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Inventory of alien marine species of Cyprus (2009)

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Abstract

*An updated inventory of alien marine species from the coastal and offshore waters of Cyprus is presented. Records were compiled based on the existing scientific and grey literature, including the HCMR database of Mediterranean alien species, technical reports, scientific congresses, academic dissertations, and websites, as well as on unpublished/personal observations. The listed species were classified in one of five categories: established, invasive, casual, cryptogenic, and questionable. The mode of introduction and the year of first sighting were also reported for each species. Eight new records based on personal observations of the authors were reported (*Chondria coerulescens*, *Neosiphonia sphaerocarpa*, *Enchelycore anatina*, *Lagocephalus spadiceus*, *Lagocephalus suezensis*, *Scomberomorus commerson*, *Sillago sihama*, and *Sphoeroides pachygaster*). Nine species, previously reported as aliens in Cypriot waters, were excluded from the inventory for various reasons. Twelve established species were characterized as invasive (*Caulerpa racemosa* var. *cylindracea*, *Cerithium scabridum*, *Strombus persicus*, *Trochus erithreus*, *Brachidontes pharaonis*, *Pinctada radiata*, *Pseudonereis anomala*, *Charybdis helleri*, *Fistularia commersonii*, *Lagocephalus sceleratus*, *Siganus luridus*, and *Siganus rivulatus*) as they have a substantial impact on biodiversity and/or local economy. The impact of alien marine species in Cyprus is expected to grow in the near future, and further effort directed towards recording alien invasions and their impact will be needed.*

Keywords: Alien marine species; Biodiversity; Eastern Mediterranean; Invasive species; Lessepsian immigrants; Cyprus.

Introduction

Biological invasions represent a significant risk for many natural ecosystems and have become an issue of increasing concern worldwide (SCHMITZ & SIMBERLOFF,

1997; EEA, 2009). Invasive alien species are considered to be the second most important cause of global biodiversity change, following direct habitat destruction (CBD, 2000). In particular, biological invasions in aquatic habitats represent a recognized glob-

al threat with a strong impact on biodiversity and local economies (PERRINGS *et al.*, 2002; PIMENTEL *et al.*, 2005; EEA, 2006; STREFTARIS & ZENETOS, 2006). Although natural invasions do occur, nowadays most biological invasions result from human activities. The Mediterranean Sea is one of the regions most severely affected by alien marine invasions, fostered by the opening of the Suez Canal, fouling and ballast transportation along shipping lines, aquaculture, and the aquarium trade (STREFTARIS *et al.*, 2005; GALIL, 2009). A recent update of the marine alien species list in the Mediterranean Sea reported a total of 925 introduced species listed by March of 2009, of which 519 were considered to be established and spreading (ZENETOS, 2009). This overall estimation of marine alien species in the Mediterranean Sea represents approximately 7.5% of the known flora and fauna; however, this percentage is higher in the Eastern Mediterranean and may exceed 20% in specific aquatic ecosystems (GALIL & ZENETOS, 2002). The number of recorded alien species in the Mediterranean Sea continues to increase at a rate of one new record every nine days (ZENETOS *et al.*, 2008).

In recent years there has been a strong interest from the scientific community and international organisations in monitoring biological invasions in the Mediterranean Sea, assessing their impact on the native flora and fauna and on local economies, investigating the causes and patterns of alien introductions, and proposing management measures (CBD, 2000; EC, 2006, 2007, 2008; EEA, 2006; IMO, 2009). Within this framework, a great effort has been made during the last decade to compile fragmentary and sporadic information on the presence and distribution of alien species in the Mediterranean Sea. CIESM has issued a series of atlases of the alien species in the Mediter-

anean Sea, covering fish, decapod and stomatopod crustaceans, molluscs, and macrophytes (www.ciesm.org). Additionally, scientists from several Mediterranean countries have created and continuously update databases of aquatic alien species, and have published national inventories usually including information on the origin of each species, the mode of introduction, and the establishment success. Such lists for marine alien species have been published for Greece (PANCUCCI-PAPADOPOULOU *et al.*, 2006; ZENETOS *et al.*, in press), Turkey (ÇINAR *et al.*, 2006), Malta (SCIBERRAS & SCHEMBRI, 2007), and Israel (GALIL, 2007a). Inventories of marine alien species on a European level have also been produced in the framework of the DAISIE project (DAISIE, 2009) but these inventories are not regularly updated for all taxonomic groups.

The Eastern Mediterranean is highly susceptible to marine biological invasions because of its location at the crossroads between the Ponto-Caspian and the Indian Ocean/Red Sea regions, the maritime traffic from the Indian Ocean, and a widespread occurrence of fish and shellfish farms. Lessepsian immigrants in particular are mostly confined to the eastern part of the Mediterranean basin (GALIL & ZENETOS, 2002). Cyprus is the largest, easternmost Mediterranean island and the one closest to the Suez Canal. Comparing the list of alien species of Cyprus with those of other Eastern Mediterranean countries will assist in understanding the invasion patterns in the area.

The first systematic effort to record the alien marine species of Cyprus was initiated in 1967 during a joint program (Biota of the Red Sea and eastern Mediterranean) by the Smithsonian Institution, the Hebrew University of Jerusalem, and the Sea Fisheries Research Station in Haifa. This proj-

ect investigated the spread of the Lessepsian immigrants in the Levant Basin (Egypt, Israel, Cyprus, Rhodes) and listed a total of 140 Erythrean and Indo-Pacific species known to have crossed the Suez Canal into the Mediterranean Sea (STEINITZ, 1970; POR *et al.*, 1972). Since then, other studies focusing on specific taxa have appeared in the literature (e.g. Mollusca: BUZZURRO & GREPPI, 1997; OZTURK *et al.*, 2004; Polychaeta: BEN-ELIAHU & PAYIATAS, 1999; ÇINAR, 2005; Macroalgae: TAŞKIN *et al.*, 2008) but information remains scattered and a complete updated list of the aliens of Cyprus is still missing. DAISIE (2009) reports a total of 75 alien marine species from Cyprus but this figure is a marked underestimation of the actual one.

The aim of this work is to present an updated list of the marine alien species of Cyprus, based on a thorough compilation of existing information, and to provide baseline information on the current situation on the island. Furthermore, it compares this list with the inventories of alien species in other eastern Mediterranean countries and comments on possible differentiation.

Materials and Methods

Records of marine alien species from the coastal and offshore waters of Cyprus were compiled based on the existing scientific and grey literature, including the Hellenic Center for Marine Research (HCMR) database of Mediterranean alien species (ZENETOS & FRAGGOS, 2008; HCMR, 2009), technical reports, scientific congresses, academic dissertations, and websites, as well as on unpublished/personal observations. Records from grey literature or personal observations were included as long as they were supported by physical evidence such as specimens or photographs. The list

has been updated based on species records up to July 2009.

The following definition of *aliens* was adopted: A species, subspecies or lower taxon, introduced outside its natural past or present distribution; it includes any part: gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (<http://www.cbd.int/invasive/terms.shtml>). Synonyms are *non-native*, *non-indigenous*, *allochthonous*, and *exotic*.

The dates of collection of the new records, rather than dates of publication, are reported, since a gap of many years may exist between the two dates. When the date of collection was not reported in a publication, we tried to obtain this information by direct communication with the author(s). In a few cases where the date of collection remained unknown, the date of publication was used instead.

The establishment success of each species was assessed and is given according to the following terminology, as proposed in ZENETOS *et al.* (2006):

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 Cyprus 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 having been recorded only once (no more than twice for fish) in the scientific and grey literature and are presumed to be non-established in Cyprus. In this paper 'casual' is used in the same sense as 'alien' in the CIESM atlas series.

Questionable: Species with insufficient information – 'suspects'. Also new entries not verified by experts or species with taxo-

onomic 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 not been witnessed, e.g. prior to 1800.

Excluded: Species previously reported as aliens in Cyprus but excluded from our list due to one of the following criteria: misidentification, native species falsely previously identified as alien, or spurious records (e.g., shells of molluscs transported by man for food or ornament and left in places where they are normally absent). Excluded species are not presented in the main list but are reported separately.

Invasive species were also indicated. Invasive were defined as those *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.

The records of marine alien species of Cyprus were compared with those of the other countries of the Levantine basin (Egypt, Israel, Lebanon, Syria, southern Turkey) (Fig. 1). Such records were taken from the HCMR database of Mediterranean alien species (HCMR, 2009).

Results

Up to July 2009, a total of 126 alien marine species has been reported in Cyprus, among which are 42 molluscs, 28 fish, 19 polychaetes, 15 phytobenthic species, 12 crustaceans, and 10 species from other taxa (ANNEX 1). Most of the species (101) have

an Indo-Pacific or Indian Ocean origin. The dominant mode of introduction (104 species) was via the Suez Canal.

Among the 126 reported alien marine species, 80 are established (including 12 invasive), 31 are casual, 9 are cryptogenic, and 6 are questionable. The species classified as invasive were the green alga *Caulerpa racemosa* var. *cylindracea*, the gastropod molluscs *Cerithium scabridum*, *Strombus persicus*, and *Trochus erithreus*, the bivalve molluscs *Brachidontes pharaonis* and *Pinctada radiata*, the polychaete *Pseudonereis anomala*, the crustacean *Charybdis helleri*, and the fish *Fistularia commersonni*, *Lagocephalus sceleratus*, *Siganus luridus*, and *Siganus rivulatus*. These species have overcome biotic and abiotic barriers, have high abundance and extensive spatial distribution in the coastal waters of Cyprus, and have evident ecological and/or economic impacts (DFMR, 2008; STREFTARIS & ZENETOS, 2006).

Six species were characterized as questionable, for various reasons:

1. *Polysiphonia atlantica* is easily confused with other Mediterranean species of the genus *Polysiphonia* (BEN MAIZ *et al.*, 1986) and its occurrence in the Mediterranean Sea needs further study.
2. *Laodicea fijiana* has been reported only once by SCHMIDT (1973) (as cited in POR, 1978) and could be a misidentification of *L. undulata* (Forbes & Goodsir, 1853) (DE VITO *et al.*, 2006).
3. *Hydroides dianthus* was found only once in a state of decomposition, and taken from a ship's propeller. There was no knowledge of the history of the ship, thus it was uncertain whether settlement took place in Cypriot waters (BEN-ELIAHU & PAYIATAS, 1999).
4. *Lysidice collaris* was probably confused with the native species *L. margaritacea* Claparède, 1868 (ZENETOS *et al.*, 2006).

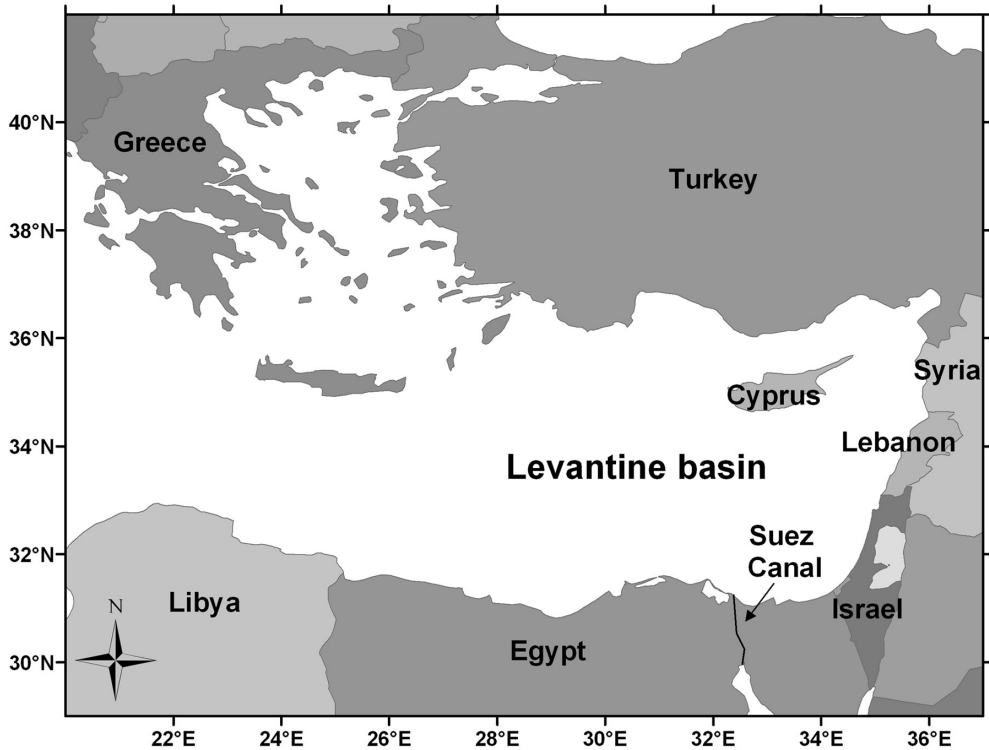


Fig. 1: Map of the Levantine basin and surrounding countries.

5. For *Terebella ehrenbergi*, insufficient data were provided in the initial record and identification was judged uncertain by ZENETOS *et al.* (2006).
6. In the distribution map of *Himantura uarnak*, provided by LAST & STEVENS (1994), Cyprus is included; however no other evidence is provided that the species was actually found in Cypriot waters.

Nine species previously reported as aliens in Cypriot waters were excluded from the inventory for various reasons (Table 1).

In the light of present knowledge, the previous reports of *Linopherus acarunculata* and *Branchiomma boholense* (ÇINAR, 2005) actually refer to *L. canariensis* and *B. bairdi* respectively (ÇINAR, 2009).

A comparison of the records of the alien marine species of Cyprus with those of the other neighboring areas of the Levantine region revealed a relatively low number of recorded species (Fig. 2). With the exception of Syria, where only 119 alien marine species have been recorded, in all the other Levantine countries much higher numbers of recorded species appear (Egypt: 212, Israel: 389, Lebanon: 262, South Turkey: 257) (ZENETOS, 2009). The relative difference of recorded alien species varies greatly among taxonomic groups. The reported number of alien polychaetes in Cyprus is similar to that of most other Levantine areas (Fig. 2). For all other major taxa there is a deficit in reported species in Cyprus when compared with the other Levantine countries, except for mol-

Table 1
Species excluded from the inventory of alien marine species of Cyprus.

Species	Reported by	Reasoning for exclusion
<i>Leonnates persicus</i> Wesenberg-Lund, 1949	GALIL, 2006	Absent from Cyprus (M.E. ÇINAR, pers. comm.).
<i>Rhodine loveni</i> Malmgren, 1865	BEN-ELIAHU, 1972	Atlanto-Mediterranean species (ZENETOS <i>et al.</i> , 2006).
<i>Branchiosyllis exilis</i> (Gravier, 1900),	ÇINAR 2003	A widespread species (Atlantic, Indo-Pacific), including east Atlantic (ZENETOS <i>et al.</i> , 2006).
<i>Monticellina dorsobranchialis</i> (Kirkegaard, 1959)	ÇINAR, 2005	Atlanto-Mediterranean species (ZENETOS <i>et al.</i> , 2006).
<i>Umbonium vestiarium</i> (Melville, 1896)	DELONGUEVILLE & SCAILLET, 2007	ZENETOS <i>et al.</i> (2004) consider it to be a spurious record. DELONGUEVILLE & SCAILLET (2007) state also that the identification is not verified.
<i>Sebastapistes nuchalis</i> (Günther, 1874)	FRÖILAND, 1972	The initial record was based upon a misidentification of a <i>Scorpaena maderensis</i> Valenciennes, 1833 specimen (GOLANI <i>et al.</i> , 2002).
<i>Radicilingua thysanorhizans</i> (Holmes) Papenfuss 1956,	CIRIK <i>et al.</i> , 2000	It was considered a native species (VERLAQUE <i>et al.</i> , in press).
<i>Thais sacellum</i> (Gmelin, 1791)	GALIL, 2006.	Not present in Cyprus
<i>Pseudochama corbieri</i> (Jonas, 1846)	GALIL, 2006	DEMETROPOULOS (1971) refers to <i>Pseudochama ferruginea</i> (Reeve, 1846), a distinct species.

luscs, where Syria had fewer records (Fig. 2). However, there is an increasing trend in the reporting of alien marine species in Cyprus (Fig. 3), and thus their total number is expected to increase in the near future.

A total of 352 alien marine species have been established in the Levantine Sea (HCMR, 2009). The established alien marine species of Cyprus represent 22% of the Levantine established alien marine species, while an extra 8% have been reported as casual or questionable. The vast majority of established Levantine alien ma-

rine species (70%) have not been reported from Cyprus.

Discussion

The present compilation of the alien marine species of Cyprus revealed a total of 126 species, which is much higher than the previously reported figures. GALIL (2006) reported 78 alien marine species from Cyprus, while 75 species are reported in DAISIE (2009). Both these studies are based in the main on 2005 data and the DAISIE data-

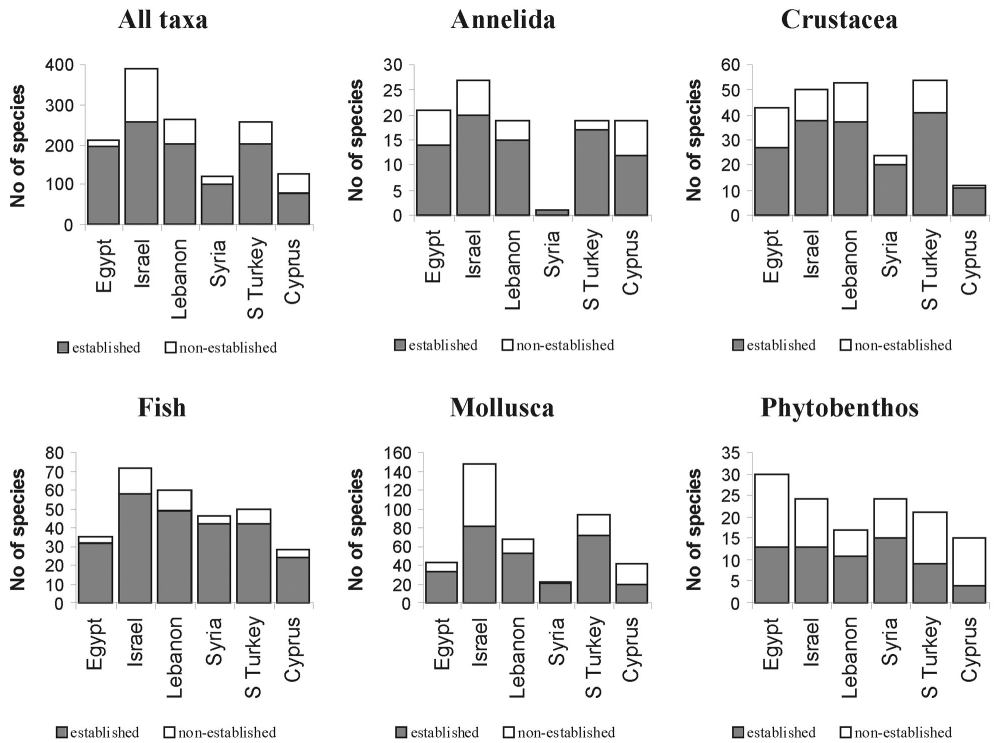


Fig. 2: Comparison of the number of reported alien marine species in the surrounding countries of the Levantine basin. For Turkey only the Levantine part (south Turkey) was considered. Non-established are the casual and questionable.

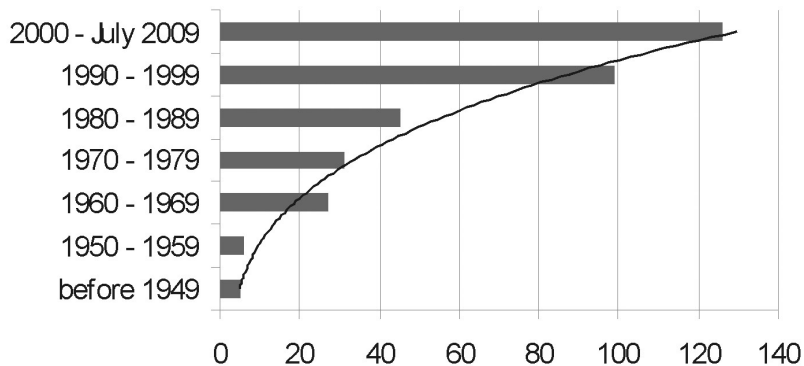


Fig. 3: Cumulative number of alien marine species in Cyprus per decade, based on the reported year of first sighting.

base seems not to have been updated since then. In the present study the number of alien marine species from Cyprus has increased by 51 species (~ 68%) compared with the DAISIE (2009) inventory. This increase is mainly due to:

1. The introduction of new alien species in Cyprus. Twenty-three alien marine species have been reported since 2005 (although this may be partly due to point (2) below). The rate of new biological invasions in the Mediterranean Sea is high and has been estimated at 1 new species every 9 days (ZENETOS *et al.*, 2008). These species are mostly introduced via the Suez Canal and their successful establishment is believed to have been assisted in recent years by climate change (OCCHIPINTI-AMBROGI, 2007).
2. More intense research in the field in recent years and rapid publication. The awareness and response of the scientific community to the issue of alien marine invasions has resulted in taxonomic competence and multinational collaboration in related projects/publications. Databases of alien marine species have been created (e.g., Si.Di.Mar, 2008; HCMR, 2009; DAISIE, 2009; ELNAIS, 2009) and electronic scientific journals promote prompt publication of findings related to alien marine species (e.g., Aquatic Invasions, Journal of the Marine Biological Association of the UK – Biodiversity Records, Mediterranean Marine Science) (GKOUVOUSI & ZENETOS, 2009).
3. A more thorough investigation of the literature. Scientific publications and grey literature that were not taken into account in the previous inventories were included in the present review.
4. New records based on personal observations of the authors. Eight species not previously reported elsewhere have been

included in this inventory.

The new records are the two Rhodophyta *Chondria coerulescens* and *Neosiphonia sphaerocarpa* (K. Tsiamis, pers. observ.) and the fish *Enchelycore anatina*, *Lagocephalus spadiceus*, *Lagocephalus suezensis*, *Scomberomorus commerson*, *Sillago sihama*, and *Spherooides pachygaster* (G. Ioannou & N. Michailidis, pers. observ.). The two Rhodophyta were characterized as cryptogenic, two of the fish were of Atlantic origin (*E. anatina* and *S. pachygaster*) and the rest of Indo-Pacific origin. Two of the fish species (*E. anatina* and *S. sihama*) were casual records, while the rest are considered established.

The number of alien marine species reported in a country is largely dependent on the scientific effort directed towards recording alien species, and on the available expertise. For example, the markedly low number of alien polychaetes from Syria (Fig. 2) is attributed rather to the lack of focussed research on these taxa than to the absence of alien polychaetes from Syrian coastal waters. Similarly, the observed low numbers of reported alien marine species from Cyprus on many taxonomic groups such as crustaceans, fish, and molluscs, in comparison to the neighbouring countries of the Levantine Sea (Fig. 2), indicates a lack of relevant information. A directed survey to record the distribution of alien marine species in Cypriot waters will surely uncover many more species than the 126 reported here, especially molluscs, fish, crustaceans, and phyto-benthic species.

Additionally, the relatively low number of alien marine species may be partly due to the insular character of Cyprus. According to the theory of island biogeography (MACARTHUR & WILSON, 2001), among the factors that influence species richness on islands is their location relative to ocean currents. The general circulation in the Le-

Levantine Sea is described as a counter clockwise flow along the Libyo-Egyptian and Middle East slopes (GERIN *et al.*, 2009). The isolation of Cyprus, with a minimum distance of 70 km from the continent and the lack of a strong connecting current with the Levant coast, is a barrier for many species in successfully colonising the island (BEN-ELIAHU & PAYIATAS, 1999). Thus, transported by the current, marine alien species entering through the Suez Canal progressively advance along the coastline through Egypt, Israel, Lebanon, Syria, Turkey, and Greece. The colonization of Cyprus by those species may be hindered by water circulation.

The established (and invasive) species in Cypriot waters are expected to increase in the future, as they currently represent a small percentage of the established alien species in the Levantine basin. The alien species introduced via the Suez Canal are thermophilic species, and it is likely that an increasing seawater temperature will favour their reproduction, growth, survival, and thus establishment in the area. Such an increase of established alien marine species is expected to have an adverse impact on the state of many native populations as well as an unpredictable impact on fisheries and local economies.

Twelve established species were characterized as invasive. Apart from *Trochus erithreus*, the other eleven species (*Caulerpa racemosa* var. *cylindracea*, *Cerithium scabridum*, *Strombus persicus*, *Brachidontes pharaonis*, *Pinctada radiata*, *Pseudonereis anomala*, *Charybdis helleri*, *Fistularia commersonii*, *Lagocephalus sceleratus*, *Siganus luridus*, and *Siganus rivulatus*) are included in the list of the 100 'Worst Invasives' in the Mediterranean (STREFTARIS & ZENETOS, 2006).

C. racemosa var. *cylindracea* exhibited an excessive rate of proliferation and has in-

vaded the entire basin of the Mediterranean Sea within the last 18 years. The rate of expansion for *C. racemosa* appears to be among the most significant ever recorded for an invasive species (KLEIN & VERLAQUE, 2008). It has stolons that can quickly elongate, and easily overgrow other macroalgal (PIAZZI *et al.*, 1997) or invertebrate species (KRUŽIĆ *et al.*, 2008) and poses a substantial threat to biodiversity. In Cyprus, it has rapidly expanded forming extensive mats and causing changes in macrofaunal assemblages (ARGYROU *et al.*, 1999).

All four invasive fish (*F. commersonii*, *L. sceleratus*, *S. luridus*, and *S. rivulatus*) are quite abundant and represent a substantial portion of the catches of the coastal fleet. *F. commersonii* is a high order carnivore and has been nicknamed the "Lessepsian sprinter" (KARACHLE *et al.*, 2004) due to its very rapid spread and successful establishment in the Mediterranean Sea, reaching as far as Spain (SANCHEZ-TOCINO, 2007) within less than a decade from its introduction into the Mediterranean Sea. The invasion of *F. commersonii* is expected to have a significant impact on the composition of the native ichthyofauna.

L. sceleratus, although a relative new invader (first record in the Mediterranean Sea was in 2003 by AKYOL *et al.*, 2005), has become abundant and well-established in the Levantine basin. In Cyprus this species has a significant negative impact on the artisanal fisheries, since it often damages both the fishing gear and the catch of the fishermen with its powerful jaws (DFMR, 2008). In some areas, many fishermen have even altered their fishing methods (gear, depths, time of the day, etc.) in order to avoid interaction with this species (G. Ioannou & N. Michailidis, pers. observ.). *L. sceleratus* has also a potential risk to humans, since it contains tetrodotoxin, which may cause poi-

soning and even death (BENTUR *et al.*, 2008; KATIKOU *et al.*, 2009).

The two species of siganid fish, *Siganus rivulatus* and *S. luridus* have become dominant in many eastern Mediterranean coastal areas. They compete with the two main native herbivores, *Sparisoma cretense* (Linnaeus, 1758) and *Sarpa salpa* (Linnaeus, 1758) and it seems that they have replaced the latter in many areas (BARICHE *et al.*, 2004). These two siganids have altered the community structure and the native food web along the Levantine rocky infralittoral zone (GALIL, 2007b). In 2008, these two species represented 4.6% in weight of the total catch of the Cypriot artisanal fisheries (DFMR, 2008).

Most of the invasive molluscs are 'old invaders' in Cyprus and have successfully spread, altering the biocommunity structure and impacting on native species. Some of them (*Strombus persicus* and *Pinctada radiata*) are edible and are being exploited for human consumption in certain areas (STREFTARIS & ZENETOS, 2006; KATSANEVAKIS *et al.*, 2008).

The polychaete *Pseudonereis anomala* and the crab *Charybdis helleri* have reached high population densities in many localities in Cyprus, impacting native species and affecting benthic biodiversity.

It is foreseen that the impact of alien species will intensify in the future in all Mediterranean countries but especially in the Levantine basin. The present study serves as a tool in the effort to monitor the expansion of alien species in Cyprus and may be utilized as a baseline for future assessments. Although the present inventory has substantially added to our previous knowledge of the extent of alien invasions in Cyprus, it is probably still an underestimation of the actual situation. Further directed effort is needed to assess the number of established

alien species and their potential impact on the island.

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ANNEX 1:
Alien marine species reported from Cyprus.

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
PHYTOBENTHOS					
Rhodophyta					
<i>Acanthophora nayadiiformis</i> (Delile) Papenfuss	1997	Indian Ocean	Suez	Cryptogenic	CIRIK <i>et al.</i> , 2000
<i>Asparagopsis armata</i> Harvey	1998	Australia	shipping (fouling)	Casual	CIRIK <i>et al.</i> , 2000
<i>Chondria coenulescens</i> (J. Agardh) Falkenberg	2008	Atlantic	aquaculture	Cryptogenic	K. TSIAMIS, pers. observ.
<i>Ganonema farinosum</i> (J.V. Lamouroux) K.C. Fan & Yung C. Wang	1997	Indian Ocean	Suez	Cryptogenic	CIRIK <i>et al.</i> , 2000
<i>Lophocladia lallemandii</i> (Montagne) F. Schmitz	1997	Indo-Pacific	Suez / Shipping (fouling)	Established	CIRIK <i>et al.</i> , 2000
<i>Neosiphonia sphaerocarpa</i> (B_rgesen) M.S. Kim & I.K. Lee	2008	Atlantic	shipping (fouling)	Cryptogenic	K. TSIAMIS, pers. observ.
<i>Polysiphonia atlantica</i> Kapraun & J.N. Norris	2008	N. Atlantic/Indo-Pacific	shipping	Questionable	TASKIN <i>et al.</i> , 2008
<i>Polysiphonia ficoides</i> (Hudson) Greville	2008	N. Atlantic	fishing nets	Cryptogenic	TASKIN <i>et al.</i> , 2008
<i>Womersleyella setacea</i> (Hollenberg)	2008	Indo-Pacific	shipping (fouling)	Casual	TASKIN <i>et al.</i> , 2008
Chlorophyta					
<i>Caulerpa racemosa</i> var. <i>cylindracea</i> (Sonder) Verlaque, Huisman & Boudouresque	1991	SW Australia	aquarium	Invasive	HADJICHRISTO-PHOROU <i>et al.</i> , 1997
<i>Caulerpa racemosa</i> var. <i>lamourouxii</i> f. <i>requienii</i> (Montagne) Weber-van Bosse	1997	Indo-Pacific	Suez	Casual	VERLAQUE <i>et al.</i> , 2000
<i>Caulerpa racemosa</i> var. <i>turbinata</i> (J. Agardh) Eubank - uvifera (C. Agardh) J. Agardh	1992	Indo-Pacific	Suez	Cryptogenic	VERLAQUE <i>et al.</i> , 2000
<i>Cladophora cf. patentiramea</i> (Montagne) Kützing	1991	Indo-Pacific	Suez	Casual	ARGYROU, 2000

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
Phaeophyta					
<i>Styopodium schimperi</i> (Buchinger ex Kützing) Verlaque & Boudouresque	1990	Red Sea	Suez	Established	VERLAQUE & BOUDOURESQUE, 1991
Spermatophyta					
<i>Halophila stipulacea</i> (Forsskål) Ascherson	1967	Red Sea	Suez	Established	LIPKIN, 1975
PHYTOPLANKTON					
<i>Pseudosolenia calvar-avis</i> Schultze, 1858	1964	Black Sea	shipping	Established	KIMOR & BERDUGO, 1967
FORAMINIFERA					
<i>Amphistegina lobifera</i> Larsen, 1976	1976	Indo-Pacific/Atlantic	Suez	Cryptogenic	LANGER & HOTTINGER, 2000; M. Langer, pers. commun.
CNIDARIA					
Scyphozoa					
<i>Cassiopeia andromeda</i> (Forsskål, 1775)	1903	Indo-Pacific	Suez	Established	MAAS, 1903
<i>Rhopilema nomadica</i> Galil, 1990	1995	Red Sea	Suez	Established	GALIL, 2006
Hydrozoa					
<i>Laodicea fijiana</i> Agassiz & Mayer, 1899	1972	Indo-Pacific	Suez	Questionable	SCHMIDT, 1973, cited in POR, 1978
ANNELIDA					
<i>Branchionna bairdi</i> (McIntosh, 1885)	1998	Pacific/Atlantic	Suez/shipping	Established	ÇINAR, 2009
<i>Branchionna luctuosum</i> (Grube, 1869)	1998	Indo-Pacific	Suez/shipping	Established	ÇINAR, 2005
<i>Ceratereis mirabilis</i> Kinberg, 1866	1997	Indo-Pacific	Suez	Established	ÇINAR, 2005
<i>Eusyllis kuppferi</i> Langerhans, 1879	1998	Atlantic	shipping	Established	ÇINAR & ERGEN, 2003
<i>Hydroides dianthus</i> (Verrill, 1873)	1997	North West Atlantic	shipping	Questionable	BEN-ELIAHU & PAYIATAS, 1999
<i>Hydroides elegans</i> (Haswell, 1883)	1996	circumtropical	shipping	Established	BEN-ELIAHU & PAYIATAS, 1999
<i>Hydroides heterocerus</i> (Grube, 1868)	1998	Indian Ocean	Suez/shipping	Established	BEN-ELIAHU & PAYIATAS, 1999
<i>Lysidice collaris</i> Grube, 1870	1968	Pacific Ocean	Suez	Questionable	BEN-ELIAHU, 1972

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Metazychis gotoi</i> (Izuka, 1902)	1997	Indo-Pacific	Suez/shipping	Established	ÇINAR, 2005
<i>Notomastus aberans</i> Day, 1957	1997	Indo-Pacific	Suez	Established	ÇINAR, 2005
<i>Notomastus mossambicus</i> (Thomassin, 1970)	1997	Pacific Ocean	Suez	Established	ÇINAR, 2005
<i>Oenone cf. fulgida</i> (Savigny, 1818)	1997	Indo-Pacific	Suez	Casual	ÇINAR, 2005
<i>Pista unibranchiata</i> Day, 1963	1997	Indo-Pacific	Suez	Established	ÇINAR, 2005
<i>Pseudoneris anomala</i> (Gravier, 1900)	1969	Indo-Pacific	Suez/shipping	Invasive	BEN-ELIAHU, 1972
<i>Linopherus cananensis</i> Langerhans, 1881	1997	Atlantic	Shipping	Established	ÇINAR, 2009
<i>Sphaerosyllis longipapillata</i> Hartmann-Schröder & Hartmann, 1979	1997	Pacific Ocean	Suez/shipping	Casual	ÇINAR <i>et al.</i> , 2003
<i>Spirobranchius tetraceros</i> (Schmarda, 1861)	1996	circumtropical	Suez/shipping	Established	BEN-ELIAHU & PAYIATAS, 1999
<i>Spirorbis marioni</i> Caullery and Mesnil, 1997	1998	East Pacific	shipping	Casual	ZIBROWIUS, 2002
<i>Terebella ehrenbergi</i> Grube, 1870	1969	Indo-Pacific	Suez/shipping	Questionable	BEN-ELIAHU, 1972
CRUSTACEA					
Isopoda					
<i>Aparthura sandalensis</i> Stebbing, 1900	1998	South Africa	Suez	Established	H. ZIBROWIUS, pers comm.
Amphipoda					
<i>Maera hamigera</i> Haswell, 1879	1997	Indo-Pacific	Suez	Established	KOCATAŞ <i>et al.</i> , 2001
Decapoda					
<i>Callinectes sapidus</i> Rathbun, 1896	1964	West Atlantic	Gibraltar/shipping	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Charybdis helleri</i> (A. Milne-Edwards, 1867)	1998	Indo-West Pacific	Suez/shipping	Invasive	GALLI <i>et al.</i> , 2002
<i>Charybdis longicollis</i> Leene, 1938	1986	Indian Ocean	Suez	Established	LEWINSOHN & HOLTHUIS, 1986
<i>Marsupenaeus japonicus</i> (Bate, 1888)	1961	Indo-Pacific	Suez/aquaculture	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Metapenaeopsis aegyptia</i> Galli & Golani, 1990	2004	Indo Pacific	Suez	Established	KIRMIRTZOGLU <i>et al.</i> , 2006

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Metapenaeus monoceros</i> (Fabricius, 1798)	1961	Indo-West Pacific	Suez	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Pilumnopus vaauquelinii</i> (Audouin, 1826)	1963	Indian Ocean	Suez	Established	GALIL, 2006
<i>Portunus pelagicus</i> (Linnaeus, 1758)	1958	Indo Pacific	Suez/shipping	Established	ELTON, 1958
<i>Thalamita poissonii</i> (Audouin, 1826)	1969	Indo-West Pacific	Suez	Cryptogenic	GILATE in POR, 1978; GITARAKOS <i>et al.</i> , 2007
Stomatopoda					
<i>Erygosquilla massavensis</i> (Kossmann, 1880)	1963	Indian Ocean	Suez	Established	INGLE, 1963
MOLLUSCA					
Gastropoda					
<i>Acteocina mucronata</i> (Philippi, 1849)	1992	Red Sea	Suez	Casual	CECALUPO & QUADRI, 1994
<i>Alvania dorbigny</i> (Audouin, 1826)	1985	Cosmopolitan	Suez?	Cryptogenic	BOGI <i>et al.</i> , 1989
<i>Aplysia dactylomela</i> Rang, 1828	2004	Circumtropical	unknown	Established	YOKES, 2006
<i>Bulla ampulla</i> Linnaeus, 1758	2000	Indo-Pacific	Suez/shipping	Casual	ZENETOS <i>et al.</i> , 2004
<i>Clathrofenella peparvula</i> (Watson, 1886)	1995	Indo-Pacific	Suez	Casual	CECALUPO & QUADRI, 1995
<i>Cerithiopsis pubis</i> (Melvill, 1896)	1985	Red Sea	Suez	Casual	BOGI <i>et al.</i> , 1989
<i>Cerithiopsis tenthenois</i> Pilsbry & Vannata, 1906	1985	Indian Ocean	Suez?	Established	TORNARITIS, 1987
<i>Cerithium nesioicum</i> Philippi, 1848	1985	Indian Ocean	Suez?	Casual	BOGI <i>et al.</i> , 1989
<i>Cerithium scabridum</i> (Watson 1886)	1983	Indian Ocean	Suez/shipping	Invasive	FISCHER, 1993
<i>Chrysalidita maiae</i> (Homung & Mermod, 1924)	1995	Red Sea	Suez	Casual	BUZZURO & GREPPI, 1997
<i>Cingulina isseli</i> (Tryon, 1886)	1998	Subtropical	Suez?	Casual	ZENETOS <i>et al.</i> , 2004
<i>Cycloscala hyalina</i> (Sowerby, 1844)	1992	Indo Pacific	unknown	Casual	CECALUPO & QUADRI, 1994
<i>Cylichnina girardi</i> (Audouin, 1826)	1996	Indo-Pacific	Suez	Casual	CECALUPO & QUADRI, 1996
<i>Ergalatax junionae</i> Houart, 2008	1993	Indian Ocean	Suez	Established	BUZZURO & GREPPI, 1997
<i>Finella pupoides</i> A. Adams, 1860	1996	Indo-Pacific	Suez	Established	CECALUPO & QUADRI, 1996

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Leucotina natalensis</i> Smith, 1910	1996	Indo Pacific	Suez	Casual	CECALUPO & QUADRI, 1996
<i>Melibe viridis</i> (Keiaart, 1858)	2007	Indo-Pacific	shipping	Casual	SANCHEZ VILLAREJO, 2007
<i>Metaxia bacillum</i> (Issel, 1869)	<1995	Red Sea	Suez?	Casual	CECALUPO & QUADRI, 1995
<i>Purpuradusta gracilis notata</i> (Gill, 1858)	2000	Indian Ocean	Suez?	Established	ZENETOS <i>et al.</i> , 2004
<i>Pyurunculus fourieri</i> (Audouin, 1826)	1995	Indo Pacific	Suez	Casual	BUZZURO & GREPPI, 1997
<i>Rhinoclavis kochi</i> (Philippi, 1848)	1976	Indo Pacific	Suez	Established	DEMETROPOULOS & HADJICHRISTOPHOROU, 1976
<i>Rissoina bertholletii</i> Issel, 1869	1985	Indian Ocean	Suez	Casual	BOGI <i>et al.</i> , 1989
<i>Sinarugdia souverbiana</i> (Montrouzier, 1863)	1995	Indo Pacific	Suez	Casual	BUZZURO & GREPPI, 1997
<i>Stictaulima cf. leniginosa</i> (A. Adams, 1861)	1995	Indo-Pacific	Suez	Casual	BUZZURO & GREPPI, 1997
<i>Strombus persicus</i> Swainson, 1821 (Roeding, 1798)	1985	Indian Ocean	Suez/shipping	Invasive	BAZZOCCHI, 1985
<i>Symola fasciata</i> (Jickeli, 1882)	1995	Indo-Pacific	Suez?	Casual	NOFRONI & TRINGALI, 1995
<i>Thais lacera</i> (von Born, 1778)	1988	Indian Ocean	Suez/shipping	Casual	HOUART, 2001
<i>Trochus erithreus</i> Brocchi, 1821	1985	Indian Ocean	Suez	Invasive	TORNARITIS, 1987
<i>Turbonilla edgarii</i> Brocchi, 1821	1996	Indo-Pacific	Suez?	Casual	CECALUPO & QUADRI, 1996
<i>Zafra savignyi</i> (Moazzo, 1939)	1995	Red Sea	Suez	Established	BUZZURO & GREPPI, 1997
<i>Zafra velasphora</i> (Melvill & Standen, 1901)	1995	Indian Ocean	Suez?	Casual	BUZZURO & GREPPI, 1997
Bivalvia					
<i>Brachidontes pharaonis</i> (Fischer P., 1870)	1960	Indian Ocean	Suez/shipping	Invasive	H. MIENIS, pers. comm.; TORNARITIS, 1987
<i>Chama pacifica</i> Broderip, 1834	1998	Indo-Pacific	Suez	Established	ZENETOS <i>et al.</i> , 2004
<i>Dendrostroma frons</i> (Linnaeus, 1758)	2008	Indo-Pacific	shipping	Established	ZENETOS <i>et al.</i> , 2009
<i>Fulvia fragilis</i> (Forsskål in Niebuhr, 1775)	1983	Indian Ocean	Suez/shipping	Established	FISCHER, 1993
<i>Gafrarium pectinatum</i> (Linnaeus, 1758)	2005	Indo-Pacific	Suez	Established	ZENETOS <i>et al.</i> , 2009
<i>Matvufundus regulus</i> (Forsskål, 1775)	1970	Indo-Pacific	Suez	Established	DEMETROPOULOS, 1971

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Paphia textile</i> (Gmelin, 1791)	2004	Indo-Pacific	Suez	Established	ZENETOS <i>et al.</i> , 2009
<i>Pinctada radiata</i> (Leach, 1814)	1899	Indo-Pacific	Suez/aquaculture	Invasive	MONTEROSATO, 1899
<i>Psammotreta praeurpta</i> (Salisbury, 1934)	2009	Indo-Pacific	Suez?	Casual	ZENETOS <i>et al.</i> , 2009
<i>Septifer forskalii</i> (Dunker, 1855)	2005	Indian Ocean	Suez/shipping	Established	ZENETOS <i>et al.</i> , 2009
<i>Sponylus spinosus</i> Schreibers, 1793	2001	Indo-Pacific	Suez/shipping	Established	ZENETOS <i>et al.</i> , 2009
ECHINODERMATA					
Holothuroidea					
<i>Synaptula reciprocans</i> (Forsskål, 1775)	1986	Indo-Pacific	Suez	Established	CHERBONNIER, 1986
Ophiuroidea					
<i>Ophiactis parva</i> Mortensen, 1926	<2002	Red Sea	Suez	Established	ZIBROWIUS, 2002
<i>Ophiactis savignyi</i> Müller & Troschel, 1842	<2002	Circumtropical	Suez	Established	ZIBROWIUS, 2002
SIPUNCULA					
<i>Phascolosoma scolops</i> (Selenka & de Man, 1883)	1998	Tropical/subtropical	Suez/shipping	Established	ACIK <i>et al.</i> , 2005
CHORDATA					
Asciacea					
<i>Herdmania momus</i> (Savigny 1816)	1998	Indo-Pacific	Suez/shipping	Established	NISHIKAWA, 2002
PISCES					
Chondrichthyes					
<i>Himantura uarnak</i> (Forsskål, 1775)	1994	Indo-West Pacific	Suez	Questionable	LAST & STEVENS, 1994
Osteichthyes					
<i>Alepes djedaba</i> (Forsskål, 1775)	1964	Indo-Pacific	Suez/shipping	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Apogon pharaonis</i> Bellotti, 1874	1964	Indo-Pacific	Suez	Established	DEMETROPOULOS & NEOCLEOUS, 1969

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Atherinomorus lacunosus</i> (Forster in Bloch and Schneider, 1801)	1929	Indo-Pacific	Suez	Established	NORMAN, 1929; DEMETROPOULOS & NEOCLEOUS, 1969
<i>Dussumieria elopsoides</i> Bleeker, 1849	1985	Indo-Pacific	Suez	Established	WHITEHEAD, 1985; GITARAKOS <i>et al.</i> 2007
<i>Encheirolepis anatina</i> (Lowe, 1838)	2008	Atlantic	Gibraltar	Casual	G. IOANNOU & N. MICHAELIDIS, pers. observ.
<i>Etrumeus teres</i> (DeKay, 1848)	1999	Indo-Pacific	Suez	Established	GOLANI, 2000
<i>Fistularia commersonii</i> (Rüppell, 1835)	1999	Indo-Pacific	Suez	Invasive	WIRTZ & DEBELIUS, 2003
<i>Hemiramphus far</i> (Forsskål, 1775)	1964	Indo-Pacific	Suez	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Henkloitsichthys punctatus</i> (Rüppell, 1837)	1985	Red Sea	Suez	Casual	WHITEHEAD, 1985
<i>Lagocephalus scleratus</i> (Gmelin 1789)	2004	Indo-Pacific	Suez	Invasive	DFMR (2006)
<i>Lagocephalus spadiceus</i> (Richardson, 1844)	2006	Indo-Pacific	Suez	Established	G. IOANNOU & N. MICHAELIDIS, pers. observ.
<i>Lagocephalus suezensis</i> Clark & Gohar, 1953	2007	Red Sea	Suez	Established	G. IOANNOU & N. MICHAELIDIS, pers. observ.
<i>Leiognathus klunzingeri</i> (Steindachner, 1898)	1961	Red Sea	Suez	Established	FODERA, 1961
<i>Parexocoetus mento</i> (Valenciennes, 1846)	<2002	Indo-Pacific	Suez	Established	GOLANI <i>et al.</i> , 2002
<i>Pempheris vanicolensis</i> (Cuvier 1831)	1995	Indo-Pacific	Suez	Established	TORCU <i>et al.</i> , 2001
<i>Pteragogus pelycus</i> Randall, 1981	1997	Indo-Pacific	Suez	Established	KAYA <i>et al.</i> , 2000
<i>Sargocentron rubrum</i> (Forsskål, 1775)	1961	Indo-Pacific	Suez	Established	FODERA, 1961
<i>Saurida undosquamis</i> (Richardson, 1848)	1960	Indo-Pacific	Suez	Established	BEN TUVIA, 1962
<i>Scomberomorus commerson</i> (Lacepède, 1800)	2008	Indo-Pacific	Suez	Established	G. IOANNOU & N. MICHAELIDIS, pers. observ.

(continued)

MARINE SPECIES	Year of first sighting	Origin	Made of Introduction	Establishment Success	Reference
<i>Siganus luridus</i> (Rüppell, 1829)	1964	Indo-Pacific	Suez	Invasive	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Siganus rivulatus</i> Forsskål, 1775	1928	Indo-Pacific	Suez	Invasive	NORMAN, 1929
<i>Sillago sihama</i> (Forsskål, 1775)	2009	Indo-Pacific	Suez	Casual	G. IOANNOU & N. MICHAILIDIS, pers. observ.
<i>Sphoeroides pachygaster</i> (Müller & Troschel, 1848)	2005	Circumglobal (temperate and tropical seas)	Gibraltar	Established	G. IOANNOU & N. MICHAILIDIS, pers. observ.
<i>Sphyræna chrysoaenia</i> Klunzinger, 1884	1964	Indo-Pacific	Suez	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Stephanolepis diaspros</i> Fraser-Brunner, 1940	1935	Indo-Pacific	Suez/shipping	Established	HORNELL, 1935; GITARAKOS <i>et al.</i> , 2007
<i>Upeneus moluccensis</i> (Bleeker, 1855)	1964	Indo-Pacific	Suez	Established	DEMETROPOULOS & NEOCLEOUS, 1969
<i>Upeneus pori</i> Ben-Tuvia & Golani, 1989	2004	Indo-Pacific	Suez	Established	TZOMOS <i>et al.</i> , 2007

