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of Greek alien species (ELNAIS), technical reports, scientific congresses, academic dissertations, websites, and unpublished/personal observations. 47 species were added to the inventory, including 34 invertebrates, one vertebrate (fish), three plants, eight protozoa, and one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 comata and Sarconema scinaeoides, the scyphomedusa Cassiopea andromedae, the cephalopod Sepioteuthis lessoni, 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 Pontic-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 disperse 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: Amphi stegina lobifera Larsen, Sorites orbiculus (Forsskål), Cymbaloporetta 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.

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Species</th>
<th>Taxon</th>
<th>Establishment success</th>
<th>Vector</th>
<th>Origin</th>
<th>source</th>
<th>First Sighting</th>
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<td>N Pacific</td>
<td>NIKOLAIDIS et al., 2005</td>
<td>1998</td>
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<td><em>Procerium triestinum</em> J. Schiller, 1918</td>
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<td>unknown</td>
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<td>2000</td>
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<td>unknown</td>
<td>BLANK VERNET, 1969</td>
<td>1955-64</td>
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<td>via Suez / shipping</td>
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<td>KOUKOUIOURA et al., 2010</td>
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<td><em>Planogypsina acervalis</em> (Brady, 1884)</td>
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<td>via Suez / spreading</td>
<td>unknown</td>
<td>KOUKOUIOURA et al., 2010</td>
<td>2001</td>
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<td><em>Triloculina fichteliana</em> D’Orbigny, 1838</td>
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<td>via Suez / shipping</td>
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<td>KOUKOUIOURA et al., 2010</td>
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<td>GERLOFF &amp; GEISSLER, 1974</td>
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<td>TSIAMIS et al., 2010</td>
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<th>Kingdom</th>
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<th>Vector</th>
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<td>MANOUSIS et al., 2010</td>
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<td>via Suez / spreading</td>
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<td>MANOUSIS et al., 2010</td>
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<td>via Suez / spreading</td>
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<td>MANOUSIS et al., 2010</td>
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<td>via Suez / spreading</td>
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<td>MANOUSIS et al., 2010</td>
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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 Peloponnnesos, Kastellorizo, Kriti and Saronikos in *Halophila* meadows (BLANC-VERNET, 1969).

*Coscinispira 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.

*Cymbaloporetta 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 predominant 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 Plimmiris 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 Gonoiodrados 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 Israeli 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 akebana 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 (ÇEVİKER, 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 ca 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 pharao - nis, 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, Saroni- kos 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 INAR & 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 KURTŞAHİN & 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 Larynma 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, Loinia medusa, Naineris quadriticeps, Polydora spongicola, Protodorvillea biarticulata, Scoletoma debilis, Sigambaria 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* (Borgesen) 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 *Circeina 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 Rodos Island’s rocky bottoms and even in Kastelorizo 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 amphi-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 scinaioides*, which was reported from Greece only in the

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**Table 2**

Alien marine species in Greece classified as established.

<table>
<thead>
<tr>
<th>Species</th>
<th>Taxon</th>
<th>Source</th>
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<tbody>
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<td><em>Enchelycore anatina</em></td>
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<td>KALOGIROU, 2010</td>
</tr>
<tr>
<td><em>Tylerius spinosissimus</em></td>
<td>Fish/Osteichthyes</td>
<td>CORSINI-FOKA et al., 2010b</td>
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<td><em>Seriola fasciata</em></td>
<td>Fish/Osteichthyes</td>
<td>ELNAIS, 2010</td>
</tr>
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<td><em>Hypnea cornuta</em></td>
<td>Rhodophyta</td>
<td>TSIAMIS et al., 2010</td>
</tr>
<tr>
<td><em>Sarconema scinaioides</em></td>
<td>Rhodophyta</td>
<td>TSIAMIS et al., 2010</td>
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<tr>
<td><em>Cassiopea andromeda</em></td>
<td>Cnidaria/Scyphozoa</td>
<td>This work</td>
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<tr>
<td><em>Gastrochaena cymbium</em></td>
<td>Mollusca/Bivalvia</td>
<td>MANOUSIS et al., 2010</td>
</tr>
<tr>
<td><em>Pseudochama corbieri</em></td>
<td>Mollusca/Bivalvia</td>
<td>MANOUSIS et al., 2010</td>
</tr>
<tr>
<td><em>Chromodoris annulata</em></td>
<td>Mollusca/Gastropoda</td>
<td>This work</td>
</tr>
<tr>
<td><em>Sepioteuthis lessoniana</em></td>
<td>Mollusca/Cephalopoda</td>
<td>This work</td>
</tr>
</tbody>
</table>
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, (Chalkoutsi, 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 PAPACONSTANTINOU (1988) cites A. djedaba as questionable based on TERTONESE (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
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 MALAQUIAS & 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

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**Table 3**

<table>
<thead>
<tr>
<th>New name</th>
<th>Old name</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equulites klunzingeri</td>
<td>Leiognathus klunzingeri</td>
<td>FISHBASE</td>
</tr>
<tr>
<td>(Steindachner, 1898)</td>
<td>(Steindachner, 1898)</td>
<td></td>
</tr>
<tr>
<td>Portunus segnis</td>
<td>Portunus pelagicus</td>
<td>LAI et al., 2010</td>
</tr>
<tr>
<td>(Forsskål, 1775)</td>
<td>(Linnaeus, 1758)</td>
<td></td>
</tr>
<tr>
<td>Conomurex persicus</td>
<td>Strombus persicus</td>
<td>WoRMS</td>
</tr>
<tr>
<td>(Swainson, 1821)</td>
<td>(Swainson, 1821)</td>
<td></td>
</tr>
<tr>
<td>Bulla arabica</td>
<td>Bulla ampulla</td>
<td>This work</td>
</tr>
<tr>
<td>Malaquias &amp; Reid, 2008</td>
<td>(Linnaeus, 1758)</td>
<td></td>
</tr>
</tbody>
</table>

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**Table 4**

<table>
<thead>
<tr>
<th>Species</th>
<th>Correct collection date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alepes djedaba (Forsskål, 1775)</td>
<td>1960 not 1916</td>
<td>BINI, 1960</td>
</tr>
<tr>
<td>Siganus rivulatus Forsskål, 1775</td>
<td>1925 not 1932</td>
<td>ZACHARIOU MAMALINGA, 1990</td>
</tr>
<tr>
<td>Apogon pharaonis Bellotti, 1874</td>
<td>1982 not 2002</td>
<td>ZACHARIOU-MAMALINGA, 1990</td>
</tr>
<tr>
<td>Conomurex persicus (Swainson, 1821)</td>
<td>1983 not 1986</td>
<td>VERHECKEN, 1984</td>
</tr>
</tbody>
</table>
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 ancylostomus* Rüppell, 1838, *Callionymus flavimaculosus* 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. ancylostomus* 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 aspera* 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 aspera* was also collected in September 2010 from Elefsis Bay, Saronikos Gulf (S. Katsonaveakis, 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 Evoikos 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 Goulandris Natural History Museum.

An established population of *Synapta la 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).](http://epublishing.ekt.gr)
July 2010 (A. Panou, pers. comm.). One of us (G. Apostolopoulos) has observed and photographed *P. gibbesi* along the north Kastelorizo 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 encountered 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*, *Dendrostrea 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.](http://epublishing.ekt.gr)
Four species reported in previous lists are now excluded. These are: the rhodophyte *Neosiphonia sphaerocarpa*, the bivalve *Circenita 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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