presence of the gastropod *Hypselodoris infucata*, the bivalves *Dendrostrea frons* and *Septifer forskali* and the chondrichthyan *Rhizoprionodon acutus* is reported here for the first time. Based on molecular analysis, the occurrence of *Bulla arabica* in Greek waters is confirmed, and the suggestion that previous records of *Bulla ampulla* in the Mediterranean should be considered as misidentification of *B. arabica* is further supported. The acclimitization status of earlier records was revised in the light of new data, and thus the fish *Enchelycore anatina*, *Seriola fasciata* and *Tylerius spinosissimus*, the red algae *Hypnea cornuta* and *Sarconema scinaoides*, the scyphomedusa *Cassiopea andromeda*, the cephalopod *Sepioteuthis lessoniana*, the nudibranch *Chromodoris annulata* and the bivalves *Gastrochaena cymbium* and *Pseudochama corbieri* were upgraded from casual records to established populations. The increased rate of introductions of warm water species confirms previous findings, which link the rate of introduction in the eastern Mediterranean to climate change.

Keywords: Marine aliens; Greece; *Hypselodoris infucata*; *Rhizoprionodon acutus*; *Dendrostrea frons*; *Septifer forskali*; *Bulla arabica*.

Introduction

The eastern Mediterranean is especially susceptible to biological invasions because of its crossroads location between the Ponto-Caspian and the Indian Sea/Red Sea regions, the maritime traffic through the Dardanelles, Gibraltar and Suez, and the existence of many fish and shellfish farms. 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.

The rate of introductions of alien marine species in the Mediterranean Sea is increasing (ZENETOS, 2010) as is the spread of alien species initially established in the Levantine, to other biogeographic areas such as the Aegean. In addition, the scientific community has intensified its efforts to study alien invasions in coastal ecosystems. While new studies are being added to the list, careful examination of historical data on little studied taxa such as hydroids, polychaetes and foraminiferan further expands the Mediterranean aliens' list.

Following a series of scattered publications dealing with single species or groups, a summary of marine alien biota in Greek waters was prepared by PANCUCCI-PAPADOPOULOU *et al.* (2005a) and updated by PANCUCCI-PAPADOPOULOU *et al.* (2005b). ZENETOS *et al.* (2007), provided some additions to the alien marine fauna of Greece. CORSINI-FOKA & ECONOMIDIS (2007) focused on the marine and estuarine fish fauna, while TSIAMIS *et al.* (2008, 2010) reviewed the alien marine flora. The most up-to-date inventory of the alien aquatic species of Greece, with comments on the sources and patterns of their introduction is given by ZENETOS *et al.* (2009a). For Greek waters, the Hellenic

Centre for Marine Research maintains and continuously updates an online database of alien marine species, with records of their presence in Greek localities and distribution maps (ZENETOS *et al.*, 2009b; ELNAIS, 2010). Systematic study of Foraminifera in the Greek Aegean Sea has provided additional data on the distributional range of alien Foraminifera in the Eastern Mediterranean (KOUKOUSIOURA *et al.*, 2010). SIMBOURA *et al.* (2010) reported cases of alien Polychaeta species that were previously collected but had not been identified until recently, or species not classified as aliens (ZENETOS *et al.*, 2009a) although they were present in Greek check lists.

Recently, MALAQUIAS & REID (2008) described a new species of the genus *Bulla* (Mollusca: Opisthobranchia) from the Red Sea and Arabian Peninsula, that they named *Bulla arabica*; the authors hypothesized that the records of *Bulla ampulla* in the Mediterranean Sea for the coasts of Israel, Greece, Cyprus and Turkey (BARASH & DANIN, 1982; ZENETOS *et al.*, 2004; MIENIS, 2004), would probably belong to *B. arabica*. Both *B. ampulla* and *B. arabica* have similar shells that can be misidentified; however their anatomy is distinct and molecular phylogenetics clearly separates these two species (MALAQUIAS & REID, 2008). Furthermore, these species do not occur sympatrically; whereas *B. arabica* is restricted to the Red Sea and Arabian Peninsula, the species *B. ampulla* is not present in these areas but has a broader Indo-West Pacific distribution.

The aim of this work is to update the ZENETOS *et al.* (2009a) list of marine alien species by a) adding all new records reported in the literature or observed by the authors up to December 2010; b) amending collection dates based on literature; c) clarifying the nomenclature of *Bulla ampulla*; and

d) revising the establishment success of earlier casual records in the light of new data.

Materials and Methods

Records of marine alien species from coastal and offshore waters of Greece are compiled based on the existing scientific and grey literature, including ELNAIS (2010), technical reports, scientific congresses, academic dissertations, and websites/online forums (e.g. <http://www.scubadive.gr>, <http://www.seaslugforum.net>), as well as on unpublished/personal observations. Records from grey literature or personal observations are included provided they are supported by physical evidence such as specimens or photographs. Additional records of species found in the period July 2009–December 2010 or previous findings reported within 2010 are discussed. The updated list also includes some records reported before June 2009 but missed by ZENETOS *et al.* (2009a).

Determination of establishment success follows terminology provided in ZENETOS *et al.* (2009a) and KATSANEVAKIS *et al.* (2009).

Established: Introduced or feral population of species settled in the wild with free-living, self maintaining and self-perpetuating populations unsupported by and independent of humans. Species with at least two records in Greece spread over time and space (at least three records for fishes) are also classified as established, in the sense of the CIESM atlas series.

Casual: Casual species are those, which have been recorded only once (no more than twice for fish) in the scientific and grey literature and are presumed to be non-established in Greece. In this paper ‘casual’ is used in the same sense as ‘alien’ in the CIESM atlas series.

Questionable: Species with insufficient information – ‘suspects’. This also includes new entries not verified by experts or species with taxonomic status unresolved.

Cryptogenic: Species with no definite evidence of their native or introduced status according to CARLTON (1996) and species whose probable introduction occurred in ‘early times’ and has not been witnessed, e.g. prior to 1800.

Invasive: Species defined as established aliens that have overcome biotic and abiotic barriers and are able to disseminate away from their area of initial introduction through the production of fertile offspring with noticeable impact, such as threat to the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems, and human health.

For some species reported as casual in ZENETOS *et al.* (2009a) there was evidence of further expansion, which led us to change the status of their establishment success. Nomenclature adopted in this paper follows the World Register of Marine Species (WoRMS <www.marinespecies.org>) and contributing databases (AlgaeBase, CLEMAM, FishBase).

To clarify the nomenclature of *Bulla ampulla*, living specimens that provided the material for DNA analysis were collected in May 2006, in Psili Ammos on Salamis Island of Saronikos Gulf and preserved in ethanol. The taxonomic identification of this material was assessed by molecular methods.

The results are structured in six units. A. The new species with a brief text on their findings; B. Species to be excluded; C. Change in establishment success with comments; D. Misidentifications and Nomenclatural changes; E. Change in introduction dates; and F. Spread of reported aliens and cur-

rent distribution of marine aliens in the Greek Seas.

Results and Discussion

A. New species

Table 1 presents the new species along with some information on their origin, speculated mode of introduction, year of first sighting, and literature. Among the new species 34 are invertebrates, 1 vertebrate (fish), 3 macroalgae, 8 protozoa, and 1 cyanobacterium (Table 1). By adding these 47 species, and excluding three species (see section B), the inventory of alien marine species of Greece now includes a total of 237 species of which 33 are macrophytes, 131 invertebrates, 42 vertebrates, 2 bacteria, and 29 protozoans (Fig. 1). All the new records of invertebrates are zoobenthic species belonging to the taxa investigated the most intensively, i.e. Polychaeta, Mollusca and Crustacea. Fifteen of the records appear to have established viable populations already. With the exception of two species [*Anotrichium okamurae* Baldock and *Chattonella verruculosa* Y. Hara & M. Chihara], originating in the North Pacific, all the new introductions are warm water species. Examination of the presumed modes of introduction, leads to the inference that some of the well established Lessepsian immigrants in the Levantine Sea are spreading northwards to the Aegean. However, the role of shipping bears equal responsibility for the transfer of warm water species to the Aegean Sea, either via Suez or via Gibraltar. It is also worth noticing that with the addition of the 47 species reported here, the number of alien species has increased by 24.4% since the last compilation (June 2009). Overall, 84 new marine alien species have been collected/sighted since 2000, this

high rate of introduction being significantly correlated to climate change (RAITSOS *et al.*, 2010). More details for each species are provided in the text that follows.

CYANOPHYCEA

The cyanobacterium *Trichodesmium erythraeum* is known from nutrient-poor tropical and subtropical ocean waters (particularly around Australia). It has been reported from the Turkish Aegean, in Sicily (BARRONE, 2004), and in the Gulf of Gabes, Tunisia (DRIRA *et al.*, 2009). In Greek waters it was found in Chalkida (Evvoikos Gulf) by METAXATOS *et al.* (2003), while blooms have been reported from Rodos island (S Aegean) and Lesvos island (NE Aegean) [Spatharis, pers. obs].

PROTOZOA

Marteilia refringens is a parasite which affects the digestive system of several bivalve species, inducing physiological disorders and eventually results in death. The first report in Greece dates back to 1997 from oyster beds in Thermaikos Gulf (ANGELIDIS *et al.*, 2001). According to the Directorate General of Veterinary Services in Athens there have been five outbreaks of the disease in farmed mussels across Greece until November 2010.

KOUKOUSIOURA *et al.* (2010) reported six cryptogenic foraminiferan species namely: *Amphistegina lobifera* Larsen, *Sorites orbiculus* (Forsskål), *Cymbaloporeta plana* (Cushman), *Triloculina fichteliana* d'Orbigny, *Planogypsina acervalis* (Brady) and *Coscinospira hemprichii* Ehrenberg from Greek coastal areas. Their distribution can be associated with several pathways, via the Atlantic during the interglacial warm

Table 1
Additional alien species in Greek Seas to those reported in ZENETOS et al. (2009a). ver= Vertebrates, inv=Invertebrates.

Kingdom	Species	Taxon	Establishment success	Vector	Origin	source	First Sighting
Bacteria	<i>Trichodesmium erythraeum</i> Ehrenberg	Cyanophyceae	unknown	unknown	tropical	METAXATOS <i>et al.</i> , 2003	1997
Protista	<i>Martellia refringers</i> Cavalier-Smith, 2002	undefined	established	aquaculture	unknown	ANGELIDIS <i>et al.</i> , 2001	1997
Protista	<i>Chattonella verruculosa</i> Y. Hara & M. Chihara	Dinophyceae	cryptogenic/ questionable	unknown	N Pacific	NIKOLAIDIS <i>et al.</i> , 2005	1998
Protista	<i>Procentrum triestinum</i> J. Schiller, 1918	Dinophyceae	unknown	shipping	unknown	NIKOLAIDIS <i>et al.</i> , 2005	2000
Protista	<i>Coccospira hemprichii</i> Ehrenberg, 1839	Foraminifera	cryptogenic/ established	unknown	unknown	BLANK VERNET, 1969	1955-64
Protista	<i>Cymbaloporetta plana</i> (Cushman, 1924)	Foraminifera	cryptogenic/ established	via Suez / shipping	unknown	KOUKOUSIOURA <i>et al.</i> , 2010	2001
Protista	<i>Planopsina acervalis</i> (Brady, 1884)	Foraminifera	cryptogenic/ established	via Suez / spreading	unknown	KOUKOUSIOURA <i>et al.</i> , 2010	2001
Protista	<i>Triloculina fichteliana</i> D'Orbigny, 1838	Foraminifera	cryptogenic/ established	via Suez / shipping	unknown	KOUKOUSIOURA <i>et al.</i> , 2010	2006
Protista	<i>Amphisstegina madagascariensis</i> D'Orbigny, 1903	Foraminifera	established	via Suez	Indian Ocean/ Red Sea	BLANC-VERNET, 1969	1955-64
Plantae	<i>Anotrichium okamurae</i> Baldock	Rhodophyta	questionable	shipping	NW Pacific	GERLOFF & GEISSLER, 1974	1973
Plantae	<i>Apoglossum gregarium</i> (E. Y. Dawson) M.J. Wynne	Rhodophyta	established	shipping	Pacific	TSIAMIS & BELLOU, 2010	2009
Plantae	<i>Chondria pygmaea</i> Garbary & Vandermeulen	Rhodophyta	questionable	via Suez / shipping	Indo-Pacific	TSIAMIS <i>et al.</i> , 2010	unknown

continued

Table 1 (continued)

Kingdom	Species	Taxon	Establishment success	Vector	Origin	source	First Sighting
Animalia (ver)	<i>Rhizoprionodon acutus</i> (Rüppell, 1837)	Fish/Chondrichthyes	casual	via Gibraltar	circumtropical	This work	2004
Animalia (inv)	<i>Nainetes quadraticeps</i> Day, 1965	Polychaeta	questionable	Via Suez	Indian Ocean	HARMELIN, 1969	1964
Animalia (inv)	<i>Capitellethys dispar</i> (Ehlers, 1907)	Polychaeta	questionable	unknown	Indo-Pacific / Red Sea	ARVANITIDIS, 2000	
Animalia (inv)	<i>Chaetozone corona</i> Berkeley & Berkeley, 1941	Polychaeta	cryptogenic	shipping	unknown	SIMBOURA <i>et al.</i> , 2010	1982
Animalia (inv)	<i>Dasybranchus carneus</i> Grube, 1870	Polychaeta	questionable	unknown	Red Sea	ARVANITIDIS, 2000	unknown
Animalia (inv)	<i>Dispio magnus</i> (Day, 1955)	Polychaeta	questionable	unknown	Indian Ocean	SIMBOURA, 1996	1981
Animalia (inv)	<i>Dodecaceria capensis</i> Day, 1961	Polychaeta	questionable	unknown	Indo-Pacific / Red Sea	BODGANOS & SATSMADJIS, 1983	1975
Animalia (inv)	<i>Hyboscolex longiseta</i> (Schmarda, 1861)	Polychaeta	questionable	unknown	cosmopolitan	FASSARI, 1982	1977
Animalia (inv)	<i>Leocrates chinensis</i> Kinberg, 1866	Polychaeta	questionable	unknown	Pacific	ARVANITIDIS & KOUKOURAS, 1994	1987
Animalia (inv)	<i>Loinia medusa</i> Savigny, 1818	Polychaeta	questionable	unknown	cosmopolitan	BOGDANOS & SATSMADJIS, 1983	1976
Animalia (inv)	<i>Lumbrineris perkinsi</i> Carrera-Parra, 2001	Polychaeta	established	shipping	Indo-Pacific	ARVANITIDIS, 1994	1990s
Animalia (inv)	<i>Marphysa disjuncta</i> Hartman, 1961	Polychaeta	established	shipping	Pacific	SIMBOURA <i>et al.</i> , 2010	1983
Animalia (inv)	<i>Neopseudocapitella brasiliensis</i> Rullier & Amoureux, 1979	Polychaeta	established	shipping	W Atlantic / Red Sea	SIMBOURA & NICOLAIDOU, 2001	1991

continued

Table 1 (continued)

Kingdom	Species	Taxon	Establishment success	Vector	Origin	source	First Sighting
Animalia (inv)	<i>Parapionospio coora</i> Wilson, 1990	Polychaeta	cryptogenic	shipping	Pacific	SIMBOURA <i>et al.</i> , 2010	1982
Animalia (inv)	<i>Polydora spongicola</i> Berkeley & Berkeley, 1950	Polychaeta	questionable	unknown	Pacific	ARVANITIDIS, 2000	unknown
Animalia (inv)	<i>Polycirrus twisti</i> Potts, 1928	Polychaeta	cryptogenic	via Suez / spreading	Red Sea	SIMBOURA, 2011	1983-84
Animalia (inv)	<i>Protodorrillea biarticulata</i> Day, 1963	Polychaeta	questionable	unknown	Indian Ocean	BODGANOS & SATMATDIS, 1985	1975
Animalia (inv)	<i>Pseudopolydora paucibranchiata</i> (Okuda, 1937)	Polychaeta	established	shipping	Pacific	SIMBOURA <i>et al.</i> , 2010	2005
Animalia (inv)	<i>Scoletoma debilis</i> (Grube, 1878)	Polychaeta	questionable	unknown	Indo-Pacific	ARVANITIDIS, 2000	unknown
Animalia (inv)	<i>Sigambra constricta</i> (Southern, 1921)	Polychaeta	questionable	unknown	Indo-Pacific	ARVANITIDIS, 2000	unknown
Animalia (inv)	<i>Syllis schulzi</i> (Hartmann-Schröder, 1962)	Polychaeta	questionable	unknown	Red Sea / Indian Ocean	ARVANITIDIS, 1994	unknown
Animalia (inv)	<i>Timarete dasylophius</i> (Marenzeller, 1879)	Polychaeta	questionable	unknown	Indo-Pacific	ARVANITIDIS, 2000	unknown
Animalia (inv)	<i>Phallusia nigra</i> Savigny 1816	Ascidiacea	established	via Suez / spreading	panropical	KONDILATOS <i>et al.</i> , 2010	2009
Animalia (inv)	<i>Clytia linearis</i> (Thornely, 1900)	Cnidaria/ Hydrozoa	established	via Suez / spreading	Indo-Pacific	MARINOPOULOS, 1979	1977
Animalia (inv)	<i>Synalpheus tumidomanus africanus</i> (Crosnier & Forest, 1965)	Crustacea/ Decapoda	cryptogenic	Via Suez?	unknown	KOUKOURAS, 1978	unknown

continued

Table 1 (continued)

Kingdom	Species	Taxon	Establishment success	Vector	Origin	source	First Sighting
Animalia (inv)	<i>Atergatis roseus</i> (Rüppell, 1830)	Crustacea/Decapoda	established	via Suez / spreading	Indo-Pacific	CORSINI-FOKA & PANCUCCI-PAPA-DOPOULOU, 2010	2009
Animalia (inv)	<i>Goniinfradens paucidentatus</i> (A. Milne Edwards, 1861)	Crustacea/Decapoda	casual	unknown	Indo-Pacific	CORSINI-FOKA <i>et al.</i> , 2010a	2010
Animalia (inv)	<i>Macrophthalmus graeffei</i> A. Milne Ewdards, 1873	Crustacea/Decapoda	casual	via Suez / spreading	Indo-Pacific	PANCUCCI-PAPA-DOPOULOU <i>et al.</i> , 2010	2009
Animalia (inv)	<i>Cardites akabana</i> (Sturany, 1899)	Mollusca/Bivalvia	casual	via Suez / shipping	Red Sea	MANOUSIS <i>et al.</i> , 2010	2008
Animalia (inv)	<i>Chama pacifica</i> Broderip, 1834	Mollusca/Bivalvia	questionable	via Suez / spreading	Indo-Pacific	MANOUSIS <i>et al.</i> , 2010	2008
Animalia (inv)	<i>Septifer forskali</i> (Dunker, 1855)	Mollusca/Bivalvia	established	via Suez / spreading	Indo-Pacific / Red Sea	This work	2010
Animalia (inv)	<i>Dendrostroma frons</i> (Linnaeus, 1758)	Mollusca/Bivalvia	established	via Suez / spreading	Indo-Pacific / Red Sea	This work	2010
Animalia (inv)	<i>Diplodonta bogii</i> van Aartsen, 2004	Mollusca/Bivalvia	casual	via Suez / spreading	Red Sea	MANOUSIS <i>et al.</i> , 2010	2008
Animalia (inv)	<i>Dosinia erythraea</i> Roemer, 1860	Mollusca/Bivalvia	casual	via Suez / spreading	Red Sea	MANOUSIS <i>et al.</i> , 2010	2007
Animalia (inv)	<i>Hypselodoris infucata</i> (Rüppell & Leuckart, 1828)	Mollusca/Opisthobranchia	established	via Suez / spreading	Indo-Pacific / Red Sea	This work	2007

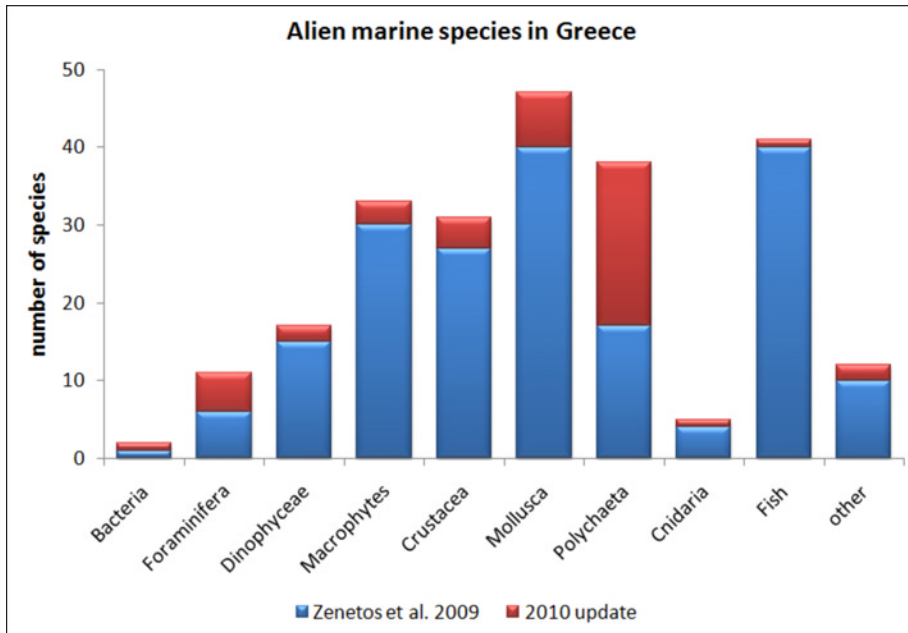


Fig. 1: Breakdown of marine alien species in Greek Seas per taxonomic group.

periods of the Pleistocene-Holocene or fairly recent invasions, now well established, most probably via the Suez Canal (KOUKOUSIOURA *et al.*, 2010). Of these, *Amphistegina lobifera* and *Sorites orbiculus* were included in the compiled list of ZENETOS *et al.* (2009a). *Coscinospira hemprichii* and *Amphistegina madagascariensis* are missing from the list although they have been known since the 1950s (BLANC-VERNET, 1969). *Amphistegina madagascariensis* was reported in the infralittoral zone of Peloponnesos, Kastellorizo, Kriti and Saronikos in *Halophila* meadows (BLANC-VERNET, 1969).

Coscinospira hemprichii is a symbiont-bearing foraminiferan exhibiting a global tropical distribution. It is reported from the Indo-Pacific and the Red Sea. Widely distributed in the Mediterranean, it is known from the coasts of Turkey under the synonym *Peneroplis arietinus* (MERIC *et al.*,

2008). In Greece *C. hemprichii* was reported from Kriti (HOLLAUS & HOTTINGER, 1997), and from the Aegean Sea under the name *Spirolina arietina* (BLANC-VERNET, 1969). KOUKOUSIOURA *et al.* (2010) found *C. hemprichii* mainly in the central and northern Aegean sites, yet in very low abundances.

Cymbaloporeta plana thrives in the shallow water environments of the Pacific Ocean. KOUKOUSIOURA *et al.* (2010) found *C. plana* mainly at the northern and central Aegean sites displaying a peak in relative abundance at the site of Mavro Lithari (Saronikos Gulf).

Planogypsina acervalis seems to be common in the Atlantic, Indian and Red Seas. BLANC-VERNET (1969) described this species from the coasts of Provence, France. KOUKOUSIOURA *et al.* (2010) reported *P. acervalis* as rare at the central Aegean and always in very low abundances.

Triloculina fichteliana thrives in the shallow water environments of the Atlantic Ocean, Pacific Ocean and Red Sea. In the Mediterranean Sea, MERIC *et al.* (2008) reported it from the coasts of Turkey. KOUKOUSIOURA *et al.* (2010) reported it as rare at the southern and central Aegean and always found in very low abundances.

DINOFLAGELLATA

The species *Chattonella verruculosa* appeared in Amvrakikos in 1998, causing mass finfish mortality (NIKOLAIDIS *et al.*, 2005). However, its presence has not been confirmed by later findings and even its identification is problematic (K. Aligizaki, pers. comm.). Blooms of *Prorocentrum triestinum* were reported in Thermaikos Gulf during 2000 and 2001 and were considered responsible for water discoloration (NIKOLAIDIS *et al.*, 2005 reported as *Prorocentrum redfeldii*).

MACROALGAE

TSIAMIS & BELLOU (2010) reported a first finding of the red macroalgae *Apoglossum gregarium* in Greece, which is also the first record in the eastern Mediterranean basin. It was found on artificial substrata (in experimental frames, after one year of deployment) at 50 m depth near Sapientza Island, southeastern Ionian Sea, Greece (Lat 36° 44' 33.6"N, Lon 21° 42' 32.5"E), on 2 April 2009. The Greek specimens were identical to the previous Mediterranean descriptions and were epiphytic on a bryozoan. Moreover, the Greek habitat is the deepest ever recorded for the species. The surrounding natural habitat was sandy mud, and the invasive alga *Caulerpa racemosa* var. *cylindracea* was the pre-

dominant species (TSIAMIS & BELLOU, 2010).

Two taxa have probably been confused under the name of *Anotrichium furcellatum*: the native taxon described from Naples and a species (*Anotrichium okamurae*) originally described from Japan, probably introduced from the Pacific at an unknown time and exhibiting invasive behaviour. In Greece, where *A. furcellatum* has frequently been recorded in the Ionian and Aegean Seas, three hypotheses have to be considered: either we have the native taxon, or the introduced species, or both taxa. Pending new information, the Greek records of *A. furcellatum* are provisionally attributed to *A. okamurae* as a debatable case (TSIAMIS *et al.*, 2010).

In the Mediterranean Sea, *Chondria pygmaea* was found among the epiflora of the introduced *Halophila stipulacea* every time that it was studied. Considering the wide distribution of the introduced seagrass in Greece, the occurrence of *C. pygmaea* is highly probable. Pending confirmation, *C. pygmaea* was provisionally included in the questionable category by TSIAMIS *et al.* (2010).

ASCIDIACEA

The ascidian *Phallusia nigra* is among the established alien species of the Levantine basin. Its presence in Greek waters was first noted in 2009. Established populations were observed by SCUBA diving offshore the beach 'Stegna' and in one of the harbours of Rodos Island (KONDILATOS *et al.*, 2010).

CRUSTACEA/DECAPODA

A single specimen of the crab *Macrophthalmus graeffei*, was collected in 2009 by

PANCUCCI *et al.* (2010) in the Gulf of Trianta (W. Rodos Island). The xanthid *Atergatis roseus* firstly recorded in 2009 at Plimiris Bay (SE Rodos) at 6-8 m depth on sandy bottom with rocks covered by vegetation (CORSINI-FOKA & PANCUCCI-PAPADOPOULOU, 2010) is now considered established (CORSINI-FOKA *et al.*, 2010). Both aforementioned species are well established in the Levantine Basin.

CORSINI-FOKA *et al.* (2010a) documented the first record for the Mediterranean Sea of the red swimming crab *Gonioinfradens paucidentatus*, from specimens collected at Rodos Island (southeastern Aegean Sea), giving a detailed description of samples and biotopes.

The Alboran populations of *Synalpheus tumidomanus africanus* may represent a natural expansion of the biogeographic distribution range of the species from the Atlantic. However, the references of *Synalpheus tumidomanus africanus* from Greece and Turkey (KOUKOURAS & KATTOULAS 1974; KOCATAŞ, 1981) could indicate a separate advance in the eastern Mediterranean littoral from the Israel populations. Recently it has been captured in Sicily (BACCI *et al.*, 2010). The unresolved question is whether the eastern Mediterranean populations are 'alien' or not. Following ZENETOS *et al.* (2010) we have classified it as cryptogenic.

MOLLUSCA

Dosinia erythraea is reported from two live specimens with length of 35 mm and 44 mm respectively, collected at a depth of 5-8 m, during 2007 at Aggelochori, Thermaikos Gulf (MANOUSIS *et al.*, 2010). The record of *Diplodonta bogii* is based on one live specimen of 7 mm, found at 5m in Palioura, Epanomi, Thermaikos Gulf in March 2008

(MANOUSIS *et al.*, 2010). *Cardites akabana* was collected from sandy-muddy bottoms of the sublittoral zone of the southern Thessaloniki Gulf and eastern Thermaikos Gulf. Following the first finding at 0.5 m depth in Cape, Epanomi in April 2008, seven live specimens and two shells (some bearing their periostracum) were found with their lengths ranging from 1.6 mm to 7.6 mm (MANOUSIS *et al.*, 2010).

Two established populations of *Dendrostrea frons* were discovered in June 2010 in northern Kriti and in June 2010 in Astypalaia Island. The species, initially reported from southern Turkey (ÇEVIKER, 2001), appears to have spread eastwards and become established in Vai Bay, Astypalaia Island (36°35'13.75"N 26°24'10.52"E), where thousands of live specimens were found on a big metallic cage brought by the sea to a sandy-muddy bottom with *Posidonia* patches at 5-6 m of depth (cages in use were situated 1.5 km away, just at the end of the bay) (R. Villa, pers. comm.) and in Kriti, as evidenced by the finding of c. 25 mature individuals in Agia Pelagia (D. Poursanidis, A. Zenetos, pers. obs.).

About ten live *Septifer forskali* specimens were found byssed on *Dendrostrea frons* at Astypalaia Island, together with *Pinctada radiata* and *Brachidontes pharaonis*, constituting the first record of this species for Greece. The species was sighted again in Agia Pelagia, Kriti in December 2010 (Poursanidis, pers. obs.) and in Alimos, Saronikos Gulf, attached on *Acanthocardia spinosa* (P. Ovalis, pers. obs.).

Hypselodoris infucata is very common in the Levantine Sea where it can be found all year round. This work reports the first finding of the species in Greek waters. A single specimen of *Hypselodoris infucata* (Ruppell & Leuckart, 1830) was photographed on a rocky bottom at a depth

of 0.5 m in the west side of the port of Kastelorizo Island, on 28 August 2007. This species was sighted again at the same site in September 2009.

The record of *Chama pacifica* is based on one specimen (6.7 mm in length) found in 2008 as epibiont of *Pinna nobilis* shell collected at Aggelochori, Thessaloniki Bay (MANOUSIS *et al.*, 2010). However, the picture shown in Fig. 2d of MANOUSIS *et al.* (2010) is not convincing. The specimen is too small to be accurately identified as *C. pacifica* and the record is based on a single individual. It is speculated here that the specimen corresponds to *Chama aspersa*.

POLYCHAETA

The presence of *Chaetozone corona* in the Mediterranean Sea was first reported by ÇINAR & ERGEN (2007) from Izmir Bay who postulated that this species might be a cryptogenic species. According to SIMBOURA *et al.* (2010), earlier records designated as *Chaetozone* sp. B are currently identified as *C. corona*. Thus, *C. corona* shows a wide distribution in North Evvoikos Gulf, Thermaikos Gulf, Kyklades and Kriti in disturbed and undisturbed sites (SIMBOURA *et al.*, 2010).

Marphysa disjuncta is a species first recorded in the Mediterranean Sea from Fethiye Bay (Levantine Sea, Turkey) by KURT ŞAHİN & ÇINAR (2009), presumably introduced from the Pacific Ocean through ballast waters. In Greece *Marphysa disjuncta* was found in North Evvoikos Gulf (Aegean Sea) at 80 m depth on mud mixed with metalliferous waste (slag), in the caldera of Santorini island (Kyklades, Aegean Sea) at 316 m depth on muddy gravel of volcanic material, and in Saronikos Gulf at 60-70 m depth in muddy sandy sediments (SIMBOURA *et al.*, 2010).

Pseudopolydora paucibranchiata was originally described from Japan and the Pacific Ocean and its establishment in the Mediterranean was attributed to ballast waters (DAGLI & ÇINAR, 2008). In Greece *P. paucibranchiata* was found in Larymna Bay (Evvoikos Gulf, Aegean Sea). It was also found casually among the endofauna of a *Zostera* meadow in Geras Gulf (Lesvos Island) and in Elefsis Bay (Saronikos Gulf) (SIMBOURA *et al.*, 2010).

Neopseudocapitella brasiliensis has been known since 1991 in the Evvoikos Gulf (from Chalkis to Larymna) and in Kriti (SIMBOURA, 1996). The species is also known in the Levantine Sea (Cyprus, Turkey), Adriatic, Central and west Mediterranean (ZENETOS *et al.*, 2010).

Lumbrineris perkinsi was first reported as *L. inflata* by GIANGRANDE *et al.* (1981), who collected it from the Ischia Harbour (Tyrrhenian Sea, western Mediterranean). In Greece (as *L. inflata*), it was found in Evvoikos and Thermaikos Gulfs in the 1990s (ARVANITIDIS, 1994). Dense populations of *L. perkinsi* on the southern coast of Turkey (ÇINAR, 2009), Egypt (ABD-ELNABY, 2009) and Greece (ARVANITIDIS, 1994) and the single record from the western Mediterranean might indicate that this species could have been introduced to the Mediterranean from the Suez Canal. However, its occurrence in the Indo-Pacific area should be checked.

The terebellid species *Polycirrus twisti* Potts, 1928 had been confused with *Polycirrus plumosus* Wollebaeck, 1912 because of incomplete or unclear descriptions and its presence in Greek Seas had been overlooked. SIMBOURA (2011) reports on its occurrence in Korinthiakos Gulf and discusses previous findings in the Aegean Sea since the eighties.

A total of 14 questionable alien poly-

chaetes (*Capitellethus dispar*, *Dasybranchus carneus*, *Dispio magnus*, *Dodecaceria capensis*, *Hyboscolex longiseta*, *Leocrates chinensis*, *Loimia medusa*, *Naineris quadraticeps*, *Polydora spongicola*, *Protodorvillea biarticulata*, *Scoletoma debilis*, *Sigambra constricta*, *Syllis schulzi* and *Timarete dasylophius*) was reported by SIMBOURA & NICOLAIDOU (2001) and ZENETOS *et al.* (2010) but they had not previously been classified as aliens.

CNIDARIA

Clytia linearis was found on algae, *Posidonia oceanica*, sponges, hydroids, bryozoans and on polychaete tubes, in shallow warm waters (BOERO & FRESI, 1986). In the Mediterranean, it has been recorded from the French coast, Ligurian Sea, Tyrrhenian Sea, Adriatic and Ionian Sea, Spanish waters, Alboran Sea off the coast of Morocco, Greek waters, and Lebanese waters. In Greece, *C. linearis* was recorded from Aspra Spitia (Korinthiakos Gulf) by MARINOPOULOS (1979) (as *Clytia gravieri*) (collection date: 1977) and from Kos Island (Aegean Sea) by MORRI & BIANCHI (1999) (collection date 1981).

FISH

The milk shark *Rhizoprionodon acutus* has a circumtropical distribution (Tropical Atlantic and Indian Ocean, Red Sea and Japan). To date it has been considered as a vagrant fish in the Mediterranean, its record based on a single specimen captured in the Gulf of Taranto, Italian Ionian Sea (PASTORE & TORTONESE, 1984). The present work reports a second sighting of the species in the Greek SW Ionian Sea (Lat 36° 52' N, Lon 20° 32' E). The individual, captured on 16 July 2004 by D. Damalas,

was measured and weighed. It was a male with a total length 162cm, a fork length 130cm, pectoral length 102cm and a round weight of 21.5 Kg. A tissue sample was kept for DNA analysis (code No 42), preserved in the Ichthyology Laboratory of the University of Athens.

B. Species to be excluded

The alga *Neosiphonia sphaerocarpa* (Borgesien) M.S. Kim & I.K. Lee was first recorded in the Mediterranean Sea from Tunisia and successively from Corsica, the Balearic Islands and Milos Island in Greece. CORMACI *et al.* (2004) considered *N. sphaerocarpa* as an alien species. However, the species is distributed worldwide and molecular data are needed to locate its place of origin. Moreover, the identification of the species is not easy. Consequently the absence of *N. sphaerocarpa* in the Mediterranean prior to 1970 could simply mean that it was overlooked or mistaken for another *Polysiphonia* species. Pending further investigations, TSIAMIS *et al.* (2010) provisionally consider this species as native in the Mediterranean Sea.

The record of *Circenita callipyga* (Born 1778) is based on one shell measuring 8.6 mm in length, found in the Gulf of Thessaloniki, Mikro Emvolo, at 5m in 2008 (MANOUSIS *et al.*, 2010). However, the picture of the shell figured in MANOUSIS *et al.* (2010) is not convincing in our opinion as it does not match the species description (size, outline, sculpture). The ovate rather than trigonal outline and the radial sculpture are diagnostic features for the species. This is not clear from Figure 3a of MANOUSIS *et al.* (2010) where a whole bivalved specimen is depicted, presumably belonging to a juvenile *Gouldia minima* (Montagu, 1803). After consideration of the

Mediterranean distribution of the species which is restricted to Israel (ZENETOS *et al.*, 2004), this record has been excluded from our list.

Two of the Atlantic invaders (*Alopias superciliosus* and *Gaidropsarus granti*) are excluded from the list of Greek alien species following ZENETOS *et al.* (2010), who consider them Atlanto-Mediterranean species.

C. Change in establishment success

The species listed in Table 2 have been reported from more than one site, and hence they are now considered to be established in Greek waters. Details on their distribution are provided below.

The establishment of the fangtooth moray eel *Enchelycore anatina* in the south Aegean is confirmed by the finding of a specimen in Rodos Island in 2010 (KALOGIROU, 2010) and another one in Karpathos Island (CORSINI-FOKA, 2010, pers. comm.) As an indication of its establishment, local fishermen state that they catch approximately 4-5 individuals per vessel with gill-nets during the summer period along Ro-

dos Island's rocky bottoms and even in Kastellorizo Island (KALOGIROU, 2010).

A second record of the small Indo-Pacific fish *Tylerius spinosissimus* (Tetraodontidae) (known as spiny blaasop) was documented at the beginning of 2009 in the waters of Rodos Island (south-eastern Aegean Sea, Greece). The finding shows the putative establishment of a population of this alien fish in the Mediterranean around the Dodekanisos islands (CORSINI-FOKA *et al.*, 2010b).

Seriola fasciata (Bloch, 1793) is a species of ampho-Atlantic origin, which made its first appearance in Rodos in 2004. Consequent findings in Rodos (2009) and Lesvos (2010) [ELNAIS, 2010] confirm its establishment success in Greek waters.

The Lessepsian immigrant *Hypnea cornuta*, found only twice in the Aegean Sea [in 1894 in Rodos Island (as *H. valentiae*) and one century later, in 2007], was found again in the Saronikos Gulf (TSIAMIS *et al.*, 2008) in August 2009; hence it appears to have become established in the area (TSIAMIS *et al.*, 2010).

The red alga *Sarconema scinaoides*, which was reported from Greece only in the

Table 2
Alien marine species in Greece classified as established.

Species	Taxon	Source
<i>Enchelycore anatina</i> (Lowe, 1839)	Fish/Osteichthyes	KALOGIROU, 2010
<i>Tylerius spinosissimus</i> (Regan, 1908)	Fish/Osteichthyes	CORSINI-FOKA <i>et al.</i> , 2010b
<i>Seriola fasciata</i> (Bloch, 1793)	Fish/Osteichthyes	ELNAIS, 2010
<i>Hypnea cornuta</i> (Kützting) J. Agardh 1851	Rhodophyta	TSIAMIS <i>et al.</i> , 2010
<i>Sarconema scinaoides</i> Børgeesen, 1934	Rhodophyta	TSIAMIS <i>et al.</i> , 2010
<i>Cassiopea andromeda</i> (Forsk. & A., 1775)	Cnidaria/Scyphozoa	This work
<i>Gastrochaena cymbium</i> Spengler 1783	Mollusca/Bivalvia	MANOUSIS <i>et al.</i> , 2010
<i>Pseudochama corbieri</i> (Jonas, 1846)	Mollusca/Bivalvia	MANOUSIS <i>et al.</i> , 2010
<i>Chromodoris annulata</i> (Eliot, 1904)	Mollusca /Gastropoda	This work
<i>Sepioteuthis lessoniana</i> Lesson, 1830	Mollusca/Cephalopoda	This work

Saronikos Gulf in the early 1980's, was found again at the same location after about 30 years (see TSIAMIS *et al.*, 2009); thus, revealing an established population in the area still surviving after three decades (TSIAMIS *et al.*, 2010).

Cassiopea andromeda, which occurs along the Levantine coastline, was recently reported from Malta (SCHEMBRI *et al.*, 2010). SCHÄFER (1955) reported the occurrence of very young specimens (2-30 mm) on Neokameni, a small volcanic island near Santorini, Aegean Sea, where the medusae flourished in rocky pools with water temperatures reaching up to 36° C due to volcanic activity. The present work reports on the finding of >15 alive individuals of *C. andromeda* in Paros Island at depths between 2–10 m (June 2010: S. Katsanevakis pers. obs.) and in S. Evvoikos, (Chalkoutsis, September 2010: A. Zenetos pers. obs.).

From six stations of the sublittoral zone of eastern Thermaikos Gulf, Thessaloniki Gulf and Thessaloniki Bay, more than 30 live specimens of *Gastrochaena cymbium*, 5.4-5.7 mm in length, were dissected out of their calcareous capsules (MANOUSIS *et al.*, 2010). Empty shells of *G. cymbium* were extracted from *Ostrea* sp. shells collected in Elefsis Bay, Saronikos Gulf (S. Katsanevakis, pers. obs.).

Two live specimens of *Pseudochama corbieri* (Jonas 1846) measuring 13.1 mm and 19.1 mm, were found in April 2006 in Epanomi, Thermaikos Gulf, North Aegean at 2 m depth (MANOUSIS *et al.*, 2010).

The presence of *Chromodoris annulata* (Eliot, 1904) in Greece was documented from a single sighting of the species in Saronikos Gulf. The species was observed again in September 2010 in Madraki, Kastellorizo at a depth of 0.5 m (G. Apostolopoulos, pers. obs.).

Sepioteuthis lessoniana Lesson, 1830 is one of the most commercially important squid species for inshore fisheries throughout its distributional range. It is common in the Levantine basin and first appeared in Greek waters at Dodekanisos in 2009 (LEFKADITOU *et al.*, 2009). Ever since, occasional reports e.g. in Kastellorizo (G. Apostolopoulos pers. obs.) and elsewhere (ELNAIS, 2010) testify to its establishment success and eastward spread.

The presence of *Alepes djedaba* (Forsskål, 1775) in Greek water has to be downgraded to questionable. The species was not reported in PANAGIOTOPOULOS (1916), as mentioned in ZENETOS *et al.* (2009a). However, under its synonym *Caranx gallus* it was reported by MALDURA (1938) in Rodos, a citation that was later corrected by LASKARIDIS (1948) as the native *Alectis alexandrinus*. It appears that PAPACONSTANTINO (1988) cites *A. djedaba* as questionable based on TORTONESE (1952) who has repeated MALDURA (1938). Although it is established in the Levantine Sea and eastern Aegean Sea, its occurrence in Greek waters, based only on BINI (1960), remains to be confirmed.

D. Misidentifications and Nomenclatural changes

Attention was paid to recent nomenclatural updates (Table 3). These are the result of the latest taxonomic and/or molecular studies. Such is the case for the commercially important swimming crab *Portunus pelagicus* (Linnaeus, 1758) and the gastropod *Bulla ampulla* (Linnaeus, 1758). Based on morphological and DNA characters as well as biogeographical considerations *P. pelagicus* is in fact *Portunus segnis*, a species confined to the western Indian

Table 3
Misidentifications and nomenclature changes.

New name	Old name	Source
<i>Equulites klunzingeri</i> (Steindachner, 1898)	<i>Leiognathus klunzingeri</i> (Steindachner, 1898)	FISHBASE
<i>Portunus segnīs</i> (Forsskål, 1775)	<i>Portunus pelagicus</i> (Linnaeus, 1758)	LAI <i>et al.</i> , 2010
<i>Conomurex persicus</i> (Swainson, 1821)	<i>Strombus persicus</i> (Swainson, 1821)	WoRMS
<i>Bulla arabica</i> Malaquias & Reid, 2008	<i>Bulla ampulla</i> (Linnaeus, 1758)	This work

Ocean from Pakistan to South Africa (LAI *et al.*, 2010).

With regard to *Bulla ampulla*, DNA was extracted and amplified for the mitochondrial genes cytochrome *c* oxidase subunit I (COI) and 16S rRNA. COI amplification was not successful but the 16S yielded good quality sequences. Those were blasted in GenBank and results retrieve maximum similarity with the two sequences of *Bulla arabica* available in this database, including with the holotype of the species (BMNH 20060103/1, United Arab Emirates; GenBank accession number: DQ986575.1). The results of molecular analysis confirm the occurrence of *Bulla arabica* in the Mediterranean Sea and support the suggestion by

MALAGUIAS & REID (2008) that previous records of *Bulla ampulla* in this basin should be considered misidentifications of *B. arabica*.

E. Change in introduction dates

Recent literature and/or re-examination of other sources make it clear that the collection date of species listed in Table 4 needs to be corrected.

F. Distribution of reported aliens

Besides those species considered as casual and reported in other locations, which reveals their establishment success, many

Table 4
Correction of collection dates reported in ZENETOS *et al.* (2009a).

Species	Correct collection date	Source
<i>Alepes djedaba</i> (Forsskål, 1775)	1960 not 1916	BINI, 1960
<i>Siganus rivulatus</i> Forsskål, 1775	1925 not 1932	ZACHARIOU MAMALINGA, 1990
<i>Apogon pharaonis</i> Bellotti, 1874	1982 not 2002	ZACHARIOU-MAMALINGA, 1990
<i>Pempheris vanicolensis</i> Cuvier, 1831	1983 not 1985	ZACHARIOU-MAMALINGA, 1990
<i>Amphistegina lessonii</i> d'Orbigny, 1826	1974 not 1997	Hottinger pers. comm.
<i>Conomurex persicus</i> (Swainson, 1821)	1983 not 1986	VERHECKEN, 1984

of the established species have expanded their geographic distribution range northwards or have spread rapidly within the same area, revealing an invasive character. Examples are presented below:

The recent records of *Lagocephalus sceleratus* (Gmelin, 1788) verify that the species is now very common along the central, southern and southeastern coasts of the Aegean Sea. Recent captures confirm the spreading of the species in the NW Aegean Sea, increasing the number of its northern records in the whole Mediterranean (MINOS *et al.*, 2010) (Fig. 2a).

Findings of the recently recorded *Petroscirtes ancylodon* Rüppell, 1838, *Callionymus filamentosus* Valenciennes, 1837, *Torquigener flavimaculosus* Hardy & Randall, 1983 and *Scomberomorus commerson* Lacepède, 1800 from Rodos in summer 2008, confirm their quick establishment (CORSINI-FOKA, 2010). *Torquigener flavimaculosus* and *P. ancylodon* were also spotted in Kastellorizo (G. Apostolopoulos, pers. obs.).

Stephanolepis diaspros Fraser-Brunner, 1940, well established in the south Aegean Sea (CORSINI-FOKA & ECONOMIDIS, 2007; CORSINI-FOKA, 2010), was captured in boat seine hauls carried out in the period 2008-2009 in the Aegean Sea, occurring in up to 60% of the hauls (LEFKADITOU *et al.*, 2010). Its current distribution is illustrated in Fig. 2b.

KOUKOUSIOURA *et al.* (2010) postulated that *Amphistegina lobifera*, is the dominant foraminifer species at the southern and central Aegean usually comprising more than 30% of total specimens of the foraminiferal assemblages. In the northern site (N. Kallikratia) *A. lobifera* was present at very low abundances.

Sorites orbiculus was regularly found at the central Aegean and southern Aegean

sites with somewhat higher percentages at Falasarna (7.5% of the foraminiferal fauna) (KOUKOUSIOURA *et al.*, 2010).

Two bivalvia species of the Chamidae family were collected from rocky bottoms of Thermaikos Gulf: *Chama asperella* Lamarck 1819 (four live specimens with length ranging from 8.2 mm to 17.6 mm) at 5m Paralia, Epanomi, in October 2008, on *Pinna nobilis*, and at Palioura, Epanomi, in December 2008, and *Chama aspersa* Reeve 1846 (two live specimens 15 mm and 26 mm in length, respectively), in 2008, from the sea shore at Paralia, Epanomi, Thermaikos Gulf (MANOUSIS *et al.*, 2010). *Chama aspersa* was also collected in September 2010 from Elefsis Bay, Saronikos Gulf (S. Katsanevakis, pers. obs.).

Brachidontes pharaonis (Fischer P., 1870), previously known only from Rodos and Saronikos Gulf, was also observed in SE Kriti (P. Ovalis, ELNAIS, 2010) and Astypalaia Island in June 2010. *Pinctada radiata* (Leach, 1814), known as north as the Evvoikos Gulf, was collected at Palioura, Epanomi, in March 2005, at Cape, Epanomi in August 2010 (S. Mitsoudi, pers. comm.) and at Astypalaia Island in June 2010 (F. Crocetta, pers. obs.).

Trochus erithraeus Brocchi, 1821 previously known from Kriti, (COSENZA & FASULO, 1997) has been spotted in 2010 in central Aegean Sea. One shell was collected on the coast of Syros Island and deposited in the collection of the Goulantris Natural History Museum.

An established population of *Synaptula reciprocans* (Forsskål, 1775) measuring 20-100 cm in length was found at Loutro, SW Kriti (35° 12' 1.68"N 24° 4' 53.70"E) at depths more than 5 m (D. Poursanidis, ELNAIS, 2010) (Fig. 2c).

Further to its spread in the North Aegean and Ionian Sea (KATSANEVAKIS &

TSIAMIS, 2009; KATSANEVAKIS *et al.*, 2011), and its population explosion along the coasts of Rodos in 2010 (M. Corsini-Foka, pers. obs.), *Percnon gibbesi* (H. Milne Edwards, 1853) was found at 10 sites in SW, W,

and NW Kriti during summer and autumn 2010 (D. Poursanidis, pers. obs.) and may thus be considered as established along the entire Cretan coastline; it was also found in Pesada, S. Kefallonia Island, Ionian Sea in

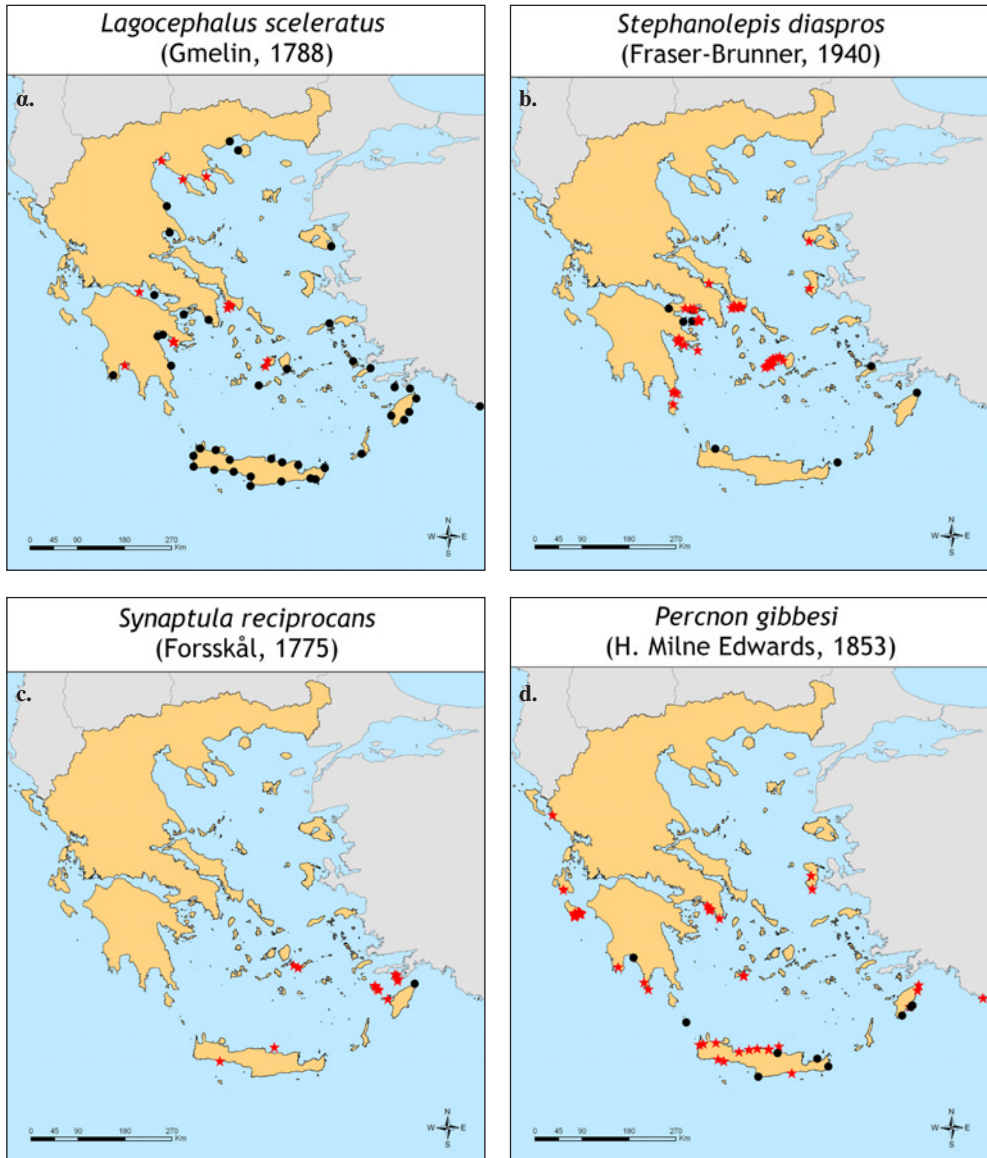


Fig. 2 (a-d): Distribution of some of the most invasive species. Asterisks indicate findings after ZENETOS *et al.* (2009).

July 2010 (A. Panou, pers. comm.). One of us (G. Apostolopoulos) has observed and photographed *P. gibbesi* along the north Kastellorizo coast repeatedly since 2004 (Fig. 2d).

Figure 3 shows aliens' zoogeographical patterns in Greek waters. The highest number (93 species) was reported in the Dodekanisos area, SE Aegean, which testifies to the importance of the area as the entrance point of Lessepsian immigrants spreading towards the Aegean Sea. Particular notice should be given to the 86 species reported in the wider area of the Saronikos Gulf, a hotspot area for bioinvasions in Greek waters, closely related to the route of ships towards Peiraias, the biggest Greek port. Relatively high (40 species) is also the number of alien species in the Thermaikos Gulf (related to the port of Thessaloniki). Many of the species en-

countered in Saronikos and/or Thermaikos Gulfs present a limited distribution in the aforementioned areas.

Conclusions

- ▶ Following the review by ZENETOS *et al.* (2009a) on marine alien species in Greek Seas, 47 additional species are reported herewith, bringing the total to 237, which is a 24.4% increase. Twenty one of the listed species were reported for the first time in 2009-2010, whereas 21 species (mostly Polychaeta) although they existed in the literature, had never been classified as aliens previously.
- ▶ The species *Hypselodoris infucata*, *Dendrostroma frons*, *Septifer forskali* and *Rhizoprionodon acutus* are reported in this work for the first time in Greek waters.

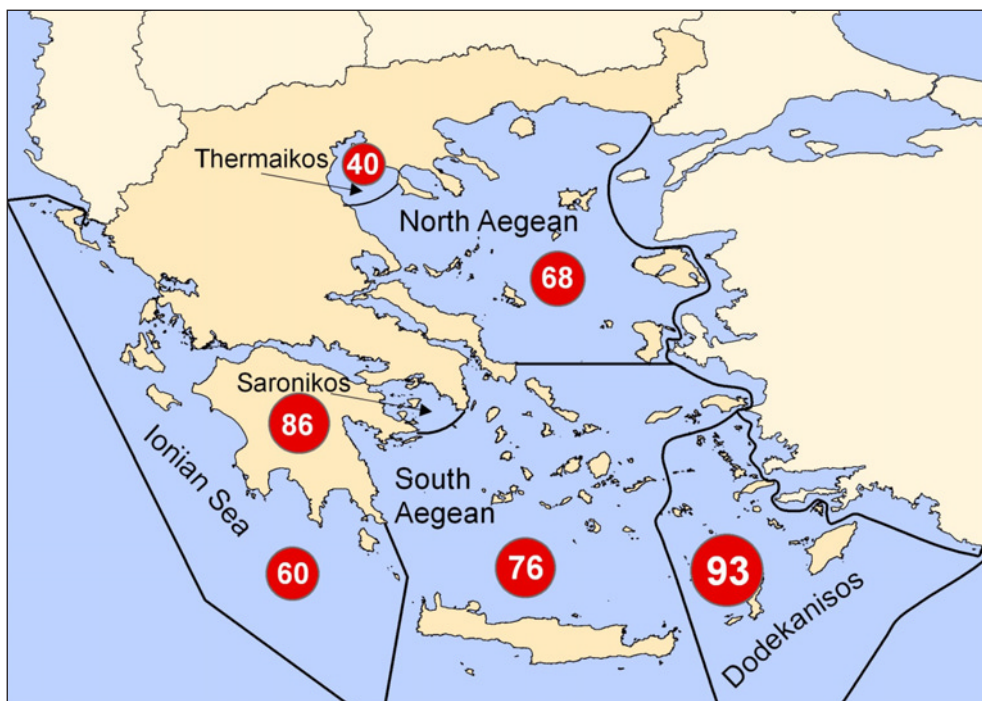


Fig. 3: Pattern of alien species distribution in Greek waters.

- ▶ Four species reported in previous lists are now excluded. These are: the rhodophyte *Neosiphonia sphaerocarpa*, the bivalve *Cirrenita callipyga*, and the fish *Alopias superciliosus* and *Gaidropsarus granti*.
- ▶ Based on molecular analysis, we confirm the occurrence of *Bulla arabica* in the Mediterranean Sea and support the suggestion by MALAQUIAS & REID (2008) that previous records of *Bulla ampulla* in the Mediterranean should be considered as a misidentification of *B. arabica*.
- ▶ In 2010, ten species previously known as casual and/or questionable immigrants, have established viable populations and spread to many localities in the Greek coasts. To-date, of the 237 alien species reported in Greek waters, 127 are established; 59 are casual records; 20 are cryptogenic and 31 are questionable records.
- ▶ The majority of alien species belong to Mollusca (47 species: 19.8%), followed by fish (41 species: 17.3%), Polychaeta (38 species: 16.0%), macroalgae (33 species: 13.9%), and Crustacea (31 species: 13.1%).
- ▶ Most of the newly introduced and/or reported species originate in tropical subtropical areas of the Pacific, Indian or Atlantic Oceans.
- ▶ The increased rate of introductions of warm water species confirms the previous findings linking the rate of introduction in the eastern Mediterranean to climate change.
- ▶ Although many of the newly reported species are Lessepsian immigrants spreading in the Aegean Sea, the role of shipping is gaining significance as a vector of alien species' transfer in the Aegean Sea.

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