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An updated review of alien species on the coasts of Turkey

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Abstract

This 2010 review of alien species along the coasts of Turkey represents a total of 400 alien species belonging to 14 systematic groups. The present paper also reports the first findings of *Vandorhorstia mertensi* in the Aegean Sea (Gökova Bay), *Chama adspersa* in the Sea of Marmara and *Mya arenaria* in the Aegean Sea. A total of 124 new alien species was determined within the last 5 years. Mollusca had the highest number of species (105 species), followed by Polychaeta (75 species), Crustacea (64 species) and Pisces (58 species). The highest number of alien species (330 species) were encountered on the Levantine coast of Turkey, followed by the Aegean Sea (165 species), Sea of Marmara (69 species) and Black Sea (20 species). The Suez Canal (66% of the total number of alien species) is the main vector for species introductions to the coasts of Turkey, followed by the ship-mediated transport (30%). The majority of species (306 species, 76% of total number of species) have become established in the area, while 59 species are classified as casual (15%), 23 species as questionable (6%) and 13 species as cryptogenic (3%). One new alien species was introduced to the coasts of Turkey every 4 weeks between 1991 and 2010. The majority of aliens were found on soft substratum (198 species) in shallow waters (0-10 m) (319 species). Some species such as *Caulerpa racemosa*, *Amphistegina lobifera*, *Amphisorus hemprichii*, *Rhopilema nomadica*, *Mnemiopsis leidy*, *Hydroides* spp., *Ficopomatus enigmaticus*, *Charybdis longicollis*, *Rapana venosa*, *Asterias rubens*, *Siganus* spp. and *Lagocephalus sceleratus* show a highly invasive character, and have great impacts both on the prevailing ecosystems and humans.

Keywords: Alien species; Species list; Black Sea; Sea of Marmara; Aegean Sea; Levantine Sea; Turkey.

Introduction

There are probably no ecosystems on earth which may resist the introduction of an alien species. The worldwide vectors for alien marine species are diverse and can be listed under 15 broad categories, including prominent factors such as commercial shipping activities, canals, aquaculture and fisheries, drilling platforms and the aquarium industry (BAX *et al.*, 2003). Success of an introduced species in the new environment generally depends on a combination of several bio-ecological factors, but as experienced drastically in the Mediterranean Sea, some ecosystems are known to be more susceptible to invasion. In a recent review of the Mediterranean alien marine biota, the presence of 955 species is mentioned, where the eastern basin is still the favorite destination for aliens due to its proximity to the Suez Canal and dense maritime traffic (ZENETOS *et al.*, 2010b). The influx of a huge number of tropical species into the Mediterranean is doubtless the most remarkable bio-geographical phenomenon of today, but POR (2009) indicates in advance that what is happening now may be considered as a partial return to the original warm water biological conditions of the ancient Mediterranean Sea, possibly a normalization event from a geological perspective.

By means of quantitative occurrence of alien species, Turkey can be placed in the center of introductions (ZENETOS *et al.*, 2008). The most detailed analysis was hitherto conducted by ÇINAR *et al.* (2005a), who compiled a list of 277 alien species recorded from all seas surrounding Turkey, with the Suez Canal being the primary vector for species introductions. Due to lack of experts in definite systematic groups and the presence of a relatively low number of scientific research projects funded by the

government, the available alien biodiversity figure is probably an underestimate, likely to be solved only by specific studies concentrating on this key diversity change. Only a few measures are currently being taken by the government, including a prohibition of human mediated species introductions to wetlands (within the framework of the Ramsar Convention) which came into force in May 2005 (Ministry of Environment and Forestry), and a fisheries ban on the two alien pufferfishes, *Lagocephalus sceleratus* and *L. spadiceus*, which appeared in November 2008 in the Fisheries Bulletin of Ministry of Agriculture and Rural Affairs.

The present study focuses on an updated list of alien species occurring on the Turkish coastline that have been gathered from research papers and results of scientific projects, especially intensified during the last decade.

Methods

The present work includes the reports of alien species on the coasts of Turkey. In the paper by ÇINAR *et al.* (2005a), a species list was presented considering species reports up to 2005. Here, we give the list of alien species based on the species reports up to December 2010, together with the first years of their collections, unlike ÇINAR *et al.* (2005a) who only mentioned the first years of their reports. Reports of some alien species along the coasts of Turkey that have not yet appeared in journals now (in press status) were also considered in the present study (i.e. AKAMCA *et al.*, 2011; ÇINAR *et al.*, 2011). The occurrences of *Chama adspersa* in the Sea of Marmara and *Mya arenaria* in the Aegean Sea were validated after personal communications with Drs. C. DELONGUEVILLE and P. OVALIS, respectively. Some species previously considered as aliens were excluded

from the list of alien species in the Mediterranean Sea for a variety of reasons (i.e. misidentification, insufficient data for species). We did not include these species in the present list, unlike the paper by ÇINAR *et al.* (2005a). The present list also includes some species (i.e. *Sigambra parva*, *Podarkeopsis capensis*, *Aplysina parvula*) that were not previously considered as aliens or overlooked in the previous list presented in 2005.

Alien species were grouped into four main categories, namely established, casual, questionable and cryptogenic. The definition of the terms can be found in ZENETOS *et al.* (2010b). Briefly, established species are the alien species with self-maintaining populations; casual species are the species which were reported only once in the region; questionable species are the species which were reported without sufficient information and their taxonomic status is uncertain; cryptogenic species are the species with no definite evidence of their native or introduced status according to CARLTON (1996). Invasive species are the established aliens that have overcome biotic and abiotic barriers in the region and are able to expand their distributional ranges through the production of fertile offspring, with noticeable impact on the prevailing ecosystem.

Results and Discussion

List of species

The present study reports a total of 400 alien species belonging to 14 systematic groups up to the year 2010. The present paper also reports the first findings of *Vanderhorstia mertensi* in the Aegean Sea (Gökova Bay, 15 m) (M. BILECENOGLU pers. obs.), *Chama adspersa* in the Sea of Marmara (C. DELONGUEVILLE, pers. comm.) and *Mya arenaria* in the Aegean Sea (P. OVALIS, pers. comm.). In addition, the reports of 6 species

that have not been published yet (in press status in journals) have also been added to the alien species list of Turkey. These species belong to Foraminifera (*Coscinospira arietina*), Polychaeta (*Laonice norgensis*, *Prionospio (Minuspio) pulchra* and *Spiophanes algidus*) and Pisces (*Trypauchen vagina* and *Tylerius spinosissimus*) (for references see Table 1). Table 1 gives the list of all species reported from the coasts of Turkey together with their possible date of introduction, establishment successes, possible origin and means of introductions, and their habitat and depth preferences. The literature emphasizing the first report of the species in the seas that border Turkey is also given with in superscript code.

In the first review of alien species on the coasts of Turkey, ÇINAR *et al.* (2005a) presented a list of 277 alien species belonging to 13 systematic groups, based on the species records up to December 2005. In contrast to the previous list, the present review also includes the species belonging to the systematic groups Sipuncula and Chaetognatha. Among the groups, Mollusca possessed the highest number of species (105 species), followed by Polychaeta (75 species), Crustacea (64 species) and Pisces (58 species). A total of 5 groups (Sipuncula, Pantopoda, Bryozoa, Chaetognatha and Tunicata) were represented by 1-3 alien species.

In the 2005 review, a total of 7 phytoplankton species were regarded as alien species. Apart from these species, *Ceratium breve* (Ostenfeld et Schmidt) Schröder (EKER & KIDEYS, 2000), *Proboscia indica* (Peragallo) Hernández-Becerril (POLAT *et al.*, 2000), *Gonyaulax pacifica* Kofoid (POLAT, 2007), *Histioneis elongata* Kofoid et Michener (POLAT & KORAY, 2007) and *Heterodinium angulatum* Kofoid et Michener (POLAT & KORAY, 2007) were also considered as alien species, which were reported on the coasts of the Levantine Sea.

Table 1

The list of alien species and their first year of observations from the Turkish coasts. The habitat and depth preferences of aliens along the coasts together with their possible origins and establishment success are also given. BS: Black Sea, SM: Sea of Marmara, AS: Aegean Sea, LS: Levantine Sea, ES: Establishment Success (E: Established, C: Casual, Q: Questionable, Cr: Cryptogenic), O: Origin (IP: Indo-Pacific, RS: Red Sea, AT: Atlantic, WA: Western Atlantic, ST: Subtropical, IO: Indian Ocean, PG: Persian Gulf, PO: Pacific Ocean, TA: Tropical Atlantic, CT: Circumtropical, BA: Boreal Atlantic, Cas: Caspian Sea, Co: Cosmopolitan)

MI = Mode of Introduction (Su: Suez Canal, S: Shipping, G: Gibraltar, Aq: Aquaculture), H: Habitat [Hs: Hard Substratum (including algae, sponge), Ss: Soft Substratum (including phanerogames), P: pelagic, Pz: parasite], DR: Depth Range (I: 0–10 m, II: 11–50m, III: 51–100 m, IV: 101–200 m, V: 201–400, VI: 401–500 m). Ps= Present study, *ÇEVİK *et al.* (2011).

	BS	SM	AS	LS	ES	O	MI	H	D
PHYTOBENTHOS									
Cyanophyta (=Cyanobacteria)									
<i>Trichodesmium erythraeum</i> Ehrenberg, 1830	-	-	1990 ⁹²	-	E	RS/IP	Su	Hs/Ss	I
Rhodophyta									
<i>Acanthophora nayadiformis</i> (Delile) Papenfuss, 1968	-	1970 ²⁸⁸	1970 ¹⁶³	1989 ⁴³	Cr,Q	RS/O	Su	Hs	I,II
<i>Acanthophora muscoides</i> (Linnaeus) Bory de Saint-Vincent, 1753	-	-	1977 ²⁸⁹	-	Q	AT	S	Hs	I,II
<i>Asparagopsis armata</i> Harvey, 1855	1973 ²⁸⁷	1984 ²⁸⁹	1973 ²⁸⁷	1969 ²⁸⁵	E	AT/PO	S	Hs	I
<i>Asparagopsis taxiformis</i> (Delile) Trevisan de Saint-Léon, 1845	-	1984 ⁴⁶	2001 ⁵³	-	E	CT	Su	Hs	I
<i>Bonnemaisonia hamifera</i> Hariot, 1891	-	1984 ²⁸⁹	1998 ⁵³	1989 ⁴³	E	IP	?S	Hs	I
<i>Botryocladia madagascariensis</i> G. Feldmann, 1945	-	-	-	1995 ²⁶⁶	E	AT/PO	S	Hs	I
<i>Chondria curvilineata</i> F.S. Collins & Hervey, 1917	-	1984 ²⁸⁹	-	-	E	AT	S	Hs	II
<i>Colaconema codicola</i> (Børgesen) H.Stegenga, J.J.Bolton, & R.J.Anderson, 1997	1994 ⁵⁴	1984 ²⁸⁹	1990 ⁹²	1988 ⁴²	E	AT/PO	S	Hs/Ss	I
<i>Ganonema farinosum</i> (Lamouroux) Fan & Wang, 1974	1992 ⁴⁴	1899 ¹⁴⁸	1972 ⁵²	1989 ⁴²	Cr	RS/IP	Su	Hs/Ss	I
<i>Gracilaria arcuata</i> Zanardini 1858	-	1984 ²⁸⁹	-	-	Q	RS/IP	Su	Hs	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Griffithsia corallinoides</i> (Linnaeus) Trevisan, 1845	-	1986 ⁴⁶	-	-	E	AT/IP	G	Hs	I
<i>Hypnea spinella</i> (C. Agardh) Kützing, 1847	-	-	1983 ⁴¹	1989 ⁴²	E	CT	S	Hs	I
<i>Lophocladia lallemandii</i> (Montagne) Schmitz, 1893	-	-	1970 ⁶³	1986 ⁸⁸	E	IP	Su	Hs	I,II
<i>Polysiphonia fucooides</i> (Hudson) Greville, 1824	1973 ²⁸⁷	-	1973 ²⁸⁷	-	E	AT/IO	S	Hs	I,II
<i>Polysiphonia morrowii</i> Harvey, 1857	-	2007 ¹³²	-	-	E	PO	S	Hs	I
<i>Polysiphonia paniculata</i> Montagne, 1842	1972 ⁵²	-	2001 ²²⁴	1998 ²²³	E	AT/PO	S	Hs	I
<i>Polysiphonia kampsaxii</i> Boergesen, 1939	-	-	1977 ⁴⁰	1989 ⁴³	Q	IP	S	Hs	I
<i>Rhodophysema georgii</i> Batters, 1900	-	1984 ²⁸⁹	-	-	C	AT/PO	?S	Hs	I
Heterokontophyta=Ochrophyta									
<i>Cladosiphon zosteræ</i> (J.Agardh) Kylin, 1940	-	1984 ⁴⁶	1983 ¹⁶⁵	1989 ⁴³	Cr	AT	S	Hs	I
<i>Chorda filum</i> (Linnaeus) Stackhouse 1797	-	1984 ²⁸⁹	-	-	C	AT/PO	?S	Hs	I,II
<i>Colpomenia peregrina</i> Sauvageau, 1927	-	1998 ⁵¹	-	-	E	IP	S	Hs	I
<i>Ectocarpus siliculosus</i> var. <i>hiemalis</i>	1973 ²⁸⁶	1972 ⁴⁷	1899 ⁴⁸	1986 ²⁴¹	Cr	AT	S	Hs	I
(Crouan frat.ex Kjellman) T.Gallardo 1992									
<i>Halothrix lumbricalis</i> (Kützing) Reinke, 1888	1998 ⁵⁵	1984 ⁴⁶	1980 ²⁸⁹	1993 ²⁴⁰	E	AT/PO	S	Hs	I
<i>Microsporgium globosum</i> Reinke 1888	-	2003 ²⁵⁶	-	-	Q	AT	S	Hs	I
<i>Pylaiella littoralis</i> (Linnaeus) Kjellman, 1872	1984 ⁴⁸	1984 ⁴⁶	1983 ¹⁶⁶	1983 ¹⁶⁶	Cr	AT/PO	S	Hs	I
<i>Punctaria tenuissima</i> (C.Agardh) Greville, 1830	1993 ⁵⁴	-	-	-	E	AT	S	Hs	I
<i>Sargassum latifolium</i> (Turner) C.Agardh, 1820	-	1984 ²⁸⁹	1984 ²⁸⁹	-	Q	RS	?Su	Hs	I,II
<i>Sphaerotrachia firma</i> (Gepp) A.D.Zinova, 1940	-	1984 ²⁸⁹	1970 ¹⁶³	1984 ²⁸⁹	E	AT/PO	S	Hs	I
<i>Syropodium schimperi</i> (Buchinger ex Kützing) Verlaque & Boudouresque, 1991	-	-	1989 ²⁷³	1991 ⁴³	E	IP	?Su	Hs	I
Chlorophyta									
<i>Caulerpa mexicana</i> Sonder ex Kützing, 1849	-	-	-	2007 ¹³³	E	RS/IP	S	Ss	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Caulerpa racemosa</i> (Forsskål) J. Agardh var. <i>cylindracea</i> Verlaque, Huisman & Boudouresque, 1873	-	-	1993 ¹⁴¹	1995 ⁸⁹	E	CT	Su	Hs/Ss	I,II
<i>Caulerpa racemosa</i> var. <i>lamourouxii</i> f. <i>requienii</i> (Montagne) Weber-van Bosse, 1898	-	-	1998 ⁹¹	1980 ⁹⁰	E	IP	Su	Hs/Ss	I,II
<i>Caulerpa scapelliformis</i> (R. Brown ex Turner) C. Agardh, 1817	-	-	-	1995 ¹³⁸	E	IP	Su	Ss	I,II
<i>Caulerpa taxifolia</i> (M. Vahl) C. Agardh, 1817	-	-	-	2006 ⁹⁶	E	PO	S	Hs/Ss	I,II
<i>Codium fragile</i> subsp. <i>fragile</i> (Suringar) Hariot, 1889	1998 ⁴⁹	1998 ²²⁴	1983 ²⁸⁹	1998 ²²³	E	AT/PO	S	Hs	-
<i>Ulva fasciata</i> Delile, 1813	1988 ⁵⁰	1984 ⁵²	1975 ¹⁶⁴	1989 ⁴⁵	Cr	Co	Su/S	Hs	-
Phanerogame									
<i>Halophila stipulacea</i> (Forsskål) Ascherson, 1867	-	-	1956 ²⁹⁰	1967 ¹⁶⁶	E	RS/IO	Su	Hs/Ss	II
FORAMINIFERA									
<i>Agglutinella arenata</i> (Saïd, 1949)	-	2002 ¹⁷¹	-	-	C	PO	?S	?	III
<i>Amphisonus hemprichii</i> Ehrenberg, 1839	-	-	2004 ²⁰³	2002 ²⁰³	E	CT	Su	Hs/Ss	I,II
<i>Amphistegina lessonii</i> d'Orbigny, 1826	-	-	2007 ²⁰⁶	-	E	CT	Su	?	II
<i>Amphistegina lobifera</i> Larsen, 1976	-	2004 ²¹⁰	2001 ²⁰¹	1997 ³⁶	E	CT	Su	Hs/Ss	I,II
<i>Articulina alticostata</i> Cushman, 1944	-	-	2004 ²⁰²	-	C	IP	?S	?	II
<i>Astacolus insolitus</i> (Schwager, 1866)	-	-	2004 ²⁰²	-	C	PO	?S	?	III
<i>Astacolus sublegumen</i> (Parr, 1950)	-	-	2004 ²⁰²	-	C	PO	?S	?	II
<i>Brizalina simpsoni</i> (Heron-Allen & Earland, 1915)	-	-	2007 ²⁰⁶	-	C	RS	Su	?	II
<i>Clavulina angularis</i> d'Orbigny, 1826	-	-	-	2001 ³⁸	E	TA/RS	Su	?	II
<i>Clavulina</i> cf. <i>multicamerata</i> Chapman, 1907	-	-	-	2002 ²⁰³	E	RS/PO	Su	?	II
<i>Coscinospira arietina</i> (Batsch, 1791)	-	-	2008 ²⁰⁷	2002 ²⁰³	E	RS/TA	Su	?	II
<i>Coscinospira acicularis</i> (Batsch, 1791)	-	-	2007 ²⁰⁴	-	E	IP	Su	?	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Cushmanina striatopunctata</i> (Parker & Jones, 1865)	-	2007 ²¹¹	2008 ²⁰⁵	-	E	TA	?S	?	I
<i>Cyclorbiculina compressa</i> (d'Orbigny)	-	-	-	2002 ²⁰³	E	TA/PO	?S	?	II
<i>Cymbaloporella plana</i> (Cushman, 1924)	-	-	2007 ²⁰⁶	2002 ²⁰³	E	IP	Su	?	II
<i>Edentostomina cultrata</i> (Brady, 1881)	-	-	2004 ²⁰²	2002 ²⁰³	E	PO	?S	?	II
<i>Elphidium cf. charlottense</i> (Vella, 1957)	-	-	-	2002 ²⁰³	E	PO	?S	?	II
<i>Elphidium striatopunctatum</i> (Fichtel & Moll, 1798)	-	-	-	1997 ³⁶	E	RS	Su	?	II
<i>Euthymonacha polita</i> (Chapman, 1900)	-	-	2007 ²⁰⁶	-	C	PO	S	?	II
<i>Hauerina diversa</i> Cushman, 1946	-	-	2007 ²⁰⁶	1997 ³⁶	E	RS/AT	Su	?	II
<i>Heterocyclus tuberculata</i> (Möbius, 1880)	-	-	-	1988 ³⁸	E	RS	Su	?	?
<i>Heterostegina depressa</i> d'Orbigny, 1826	-	-	-	1988 ³⁸	E	CT	Su	Hs/Ss	II
<i>Miliolinella cf. hybrida</i> (Terquem, 1878)	-	-	-	2002 ²⁰³	E	RS/PO	Su	?	II
<i>Nodopthalmidium antillarum</i> (Cushman, 1922)	-	-	2002 ²⁰⁵	1995 ²⁰³	E	RS/TA	Su	?	II
<i>Planogypsina acervalis</i> (Brady, 1884)	-	-	2002 ²⁰²	2002 ²⁰³	E	RS/TA	Su	?	II
<i>Planogypsina squamiformis</i> (Chapman, 1901)	-	-	2001 ²⁰³	-	E	RS/TA	Su	?	II
<i>Pseudomassilina reticulata</i> (Heron-All. & Earland, 1915)	-	-	-	1988 ³⁸	E	RS/IP	Su	?	?
<i>Pulleniatina obliquiculata</i> (Parker & Jones, 1865)	-	-	2004 ²⁰⁹	-	C	IP	?	P	?
<i>Pyramidulina catesbyi</i> (d'Orbigny, 1839)	-	-	2008 ²⁰⁷	1988 ³⁸	E	CT	Su	?	II
<i>Pyrgo denticulata</i> (Brady, 1884)	-	-	-	2002 ²⁰³	C	RS/PO	Su	?	II
<i>Quinqueloculina cf. mosharafai</i> Saïd, 1949	-	-	-	2002 ²⁰⁵	C	RS	Su	?	II
<i>Schlumbergerina abveoliniformis</i> (Brady, 1879)	-	-	-	2002 ²⁰⁵	E	CT	Su	?	II
<i>Sorites orbiculus</i> Ehrenberg, 1839	2010 ²⁰⁸	-	2001 ²⁰¹	1988 ³⁸	E	CT	Su	Hs/Ss	I-III
<i>Sorites variabilis</i> Lacroix, 1941	-	-	2007 ²⁰⁶	2002 ²⁰⁵	E	RS	Su	Hs/Ss	II
<i>Spiroloculina angulata</i> (Cushman, 1917)	-	-	-	1988 ³⁸	E	IP	Su	?	I-II
<i>Spiroloculina antillarum</i> d'Orbigny, 1839	-	2007 ²⁰⁵	2004 ²⁰³	1988 ³⁸	E	CT	Su	?	I-II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Triloculina</i> cf. <i>fichteliana</i> d'Orbigny, 1839	-	-	2008 ²⁰⁷	2004 ²⁰³	E	RS/TA	Su	?	II
CNIDARIA									
<i>Cortylophora caspia</i> (Pallas, 1771)	-	-	2004 ¹¹³	-	E	Co	S	Hs	I
<i>Macrorhynchia philippina</i> Kirchenpauer, 1872	-	-	-	2005 ¹¹⁰	E	CT	Su	Hs	I
<i>Cassiopea andromeda</i> (Forsskål, 1775)	-	-	-	2000 ⁶⁷	E	RS/IP	Su	P	I
<i>Rhopilema normadica</i> Gall, Spanier & Ferguson, 1990	-	-	-	1995 ¹⁷⁸	E	RS/IP	Su	P	I
<i>Phyllorhiza punctata</i> von Lendenfeld, 1884	-	-	-	2010 [*]	C	RS	Su	P	I
<i>Ocullina patagonica</i> De Angelis, 1908	-	-	-	2005 ¹¹⁰	E	WA	S	Hs	I
CTENOPHORA									
<i>Mnemiopsis leidyi</i> (Agassiz, 1865)	1993 ²¹⁷	1994 ¹⁷⁹	1994 ¹⁷⁹	1992 ²⁶⁸	E	WA	S	P	I, II
<i>Beroë ovata</i> Mayer 1912	1996 ¹⁸⁰	2004 ¹⁷⁰	-	-	E	WA	S	P	I, II
SIPUNCULA									
<i>Apionsoma</i> (<i>A.</i>) <i>misakianum</i> (Ikeda, 1904)	-	-	2000 ¹³	2008 ¹⁶	E	IP/WA	S	Ss	II-IV
<i>Aspidosiphon</i> (<i>A.</i>) <i>mexicanus</i> (Murina, 1967)	-	-	2000 ¹⁵	-	E	IO/WA	S	Ss	III-IV
<i>Aspidosiphon</i> (<i>A.</i>) <i>elegans</i> (Chamisso & Eysen., 1821)	-	-	2006 ¹⁴	2005 ¹⁴	E	RS/IP	Su	Hs	I
POLYCHAETA									
<i>Lepidonotus carinulatus</i> (Grube, 1870)	-	1959 ²⁴⁶	-	-	Q	RS/IP	S	Ss	?
<i>Lepidonotus tenuisetosus</i> (Gravier, 1902)	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs	I
<i>Pistone guanche</i> San Martín, López & Núñez, 1999	-	-	-	2005 ¹⁰²	C	AT	S	Ss	I
<i>Eurythoe complanata</i> (Pallas, 1766)	-	-	-	1993 ¹³⁵	Q	?IP	Su	Hs	I
<i>Linopherus canariensis</i> Langerhans, 1881	-	-	2005 ¹⁰²	1993 ¹³⁵	E	At	S	Hs/Ss	I
<i>Podarkeopsis capensis</i> (Day, 1963)	-	-	1972 ¹³⁴	-	Q	IP	S	Ss	I
<i>Sigambra constricta</i> (Southern, 1921)	-	1959 ²⁴⁶	-	-	Q	RS/IP	S	Ss	?
<i>Sigambra parva</i> (Day, 1963)	-	-	1972 ¹³⁴	-	Q	IO	S	Ss	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Synelmis rigida</i> (Fauvel, 1919)	-	1959 ²⁴⁶	-	-	Q	RS/IP	S	Ss	?
<i>Eusyllis kupperi</i> Langerhans, 1879	-	-	-	2005 ¹⁰²	E	?AT	S	Hs	I
<i>Exogone breviannata</i> Hartmann-Schröder, 1959	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs	I
<i>Prosphaerosyllis longipapillata</i> (Hart.-Schröder, 1979)	-	-	-	2005 ¹⁰²	E	PO	S	Ss	II
<i>Syllis pectinans</i> Haswell, 1920	-	-	2004 ¹¹³	-	E	PO	S	Hs	I
<i>Ceratonereis mirabilis</i> Kinberg, 1866	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs/Ss	I-III
<i>Leonnates decipiens</i> Fauvel, 1929	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs	I
<i>Leonnates indicus</i> Kinberg, 1866	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs	I
<i>Leonnates persicus</i> Wesenberg-Lund, 1949	-	-	2001 ¹⁰⁸	2000 ¹³⁷	E	RS/IP	Su	Ss	II-IV
<i>Nereis jacksoni</i> Kinberg, 1866	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Ss	I,II
<i>Nereis persica</i> Fauvel, 1911	-	1959 ²⁴⁶	-	2005 ¹⁰²	E	RS/IP	Su	Ss	I-III
<i>Pseudonereis anomala</i> Gravier, 1900	-	-	2004 ¹⁰⁵	1973 ⁶¹	E	RS/IP	Su	Hs	I
<i>Glycinde bonhourei</i> Gravier, 1904	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Ss	I
<i>Lumbrineris perkinsi</i> Carrera-Parra, 2001	-	-	-	2005 ¹⁰²	E	IP	?Su	Hs	I,II
<i>Scoletoma debilis</i> Grube, 1878	-	1959 ²⁴⁶	-	-	Q	IP	S	Ss	?
<i>Eunice antennata</i> (Savigny, 1820)	-	-	-	1993 ¹⁹⁵	E	RS/IP	Su	Hs	I
<i>Lysidice collaris</i> Grube, 1870	-	-	1993 ¹⁰³	1993 ¹³⁵	E	RS/IP	Su	Hs/Ss	I,II
<i>Marphysa disjuncta</i> Hartman, 1961	-	-	-	2005 ¹⁹⁶	C	PO	S	Ss	III
<i>Palola valida</i> (Gravier, 1900)	-	-	-	2005 ¹⁹⁵	E	RS	Su	Hs	I
<i>Onuphis eremita oculata</i> Hartman, 1951	-	-	-	2005 ¹⁰²	E	WA	S	Ss	I,II
<i>Dorvillea similis</i> (Crossland, 1924)	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Hs/Ss	I,II
<i>Laonice norgensis</i> Sikorski, 2003	-	-	2000 ¹¹⁹	-	C	AT	S	Ss	IV
<i>Paraprionospio coora</i> Wilson, 1990	-	2008 ²⁸²	1999 ²⁸²	-	Cr	?IP	S	Ss	II-IV
<i>Polydora cornuta</i> Bosc, 1802	-	2002 ¹¹⁸	1986 ¹¹¹	-	E	WA	S	Ss	I,II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Priosteopio (Aquilaspio) krusadensis</i> Fauvel 1929	-	-	-	2005 ¹¹⁶	E	IP	S	Ss	I
<i>Priosteopio (A.) sexoculata</i> Augener, 1918	-	-	-	2005 ¹¹⁶	E	RS/IP	S	Ss	I
<i>Priosteopio (Priosteopio) depauperata</i> Imajima, 1990	-	-	2000 ¹⁹	2005 ¹¹⁶	E	PO	S	Ss	I,II
<i>Priosteopio (P.) paucipinnulata</i> Blake & Kudenov, 1978	-	-	2000 ¹¹⁷	2009 ¹¹⁷	E	PO	S	Ss	I,II
<i>Priosteopio (P.) saccifera</i> Mackie & Hartley, 1990	-	-	2000 ¹¹⁹	1995 ¹⁰⁴	E	RS/IP	Su	Ss	I-III
<i>Priosteopio (Minuspio) pulchra</i> Imajima 1990	-	2008 ⁰⁷	2000 ¹¹⁹	-	E	IP	S	Ss	I-II
<i>Pseudopolydora paucibranchiata</i> Okuda, 1937	-	2008 ⁰⁷	2000 ¹¹⁵	2005 ¹¹⁵	E	IP	S	Hs/Ss	I
<i>Spitophanes algidus</i> Meißner, 2005	-	-	2000 ¹¹⁹	-	C	IO	S	Ss	IV
<i>Sreblospio gynobranchiata</i> Rice & Levin, 1998	-	2005 ¹¹²	2000 ¹¹¹	-	E	WA	S	Ss	I,II
<i>Capitellethus dispar</i> (Ehlers, 1907)	-	1959 ²⁴⁶	-	-	Q	RS/IP	S	Ss	?
<i>Dasybranchus carneus</i> Grube, 1870	-	1959 ²⁴⁶	-	-	Q	RS	S	Ss	?
<i>Neopseudocapitella brasiliensis</i> Rullier & Amoureaux, 1979	-	-	2001 ⁰⁹	-	E	RS/WA	S	Ss	II
<i>Notomastus aberans</i> Day, 1957	-	-	1980 ²³⁸	2000 ²¹⁶	E	IP	Su	Ss	I-III
<i>Notomastus mossambicus</i> (Thomassin, 1970)	-	-	-	2005 ¹⁰²	E	IO	Su	Ss	I-III
<i>Chaetozone corona</i> Berkeley & Berkeley, 1941	-	2010 ⁰⁷	1980 ¹⁰⁶	2005 ¹⁰²	Cr	?PO	S	Ss	I,II
<i>Timarete anchylochaeta</i> (Schmarda, 1861)	-	1959 ²⁴⁶	-	-	Q	IP	S	Ss	?
<i>Timarete caribous</i> (Grube, 1859)	-	-	-	2005 ¹⁰²	C	WA	S	Hs	I
<i>Timarete dasylophius</i> (Marenzeller, 1879)	-	1959 ²⁴⁶	-	-	Q	IP	S	Ss	?
<i>Timarete punctata</i> (Grube, 1859)	-	-	-	2005 ¹⁰¹	E	RS/IP	Su	Hs	I
<i>Pherusa parvata</i> (Grube, 1878)	-	-	-	2005 ¹⁰²	E	IP	S	Hs	I
<i>Pherusa saldanha</i> Day, 1961	-	-	-	2005 ¹⁰²	E	IO	S	Hs	I
<i>Metasychis gotoi</i> (Izuka, 1902)	-	2008 ¹⁰⁷	1996 ¹³⁶	2000 ¹⁰²	E	RS/IP	Su	Ss	II,III
<i>Loimia medusa</i> (Savigny, 1818)	-	1959 ²⁴⁶	-	-	Q	RS	?Su	Ss	?

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Pista unibranchia</i> Day, 1963	-	-	1998 ²⁰⁹	1993 ¹³⁵	E	RS/IP	Su	Ss	I,II
<i>Pobycirus twisti</i> Potts, 1928	-	-	-	2005 ¹⁰²	E	RS	Su	Hs/Ss	I
<i>Sreblosoma comatus</i> (Grube, 1856)	-	-	-	2005 ¹⁰²	E	IP	?Su	Hs	I
<i>Branchionma bairdi</i> (McIntosh, 1885)	-	-	-	2005 ¹⁰²	E	WA/PO	?S	Hs/Ss	I
<i>Branchionma luctuosum</i> Grube, 1869	-	-	-	2005 ¹¹⁰	E	RS/IP	Su	Hs	I
<i>Desdemona omata</i> Banse, 1957	-	2005 ¹¹²	-	-	E	IP	S	Ss	I
<i>Laonome triangularis</i> Hutchings & Murray, 1984	-	-	-	2005 ¹⁰²	E	PO	S	Ss	I
<i>Ficopomatus enigmaticus</i> (Fauvel, 1923)	-	1952 ¹²³	1972 ¹³⁴	-	E	ST	S	Hs	I
<i>Hydroides brachyacanthus</i> Rioja, 1941	-	-	-	2005 ¹⁰⁰	E	IP	?S	Hs	I
<i>Hydroides dianthus</i> (Verrill, 1873)	-	-	1865 ²⁴⁵	-	E	WA	S	Hs	I
<i>Hydroides diramphus</i> Mörech, 1863	-	1894 ²²⁷	-	2005 ¹⁰⁰	E	CT	S	Hs	I
<i>Hydroides elegans</i> (Haswell, 1883)	-	-	1972 ¹³⁴	1991 ⁶²	E	CT	S	Hs	I
<i>Hydroides heterocerus</i> (Grube, 1868)	-	-	-	2005 ¹⁰⁰	E	RS/IO	Su	Hs	I,II
<i>Hydroides homoceros</i> Pixell, 1913	-	-	-	2005 ¹⁰⁰	E	RS/IO	Su	Hs	I
<i>Hydroides minax</i> (Grube, 1878)	-	-	-	2005 ¹⁰⁰	E	IP	Su	Hs	I
<i>Hydroides operculatus</i> (Treadwell, 1929)	-	-	-	2005 ¹⁰⁰	E	IO	S	Hs	I
<i>Spirobranchus kraussi</i> (Baird, 1865)	-	-	-	2005 ¹⁰⁰	E	IP	Su	Hs	I
<i>Spirobranchus tetracerus</i> (Schmarda, 1861)	-	-	-	2005 ¹⁰⁰	E	IP	Su	Hs	I,II
<i>Janua</i> (<i>Dextospira</i>) <i>steueri</i> (Sterzinger, 1909)	-	-	-	2005 ¹⁰²	E	RS/IP	Su	Ss	I,II
<i>Spirobranchus marioni</i> Caullery & Mesnil, 1897	-	-	1987 ¹⁸³	2005 ¹⁰²	E	PO	S	Hs	I
PANTOPODA									
<i>Anoplodactylus californicus</i> Hall, 1912	-	-	-	1959 ²⁵¹	E	CT	Su	Hs	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
CRUSTACEA									
Copepoda									
<i>Centropages furcatus</i> (Dana, 1846)	-	2000 ²⁷⁰	-	1999 ²⁵⁹	E	RS/IP	Su	P	I-III
<i>Calanopia elliptica</i> (Dana, 1846)	-	-	-	1999 ²⁵⁹	E	RS/IP	Su	P	I
<i>Calanopia biloba</i> Bowman, 1957	-	-	-	2002 ²⁶⁹	E	RS/IP	Su	P	I-III
<i>Calanopia minor</i> Scott, 1902	-	-	-	1998 ²⁶⁹	C	RS/IP	Su	P	I-III
<i>Labidocera pavo</i> Giesbrecht, 1889	-	-	-	1999 ²⁵⁹	E	RS/IP	Su	P	I
<i>Subeucalanus suberassus</i> (Giesbrecht, 1888)	-	-	-	1998 ²⁶⁹	Q	IP	Su	P	I-III
<i>Parvocalanus latus</i> Andronov, 1972	-	1998 ²⁷⁰	-	1998 ²⁶⁹	E	IO	Su	P	I-III
<i>Parvocalanus elegans</i> Andronov, 1972	-	2000 ²⁷⁰	-	1998 ²⁶⁹	E	RS/IP	Su	P	I-III
<i>Acartia tonsa</i> Dana, 1848	-	1993 ¹⁶⁷	2001 ²⁵⁷	-	E	WA, IP	S	P	I
<i>Paracartia grani</i> Sars G.O., 1904	-	-	1998 ³⁰⁰	-	E	AT	S	P	I
<i>Spinocalanus temanovae</i> Damkar, 1975	-	-	-	1987 ²⁶⁹	Q	?	S	P	?
Cirripedia									
<i>Amphibalanus eburneus</i> (Gould, 1841)	1968 ²⁴⁴	1939 ²¹⁸	1968 ²⁴⁴	1968 ²⁴⁴	E	AT	S	Hs	I
<i>Balanus trigonus</i> Darwin, 1854	-	-	1993 ¹⁹⁰	-	E	CT	S	Hs	I
<i>Heterosaccus dollfusi</i> Boschma, 1960	-	-	-	1994 ²⁴²	E	RS	Su	Pz	I-II
Amphipoda									
<i>Elasmopus pectenicrus</i> (Bate, 1862)	-	-	-	2005 ²⁵⁰	C	CT	Su	Hs	I
<i>Gammaropsis togoensis</i> (Schellenberg, 1925)	-	-	-	2005 ²⁵⁹	E	Co	Su	Hs	I
<i>Haminera hamigera</i> (Haswell, 1879)	-	-	1976 ¹⁸⁶	1976 ¹⁸⁶	E	IP	Su	Hs	I
<i>Monocorophium sextonae</i> (Crawford, 1937)	-	2006 ³⁷	-	-	C	PO	S	Hs/Ss	II
<i>Parhyale explorator</i> Arresti, 1989	-	-	-	2005 ²⁵⁸	C	AT	S	Hs	I
<i>Stenothoe gallensis</i> Walker, 1904	-	-	1977 ¹⁸⁶	1976 ¹⁸⁶	E	IP	Su	Hs/Ss	I-II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
Isopoda									
<i>Paradella diana</i> Menzies, 1962	-	-	2004 ¹¹³	-	E	Co	?S	Hs/Ss	I
<i>Sphaeroma walkeri</i> (Stebbing, 1905)	-	-	1995 ¹⁸²	-	E	IP	Su	Hs	I
Cumacea									
<i>Eucoma sarsii</i> (Kossmann, 1880)	-	-	1976 ¹⁷⁴	-	E	IP	Su	Hs/Ss	I,II
Decapoda									
<i>Fenneropenaeus merguensis</i> (De Man, 1888)	-	-	-	2006 ²³⁴	C	IP/PG	Aq	Ss	II
<i>Farfantepenaeus aztecus</i> (Ives, 1891)	-	-	-	2009 ¹²⁵	C	WA	S	Ss	II
<i>Marsupenaeus japonicus</i> (Bate, 1888)	-	2001 ²⁸³	2001 ²⁸³	1930 ²¹⁵	E	IP	Su	Ss	I-III
<i>Melicerus halhor</i> (Burkenroad, 1959)	-	-	2005 ²³⁰	2002 ¹⁹⁴	E	IP	Su	Ss	I-II
<i>Metapenaeopsis aegyptia</i> Galil & Golani, 1990	-	-	-	2003 ²⁷⁶	E	IP	Su	Ss	I
<i>Metapenaeopsis mogensis consobrina</i> (Nobili, 1904)	-	-	-	2003 ²⁷⁶	E	IP	Su	Ss	I
<i>Metapenaeus affinis</i> (H. Milne Edwards, 1837)	-	-	2008 ³⁹	-	E	IP	Su	Ss	I-II
<i>Metapenaeus monoceros</i> (Fabricius, 1798)	-	-	-	1959 ¹⁶⁸	E	IP	Su	Ss	I-II
<i>Metapenaeus stebbingi</i> (Nobili, 1904)	-	-	-	1966 ¹⁸⁵	E	RS/O	Su	Ss	I-III
<i>Penaeus semisulcatus</i> de Haan, 1844	-	-	-	1930 ¹⁶¹	E	IP	Su	Ss	I-IV
<i>Trachysalambria palaestinensis</i> Steinitz, 1932	-	-	-	1968 ¹⁵³	E	IO	Su	Ss	I-V
<i>Leptocheila pugnax</i> de Man, 1916	-	-	2000 ³³	1966 ¹⁸⁵	E	IP	Su	Ss	I-IV
<i>Palaemonella rotumana</i> (Borradaile, 1898)	-	-	-	1999 ³⁵	E	IP	Su	Hs	I-II
<i>Urocaridella pulchella</i> Yokes & Galil, 2006	-	-	-	2003 ²⁷⁹	E	IP	Su	?	II
<i>Alpheus audouini</i> Coutière, 1905	-	-	-	2002 ¹⁴⁹	E	IP	Su	Hs	I-II
<i>Alpheus inopinatus</i> Holthuis & Gottlieb, 1958	-	-	-	1969 ¹⁵¹	E	IP	Su	Hs/Ss	I-II
<i>Alpheus migrans</i> Lewinsohn & Holthuis, 1978	-	-	-	1993 ¹⁸⁷	E	RS	Su	Ss	I-III
<i>Alpheus rapacida</i> de Man, 1908	-	-	2005 ²³⁰	1981 ¹⁸⁵	E	IP	Su	Ss	I-III

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Ogyrides njoiebergi</i> (Balss, 1921)	-	-	-	2005 ²³²	E	IP	Su	Ss	I
<i>Processa macrodactyla</i> Holthuis, 1952	-	-	1995 ³⁴	-	E	TA	G	Ss	II
<i>Calappa hepatica</i> (Linnaeus, 1758)	-	-	-	1992 ⁶⁰	C	IP	Su	Ss	I-III
<i>Ixa monodi</i> Holthuis & Gottlieb, 1956	-	-	2005 ⁸⁶	1955 ¹⁶⁹	E	RS	Su	Ss	I-II
<i>Coleusia signata</i> (Paulson, 1875)	-	2006 ³²	-	1976 ¹⁵⁹	E	RS	Su	Hs/Ss	I-II
<i>Euycarcinus integrifrons</i> De Man, 1879	-	-	-	2009 ²³³	C	IO	S	Ss	II
<i>Myra subgranulata</i> Kossmann, 1877	-	-	-	1930 ²¹⁵	E	RS/IO	Su	Ss	I-IV
<i>Micippa thalia</i> (Herbst, 1803)	-	-	2006 ²⁸¹	1994 ¹²⁹	E	IP	Su	Ss	I-IV
<i>Callinectes sapidus</i> Rathbun, 1896	-	2001 ²⁸³	1967 ¹⁸⁴	1959 ¹⁶⁸	E	WA	S	Ss	I-II
<i>Charybdis hellerii</i> (H. Milne Edwards, 1867)	-	-	2005 ²³⁰	1987 ¹²⁸	E	IP	Su	Hs/Ss	I-II
<i>Charybdis longicollis</i> Leene, 1938	-	-	2002 ²⁸¹	1959 ¹⁶⁸	E	IP	Su	Ss	I-IV
<i>Portunus segris</i> (Forskål, 1775)	-	-	2004 ²⁸¹	1928 ¹⁶⁰	E	IP	Su	Ss	I-IV
<i>Thalamita poissionii</i> (Audouin, 1826)	-	-	1981 ¹⁸⁵	1959 ¹⁶⁸	E	IP	Su	Ss	I-II
<i>Carupa tenuipes</i> Dana, 1851	-	-	2003 ²⁸¹	1996 ²⁷⁶	E	IP	Su	Hs	I-II
<i>Pilumnopus vauquelini</i> (Audouin, 1826)	-	-	-	1966 ¹⁸⁵	E	RS/PG	Su	Hs	I
<i>Pilumnus minutus</i> De Haan, 1835	-	-	2000 ¹⁸⁸	2003 ¹⁸⁸	C	IP	Su	Hs	I
<i>Atergatis roseus</i> (Rüppell, 1830)	-	-	2004 ²⁸¹	1987 ¹²⁸	E	IP	Su	Hs	I-II
<i>Daira perlata</i> (Herbst, 1790)	-	-	-	1988 ¹²⁹	C	IP	Su	Hs/Ss	I-II
<i>Eucreate crenata</i> de Haan, 1835	-	-	-	1987 ¹²⁸	E	IP	Su	Ss	I-IV
<i>Percnon gibbesi</i> (H. Milne Edwards, 1853)	-	-	-	2005 ²⁷⁸	E	AT/TA	S	Hs	I-II
<i>Macrophtalmus graeffei</i> Milne Edwards, 1873	-	-	2000 ³³	1994 ¹²⁹	E	IP	Su	Ss	I-IV
Stomatopoda									
<i>Clorida albolitura</i> Ahyong & Naiyanetr, 2000	-	-	-	2009 ¹⁵⁰	E	IP	Su	Ss	II
<i>Eragosquilla massavensis</i> (Kossmann, 1880)	-	2002 ¹⁷⁵	2007 ²³¹	1959 ¹⁶⁸	E	IP	Su	Ss	I-IV

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
MOLLUSCA									
Gastropoda									
<i>Diodora ruppellii</i> (Sowerby, G.B.I., 1834)	-	-	-	1988 ¹³⁰	E	RS/IP	Su	Hs	I
<i>Nerita sanguinolenta</i> Menke, 1829	-	-	-	2004 ¹⁴²	E	RS	Su	Ss	I
<i>Smaragdia souverbiana</i> (Montrouzier, 1863)	-	-	-	1989 ⁸³	E	RS/IP	Su	Ss	I
<i>Trochus erythreus</i> Brocchi, 1821	-	-	-	1992 ¹²⁶	E	RS	Su	Hs	I
<i>Pseudomolinia nelyma</i> (Melville, 1897)	-	-	-	1992 ¹²⁶	E	RS/IO	Su	Ss	I,II
<i>Parviturbo dibellai</i> Buzzurro & Greppi, 2006	-	-	-	2006 ⁸²	Cr	?	?S	Ss	I
<i>Stomatella impertusa</i> (Burrow, 1815)	-	-	-	1999 ²⁴⁹	C	RS/IP	Su	Hs	I
<i>Cerithium scabridum</i> Philippi, 1848	-	-	1990 ⁹	1986 ¹⁹⁷	E	RS/IO	Su	Hs/Ss	I
<i>Cerithidium diplax</i> (Watson, 1886)	-	-	-	1986 ⁴	E	PG	S	Ss	I-II
<i>Cerithidium perparvulum</i> (Watson, 1886)	-	-	-	1995 ⁴	E	PO	S	Ss	I
<i>Rhinoclavis kochi</i> (Philippi, 1848)	-	-	-	1986 ¹⁹⁷	E	RS/IP	Su	Ss	I
<i>Diala varia</i> A. Adams, 1861	-	-	-	2002 ¹²¹	E	RS/IP	Su	Ss	I
<i>Gibborissoa virgata</i> (Philippi, 1849)	-	-	-	1997 ³	E	IP	Su	?	?
<i>Alvania dorbignyi</i> (Audouin, 1826)	-	-	-	1996 ⁸⁴	Cr	Co	?	Ss	I,II
<i>Finella pupoides</i> A. Adams, 1860	-	-	2001 ²³⁷	1958 ⁴	E	IP	Su	Ss	I
<i>Cerithiopsis pulvis</i> (Issel, 1869)	-	-	2003 ²³⁵	1990 ²⁶²	E	RS	Su	Ss	I
<i>Cerithiopsis tenthrenois</i> (Melville, 1896)	-	-	-	1990 ²⁶²	E	IO	Su	Ss	I
<i>Metaxia bacillum</i> (Issel, 1869)	-	-	-	1992 ¹²⁶	E	RS	Su	?	?
<i>Rissoina ambigua</i> (Gould, 1849)	-	-	-	2003 ²¹³	C	IP	?	Ss	II
<i>Rissoina bertholleti</i> Issel, 1869	-	-	-	1985 ¹³⁰	E	RS/IO	Su	Ss	I
<i>Conomurex persicus</i> (Swainson, 1821)	-	-	1991 ²²⁰	1978 ²¹⁹	E	PG	?S	Hs/Ss	I,II
<i>Purpuradusta gracilis notata</i> (Gill, 1858)	-	-	-	1982 ⁷⁸	E	RS/IO	Su	Hs	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Cycloscala hyalina</i> (Sowerby, 1844)	-	-	-	1995 ¹⁵⁴	E	RS/IP	Su	Ss	I
<i>Sticteulima</i> cf. <i>lentiginosa</i> (A. Adams, 1861)	-	-	-	1989 ²⁶¹	C	IP	?Su	?	?
<i>Ergalatax junionae</i> Houart, 2008	-	-	2002 ¹⁷²	1992 ¹²⁶	E	RS	S	Hs	I
<i>Thais lacera</i> (Bom, 1778)	-	-	-	1991 ²²⁰	E	PG/O	S	Hs/Ss	I
<i>Rapana venosa</i> (Valenciennes, 1846)	1960 ¹⁴⁶	1993 ²⁶	1995 ¹²⁶	-	E	PO	S	Ss	I
<i>Zafra savignyi</i> (Moazzo, 1939)	-	-	-	1986 ²	E	RS	Su	Ss	I, II
<i>Zafra selaphora</i> (Melvill & Standen, 1901)	-	-	-	1993 ²⁴³	E	RS/O	Su	Ss	I
<i>Lienardia mighelsi</i> Iredale & Tomlin, 1917	-	-	2003 ²¹³	-	C	IP	?Su	?	III
<i>Murchisonella columna</i> (Hedley, 1907)	-	-	-	1993 ⁷⁹	E	IP	?Su	Hs	I
<i>Chysallida fischeri</i> (Hornung & Mermod, 1925)	-	-	-	1989 ²¹²	E	RS	?Su	Ss	I
<i>Chysallida maiae</i> (Hornung & Mermod, 1924)	-	-	-	1963 ¹	E	RS	Su	Hs/Ss	I
<i>Chysallida micronana</i> (Öztürk & Aartsen, 2006)	-	-	2000 ²³⁶	1997 ²³⁶	C	RS	?S	Ss	I, II
<i>Chysallida pirintheta</i> (Melvill, 1910)	-	-	-	1989 ²¹²	E	RS	Su	Ss	I, II
<i>Amathina tricarinata</i> (Linnaeus, 1767)	-	-	-	2000 ⁹⁹	E	RS	Su	Hs	I
<i>Leucotina</i> cf. <i>eva</i> Thiele, 1935	-	-	2000 ²³⁹	1995 ¹⁵⁴	C	IP	?Su	Ss	I, II
<i>Leucotina natalensis</i> Smith, 1910	-	-	-	1986 ⁸	E	RS/IP	?Su	Ss	I
<i>Monotigma fuba</i> (A. Adams, 1853)	-	-	2008 ⁵	-	C	IP	Su	Ss	II
<i>Monotigma lauta</i> (A. Adams, 1853)	-	-	-	1989 ²¹²	E	RS/IP	Su	Ss	I, II
<i>Cingulina isseli</i> (Tryon, 1886)	-	-	-	1986 ¹¹	E	RS	Su	Ss	I
<i>Turbonilla edgarii</i> (Melvill, 1896)	-	-	-	1989 ²¹²	E	IP	Su	Ss	?
<i>Symola cinctella</i> A. Adams, 1860	-	-	-	1994 ¹⁰	C	RS/IP	Su	Ss	I
<i>Symola fasciata</i> Jickeli, 1882	-	-	2001 ²³⁷	1963 ¹¹	E	IP	Su	Ss	I
<i>Symola lendix</i> (A. Adams, 1853)	-	-	-	1988 ²¹²	E	PG	?Su	Ss	I
<i>Olostomia lonioli</i> (Hornung & Mermod, 1924)	-	-	-	2007 ¹²¹	C	RS	?Su	Ss	I, II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Iolaea neofelixoides</i> (Nomura, 1936)	-	-	-	1994 ¹⁰	C	PO	?S	Ss	I
<i>Hinemoa cylindrica</i> (de Folin, 1879)	-	-	-	1992 ⁸⁵	C	IP	?S	?	?
<i>Acteocina criihodes</i> Melvill & Standen, 1907	-	-	-	2003 ²¹³	C	IP	?S	Ss	II
<i>Acteocina mucronata</i> (Philippi, 1849)	-	-	-	1986 ¹²	E	RS	Su	Ss	?
<i>Cylindrina girardi</i> (Audouin, 1826)	-	-	1996 ⁸⁴	1990 ¹²	E	IP	Su	Ss	II
<i>Pyronculus fourierii</i> (Audouin, 1826)	-	-	-	1989 ¹¹	E	RS/IP	Su	Ss	II,III
<i>Bulla arabica</i> Malaquias & Reid, 2008	-	-	-	2001 ²⁸⁰	E	IP	?Su	Ss	II
<i>Haminoea cyanomarginata</i> Heller & Thomson, 1983	-	-	2002 ²⁸⁰	2002 ²⁸⁰	E	RS	Su	Hs	II
<i>Alys angustatus</i> Smith, 1872	-	-	-	1986 ⁷	Cr	RS	Su	Ss	I
<i>Chelidonura fulvipunctata</i> Baba, 1938	-	-	-	1959 ²⁵³	E	IP	?Su	Ss	I,II
<i>Oxynoe viridis</i> (Pease, 1861)	-	-	-	2002 ²⁸⁰	E	IP	?Su	Ss	I
<i>Elysia grandifolia</i> Kelaart, 1858	-	-	-	2001 ²⁸⁰	E	IO	?Su	Hs	I
<i>Elysia tomentosa</i> Jensen, 1997	-	-	-	2001 ²⁸⁰	E	?IP	?Su	Hs	I,II
<i>Aplysia dactylomela</i> Rang, 1828	-	-	-	2005 ¹¹⁰	E	CT	?Su	Hs	I
<i>Aplysia parvula</i> Guilding in Mörch, 1863	-	1961 ²⁵³	2004 ²⁶⁷	1961 ²⁵³	Cr	CT	?	Hs	I
<i>Bursatella leachii</i> Blainville, 1817	-	-	1959 ²⁵³	1959 ²⁵³	E	CT	?Su	Hs	I
<i>Siphonota geographica</i> (Adams & Reeve, 1850)	-	-	-	1999 ⁸¹	E	IP	Su	Ss	I,II
<i>Plocamopherus ocellatus</i> Rüppell & Leuckart, 1830	-	-	-	1998 ²⁸⁰	E	RS	Su	Hs	I
<i>Hypselodoris infucata</i> Rueppell & Leuckart, 1828	-	-	-	1999 ⁹³	E	RS/IP	Su	Hs	I
<i>Chromodoris annulata</i> Eliot, 1904	-	-	-	2008 ¹⁵⁶	E	RS/IP	Su	Hs	I
<i>Chromodoris quadricolor</i> (Rüppell & Leuckart 1830)	-	-	-	2004 ²³⁷	C	RS/IO	?Su	Hs	II
<i>Melibe viridis</i> (Kelaart, 1858)	-	-	-	2000 ²⁸⁰	E	IP	?Su	Hs	I
<i>Flabellina rubrolineata</i> (O'Donoghue, 1929)	-	-	2003 ²⁸⁰	2001 ²⁸⁰	E	RS/IP	Su	Hs	I,II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Siphonaria crenata</i> de Blainville 1827	-	-	-	1999 ²⁸	E	RS/PG	Su	Hs	I
Bivalvia									
<i>Anadara transversa</i> (Say, 1822)	-	-	1977 ¹²⁴	-	E	WA	S	Ss	I,II
<i>Anadara inflata</i> (Reeve, 1844)	-	-	-	1998 ⁹⁸	C	IO	S	Ss	?
<i>Anadara kagoshimensis</i> (Tokunaga, 1906)	2003 ²³	1993 ²⁵	1995 ¹²⁶	-	E	IP	S	Ss	I,II
<i>Anadara natalensis</i> (Krauss, 1848)	-	-	-	1985 ²²⁰	E	RS/IO	Su	Ss	I,II
<i>Brachidontes phanaonis</i> (Fischer, P., 1870)	-	-	1990 ⁹	1978 ¹⁸¹	E	RS/IO	Su	Hs	I
<i>Septifer bilocularis</i> (Linnaeus, 1758)	-	-	-	2006 ²⁷	C	RS	S	Hs	II
<i>Septifer forskali</i> Dunker, 1855	-	-	-	2001 ²⁸	E	RS	S	Hs	I
<i>Crassostrea gigas</i> (Thunberg, 1793)	-	2004 ³⁰	-	1998 ⁹⁴	E	PO	Aq	Hs	I
<i>Saccostrea cucullata</i> (Born, 1778)	-	-	-	1998 ⁹⁴	E	RS/IP	S	Hs	I,II
<i>Dendrostrea frons</i> (Linnaeus, 1758)	-	-	-	1998 ⁹⁷	E	IP	?S	Hs	I
<i>Pinctada radiata</i> (Leach, 1814)	-	-	1990 ³⁶²	1982 ¹⁸¹	E	RS/IP	Su	Hs	I
<i>Electroma vexillum</i> (Reeve, 1857)	-	-	-	2002 ⁹⁵	E	RS/IP	Su	Hs	I
<i>Maifundus regulus</i> (Forsskål, 1775)	-	-	-	1973 ¹⁴³	E	RS/IP	Su	Hs	I
<i>Spondylus cf. multisetosus</i> Reeve, 1856	-	-	-	1992 ⁹⁷	Q	IP	?Su	Hs	I,II
<i>Spondylus spinosus</i> Schreibers, 1793	-	-	-	1991 ⁹⁷	E	RS/IP	Su	Hs	I,II
<i>Cardites akabana</i> (Sturany, 1899)	-	-	-	2005 ⁹⁹	C	RS	Su	Ss	I
<i>Chama aspersa</i> Reeve, 1846	-	1990 ⁸	2006 ²¹⁴	1993 ¹²²	E	RS/IP	?S	Hs	I
<i>Chama pacifica</i> Broderip, 1834	-	-	-	2000 ⁹⁷	E	RS/IP	Su	Hs	I,II
<i>Fulvia fragilis</i> (Forsskål, 1775)	-	-	2001 ²³⁸	1986 ¹⁹⁷	E	RS/IO	Su	Ss	I
<i>Afrocardium richardi</i> (Audouin, 1826)	-	-	-	2000 ⁶	E	RS	Su	Ss	?
<i>Tellina valtonis</i> Hanley, 1844	-	-	-	1995 ¹⁵⁴	C	RS/IO	Su	Ss	I
<i>Teredo navalis</i> Linnaeus, 1758	2007 ²⁵⁴	1966 ²²¹	2007 ²⁵⁴	2007 ²⁵⁴	Cr	CT	S	Hs	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Psammotreta praerupta</i> (Salisbury, 1934)	-	-	-	1992 ¹²⁷	C	WA	S	Ss	IV
<i>Gafarium pectinatum</i> (Linnaeus, 1758)	-	-	-	1986 ¹⁹⁷	E	RS/IP	Su	Ss	I
<i>Petricola henprichi</i> Issel, 1869	-	-	-	1999 ⁹⁹	Q	RS	Su	Hs	I
<i>Clementia papyracea</i> (Gmelin, 1791)	-	-	-	1985 ¹³⁰	E	RS/IP	Su	Ss	III
<i>Paphia textile</i> (Gmelin, 1791)	-	-	-	1985 ¹³⁰	E	RS/IP	Su	Ss	I,II
<i>Ruditapes philippinarum</i> (Adams & Reeve, 1850)	-	2004 ²⁴	2000 ²⁹	-	E	PO	Aq	Ss	I
<i>Antigona lamellaris</i> Schumacher, 1817	-	-	-	1988 ¹²⁷	C	RS/IP	Su	Ss	I
<i>Mya arenaria</i> Linnaeus, 1758	-	1993 ²⁵	2008 ⁸⁵	-	E	WA	S	Ss	II
<i>Sphenia rueppelli</i> A. Adams, 1850	-	-	-	1998 ²⁸⁴	E	IO	?Su	Hs	I
<i>Gastrochaena cymbium</i> Spengler, 1783	-	-	-	1990 ²²⁰	E	RS/IP	Su	Ss	I-III
<i>Latemula anatina</i> (Linnaeus, 1758)	-	-	-	1992 ¹²⁶	E	RS/IP	Su	Ss	I-III
Cephalopoda									
<i>Octopus aegina</i> Gray, 1849	-	-	-	1992 ²⁴⁸	E	IP	Su	Ss	III
<i>Sepioteuthis lessoniana</i> Lesson, 1830	-	-	-	2002 ²⁴⁷	E	IP	Su	P	I-III
BRYOZOA									
<i>Celleporaria brunnea</i> (Hincks, 1884)	-	-	2004 ¹⁸⁹	-	E	AT	S	Ss	I
<i>Rhynchozoon larreyi</i> (Audouin, 1826)	-	-	1962 ²⁷¹	-	E	RS/IP	Su	Ss	I
ECHINODERMATA									
<i>Amphiodia (Amphispina) oblecta</i> Mortensen, 1940	-	-	-	2005 ²⁵²	E	IP	S	Ss	I-III
<i>Asterias rubens</i> Linnaeus, 1758	2003 ¹⁷³	1990 ²²	-	-	E	AT	S	Hs	I,II
<i>Diadema setosum</i> (Leske, 1778)	-	-	-	2006 ²⁷⁷	C	RS/IP	Su	Hs	I
<i>Ophiactis macrolepidota</i> Marktanner-Turneretscher, 1887	-	-	-	2005 ²⁵²	C	AT/PO	Su	Ss	I
<i>Ophiactis savignyi</i> (Müller & Troschel, 1842)	-	-	1993 ¹⁰³	2005 ²⁵²	E	RS/IP	Su	Hs	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Synaptula reciprocans</i> (Forsskål, 1775)	-	-	2001 ²⁸³	2005 ¹¹⁰	E	RS/IP	Su	Hs	I,II
CHAETOGNATHA									
<i>Ferosagitta galerita</i> (Dallot, 1971)	-	-	-	2003 ²⁵⁸	E	IO	S	P	I,II
TUNICATA									
<i>Phallusia nigra</i> Savigny, 1816	-	-	-	2005 ¹¹⁰	E	WA	?S	Hs	I,II
<i>Pyura</i> (= <i>Herdmania</i>) <i>momus</i> (Savigny, 1816)	-	-	-	2001 ¹¹⁰	E	RS	Su	Hs	I,II
<i>Synplegma brakenhielmi</i> (Michaelsen, 1904)	-	-	-	2005 ¹¹⁰	E	RS/IO	Su	Hs	I,II
PISCES									
Elasmobranchii									
<i>Carcharhinus altimus</i> (Springer, 1950)	-	-	-	1994 ⁵⁶	C	TA	G	Ss	I-VI
<i>Himantura uarnak</i> (Forsskål, 1775)	-	-	-	1966 ⁶⁵	E	RS/IP	Su	Ss	I,II
Actinopterygii									
<i>Chirocentrus dorab</i> (Forsskål, 1775)	-	-	-	1999 ¹⁷	Q	RS/IP	Su	P	I-III
<i>Dussumieria elopsooides</i> Bleeker, 1849	-	-	-	1952 ⁶⁴	E	RS/IP	Su	P	I,II
<i>Etrumeus teres</i> (DeKay, 1848)	-	-	2002 ²²⁵	1994 ⁵⁷	E	RS/IP	Su	P	I,II
<i>Herklotsichthys punctatus</i> (Rüppell, 1837)	-	-	-	1984 ²⁷⁴	E	RS	Su	P	I,II
<i>Enchelycore anatina</i> (Lowe, 1839)	-	-	2002 ²²⁵	1998 ³¹	E	TA	G	Hs	I,II
<i>Pisodonophis semicinctus</i> (Richardson, 1848)	-	-	-	2009 ⁷⁴	C	TA	G	Ss	I
<i>Bregmaceros atlanticus</i> Goode & Bean, 1886	-	-	2005 ¹⁴⁴	2002 ²⁷⁵	E	CT	Su/S	Ss	I, II
<i>Saurita undosquamis</i> (Richardson, 1848)	-	-	1973 ⁶⁶	1951 ¹⁹²	E	RS/IP	Su	Ss	I-III
<i>Parexocoetus mento</i> (Valenciennes, 1846)	-	-	1966 ⁶⁵	1966 ⁶⁵	E	RS/IP	Su	P	I
<i>Hemiramphus far</i> (Forsskål, 1775)	-	-	1942 ²⁶⁰	1942 ¹⁹¹	E	RS/IP	Su	P	I
<i>Fistularia commersonii</i> (Rüppell, 1835)	-	-	2002 ⁷⁷	2001 ⁷⁵	E	IP/IO	Su	Hs/Ss	I,II
<i>Hippocampus fuscus</i> Rüppell 1838	-	-	-	2003 ¹⁵⁸	E	RS/IO	Su	Ss	I

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Syngnathus rostellatus</i> Nilsson, 1855	-	-	-	2003 ¹⁵⁸	Q	BA	G	Hs/Ss	I
<i>Atherinonotus forskalii</i> (Rüppell, 1838)	-	-	1966 ¹⁵²	1949 ¹⁹¹	E	RS/IP	Su	P	I
<i>Sargocentron rubrum</i> (Forsskål, 1775)	-	-	1949 ¹⁹¹	1949 ¹⁹¹	E	RS/IP	Su	Hs	I-III
<i>Pelates quadrilineatus</i> (Bloch, 1790)	-	-	-	1984 ¹⁹⁹	E	RS/IP	Su	Ss	I,II
<i>Pomadoury stridens</i> (Forsskål, 1775)	-	-	-	2009 ⁷⁴	C	RS/O	Su	Ss	I
<i>Apogon pharaonis</i> Bellotti, 1874	-	-	2002 ²²⁵	1984 ¹⁹⁹	E	RS/IP	Su	Hs/Ss	I,II
<i>Apogon fasciatus</i> (White, 1790)	-	-	-	2009 ²⁶⁵	E	RS/IP	Su	Ss	I-II
<i>Apogon queketti</i> Gilchrist, 1903	-	-	2009 ¹⁴⁵	2004 ¹³⁹	E	RS/O	Su	Ss	I-III
<i>Apogon smithi</i> (Kotthaus, 1970)	-	-	-	2008 ¹⁵⁵	E	RS/IP	Su	Ss	I,II
<i>Sillago sihama</i> (Forsskål, 1775)	-	-	2004 ⁶⁹	1983 ¹⁶²	E	RS/IP	Su	Ss	I,II
<i>Monotaxis grandoculis</i> (Forsskål, 1775)	-	-	-	2007 ⁷⁰	C	RS/IP	Su	Ss	I,II
<i>Alepes djedaba</i> (Forsskål, 1775)	-	-	1966 ¹⁵²	1955 ²¹	E	RS/IP	Su	P	I-III
<i>Nemipterus randalli</i> Russell, 1986	-	-	-	2007 ⁷²	E	RS/O	Su	Ss	I-II
<i>Equulites klunzingeri</i> (Steindachner, 1898)	-	-	1966 ⁶⁵	1942 ¹³¹	E	RS	Su	Ss	I-III
<i>Decaptenus russelli</i> (Rüppell, 1830)	-	-	-	2009 ¹⁹	E	RS/IP	Su	P	I-II
<i>Trachurus indicus</i> Nekrasov, 1966	-	-	-	2004 ¹²⁰	C	IO	Su	P	I-III
<i>Parupeneus forskalli</i> (Fourmanoir & Guézé, 1976)	-	-	-	2000 ¹¹⁰	C	RS/IP	Su	Ss	I
<i>Upeneus moluccensis</i> (Bleeker, 1855)	-	-	1956 ¹⁹³	1942 ¹⁹¹	E	IP	Su	Ss	I-IV
<i>Upeneus pori</i> Ben-Tuvia & Golani, 1989	-	-	2000 ²²²	1942 ¹⁹¹	E	RS/IP	Su	Ss	I,II
<i>Penptheris vanicolensis</i> Cuvier, 1831	-	-	1994 ¹⁹⁸	1983 ¹⁶²	E	RS/IP	Su	Hs	I,II
<i>Heniochus intermedius</i> Steindachner, 1893	-	-	-	2002 ¹⁵⁷	C	RS/IP	Su	Hs/Ss	I
<i>Liza carinata</i> (Valenciennes, 1836)	-	-	-	1955 ¹⁹³	E	RS/O	Su	P	I
<i>Liza haematocheila</i> (Temminck & Schlegel, 1845)	1992 ²⁷²	1995 ¹⁷⁷	1995 ¹⁷⁷	-	E	PO	Aq	P	I
<i>Splyraena chrysotaenia</i> Klunzinger, 1884	-	-	1966 ¹⁵²	1955 ²¹	E	RS/IP	Su	P	I,II

(Continued)

Table 1 (Continued)

	BS	SM	AS	LS	ES	O	MI	H	D
<i>Sphyaena flavicauda</i> Rüppell, 1838	-	-	-	2001 ⁷⁵	E	RS/IP	Su	P	I,II
<i>Platax teira</i> (Forsskål, 1775)	-	-	-	2006 ⁷¹	C	RS/IP	Su	Hs	I
<i>Pteragogus pelycus</i> Randall, 1981	-	-	2002 ⁷⁷	1998 ²⁵⁵	E	RS/IP	Su	Hs/Ss	I,II
<i>Champsodon nudivittis</i> (Ogilby, 1895)	-	-	-	2008 ¹¹⁴	C	IP/IO	Su/S	Ss	I,II
<i>Petroscirtes ancylodon</i> Rüppell, 1838	-	-	2005 ²²⁶	1997 ²⁵⁵	E	RS/IP	Su	Hs/Ss	I
<i>Callionymus filamentosus</i> Valenciennes, 1837	-	-	-	1983 ¹⁶²	E	RS/IP	Su	Ss	I-III
<i>Oxyurichthys petersi</i> (Klunzinger, 1871)	-	-	1991 ⁶³	1991 ¹⁷⁶	E	RS	Su	Ss	I-III
<i>Trypauchen vagina</i> (Bloch & Schneider, 1801)	-	-	-	2010 ¹⁸	C	IP/IO	Su	Ss	II
<i>Vanderhorstia mertensi</i> Klausewitz, 1974	-	-	2010 ⁸	2008 ⁷⁶	E	RS/IP	Su	Ss	I-III
<i>Siganus luridus</i> (Rüppell, 1829)	-	-	1973 ⁶⁶	1973 ¹⁴⁷	E	RS/IP	Su	Hs	I,II
<i>Siganus rivulatus</i> Forsskål, 1775	-	-	1943 ²⁶⁰	1942 ¹⁹¹	E	RS/IP	Su	Hs	I,II
<i>Scomberomorus commersoni</i> Lacepède, 1800	-	-	1994 ⁸⁰	1981 ¹⁶²	E	RS/IP	Su	P	I,II
<i>Cymoglossus sinusarabici</i> (Chabanaud, 1913)	-	-	-	1955 ²¹	E	RS	Su	Hs	I,II
<i>Stephanolepis diaspros</i> Fraser-Brunner, 1940	-	-	1943 ²⁶⁰	1949 ¹⁹¹	E	RS/IP	Su	Hs/Ss	I,II
<i>Lagocephalus sceleratus</i> (Gmelin, 1789)	-	-	2003 ²⁰	2004 ⁷³	E	RS/IP	Su	Ss	I,II
<i>Lagocephalus spadiceus</i> (Richardson, 1844)	-	2007 ²⁶³	1966 ⁶⁵	1949 ¹⁹¹	E	RS/IP	Su	Ss	I,II
<i>Lagocephalus suezensis</i> Clark & Gohar, 1953	-	-	2001 ⁷⁵	1998 ³⁷	E	RS	Su	Ss	I,II
<i>Sphoeroides pachygaster</i> (Müller & Troschel, 1848)	-	-	1999 ¹⁴⁰	1999 ¹⁹⁸	E	TA	G	Hs/Ss	I-V
<i>Torquigener flavimaculosus</i> Hardy & Randall, 1983	-	-	-	2002 ⁶⁸	E	RS/IP	Su	Ss	I,II
<i>Tylerius spinosissimus</i> (Regan, 1908)	-	-	-	2010 ²⁶⁴	C	IP	Su	Ss	II,III

However, GÓMEZ (2006; 2008, pers comm.) did not accept the alien status of these species in the Mediterranean Sea. He postulated that these species had been known for many years under different names or were very rare in the region. Therefore, we did not put these species in Table 1.

The algae species, *Polysiphonia kampsaxii*, *Acanthophora muscoides* and *Sargassum latifolium*, which were excluded from the alien list of the Mediterranean by ZENETOS *et al.* (2010b), are given here as questionable. General morphological features of these species match with their original and subsequent descriptions, but more material is needed to clarify their real taxonomic positions. ZENETOS *et al.* (2010b) cited the report of *Caulerpa taxifolia* from Iskenderun Bay by ÇEVİK *et al.* (2007) as *Caulerpa distichophylla* Sonder. However, we prefer to keep the previous name until new evidence for its taxonomic position has been presented.

In the review by ZENETOS *et al.* (2010b), some foraminiferan species were cited as casual but we have changed their established success to established here, based on personal observations and communications. For example, MERİÇ *et al.* (2010a) reported a single specimen of *Euthymonacha polita* collected near a submarine spring in Kusadası, Turkey. However, this species was later observed in different locations in the Aegean Sea (Ilica, NW Karaburun Peninsula and Kusadası), again around submarine springs (E. MERİÇ, pers. comm.), indicating that it has become established in the area. Again, only two specimens of *Cushmanina striatopunctata* were reported from the Dardanelles (MERİÇ *et al.*, 2009) and the Aegean Sea (MERİÇ *et al.*, 2008b). However, another specimen was also collected in the North Aegean Sea (Ayvalık, YOKES, unpublished data), suggesting that

it may be a rare species with a wide range of distribution along the Turkish coastline.

Five unidentified alien foraminiferan species, namely *Entosigmomorphina* sp., *Euuvigerina* sp., *Haddonina* sp., *Quinqueloculina* sp.C and *Triloculina* sp.A, were reported along the Turkish coasts (MERİÇ *et al.*, 2008a; 2010a; 2010b). These species are not included in Table 1. *Haddonina* sp., *Quinqueloculina* sp.C and *Triloculina* sp.A were also reported from the Gulf of Aqaba (HOTTINGER *et al.*, 1993). *Haddonina* sp. was abundantly observed on the Turkish Mediterranean coast (MERİÇ *et al.*, 2008a), and the latter two on the Aegean coast (MERİÇ *et al.*, 2010a; 2010b). *Entosigmomorphina* sp. seems to have originated from the Pacific and was rarely observed on the SW coast of Turkey (MERİÇ *et al.*, 2008a). *Euuvigerina* sp. seems to be a cryptogenic species, which was only reported from the North Aegean Sea. The species *Acervulina inhaerens*, *Iridia diaphana*, *Cymbaloporetta squamosa*, *Pyramidulina per-versa* and *Triloculina affinis* were given as alien by ZENETOS *et al.* (2008). These species have seldom been recorded or poorly preserved in the sediment or known as fossils in the Mediterranean area, thus they were excluded from the alien list of the Mediterranean Sea by ZENETOS *et al.* (2010b).

A debate is still continuing on the validity of two foraminiferan species, *Coscinospira hemprichii* and *Peneroplis arietina*. HOTTINGER *et al.* (1993) considered *Peneroplis arietina* as a junior synonym of *Coscinospira hemprichii*. Their explanation was based on the aberrant morphologies observed in the populations of peneroplids found in extreme environments with high salinity. They have compared specimens from the Gulf of Aqaba with those from the Persian Gulf and decided to include peneropliform and spiroliniform specimens with similar ornamentation and proportions of

the early growth stages within the same species. However, they mentioned that the generic separation of *Coscinospira* and *Peneroplis* could be justified only in the framework of a revision of the history of peneroplids during Tertiary times. *Coscinospira hemprichii* is also distributed in the Atlantic and Mediterranean areas. However, in the eastern Mediterranean, the two distinct morphologies were found together in high abundances. The test morphologies were very prominent in terms of many characteristics. Hybrid morphologies have not been observed. Besides, the specimens which fit the description of *Peneroplis arietina* well were observed in the Levantine Basin, but not in the western Mediterranean. Thus, the two distinct morphologies cannot be related to environmental factors, but this suggests the presence of two distinct species in the eastern Mediterranean. In accordance with GROSS (2010), *Coscinospira arietina* is used as the valid name in the present study. It is also suggested that the native *Coscinospira hemprichii* is a distinct species.

Distribution of alien species in the seas.

The highest number of alien species (330 species) was encountered on the Levantine coast of Turkey, followed by the Aegean Sea (165 species), the Sea of Marmara (69 species) and the Black Sea (20 species) (Fig. 1). A total of 124 new alien species were reported on the coasts of Turkey within five years (2005-2010) (increment: ca. 44%). Increase in the number of species varies among the seas. For example, the number of alien species was stable in the Black Sea, increased from 48 to 69 in the Sea of Marmara (increment: ca. 44%), from 98 to 165 in the Aegean Sea (increment: ca. 69%) and from 216 to 330 in the Levantine Sea (increment: ca. 52%). The reasons for the high increase in the number of alien

species within five years are mainly based on the increase in scientific efforts to determine the presence of alien species on the coasts and the reports of some species here that were not previously considered as aliens in the 2005 paper.

The increase in the number of alien species after the previous list also varies among groups. For example, the number of alien species rise from 26 to 75 in Polychaeta (increment: 189%), from 5 to 37 in Foraminifera (increment: 660%), from 51 to 64 in Crustacea (increment: 25%), from 90 to 105 in Mollusca (increment: 17%) and from 45 to 58 in Fishes (increment: 29%).

Phytobenthos (algae and phanerogame) rank first in terms of the number of alien species in the Black Sea (11 species, 55% of total number of alien species reported in the area) and the Sea of Marmara (22 species, 32%), whereas the group Pisces (31 species, 19%) and Mollusca (98 species, 30%) have the highest number of species in the Aegean and Levantine Seas, respectively (Fig. 1).

Probable vectors of Introduction

The main vector for the species introductions to the Turkish coasts is the Suez Canal, followed by shipping and Gibraltar (Fig. 2). Almost 66% of the total number of alien species used the Suez Canal as a gateway for entering the area. However, the importance of this vector is more distinct in the Levantine Sea, where the introduction of the majority of species (74% of total species) has been attributed to the Suez Canal. The importance of the Suez Canal as a vector of species introductions gradually diminishes from the Levantine Sea to the Black Sea. A total of 4 species (*Fenneropenaeus merguensis*, *Crassostrea gigas*, *Ruditapes philippinarum* and *Liza haematocheila*) were introduced to the Mediterranean and Black Seas for aquaculture pur-

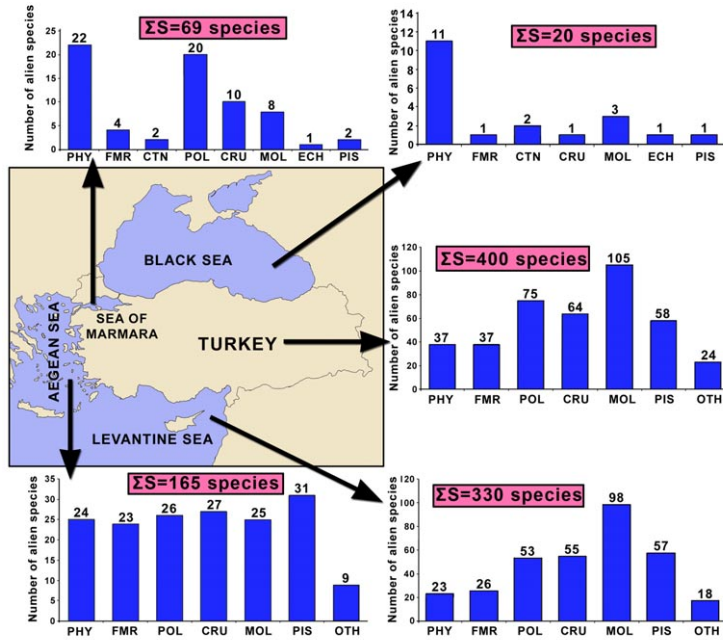


Fig. 1: The number of alien species along the coasts of Turkey. PHY: Phytobenthos, FMR: Foraminifera, CTN: Ctenophora, POL: Polychaeta, CRU: Crustacea, MOL: Mollusca, BRY: Bryozoa, ECH: Echinodermata, PIS: Pisces, OTH: Others. ΣS indicates the total number of species.

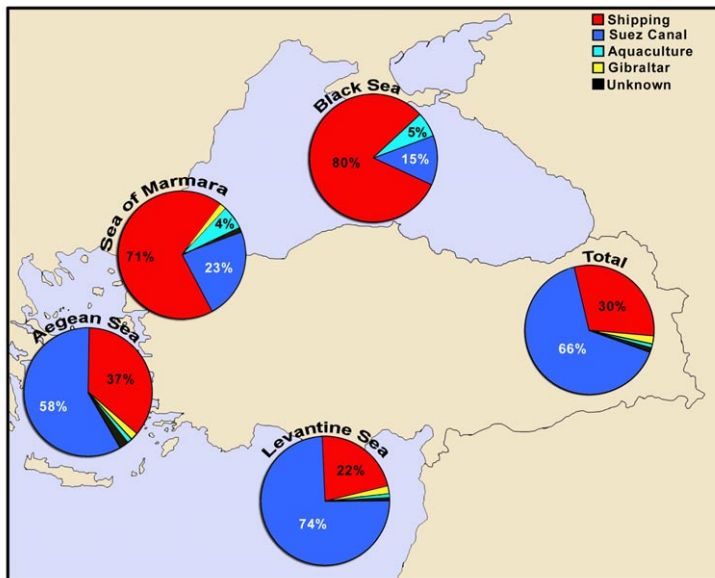


Fig. 2: The modes of introduction for alien species on the coasts of Turkey.

poses. The most successful species among them is *L. haematochelia*, which was first released into the Azov Sea from the Molochny Lagoon in 1985 and then largely expanded its distribution range to the Aegean Sea (Homa Lagoon) within 10 years (KAYA *et al.*, 1992). Ballast water and hull fouling are known to be main vectors for species translocations (CARLTON, 1985; GODWIN *et al.*, 2004). The number of introduced species has greatly increased worldwide since transoceanic shipping times became shorter than the larval life of most marine invertebrates (JENSEN & KNUDSEN, 2005). Huge volumes of ballast water (ca. 12 billion t annually) are discharged into or near ports (NETWIG, 2007), leading to establishment of some alien species that have remained alive in ballast tanks during voyage. GOLLASCH (2007) postulated that almost 33% and 27% of total marine alien species worldwide have been introduced from one area to another by hull fouling and ballast water, respectively. Almost 122 alien species have been introduced to the coasts of Turkey via shipping. This type of vector is more ap-

parent in the Sea of Marmara and the Black Sea. Ship-mediated alien species account for 71% and 80% of total alien species in the Sea of Marmara and the Black Sea, respectively. Some sessile species such as *Hydroides* spp., *Ficopomatus enigmaticus* and barnacles, which play important roles in biofouling, could have been transferred to the area by hull fouling. The invasive spionid polychaetes such as *Polydora cornuta*, *Streblospio gynobranchiata* and *Pseudopolydora paucibranchiata* were reported to have been introduced to Izmir Bay via ballast water from ships (ÇINAR *et al.*, 2005b).

The importance of type of vector for species introductions in each systematic group is depicted in Figure 3. Shipping is responsible for more than 50% of the species introductions in 6 systematic groups, whereas the Suez Canal is the main vector for species introductions in Foraminifera (71% of total foraminifer species), Crustacea (78%), Mollusca (74%), Echinodermata (67%), Tunicata (67%) and Pisces (86%). Two alien bryozoan species, *Celleporaria brunnea* and *Rhynchozoon larreyi* seem to

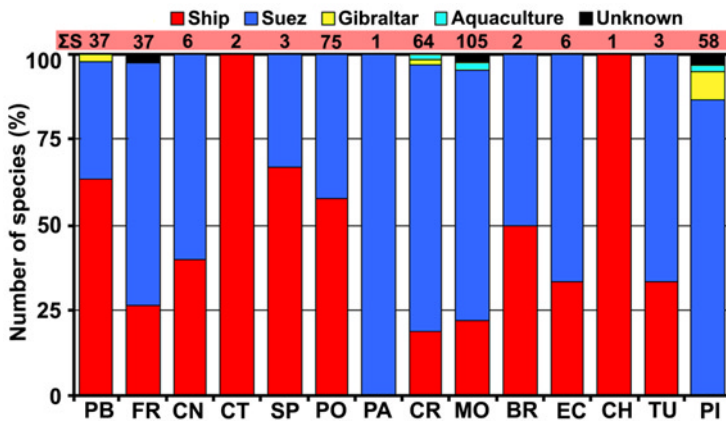


Fig. 3: The modes of introduction for alien species in each systematic group. PB: Phytobenthos, FR: Foraminifera, CN: Cnidaria, CT: Ctenophora, SP: Sipuncula, PO: Polychaeta, PA: Pantopoda, CR: Crustacea, MO: Mollusca, BR: Bryozoa, EC: Echinodermata, CH: Chaetognatha, TU: Tunicata, PI: Pisces.

have been introduced to the coasts of Turkey via ships and the Suez Canal, respectively (KOÇAK, 2007; ÜNSAL & d'HONDT, 1979). All ctenophore and chaetognath species were transferred to the area via ships. No fish species was recorded as having been introduced into Turkish waters via ships. However, only a single tropical Atlantic originated species, *Pinguipes brasilianus*, was mentioned in the CIESM atlas as having probably been introduced by ballast waters (GOLANI *et al.*, 2002). Other alien fish suspected to have arrived via shipping activities include *Omobranchus punctatus*, *Bregmaceros atlanticus*, *Champsodon nudivittis*, *Tridentiger trigonocephalus* and *Opleognathus fasciatus* (GOLANI, 2004; ÇIÇEK & BILECENOGLU, 2009; GOREN *et al.*, 2009; SCHEMBRI *et al.*, 2010), since they are encountered far distant from their source populations and have never been found in the Red Sea. However, a possible penetration of these species from the Suez Canal cannot be neglected by the authors, i.e. cases of *B. atlanticus* (GOREN & GALIL, 2006) and *C. nudivittis* (ÇIÇEK & BILECENOGLU, 2009) are good examples on the matter. Suspicion about the vector of origin of a definite species may only change with further studies and additional records from other localities. For example *Platax teira*, which was previously assumed to be an aquarium escape without excluding the possibility of Lessepsian migration by BILECENOGLU & KAYA (2006), has recently been found off Israeli shores, indicating the Suez Canal as a mode of entry (GOLANI *et al.*, 2011). Similarly, the recent occurrence of the spiny blaasop, *Tylerius spinosissimus*, at Iskenderun Bay could not be clearly linked to any vectors by TURAN & YAGLIOGLU (2011). However, after it was found off Israeli coasts, GOLANI *et al.* (2011) stated that we should

consider the species as a Lessepsian migrant, without neglecting the possible distribution of the species in Red Sea.

Establishment Success

Of the 400 alien species reported from the coasts of Turkey, 305 species (76% of total number of species) can be classified as established, 59 species as casual (15%), 23 species as questionable (6%) and 13 species as cryptogenic (3%) (Fig. 4). As only eggs and yolk-sac larvae of *Chirocentrus dorab* were reported from the Levantine coast of Turkey (AK-ÖREK & UYSAL, 2008), its establishment success was considered as questionable. The status of casual species could be turned into established ones if further evidence of their presence in other areas is provided. Of three groups (Thallophyta, Polychaeta and Mollusca) that have cryptogenic species, Thallophyta possess the highest number of species (6 species), followed by Mollusca (5 species) and Polychaeta (2 species). The percentages of established species in total number of alien species reported from the Turkish coasts vary from 63% (Sea of Marmara) to 83% (Aegean Sea). The highest percentage of cryptogenic species (25%) was encountered in the Black Sea. The Sea of Marmara was characterized by the highest percentage of questionable species (12 species, 17% of total number of species), the majority of which (9 species) belong to Polychaeta. These species were given by RULLIER (1963), but their presences in the area are still in debate, due to poor descriptions (no figures) of the species. All alien species belonging to the groups Ctenophora, Sipuncula, Pantapoda, Bryozoa, Chaetognatha and Tunicata seem to have become established on the coasts of Turkey (Fig. 5). Mollusca (79 species) and Polychaeta (56 species) have the highest number of established

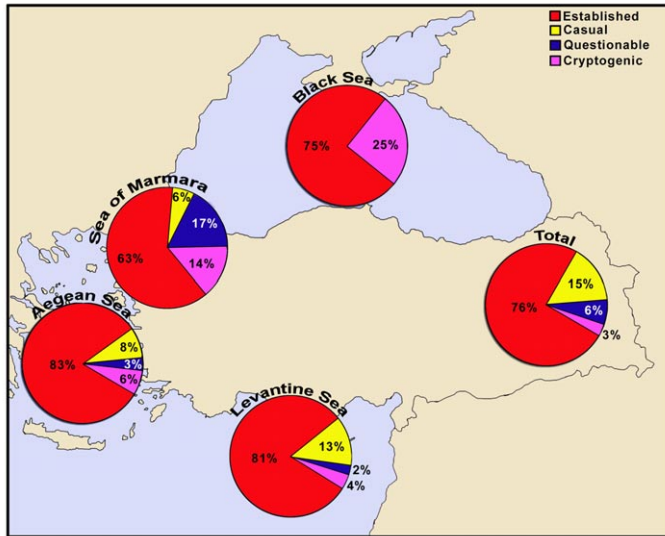


Fig. 4: The establishment successes of alien species reported on the coasts of Turkey.

species. The high number of casual species was reported within the groups Mollusca (19 species) and Pisces (11 species). Polychaeta (12 species) and Phytobenthos (5 species) have high numbers of questionable species.

Rate of Invasion

The new additions to the number of alien species on the coasts of Turkey greatly increased after 1990. A total of 154 alien species were known from the area before 1990 and 247 alien species were added to the list after 1990 (increment: 160%) (Fig. 6). A decreasing pattern is apparent in the yearly rate of introduction over the past years (Table 2). While one new alien species was introduced every 22 weeks from 1951 to 1970 on the coast of Turkey, the time span decreased to 4 weeks between 1991 and 2010. Increase in the invasion rate is most probably due to the acceleration in species introduction to the region, the range extensions of some species that were pre-

viously reported from the south-west of the Levantine Sea and the increase in the number of papers regarding alien species. The correlation analysis showed that a significant relationship ($R^2=0.98$, $p<0.05$) exists between the number of new records of alien species and the number of papers on them over the years. In the last 5 years (2005-2010), a total of 100 papers regarding alien species on the Turkish coasts have been published, reporting a total of 124 new alien species belonging to different groups, mostly Foraminifera and Polychaeta.

Depth and habitat preferences of alien species

The distributions of the total number of alien species by depth and habitat are depicted in Figure 7. The majority of aliens reported from the Turkish coasts were found on soft substrata (198 species) in shallow waters (319 species). A total of 34 species, mostly fishes, live in pelagic environment (Fig. 8). Some species such as *Dorvillea similis*, *Stenothoe gallensis*, *Charybdis hellerii*,

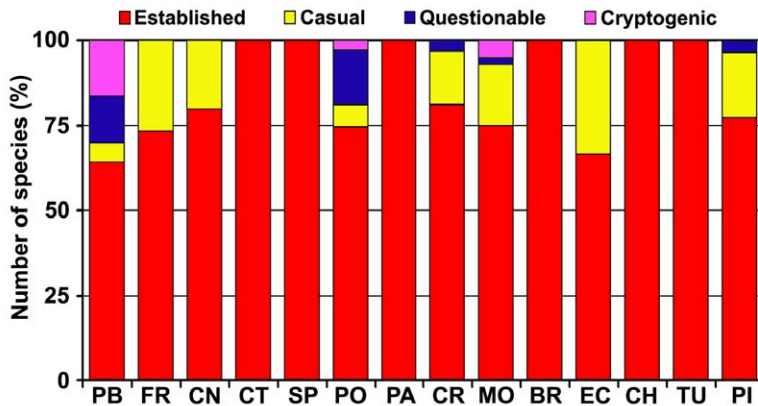


Fig. 5: The establishment successes of alien species in each systematic group. For abbreviations, see Figure 3.

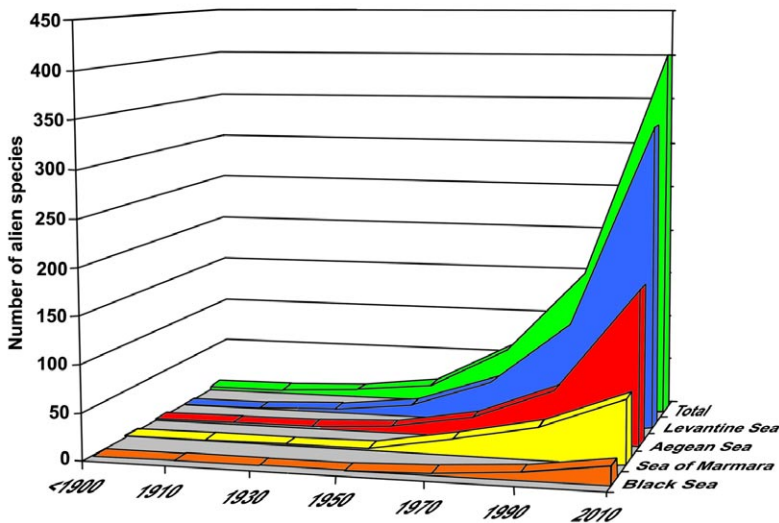


Fig. 6: Rate of introduction of alien species along the coasts of Turkey.

Thais lacera and *Chrysallida maiae* were reported both from the hard and soft substrata. The habitat types of many alien foraminifer species are unknown as species descriptions were based on their dead tests (i.e. MERIÇ *et al.*, 2004a; 2010a) that had accumulated in the benthic area. Only

Heterosaccus dollfusi, which was found on the Lessepsian crab *Charybdis longicollis* (ØKSNEBJERG *et al.*, 1997), was reported as a parasite. All alien species of Pantopoda, Bryozoa and Tunicata, and more than 50% of a number of species of Phyto-

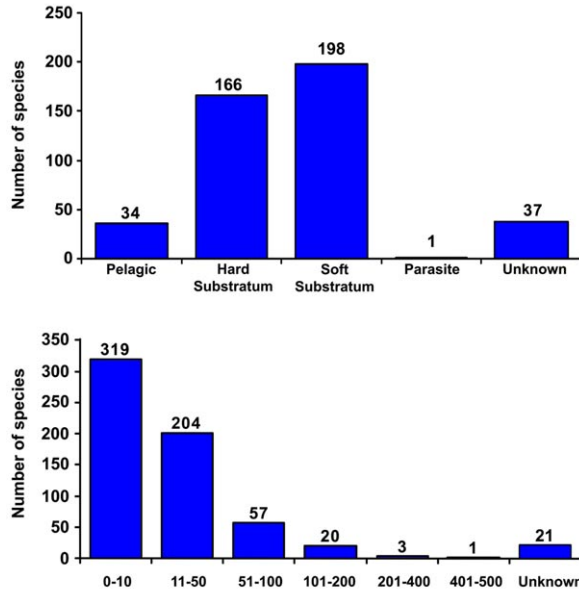


Fig. 7: The habitat (upper graphic) and depth (lower graphic) preferences of alien species along the coasts of Turkey.

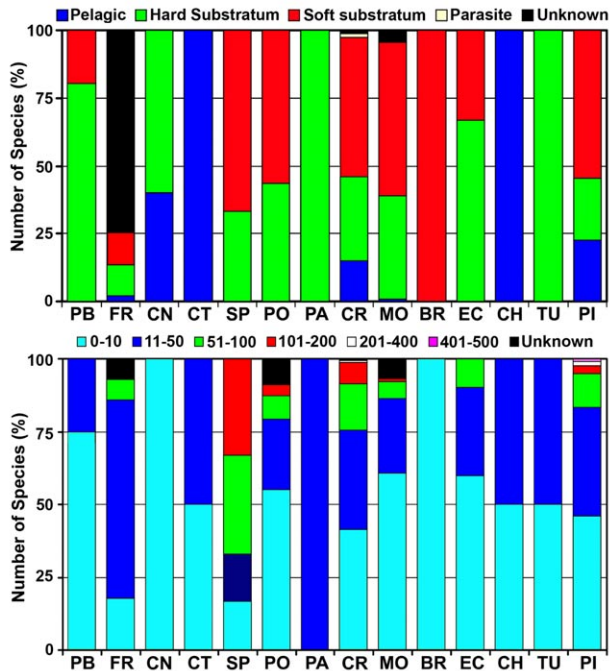


Fig. 8: The habitat (upper graphic) and depth (lower graphic) preferences of alien species in each systematic group. For abbreviations, see Figure 3.

Table 4
Time span (weeks) for alien species' introduction along the Turkish coasts.

	1951-1970	1971-1990	1991-2010
	Weeks per 1 alien species		
Black Sea	494	164.6	82.3
Sea of Marmara	70.6	54.9	29.1
Aegean Sea	65.9	29.1	8.8
Levantine Sea	34.1	14.3	4.5
Total	22	10.9	4

ed on hard substrata. The majority of species belonging to the groups Sipuncula, Polychaeta, Crustacea, Mollusca and Pisces were reported from soft substrata.

The number of alien species decreases with increasing depths. A sharp decrease occurs from 11 m downwards. Alien species greatly dominate the shallow water (0-10 m) habitats (319 species, 80% of total number of species). The alien species that were reported in deep waters are *Trachysalambria palaestinensis*, *Carcharhinus altimus* and *Spherooides pachygaster*. All species of Cnidaria and Bryozoa, and more than 50% of the species of Phytobenthos, Polychaeta, Mollusca, Echinodermata and Pisces were reported between 0 and 10 m depths. Alien sipunculans species were reported between 11 and 200 m depths.

Impacts of Alien species

It is generally accepted that alien species may have ecological, economic or health related influences, especially after they succeed in establishing dense populations, or presenting invasive characters. Although a wide range of scientific literature has tended towards the negative impacts of alien species-giving rise to the axiomatic 'native good, aliens bad' philosophy, facilitative alien-native interactions also occur frequently

as an indication of the positive alien impact (GOODENOUGH, 2010). The review by ÇINAR *et al.* (2005a) presented concise data on the impact of alien species on Turkey (for example *Caulerpa racemosa*, *Mnemiopsis leidyi*, *Beroe ovata*, *Rapana venosa* etc.), while some new and updated information is given below.

Alien species have become very important components of benthic and pelagic communities in Iskenderun Bay. A bottom trawl haul in August 2009 (30 m depth) near Yumurtalık revealed that 92% of the number of specimens and 89% of total biomass belonged to Lessepsian species (unpublished data). *Rhopilema nomadica* (58% of total biomass), *Charybdis longicollis* (17%), *Penaeus semisulcatus* (5%) and *Equulites klunzingeri* (4%) comprised the majority of biomass (84%) in the area. The most abundant species in the catch were *C. longicollis* (63% of total specimens) and *E. klunzingeri* (20%).

The genus *Caulerpa* was represented by two alien species on the coasts of Turkey, i.e. *C. racemosa* and *C. scalpelliformis* (ÇINAR *et al.*, 2005a), while CEVIK *et al.* (2007) later added *C. taxifolia* to the list based on the material collected off Yumurtalık coasts (Iskenderun Bay) during 2006. The DNA sequences revealed that

the Turkish population was different from that inhabiting the Western Mediterranean Sea. Shipping (most probably) or aquarium dumping was suspected as a possible vector of the introduction of the Turkish population. Its origin was thought to be the Australian coast. However, there is a debate on its taxonomic position. ZENETOS *et al.* (2010b) regarded the report of *C. taxifolia* from Iskenderun Bay as *C. distichophylla*. However, we use the previous name as evidence for *C. distichophylla* has not been presented till now. Although *C. taxifolia* seems to be established in Iskenderun Bay, there is not enough data at the moment to indicate any possible negative impacts on the biota. A recent observation (July 2009) by M.E. ÇINAR and M. BILECENOĞLU revealed that the population of *C. taxifolia* was very scarce in the area. However, a monitoring programme specific to this species is urgently needed.

Halophila stipulacea is a locally abundant species, forming meadows generally at depths below 25 m. A competition between native seagrasses and *H. stipulacea* has not been observed yet. This alien seagrass seems to support a diverse local biota including epiphytes and benthic invertebrates, which constitute food sources for organisms at higher trophic levels (AKCALI & CIRIK, 2007).

It has been suggested that the majority of the alien foraminifer species observed on the coasts of Turkey were introduced from the Red Sea. The most abundant species are *Amphistegina lobifera*, *Amphisorus hemprichii*, *Sorites orbiculus*, *Heterostegina depressa* and *Coscinospira arietina*. The alien foraminifer species are found to coexist with other native benthic foraminifers. However, *A. lobifera* and *A. hemprichii* were found to be exceptionally common on the southwestern coasts of Turkey. They fully cover

benthic habitats in shallow waters and even colonize biota such as the alien phanerogame *Halophila stipulacea* (Fig. 9). Holes among crusts formed by overlapped tests of *A. hemprichii* can also serve as hiding places for some species, such as small individuals of *Octopus vulgaris* (Fig. 9).

Amphistegina lobifera shows a wide distribution range in the Indo-Pacific and Atlantic Oceans (LANGER & HOTTINGER, 2000), and it is the most abundant alien foraminifer species in the Mediterranean Sea. It was recorded in Israel (LANGER & HOTTINGER, 2000), Lebanon (MONCHARMONT ZEI, 1968), Greece (KOUKOUSIOURA *et al.*, 2010), Turkey (AVŞAR, 1997), Libya (BLANC-VERNET *et al.*, 1979), Tunisia (GLACON, 1962) and Malta (YOKEŞ *et al.*, 2007a). According to LANGER & HOTTINGER (2000), the occurrences of living amphisteginids are delimited by the 14°C winter isotherms. However, *A. lobifera* is observed almost everywhere on the Aegean and Mediterranean coasts of Turkey, and even in the Sea of Marmara. Dense populations of *A. lobifera* observed around the submarine springs on the Aegean coast of Turkey suggest that the environmental conditions created by the warm springs help the thermophilic aliens to form dense local colonies and find the chance to spread the larval forms (MERİÇ *et al.*, 2010a).

Amphisorus hemprichii is also widely distributed in the Indo-Pacific and abundantly found in the Gulf of Aqaba, Red Sea (REISS & HOTTINGER, 1984; HAUNOLD *et al.*, 1998). Populations of *A. hemprichii* were first determined in June 2002 in sediment samples from a few coves around Kalkan, Kas, and Kekova (Antalya-SW Turkey). However, within two years, it had covered more than 100 km coastline and is still spreading towards the



Fig. 9: Dense settlements of *Amphisorus hemprichii* on leaves of *Halophila stipulacea* (upper figure) and on hard substrates, serving as a hiding place for a young individual of *Octopus vulgaris* (lower figure) (Photograph: Baki Yokeş).

Aegean Sea. Both *Amphistegina lobifera* and *A. hemprichii* form uncountable dense populations on the benthos along the coasts of Antalya (SW Turkey) (MERIÇ *et al.*, 2008a). The density of living *A. lobifera* individuals on rocks can reach 230000-310000 ind. m⁻². The high ratio of tests in the sediment (>350 ind./g; 0.75 g tests/g) results in large amounts of sand formation at an extreme rate. Certain stations off Kaş (Antalya) were monitored for six years and the deposition of the test belonging to these two species was found to be 2-4.5 cm/year. The extensive accumulation of sand is creating an immense ecological problem by changing the whole habitat type and coastal structure, while definitely altering the species composition of the

coastal ecosystem (YOKEŞ & MERIÇ, 2004).

Massive swarms of the stinging nomadic jellyfish *Rhopilema nomadica* have been considered a threat to human health, tourism and fisheries since their first occurrence on the Mersin coasts during August 1995 (KIDEYS & GÜCÜ, 1995). In summer 2009, several blooms were observed along the coastline between Antalya and Adana, where 815 hospitalized cases were recorded (ÖZTÜRK & ISINIBİLİR, 2010). Some injuries were quite serious, leaving whip-like marks on the body (Fig. 10). The other alien jellyfish, *Cassiopea andromeda*, not currently as widespread as *R. nomadica*, form only locally abundant populations.

A recent study in Ölüdeniz Lagoon (Fethiye) indicated that *C. andromeda* reached a maximum density of 14 individuals per 100 m², but no injury has been reported to date, despite its potential threat to human health (ÖZGÜR & ÖZTÜRK, 2008). Recently, a single specimen of the Lessepsian jellyfish, *Phyllorhiza punctata*, was captured in Iskenderun Bay (ÇEVİK *et al.*, 2011). If it forms a proliferating population in the area, it would become a pest for tourism activities and fisheries.

The other alien invertebrates that pose risks to human health are *Macrorhynchia philippina* (Hydrozoa), *Eurythoe complanata* (Polychaeta) and *Diadema setosum* (Echinoidea). The first two species, which have nematocysts and venomous chaetae, respectively, have built up dense populations on the Levantine coast of Turkey and may cause continuous itching and painful stinging when touched (ÇINAR *et al.*, 2006a, pers. obs.). The long spines of *D. setosum* with barbed tips can penetrate human skin

and release venom from their tissue and lumen. The venom may cause redness, swelling and acute pain, which subsides after a few hours; however, spine fragments are difficult to remove, and healing may take several weeks (YOKEŞ & GALİL, 2006a).

The sipunculan species, *Aspidosiphon* (*A.*) *elegans*, which is a bio-eroder species, has an impact on shapings of limestone in shallow waters, together with other boring species such as *Lithophaga lithophaga* (LINNAEUS, 1758) [AÇIK, 2008a, pers. obs. (MEÇ)]. The eunicid worms, *Eunice antennata* and *Palola valida*, also play important roles in the erosion of calcareous structures in the area. The former species is locally abundant (KURT SAHİN & ÇINAR, 2009a).

The ballast water-mediated polychaete species such as *Polydora cornuta*, *Streblospio gynobranchiata* and *Pseudopolydora paucibranchiata* dominate the polluted soft-bottom benthic environments in Izmir Bay (ÇINAR *et al.*, 2006b) and the Golden Horn



Fig. 10: A swimmer stung by *Rhopilema nomadica* at Yumurtalik (Adana) during fall 2009 (Photograph: Tahir Özcan).

Estuary (ÇINAR *et al.*, 2009) and seem to have replaced some other opportunistic polychaete species such as *Capitella* spp. and *Malacoceros fuliginosus* (CLAPARÈDE, 1869). These alien species account for almost 90% of total zoobenthic populations in Alsancak Harbour and its vicinity (ÇINAR *et al.*, 2006b; DAĞLI & ÇINAR, 2008).

The natural and artificial hard substrates in Iskenderun and Mersin Bays (south-east of Turkey) were densely colonized by alien serpulid polychaetes such as *Hydroides operculatus* and *Pomatoleios kraussii*, comprising 95% of the total serpulid specimens in the area. The Lessepsian species, *P. kraussii*, formed a densely populated belt in shallow-water areas in Mersin Bay, providing a suitable habitat for small vagile fauna (ÇINAR, 2006). In the area, the population density and biomass values of *H. operculatus* reached up to 384000 ind.m⁻² and 246 g.m⁻², respectively. *Hydroides elegans* and *H. dianthus* form dense populations in Alsancak Harbour (Izmir Bay) and their population densities may attain 110700 ind.m⁻² and 33050 ind.m⁻², respectively (ÇINAR *et al.*, 2008). *Hydroides elegans* is one of main pests for aquaculturists in the Aegean Sea [pers. obs. (MEÇ)]. This species together with other fouling organisms can block the net mesh and greatly reduce water circulation. The reef builder species, *Ficopomatus enigmaticus*, was considered an ecosystem engineer by providing a suitable habitat for other species and also by changing the physical factors of the invaded environment (SCHWINDT *et al.*, 2001). This species was reported from the Sea of Marmara (DEMİR, 1952-1954) and the Aegean Sea (ERGEN, 1976), and forms dense aggregates on artificial substrates like wood or concrete piles. These species, with their calcareous tubes, may become a nuisance to humans when they attach themselves to hard underwater

structures such as quays, mariculture equipment and ship hulls.

The invasive crab, *Percnon gibbesi*, was first recorded along the coast of Turkey in the Kaş-Kekova Marine Protected Area in 2006 (YOKEŞ & GALİL, 2006b). Only two individuals were found at two locations in 2006, whereas 112 individuals at 27 locations were observed in 2010 (KATSANEVAKIS *et al.*, 2011). This species is omnivorous, primarily feeding on algae. Its impact on the prevailing ecosystem is unpredictable at the moment but because of its invasive character, *P. gibbesi* is a pest species candidate.

The sea-star *Asterias rubens* has intensively invaded the shallow-water benthic habitats of the Sea of Marmara and expanded its distributional range to the Black Sea (ALBAYRAK, 1996; KARHAN *et al.*, 2007). This species consumes large quantities of the native mussel *Mytilus galloprovincialis* (LAMARCK, 1819) and competes with the large sea-star *Marthasterias glacialis* (LINNAEUS, 1758) for food and space (KARHAN *et al.*, 2007). The dimension of its impact on the prevailing ecosystem is still unknown and requires further investigation.

The newly discovered alien bristle star in the Mersin and Iskenderun Bays, *Amphiodia obtecta*, was reported to be of invasive character, reaching a maximum density of 420 ind.m⁻² in summer (STÖHR *et al.*, 2010). Bristle stars are known to feed on small invertebrates such as polychaetes and crustaceans (KISSELEVA, 1981). It was shown that the density and biomass of *A. obtecta* were negatively correlated with those of sipunculan and other echinoderm species (STÖHR *et al.*, 2010). However, the impact of *A. obtecta* on the prevailing ecosystem is still little understood and requires further investigation.

Lagocephalus sceleratus, which poses a great risk to human health due to tetrodotoxin in its flesh and is also a major nuisance to small-scale fisheries (BILECENOGLU, 2010), is probably the worst invasive alien fish species throughout the entire Levant basin. Cases of poisonings in Turkey have become quite frequent over the last few years. However, there has been no report of a death until now. The fishing, landing and marketing of *L. sceleratus* were totally banned by the Turkish government in November 2008, but human consumption of this highly toxic pufferfish still continues, especially in the vicinity of Antalya, increasing the potential lethal risks. The species have powerful jaws that easily cut bottom longlines, thus also resulting in a financial loss for small scale fisheries.

Siganus spp. present complicated impacts on the eastern Mediterranean ecosystem. Their grazing pressure on the intertidal rocky algae have likely resulted in the eradication of some local vegetation and enhanced settlement of the alien mussel, *Brachiodontes pharaonis* (GALIL, 2007). Although we also suspect a similar negative impact on the Turkish coasts, further research is required. The venomous spines of *Siganus* spp. have a potential risk to humans, but envenomations are generally rapidly recovered from due to the relatively weak toxin of the species. It is worth noting that siganids are frequently marketed (sometimes at a high price during the summer season) and commercially support local fisheries.

The red-eye round herring (*Etrumeus teres*), which expanded its range to the Aegean Sea, has regularly been caught off the Turkish Levant coast since the 1990's (BILECENOGLU, 2010) and a commercially fishable population was reported from the Rhodes area (CORSINI *et al.*, 2005).

Considering the southern Aegean coasts of Turkey, local purse seiners frequently capture the species in small quantities (100-200 kg/day), but a larger scale fishery was recently observed (ca. 20 tonnes within 2 days) on the Marmaris coast on 8th February 2011 and appeared in many Turkish newspapers, erroneously called '*Japon Hamsisi*' (Japanese anchovy). The fish was transported to Izmir to be sold at a price of ca. 2.5 euros/kg. Although the reasons for this unexpectedly dense population of *E. teres* cannot be easily explained at the moment, it seems to have the potential to support local fisheries. The species was recently observed in the Northern Aegean Sea (YARMAZ *et al.*, 2010) without any clues to indicate an established population. However, we should not discount a population increase in the area.

The recent invasion of shrimp-goby, *Vanderhorstia mertensi*, was documented from Turkey by BILECENOGLU *et al.* (2008). After its first occurrence in Fethiye Bay, *V. mertensi* has rapidly increased its population especially in soft substrates of shallow coasts and spread to southern Turkey (YOKES *et al.*, 2009). The species is known to live in symbiosis with *Alpheus* spp., but more specifically with the Lessepsian migrant *A. rapacida*. According to a recent study conducted in Gökova Bay, a small population of *V. mertensi* was observed at a depth of 15 m, which represents the first record of this species in the Aegean Sea. The existence of the shrimp-goby along the Turkish coasts currently seems to have no negative impact on the local fauna, while some indirect positive influences may be suspected. The biodiversity of the Kas-Kekova Specially Protected Area has long been monitored by one of us (MBY), where the alien alpheid *A. rapacida* appeared in remarkable quantities only after the shrimp-

goby introduction. Since alpheid crustaceans constitute a common prey item of several Mediterranean demersal fish species, we may suspect a facilitative impact of the increased alien alpheid population as a potential food resource. Another alien burrowing goby, *Trypauchen vagina*, has recently been reported from Iskenderun Bay (AKAMCA *et al.*, 2011) shortly after its first Mediterranean occurrence on the Israeli coast (SALAMEH *et al.*, 2010), but it is not clear at the moment if the species has the potential to impact on the food web structure in the future.

Conclusions

The present review elucidates that the coasts of Turkey, especially the Levantine coast, are under heavy invasion by alien species, mostly coming from the Red Sea and Indo-Pacific areas. Scientific and public interest in the species introductions and their impacts have resulted in the production of new papers and synthesis on them, and made great contributions to our understanding of the dimensions of this phenomenon. Therefore, this up-to-date inventory of the alien species on the coasts of Turkey, apart from its scientific merits, can fulfil the needs of the regulatory requirements and environmental management options for decision makers. Unfortunately, strict precautions and regulations to limit the spread of invasive species have not been implemented in Turkey. To date, no regulation concerning the control of ballast water discharge (except for polluted ballast waters) has been put into effect. However, some developments relating to this are said to be taking place in the near future.

Monitoring studies to be held along the coasts of Turkey are crucial to determine the new entry of alien species to the area.

Such studies might also provide extensive information about prompt action for their control and eradications. Therefore, bioecological studies in hot spot areas for alien species such as the Iskenderun and Mersin Bays, large international harbors, estuarine areas and deltas should be performed and monitored.

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