

Annotated list of marine alien species in the Mediterranean with records of the worst invasive species

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Abstract

This collaborative effort by many specialists across the Mediterranean presents an updated annotated list of alien marine species in the Mediterranean Sea. Alien species have been grouped into six broad categories namely established, casual, questionable, cryptogenic, excluded and invasive, and presented in lists of major ecofunctional/taxonomic groups. The establishment success within each group is provided while the questionable and excluded records are commented in brief.

A total of 963 alien species have been reported from the Mediterranean until December 2005, 218 of which have been classified as excluded (23%) leaving 745 of the recorded species as valid aliens. Of these 385 (52%) are already well established, 262 (35%) are casual records, while 98 species (13%) remain "questionable" records. The species cited in this work belong mostly to zoobenthos and in particular to Mollusca and Crustacea, while Fish and Phytobenthos are the next two groups which prevail among alien biota in the Mediterranean.

The available information depends greatly on the taxonomic group examined. Thus, besides the three groups explicitly addressed in the CIESM atlas series (Fish, Decapoda/Crustacea and Mollusca), which are however updated in the present work, Polychaeta, Phytobenthos, Phytoplankton and Zooplankton are also addressed in this study. Among other zoobenthic taxa sufficiently covered in this study are Echinodermata, Sipuncula, Bryozoa and Ascidiacea. On the contrary, taxa such as Foraminifera, Amphipoda and Isopoda, that are not well studied in the Mediterranean, are insufficiently covered. A

gap of knowledge is also noticed in *Parasites*, which, although ubiquitous and pervasive in marine systems, have been relatively unexplored as to their role in marine invasions. Conclusively the lack of funding purely systematic studies in the region has led to underestimation of the number of aliens in the Mediterranean.

Emphasis is put on those species that are current or potential threats to the marine ecosystems, namely the Worst Invasive Alien Species providing their record across major groups.

Keywords: Alien taxa; Establishment success; Worst IAS; Mediterranean.

Introduction

The significance of alien species in marine ecosystems worldwide has been highlighted in recent years. International organisations (UNEP/MAP/RAC/SPA, FAO/DIAS, IUCN, ICES, IMO, CIESM) and the scientific community have addressed the issue through articles, review papers, databases and directories. The most representative and recent work regarding the distribution, impact and management of invasive aquatic species in Europe can be found in a series of papers compiled in one edition by LEPPA-KOSKI *et al.* (2002).

STREFTARIS *et al.* (2005) have summarised and compiled a list of alien species in European Seas including 615 species in the Mediterranean up to the end of 2003 plus 23 additional species from literature accessible within 2004. This led them to consider the Mediterranean as a major recipient of alien species.

Following POR (1978) who focused on introductions via the Suez Canal, the so-called Lessepsian migrators, ZIBROWIUS (1992) attempted a compilation of data on alien species in the Mediterranean. He pointed out that while taxa with well-known taxonomy and established historical distribution records (e.g. benthic organisms, fish) have received more attention than other groups, many of the small, less-conspicuous, less-studied species are necessarily overlooked, leading to an underestimation of the extent of aliens' presence.

The chaos in nomenclature and fragmentary and sporadic information, based widely on selective scientific interest, prompted CIESM to issue a series of atlases (GOLANI *et al.*, 2002; GALIL *et al.*, 2002; ZENETOS *et al.*, 2004). The list of STREFTARIS *et al.* (2005) intended to include as many seemingly valid records as possible and compared trends between the various European Seas. However, even in this work the effort has been focused on certain taxonomic groups, mainly fish and benthos (major "popular" groups treated extensively in the recent CIESM atlas series) while many pelagic groups have not even been mentioned. Other recent efforts to compile updating lists in marine algae, phytoplankton and zooplankton are those by ATHANASIADIS (2002); CORMACI *et al.* (2004); VERLAQUE *et al.* (2005); GÓMEZ, 2005; UYSAL *et al.*, (2002); BOUILLON *et al.* (2004). However, in spite of these efforts, one should remain aware, that as stated by STREFTARIS *et al.* (2005), there are arguments against the accuracy and validity of registration of various groups (these authors specially mentioned bryozoans, entoprocts, hydroids, sponges, polychaetes, oligochaetes, amphipods, flatworms, nematodes, nemerteans).

As an important step in the ongoing review of implementation of the European Community Biodiversity Policy, a broad consultative process culminating in a conference in Malahide, Ireland (25-27 May, 2004), re-confirmed Invasive Alien Species (IAS) as

a priority issue. The Environment Council, on 28 June, 2004 asked the Commission to come forward with a communication taking the “Message from Malahide” into account.

Under the Sixth Framework Programme, there are currently ongoing Community-funded research projects and collaborative partnerships which address marine IAS issues, ALARM (*Assessing Large-scale environmental Risks for biodiversity with tested Methods*) and DAISIE (*Delivering Alien Invasive Species Inventories for Europe*) being two of those. The latter aims to create an inventory of IAS that threaten European environments structured in such a way as to provide the basis for prevention and control of biological invasions.

In January 2005, the European Environment Agency commenced a project on “Streamlining European 2010 Biodiversity Indicators” (SEBI2010). One of the expert groups (Group 5) in this project is addressing the indicator on “*number and cost of IAS*”. The cumulative increase in the number of alien species in Europe over time, with 1900 as a baseline, is one of the first indicators to be demonstrated at European level (<http://biodiversity-chm.eea.eu.int/information/indicator>).

The aim of the current work (a collaborative effort by many specialists across the Mediterranean) is to present an updated annotated list of alien marine species in the Mediterranean Sea including information on excluded species. Emphasis is put on those species that are current or potential threats to the marine ecosystems, namely the Worst Invasive Alien Species.

Methodology

The list is updated based on species records up to December 2005. Alien species have been grouped into six broad categories namely established, casual, questionable, cryptogenic, excluded and invasive.

Alien: Species, subspecies or lower taxa

occurring outside their historically known range (occupied naturally) and beyond their natural dispersal potential (minor climate oscillations) as a result of direct or indirect introduction or care by humans. Synonyms are *non-native*, *non-indigenous*, *foreign*, and *exotic*.

Established: Introduced or feral population of species established in the wild with free-living, self-maintaining and self-perpetuating populations unsupported by and independent of humans (EUROPEAN COMMISSION, 2004). As established here are also classified species with at least two records spread over time and space in the sense of CIESM atlas series. Synonym: *Naturalized*.

Casual: Casual species are identified those having been recorded only once (no more than twice for fishes) in the scientific literature: they are presumed to be non-established in the basin. In this paper casual is used in the same sense as alien in the CIESM atlas series.

Questionable: Species with insufficient information - ‘suspects’. Also native/ new entries not verified by experts. 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 has occurred “in early times” and not been witnessed e.g., prior to 1800. Often these species are excluded from lists of aliens or included among the established ones. In this review we considered it best to separate them.

Excluded: We have tabulated those species fulfilling some of CIESM’s criteria for exclusion such as:

- Misidentification
- Native species, falsely identified as alien or exotic: species formerly considered exotic and later revealed to be indigenous.
- Spurious records. This category reflects a

problem which is specific to molluscs. The shells of molluscs are liable to be transported by man for food or ornament and left in places where they do not live.

Invasive: Introduced species 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. An earlier presentation by RICHARDSON *et al.* (2000) did not refer to impact. In many definitions the term invasive is also associated with established species which are agents of change and threaten native biological diversity (IUCN, 2002) or species that threaten the diversity or abundance of native species, the ecological stability of infested ecosystems, economic activities dependent on these ecosystems and/or human health (EPA, 2001). In this paper we are adapting the definition that encompasses impacts as an essential dimension for the categorisation of an alien species as invasive.

Commented synonyms. In compiling the list, for taxonomic groups other than those treated by CIESM atlas series, we came across various records which needed further investigation. Thus we addressed experts in the fields of phytoplankton, zooplankton, phytobenthos, various invertebrate groups such as amphipods, polychaetes etc. In addition, the ITIS (Integrated Taxonomic Information System), and the ALGAEBASE (Information on the algae of the world, including terrestrial, marine, and freshwater forms) websites were visited. The species removed from the list as synonyms are presented in the list of excluded.

The species lists are presented in 9 units which are ecofunctional/taxonomic groups. These are: 1: Fish, 2: Zoobenthos/Mollusca, 3: Zoobenthos/Polychaeta, 4: Zoobenthos/Crustacea, 5: Zoobenthos /Miscellanea, 6: Parasites, 7: Phytoplankton, 8: Zooplankton and 9: Phytobenthos. The reasoning for questioning or excluding some species per group is presented in detail only for the Bryozoa. A full list of the experts who contributed in various ways is provided in the acknowledgements.

Results

A total of 963 species have been reported as aliens from the Mediterranean until December 2005, 218 of which are classified as excluded and 745 as valid species among which 98 as questionable (Fig. 1). The species retained as aliens in this study belong mostly to zoobenthos and in particular to Mollusca, while Fish and Phytobenthos are the next two groups rich in species. In the lists that follow, the establishment success within each group is provided with no further comments for the species established and those with casual records. In contrast, the questionable and excluded records are commented in brief (citation of source and reason for exclusion, questioning the validity). No details are provided for the excluded species of Mollusca, Fish and Decapoda treated extensively in the CIESM atlas series and the reader is referred for further details on those to (GOLANI *et al.*, 2002; GALIL *et al.*, 2002; ZENETOS *et al.*, 2004). It should be pointed out that many of the questionable records are expected to be clarified in the near future and most probably moved to the casual records.

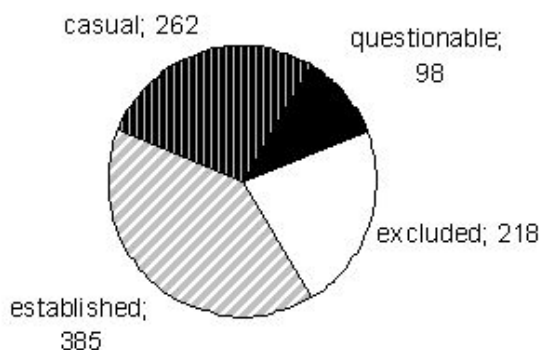


Fig. 1: Establishment success of recorded alien species including non-valid records.

Species lists per group

1. Fish

Fish established

Note: * denotes species reported as casual in CIESM 2005 on line

<i>*Acanthurus monroviae</i>	<i>*Lagocephalus sceleratus</i>	<i>Scomberomorus commerson</i>
<i>Alepes djedaba</i>	<i>Lagocephalus spadiceus</i>	<i>Seriola carpenteri</i>
<i>Apogon pharaonis</i>	<i>Lagocephalus suezensis</i>	<i>Seriola fasciata</i>
<i>Atherinomorus lacunosus</i>	<i>Leiognathus klunzingeri</i>	<i>Siganus luridus</i>
<i>Callionymus filamentosus</i>	<i>Liza haematocheila</i>	<i>Siganus rivulatus</i>
<i>Carcharhinus altimus</i>	<i>Microchirus hexophthalmus</i>	<i>Silhouetta aegyptia</i>
<i>Carcharhinus falciformis</i>	<i>Oxyurichthys petersi</i>	<i>Sillago sihama</i>
<i>Chelon carinata</i>	<i>Pagellus bellottii</i>	<i>Solea senegalensis</i>
<i>Crenidens crenidens</i>	<i>Parexocoetus mento</i>	<i>*Spratelloides delicatulus</i>
<i>Cynoglossus sinusarabici</i>	<i>Pelates quadrilineatus</i>	<i>Sphoeroides pachygaster</i>
<i>Diplodus bellottii</i>	<i>Pempheris vanicolensis</i>	<i>Sphyræna chrysotaenia</i>
<i>Dussumieria elopsoidea</i>	<i>*Petroscirtes ancyllodon</i>	<i>*Sphyræna flavicauda</i>
<i>*Enchelycore anatina</i>	<i>Pisodonophis semicinctus</i>	<i>Stephanolepis diaspros</i>
<i>Epinephelus coioides</i>	<i>Platycephalus indicus</i>	<i>Synaptura lusitanica</i>
<i>Epinephelus malabaricus</i>	<i>Plotosus lineatus</i>	<i>Syngnathus rostellatus</i>
<i>Etrumeus teres</i>	<i>Pomadasys stridens</i>	<i>Terapon puta</i>
<i>Fistularia commersonii</i>	<i>Psenes pellucidus</i>	<i>Tetrosomus gibbosus</i>
<i>Gymnammodytes semisquamatus</i>	<i>Pteragogus pelycus</i>	<i>Trachyscorpia cristulata echinata</i>
<i>Hemiramphus far</i>	<i>Rhabdosargus haffara</i>	<i>Upeneus moluccensis</i>
<i>Herklotsichthys punctatus</i>	<i>Sargocentron rubrum</i>	<i>Upeneus pori</i>
<i>Himantura uarnak</i>	<i>Saurida undosquamis</i>	
	<i>Scarus ghobban</i>	

Fish casual

Note: underlined species are new species post CIESM 2005 on line

<i>Abudefduf vaigiensis</i>	<i>Hippocampus fuscus</i>	<i>Rhizoprionodon acutus</i>
<u><i>Anarhichas lupus</i></u>	<i>Hyporhamphus affinis</i>	<i>Rhynchoconger trewavasae</i>
<i>Arius parkii</i>	<u><i>Iniistius pavo</i></u>	<i>Scorpaena stephanica</i>
<i>Beryx splendens</i>	<i>Lutjanus argentimaculatus</i>	<i>Seriola rivoliana</i>
<i>Centrolabrus exoletus</i>	<i>Makaira indica</i>	<i>Sorsogona prionota</i>
<i>Chaunax suttkusi</i>	<i>Microchirus boscanion</i>	<u><i>Sphoeroides marmoratus</i></u>
<i>Cheilopogon furcatus</i>	<i>Muraenesox cinereus</i>	<i>Sphyrna mokarran</i>
<i>Chilomycterus spilostylus</i>	<i>Omobranchus punctatus</i>	<i>Synagrops japonicus</i>
<i>Coryogalops ochetica</i>	<i>Papilloculiceps longiceps</i>	<i>Torquigener flavimaculosus</i>
<i>Diodon hystrix</i>	<i>Pinguipes brasilianus</i>	<u><i>Tylerius spinosissimus</i></u>
<i>Fistularia petimba</i>	<u><i>Priacanthus hamrur</i></u>	<i>Tylosurus choram</i>
<i>Galeocerdo cuvier</i>	<i>Pseudupeneus prayensis</i>	<u><i>Tylosurus crocodilus</i></u>
<i>Gephyroberyx darwini</i>	<i>Pterois miles</i>	
<i>Halosaurus ovenii</i>	<i>Rachycentron canadum</i>	
<i>Heniochus intermedius</i>	<i>Rastrelliger kanagurta</i>	

Fish Questionable

Species	Cited by	Reasoning
<i>Alopias superciliosus</i>	SAAD <i>et al.</i> , 2005	Insufficient data, origin uncertain
<i>Torpedo sinuspersici</i>	SAAD <i>et al.</i> , 2004	Insufficient data
<i>Dasyatis</i> sp. cf. <i>tortonesei</i>	SAAD <i>et al.</i> , 2005	Complex taxonomy
<i>Gaidropsarus granti</i>	ZACHARIOU-MAMALINGA, 1999	Insufficient data, origin uncertain
* <i>Pampus argenteus</i>	ŠOLJAN, 1975	See details

**Pampus argenteus* (Euphrasen, 1788). A specimen of silver pomfret captured in Rijeka (northern Adriatic) in 1896, was initially identified as *Stromateus fiatola*. The specimen, which is preserved in the collection of the Zoological Museum of Zagreb, was tentatively identified as *Pampus argenteus* by ŠOLJAN (1975), but he doubted its identification. The validity of the record was re-examined by DULČIĆ *et al.* (2004) who claim that the record of 1896 represents the first lessepsian migrant in the Mediterranean.

Fish excluded: for reasoning see GOLANI *et al.* (2002)

<i>Ammodytes tobianus</i>	<i>Bothus pantherinus</i>	<i>Cataetys laticeps</i>
<i>Aphanius dispar</i>	<i>Caranx gallus</i>	<i>Clupea kowal</i>
<i>Apogon taeniatus</i>	<i>Caranx kiliche</i>	<i>Coryphaenoides guentheri</i>
<i>Arius thalassinus</i>	<i>Carcharhinus brevipinna</i>	<i>Demichthys unicolor</i>
<i>Borostomia antarcticus</i>	<i>Carcharhinus melanopterus</i>	<i>Dussumieria acuta</i>

Epinephelus
coromandelicus
Epinephelus morrhua
Epinephelus tauvina
Gobius couchi
Gobius roulei
Hemiramphus gamberur
Hemiramphus marginatus
Hemiramphus unifasciatus
Hyporhamphus dussumieri
Hyporhamphus
xanthopterus
Istiophorus gladius
Laemonema latifrons
Lepidion guentheri

Lipophrys pholis
Melanostigma atlanticum
Oxyurichthys papuensis
Parablennius pilicornis
Parexocoetus brachypterus
Pempheris molucca
Pempheris oualensis
Pristis pectinata
Remora australis
Rhinobatos halavi
Sardinella sirm
Sargus noct
Scarichthys
coerulopunctatus

Sebastapistes nuchalis
Serranus melanurus
Serranus morrhua
**Sphoeroides spengleri*
Sphyaena viridensis
Squalus megalops
Therapon jarbua
Trichiurus haumela
Upeneus asymmetricus
Upeneus barberinus
Upeneus tragula
Upeneus vittatus

**Sphoeroides spengleri*, originally reported by REINA-HERVÁS *et al.* (2004), has been added to the excluded list since it is regarded a misclassification of *Sphoeroides marmoratus* (M. Vacchi pers. commun.)

2. Zoobenthos/Mollusca

Mollusca established

Notes: underlined are new species post CIESM 2005 on line

Bold indicates cryptogenic species

Acteocina mucronata
Adelactaeon amoenus
Adelactaeon fulvus
Afrocardium richardi
Alvania dorbignyi
Amathina tricarinata
Anadara demiri
Anadara inaequalis
Anadara natalensis
Aplysia dactylomela
Brachidontes pharaonis
Bulla ampulla
Bursatella leachi
Cellana rota
Cerithiopsis pulvis
Cerithiopsis tenthrenoisi
Cerithium scabridum
Chama pacifica
Chelidonura fulvipunctata
Chrysallida fischeri
Chrysallida maiae
Chrysallida pirintella

Cingulina isseli
Clathrofenella ferruginea
Clementia papyracea
Crassostrea gigas
Crepidula aculeata
Crepidula fornicata
Cycloscala hyalina
Cylichnina girardi
Dendrostrea frons
Diala varva
Diodora funiculata
Diodora ruppellii
Discodoris lilacina
Divalinga arabica
Elysia grandifolia
Ergalatax contracta
Ergalatax obscura
Erosaria turdus
Favorinus ghanensis
Finella pupoides
Flabellina rubrolineata
Fulvia australis

Fulvia fragilis
Fusinus verrucosus
Gafrarium pectinatum
Gastrochaena cymbium
Gibborissoa virgata
Haminoea callidegenita
Haminoea cyanomarginata
Hiatula ruppelliana
Hypselodoris infucata
Laternula anatina
Littorina saxatilis
Macra lilacea
Macra olarina
Malvufundus regulus
Melibe fimbriata
Mercenaria mercenaria
Metaxia bacillum
Murex forskoehllei
Musculista perfragilis
Musculista senhousia
Mya arenaria
Natica galaterrana

Octopus aegina
Paphia textile
Perna picta
Pinctada margaritifera
Pinctada radiata
Plocamopherus ocellatus
Polycerella emertoni
Pseudochama corbieri
Pseudominolia nedyma
Purpuradusta gracilis
notata
Pyrunculus fourierii
Rapana venosa

Rhinoclavis kochi
Rissoina bertholleti
Ruditapes philippinarum
Saccostrea commercialis
Saccostrea cucullata
Sepia pharaonis
Sepioeuthis lessoniana
Siphonaria crenata
Smaragdia souverbiana
Spondylus spinosus
Strombus persicus
Styloptygma beatrix
Syphonota geographica

Syrnola fasciata
Tellina valtonis
Teredo navalis
Thais lacera
Thais sacellum
Theora lubrica
Timoclea maurica
Trochus erythraeus
Turbonilla edgarii
Xenostrobus securis
Zafra savignyi
Zafra selasphora

Mollusca casual

Note: underlined species are new species post CIESM 2005 on line

Acar plicata
Aeolidiella indica
Anadara inflata
Angiola punctostriata
Antigona lamellaris
Atactodea glabrata
Caloria indica
Cantharus tranquebaricus
Cardites akabana
Cerithium egenum
Cerithium nesioticum
Chama aspera
Chiton hululensis
Chlamys lischkei
Chromodoris annulata
Chromodoris quadricolor
Circenita callipyga
Clypeomorus bifasciatus
Conus fumigatus
Cuthona perca
Dendrodoris fumata
Diplodonta cf. subrotunda

Dosinia erythraea
Electroma vexillum
Elysia tomentosa
Engina mendicaria
Glycymeris arabicus
Haliotis pustulata cruenta
Hinemoa cylindrica
Iolaea neofelixoides
Leucotina cfr. eva
Lienardia mighelsi
Limopsis multistriata
Modiolus auriculatus
Murchisonella columna
Nassarius arcularius
plicatus=N. obvelatus?
Nerita sanguinolenta
Octopus cyanea
Odostomia lorioli
Oscilla jocosa
Oxynoe viridis
Palmadusta lentiginosa
lentiginosa

Petricola hemprichi
Petricola pholadiformis
Planaxis griseus
Pleurobranchus forskalii
Polycera hedgpethi
Psammotreta praerupta
Retusa desgenettii
Rissoina spirata
Semipallium coruscans
coruscans
Septifer forskali
Siphonaria belcheri
Sphenia rueppelli
Spondylus nicobarius
Sticteulima cf. lentiginosa
Stomatella impertusa
Syrnola cinctella
Trapezium oblongum
Tremoctopus gracilis
Vexillum depexum
Voorwindia tiberiana

Mollusca questionable

Note: * denotes species collected alive from biofouling on the pillars of a gas platform, which had been towed from Australia to its current position off the coast of Ashqelon (Israel) (MIENIS, 2004).

Species	Cited by	Reasoning
<i>Acteocina crithodes</i>	MIENIS, 2004	Insufficient data
<i>Alectryonella crenulifera</i>	SHARON <i>et al.</i> , 2005	One specimen epibiont on a spiny oyster
<i>Angulus flacca</i>	MIENIS, 2004	Insufficient data
* <i>Aplysia parvula</i>	TERLIZZI <i>et al.</i> , 2003	Identification uncertain See remark under table
<i>Atys cylindricus</i>	MIENIS, 2004	Insufficient data
* <i>Barbatia trapezina</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Callista florida</i>	MIENIS, 2005	Old record (1927-32), shells in museum collection
<i>Cerithium columna</i>	MIENIS, 2003a	Insufficient data 1 single shell from Caesarea 1966
<i>Cerithium erythraeoense</i> / <i>Cerithium nodulosum</i>	HAAS, 1937	Its record merits further investigation (MIENIS, 2001b)
* <i>Chama asperella</i>	MIENIS, 2004	Offshore gas platform March 2003
* <i>Chama brassica elatensis</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Ethminolia hemprichi</i>	MIENIS, 2004	Insufficient data
* <i>Hyotissa hyotis</i>	MIENIS, 2004	Offshore gas platform March 2003
* <i>Isognomon ephippium</i>	MIENIS, 2004	Offshore gas platform March 2003
* <i>Leiosolenus hanleyanus</i>	MIENIS, 2004	Offshore gas platform March 2003
* <i>Malvufundus decurtatus</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Nanostrea exigua</i>	LUBINEVSKY & MIENIS, 2005	Record based on one specimen only
* <i>Parahyotissa imbricata</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Patelloida saccharina</i>	MIENIS, 2004	Insufficient data
<i>Pedicirce sulcata</i>	MIENIS, 2004	Insufficient data
* <i>Planostrea pestigris</i>	MIENIS, 2004	Offshore gas platform March 2003
* <i>Plicatula chinensis</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Pteria occa</i>	BEN-ELIAHU & HOVE TEN, 1992	Insufficient data
<i>Rapana rapiformis</i>	BARASH & DANIN, 1977	Insufficient data
<i>Rhinoclavis sinensis</i>	MIENIS, 2004	Insufficient data
<i>Rissoina ambigua</i>	MIENIS, 2004	Insufficient data. Turkey

<i>Sabia conica</i>	BARASH & DANIN, 1986	Insufficient data (MIENIS, 2004)
* <i>Septifer bilocularis</i>	MIENIS, 2004	Offshore gas platform March 2003
<i>Spondylus groschi</i>	LAMPRELL, 1998	Complex taxonomy
<i>Spondylus</i> cf. <i>multisetosus</i>	ÇEVIKER, 2001	Complex taxonomy
<i>Strombus mutabilis</i>	MIENIS, 2001a	Common species in souvenir trade

**Aplysia parvula* Guilding in Mörch, 1863 was originally described from St. Thomas, Lesser Antilles, in the Caribbean. It has been recorded worldwide between about 40° N and 40° S. The species recorded as *Aplysia parvula* in the Indo-Pacific area is clearly different from the Mediterranean specimens attributed to this species. So, two or more species may be involved worldwide under this name. The Mediterranean specimens may be young specimens of *Aplysia punctata* (J. Templado, pers. commun.)

Mollusca excluded (including very old records): For reasoning see ZENETOS *et al.* (2004)

<i>Aglaja taila</i>	<i>Dolabrifera holboelli</i>	<i>Parvicardium hauniense</i>
<i>Anadara notabilis</i>	<i>Erronea caurica</i>	<i>Penicillus vaginiferus</i>
<i>Aplysia juliana</i>	<i>Galeomma polita</i>	<i>Petalifera gravieri</i>
<i>Arctinula groenlandica</i>	<i>Gibbula cineraria</i>	<i>Placopecten magellanicus</i>
<i>Aspella anceps</i>	<i>Hippopus hippopus</i>	<i>Polynices lacteus</i>
<i>Atys blainvilliana</i>	<i>Hochstetteria munieri</i>	<i>Potamides conicus</i>
<i>Berthellina citrina</i>	<i>Laevicardium flavum</i>	<i>Pusionella nifat</i>
<i>Bittium proteum</i>	<i>Latirus polygonus</i>	<i>Rissoina chesneli</i>
<i>Bursa marginata</i>	<i>Linga aurantia</i>	<i>Rissoina decussata</i>
<i>Callostracum gracile</i>	<i>Littorina abtusata</i>	<i>Saxidomus purpuratus</i>
<i>Cerithium caeruleum</i>	<i>Littorina littorea</i>	<i>Scaliola elata</i>
<i>Cerithium echinatum</i>	<i>Lophiotoma indica</i>	<i>Sclerodoris</i> cf. <i>tuberculata</i>
<i>Chromodoris clenchi</i>	<i>Macrinula tryphera</i>	<i>Spondylus limbatus</i>
<i>Clelandella infucata</i>	<i>Mazatlantica cosentini</i>	<i>Spondylus spectrum</i>
<i>Conus arenatus</i>	<i>Melanochlamys seurati</i>	<i>Staphylaea nucleus</i>
<i>Coralliobia madreporarum</i>	<i>Mesalia opalina</i>	<i>Strigatella virgata</i>
<i>Crassostrea virginica</i>	<i>Monetaria annulus</i>	<i>Strombus lentiginosus</i>
<i>Cybium rubiginosum</i>	<i>Monetaria moneta</i>	<i>Umbonium vestiarium</i>
<i>Cylichna</i> cf. <i>mongii</i>	<i>Natica marochiensis</i>	<i>Vasum turbinellus</i>
<i>Cyprea pantherina</i>	<i>Notarchus indicus</i>	

Additional excluded mollusca post ZENETOS *et al.* (2004)

Species	Cited by	Reasoning
<i>Octopus macropus</i>	BELLO <i>et al.</i> , 2004	Known in the Mediterranean Lefkaditou, pers. commun.
<i>Trochus niloticus</i>	MIENIS, 2003b	Only shells, old records
<i>Tricornis tricornis</i>	MIENIS, 2004	Fragment of a shell only
<i>Vexillum cadaverosum</i>	MIENIS, 2004	Incorrect locality data

3. Zoobenthos/Polychaeta

Polychaeta established

Note: bold indicates cryptogenic species

<i>Branchiomma boholense</i>	<i>Hydroides elegans</i>	<i>Notomastus mossambicus</i>
<i>Branchiomma luctuosum</i>	<i>Hydroides heterocerus</i>	<i>Pileolaria berkeleyana</i>
<i>Ceratonereis mirabilis</i>	<i>Hydroides homoceros</i>	<i>Pista unibranchia</i>
<i>Desdemona ornata</i>	<i>Hydroides minax</i>	<i>Polydora cornuta</i>
<i>Eunice tubifex</i>	<i>Hydroides operculatus</i>	<i>Pomatoleios kraussii</i>
<i>Eusyllis kupfferi</i>	<i>Leonnates decipiens</i>	<i>Prionospio saccifera</i>
<i>Ficopomatus enigmaticus</i>	<i>Leonnates indicus</i>	<i>Pseudonereis anomala</i>
<i>Glycinde bonhourei</i>	<i>Leonnates persicus</i>	<i>Spirobranchus tetraceros</i>
<i>Hydroides</i> cf.	<i>Linopherus acarunculata</i>	<i>Spirorbis marioni</i>
<i>branchyacanthus</i>	<i>Metasychis gotoi</i>	<i>Streblospio gynobranchiata</i>
<i>Hydroides dianthus</i>	<i>Nereis zonata persica</i>	
<i>Hydroides diramphus</i>	<i>Notomastus aberans</i>	

Polychaeta casual

<i>Amphicorina pectinata</i>	<i>Longibranchium atlanticum</i>	<i>Paradyte</i> cf. <i>crinoidicola</i>
<i>Fabriciella ghardaqa</i>	<i>Lumbrineris neogesae</i>	<i>Perinereis nuntia</i>
<i>Hydroides albiceps</i>	<i>Lumbrineris inflata</i>	<i>Prionospio pulchra</i>
<i>Hydroides steinitzi</i>	<i>Neanthes willeyi</i>	<i>Prionospio pygmaea</i>
<i>Laonome elegans</i>	<i>Nereis gilchristi</i>	<i>Sphaerosyllis longipapillata</i>
<i>Leiochrides australis</i>	<i>Oenone</i> cf. <i>fulgida</i>	<i>Streblosoma hesslei</i>
<i>Lepidonotus tenuisetosus</i>	<i>Ophyotrocha japonica</i>	

Polychaeta questionable

Species	Cited by	Reasoning
<i>Cirriiformia semicincta</i>	LAUBIER, 1966; BITAR & KOULI-BITAR, 2001	Insufficient data, identification is not certain
<i>Cossura coasta</i>	BOGDANOS & FREDJ, 1983	Insufficient data, identification is not certain
<i>Epidiopatra hupferiana</i>	CANTONE & FASSARI, 1982	Insufficient data, identification is not certain
<i>Eunice indica</i>	BEN-ELIAHU, 1976	Insufficient data, identification is not certain
<i>Eurythoe complanata</i>	FAUVEL 1937; ERGEN & ÇINAR, 1997	Insufficient data, identification is not certain
<i>Isolda pulchella</i>	CANTONE, 2001	Insufficient data, identification is not certain
<i>Lysidice collaris</i>	BEN ELIAHU, 1972a	Probably confused with the native species <i>L. margaritacea</i>

<i>Lysidice natalensis</i>	BITAR & KOULI-BITAR, 2001	Insufficient data, identification is not certain
<i>Naineris quadraticeps</i>	HARMELIN, 1969a	Identification is not certain
<i>Notopygos crinita</i>	A. Castelli, pers. commun. OCCHIPINTI AMBROGI, 2004	Insufficient data, identification is not certain
<i>Mediomastus capensis</i>	GRAVINA & SOMASCHINI, 1990; OCCHIPINTI AMBROGI, 2002a	Insufficient data, identification is not certain
<i>Platynereis cf. australis</i>	A. Castelli, pers. commun. OCCHIPINTI AMBROGI, 2004	Insufficient data, identification is not certain
<i>Protodorvillea egena</i>	A. Castelli, pers. commun. OCCHIPINTI AMBROGI, 2004	Insufficient data, identification is not certain
<i>Streptosyllis arenae</i>	CASTELLI & LARDICCI, 1986	Identification is not certain
<i>Terebella ehrenbergi</i>	BEN ELIAHU 1972b; ÇINAR, 2005	Insufficient data, identification is not certain
<i>Timarete anchylochaeta</i>	LAUBIER, 1966; BITAR & KOULI-BITAR, 2001	Insufficient data, identification is not certain

Polychaeta excluded

Species	Cited by	Reasoning
<i>Amphicorina eimeri</i>	GAMBI <i>et al.</i> , 1983	Atlanto-Mediterranean
<i>Bhawania goodei</i>	BITAR & KOULI-BITAR, 2001	Circumtropical
<i>Branchiosyllis exilis</i>	MONRO, 1937; BEN ELIAHU 1972b	Widespread even in the eastern Atlantic
<i>Chrysopetalum debile</i>	LAUBIER, 1966	Native: type locality Villefranche
<i>Dispio uncinata</i>	ICES, 2001	widespread in the Atlantic
<i>Fabricia filamentosa</i>	GIANGRANDE & CASTELLI, 1986; SIMBOURA, 1990	Misidentification of <i>Pseudofabriciola analis</i> and <i>P. longipyga</i>
<i>Hydroides novaepommeraniae</i>	ZIBROWIUS & BITAR, 1981 as <i>H. grubei</i>	Undeterminable juvenile (HOVE TEN & BEN ELIAHU, 2005)

<i>Monticellina dorsobranchialis</i>	HARMELIN, 1969a; BEN ELIAHU 1972b	Type locality Atlantic, widespread in the Mediterranean and Atlantic
<i>Neopseudocapitella brasiliensis</i>	GRAVINA & SOMASCHINI, 1990	A circumtropical species
<i>Opisthosyllis brunnea</i>	MONRO, 1937	Widespread even in the eastern Atlantic
<i>Paleonotus chrysolepis</i>	BITAR & KOULI-BITAR, 2001	Cosmopolitan
<i>Prionospio salzi</i>	LAUBIER, 1970	Endemic in the Mediterranean
<i>Questa caudicirra</i>	SOMASCHINI & GRAVINA 1993	<i>Questa mediterranea</i> sp. n. GIERE & ERSEUS, 1998
<i>Rhodine loveni</i>	FAUVEL, 1957; BEN ELIAHU 1972a	Type locality north Atlantic, widespread in Mediterranean and Atlantic
<i>Scoloplos (Leodomas) chevalieri candiensis</i>	HARMELIN, 1969a	Type locality Crete, endemic species for the eastern Mediterranean
<i>Spirobranchus giganteus</i>	LAUBIER, 1966	Misidentification, the reports belong to <i>S. tetracerus</i>

4. Zoobenthos/Crustacea

Crustacea established

Decapoda+Stomatopoda

<i>Alpheus audouini</i>	<i>Eucrate crenata</i>	<i>Micippa thalia</i>
<i>Alpheus inopinatus</i>	<i>Herbstia nitida</i>	<i>Myra subgranulata</i>
<i>Alpheus migrans</i>	<i>Ixa monodi</i>	<i>Ogyrides mjoeborgi</i>
<i>Alpheus rapacida</i>	<i>Leptochela pugnax</i>	<i>Palaemonella rotumana</i>
<i>Atergatis roseus</i>	<i>Leucosia signata</i>	<i>Penaeus semisulcatus</i>
<i>Calappa pelii</i>	<i>Libinia dubia</i>	<i>Percnon gibbesi</i>
<i>Callinectes sapidus</i>	<i>Marsupenaeus japonicus</i>	<i>Pilumnopus vauquelini</i>
<i>Carupa tenuipes</i>	<i>Melicerus hathor</i>	<i>Portunus pelagicus</i>
<i>Charybdis helleri</i>	<i>Metapenaeopsis aegyptia</i>	<i>Rhithropanopeus harrisi</i>
<i>Charybdis longicollis</i>	<i>Metapenaeopsis mogiensis</i>	<i>Trachysalambria palaestinensis</i>
<i>Dorippe quadridens</i>	<i>consobrina</i>	
<i>Dyspanopeus sayi</i>	<i>Metapenaeus monoceros</i>	
<i>Erugosquilla massavensis</i>	<i>Metapenaeus stebbingi</i>	

Crustacea (other than Decapoda)

Note: species in bold are ancient records, possibly cryptogenic

Amphipoda	<i>Caprella scaura</i> , <i>Elasmopus pecteniscrus</i> , <i>Maera hamigera</i> , <i>Stenothoe gallensis</i> , <i>Cymadusa filosa</i>
Cirripedia	<i>Balanus improvisus</i> , <i>Balanus eburneus</i> , <i>Balanus reticulatus</i> , <i>Balanus trigonus</i> , <i>Elminius modestus</i> , <i>Megabalanus tintinnabulum</i>
Cumacea	<i>Eocuma sarsii</i>
Isopoda	<i>Paracerceis sculpta</i> , <i>Sphaeroma walkeri</i>

Crustacea casual

Notes: * denotes species described as established in CIESM 2005 on line
underlined are new species post CIESM 2005 on line

Decapoda	<u><i>Actumnus globulus</i></u> , <i>Ashtoret lunaris</i> , <i>Calappa hepatica</i> , <i>Callinectes danae</i> , <i>Cryptosoma cristatum</i> , <i>Daira perlata</i> , <i>Dromia spinirostris</i> , <i>Eriocheir sinensis</i> , <i>Halimede tyche</i> , <i>Hemigrapsus sanguineus</i> , <i>*Heteropanope laevis</i> , <i>*Hyastenus hilgendorfi</i> , <i>Leptochela aculeocaudata</i> , <i>Lucifer hansenii</i> , <i>Macrophthalmus graeffei</i> , <i>Menaethius monoceros</i> , <i>Merhippolyte ancistrotia</i> , <i>Notopus dorsipes</i> , <i>Panulirus ornatus</i> , <i>Periclimenes calmani</i> , <i>Pilumnus hirsutus</i> , <i>Plagusia squamosa</i> , <i>Processa macrodactyla</i> , <i>Scyllarus caparti</i> , <i>Scyllarus posteli</i> , <i>Solenocera crassicornis</i> , <i>Sphaerozius nitidus</i> , <i>Thalamita gloriensis</i>
Amphipoda	<i>Bemlos leptocheirus</i> , <i>Gammaropsis togoensis</i> , <i>Photis lamelligera</i>
Isopoda	<i>Apanthura sandalensis</i> , <i>Paradella diana</i>
Tanaidacea	<i>Leptochelia dubia</i>

Crustacea questionable

Note: * denotes species described as established in CIESM 2005 on line

Species	Cited by	Reasoning
Decapoda	<i>*Thalamita poissonii</i>	HOLTHUIS, 1956 Cosmopolitan: known from E. Atlantic as <i>T. africana</i> (D'UDEKEM D'ACOUZ, 1999)
Cumacea	<i>Iphinoe crassipes haifae</i>	BACESCU, 1961a Widely distributed

Crustacea excluded: for reasoning see GALIL *et al.* (2002)

<i>Automate branchialis</i>	<i>Peneopsis serrata</i>	<i>Portunus sanguinolentus</i>
<i>Chaceon maritae</i>	<i>Persephona mediterranea</i>	<i>Synalpheus tumidomanus</i>
<i>Charybdis sexdentata</i>	<i>Pethrolisthes boscii</i>	<i>Thalamita admete</i>
<i>Gonodactylaceus falcatus</i>	<i>Petrolisthes digitalis</i>	<i>Thenus orientalis</i>
<i>Gonodactylus chiragra</i>	<i>Philyra globosa</i>	<i>Uca coarctata</i>
<i>Hymenopenaeus debilis</i>	<i>Plagusia chabrui</i>	
<i>Panulirus regius</i>	<i>Platymaia wyvillethomsoni</i>	

Additional excluded Crustacea post GALIL *et al.* (2002)

Species	Cited by	Reasoning
<i>Lucifer typus</i> (Decapoda)	HENDRICKX & ESTRADA- NAVARRETE, 1994	Atlanto-Mediterranean
<i>Urocaridella</i> <i>antobrunii</i> (Decapoda)	YOKES & GALIL, 2004	Misidentification of <i>Urocaridella</i> n. sp. (YOKES & GALIL, in press)
<i>Echinogammarus</i> <i>pungentoides</i> (Amphipoda)	COGNETTI, 1994	Native: type locality Po estuary
<i>Unciolella lunata</i> (Amphipoda)	BELLAN-SANTINI <i>et al.</i> , 1998	Native: Described from Algeria
<i>Kalliapseudes</i> <i>omercooperi</i> (Tanaidacea)	BACESCU, 1961b	Wide distribution: Atlantic, Indo-Pacific
<i>Apseudes</i> <i>intermedius</i> (Tanaidacea)	LARWOOD, 1940	Wide distribution: Atlantic, Indo-Pacific

5. Zoobenthos/Miscellanea

Miscellanea established

Group	Species
Echinodermata	<i>Asterina burtoni</i> , <i>Ophiactis savignyi</i> , <i>Ophiactis parva</i> , <i>Synaptula reciprocans</i>
Foraminifera	<i>Amphisorus hemprichii</i> , <i>Astacolus insolitus</i> , <i>Astacolus sublegumen</i> , <i>Heterostegina depressa</i> , <i>Planogypsina acervalis</i> , <i>Planogypsina squamiformis</i> , <i>Amphistegina lobifera</i>
Cnidaria/Actinaria	<i>Haliplanella lineata</i>
Cnidaria/Anthozoa	<i>Oculina patagonica</i> , <i>Acabaria erythraea</i>
Cnidaria/Hydrozoa	<i>Bugainvillia niobe</i> , <i>Macrorhynchia philippina</i> , <i>Garveia franciscana</i> , <i>Gonionemus vertens</i> , <i>Clytia hummelinckii</i>
Cnidaria/Scyphozoa	<i>Cassiopea andromeda</i>
Tunicata/Ascidiacea	<i>Herdmania momus</i> , <i>Botryllus schlosseri</i> , <i>Microcosmus squamifer</i> , <i>Phallusia nigra</i> , <i>Polyandrocarpa zorritensis</i> , <i>Rhodosoma turcinum</i> , <i>Symplegma brakenhielmi</i>
Arthropoda/Pycnogonida	<i>Ammothea hilgendorfi</i> , <i>Anoplodactylus digitatus</i> , <i>Anoplodactylus californicus</i>

Miscellanea casual

Group	Species
Echinodermata	<i>Amphioplus laevis</i>
Sipuncula	<i>Apionsoma trichocephalus</i> , <i>Phascolosoma scolops</i>
Cnidaria/Anthozoa	<i>Diadumene cincta</i>
Cnidaria/Hydrozoa	<i>Diphasia margarita</i> , <i>Euphysora bigelowi</i>
Asciacea	<i>Ascidia cannellata</i> , <i>Ascidia</i> cf. <i>savignyi</i> , <i>Eusynstyela hartmeyeri</i> , <i>Microcosmus exasperatus</i> , <i>Symplegma viride</i>

Miscellanea questionable

Group	Species	Cited by	Reasoning
Enteropneusta	<i>Saccoglossus querneyi</i>	STEUER, 1939	Old record, insufficient data
Sipuncula	<i>Aspidosiphon mexicanus</i>	MURINA & ZAVODNIC, 1986	Wide distribution, Atlantic, Indian Ocean
	<i>Aspidosiphon elegans</i>	WESENBERG-LUND, 1957	Wide distribution, its mode of introduction is disputed by POR, 1978
Porifera	<i>Haliclona viridis</i>	BURTON, 1936	Unverified record, J. Vacelet pers. commun.
	<i>Cinachyrella australiensis</i>	BURTON, 1936	Unverified record, J. Vacelet pers. commun.
	<i>Lissodendoryx schmidtii</i>	TSURNAMAL, 1969	Unverified record, J. Vacelet pers. commun.
	<i>Geodia micropunctata</i>	TSURNAMAL, 1969	Unverified record, J. Vacelet pers. commun.
	<i>Hyrtios erecta</i>	TSURNAMAL, 1969	Unverified record, J. Vacelet pers. commun.
	<i>Mycale erythraeana</i>	BURTON, 1936	Unverified record, J. Vacelet pers. commun.
	<i>Reniera spinosella</i>	BURTON, 1936	Unverified record, J. Vacelet pers. commun.
Arthropoda/ Pycnogonida	<i>Pigrogromitus timsanus</i>	ARNAUD, 1987	Old record, insufficient data circum-tropical and Mediterranean R. Bamber pers. commun.

Miscellanea excluded

Group	Species	Cited by	Reasoning
Porifera	<i>Haliclona loosanoffi</i>	SOEST, 1976	Absent from the Mediterranean
Cnidaria/ Hydrozoa	<i>Bugainvillia platygaster</i>	GOY <i>et al.</i> , 1988	According to BOUILLON <i>et al.</i> , 2004 all previous records from E. Mediterranean are <i>B. niobe</i>
Cnidaria/ Hydrozoa	<i>Pennaria disticha australis</i>	BILLARD, 1926	BOUILLON <i>et al.</i> , 2004
Ascidiacea	<i>Ecteinascidia turbinata</i>	HARANT, 1927	Old records circumtropical, A. Ramos, pers.commun.
	<i>Botrylloides nigrum</i>	PÉRÈS, 1954	Old records circumtropical A. Ramos, pers.commun.
Brachiopoda	<i>Frenulina sanguinolenta</i>	TADDEI RUGGIERO, 2000	Confused origin: see LOGAN <i>et al.</i> , 2004

Other Miscellanea: BRYOZOA

The following list is partial as it only includes published records. A survey of bryozoans in progress from Lebanon (J.G. Harmelin, in prep.) will show evidence of several new Lessepsian immigrants well established in the Levantine basin. Furthermore, it is most likely that a thorough study of the bryozoan

assemblages from Mediterranean harbours and sites of oyster culture will bring evidence of introduced species. Among the species recorded by HASTINGS (1927) in the collection by the Cambridge Expedition in the Suez Canal (1924), only those collected at Port Said are considered here. Questionable and excluded records are discussed below.

Species	*Origin	Establishment success	Cited by
<i>Rhynchozoon lareyi</i>	RS, IO	established	ÜNSAL & D'HONDT, 1979
<i>Scrupocellaria jolloisii</i>	RS, IO	established	HASTINGS, 1927
<i>Smittina malleolus</i>	RS, IO	established	D'HONDT, 1988
<i>Tricellaria inopinata</i>	IP	established	D'HONDT & OCCHIPINTI, 1985
<i>Aeverrillia setigera</i>	PO, Atlantic	casual	HASTINGS, 1927
<i>Celleporaria aperta</i>	circumtropical	casual	HASTINGS, 1927
<i>Celleporella carolinensis</i>	W Atlantic	casual/ established	OCCHIPINTI AMBOGI & D'HONDT, 1996
<i>Electra tenella</i>	W Atlantic	casual	ROSSO, 1994

<i>Hippopodina fegeensis</i>	PO	casual	POWELL, 1969
<i>Reteporella jermanensis</i>	RS	casual	D'HONDT, 1988
<i>Pherusella brevituba</i>	PO	casual	CHIMENZ GUSSO & D'HONDT, 2005
<i>Crepidacantha poissonii</i>	circumtropical	questionable	OCCHIPINTI AMBROGI, 1986
<i>Hippaliosina acutirostris</i>	IP	questionable	POWELL, 1969
<i>Parasmittina egyptiaca</i>	RS, IP	questionable	HASTINGS, 1927
<i>Arachnoidea protecta</i>	IP	excluded	CHIMENZ GUSSO <i>et al.</i> , 1998
<i>Thalamoporella gothica</i> (Busk) <i>indica</i>	IP	excluded	POWELL, 1969; BITAR & KOULI-BITAR, 2001
<i>Watersipora subtorquata</i>	??	excluded	D'HONDT, 1988

*Origin: IO=Indian Ocean, IP=Indo-Pacific, RS=Red Sea, PO=Pacific Ocean

***Aeverrillia setigera* (Hincks, 1887)**

This ctenostomate bryozoan widely distributed in warm waters, including Australia, Indonesia and Brazil, has never been noticed again in the Mediterranean since its finding by HASTINGS (1927).

***Celleporaria aperta* (Hincks, 1882)**

This species was fouling barges in the Suez Canal in 1924 (HASTINGS, 1927). It was collected in 1968 at Ashod Port and Acre by POWELL (1969), who previously found it in the southern Red Sea (POWELL, 1967). The alleged circum-tropical (from Cape Verde to Philippines), eury-bathic distribution of this species may indicate the existence of a species group.

***Crepidacantha poissonii* (Audouin, 1826)**

This 'circumtropical' species has not been recorded again in the Mediterranean since the finding of OCCHIPINTI AMBROGI (1986) on rhizomes of *Posidonia oceanica* from the Apulian coast of Italy. Although presumably considered as a lessepsian species by OC-

CHIPINTI AMBROGI (1986) considering its occurrence in the Gulf of Suez (BALA-VOINE, 1959), this species has also been listed from Madeira and Canaries. The specific status of the Atlanto-Mediterranean material should thus be re-examined.

***Hippaliosina acutirostris* Canu & Bassler, 1929**

The record of this Indo-Pacific species in the Levantine basin (POWELL, 1969) is questionable. Particularly diagnostic features of the avicularium are not visible on the illustration by POWELL (1969), who curiously did not compare his specimens with *H. depressa* (Busk, 1854), a Mediterranean endemic particularly abundant in the eastern basin (HARMELIN, 1969b; HAYWARD, 1974). *Hippaliosina acutirostris* is known from the Philippines and various Indo-Pacific localities (HARMER, 1957).

***Parasmittina egyptiaca* (Waters, 1909)**

Species recorded from the Red Sea and the

Indian Ocean, and only once from the Mediterranean (HASTINGS, 1927). However, the identification of *Parasmittina* species is difficult and the bryozoan fauna of the Eastern Mediterranean is poorly documented.

***Arachnoidea protecta* Harmer, 1915**

Arachnoidea protecta was only known from the Celebes archipelago (Indonesia). As noticed by CHIMENZ GUSSO *et al.* (1998), the present knowledge of the geographic distribution of *A. protecta* is probably very partial because of the difficulty to notice and identify this inconspicuous ctenostomate bryozoan. However, the morphological divergence observed between the Celebes and Mediterranean forms may justify the existence of a new species.

***Thalamoporella gothica* (Busk) *indica* (Hincks, 1880)**

? = *Thalamoporella harmelini* Soule, Soule & Chaney, 1999

The intricate status of the form described by Hincks was clarified by SOULE *et al.* (1999), who gave it a species rank, *T. indica* (Hincks,

1880). This species is presently known only from the Indian Ocean. In the same paper they described a new species, *T. harmelini*, from a specimen collected at Beirut, Lebanon. The differences between *T. harmelini* and the Mediterranean specimens from Israel figured by POWELL (1969) and D'HONDT (1988) appear to be light and may fall within the range of variation of this species. Presently known only from the Levantine basin, *Thalamoporella harmelini* cannot be considered as an alien species.

***Watersipora subtorquata* (d'Orbigny, 1852)**

D'HONDT (1988) recorded both *W. subtorquata* and *W. cucullata* (Busk, 1854) from the same Israeli locality (Acre old harbour, 1-2m) but did not comment the differences observed between these specimens. Considering that *W. cucullata* has been described from the Aegean Sea and that the assessment of morphological differences between *Watersipora* species requires precise comparative studies (SOULE & SOULE, 1975), it seems preferable not to include *W. subtorquata* among the alien bryozoans in the Mediterranean.

6. Parasites

Group	Establishment success	Species
Monogenea	casual	<i>Neothoracocotyle acanthocybii</i> : accidental parasite on fish
Digenea	questionable	<i>Hysterolecitha sigani</i> : accidental parasite on wild Siganidae (DIAMANT, 1989). Never observed again
Trematoda	casual	<i>Hirudinella ventricosa</i> : accidental parasite on fish
Protozoa	casual	<i>Bonamia ostrea</i> : accidentally with aquaculture
Crustacea/Copepoda	established	<i>Mytilicola orientalis</i> , <i>Myicola ostreae</i> : on oyster beds
Crustacea/Cirripedia	established	<i>Heterosaccus dollfusi</i> : mostly on <i>Charybdis longicollis</i> (GALIL & LÜTZEN, 1998)
Crustacea/Cirripedia	casual	<i>Loxothylacus texanus</i> : on <i>Callinectes sapidus</i>

7. Zooplankton

Zooplankton established

Group	Species
Copepoda	<i>Acartia (Acanthacartia) tonsa</i> , <i>Acartia centrura</i> , <i>Arietellus pavoninus</i> , <i>Calanopia elliptica</i> , <i>Calanopia media</i> , <i>Centropages furcatus</i> , <i>Labidocera madurae</i> , <i>Labidocera pavo</i> , <i>Paracartia grani</i> , <i>Pontellina plumata</i> , <i>Pseudocalanus elongatus</i> , <i>Pteriacartia josephinae</i>
Ctenophora	<i>Mnemiopsis leidyi</i>
Cnidaria/Scyphozoa	<i>Rhopilema nomadica</i>
Siphonophora	<i>Forskalia formosa</i>
Cnidaria/Hydrozoa	<i>Eucheilota paradoxica</i> , <i>Moerisia carine</i> , <i>Tetrorchis erythrogaster</i>

Zooplankton casual

Group	Species
Copepoda	<i>Acartia (Acanthacartia) fossae</i> , <i>Calanopia biloba</i> , <i>Calanopia minor</i> , <i>Corycaeus speciosus</i> , <i>Eucalanus crassus</i> , <i>Eucalanus subcrassus</i> , <i>Euchaeta concinna</i> , <i>Labidocera agilis</i> , <i>Labidocera detruncata</i> , <i>Labidocera orsinii</i> , <i>Oncaea rufa</i> , <i>Paracalanus crassirostris</i> , <i>Parvocalanus elegans</i> , <i>Parvocalanus latus</i> , <i>Scaphocalanus amplius</i> , <i>Scaphocalanus brevirostris</i> , <i>Scolecithrix valens</i> , <i>Spinocalanus terranovae</i>
Cnidaria/Hydrozoa	<i>Aequorea conica</i> , <i>Kantiella enigmatica</i> , <i>Laodicea fijiana</i> , <i>Nubiella mitra</i> , <i>Paracytaeis octona</i> , <i>Russellia mirabilis</i>
Cnidaria/Scyphozoa	<i>Phyllorhiza punctata</i>

Zooplankton questionable

Group	Species	Cited by	Reasoning
Copepoda	<i>Canuellina insignis</i>	POR, 1972	Old record. Only in Bardawil lagoon
	<i>Enhydrosoma hopkinsi</i>	POR, 1972	Old record. Only in Bardawil lagoon
	<i>Robertsonia salsa</i>	POR, 1972	Old record. Only in Bardawil lagoon
	<i>Scottolana longipes</i>	POR, 1964	Possible pre-lessepsian element (POR, 1978)
	<i>Stenhelia inopinata</i>	POR, 1972	Old record. Only in Bardawil lagoon
	<i>Stenhelia minuta</i>	POR, 1964	Possible pre-lessepsian element (POR, 1964)

Zooplankton excluded

Group	Species	Cited by	Reasoning
Copepoda	<i>Acartia hasanii</i>	ÜNAL <i>et al.</i> , 2002	Native: Described as new species in the area
	<i>Paracartia ioannae</i>	ÜNAL <i>et al.</i> , 2002	Native: Described as new species in the area
	<i>Paracartia janetae</i>	ÜNAL <i>et al.</i> , 2002	Native: Described as new species in the area
	<i>Paramphiascella sirbonica</i>	POR, 1972	Native: First described in Mediterranean
	<i>Pseudodiaptomus salinus</i>	THOMPSON & SCOTT, 1903	Not in Mediterranean: WALTER, 1998
	<i>Scottolana bulbosa</i>	POR, 1967	Insufficient data
Chaetognatha	<i>Sagitta neglecta</i>	GUERGUESS & HALIM, 1973	Insufficient data (CASANOVA, 1985)
Ctenophora	<i>Coeloplana</i> sp.	HAAS, 1942	Insufficient data
Siphonophora	<i>Muggiaea atlantica</i>	GAMULIN & KRŠINIĆ, 1999	According to BOUILLON <i>et al.</i> , (2004), it is a neritic cosmopolitan species
Foraminifera	<i>Globigerina bulloides</i>	LAKKIS <i>et al.</i> , 1996	circumtropical
	<i>Globigerinoides ruber</i>	LAKKIS <i>et al.</i> , 1996	cosmopolitan
	<i>Orbulina universa</i>	LAKKIS <i>et al.</i> , 1996	cosmopolitan

8. Phytoplankton

Phytoplankton established

Note: bold indicates cryptogenic species

<i>Alexandrium andersonii</i>	<i>Chaetoceros coarctatus</i>	<i>Gymnodinium fusus</i>
<i>Alexandrium catenella</i>	<i>Coolia monotis</i>	<i>Ostreopsis ovata</i>
<i>Alexandrium taylori</i>	<i>Gonyaulax grindley</i>	<i>Phaeocystis poucheti</i>
<i>Ceratium breve</i>	<i>Gymnodinium catenatum</i>	<i>Skeletonema tropicum</i>

Additional established species cited in GÓMEZ, 2005

<i>Ceratoperidinium cf. yeye</i>	<i>Gymnodinium</i>	<i>Leptodiscus medusoides</i>
<i>Gonyaulax ligustica</i>	<i>sphaeroideum</i>	<i>Oxytoxum areolatum</i>
<i>Gymnodinium canus</i>	<i>Gyrodinium acutum</i>	

Phytoplankton casual

<i>Asterodinium gracile</i>	<i>Ostreopsis lenticularis</i>	<i>Protoceratium pepo</i>
<i>Chattonella antiqua</i>	<i>Ostreopsis cf. siamensis</i>	<i>Trichodesmium erythreum</i>
<i>Lingulodinium polyedrum</i>	<i>Prorocentrum mexicanum</i>	

Additional casual species cited in GÓMEZ, 2005

<i>Alexandrium insuetum</i>	<i>Gymnodinium attenuatum</i>	<i>Heterodinium crassipes</i>
<i>Amphidinium inflatum</i>	<i>Gymnodinium lineatum</i>	<i>Heterodinium dubium</i>
<i>Amphidinium lissae</i>	<i>Gymnodinium lira</i>	<i>Histioneis detonii</i>
<i>Amphidinium vasculum</i>	<i>Gymnodinium multilineatum</i>	<i>Parahistioneis acutiformis</i>
<i>Amphidoma elongata</i>	<i>Gymnodinium ovulum</i>	<i>Petalodinium porcelio</i>
<i>Amphisolenia complanata</i>	<i>Gymnodinium ravenescens</i>	<i>Protoperidinium tregouboffii</i>
<i>Centrodinium elongatum</i>	<i>Gymnodinium sulcatum</i>	<i>Pyrodinium bahamense</i>
<i>Cochlodinium turbineum</i>	<i>Gymnodinium translucens</i>	<i>Triposolenia longicornis</i>
<i>Craspedotella pileolus</i>	<i>Gyrodinium biconicum</i>	<i>Warnowia pulchra</i>
<i>Gonyaulax rugosum</i>	<i>Gyrodinium rubricaudatum</i>	

Phytoplankton questionable

Species	Cited by	Reasoning
<i>Ceratium egyptiacum</i>	DOWIDAR, 1972	Origin questionable. Defined by HALIM (1990) near Suez canal. Absent from the IP.
<i>Gymnodinium breve</i>	SATSMADJIS & FRILIGOS, 1983	Complex taxonomy

<i>Gymnodinium mikimotoi</i>	ICES, 2001	Complex taxonomy
<i>Gyrodinium aureolum</i>	MOSCATELLO <i>et al.</i> , 2004.	Complex taxonomy
<i>Heterosigma</i> cf. <i>akashiwo</i>	BIZSEL & BIZSEL, 2002	Insufficient data

Phytoplankton excluded

Species	Cited by	Reasoning
<i>Alexandrium minutum</i>	HALIM, 1960	Native: type locality Alexandria
<i>Alexandrium pseudogoniaulax</i>	BIECHELER, 1952	Native: type locality France
<i>Alexandrium tamarense</i>	WALLENTINUS, 2002	Cosmopolitan
<i>Rhizosolenia alata</i>	KIMOR, 1973	Cosmopolitan
<i>Scrippsiella precaria</i>	MONTRESOR & ZINGONE, 1988	Native: type locality Naples

9. *Phytobenthos*

Phytobenthos established

<i>Acetabularia calyculus</i>	<i>Chordra filum</i>	<i>Laurencia okamurae</i>
<i>Acrochaetium codicola</i>	<i>Chrysonephos lewisii</i>	<i>Leathesia difformis</i>
<i>Acrothamnion preissii</i>	<i>Chrysomenia wrightii</i>	<i>Lithophyllum yessoense</i>
<i>Acrothrix gracilis</i>	<i>Cladophoropsis javanica</i>	<i>Lomentaria hakodatensis</i>
<i>Agardhiella subulata</i>	<i>Codium fragile</i>	<i>Lophocladia lallemandii</i>
<i>Aglaothamnion feldmanniae</i>	<i>tomentosoides</i>	<i>Monostroma obscurum</i>
<i>Ahnfeltiopsis flabelliformis</i>	<i>Codium taylorii</i>	<i>Neosiphonia harveyi</i>
<i>Antithamnion amphigeneum</i>	<i>Colpomenia peregrina</i>	<i>Neosiphonia sphaerocarpa</i>
<i>Antithamnion pectinatum</i>	<i>Derbesia rhizophora</i>	<i>Padina boergesenii</i>
<i>Apoglossum gregarium</i>	<i>Fucus spiralis</i>	<i>Pleonosporium caribaeum</i>
<i>Asparagopsis armata</i>	<i>Galaxaura rugosa</i>	<i>Polysiphonia morrowii</i>
<i>Bonnemaisonia hamifera</i>	<i>Grateloupia asiatica</i>	<i>Pterosiphonia tanakae</i>
<i>Botryocladia madagascariensis</i>	<i>Grateloupia lanceolata</i>	<i>Sarconema filiforme</i>
<i>Caulerpa racemosa</i>	<i>Grateloupia patens</i>	<i>Sargassum muticum</i>
<i>Caulerpa scalpelliformis</i>	<i>Grateloupia subpectinata</i>	<i>Scytosiphon dotyi</i>
<i>Caulerpa taxifolia</i>	<i>Grateloupia turuturu</i>	<i>Solieria dura</i>
<i>Chondria collinsiana</i>	<i>Griffithsia corallinoides</i>	<i>Stypopodium schimperi</i>
<i>Chondria curvilineata</i>	<i>Halophila stipulacea</i>	<i>Ulva pertusa</i>
<i>Chondria polyrhiza</i>	<i>Halothrix lumbricalis</i>	<i>Undaria pinnatifida</i>
<i>Chondria pygmaea</i>	<i>Herposiphonia parca</i>	<i>Womersleyella setacea</i>
<i>Chondrus giganteus</i> f. <i>flabellatus</i>	<i>Hypnea cornuta</i>	
	<i>Hypnea spinella</i>	
	<i>Hypnea valentiae</i>	

Phytobenthos casual

<i>Antithamnionella ternifolia</i>	<i>Heterosiphonia japonica</i>	<i>Rhodymenia erythraea</i>
<i>Audouinella robusta</i>	<i>Hypnea spicifera</i>	<i>Sarconema scinaoides</i>
<i>Audouinella subseriata</i>	<i>Neomeris annulata</i>	<i>Solieria filiformis</i>
<i>Caulerpa mexicana</i>	<i>Padina antillarum</i>	<i>Sorocarpus</i> sp.
<i>Ceramium strobiliforme</i>	<i>Padina boryana</i>	<i>Sphaerotrichia firma</i>
<i>Dasya sessilis</i>	<i>Plocamium secundatum</i>	<i>Symphycloadia</i>
<i>Derbesia boergesenii</i>	<i>Porphyra yezoensis</i>	<i>marchantioides</i>

Phytobenthos questionable

Species	Cited by	Reasoning
<i>Acanthophora muscoides</i>	ZEYBEK <i>et al.</i> , 1986	Needs confirmation (ALGAEBASE). According to PERRONE <i>et al.</i> , 2006 it is a Taxon inquirendum
<i>Antithamnionella sublittoralis</i>	RIBERA SIGUAN, 2002	Taxonomy of species uncertain. Synonymy with <i>A. elegans</i> questioned
<i>Batophora</i> sp.	ICES/IOC/IMO, 2003	Insufficient data
<i>Cladophora</i> cf. <i>patentiramea</i>	VERLAQUE, 1994	Identification uncertain
<i>Goniotrichopsis sublittoralis</i>	MAGNE, 1992	Probably confused with species of <i>Stylonema</i>
<i>Hypnea variabilis</i>	ZEYBEK <i>et al.</i> , 1986	Not documented records
<i>Laminaria japonica</i>	PEREZ <i>et al.</i> , 1984	Insufficient data
<i>Laurencia caduciramulosa</i>	FURNARI <i>et al.</i> , 2001	Taxonomic complexity
<i>Laurencia intricata</i>	GODEH <i>et al.</i> , 1992	Probably confused with other species of <i>Laurencia</i>
<i>Laurencia chondrioides</i>	BOISSET <i>et al.</i> , 1998	Overlook deep water species. Probably confused with <i>Chondria</i> sp.
<i>Laurencia majuscula</i>	CACCAMESE <i>et al.</i> , 1986	Probably confused with <i>L. obtusa</i>
<i>Parvocaulis parvula</i>	ALEEM, 1948	Probably Tethyan relict
<i>Polysiphonia atlantica</i>	BEN MAIZ <i>et al.</i> , 1986	Probably confused with other Mediterranean species of <i>Polysiphonia</i>
<i>Polysiphonia kampsaxiii</i>	AYSEL, 1984	Insufficient data
<i>Polysiphonia paniculata</i>	LAURET, 1970	Insufficient data
<i>Rhodophysema georgei</i>	VERLAQUE, 1981	Insufficient data
<i>Sargassum latifolium</i>	ZEYBEK <i>et al.</i> , 1986	Not documented records

Phytobenthos excluded

A. Not occurring in the Mediterranean

Species	Cited by	Reasoning
<i>Audouinella spatoglossi</i>	ALEEM, 1950	Old record based on cast ashore thalli
<i>Cystoseira myrica</i>	VERLAQUE, 1994	Doubtful old record
<i>Gracilaria arcuata</i>	BOUDOURESQUE & RIBERA, 1994	Doubtful record: GARGIULO <i>et al.</i> (1992)
<i>Gracilaria disticha</i>	VERLAQUE, 1994	Old record to be confirmed
<i>Hypnea esperi</i>	LIPKIN, 1972	Nomenclatural and taxonomic complexity ATHANASIADIS (1987)
<i>Hypnea nidifica</i>	REINBOLD, 1898	Old record based on cast ashore thalli
<i>Mastocarpus stellatus</i>	FURNARI <i>et al.</i> , 2003	Misidentification
<i>Spatoglossum variabile</i>	ALEEM, 1950	Old record based on cast ashore thalli
<i>Spatoglossum asperum</i>	LUNDBERG, 1989	Misidentification

B. Occurring in the Mediterranean

Species	Cited by	Reasoning
* <i>Acanthophora nayadiformis</i>	BOUDOURESQUE & RIBERA, 1994	Tethyan relict
<i>Antithamnion decipiens</i>	Various authors	Native: type locality: Nice, France
<i>Antithamnionella elegans</i>	CORMACI & FURNARI, 1988	Native: type locality: Naples
<i>Antithamnionella spirographidis</i>	RIBERA & BOUDOURESQUE, 1995	Native: type locality: Trieste
** <i>Asparagopsis taxiformis</i>	VERLAQUE, 1994	Tethyan relict
<i>Bryopsis plumosa</i>	GIACCONE, 1969	Not introduced/ cosmopolitan
<i>Ceramium bisporum</i>	SARTONI & BODDI, 2002	Probably confused with <i>C. codii</i>
<i>Cladophora liebetruithii</i>	DURAL & AYSEL, 1996	Old record: present in the Mediterranean Sea since 1854
<i>Chondrophycus papillosus</i>	ZEYBEK, 1969	Tethyan relict
<i>Cladosiphon zosterae</i>	BATTIATO & PONTE, 1975	Not introduced/ cosmopolitan
<i>Desmarestia viridis</i>	VERLAQUE, 1981	KÜTZING, 1849: Adriatic

<i>Dipterosiphonia dendritica</i>	VERLAQUE, 1981	Not introduced
<i>Ectocarpus siliculosus</i>	BELLEMO <i>et al.</i> , 1999	Not introduced
<i>Ganonema farinosum</i>	VERLAQUE, 1994	Tethyan relict
<i>Halymenia ulvoidea</i>	ALEEM, 1993	Endemic species of the Mediterranean Sea
<i>Hypnea musciformis</i>	GIACCONE, 1969	Not introduced/ cosmopolitan
<i>Microdictyon tenuius</i>	ZEYBEK, 1969	Old record: present in the Mediterranean Sea since 1860
<i>Myrionema strangulans</i>	AYSEL, 1997	Cosmopolitan several ancient reports of this species
<i>Pilayella littoralis</i>	BEN MAIZ <i>et al.</i> , 1986	Not introduced
<i>Polysiphonia fucoides</i>	BOUDOURESQUE & RIBERA, 1994	Known in ancient flora as <i>P. violacea</i>
<i>Polysiphonia elongata</i>	GIACCONE 1969	Not introduced
<i>Punctaria tenuissima</i>	RIBERA <i>et al.</i> , 1992	Not introduced
<i>Radicilingua thysanorhizans</i>	CURIEL <i>et al.</i> , 1994	Not introduced
<i>Spyridia hypnoides</i>	FURNARI <i>et al.</i> , 1999	Native: Type locality: Algeria
<i>Sphacelaria rigidula</i>	ZEYBEK <i>et al.</i> , 1986	Old record: Istria, 1901
<i>Ulva fasciata</i>	DELILE, 1813	Not introduced
<i>Ulva scandinavica</i>	BATTELLI & TAN, 1998	Not introduced.

* Species classified among the potentially invasive ones in the Mediterranean by VERLAQUE *et al.* (2005).

** Species classified among the most invasive ones in the Mediterranean, by VERLAQUE *et al.* (2005).

Synonyms / Misidentifications / Species Updates

In the lists that follow, the first name is the current name used in this paper. For full synonymity of fish, decapods and molluscan the reader is referred to the CIESM atlas volumes 1 to 3.

Fish

Apogon pharaonis = *Apogon nigripinnis*

Chelon carinata = *Liza carinata*

Liza haematocheila = *Mugil soiyu*

Sphyraena pinguis = *Sphyraena chrysotaenia*

Sphyraena obtusata = *Sphyraena flavicauda*

Zoobenthos

Group	Synonyms/misidentifications
Mollusca/Cephalopoda	<i>Octopus aegina</i> = <i>Octopus kagoshimenis</i>
Polychaeta	<i>Branchiosyllis exilis</i> = <i>Branchiosyllis uncinigera</i> = <i>Syllis exilis</i> <i>Branchiomma boholene</i> = <i>Branchiomma cingulata</i> = <i>Dasychone cingulata</i> <i>Chrysopetalum debile</i> = <i>Chrysopetalum</i> sp. <i>Hydroides diramphus</i> = <i>Hydroides lunulifera</i> <i>Hydroides novaepommeraniae</i> = <i>Hydroides grubei</i> <i>Hydroides operculatus</i> = <i>Hydroides inornata</i> <i>Linopherus acarunculata</i> = <i>Pseudeurythoe acarunculata</i> <i>Neanthes willeyi</i> = <i>Neanthes capensis</i> <i>Nereis zonata persica</i> = <i>Nereis persica</i> <i>Leonnates indicus</i> = <i>Leonnates jousseaumei</i> <i>Spirobranchus tetraceros</i> = <i>Spirobranchus jousseaumei</i>
Crustacea/Decapoda	<i>Erugosquilla massavensis</i> = <i>Squilla africana</i>
Crustacea/Tanaidacea	<i>Kalliapseudes omercooperi</i> = <i>Cristapseudes omercooperi</i>
Crustacea/Amphipoda	<i>Maera hamigera</i> = <i>Linguimaera caesaris</i>
Arthropoda/ Pycnogonida	<i>Anoplodactylus californicus</i> = <i>Anoplodactylus portus</i>
Echinodermata	<i>Synaptula reciprocans</i> = <i>Synaptula nigra</i>
Porifera	<i>Haliclona viridis</i> = <i>Callyspongia viridis</i> <i>Cinachyrella australiensis</i> = <i>Chrotella cavernosa</i> <i>Lissodendoryx schmidt</i> = <i>Damiriana schmidt</i> <i>Hyrtios erecta</i> = <i>Heteroneme erecta</i>
Ascidacea	<i>Botrylloides nigrum</i> = <i>Metrandrocarpa nigra</i> <i>Ecteinascidia turbinata</i> = <i>Ecteinascidia moorei</i> <i>Botryllus schlosseri</i> = <i>Botryllus violaceus</i>
Bryozoa	<i>Aeverrillia setigera</i> = <i>Buskia setigera</i> <i>Celleporaria aperta</i> = <i>Holoporella aperta</i> <i>Parasmittina egyptiaca</i> = <i>Smittia egyptiaca</i> <i>Reteporella jermanensis</i> = <i>Sertella jermanensis</i>
Cnidaria/Hydrozoa	<i>Macrorhynchia philippina</i> = <i>Lytocarpus philippinus</i>

Zooplankton

Enhydrosoma hopkinsi = *Enhydrosoma vicinum*
Spinocalanus terranova = *Ctenocalanus citer*
Stenhelia inopinata = *Sunaristes inopinata*
Scottolana longipes = *Canuella longipes*
Sagitta neglecta = *Aidanosagitta neglecta*

Phytoplankton

Alexandrium catenella = *Gonyaulax catenella*
Alexandrium minutum = *Alexandrium lusitanicum*
Alexandrium tamarense = *Gonyaulax tamarensis*
Ceratium egyptiacum = *Ceratium pulchellum*
Coolia monotis = *Ostreopsis monotis* = *Glenodinium monotis*
Gonyaulax grindleyi = *Protoceratium reticulatum*
Gymnodinium mikimotoi = *Gymnodinium nagasakiense* = *Gyrodinium aureolum*
Gymnodinium breve = *Karenia brevis*
Gymnodinium fusus = *Pseliodinium vaubanii*
Prorocentrum mexicanum = *Prorocentrum maximum*
Rhizosolenia alata = *Rhizosolenia truncata* = *Rhizosolenia alata* f. *indica*
Pyrodinium bahamense = *Pyrodinium schilleri*

Phytobenthos

Acrochaetium (*Rhodothamniella*) *codicola* = *Audouinella codicola*
Agardhiella subulata (also reported as *Solieria chordalis*)
Antithamnion amphigeneum = *Antithamnion algeriense*
Antithamnion pectinatum: quoted as *Antithamnion nipponicum*
Asparagopsis armata = *Falkenbergia rufolanosa*
Audouinella robusta = *Acrochaetium sargassicola*
Chondrophycus papillosus = *Laurencia papillosa*
Cladophoropsis javanica = *Cladophora/Cladophoropsis zollingeri*
Dasya sessilis = *Dasya* sp.
Galaxaura rugosa = *Galaxaura lapidescens*
Grateloupia asiatica = *Grateloupia* sp. and erroneously as *Grateloupia filicina*
Grateloupia patens = *Prionitis patens*
Grateloupia subpectinata = *Grateloupia filicina* var. *luxurians* = *Grateloupia luxurians*
Grateloupia turuturu: recorded as *Grateloupia doryphora*
Heterosiphonia japonica = *Dasysiphonia* sp.
Hypnea spicifera = *Hypnea harveyi*
Hypnea spinella = *Hypnea cervicornis*
Hypnea valentiae var. *hamulosa* = *Fucus hamulosa*
Mastocarpus stellatus: recorded as *Gigartina stellata* and *Petrocelis cruenta*
Microdictyon tenuius: quoted as *Microdictyon agardhianum*
Monostroma obscurum = *Ulvaria obscura*
Myrionema strangulans = *Myrionema vulgare*
Neosiphonia harveyi = *Polysiphonia mottei* = *Polysiphonia harveyi*
Padina antillarum = *Padina tetrastromatica*
Parvocaulis parvula = *Acetabularia parvula* = *Acetabularia moebii*
Porphyra yezoensis: recorded as *P. tenera*
Pterosiphonia tanakae = *Pterosiphonia* sp.
Sphacelaria rigidula = *Sphacelaria furcigera*
Sphaerotrichia divaricata is a misidentification of *Sphaerotrichia firma*
Spyridia hypnoides = *Spyridia aculeata*
Stypopodium schimperi = *Stypopodium tubrugense* = *Stypopodium zonale*
Womersleyella setacea = *Polysiphonia setacea*

Worst Invasive Alien Species in the Mediterranean coastal ecosystem

Among invasive alien species, a list of the worst invasive species threatening biodiversity in Europe has been endorsed by the SEBI2010 Working Group 5. The list is not an indicator by itself. However, it can be developed into an indicator and it will serve as a basis for more specific indicators focusing on *impacts* and *economic cost* of invasive alien species. Further, and perhaps most importantly, it is a very powerful awareness tool.

As worst IAS threatening biodiversity have been defined species that:

- a. have a serious impact on biological diversity e.g. severe impacts on ecosystem structure and function (alteration of habitat, competing with native species, entering food chain, altering energy and nutrient flow etc.); replacement of native species throughout a significant proportion of its range; hybridization with native species; and threats to unique biodiversity (e.g. habitats in need of conservation measures, isolated ecosystems, endemic species).
- b. may have negative consequences for human activities, health and/or economic interests (e.g. are pests, pathogens or vectors of disease)

Documenting impacts of marine invaders is a subject of hot debate. The evidence and nature of the impact of invasive species on particular ecosystems and habitats are often unclear and it appears that it is the interaction between invaders and other anthropogenic stresses that influence the impact (RUIZ *et al.*, 1999). Invasion success depends not only on the invader's advantage over potential native enemies/competitors but also on the environmental characteristics of the host ecosystem (primarily species richness and disturbance) and the level of stress already

imposed on it (SIMBERLOFF, 1989 ; RIBERA, 1995; COHEN & CARLTON, 1998; GOODWIN *et al.*, 1999; OCCHIPINTI AMBROGI, 2000; KEANE & CRAWLEY, 2002).

The adverse impacts of invasive species on genetics, populations, ecosystems and economics in the Mediterranean have been discussed to some extent in synthetic studies (BOUDOURESQUE, 1994 ; BOUDOURESQUE & RIBERA, 1994; VERLAQUE, 1994; RIBERA, 1995; GOLANI, 1998; OCCHIPINTI AMBROGI, 2000; 2001; 2002a; 2002b; GALIL, 2000a, and 2000b; ZIBROWIUS, 2002 ; BOUDOURESQUE & VERLAQUE, 2002a and 2002b; GALIL & ZENETOS, 2002; OCCHIPINTI AMBROGI & SAVINI, 2003; GOFAS & ZENETOS, 2003).

In the Mediterranean, stressed environments (polluted or physically degraded) appear to be more prone to invasion than pristine sites (RIBERA & BOUDOURESQUE, 1995, GALIL, 2000b; OCCHIPINTI AMBROGI, 2000; RIBERA SIGUAN, 2002; OCCHIPINTI AMBROGI & SAVINI, 2003). The fact that mariculture introductions are mostly restricted to lagoonal or estuarine habitats and vessel-transported aliens to polluted harbours (ZIBROWIUS, 1992), environments that are known for their low biodiversity, support this theory. A recent study of macrofouling organisms concluded that many more species are found in a polluted than in a non-polluted marina (KOÇAK *et al.*, 1999). However, there are suggestions of the opposite. According to KLEIN *et al.*, (2005) there is no relationship between the number of introductions, diversity of the host ecosystem and disturbance acting on the community when examining the impact of introduced macrophytes on the shallow subtidal macrophytic assemblages along the French Mediterranean coast.

Invasive records

A number of alien species have been described as invasive or locally invasive by different authors in different parts of the Mediterranean. The qualification as invasive is based on their proliferation, and/or their geographical spread and/or impact on native populations. The Worst Invasive Species among them are presented below per eco-functional/ taxonomic group.

1. Fish

The term invasive is debatable if used for describing the present situation in the Levantine Sea given the lack of reliable information on distribution and abundance prior to the opening of Suez Canal (GOLANI, 1998). Notwithstanding, definite changes in fish assemblages in the Levantine ecosystem have been attributed to Lessepsian migrants (GOLANI *et al.*, 2002; GOREN & GALIL, 2005; HARMELIN-VIVIEN *et al.*, 2005; SAAD, 2005).

Eighteen of the alien fish species were already considered as very common and of positive economic importance by GOLANI *et al.* (2002). These are: *Alepes djedaba*, *Atherinomorus lacunosus*, *Dussumieria elopoides*, *Etrumeus teres*, *Gymnammodytes semisquamatus*, *Hemiramphus far*, *Herklotsichthys punctatus*, *Liza carinata*, *Sargocentron rubrum*, *Saurida undosquamis*, *Scomberomorus commerson*, *Siganus luridus*, *S. rivulatus*, *Sillago sihama*, *Sphyræna chrysotaenia*, *Solea senegalensis*, *Upeneus moluccensis* and *Upeneus pori*. *Seriola fasciata* and *Fistularia commersonii* now have to be added to that list, following recent records of their spread across the Mediterranean.

Abundant populations of alien fish without direct economic use are also included in the worst IAS since they are considered as pests, an economic burden to fishermen who have to discard them from their gear (GOLANI *et al.*, 2002: *Sphoeroides pach-*

ygaster, *Cynoglossus sinusarabici*, *Stephanolepis diaspros*, *Lagocephalus spadiceus*, *Lagocephalus suezensis* and *Callionymus filamentosus*).

2. Zoobenthos/Mollusca

Ten species of molluscs have been described as locally invasive: the gastropods *Cerithium scabridum*, *Rhinoclavis kochi*, *Strombus persicus* and *Bursatella leachi* and the bivalves *Pinctada radiata* and *Brachidontes pharaonis* in the eastern Mediterranean, the gastropod *Rapana venosa* and the bivalves *Anadara inaequalis*, *Musculista senhousia*, and *Xenostrobus securis* in the northern Adriatic and the western Mediterranean lagoons (GOFAS & ZENETOS, 2003). In addition, the bivalves *Chama pacifica* and *Spondylus spinosus* have been regarded as invasive in the Levantine (ZENETOS *et al.*, 2004) and in the western Mediterranean lagoons *Crepidula fornicata* has been found to compete with commercial shellfish (BLANCHARD, 1996).

When assessing the scale and impact of ship transported alien fauna in the Mediterranean ZIBROWIUS (2002) regarded the following molluscan species as invasive, primarily based on their spread: *Crepidula aculeata* (Alicante harbour Spain), *Anadara demiri* (in the Adriatic and Aegean Seas along with the aforementioned *A. inaequalis*) and *Mya arenaria* (with mass proliferation in the Berre lagoon near Marseilles). More recently the bivalve *Musculista senhousia* also proliferated in Berre lagoon.

Bivalves originally imported for aquaculture purposes such as the venus clam *Ruditapes philippinarum*, the Pacific oyster *Crassostrea gigas* and *Anadara inaequalis* are well known examples of negative impact caused by alien species in the Mediterranean, as it has been demonstrated in the case of the Venice lagoon. They are out-competing native species (OCCHIPINTI AMBROGI, 2000) and their harvesting has

caused heavy stress on bottom communities and the whole lagoon ecosystem (OCCHIPINTI AMBROGI, 2002b; PRANOVI *et al.*, 2003; 2004).

The cryptogenic shipworm *Teredo navalis* can be included here, being one of the most effective and harmful marine invaders (HOPPE, 2002).

3. Zoobenthos/Polychaeta

Various species have been considered as invasive in various parts of the Mediterranean. *Pomatoleios kraussii* has been highly successful in the Levantine basin (Lebanon, G. Bitar & H. Zibrowius, unpublished; Iskenderun Bay, M.E. Çinar, unpublished), *Hydroides elegans*, *H. dianthus* and *Spirorbis marioni* in harbour environments all over the Mediterranean. In addition to *P. kraussii*, various other lessepsian serpulids spread over the Levantine area. Among these, *Hydroides minax* now seems to be omnipresent and may locally have particular dense populations. Of the soft bottom species *Branchiommia luctuosum*, *Polydora cornuta*, *Streblospio gynobranchiata*, *Leonnates persicus* and *Pseudonereis anomala* have to be added to the worst IAS (ÇINAR *et al.*, 2002; 2005; ÇINAR & ERGEN, 2005; KAMBOUROGLOU & NICOLAIDOU, 2006).

4. Zoobenthos/Crustacea

A number of alien decapod crustaceans have been described as abundant in the Mediterranean. More common are: *Charybdis helleri* and *Charybdis longicollis* (the latter constituting 70 % of the benthic biomass on sandy-silt bottoms off the Israeli coast (GALIL, 1986). Further species have been described as either abundant or very abundant and have an impact on the environment and/or the economy (GALIL *et al.*, 2002): *Dyspanopeus sayi* (very abundant in the Venice lagoon), *Marsupenaeus japonicus* (very abundant in the Levantine and southern Turkey), *Metapenaeus monoceros*, *M. stebbingi*,

and *Penaeus semisulcatus* (abundant along the Levantine coast), *Callinectes sapidus* (common in Greece), *Portunus pelagicus* (abundant along the Levantine since the 1920's, presently rare), *Melicertus hathor* (locally common and of some commercial importance in Iskenderun Bay), and *Erugosquilla massavensis* (abundant in the eastern Levantine and southeastern Turkey).

In addition, the decapods *Libinia dubia* (in Tunisia), *Rithropanopeus harrissi* (established in North Adriatic lagoons along with *Dispanopeus sayi*), and the amphipod *Elasmopus pecteniscus* (Levantine Sea and Venice lagoon) have been regarded as invasive (ZIBROWIUS, 2002). The shrimps *Alpheus lobidens* and *A. edwardsii* have also been reported as invasive in the Eastern Mediterranean (GALIL & ZENETOS, 2002). The Atlantic crab *Percnon gibessi*, first recorded in the central Mediterranean (RELINI *et al.*, 2000) has rapidly spread to the western and eastern Mediterranean (THESSALOU-LEGAKI *et al.*, 2006).

5. Zoobenthos/Miscellanea

ZIBROWIUS (2002) regarded the following species as invasive primarily based on their spread: *Oculina patagonica* (Scleractinian coral reported in Spain, Ligurian coast of Italy, Alexandria, Lebanon, Israel and recently in Turkey and Greece); the ascidian *Microcosmus exasperatus* (dense populations in Mediterranean harbours). The echinoderm *Asterina burtoni* has been regarded as invasive in the Eastern Mediterranean (GALIL & ZENETOS, 2002). In addition, the bryozoan *Tricellaria inopinata* was discovered to have a profound impact on the bryozoan community by colonizing all possible hard substrata in the Lagoon of Venice and out competing the native species (OCCHIPINTI AMBROGI, 2000; OCCHIPINTI AMBROGI & SAVINI, 2003). However, the synergy between the invader and the stress already imposed in the ecosystem is not clear

(OCCHIPINTI AMBROGI, 2000).

Two foraminiferan species, namely, *Amphistegina lobifera* and *Amphisorus hemprichii* show invasive characteristics. *A. lobifera* populations have been expanded to such an extent that the dead tests locally accumulated as a 30-60cm thick layer on the sea bed [Antalya, Kaş, Kekova, Beş Adalar and Üç Adalar] (MERİÇ *et al.*, 2002 ; 2004; YOKES & MERİÇ, 2004). *Amphistegina lobifera* has been reported on the Eastern Mediterranean coasts as far as Cyprus (HYAMS *et al.*, 2002) and *Amphisorus hemprichii* has been reported in Southwestern Turkey and Israel (B. Yokes, pers. commun.)

6. Parasites

Parasites are ubiquitous and pervasive in marine systems, yet their role in marine invasions is relatively unexplored. Although data on parasites of marine organisms exist, the extent to which parasites can mediate marine invasions, or the extent to which invasive parasites and pathogens are responsible for infecting or potentially decimating native marine species have not been examined.

Parasitic copepods that infect shellfish have been widely introduced with the transport and culture of bivalves. *Mytilicola orientalis* and *Myicola ostrae* are both parasitic copepods of the Pacific oyster, *Crassostrea gigas*, in Asia, where they are native. Both species infect native bivalves and *M. orientalis* is considered a serious pest (HOLMES & MINCHIN, 1995).

7. Zooplankton

The zooplanktonic jellyfish *Rhopilema nomadica* have been reported as invasive in the Levantine (Eastern Mediterranean) (GALIL *et al.*, 1990). The jellyfish has entered the Mediterranean via the Suez Canal in the 1970s, and since the mid 1980s forms large swarms annually along the Levantine coast. When the jellyfish swarms draw nearer shore they adversely affect tourism, fisheries

and coastal installations.

8. Phytoplankton

Algal species responsible for the occurrence of Harmful Algal Blooms have been regarded as invasive. The toxics *Alexandrium catenella*, *Ostreopsis ovata* and *Coolia monotis* and the non toxic dinoflagellate *Alexandrium taylori* have been detected in the western Mediterranean (PENNA *et al.*, 2005; GIACOBBE & YANG, 1999; GARCÉS *et al.*, 1999; GARCÉS *et al.*, 2000; SIMONI *et al.*, 2003, 2004; BASTERREXTEA *et al.*, 2005), and also in Greece (STRATEGY Workshop, 2004). *Alexandrium catenella* toxic blooms have been reported in the western Mediterranean (GARCÉS *et al.*, 2000; VILA *et al.*, 2001) and concern has been raised about the eastern Mediterranean (MIKHAIL, 2001) for the same species. The presence of *Gymnodinium catenatum* in the western Mediterranean has also been perceived as a probable 'protagonist of future red tides events' (GÓMEZ & CLAUSTRE, 2001) but has not been included in the worst IAS as it is regarded a potentially invasive species.

9. Phytobenthos

Many authors have provided lists of invasive macrophytes in Mediterranean. WALLENTINUS (2002) for example has provided a different aspect where 25 macroalgae are considered as invasive and nine as highly invasive. A more accurate account has been provided by Mediterranean experts.

Caulerpa taxifolia and *Caulerpa racemosa* aff. var. *cylindracea* are perhaps the most notorious invaders in the Mediterranean. In many cases their invasive spread has radically altered the structure and function of native ecosystems causing a decrease in macrofaunal and macroalgal biodiversity (RUITTON & BOUDOURESQUE, 1994 ; BOUDOUR-ESQUE *et al.*, 1995; HARMELIN-VIVIEN *et al.*, 1996 ; CECCHERELLI & CAMPO,

2002; BALATA *et al.*, 2004; PIAZZI *et al.*, 2005; RUITTON *et al.*, 2005). In fact the invasive proliferation of *Caulerpa taxifolia*, the ‘killer algae’ (MEINESZ, 1999), consists the most infamous example of the impact of invasive species in the Mediterranean.

According to BOUDOURESQUE & VERLAQUE (2002a), and references therein, at least eight phytobenthic species can be described as invasive organisms in the Mediterranean as “they play a conspicuous role in the recipient ecosystems, becoming the dominant species and/or taking the place of keystone species”. These are: *Acrothamnion preissii* in western Italy, *Asparagopsis armata* in the north-western basin, *Lophocladia lallemandii* in the Balearic Islands, *Womersleyella setacea* in western Italy, Corsica and the Aegean Sea, *Sargassum muticum* in Thau lagoon, France, *Stypopodium schimperi* in the eastern Mediterranean, especially along the Levantine coasts, *Caulerpa racemosa* aff. var. *cylindracea* in various localities throughout the Mediterranean and *Caulerpa*

taxifolia along the French and Italian Rivièras. An additional species, *Halophila stipulacea* in the Eastern Mediterranean, can be tentatively added to this list.

A specific study on algal introductions to European waters (ALIENS project: VERLAQUE *et al.*, 2005) considered as generally invasive the following species: *Asparagopsis armata*, *Heterosiphonia japonica*, *Asparagopsis taxiformis*, *Bonnemaisonia hamifera*, *Colpomenia peregrina*, *Codium fragile*, *Grateloupia turuturu*, *Antithamnion pectinatum* and *Undaria pinnatifida*.

Discussion

Of the examined records about 23% are excluded. A total of 745 alien species are reported, 98 of which (13%) are questionable records. The available information depends greatly on the taxonomic group examined. The establishment success per ecofunctional/taxonomic group is shown in Figure 2. In the sections that follow the state of art in species

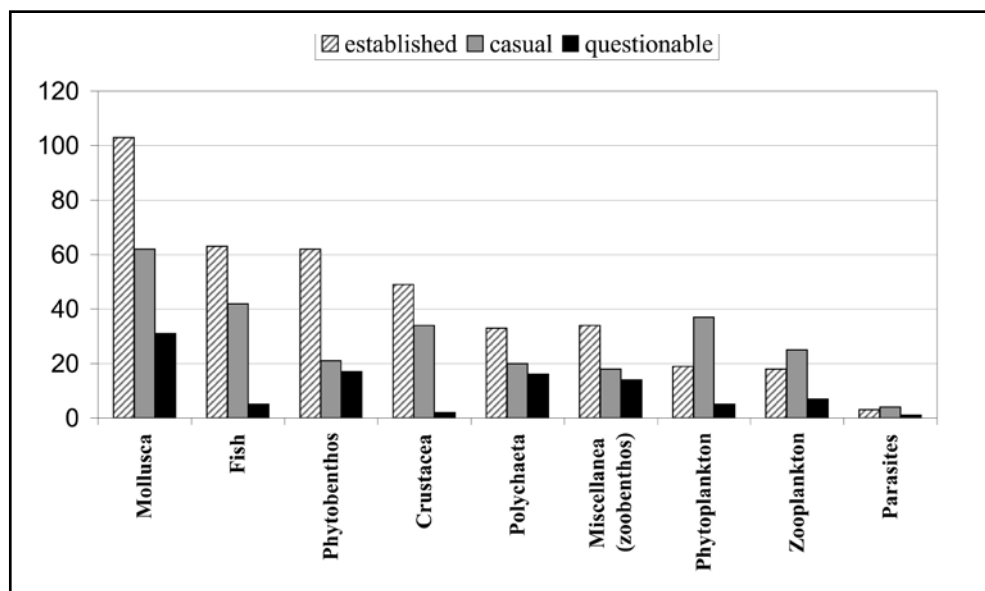


Fig. 2: Establishment success per ecofunctional Pycnogonida/taxonomic group. Miscellanea (zoobenthos) include Foraminifera, Echinodermata, Ascidiacea, Cnidaria, Sipuncula, Pycnogonida, Enteropneusta, Porifera and Bryozoa.

diversity and distribution and in alien monitoring per ecofunctional/taxonomic group is discussed.

1. Fish

Fish is a well studied group in the Mediterranean. The paper version of the CIESM atlas (GOLANI *et al.*, 2002) enumerated 90 alien species. By December 2005 the updated CIESM check-list of alien species included 8 more species (CIESM on line, 2005). As with all groups, more intensive observations and modifications of the status of the already reported species, have increased the number of aliens which is now 110 species. Species of uncertain origin, reported in latest publications such as that of SAAD (2005) are tentatively classified as questionable.

Nomenclature composes the major concern for monitoring alien fish species. Considering that *Official Lists and Indexes of Names and Works in Zoology* is not updated, we normally use the FISHBASE names that are generally used by ichthyologists. The FISHBASE is not a perfect instrument; for example, *Mugil soiyuy* Basilewsky, 1855 and *Chelon haematocheilus* (Temminck & Schlegel, 1845) are both listed as valid names in FISHBASE as separated species. However, there is presently no other common reference point for ichthyologists world-wide and it is the reference list for "*Species 2000 catalogue of life*".

2. Zoobenthos/Mollusca

Mollusca are also well studied in the Mediterranean. By the end of 2002, 139 alien species were recorded and 62 species were excluded as spurious records (GOFAS & ZENETOS, 2003). As suggested by GOFAS & ZENETOS (2003), there is still a pool of about 90 species reported from the Suez Canal, which are likely to be found in the Mediterranean in the near future. Indeed, the number of molluscan alien species has increased to 196, of which 31 are recorded as questionable. The rate of increase is due

to the increased interest of malacologists and the relatively easy collection/identification of mollusca.

3. Zoobenthos/Polychaeta

Absence of an updated monograph of polychaetes covering all families is an obstacle for determining changes in polychaete diversity in the Mediterranean. FAUVEL's outdated fauna (1923; 1927) is still widely used for identifying polychaetes, leading to erroneous lists and confusions as a number of species have been synonymized or proved to be absent in the Mediterranean while many additional species were discovered. However, promising attempts have been recently made in the understanding of the superfamily Aphroditoidea (BARNICH & FIEGE, 2003), and the families Glyceridae (BÖGGEMANN, 2002), Goniadidae (BÖGGEMANN, 2005) and Syllidae (SAN MARTÍN, 2003).

Within Polychaeta, more reliable evidence of Lessepsian migration is only known in Nereidae and Serpulidae. Records of alien species within the families Syllidae, Cirratulidae, Maldanidae, Terebellidae seem to be speculative. Another possibility, that should not be neglected, is that the seemingly Indo-Pacific species recognized in the Mediterranean might be Miocene relicts. Currently 69 species are described as valid records.

4. Zoobenthos/Crustacea (85 species)

4.1. Decapoda

A well studied group with a recent inventory (D'UDEKEM D'ACÓZ, 1999), a photographic website of the Eastern Atlantic, the Mediterranean Sea, and the adjacent continental waters decapoda (CRUSTIKON) and the CIESM atlas with regular updates online

4.2. Amphipoda

There are few alien species documented even on a worldwide scale. Although there are a lot of carcinological studies in the Mediterranean, very few have been identified as

aliens which represent 1.7% of the total amphipod fauna of the region (KOCATAŞ *et al.*, 2002). The recent inventories of BELLAN-SANTINI *et al.*, (1998), BELLAN-SANTINI & COSTELLO (2001), BELLAN-SANTINI & RUFFO (2003) and the AMPHIPODA homepage, accurately list the species' distribution. However, as BELLAN-SANTINI & RUFFO (2003) report “....we have no confirmation on the true origin of these species...”.

4.3. Isopoda

One of the least studied groups; not even an inventory exists for the whole Mediterranean. Effort is increasing, but at a regional scale: covering Spain only (JUNOY & CASTELLÓ, 2003) and Italy (ARGANO *et al.*, 1995). Collections from Lebanon are under current study by J. Castelló (Barcelona, Spain) and it is assumed that some Indo-Pacific species not yet reported will be ‘discovered’. A new species known from tropical areas was recorded in Salerno harbour (Tyrrhenian Sea, southern Italy): it is probably *Mesanthura romulea* (LORENTI *et al.*, in press).

4.4. Tanaidacea

Relatively few comprehensive faunal lists of Tanaidacea exist. The only recent comprehensive study of this group in the Mediterranean by S. Riggio tends to cover the fauna observed in Italy (ARGANO *et al.*, 1995). The collection from the Lebanon studied by R. Bamber (pers. commun.) bears no evidence of newcomers from the Red Sea.

5. Zoobenthos/Miscellanea (66 species)

5.1. Arthropoda / Pycnogonida

Four species have been recorded so far, three of which are established. The taxon is well studied in Italy and France and in addition to a review in 1987 (ARNAUD, 1987) there are regular updates on the distribution of the species in Italy including alien ones

(CHIMENZ GUSSO & LATTANZI, 2003).

5.2. Porifera

Studies on Porifera in general in the Mediterranean and Red Seas are poor. To the very experienced J. Vacelet, the identifications and interpretations, by BURTON (1936) and TSURNAMAL (1969) do not seem reliable (J. Vacelet, pers. commun.). It is therefore difficult to compare the species new to the Mediterranean with the Red Sea fauna since the Red Sea sponge fauna is not well known. Hence, the presence of Red Sea species in the SE Mediterranean cannot be excluded. A recent collection from the Lebanon included two new species which cannot be aliens from the Red Sea (PEREZ *et al.*, 2004). But incertitudes prevail concerning other species under study.

5.3. Ascidiacea

Ascidians have a great invasive potential, and their expansion in the Mediterranean harbours and marinas since the seventies is well documented. Interest has revived and Italian (MASTROTOTARO & DAPPIANO, 2005), and Spanish (RAMOS *et al.*, 1992) experts are examining material from Mediterranean ports. To ascertain the spread of *Microcosmus squamiger* and *M. exasperatus* in the Mediterranean, the material in the collection of the Museum National d'Histoire Naturelle, Paris, was re-examined and the identification of specimens previously classified as *M. exasperatus* revised. The results show that specimens unambiguously attributable to *M. squamiger* are common in Spain, France, Italy and Morocco (TURON & NISHIKAWA, 2005; A. Ramos pers. commun.). This instance illustrates the crucial importance of taxonomy in studies of invasive species.

5.4. Cnidaria/Anthozoa

The Mediterranean is the first area in the world where the invasion by an alien scleractinian coral has been reported. The coral in

question is now commonly known as *Oculina patagonica* and is considered to be of temperate Atlantic-South American origin. This invasive coral in the Mediterranean was hypothesised (ZIBROWIUS, 1974) to be the same species as a coral described from the Holocene beach deposit from Argentina. The invasive Mediterranean form still needs to be compared with live samples from the presumed area of origin. It is exceptional that a scleractinian coral invades a distant area. The second case recognized is the spreading of *Tubastraea* over the tropical American Atlantic.

Cnidaria/Hydrozoa

The knowledge of the biogeography of the Mediterranean Hydrozoa is far from being complete not only due to the continuous recording of new species in the basin, but also due to insufficient or geographically too concentrated research efforts, so leading to inefficient coverage of distribution areas. All presently known Mediterranean hydrozoan species including hydroids, hydromedusae and siphonophores are well covered in the recent book of BOUILLON *et al.* (2004). Species newly entered the Mediterranean basin via the Suez canal were first compiled by POR (1978). According to BOUILLON *et al.* 2004, not many of Por's records were noticed until recent times. A modest collection from Lebanon is under study. The study of the Hydrozoa of the Alboran Sea has led to many new records of Atlantic origin which are however not treated in this study.

5.5. Bryozoa

Bryozoans are common components of fouling communities and can disperse over long distances on rafting substrates. Despite these capacities, the number of non-indigenous species recorded in the Mediterranean is relatively modest (ROSSO, 2003; D'HONDT, in press). The latest record

presented as an alien was *Pherusella brevityuba*, which was collected from Ustica Island in 1996 growing on *Posidonia* leaves (CHIMENZ GUSSO & D'HONDT, 2005). Together with other species of Bryozoa previously recorded in Italian waters, it should better be considered a cryptogenic species, being inconspicuous and belonging to a difficult taxonomic group.

5.6. Foraminifera

It is far more difficult to document the invasion of alien meiofaunal elements into the Mediterranean Sea, as early records are significantly scarce. However, benthic foraminifera have a good preservation potential and may be present in large numbers, tending to leave behind a superior record of their presence over time, in comparison with macrofaunal elements. A recent, extensive study on benthic foraminifera from the shallow continental shelf along the SE Mediterranean (HYAMS, 2001) indicates that nearly 20% of the local Foraminifera species are suspected to be of an exotic origin. The ability to make this estimation may in part be attributed to the recent publication of the Atlas of Recent Foraminiferida of the Gulf of Aqaba (HOTTINGER *et al.*, 1993) and modern compilations of Mediterranean species (YANKO *et al.*, 1998), which enable comparison of the benthic Foraminifera assemblages in both regions. According to B. Yokes (pers. commun.) in Turkish waters there are more than 30 alien lessepsian Foraminifera species. The new findings are to be published by the local scientists.

6. Parasites

Parasites of Mediterranean lessepsian immigrants have been investigated very little over the years pioneered by Ilan Paperna in the early 70s. Only few scientists have been looking for parasitological aspects in the wild. Alien monogeneans have been reported more commonly from freshwater fish

species than from marine fishes. In an early parasitological study of Lessepsian Siganiidae, the digenean *Hysterolecitha sigani* was mentioned from the rabbitfish *Siganus luridus* and *S. rivulatus* (DIAMANT, 1989). Later studies concluded that there is no serious data on potentially Lessepsian trematodes (DIAMANT, 1998). Cymothoids (Isopoda) are a group of crustaceans typically parasitic of teleost fishes. However, they are poorly studied animals and some groups remain completely undescribed. Studies of parasitic isopods on Lessepsian fish are in progress in the Levantine.

The best known parasites in the Mediterranean are the benthic copepods *Mytilicola orientalis* and *Myicola ostreae* on oyster beds. They were likely introduced with infected oysters imported for culture.

A rhizocephalan barnacle, *Heterosaccus dollfusi*, followed its portunid host crab, *Charybdis longicollis*, from the Red Sea through the Suez Canal to the Mediterranean Sea (GALIL & LÜTZEN, 1998). Other reports of rhizocephalans introduced with their hosts are anecdotal and lack confirmation (TORCHIN *et al.*, 2002).

7. Zooplankton

Only 18 zooplanktonic alien species seem to be well established in the Mediterranean, while 32 are considered casual or questionable records. The continuity of the marine pelagic environment, as well as the seasonality of species appearance have to be considered as the most important causes of this lack of information (VAN DER SPOEL, 1994). The eastern Mediterranean zooplankton have been distinctly understudied until the second half of the 20th century while a large number of species of Atlantic origin found in the Western Basin during the past century have been reported without any attempt to discriminate if their presence was due to natural water exchange or human mediation. Moreover, the huge increase of

aquaculture and commercial and tourism activities during the last century have obviously enhanced the transport of planktonic species in ballast waters. Relatively few seem to be planktonic lessepsian migrants, even though it is believed that their contribution will increase with time, due to the decreasing of the Nile fresh water inflow into the Mediterranean and lower salinity in the Bitter lakes (HALIM, 1990).

8. Phytoplankton

The list of Mediterranean Indo-Pacific taxa is full of dubious or poorly known species. As an example of a recent Erythrean invader *Ceratium egyptiacum* was reported by HALIM (1990). The taxon shows variable morphology associated with the stress of environmental changes (salinity > 47psu) in the Suez Canal (DOWIDAR, 1972). It was reported only from the proximity of the Suez Canal, with no records in the Indian or Pacific Oceans. The absence of information on several groups such as the dinoflagellates before the opening of the Suez Canal hinders attempts to determine biogeographical origins of present Mediterranean species (GÓMEZ, 2005). HALIM (1990) reported a tentative list of 17 Mediterranean Indo-Pacific species. Most of these dinoflagellates have been also reported in the Tyrrhenian Sea. However, the Indo-Pacific origin of these species is questionable due to the fact they were also reported in the Atlantic. Furthermore, as with many other groups, several of the species are dubious or invalid taxa. Results of recent EU funded research projects such as STRATEGY as well as compiled works for a few countries have been considered in this update i.e. LAKKIS (1984; 1990), LAKKIS & ZEIDANE (1988; 2004), LAKKIS *et al.* (1990; 1996; 2002), MALT *et al.* (1989) (Lebanon); SIMONI *et al.* (2003) (Italy), VILLA *et al.* (2001) (Spain), KORAY (2002) (Turkey). One of the latest findings is the planktonic diatom *Skeletonema tropicum* which was

found for the first time in the Gulf of Naples, in the autumn of 2002 (SARNO *et al.*, 2005) and seems to be established in the Gulf.

9. *Phytobenthos*

A well studied group with many representatives. Easy access to alien plants and high level of expertise at Mediterranean scale has resulted in the recognition of a high number of aliens especially in transitional waters (west Mediterranean and Adriatic Sea lagoons). However, many species considered as introduced in literature are under criticism. To a great extent this was due to the chaos in nomenclature and literature. The issue is partly resolved in a recent review (CORMACI *et al.*, 2004) which is further updated in the current work. The establishment success still remains unclear for some records. Discrepancies were brought forward among specialists and the results of the ALIENS project (VERLAQUE *et al.*, 2005). However, genetics along with morphological studies are expected to further clarify the situation. For example, *Asparagopsis taxiformis* is a red alga, originally described from an Egyptian specimen (DELILE, 1813), but considered a cosmopolitan member of subtropical and tropical communities worldwide. A debate has risen whether the species is introduced, or native. In this work, *Asparagopsis taxiformis* is proposed to be excluded (tethyan relict), along with *Acanthophora naydaformis* although they are considered as invasive by some Mediterranean specialists. Genetic studies in *A. taxiformis* have demonstrated that several strains co-occur in the Mediterranean and one of them is definitely introduced (ANDREAKIS *et al.*, 2004). The same situation applies for *Desmarestia viridis*; it is believed that the strains reported in the coastal lagoons have been introduced with oysters imported from NE Atlantic or NW Pacific (M. Verlaque pers. commun.).

Conclusions

The number of alien biota in the Mediterranean appears to be underestimated. Some hot spot areas for possible species introductions such as the coast of the Levantine basin, North Africa coasts, big commercial harbours and estuarine areas are not well studied. The biased scientific interest towards taxa with well-known taxonomy and established historical distribution records (e.g. benthic organisms, fish) coupled with the chaos in nomenclature and fragmentary and sporadic information have lead to a possible underestimation of the extent of aliens' presence particularly of the small, less-conspicuous, less-studied species. Thus, despite the collective effort, the information presented in these annotated lists depends greatly on the taxonomic group examined.

On-going monitoring studies along the coasts of the Mediterranean reveal continuous changes in the biodiversity of the region and evidence new alien species. At the same time genetics becomes an increasingly powerful tool in further investigating the identity and origin of many species that, constitute complexes of what may be cryptogenic or sibling (closely related) species. Most studies focus on ecological problems and omit the precise identification of species collected. This is mainly due to the lack of funding for supporting essentially systematic studies and concomitantly the extinction of taxonomists.

Over the last 5 years the scientific interest on alien species in the Mediterranean has revived and many new aliens are recorded each year. Within 2006, at least ten new alien species have been recorded, nine of them in the eastern Mediterranean. Services like the new on-line journal "*Aquatic Invasions*" (<http://www.aquaticinvasions.ru>), ensure a rapid publication and communication of new findings.

In order to maintain a valid list of the alien species in the Mediterranean, it becomes necessary to ensure its continuous updating and revision and promote more systematic

efforts supported by modern taxonomical tools such as genetics.

Addendum

After the original deadline of December 2005, additional alien species have been recognized. The following 10 species are just those that came to our attention. These are:

- a. the Indo-Pacific crab *Charybdis feriata* caught in a gillnet off Barcelona (ABELLÓ & HISPANO, 2006)
- b. the isopod *Cymothoa indica* parasitizing mainly barracudas (Sphyraenidae) from Lebanon (TRILLES & BARICHE, 2006)
- c. the parasitic cymothoid isopod *Anilocra pilchardi* n. sp., from off Lebanon (BARICHE & TRILLES, 2006)
- d. the western Atlantic ascidian *Distaplia bermudensis*, found for the first time in 2000 at Taranto (Ionian Sea, southern Italy), where an abundant population of colonies is now present (MASTROTOTARO & BRUNETTI, 2006);
- e. the Indo-Pacific mantis shrimp *Clorida albolitura* from Ashdod, Israel (AHYONG & GALIL, 2006);
- f. the needle-spined urchin *Diadema setosum* from off Kaş peninsula, Turkey (YOKES & GALIL, 2006);
- g. the fish *Platax teira* captured off Bodrum (S. Turkey), possibly a specimen escaped from aquaculture facilities (BILECENOĞLU & KAYA, 2006);
- h. the fish *Parupeneus forsskali*, from Tasuğu (Levantine coast of Turkey) (ÇINAR *et al.*, 2006);
- i. the fish *Nemipterus japonicus* from Haifa Bay (GOLANI & SONIN, 2006) and
- j. the fish *Decapterus russelli* from Haifa Bay (GOLANI, 2006)

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