RESEARCH ARTICLE

Current status (as of end of 2020) of marine alien species in Turkey

Melih Ertan Çınar1,*, Murat Bilecenoğlu2, M. Baki Yokeş3, Bilal Öztürk1, Ergün Taşkin4, Kerem Bakir1, Alper Doğan1, Şermin Akıncı5

1 Department of Hydrobiology, Faculty of Fisheries, Ege University, Bornova, İzmir, Turkey, 2 Department of Biology, Faculty of Arts & Sciences, Aydın Adnan Menderes University, Aydın, Turkey, 3 AMBRD Doğa Bilimleri, Şişli, İstanbul, Turkey, 4 Department of Biology, Faculty of Arts & Sciences, Celal Bayar University, Manisa, Turkey, 5 Institute of Marine Sciences and Technology, Dokuz Eylül University, İnciraltı, İzmir, Turkey

* melih.cinar@ege.edu.tr

Abstract

The 2020’s update of marine alien species list from Turkey yielded a total of 539 species belonging to 18 taxonomic groups, 404 of which have become established in the region and 135 species are casual. A total of 185 new alien species have been added to the list since the previous update of 2011. The present compilation includes reports of an ascidian species (Rhodosoma turcicum) new to the marine fauna of Turkey and range extensions of six species. Among the established species, 105 species have invasive characters at least in one zoogeographic region, comprising 19% of all alien species. Mollusca ranked first in terms of the number of species (123 species), followed by Foraminifera (91 species), Pisces (80 species) and Arthropoda (79 species). The number of alien species found in seas surrounding Turkey ranged from 28 (Black Sea) to 413 (Levantine Sea). The vectoral importance of the Suez Canal diminishes when moving from south to north, accounting for 72% of species introductions in the Levantine Sea vs. only 11% of species introductions in the Black Sea. Most alien species on the coasts of Turkey were originated from the Red Sea (58%), due to the proximity of the country to the Suez Canal. Shipping activities transported 39% of alien species, mainly from the Indo-Pacific area (20%) and the Atlantic Ocean (10%). Misidentified species (such as Pterois volitans, Trachurus declivis, etc.) and species those classified as questionable or cryptogenic were omitted from the list based on new data gathered in the last decade and expert judgements. The documented impacts of invasive species on socio-economy, biodiversity and human health in the last decade as well as the legislation and management backgrounds against alien species in Turkey are presented.

Introduction

The human mediated translocations of marine species have drastically altered the biodiversity and food web structures of the Mediterranean Sea at an unprecedented rate. This semi-enclosed ecosystem is not only a biodiversity hotspot owing to the relatively high levels of
and analysis, decision to publish, or preparation of the manuscript. There was no additional external funding received for this study.

Competing interests: The authors have declared that no competing interests exist.

endemism and endangered taxa [1], but also one of the prominent hotspots of marine bioinvasions on earth [2, 3]. Monitoring the spread of alien organisms is thus among the most immediate nature conservation issues to be faced.

The recent alien diversity estimates, excluding questionable and cryptogenic species, indicate the presence of nearly 900 species, 75% of which have established successfully breeding populations in the region [4, 5]. Although there were serious concerns that the recent expansion of the Suez Canal by 2015 could trigger a huge wave of invasions [6], the annual rate of introductions in the Mediterranean seems to be in a decreasing trend, currently with no rational explanations, except for the survey intensity over years [7]. One new species record in every two weeks was given for the period of 2011–2012 [8], which sharply has decreased to a level of 4 sp./year between 2017 and 2019, regardless of the pathway [5]. Alien species diversity displays significant differences among basins of the Mediterranean Sea. Highest number of species were recorded from the eastern basin, dominated by Indo-Pacific taxa introduced via the Suez Canal, while almost 6 folds lower diversity figures exist at the western part, in which fouling and ballast water transportation along shipping lines appear to be the main vector [8, 9].

Located at the junction of three continents, Turkey is among the most impacted countries from bioinvasions for a couple of reasons. The distance between Suez Canal and Iskenderun Bay is almost 350 nautical miles and such proximity facilitates alien species that traversed the canal to easily flux through the prevailing counter-clockwise Mediterranean currents. Moreover, there is a dense maritime traffic in the Turkish Straits System (Çanakkale and Istanbul Straits); number of vessels passing through the Istanbul Strait was over 40,000 vessels during 2019 [10], which is significantly higher from the Suez Canal where some 17,000 vessels pass annually [6]. Although responsible from a minor magnitude of impact, existence of several coastal aquaculture facilities is also a known potential vector for species introductions.

So far, the alien biota of Turkey has been compiled by a group of national experts in two comprehensive checklists [7, 11]. Obviously, both lists are currently out of date, since i) several new records were given during the last decade (Berthellina citrina, Styela clava, Equulites popei, etc.) [12–14], ii) the establishment success of some species have changed (for example Parupeneus forsskali remained as a casual species for over a decade after its first record [15], which currently invaded the entire northern Levant shores), iii) the distribution ranges of already recorded species expanded (the veteran alien fish Stephanolepis diaspros has penetrated to the Sea of Marmara [16]), iv) taxonomical revisions reveal misidentifications (Lagocephalus guentheri was erroneously misidentified as L. spadiceus [17]), v) native/alien status of some species changed (as in the case of Oculina patagonica, which was previously considered as an alien species, now shifted to native category [18]), vi) some Red Sea/Indo-Pacific species have recently been described as new species from the Mediterranean Sea (Hazeus ingressus [19] and Chrysaora pseudoocellata [20]).

The Convention on Biological Diversity calls on in its Article 8 (h) each Contracting Party, as far as possible and as appropriate “to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species”, in which dealing with the ongoing threat through available measures relies primarily on updated inventories [21]. Avoiding errors and inaccuracies in species listing processes are also vital for many areas in conservation biology [22] and regional datasets of marine alien species are of utmost importance for the success of regulation on the prevention and management of invasive taxa [23]. It is therefore necessary to review, validate and update the list of alien species in accordance with current scientific information. We here present a comprehensive treatise on the recent status of all alien marine taxa reported from Turkey, a core area drastically impacted by bioinvasions.
Reducing geographical data gaps is a prerequisite for mitigation actions that will also serve as a baseline for the development of open data infrastructures, presently lacking in Turkey.

Material and methods

The present study is an update of the alien species list given by [7], based on new information on the taxonomic entities and distributions of alien species. The present study also adds new information about the presence of alien species along the coasts of Turkey. As having different oceanographic characteristics, the current status of alien species in the seas (Black Sea, Sea of Marmara, Aegean Sea and Levantine Sea) surrounding Turkey were evaluated separately. The first collection year of the species were extracted in the respective papers, but if there is no information about it, the year of sample collection was determined by making a personal interview with the corresponding author. For example, as there is no indication on the collection date of the hydroid *Eudendrium merulum* [24], the publication date (2000) of the paper was regarded as the collection date of the species in the Sea of Marmara and Aegean Sea [25]. However, after interviewed with the corresponding author (A.C. Marques), the collection date of the species was corrected as 1953 for the Sea of Marmara and 1977 for the Aegean Sea.

Some species previously regarded as alien species in the region were excluded from the list because of several reasons including misidentification, or misinterpretation of its origin and pathway of arrival. The species excluded from the alien species list given by [7] and the reasons for their eliminations are presented.

Alien species were grouped into two categories, namely established and casual alien species [26]. Species that formed self-maintaining populations with at least two records in the area (three records for fish) spread over time and space are classified as established species, while those having been recorded only once (no more than twice for fish) with no evidence of self-sustaining populations are classified as casual species. If detected in countries (Syria, Lebanon, Israel, Greece) close to Turkey, the recent appeared species on the coast with specimens/colonies higher than 2 were also categorized as established alien species. Among the established aliens, the species that affect biodiversity, human health and socio-economy are categorized as invasive alien species. In addition, some species with no definite evidence of their native or introduced status are considered as cryptogenic according to [27]. In the classification of the pathways for the introductions of alien species to Turkey, only primary pathways are considered.

In order to assess the distribution of alien species along the coasts of Turkey, the coasts were divided into grids with squares of 15 × 15 km. All data for the species distribution were extracted from respective papers and then entered to an Excel file, and then imported and digitized with ArcGIS 9.3 software. The coordinate system used in the Arcgis v9.3 software is WGS84.

Results and discussion

New knowledge on alien diversity in Turkey

In the present paper, two specimens (around 5 cm high) of the ascidian *Rhodosoma turcicum* are being reported for the first time from the coasts of Turkey (Levantine Sea), in Fethiye Bay (36°42'46.02''N-28°54'29.91''E) at 6 m depth on a dead shell of *Pinna nobilis* in 2008 (Fig 1). This species was originally described from the Red Sea on a madreporarian coral [28] and is widely distributed in tropical and some temperate areas (for the distribution, see [29]). This species was firstly reported from the Mediterranean in Lebanon in 1999 [30], and subsequently in Israel in 2004 [31]. The report of this species in Greece was unverified and excluded from...
the alien list of the country [32]. The main distinguishing character of the species is the horizontal fold of the body that acts as a lid over the apertures (Fig 1).

The present study also includes yet unpublished data on range extensions (to different sea) of some alien species (personal observations by experts): the red alga *Polysiphonia morrowii* was found for the first time in the Aegean Sea (Saroz Bay) in 2018; the polychaetes *Leodice antennata* and *Dorvillea similis* in the Aegean Sea (Ildir Bay) in 2011; the bivalves *Arcuatula perfragilis* and *Paratapes textilis* in the Aegean Sea (Akbük) in 2018, and the fish *Paranthias furcifer* in the Levantine Sea (Antalya Bay) in 2003. The latter species was observed for almost a period of three months at the same reef in Üçadalar region and was photographed during scuba dives, but the finding remained unpublished until now since a specimen could not be captured.

**The actual number of alien species on the coasts of Turkey**

The 2020’s update of marine alien species along the coasts of Turkey included 539 species belonging to 18 taxonomic groups, of which 404 species have become established in the regions and 135 species are casual (Table 1).

Among the established species, 105 species have invasive characters at least in one zoogeographic region, comprising 19% of all alien species and 26% of established alien species. Mollusca ranked first in terms of the number of alien species (123 species), followed by Foraminifera, Arthropoda and Pisces (Fig 2). The groups with the highest casual alien species are Foraminifera (51 species), Mollusca (27 species) and Pisces (28 species). Casual species are absent in 7 taxonomic groups. Established species accounted for more than 60% of total number of species in 5 groups [Chaetognatha (100%), Cnidaria (78%), Bryozoa (71%), Ochrophyta (67%) and Arthropoda (66%)]. The number of invasive alien species varied among groups, with the highest scores being calculated in Pisces (26 species) and Polychaeta (19 species). All
Table 1. The list of alien species and their first year of observations from the coasts of Turkey.

| GROUPS/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| **RHODOPHYTA** |     |    |    |    |    |   |    |   |    |
| Asparagopsis armata Harvey, 1855 | 1973 | 1984 | 1973 | 1968 | Inv | Unk | S | Hs | I |
| Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845 | 1984 | 2001 | 2005 | Inv | RS | Co | Hs | I |
| Acanthophora nayadiformis (Delile) Papenfuss, 1968 | 1970 | 1845 | 1989 | E | RS | Co | Hs | I,II |
| Ganonema farinosum (Lamouroux) Fan & Wang, 1974 | 1984 | 1970 | 1970 | E | RS | Co | Hs | II |
| Rhodophysema georgei Batters, 1900 | 1984 | 2001 | 1989 | E | RS | Co | Hs | I |
| Gayliella fimbriata (Setchell & N.L.Gardner) T.O.Cho & S.M.Boo, 2008 | 2015 | 1977 | 1989 | E | IP | S | Hs | I |
| Oppiophora macrocarpa (Bergesen) H.Stegenga, J.J.Bolton, & R.J.Anderson, 1997 | 1984 | 1990 | 1988 | E | Unk | S | Hs | Ss | I |
| Griffithsia corallinoides (Linnaeus) Trevisan, 1845 | 1986 | 1973 | 1989 | E | Unk | S | Hs | I,II |
| **OCHROPHYTA** |     |    |    |    |    |   |    |   |    |
| Cladosiphon zosterae (J.Agardh) Kylin, 1940 | 1984 | 1983 | 1989 | E | AT | S | Hs | I |
| Chorda filum (Linnaeus) Stackhouse 1797 | 1984 | 1973 | 1997 | E | Unk | S | Hs | I,II |
| Colpomenia peregrina Sauvageau, 1987 | 1970 | 1986 | E | AT | S | Hs | I,II |
| Halothrix lumbricalis (Kützing) Reinke, 1888 | 1984 | 1984 | 1989 | E | Unk | S | Hs | I |
| Galaxaura rugosa (Hudson) Kuntze 1891 | 1983 | 1984 | 1989 | E | Unk | S | Hs | I,II |
| Rhodophysema georgei Batters, 1900 | 1984 | 2001 | 1989 | E | AT | S | Hs | I |

(Continued)
Table 1. (Continued)

| GROUPS/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| Pseudocodium okinawense E.J.Faye, M.Uchimura & S.Smimada, 2008 | | | | | | | | | |
| Ulva australis Areschoug, 1854 | 2015 | C | IP | Aq | Hs | I | |
| SPERMATOPHYTA | | | | | | | | | |
| Halophila stipulacea (Forsskål) Ascherson, 1867 | 1956 | 1967 | Inv | RS | Co | Ss | II |
| FORAMINIFERA | | | | | | | | | |
| Adelosina colonii (Le Calvez & Le Calvez, 1958) | 2003 | C | NA | S | Hs/Ss | II,III | |
| Adelosina longirostra (d’Orbigny, 1826) | 2002 | C | Unk | S | Hs/Ss | II-V | |
| Adelosina milletti Wiesner, 1923 | 2002 | E | PO | S | Hs/Ss | ? | |
| Ammodiscus gullmarensis Höglund, 1948 | 2003 | C | Unk | S | Hs/Ss | II-VI | |
| Amphisorus hemprichii Ehrenberg, 1840 | 2004 | 2002 | Inv | Unk | ? | Hs/Ss | I,II | |
| Amphistegina lessonii d’Orbigny in Guérin-Ménéville, 1832 | 2013 | 2007 | 2008 | E | Unk | ? | Hs/Ss | I,II | |
| Amphistegina lobifera Larsen, 1976 | 2004 | 2001 | 1997 | Inv | RS | Co | Hs/Ss | I-III | |
| Articulina alticostata Cushman, 1944 | 2004 | 2001 | E | PO | S | Hs/Ss | II | |
| Articulina carinata Wiesner, 1923 | 1999 | E | PO | S | Hs/Ss | I,II | |
| Articulina majori Cushman, 1922 | 1988 | C | AT | S | Hs/Ss | III,IV | |
| Aschemonella aspera Gooday and Holzmann, 2017 | 2010 | C | PO | S | Hs/Ss | III | |
| Astacolus insolitus (Schwager, 1866) | 2008 | 2004 | E | PO | S | Hs/Ss | II-VI | |
| Bolivina arta MacFadyen, 1931 | 2003 | C | PO | S | Hs/Ss | ? | |
| Bolivina striatula Cushman, 1922 | 1995 | 2003 | 1988 | E | Unk | ? | Hs/Ss | II | |
| Brizalina simpsoni (Heron-Allen and Earland, 1915) | 2007 | E | RS | Co | Hs/Ss | II | |
| Bulimina biserialis Millet, 1900 | 1988 | C | RS | Co | Hs/Ss | II,III | |
| Bulimina demudata Cushman & Parker, 1938 | 2002 | C | PO | S | Hs/Ss | II-V | |
| Candeina nitida d’Orbigny, 1839 | 2011 | C | Unk | S | Hs/Ss | VII | |
| Clavulina cf. multicamerata Chapman, 1907 | 2002 | 2001 | E | RS | Co | Hs/Ss | II | |
| Cornuspiroides striolata (Brady) | 2008 | 2014 | E | Unk | S | Hs/Ss | III | |
| Coscinospira acicularis (Batsch, 1791) | 2007 | C | AT | S | Hs/Ss | I | |
| Cushmanina striatopunctata (Parker and Jones, 1865) | 2007 | 2002 | C | Unk | S | Hs/Ss | II | |
| Cyclorbiculina compressa (d’Orbigny, 1839) | 2002 | C | Unk | ? | Hs/Ss | II | |
| Cymbaloporetta plana (Cushman, 1915) | 2011 | 2007 | 2002 | E | RS | Co | Hs/Ss | I-III | |
| Cymbaloporetta squammosa (d’Orbigny, 1839) | 2012 | 2002 | 2001 | E | Unk | ? | Hs/Ss | I,II | |
| Dendronina arborescens Heron-Allen and Earland, 1922 | 2012 | C | Unk | S | Hs/Ss | II | |
| Dentalina albatrossi (Cushman, 1923) | 2002 | 2004 | E | Unk | ? | Hs/Ss | III | |
| Dentalina vertebralis (Batsch, 1791) | 2008 | E | PO | S | Hs/Ss | III,IV | |
| Discogypsina vesicularis A. Silvestri, 1937 | 2011 | C | Unk | S | Hs/Ss | III | |
| Elphidium striatopunctatum (Fichtel and Moll, 1798) | 1997 | C | RS | Co | Hs/Ss | II-IV | |
| Entosigmomorpha sp. | 2002 | C | PO | S | Hs/Ss | II | |
| Euthymonachia polita (Chapman, 1904) | 2007 | E | Unk | S | Hs/Ss | II | |
| Faussa carinata d’Orbigny, 1839 | 2008 | C | NA | S | Hs/Ss | III,IV | |
| Fissurina faba (Balkwill & Millet, 1884) | 2002 | C | NA | S | Hs/Ss | IV | |
| Globobulimina auriculata (Bailey, 1894) | 2003 | C | Unk | S | Hs/Ss | ? | |
| Guttulina ovata (d’Orbigny, 1846) | 2011 | C | Unk | S | Hs/Ss | II,III | |
| Guttulina yabei Cushman and Ozawa, 1929 | 2011 | C | PO | S | Hs/Ss | II | |
| Haddonia sp. | 2009 | 2002 | E | RS | Co | Hs/Ss | II,III | |
| Hansenisca soldanii (d’Orbigny, 1826) | 2008 | C | RS | Co | Hs/Ss | I | |
| Hauerina diversa Cushman, 1946 | 2007 | 1997 | E | RS | Co | Hs/Ss | II | |
| Haynesina paucilocula (Cushman, 1944) | 2005 | E | NA | S | Hs/Ss | III-V | |
| Heterocythere tuberculata (Mobius, 1880) | 1988 | E | RS | Co | Hs/Ss | II | |

(Continued)
| GROUPS/Species                  | BS     | SM | AS | LS | ES | O | PW | H | DR |
|--------------------------------|--------|----|----|----|----|---|----|---|----|
| Heterostegina depressa d’Orbigny, 1826 | 1988   | E  | RS | Co | Hs/Ss | I,II |
| Iridia diaphana Heron-Allen and Earland, 1914 | 2006   | E  | PO | S  | Hs/Ss | I   |
| Laevidentalina filiformis (d’Orbigny, 1826) | 2011   | C  | Unk | S  | Hs/Ss | III |
| Marginulina gummi Saidova, 1975 | 2005   | C  | PO | S  | Hs/Ss | III |
| Marsipella elongata Norman, 1878 | 2012   | C  | Unk | S  | Hs/Ss | II  |
| Melonis affinis (Reuss, 1851) | 1995   | E  | NA | S  | Hs/Ss | II-VI |
| Milolinelia cf. hybrida (Terquem, 1878) | 2002   | C  | RS | Co | Hs/Ss | II  |
| Nodobucalariella cristobalensis McCulloch, 1977 | 2014   | E  | PO | S  | Hs/Ss | I,II |
| Nodobucalariella galapagosensis McCulloch, 1977 | 2014   | C  | PO | S  | Hs/Ss | II  |
| Nodanthalmidium antillarum (Cushman, 1922) | 2002   | 1995 | E  | RS | Co | Hs/Ss | III |
| Nonion fabum (Fichtel and Moll, 1798) | 2011   | C  | AT | S  | Hs/Ss | III |
| Nonion subtergatum (Cushman, 1924) | 2005   | C  | IP | S  | Hs/Ss | III |
| Peneroplis arietinus (Batsch, 1791) | 2008   | 2002 | E  | RS | Co | Hs/Ss | I,II |
| Planispirinella exigua (Brady, 1879) | 1998   | 1999 | 1988 | E  | RS | Co | Hs/Ss | I,II |
| Planogypsina acervalis (Brady, 1884) | 2002   | 2002 | E  | RS | Co | Hs/Ss | I,II |
| Planogypsina squamiformis (Chapman, 1901) | 2001   | 2002 | E  | RS | Co | Hs/Ss | I,II |
| Polymorpha fistulosa Williamson, 1858 | 2015   | 2012 | E  | RS | Co | Hs/Ss | II,III |
| Procerolagena gracilis (Williamson, 1848) | 2008   | C  | Unk | S  | Hs/Ss | IV-VII |
| Pseudoclavulina humilis (Brady, 1884) | 2012   | C  | Unk | S  | Hs/Ss | VII |
| Pseudomassilina australis (Cushman, 1932) | 1988   | C  | RS | Co | Hs/Ss | II |
| Pseudomassilina reticulata (Heron-Allen and Earland, 1915) | 1988   | C  | RS | Co | Hs/Ss | II |
| Pseudonodosaria brevis (d’Orbigny, 1846) | 2014   | C  | PO | S  | Hs/Ss | III |
| Pulleniatina obliquiloculata (Parker & Jones, 1862) | 2004   | C  | PO | S  | Hs/Ss | II,III |
| Pyramidulina catesbyi (d’Orbigny, 1839) | 2008   | 1988 | E  | RS | Co | Hs/Ss | II,III |
| Pyramidulina perversa (Schwager, 1866) | 2002   | 2002 | E  | PO | S  | Hs/Ss | II |
| Pygo denticulata (Brady, 1917) | 2002   | 2002 | E  | Unk | ?  | Hs/Ss | II |
| Quinqueloculina carinatastriata (Wiesner, 1923) | 2002   | 2003 | E  | PO | S  | Hs/Ss | II-V |
| Quinqueloculina cf. mosharrafai Said, 1949 | 2002   | C  | RS | Co | Hs/Ss | II |
| Quinqueloculina sp. C | 2009   | C  | RS | Co | Hs/Ss | II |
| Recurvoidella bradyi (Robertson, 1891) | 2003   | C  | Unk | S  | Hs/Ss | III-VII |
| Schlumbergerina alveoliniformis (Brady, 1879) | 2002   | 2002 | E  | RS | Co | Hs/Ss | II |
| Sigmoihauerina bradyi (Cushman, 1917) | 1988   | C  | Unk | ?  | Hs/Ss | ? |
| Siphonaperta arenata (Said, 1949) | 2002   | C  | Unk | ?  | Hs/Ss | III |
| Siphonina tubulosa Cushman, 1924 | 2005   | 2008 | C  | Unk | S  | Hs/Ss | I |
| Sorites orbiculus Ehrenberg, 1839 | 2010   | 2001 | 1988 | E  | Unk | ?  | Hs/Ss | II |
| Sorites variabilis Lacoix, 1941 | 2007   | 2002 | E  | RS | Co | Hs/Ss | II |
| Spiroloculina angulata Cushman, 1917 | 2004   | 2006 | 1988 | E  | RS | Co | Hs/Ss | I-III |
| Spiroloculina subcommunis McCulloch, 1981 | 2008   | C  | AT | S  | Hs/Ss | III-VII |
| Stainforthia concava (Hoeglund, 1947) | 2008   | C  | Unk | S  | Hs/Ss | IV |
| Stainforthia fusiformis (Williamson, 1848) | 2008   | C  | Unk | S  | Hs/Ss | VI,VII |
| Textularia cushmani Said, 1949 | 2002   | C  | IP | S  | Hs/Ss | IV |
| Triloculina affinis d’Orbigny, 1852 | 2009   | C  | Unk | S  | Hs/Ss | II |
| Triloculina cf. fichteliana d’Orbigny, 1839 | 2008   | 2004 | E  | RS | Co | Hs/Ss | II |
| Triloculina sp. A | 2009   | C  | RS | Co | Hs/Ss | II |
| Triloculinella asymetrica (Said, 1949) | 1988   | C  | RS | Co | Hs/Ss | II,III |
Table 1. (Continued)

| GROUPS/Species | BS   | SM | AS | LS  | ES | O | PW | H   | DR      |
|----------------|------|----|----|-----|----|---|----|-----|---------|
| **BSM**       |      |    |    |     |    |   |    |     |         |
| Vaginulopsis sublegumen Parr, 1950 | 2004 | E  | PO | S   | Hs/Ss | II |
| Veleronoides scitulus (Brady, 1881) | 2003 | C  | Unk| S   | Hs/Ss | III-VII |
| **PORIFERA**  |      |    |    |     |    |   |    |     |         |
| Paraleucilla magna Klautau, Monteiro & Borovevic, 2004 | 2012 | 2004 | Inv | WA | S | Hs | I |
| Niphates toxifer Vacelet, Bitar, Carteron, Zibrowius & Pérez, 2007 | 2019 | E | ?RS | ?Co | Hs | I |
| **CNIDARIA**  |      |    |    |     |    |   |    |     |         |
| Aequorea globosa Eschscholtz, 1829 | 2011 | E  | RS | Co | P | I,II |
| Aequorea vitrina Gosse, 1853 | 2015 | E  | EA | S  | P | I |
| Cordylophora caspia (Pallas, 1771) | 1977 | E  | Unk| S  | Hs | I |
| Coryne eximia Allman, 1859 | 1950 | E  | CT | S  | Hs | I |
| Clytia linearis (Thorney, 1890) | 1977 | E  | RS | Co | Hs | I |
| Eudendrium merulum Watson, 1985 | 1953 | 1977 | E  | CT | S  | Hs | I |
| Filellum serratum (Clarke, 1879) | 1980 | 1977 | E  | CT | S  | Hs | I |
| Macrorhynchia philippina Kirchenpauer, 1872 | 2005 | Inv | RS | Co | Hs | I |
| Sertularia marginata (Kirchenpauer, 1864) | 1977 | E  | CT | S  | Hs | I |
| Cassiopea andromeda (Forskål, 1775) | 2011 | 2000 | Inv | RS | Co | P | I |
| Chrysaora pseudoocellata Mutilu, Çağtay, Olguner & Yılmaz, 2020 | 2018 | E | ?RS | ?Co | P | I |
| Phyllorhiza punctata von Lendenfeld, 1884 | 2011 | 2010 | E  | RS | Co | P | I |
| Rhopilema nomadica Galil, Spanier & Ferguson, 1990 | 2011 | 1995 | Inv | RS | Co | P | I |
| Marivagia stellata Galil and Gershwin, 2010 | 2019 | E  | RS | Co | P | I |
| Sagartiogeton laceratus (Dalyell, 1848) | 1998 | E  | EA | S  | Hs | II |
| Pachycerianthus multiplicatus Carlgren, 1912 | 2009 | E  | EA | S  | Ss | I |
| Diadumene lineata (Verrill, 1869) | 1997 | E  | PO | S  | Hs | I |
| Diadumene cincta Stephenson, 1925 | 2011 | Inv | NA | S  | Hs | I |
| **CTENOPHORA** |      |    |    |     |    |   |    |     |         |
| Mnemiopsis leidyi (Agassiz, 1865) | 1993 | 1994 | 1994 | 1992 | Inv | NA | S | P | I, II |
| Beroe ovata Mayer 1912 | 1996 | 2004 | Inv | NA | S  | P | I, II |
| **SIPUNCULA** |      |    |    |     |    |   |    |     |         |
| Aspidosiphon (A.) elegans (Chamisso & Eysenhardt, 1821) | 2006 | 2005 | E  | RS | Co | Hs | I |
| Nephasoma (Nephasoma) eremita (Sars, 1851) | 2005 | C  | ?PO | S  | Ss | III |
| **POLYCHAETA** |      |    |    |     |    |   |    |     |         |
| Leptonotus tenuisetosus (Gravier, 1902) | 2005 | E  | RS | Co | Hs | I |
| Pisione guanche San Martin, López & Núñez, 1999 | 2005 | E  | AT | S  | Ss | I |
| Phyllophora longifrons Ben-Eliahu, 1972 | 2011 | E  | RS | Co | Hs/Ss | I |
| Eurythoe complanata (Pallas, 1766) | 1993 | Inv | ?RS | ?Co | Hs | I |
| Linopherus canariensis Langerhans, 1881 | 2005 | 1993 | E  | AT | S  | Hs/Ss | I |
| Eusyllis kupfferi Langerhans, 1879 | 2005 | E  | ?AT | S  | Hs | I |
| Exogone africana (Hartmann-Schröder, 1974) | 2011 | E  | RS | Co | Ss | II |
| Exogone brevianternata Hartmann-Schröder, 1959 | 2005 | E  | RS | Co | Hs | I |
| Prosphaerocyllis longipapillata (Hartmann-Schröder, 1979) | 2004 | 2005 | E  | PO | S  | Ss | II |
| Syllis ergeni Çınar, 2005 | 2004 | 2005 | Inv | RS | Co | Hs | I |
| Syllis pectinans Haswell, 1920 | 2004 | E  | PO | S  | Hs | I |
| Ceratonereis mirabilis Kinberg, 1866 | 2011 | 2005 | E  | RS | Co | Hs/Ss | I,II,III |
| Leonnates decipiens Faavel, 1929 | 2005 | E  | RS | Co | Hs | I |
| Leonnates indicus Kinberg, 1866 | 2005 | Inv | RS | Co | Hs | I |
| Leonnates persicus Wesenberg-Lund, 1949 | 2001 | 2000 | E  | RS | Co | Ss | II-IV |
| Nereis persica Faavel, 1911 | 1959 | 2005 | E  | RS | Co | Ss | I,II,III |

(Continued)
Table 1. (Continued)

| GROUPS/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| Nereis jacksoni Kinberg, 1866 | 2005 | E | RS | Co | Ss | I,II |
| Pseudonereis anomala Gravier, 1900 | 2004 | 1973 | Inv | RS | Co | Hs | I |
| Glycinde bonhourei Gravier, 1904 | 2009 | 2005 | E | RS | Co | Ss | I |
| Diopatra marocensis Paxton, Fadlaoui & Lechapt, 1995 | 2005 | 2005 | E | EA | S | Ss | I,II |
| Lumbrineris perkinsi Carrera-Parra, 2001 | 2005 | E | RS | ?Co | Hs | I,II |
| Leodice antennata (Savigny, 1820) | 2011 | 1993 | Inv | RS | Co | Hs | I |
| Lysidice collaris Grube, 1870 | 1993 | 1993 | E | RS | Co | Ss | Ss | I,II |
| Palola valida (Gravier, 1900) | 2005 | E | RS | Co | Hs | I |
| Dorvillea similis (Crossland, 1924) | 2011 | 2005 | Inv | RS | Co | Hs/Ss | I,II |
| Arcidea bulbosa Hartley, 1984 | 2013 | 2017 | E | RS | Co | Ss | I-III |
| Laomice norgensis Sikorski, 2003 | 2000 | C | AT | S | Ss | IV |
| Polydora cornuta Bosc, 1802 | 2012 | 2002 | 1986 | Inv | WA | S | Ss | I,II |
| Prionospos (Aquilaspio) krusadensis Fauvel 1929 | 2005 | E | IP | S | Ss | I |
| Prionospos (Aquilaspio) sexoculata Augener, 1918 | 2005 | E | IP | S | Ss | I |
| Prionospos (Prionospos) depauwerata Imajima, 1990 | 2000 | 2005 | Inv | PO | S | Ss | I,II |
| Prionospos (Prionospos) paucipinnulata Blake & Kudenov, 1978 | 2000 | 2005 | E | PO | S | Ss | I,II |
| Prionospos (Prionospos) sacicera Mackie & Hartley, 1990 | 2000 | 1995 | E | RS | Co | Ss | I-III |
| Prionospos (Minospio) pulchra Imajima 1990 | 2000 | 2008 | 2000 | 2005 | Inv | IP | S | Ss | I |
| Pseudopolydora paucibranchiata Okuda, 1937 | 2008 | 2000 | 2005 | Inv | IP | S | Hs/Ss | I |
| Spiophanes algidus Meißner, 2005 | 2000 | C | IO | S | Ss | IV |
| Streblospio gynobranchiata Rice & Levin, 1998 | 2005 | 2000 | Inv | WA | S | Ss | I,II |
| Neopseudocapitella brasiliensis Rullier & Amoureux, 1979 | 2001 | E | Unk | S | Ss | II |
| Notomastus aberans Day, 1957 | 2013 | 1980 | 2000 | E | RS | Co | Ss | I-III |
| Notomastus mosaicus (Thomassin, 1970) | 2005 | Inv | RS | Co | Ss | I-III |
| Chaetozoae corona Berkeley & Berkeley, 1941 | 2010 | 1980 | 2005 | E | ?PO | S | Ss | I,II |
| Timarete carinosa (Grube, 1859) | 2005 | C | WA | S | Hs | I |
| Timarete punctata (Grube, 1859) | 2005 | E | RS | Co | Hs | I |
| Semiodera cinari Salazar-Vallejo, 2012 | 2005 | E | IP | S | Hs | I |
| Stylarioides gruei Salazar-Vallejo, 2011 | 2005 | E | IO | S | Hs | I |
| Metasychis gottu Izuka, 1902 | 2008 | 1996 | 2000 | E | RS | Co | Ss | II,III |
| Pista unibranchia Day, 1963 | 1998 | 1993 | E | RS | Co | Ss | I,II |
| Loimia medusa (Savigny, 1818) | 1959 | 2005 | E | RS | ?Co | Ss | ? |
| Polycirrus twisti Potts, 1928 | 2005 | E | RS | Co | Hs/Ss | I |
| Branchionyma bairdi (McIntosh, 1885) | 2005 | Inv | Unk | 7S | Hs/Ss | I |
| Branchionyma luctuosum Grube, 1869 | 2005 | Inv | RS | Co | Hs | I |
| Desdemona ornata Banse, 1957 | 2005 | E | IP | S | Hs | I |
| Laomone triangularis Hutchings & Murray, 1984 | 2005 | E | PO | S | Ss | I |
| Ficopomatus enigmaticus (Fauvel, 1923) | 1952 | 1972 | Inv | ST | S | Hs | I |
| Hydroides brachycanthus Rioja, 1941 | 2005 | Inv | IP | 7S | Hs | I |
| Hydroides diramphus Mörch, 1863 | 1894 | 2005 | Inv | CT | S | Hs | I |
| Hydroides elegans (Haswell, 1883) | 2012 | 1972 | 1991 | Inv | CT | S | Hs | I |
| Hydroides heterocerus (Grube, 1868) | 2005 | E | RS | Co | Hs | I,II |
| Hydroides homoceros Pixell, 1913 | 2005 | E | RS | Co | Hs | I |
| Hydroides minax (Grube, 1878) | 2005 | E | RS | Co | Hs | I |
| Hydroides operculata (Treadwell, 1929) | 2005 | Inv | IO | S | Hs | I |
| Spirobranchus kraussii (Baird, 1865) | 2005 | Inv | RS | Co | Hs | I |
| Spirobranchus tetracerus (Schmarda, 1861) | 2005 | E | RS | Co | Hs | I,II |
Table 1. (Continued)

| Groups/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| Janua (Dexiospira) steueri (Sterzinger, 1909) | 2005 | E | RS | Co | Ss | I,II |
| Spirobranchus marioni Caullery & Mesnil, 1897 | 1987 | 2005 | E | PO | S | Hs | I |

**Arthropoda**

| Groups/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| Anoplodactylus californicus Hall, 1912 | 1959 | E | RS | Co | Hs | I |
| Ammobarea hilgendorfi (Böhm, 1879) | 2010 | E | PO | S | Hs | I |
| Amphibalanus eburneus (Gould, 1841) | 1968 | 1939 | 1968 | Inv | AT | S | Hs | I |
| Amphibalanus improvisus (Darwin, 1854) | 1988 | 1892 | 1968 | Inv | WA | S | Hs | I |
| Balanus trigonus Darwin, 1854 | 1993 | E | CT | S | Hs | I |
| Heterocarpus dollfusi Boschma, 1960 | 1994 | Inv | RS | Co | Pz | II |
| Pleopsis schmackeri (Poppe, 1889) | 2017 | 2012 | E | IP | Co/S | P | II |
| Acartia tonsa Dana, 1848 | 1993 | 2001 | 1998 | E | Unk | S | P | I |
| Acrocalanus gibber Giesbrecht, 1888 | 1998 | 1999 | E | ST | S | P | I |
| Calanopsis elliptica (Dana, 1846) | 1999 | E | RS | Co | P | I |
| Caligus lagocephali Pillai, 1961 | 2011 | C | IP | ? | Pz | II |
| Centropages furcatus (Dana, 1849) | 1998 | 1999 | E | RS | Co | P | I-III |
| Dielithina ovalata (Farran, 1913) | 2013 | E | IP | S | P | II |
| Mitropus oblongus (Pillai, 1964) | 2010 | E | RS | Co | Pz | ? |
| Labidocera pavo Giesbrecht, 1889 | 1999 | E | RS | Co | P | I |
| Lernanthropus callionymicola El-Rashidy & Boxshall, 2012 | 2013 | E | RS | Co | Pz | ? |
| Oithona davisae Ferrari and Orsi, 1984 | 2009 | 2014 | 2017 | 2018 | Inv | PO | S | P | II |
| Paracartia grani Sars G.O., 1904 | 1998 | E | AT | S | P | II |
| Parvocalanus crassirostris (Dahl F., 1894) | 1998 | 1998 | E | RS | Co | P | II |
| Parvocalanus elegans Andronov, 1972 | 1998 | 1998 | E | RS | Co | P | I-III |
| Parvocalanus latus Andronov, 1972 | 1998 | 1998 | E | RS | Co | P | I-III |
| Taeniactanus lagocephali Pearse, 1952 | 2011 | C | IP | ? | Pz | II |
| Cloridina cf. ichneumon (Fabricius, 1798) | 2019 | C | RS | Co | Ss | II |
| Erugosquilla massavensis (Kossmann, 1880) | 2002 | 1987 | 1959 | Inv | RS | Co | Ss | I-IV |
| Ampithec bizzeli Ozaydmh and Coleman, 2012 | 2010 | E | IP | S | Hs | I |
| Caprella scabra Templeton, 1836 | 2012 | 2008 | E | IP | S | Hs | I |
| Latigammaropsis togoensis (Schellenberg,1925) | 2005 | E | Unk | Ss | Hs | I |
| Linguemera caesaris Krapp-Schickel, 2003 | 1976 | 1976 | E | RS | Co | Hs | I |
| Paracerceis sculpta Holmes,1904 | 2015 | C | IP | S | Hs | I |
| Paradella dianae Menzies,1962 | 2004 | 2008 | E | Unk | Ss | Hs/Ss | I |
| Sphaeroma walkeri (Stebbing, 1905) | 1995 | 2015 | E | RS | Co | Hs | I |
| Paradoxospeudes intermedius (Hansen, 1895) | 2006 | 1972 | E | AT | Ss | Hs/Ss | II |
| Eucoma sarsi (Kossmann, 1880) | 1976 | E | RS | Co | Hs/Ss | II |
| Actaea savignii (H. Milne Edwards, 1834) | 2017 | 2011 | E | RS | Co | Hs/Ss | I |
| Alpheus lobidens De Haan, 1849 | 2014 | 1969 | E | RS | Co | Ss | I |
| Alpheus migrans Lewinsohn & Holthuis, 1978 | 1993 | E | RS | Co | Ss | I-III |
| Alpheus rapacida de Man, 1908 | 2005 | 1981 | E | RS | Co | Ss | I-III |
| Arcania brevifrons Chen 1989 | 2019 | C | RS | Co | Ss | II |
| Atergatis roseus (Rüppell, 1830) | 2004 | 1987 | E | RS | Co | Hs | II |
| Calappa hepatica (Linnaeus, 1758) | 1992 | C | RS | Co | Ss | I-III |
| Callinectes sapidus Rathbun, 1896 | 2013 | 2001 | 1967 | 1959 | Inv | WA | S | Ss | II |
| Carupa tenuipes Dana, 1851 | 2003 | 1996 | E | RS | Co | Hs | I |
| Charybdis helleri (Milne Edwards, 1867) | 2003 | 1987 | Inv | RS | Co | Hs/Ss | II |

(Continued)
| GROUPS/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| Charybdis longicollis Leene, 1938 | 2002 | 1959 | Inv | RS | Co | Ss | I-IV |
| Coleusia signata (Paulson, 1875) | 2006 | 1976 | E | RS | Co | Hs/Ss | I-II |
| Daira perlata (Herbst, 1790) | 1988 | C | RS | Co | Hs/Ss | I-II |
| Eucrate crenata de Haan, 1835 | 2018 | 1987 | E | RS | Co | Ss | I-IV |
| Euryacarcinus integrifrons De Man, 1879 | 2009 | E | IO | S | Ss | II |
| Gonioinfradens giardi (Nobili, 1905) | 2009 | C | IP | S | Hs/Ss | I |
| Ixa monodi Holthuis & Gottlieb, 1956 | 2005 | 1955 | E | RS | Co | Ss | I-II |
| Leptochela pugnax de Man, 1916 | 2000 | 1966 | E | RS | Co | Ss | I-IV |
| Macrocephalus indicus Davie, 2012 | 2000 | 1994 | E | RS | Co | Ss | I-IV |
| Metapeneopis aegyptia Galil & Golani, 1990 | 2003 | E | RS | Co | Ss | I |
| Metapeneopis mogensis consobrina (Nobili, 1904) | 2003 | E | RS | Co | Ss | I |
| Metapeneopis affinis (H. Milne Edwards, 1837) | 2008 | E | RS | Co | Ss | I-II |
| Metapeneopis monoceros (Fabricius, 1798) | 1959 | Inv | RS | Co | Ss | I-II |
| Metapeneopis stebbingi (Nobili, 1904) | 1966 | Inv | RS | Co | Ss | I-III |
| Micippa thalia (Herbst, 1803) | 2006 | 1994 | E | RS | Co | Ss | I-IV |
| Matuta victor (Fabricius, 1781) | 2017 | 2015 | E | RS | Co | Ss | I-II |
| Myra subgranulata Kossmann, 1877 | 1930 | E | RS | Co | Ss | I-II |
| Ogyridea mjoaergi (Balss, 1921) | 2005 | E | RS | Co | Ss | I |
| Palaemonella rotunana (Borradaile, 1898) | 1999 | E | RS | Co | Hs | I-II |
| Peneaustacus Ives, 1891 | 2017 | 2015 | 2009 | E | WA | S | Ss | I-II |
| Peneaustacus Ives, 1891 | 2006 | 2002 | Inv | RS | Co | Ss | I-II |
| Peneaustacus Ives, 1891 | 2006 | C | IP | Aq | Ss | II |
| Peneaustacus Ives, 1891 | 2001 | 1930 | Inv | RS | Co | Ss | I-II |
| Peneaustacus Ives, 1891 | 1930 | Inv | RS | Co | Ss | I-II |
| Peneaustacus Ives, 1891 | 2012 | C | AT | S | Ss | II |
| Peneaustacus Ives, 1891 | 2005 | Inv | TA | S | Hs | I-II |
| Peneaustacus Ives, 1891 | 1966 | E | RS | Co | Hs | I |
| Peneaustacus Ives, 1891 | 2000 | 2003 | E | RS | Co | Hs | I |
| Peneaustacus Ives, 1891 | 2004 | 1928 | Inv | RS | Co | Ss | I-II |
| Peneaustacus Ives, 1891 | 1995 | E | TA | S | Ss | II |
| Peneaustacus Ives, 1891 | 2018 | C | RS | Co | Hs | II |
| Peneaustacus Ives, 1891 | 2014 | C | RS | Co | Ss | III |
| Peneaustacus Ives, 1891 | 1981 | 1959 | E | RS | Co | Ss | I-II |
| Peneaustacus Ives, 1891 | 1968 | E | RS | Co | Ss | I-V |
| Peneaustacus Ives, 1891 | 2003 | E | RS | Co | ? | II |

**MOLLUSCA**

| Diodora ruggelii (Sowerby I, G.B., 1835) | 1988 | E | RS | Co | Hs | I |
| Trochus erithreus Brocchi, 1821 | 1992 | E | RS | Co | Hs | I |
| Pseudominolia nedyma (Melville, 1897) | 1992 | E | RS | Co | Ss | I-II |
| Stomatella impertusa (Burrow, 1815) | 1999 | C | RS | Co | Hs | I |
| Nerita sanguinolenta Menke, 1829 | 2004 | E | RS | Co | Ss | I |
| Smaragdia souverbiana (Montouzrier in Souverbie & Montouzrier, 1863) | 1993 | E | RS | Co | Ss | I-
| Cerithium diplax (Watson, R. B., 1886) | 1986 | Inv | PG | S | Ss | I-II |
| Cerithium perparvulum (Watson, R. B., 1886) | 1992 | E | PO | S | Ss | I |
| Cerithium scabrum (Philippi, 1848) | 1990 | 1986 | Inv | RS | Co | Hs/Ss | I |
| Rhinoclavis kochi (Philippi, 1848) | 1986 | E | RS | Co | Ss | I |
| Varicopeza pauxilla (A. Adams, 1855) | 2016 | E | RS | Co | Ss | I-II |

(Continued)
Table 1. (Continued)

| GROUPS/Species | BS | SM | AS | LS | ES | O | PW | H | DR |
|----------------|----|----|----|----|----|---|----|---|----|
| **Diala semistriata** (Philippi, 1849) | 2002 | E | RS | Co | Ss | I |     |    |     |
| **Gibborissoa virgata** (Philippi, 1849) | 1997 | E | RS | Co | Hs | I |     |    |     |
| **Finella popoides** Adams, A., 1860 | 2001 | 1958 | Inv | RS | Co | Ss | I |     |     |
| **Metaxia bacillum** (Issel, 1869) | 1992 | E | RS | Co | Hs | I |     |    |     |
| **Viriola bayani** Jousseaume, 1884 | 2017 | E | RS | Co | Ss | I,II |     |    |     |
| **Cerithiopsis pulvis** (Issel, 1869) | 1990 | E | RS | Co | Ss | I |     |    |     |
| **Cerithiopsis tentrenais** (Melvill, 1896) | 1990 | E | RS | Co | Ss | I |     |    |     |
| **Cycloscala hyalina** (Sowerby II, G. B., 1844) | 1995 | E | RS | Co | Ss | I |     |    |     |
| **Sticteulima lentiginosa** (Adams, A., 1861) | 1989 | E | RS | Co | Ss | I |     |    |     |
| **Rissoina ambigua** (Gould, 1849) | 2003 | C | RS | Co | Ss | II |     |    |     |
| **Rissoina bertholleti** Issel, 1869 | 1985 | E | RS | Co | Ss | I |     |    |     |
| **Caecum septimentum** de Folin, 1868 | 2013 | C | RS | ?Co | Ss | I |     |    |     |
| **Conomurex persicus** (Swainson, 1821) | 1991 | 1978 | Inv | PG | S | Hs/Ss | I,II |     |     |
| **Circulus novemcarinatus** (Melvill, 1906) | 2010 | E | RS | Co | Ss | I |     |    |     |
| **Crepidula fornicatea** (Linnaeus, 1758) | 2012 | E | Unk | Ag/S | Ss | I |     |    |     |
| **Eratoena sulcifera** (Gray in Sowerby I, G. B., 1832) | 2013 | C | IP | ?S | Hs | I |     |    |     |
| **Purpuradusta gracilis notata** (Gill, 1858) | 1982 | E | RS | Co | Hs | I |     |    |     |
| **Eunaticina papilla** Gmelin, 1791 | 2013 | C | IP | S | Ss | I |     |    |     |
| **Ergalatax junionae** Houart, 2008 | 2002 | 1992 | E | RS | S | Hs | I |     |     |
| **Rapana venosa** (Valenciennes, 1846) | 1960 | 1993 | 1995 | Inv | PO | S | Ss | I |     |
| **Indothais lacera** (Born, 1778) | 1991 | E | IO | S | Hs/Ss | I |     |    |     |
| **Critho cossinea** T. Cossignani, 1997 | 2014 | C | IP | S | Ss | II |     |    |     |
| **Zafra obesula** (Hervier, 1899) | 2010 | C | RS | ?Co | Ss | II |     |    |     |
| **Zafra pumila** (Dunker, 1858) | 2010 | C | RS | ?Co | Ss | II |     |    |     |
| **Zafra savignyi** (Moazzo, 1939) | 1986 | E | RS | Co | Ss | I,II |     |    |     |
| **Zafra selasphora** (Melvill & Standen, 1901) | 1993 | E | RS | Co | Ss | I |     |    |     |
| **Lienardia migihesi** Iredale & Tomlin, 1917 | 2003 | C | IP | Co/S | Ss | III |     |    |     |
| **Pseudorhaphitoma iodolabiata** (Hornung & Mermod, 1929) | 2011 | E | RS | Co | Ss | II |     |    |     |
| **Pyrgulina fischeri** Hornung & Mermod, 1925 | 1989 | E | RS | Co | Ss | I |     |    |     |
| **Pyrgulina papaformis** (Souverbie, 1865) | 1963 | E | RS | Co | Hs/Ss | I |     |    |     |
| **Pyrgulina nana** Hornung & Mermod, 1924 | 2000 | 1997 | C | RS | ?S | Ss | I |     |     |
| **Pyrgulina pinthehlla** Melvill, 1910 | 1989 | E | RS | Co | Ss | I |     |    |     |
| **Cingulina isseli** (Tryon, 1886) | 1986 | E | RS | Co | Ss | I |     |    |     |
| **Iolaea neofelixoides** (Nomura, 1936) | 1994 | C | PO | ?S | Ss | I |     |    |     |
| **Monotygna fulva** (Adams, A., 1853) | 2000 | 2017 | E | RS | Co | Ss | II |     |     |
| **Monotygna lauta** (Adams, A., 1853) | 2014 | 1989 | E | RS | Co | Ss | I |     |     |
| **Odostomia lorioli** (Hornung & Mermod, 1924) | 2007 | E | RS | Co | Ss | I |     |    |     |
| **Oscilla galilae** Bogi, Karhan & Yokø, 2012 | 1992 | C | IP | ?S | ? | I |     |    |     |
| **Syrnola cinctella** Adams, A., 1860 | 1994 | C | RS | Co | Ss | I |     |    |     |
| **Syrnola fasciata** Jickeli, 1882 | 2001 | 1963 | Inv | RS | Co | Ss | I |     |     |
| **Syrnola lendix** (Adams, A., 1853) | 1988 | E | IO | Co | Ss | I |     |    |     |
| **Turbonilla edgarii** (Melvill, 1896) | 1989 | E | RS | Co | Ss | I |     |    |     |
| **Amathia tricarinata** (Linnaeus, 1767) | 2000 | E | RS | Co | Hs | I |     |    |     |
| **Leucotina natalensis** Smith, E. A., 1910 | 2015 | 1986 | E | RS | Co | Ss | I |     |     |
| **Bulla arabica** Malaquias & Reid, 2008 | 1998 | 2001 | E | RS | ?Co | Ss | II |     |     |
| **Pyrsulus fourierii** (Audouin, 1826) | 2015 | 1989 | Inv | RS | Co | Ss | II,III |     |     |
| **Retusa degenetii** (Audouin, 1826) | 2002 | E | RS | Co | Ss | I |     |    |     |

(Continued)
| GROUPS/Species                                         | BS | SM | AS | LS | ES | O  | PW | H  | DR  |
|-------------------------------------------------------|----|----|----|----|----|----|-----|----|-----|
| Lamprohaminoea cyanomarginata (Heller & Thompson, 1983) | 2002 | 2002 | E  | RS | Co | Hs | II  |    |     |
| Bivae fulvipunctata (Baba, 1938)                      | 1959 |     | E  | RS | Co | Ss | I,II|    |     |
| Acteocina crithodes (Melvill & Standen, 1901)         | 2003 |     | C  | IP | S  | Ss | II  |    |     |
| Acteocina mucronata (Philippi, 1849)                  | 1986 |     | E  | RS | Co | Ss | ?   |    |     |
| Mnestia girardi (Audouin, 1826)                       | 1996 | 1990 | E  | RS | Co | Ss | II  |    |     |
| Oxyne viridis (Pease, 1861)                          | 2002 |     | E  | IP | S  | Ss | I   |    |     |
| Elysia grandifolia Kelaart, 1858                      | 2001 |     | E  | IO | S  | Hs | I   |    |     |
| Elysia tomentosa Jensen, 1997                         | 2001 |     | E  | IP | S  | Hs | II  |    |     |
| Bursatella leachi Blainville, 1817                    | 1959 | 1959 | E  | RS | Co | Hs | I   |    |     |
| Notarchus punctatus Philippi, 1836                    | 2004 | 2002 | E  | IP | S  | Ss | I,II|    |     |
| Syphonata geographica (Adams, A. & Reeve, 1850)       | 1999 |     | E  | RS | Co | Ss | I,II|    |     |
| Berthellina citrina (Rüppell & Leuckart, 1828)        | 2005 |     | E  | RS | Co | Hs | I   |    |     |
| Chromodoris quadricolor (Rüppell & Leuckart 1830)     | 2004 | 2004 | C  | IO | S  | Hs | II  |    |     |
| Goniodrangus annulatus (Eliot, 1904)                  | 2020 | 2008 | E  | RS | Co | Hs | I   |    |     |
| Goniodrangus obsoletus (Rüppell & Leuckart, 1830)     | 2019 |     | E  | RS | Co | Hs | I   |    |     |
| Hypselodoris infucata Rueppel & Leuckart, 1828        | 1999 |     | E  | RS | Co | Hs | I   |    |     |
| Dendrodoris fumata (Rüppell & Leuckart, 1830)         | 2010 |     | E  | RS | Co | Hs | I   |    |     |
| Plocamopherus ocellatus Rüppell & Leuckart, 1828      | 1998 |     | E  | RS | Co | Hs | I   |    |     |
| Plocamopherus tilesii Bergh, 1877                     | 2009 |     | C  | IP | S  | Hs | III |    |     |
| Melibe viridis (Kelaart, 1858)                        | 2000 |     | E  | IO | S  | Hs | I   |    |     |
| Baeolidia moebii Bergh, 1888                          | 2007 |     | C  | RS | Co | Ss | I   |    |     |
| Coryphellina rubrolineata O’Donoghue, 1929            | 2003 | 2001 | E  | RS | Co | Hs | I,II|    |     |
| Siphonaria belcheri Hanley, 1858                      | 1999 |     | E  | IO | S  | HS | I   |    |     |
| Siphonaria crenata Blainville 1827                    | 1999 |     | E  | RS | Co | Hs | I   |    |     |
| Anadara transversa (Say, 1822)                        | 1994 |     | E  | IO | S  | Hs | II  |    |     |
| Anadara brouottonii (Schrenck, 1867)                   | 1998 |     | E  | IO | S  | Ss | ?   |    |     |
| Anadara kagoshimensis (Tokunaga, 1906)                | 2003 | 1993 | 1995 | E  | IP | S  | Ss | I,II|    |     |
| Anadara natalensis (Krauss, 1848)                     | 1985 |     | Inv | RS | Co | Ss | I,II|    |     |
| Arcuatula perfragilis (Dunker, 1857)                  | 2018 | 2010 | C  | RS | S  | Ss | I   |    |     |
| Arcuatula senhousia (Benson, 1842)                    | 2012 | 2012 | 2007 | E  | IP | Ss | Ss | I   |    |     |
| Brachidontes pharaonis (Fischer, P., 1870)            | 1990 | 1978 | Inv | RS | Co | Hs | I   |    |     |
| Septifer bilocularis (Linnaeus, 1758)                 | 2006 |     | C  | RS | S  | Hs | I   |    |     |
| Septifer cumingii Récluz, 1849                        | 2017 | 2001 | E  | RS | S  | Hs | I   |    |     |
| Magallana gigas (Thunberg, 1793)                      | 2004 | 2006 | 1998 | E  | PO | Aq | HS | I,II|    |     |
| Saccostrea cucullata (Born, 1778)                     | 1998 |     | E  | IP | S  | Hs | I,II|    |     |
| Dendostrea folium (Linnaeus, 1758)                    | 2015 | 1998 | E  | IP | Ss | Hs | I   |    |     |
| Pinctada imbricata radiata (Leach, 1814)              | 1987 | 1971 | Inv | RS | Co | Hs | I   |    |     |
| Electrum vexillum (Reeve, 1857)                       | 2002 |     | E  | RS | Co | Hs | I   |    |     |
| Isognomon legumen (Gmelin, 1791)                      | 2017 |     | E  | RS | Co | Hs | I   |    |     |
| Malleus regula (Forsskål in Niebuhr, 1775)            | 2004 | 1973 | E  | RS | Co | Hs | I   |    |     |
| Spondylus spinosus Schrebers, 1793                    | 1991 |     | Inv | RS | Co | Hs | I,II|    |     |
| Centrocardita akabana (Sturany, 1899)                 | 2005 |     | C  | RS | Co | Ss | I   |    |     |
| Chama asperella Lamarck, 1819                         | 1990 | 2006 | 2006 | E  | IP | Ss | HS | I   |    |     |
| Chama pacifica Broderip, 1835                         | 1992 |     | Inv | RS | Co | Hs | I,II|    |     |
| Afrocardium richardi (Audouin, 1826)                  | 2000 |     | E  | RS | Co | Ss | ?   |    |     |
| Fulvia fragilis (Forsskål in Niebuhr, 1775)           | 2001 | 1986 | Inv | RS | Co | Ss | I   |    |     |
| Psammacoma gubernaculum (Hanley, 1844)                | 1992 |     | C  | WA | S  | Ss | IV  |    |     |

(Continued)
Table 1. (Continued)

| GROUPS/Species                                    | BS | SM | AS | LS | ES | O | PW | H | DR |
|---------------------------------------------------|----|----|----|----|----|---|----|---|----|
| Nitidotellina valtonis (Hanley, 1844)              | 1995 | C | RS | Co | Ss | I |
| Ervilia scaliola Issel, 1869                       | 2013 | C | RS | Co | Ss | I,II |
| Clementia papyracea (Gmelin, 1791)                 | 1985 | E | RS | Co | Ss | III |
| Gafrarium pectinatum (Linnaeus, 1758)              | 1986 | E | RS | Co | Ss | I |
| Microcirce consternans P. G. Oliver & Zuschin, 2001| 2013 | C | RS | Co | Ss | I |
| Paratapes textilis (Gmelin, 1791)                  | 2018 | 1985 | E | RS | Co | Ss | I,II |
| Petricola fabagella Lamarck, 1818                  | 1999 | E | RS | Co | Hs | I |
| Radiatipes philippinarum (Adams & Reeve, 1850)    | 2004 | 2000 | Inv | PO | Aq | Ss | I |
| Timocea roemeriana (Issel, 1869)                  | 2010 | C | RS | Co | Ss | II |
| Mya arenaria Linnaeus, 1758                        | 1998 | 1993 | 2008 | E | WA | S | Ss | II |
| Sphenia rueppelli Adams, A., 1850                  | 1998 | E | RS | ?Co | Hs | I |
| Martesia striata (Linnaeus, 1758)                  | 2014 | C | Unk | S | Hs | I |
| Teredo bartschi Clapp, 1923                        | 2013 | E | RS | Co | Hs | I |
| Teredothea dominicensis (Bartsch, 1921)            | 2010 | E | WA | S | Hs | II |
| Cucurbitula cymbium (Spengler, 1783)               | 1990 | E | RS | Co | Ss | I-III |
| Laternula anatina (Linnaeus, 1758)                 | 1992 | E | RS | Co | Ss | I-III |
| Amphioctopus aegina (Gray, 1849)                   | 1992 | E | RS | Co | Ss | III |
| Sepioteuthis lessoniana d’Orbignyi, 1826          | 2002 | Inv | RS | Co | P | I-III |
| BRYOZOAA                                          |     |     |     |     |     |     |     |     |     |
| Amathia verticillata (delle Chiaie, 1822)          | 2015 | Inv | AT | S | Hs | I |
| Celleporaria brunnea (Hincks, 1884)                | 2004 | Inv | AT | S | Hs | I |
| Hippopodina sp. A                                  | 2015 | E | RS | Co | Hs | I |
| Microporella coronata (Audouin, 1826)              | 1992 | E | RS | Co | Hs | II,III |
| Parasmittina egyptiaca (Waters, 1909)              | 2015 | E | RS | Co | Hs | I |
| Rhynechozoon larreyi (Audouin, 1826)               | 1962 | E | RS | Co | Ss | I |
| Water HORUP banta (Banta, 169)                      | 2015 | 2015 | E | PO | S | Hs | I |
| ECHINODERMATA                                      |     |     |     |     |     |     |     |     |     |
| Asterias rubens Linnaeus, 1758                     | 2003 | 1993 | Inv | AT | S | Hs | I,II |
| Amphioidea (Amphipin) obtecta Mortensen, 1940      | 2005 | E | IP | S | Ss | I-III |
| Ophiactis macrolepidota Markanner-Turneretischer, 1887 | 2005 | C | RS | Co | Ss | I |
| Ophiactis savignyi (Müller & Troschel, 1842)       | 1993 | 2005 | E | RS | Co | Hs | I |
| Diadema setosum (Leske, 1778)                      | 2014 | 2006 | Inv | RS | Co | Hs | I |
| Holothuria (Theleholurida) hamata Pearson, 1913     | 2007 | E | RS | Co | Ss | I,II |
| Synaptula reciprocans (Forrskål, 1775)             | 2001 | 2005 | Inv | RS | Co | Hs | I,II |
| CHAETOGNATHA                                       |     |     |     |     |     |     |     |     |     |
| Ferosagitta galerita (Dallot, 1971)                | 2003 | E | IO | S | P | I,II |
| TUNICATA                                           |     |     |     |     |     |     |     |     |     |
| Asciella aspersa (Müller, 1776)                    | 1973 | 1884 | 1969 | 1973 | E | NA | S | Hs | I |
| Ciona robusta (Hoshino & Tokioka, 1967)            | 2016 | Inv | ?IP | S | Hs | I |
| Clavelina oblenga Herdman, 1880                    | 2015 | E | WA | S | Hs | I |
| Didemnum abu Monniot C. & Monniot F., 1987        | 2015 | E | ?CT | S | Hs | I |
| Diplosoma lysterianum (Milne Edwards, 1841)        | 1894 | 1968 | 2015 | E | ?AT | S | Hs | I |
| Microcosmus exasperatus Heller, 1878              | 2004 | 2008 | E | RS | Co | Hs | I |
| Microcosmus squamiger Michaelson, 1927             | 2015 | E | ?ST | S | Hs | I |
| Phallusia nigra Savignyi, 1816                     | 2011 | 2005 | Inv | WA | ?S | Hs | I,II |
| Polyplumum constellatum Savigny, 1816             | 2016 | E | RS | Co | Hs | I |
| Pyura (= Herdmania) momus (Savigny, 1816)          | 2001 | E | RS | Co | Hs | I,II |

(Continued)
| GROUPS/Species                      | BS | SM | AS | LS | ES | O  | PW | H    | DR |
|------------------------------------|----|----|----|----|----|-----|-----|------|----|
| Rhodosoma turcicum (Savigny, 1816) |    |    |    |    |    |     |     |      |    |
| Styela clava Herdman, 1881         | 2008 | E  | CT | S  | Hs | I   |     |      |    |
| Styela picata (Lesueur, 1823)      | 1973 | 1968 | Inv | PO | S  | Hs | I   |      |    |
| Symplegma brakenhielmi (Michaelsen, 1904) | 2016 | 2005 | Inv | RS | Co | Hs | I,II |      |    |
| **PISCES**                         |    |    |    |    |    |     |     |      |    |
| Himantura leoparda (Manjaji, Matsumoto & Last, 2008) | 2016 | C  | RS | Co | Ss | IV  |     |      |    |
| Himantura uarnak (Forsskål, 1775)  | 1966 | E  | RS | Co | Hs/Ss | I,II |     |      |    |
| Abudelfs cf. saxatilis/vaigiensis/troschelii | 2002 | 1984 | E  | RS | Co | Hs/Ss | I,II |      |    |
| Acanthopagrus bifasciatus (Forsskål, 1775) | 2018 | C  | RS | Co | Ss | I   |     |      |    |
| Alepes djedaba (Forsskål, 1775)    | 2017 | 1966 | 1955 | Inv | RS | Co | P   | I-III |    |
| Apogonichthyoides pharaonis (Bellotti, 1874) | 2014 | 1983 | E  | RS | Co | Ss | I   |      |    |
| Atherinomorus forskalii (Rüppell, 1838) | 1984 | E  | RS | Co | Ss | I   |      |      |    |
| Bodianus speciosus (Bowdich, 1825) | 2014 | 1983 | E  | RS | Co | Ss | I   |      |    |
| Bregmaceros nectabanus (Whitley, 1941) | 2005 | 2002 | E  | RS | Co | Ss | I,II |      |    |
| Callionymus filamentosus Valenciennes, 1837 | 2014 | 2008 | Inv | RS | Co | Ss | I,II |      |    |
| Champsodon nudivittus (Ogilby, 1895) | 2014 | 2008 | Inv | RS | Co | Ss | I,II |      |    |
| Chelodipterus novemstratus (Rüppell, 1838) | 2014 | 2008 | Inv | RS | Co | P   | III  |      |    |
| Cynoglossus sinusarabici (Chabanaud, 1913) | 1966 | 1942 | Inv | RS | Co | Ss | I   |      |    |
| Diplogrammus randalli Fricke, 1983 | 2017 | 1966 | 1955 | Inv | RS | Co | P   | III  |    |
| Dussumeria elopoides Bleeker, 1849 | 1952 | 1984 | E  | RS | Co | Hs/Ss | I,II |      |    |
| Enacrasicholina punctifer Fowler, 1938 | 2014 | 1983 | E  | RS | Co | Ss | I   |      |    |
| Epinephelus coioides (Hamilton, 1822) | 2014 | 1983 | E  | RS | Co | Ss | I   |      |    |
| Equulites klanzingeri (Steindachner, 1898) | 1966 | 1942 | Inv | RS | Co | Ss | I,II |      |    |
| Equulites popei (Whitley, 1932)     | 2009 | 2008 | Inv | RS | Co | Ss | II-IV |      |    |
| Erythrinus galanii DiBatistta, Randall and Bowen, 2012 | 2002 | 1994 | Inv | RS | Co | P   | III  |      |    |
| Fistularia commersonii (Rüppell, 1835) | 2002 | 2000 | Inv | RS | Co | Hs/Ss | I,II |      |    |
| Fistularia petimba Lacepède, 1803   | 2016 | 1984 | Inv | RS | Co | Ss | II  |      |    |
| Hazeus ingressus Engin, Larson, Irmak, 2018 | 2015 | 1984 | E  | RS | Co | Ss | I   |      |    |
| Hemiramphus far (Forskål, 1775)     | 2009 | 1942 | E  | RS | Co | P   | I    |      |    |
| Heniochus intermedius Steindachner, 1893 | 2002 | 2000 | Inv | RS | Co | Hs/Ss | I,II |      |    |
| Herklotsichthys punctatus (Rüppell, 1837) | 1984 | 1942 | E  | RS | Co | P   | I,II |      |    |
| Hippocampus fuscus Rüppell 1838     | 2000 | 1984 | E  | RS | Co | Ss | I   |      |    |
| Jaydia queketti (Gilchrist, 1903)   | 2009 | 2000 | E  | RS | Co | Ss | I-III |      |    |
| Jaydia smithi Kothaus, 1970         | 2008 | 1984 | E  | RS | Co | Ss | I,II |      |    |
| Lagocephalus guentheri (Richardson, 1844) | 2007 | 1966 | 1949 | Inv | RS | Co | Ss | II  |      |
| Lagocephalus sceleratus (Gmelin, 1789) | 2017 | 2008 | 2003 | Inv | RS | Co | Ss | II  |      |
| Lagocephalus suezensis Clark & Gohar, 1953 | 2001 | 1998 | Inv | RS | Co | Ss | I,II |      |    |
| Liza carinata (Valenciennes, 1836)  | 1955 | 1984 | E  | RS | Co | P   | I    |      |    |
| Lutjanus argentimaculatus (Forskål, 1775) | 2018 | 1984 | E  | RS | Co | Ss | I,II |      |    |
| Monotaxis grandoculis (Forsskål, 1775) | 2007 | 1984 | E  | RS | Co | Ss | I,II |      |    |
| Nemipterus randalli Russell, 1986   | 2011 | 2007 | Inv | RS | Co | Ss | I,II |      |    |
| Ostorhinchus fasciatus (White, 1790) | 2011 | 2009 | E  | RS | Co | Ss | I,II |      |    |
| Ostracion cubicus Linnaeus, 1758    | 2017 | 1984 | E  | RS | Co | Hs | II   |      |    |
| Oxyurichthys peteri (Kunzinger, 1871) | 1991 | 1991 | E  | RS | Co | Ss | I,III |      |    |

(Continued)
### Table 1. (Continued)

| GROUPS/Species                      | BS | SM | AS | LS | ES | O   | PW | H   | DR               |
|-------------------------------------|----|----|----|----|----|-----|-----|-----|------------------|
| Parablennius thysanius (Jordan & Seale, 1907) | 2013 | C  | IP |    | S  | Hs  | I   |     |                  |
| Paranthias furcifer (Valenciennes, 1828) | 2020 | C  | AT |   | ?  | Hs  | I,II|     |                  |
| Parexocoetus mento (Valenciennes, 1846) | 1966 | 1966 | E  | RS | Co | P   |     |     |                  |
| Parupeneus forskalli (Fourmanoir & Guézé, 1976) | 2016 | 2000 | Inv | RS | Co | Ss  | I,II|     |                  |
| Pelates quadrilineatus (Bloch, 1790) | 1984 | E  | RS | Co | Ss | I,II|     |     |                  |
| Pempheris rhomboidea Kossmann & Räuber, 1877 | 2020 | 1994 | 1983 | E  | RS | Co | Hs  | I,II|     |
| Petroscirtes ancylodon Rüppell, 1838 | 2005 | 1997 | E  | RS | Co | Hs/Ss | I  |     |                  |
| Planiliza haematocheilus (Temminck & Schlegel, 1845) | 1992 | 1995 | 1995 | Inv | PO | Aq | P   |     |                  |
| Platax teira (Forsskål, 1775) | 2006 | C  | RS | Co | Hs | I   |     |     |                  |
| Ploetas lineatus (Thunberg, 1877) | 2016 | C  | RS | Co | Hs/Ss | II  |     |     |                  |
| Pomacanthus imperator (Bloch, 1787) | 2019 | C  | RS | Co | Hs | I   |     |     |                  |
| Pomadasys stridens (Forsskål, 1775) | 2015 | 2009 | E  | RS | Co | Ss  | I,II|     |                  |
| Priacanthus hamrur (Forsskål, 1775) | 2017 | C  | RS | Co | Ss | II  |     |     |                  |
| Priacanthus proliris Starnes, 1988 | 2016 | C  | RS | Co | Ss | III |     |     |                  |
| Priacanthus sagittarius Starnes, 1988 | 2017 | C  | RS | Co | Ss | III |     |     |                  |
| Pterogogus trispilus Randall, 2013 | 2002 | 1998 | E  | RS | Co | Hs/Ss | I,II|     |                  |
| Pterois miles (Bennett, 1828) | 2015 | 2014 | Inv | RS | Co | Hs  | I,II|     |                  |
| Rachycentron canadum (Linnaeus, 1766) | 2013 | C  | CT | Co? | P |     |     |     |                  |
| Sargocentron rubrum (Forsskål, 1775) | 1949 | 1949 | E  | RS | Co | Hs  | I-III|     |                  |
| Saurida lessepsianus (Russell, Golani and Tikochinski, 2015) | 1973 | 1951 | Inv | RS | Co | Ss | I-III|     |                  |
| Scarus ghobban Forsskål, 1775 | 2013 | C  | RS | Co | Hs | I   |     |     |                  |
| Scrombomorus commerson Lacepède, 1800 | 1994 | 1981 | E  | RS | Co | P   | I,II|     |                  |
| Siganus luridus (Rüppell, 1829) | 1973 | 1973 | Inv | RS | Co | Hs  | I,II|     |                  |
| Siganus rivulatus Forsskål, 1775 | 2019 | 1966 | 1942 | Inv | RS | Co | Hs  | I,II|     |
| Sillago suezensis Golani, Fricke and Tikochinski, 2014 | 2004 | 1983 | E  | RS | Co | Ss  | I,II|     |                  |
| Sphyraena chrysotaenia Klunzinger, 1884 | 1966 | 1955 | Inv | RS | Co | P   | I,II|     |                  |
| Sphyraena flavicauda Rüppell, 1838 | 2001 | Inv | RS | Co | P   | I,II|     |     |                  |
| Stephanolepis diaspros Fraser-Brunner, 1940 | 2011 | 1943 | 1949 | E  | RS | Co | Hs/Ss | I,II|     |
| Stolephorus insularis Hardenberg, 1933 | 2012 | C  | RS | Co | P   | II,III|     |     |                  |
| Synanceia verrucosa Bloch & Schneider, 1801 | 2011 | C  | RS | Co | Ss | II  |     |     |                  |
| Synchiropus sechellensis Regan, 1908 | 2014 | E  | RS | Co | Ss | II,III|     |     |                  |
| Torquigener flavimaculatus Hardy & Randall, 1983 | 2014 | 2002 | Inv | RS | Co | Ss  | I,II|     |                  |
| Trachurus indicus Nekrasov, 1966 | 2004 | C  | RS | Co | P  | I-III|     |     |                  |
| Trypauchen vagina (Bloch & Schneider, 1801) | 2010 | E  | RS | Co | Ss | II  |     |     |                  |
| Tylosurus spinosissimus (Regan, 1908) | 2010 | C  | RS | Co | Ss | II,III|     |     |                  |
| Upeneus moluccensis (Bleecker, 1855) | 1973 | 1942 | Inv | RS | Co | Ss  | I-IV|     |                  |
| Upeneus pori Ben-Tuvia & Golani, 1989 | 2000 | 1942 | Inv | RS | Co | Ss  | I,II|     |                  |
| Vanderhorstia mertensi Klausewitz, 1974 | 2010 | 2008 | E  | RS | Co | Ss  | I-III|     |                  |

**MAMMALIA**

| Sousa plumbea (G. Cuvier, 1829) | 2016 | C  | RS | Co | P  | I   |     |     |                  |

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, Inv: Invasive), O: Origin (IP: Indo-Pacific, RS: Red Sea, AT: Atlantic, NA: North Atlantic, WA: Western Atlantic, ST: Subtropical Atlantic/Pacific, IO: Indian Ocean, PG: Persian Gulf, PO: Pacific Ocean, TA: Tropical Atlantic, CT: Circumtropical, Unk: Unknown) PW = Pathway (Co: Corridor/Canal (vector: Suez Canal), S: Ships, Aq: Aquaculture activities), H: Habitat (Hs: Hard Substratum (including epibiontic species on algae, sponges), Ss: Soft Substratum (including soft substrata with phanerogames), P: pelagic, Pz: parasite), DR: Depth Range (I: 0–10 m, II: 11–50 m, III: 51–100 m, IV: 101–200 m, V: 201–400, VI: 401–500 m, VII: >500 m).

https://doi.org/10.1371/journal.pone.0251086.t001
species in Ctenophora (Beroe ovata and Mnemiopsis leidyi) and Spermatophyta (Halophila stipulacea) are invasive. The other groups with the highest percentage of invasive alien species are Echinodermata (57%), Porifera (50%), Tunicata (36%), Pisces (33%) and Chlorophyta (30%).

The number of alien species found in seas surrounding Turkey ranged from 28 (Black Sea) to 413 (Levantine Sea) (Fig 3). The decrease in the number follows a clockwise direction along the coasts, from south to north, from proximity to farness with regards to the Suez Canal, which is the main vector of the species introduction in the Mediterranean Sea [3, 7, 26]. The percentage of invasive alien species within the total number of alien species differs among the regions, with the highest percentage being estimated in the Black Sea. Having brackish water body and high primary productivity makes this sea vulnerable to biotic invasions [33]. The excessive proliferation of invasive species transported by ships in the region has had enormous ecological and economic consequences [7]. The percentage of invasive fish species in the total number is generally high in seas, but the decrease in the percentage follows an anti-clockwise direction from the Black Sea (100%) to the Levantine Sea (30%), that is also apparent for other groups such as Polychaeta and Arthropoda.

The coasts of Turkey have been densely invaded by alien species, there is no grid area (15x15 km) along the coast remained unoccupied by alien species. The worst conditions are prevailing on the Levantine coast, where some grids in İskenderun, Mersin and Antalya Bay have more than 100 alien species. The south Aegean Sea is also represented by higher number of alien species, and the number diminishes when moving to north, except for the Çanakkale Strait, where relatively higher number of alien species has been reported. According to the grid map depicted in Fig 4, six hot-spot areas can be identified for the settlement of alien species, namely İskenderun Bay, Mersin Bay, Antalya Bay, Fethiye Bay, Gökova Bay and İzmir Bay, where more than one pathway of species introductions (e.g., corridor and ship) are present.
The distribution pattern of alien species found in the general picture depicted in Fig 4 is also applicable for the distribution of alien species belonging to major taxonomic groups (Fig 5). The highest scores in grids were estimated for Pisces (maximum 51 species in İskenderun Bay), followed by Mollusca (43 species). The maximum number of alien species in grids (21–24 species) is more or less similar for other major groups. İskenderun Bay hosts the highest number of alien species for all major groups, except for the group Macrophytes, which has three hot-spots areas, distant from each other, namely Çanakkale Strait, İzmir Bay and
Antalya. This is not related to the hydrographic characters of the areas, but primarily related to the availability of taxonomic experts in the institutions located in the areas which have been studied and monitored comprehensively over time. Such biodiversity pattern was also previously noted along the coasts of Turkey for many taxonomic groups (see [25]).

Invasive and established alien species have been reported on all grids along the coasts, but the casual species are general found on the Levantine coast, especially in Iskenderun Bay, which acts as a gate to the marine waters of Turkey for the introduced Red Sea species (Fig 6). Some grids in Iskenderun and Mersin Bays had the number of invasive and established alien species higher than 40. The majority of them are the Red Sea invaders that have been colonizing all shallow-water benthic pelagic habitats including harbors [34] and estuarine areas [35].

The species list presented here complies with the previous lists prepared for countries or specific taxonomic groups in the Mediterranean Sea. However, there are some discrepancies among the lists, mainly due to difference in the evaluations of available data by experts. For example, the presence of Eurythoe complanata, Neopseudocapitella brasiliensis, Metasychis gotoi and Pista unibranchia in the Mediterranean were reported as questionable [36], whereas we considered them as established alien species. The judgements by [36] were not based on new molecular and morphological data, or comparisons of the Mediterranean specimens with the type specimens of the species. The presence of E. complanata was also previously regarded as questionable because of the confusion with the native, but very poorly described species E. syriaca [7, 37]. However, [38] examined some Eurythoe specimens collected from different parts of the Mediterranean and identified them as E. complanata. The presence of M. gotoi and Pista unibranchia in the Red Sea was confirmed by [39] and [40]. In addition, the morphological features of N. brasiliensis, M. gotoi and P. unibranchiata match with their original descriptions (MEÇ, personal data), so they likely occur in the region. However, further studies (especially comparison with type specimens) are needed to clarify the real taxonomic identities of the specimens reported under these names from the Mediterranean Sea.

In a new revision on alien foraminiferans [41], 44 established alien species were reported from the Mediterranean Sea, almost half the species presented in our list. One of the main
reasons of this great difference in the number of species is that the authors have not considered many of the species recorded as alien from the Mediterranean coasts of Turkey and the Sea of Marmara as well as the recently recorded alien species from the Mediterranean coasts of Turkey. Besides, the authors have excluded the species which have fossil records in the Eastern Mediterranean. *Sorites orbiculus*, which is common in the eastern Mediterranean, was also found in cores from Ashqelon (Israel), dated back to 320–2 ka BP [42–44]. However, the genetic analysis showed that the population found in Shikmona (Israel) was genetically identical to a population of it living in the Gulf of Elat (Red Sea) [45]. One of the most invasive alien foraminifer species, *Amphistegina lobifera*, was found in the core materials from Mersin (Turkey), dated back to 227.3 ± 17.8, ka BP [46]. Some Indo-Pacific foraminifer species were also found together with the Mediterranean species in the Quaternary sediments collected from the Asi River (Orontes) Delta [47]. It was suggested that these species might have been introduced to the Eastern Mediterranean much before the opening of the Suez Canal. However, rDNA analyses on *A. lobifera* showed that both the Mediterranean and the Red Sea populations are genetically clustered together and distinct from the Australian populations [48], suggesting that the population of *A. lobifera* currently spreading in the Mediterranean is originated from the Red Sea.
Fig 6. The distribution of invasive, established and casual alien species along the coasts of Turkey.

https://doi.org/10.1371/journal.pone.0251086.g006
What changed after the last update?

After the last update (2011 update, [7]), a total of 184 new alien species have been registered in the regions, bringing the number of alien species from 359 to 539. The major increments are seen in Tunicata (367%), Cnidaria (260%), Bryozoa (250%) and Porifera (200%) (Fig 7). Based on new evidence (see [4]), the present study classified some ascidians (*Styela plicata*, *Ascidella aspersa* and *Diplosoma listerianum*) as aliens, which were known as native from the region for a long time [49–51]. Another high increment (176%) was encountered in Foraminifera. This is partly due to the new species additions (58 species) and partly due to the inclusions of some species that were not treated as aliens in the 2011’s species list, because of the lack of enough data for the assessment of their status as native or alien.

The establishment success or status of alien species has been changed for several species since 2011. For example, the algal species such as *Acanthophora nayadiformis*, *Ganonema farinosum*, *Cladosiphon zosterae* and *Pylaiella littoralis*, which were previously classified as questionable or cryptogenic are considered herein as established alien species, because of the new evidences on the proper taxonomic entities of these species [52, 53] and their pathways of introductions: *A. nayadiformis* and *G. farinosum* might have been introduced by multiple vectors (shipping or via the Suez Canal), while others (*C. zosterae* and *P. littoralis*) by shellfish and oysters farming [54]. Based on the new data accumulated since 2011, ten casual species (*Phyllophora punctata*, *Pisione guanche*, *Monocorophium sextonae*, *Eurycarcinus integrifrons*, *Penaeus aztecus*, *Pilumnus minitus*, *Sticteulima lentiginosa*, *Monotigma lorioli* and *Pomadasys stridens*) in the 2011’s species list have turned to become established alien species. In the last decade, a radical change observed in the establishment success of *Parupe- neus forskalli*, which was very rare (casual) before 2011, is now an invasive alien species in the region, having expanded its distribution range to the Aegean Sea [55].
Yearly changes in the number of alien species

The cumulative number of alien species increases over years in all seas surrounding Turkey (Fig 8). The new alien species are being reported from all coasts, but especially from the east Levantine Sea, because of the impact of the Suez Canal as a primary vector. However, as shown in the last time interval (2010–2020), the trend slows down over time. The number of new alien occurrence (collection date) decreased in the last 10 years (2010–2020) on the coasts of Turkey, when compared to the previous time intervals since 1980. The sharp decrease was encountered in the Levantine Sea, where 153 new alien occurrences were reported between 2000 and 2010, whereas 63 species (a 59% decrease) were determined between 2010 and 2020.
Such decreases were also estimated between the periods in the Aegean (-38%) and the Sea of Marmara (-25%), but on the contrary an increase (25%) was observed in the Black Sea. The increase and decrease in the numbers are partly related to the scientific efforts devoted to assessing of alien species in the areas, but also partly related to the number of new incomers from different pathways and range extensions of the alien species. For example, it is very surprising to see that the Black Sea’s brackish water habitats started to host the Red Sea originated alien species, such as the puffer fish *Lagocephalus sceleratus* [56] and the shrimp scad *Alepis djedaba* [57]. As in the case of the Levantine Sea, whether the pufferfish would be a nuisance for the Black Sea or not is currently a mystery.

**Primary pathways of species introductions**

The assessment of primary pathways of species introduction sometimes remains very controversial, as more than one pathway can be incorporated with the species introduction. The step-by-step distributional patterns of the Red Sea species, so called Lessepsian species, can indicate an introduction via the corridor, the Suez Canal. It is sometimes hard to assess the pathway or even the assignation of species as native or alien for suddenly appearing species with high abundances in one area far from the Canal. For example, *Syllis ergeni*, which was originally described in Izmir Bay (Aegean Sea) in 2005 [58], was previously considered as an endemic species for the Mediterranean Sea, but due to its high abundance in the shallow-water benthic habitats in the Levantine Sea and the presence of it in the Red Sea [59], it was classified as alien species.

In this review, we evaluated the primary pathways of alien species as almost all species of the introduced Red Sea species have reached to the coasts of Turkey by natural dispersal mechanism from the neighboring countries, following the main current direction prevailing in the region. There are few numbers of ship-transferred species (e.g., *Asterias rubens* and *Streblospio gynobranchiata*) that have been firstly reported from the coasts of Turkey within the Mediterranean Sea. The importance of the Suez Canal in the species introduction diminishes when moving from south to north in Turkey, accounting for 72% of species introductions in the Levantine Sea, whereas it comprised only 11% of species introductions in the Black Sea, where majority of the introductions (78%) were carried out by ships (ballast water or hull fouling) (Fig 9). Eight established alien species, namely the brown algae *Scytosiphon dotyi* and *Cutleria multifida*, the green algae *Ulva australis*, the shrimp *Penaeus merguiensis*, the gastropod *Crepidula fornicate*, the bivalves *Magallana gigas* and *Ruditapes philippinarum* and the fish *Planiliza haematocheilus*, were introduced to the Mediterranean/Black Sea via aquaculture activities and then secondarily to the coasts of Turkey.

The trends in the importance of pathways in species introductions in all seas over years are indicated in Fig 10. Since 1990, the number of corridor-borne species increased in the Aegean Sea (110 species entered) and the Sea of Marmara (21 species entered), as a consequence of the range expansions of the Red Sea originated species from the Levantine Sea. In the last decade, the number of corridor-borne species entering the Black Sea has increased approximately two times when compared to other years, indicating that the sea is also under threat by the Red Sea species of wider ecological valances such as *Lagocephalus sceleratus*. In the last decade, the corridor-borne species comprised higher percentages in species introductions in all seas. An increasing trend in the number of ship-borne species is evident between the periods 1990–2010 in the Levantine Sea, but its importance in the species introduction was dropped from 32% to 22% in the last decade. Considering data from all coasts, there are four clear peaks in the number of ship-borne species over years: 65% (4 species) in <1900, 100% (1 species) in 1931–1940, 52% (12 species) in 1971–1980 and 45% (88 species) in 2001–2010.
Origins of alien species

Most alien species reported from the coasts of Turkey were originated from the Red Sea (58%), due to the proximity of the country to the Suez Canal (Fig 11). The shipping activities transported 39% of total number of alien species, mainly from the Indo-Pacific area (20%) and the Atlantic Ocean (10%). However, the origins of alien species differ from the seas surrounding Turkey. Majority of the species in the Black Sea was originated from the western Atlantic (25%), whereas those of the Sea of Marmara (21%), Aegean Sea (54%) and Levantine Sea (72%) were originated from the Red Sea. The north Atlantic-originated species such as Adelosina colomii, Diadumene cincta, Beroe ovata and Asterias rubens occurred solely in the Sea of Marmara and Black Sea, at least at the time being.

Habitat and depth preferences

The habitat preferences of alien species varied along the coasts of Turkey (Fig 12). In general, majority of alien species were recorded from the soft bottom (309 species), accounting for 57% of total number of species. The pelagic realm hosted 42 alien species (8%). One rhizocephalan
and 4 copepod parasitic species were found on the alien and native species only in the Levantine Sea: *Heterosaccus dollfusi* on the alien crab *Charybdis longicollis* [60]; *Caligus lagocephali* (cited as *C. fugu*) on the pufferfish, *Lagocephalus suezensis* and *L. guentheri* [61]; *Mitrapus oblongus* on the native fish *Sardinella aurita* [62]; *Lernanthropus callionymicola* on the alien fish *Callionymus filamentosus* [63]; and *Taeniacanthus lagocephali* on the alien fish *Lagocephalus guentheri* [61]. The habitat preferences of alien species are almost similar each other in the Sea of Marmara, Aegean Sea and Levantine Sea, but hard-bottom species are numerically dominant in the Sea of Marmara (73%) and Aegean Sea (61%), whereas soft-bottom species in the Levantine Sea (58%). The Black Sea’s alien species mainly occupied hard bottom (totally 54%). The percentage of pelagic alien species (18%) in the Black Sea is at least two times higher than those estimated in other seas.

A total of 5 taxonomic groups (Ochrophyta, Porifera, Sipuncula, Bryozoa and Tunicata) occurred only on hard substrata, whereas the phanerogame *Halophila stipulacea* and majority of the species in Polychaeta, Arthropoda, Mollusca and Pisces occupied soft substrata (Fig 13). All species in Scyphozoa, Ctenophora and Mammalia were reported in the pelagic environment. All foraminiferans were found both in hard and soft substrata.

![Fig 10. The trends in the importance of primary pathways in species introductions in seas per decade.](https://doi.org/10.1371/journal.pone.0251086.g010)
In all taxonomic groups, a large portion of the species (>70% of the total number of species) were found in the depth interval 0–10 m, except for Foraminifera that were represented by a higher number of species (62%) in the depth interval 11–50 m (Fig 14). All alien species of Cnidaria and Tunicata were found in 0–10 m depth, but a few in 10–50 m. The macrophytes (94%) and Polychaeta (88%) primarily occurred in the shallow water (0–10 m). In general, the number of alien species dropped at least two times at 10–50 m depth, with the exceptions of Foraminifera (increase, +>100%), Pisces (slight decrease -4%) and Echinodermata (-34%). A sharp decrease was seen in the depth intervals 50–100 m (totally 94 species, 17% of total alien species) and 100–200 m (totally 33 species, 6%). Only five groups [Mollusca (1 species), Arthropoda (10 species), Pisces (3 species), Polychaeta (3 species) and Foraminifera (16 species)] occurred at 100–200 m depths. The deep-water (>200 m depth) alien species registered to Arthropoda (1 species, Trachysalambria palaestinensis) and Foraminifera (12 species). Among the foraminiferans, Ammodiscus gullmarensis (11–500 m), Astacolus insolitus (11–500 m), Melonis affinis (11–500 m), Spiroloculina subcommunis (61–1042 m), Veleroninoides scitulus (70–500 m), Recurvoidella bradyi (90–500 m) and Procerolagena gracilis (104–807 m) are
characterized by having a vast depth range, whereas *Pseudoclavulina humilis* (1224 m), *Stainforthia fusiformis* (427–1100 m) and *Candeina nitida* (760 m) only occur in deep waters.

**Questionable species**

The muzzled blenny *Omobranchus punctatus*, which was first reported from an aquaculture cage in the port of Ashdod (Israel) in 2003 [64], was reported from the Great Harbour of Antalya (Levantine Sea) in 2013 without any figure and description [65]. Until new evidence is provided, it is better to keep the presence of the species in the region as questionable. A recent checklist of Sea of Marmara fishes [66] included 42 erroneous and/or misidentified species, including several incorrect data for alien taxa (i.e *Atherinomorus forskali*, *Epinephelus fasciatus*, *Equulites klunzingeri*, *Hemiramphus marginatus* and *Parexocoetus mento*) [67], therefore, records of *Alepes djedaba*, *Sargocentron rubrum* and *Upeneus moluccensis* [68–70] will also be treated as questionable, unless their occurrence in the region is substantiated by further research.

Three bivalve species are treated here as questionable: *Spondylus multisetosus*, which was solely reported from the Levantine Sea by [71], might have been confused with its congeneric
*S. spinosus* [72]: *Nudiscentilla cf. glabra*, which was reported only from the Levantine Sea by [73], has uncertainty in its taxonomic identity; *Antigona lamellaris*, whose presence in the Mediterranean Sea was based on a single shell [74].
Excluded species

In the present study, most alien species previously classified as questionable in the 2011’s review by [7] have been excluded from the marine alien species inventory of Turkey, because their presence has not been subsequently confirmed from the region and do not have proper descriptions and figures in the relevant papers. In addition, some species were also excluded from the alien list of Turkey under the light of new molecular and morphological findings during the decade.

Since the presence of two algal species, *Gracilaria arcuata* and *Litosiphon laminariae* in the Sea of Marmara, which were found in 1984 [75, 76] have not been re-confirmed by subsequent papers in any place of the Mediterranean Sea, they were considered as misidentification or unsuccessful introductions, so here excluded from the alien species list of Turkey.

Three alien foraminiferan species, namely *Edentostomina culturata*, *Spiroloculina antilarum* and *Elphidium charlottense*, were excluded from the previous list, as they were proved to have fossil records in the region [41, 77, 78].

The colonial scleractinid *Oculina patagonica*, which was found as a patch (ca. 1.5 m in diameter) in only one locality (Akkuyu, Levantine Sea) in 2005 in Turkey [15], has been recently proved to be a native species, based on a molecular study by [18] indicating that the Mediterranean population of it have been long isolated from the western Atlantic and recent outburst of it in the region relates to ongoing environmental changes.

The casual and established polychaete species in the 2011’s review, *Marphysa disjuncta*, *Onuphis eremita oculata* and *Streblosoma comatus*, have been re-identified as *M. cinari* [79], *Onuphis eremita* by [80] and *S. pseudocomatus* by [81], all being considered as native species. The molecular analysis indicated that the so-called invasive alien species in the Mediterranean, *Hydroides dianthus*, turned to be a native species, but the Black Sea populations of it were introduced from the Gulf of Mexico (west Atlantic) [82].

Although they are absent in the 2011’s species list, [83] classified three copepod crustacean species, namely *Pontellina plumata*, *Pseudocalanus elongatus* and *Pteriacartia josephinae*, as alien species, based on the records from the paper by [84]. However, their alien status was later questioned, and all have been re-evaluated as Atlanto-Mediterranean species [85]. A total of six copepod species (*Acrocalanus longicornis*, *Acrocalanus monachus*, *Calanopia americana*, *Calanopia biloba*, *Calanopia minor* and *Parvocalanus latus*), which were only reported from the Sea of Marmara and Levantine Sea [86, 87] and included in the alien species lists [7, 83], were excluded from the alien species lists due to the lack of proper descriptions of the species in the relevant papers and the lack of confirmation upon their presence in the regions by other scientists.

Two alien crustaceans (*Penaeus semisulcatus* and *Portunus segnis*) included to the faunal list of Sea of Marmara [88] are most probably erroneous identifications of *P. kerathurus* and *Callinectes sapidus*, respectively. Likewise, the Black Sea record of *P. japonicus* [89] is also a misidentification of the native *P. kerathurus*.

The Red Sea invader *Diadema setosum* was reported [90] to have an already established population in the upper layer of the Sea of Marmara (4–6 m depths, collection date: July 2018), which is formed by the Black Sea brackish waters. This new report of this species represents its northernmost distributional point in the Mediterranean, almost 300 nautical miles far from the previous confirmed northern limit (Gökova Bay) of the species. However, this report is totally questionable, as the photographs (Fig 3 in the paper by [90]) they provided cannot belong to the Sea of Marmara, but most probably to the Levantine or southern Aegean coast. The evidences from the photographs are; 1) The presence of the barren habitat in the photograph (absent in the Sea of Marmara): This is a habitat type specific to the Levantine Sea and
the southern Aegean Sea mainly due to the intensive grazing of the herbivorous alien invasive species (e.g. *Siganus* spp.) on prevailing algal canopies [91]; 2) The presence of the thermophilic *Arbacia lixula* in the photograph (absent in the Sea of Marmara): the previous report of the species [50] was regarded as questionable [92]; 3) The presence of the thermophilic *Ostrea stentina* in the photograph (absent in the Sea of Marmara): The northern limit of this species is around Izmir Bay (central Aegean Sea) [93]; 4. The presence of the Red-Sea invader *Cerithium scabridum* in the photograph (absent in the Sea of Marmara): Goğçeda Island (north Aegean Sea) constituted its northern limit in the Aegean Sea [94]. The report of this species in Saros Bay [95] was also not considered in the present update with a similar reason.

In the 2011’s reports, the tropical Atlantic fish species that were classified as established (*Enchelycore anatina* and *Sphoeroides pachygaster*) and casual (*Carcharhinus altimus* and *Pisodonophis semicinctus*) alien species were excluded from the list as they were proved to be Atlanto-Mediterranean species that had entered the Mediterranean via the Gibraltar Strait without human assistance (see [8]). The boreal Atlantic pipefish *Syngnathus rostellatus* and dorab wolf-herring *Chirocentrus dorab* of the Indo-Pacific distribution that were treated as questionable in the 2011’s list was eliminated here as the former species is a misidentification of *S. tenuirostris* or *S. acus* (see [96]) and the latter species was identified solely based on larvae and eggs [8].

In the National Center for Biotechnology Information (NCBI) GenBank and in Barcode of Life Data System (BOLD), there are a total of 155 *Pterois miles* mitochondrial cytochrome c oxidase subunit 1 (COI) sequences obtained from Israel, Lebanon, Cyprus, Turkey and Greece [97–99]. The researchers investigated the *P. miles* populations in the Eastern Mediterranean and concluded that the invasion has occurred by multiple introductions. They have also included COI sequences of *P. miles*, *P. lunulata*, *P. russelli* and *P. volitans* from the Indian and Pacific Oceans to reveal the phylogenetic relationships. In none of the above-mentioned studies, occurrence of *P. volitans* has been validated in the Mediterranean Sea. Recently COI barcodes allegedly belonging to *P. miles* and *P. volitans* individuals collected from Iskenderun Bay was presented [100]. They have neither included any previously published genetic data in their study, nor have they deposited their sequences in NCBI or BOLD databases. The only accessible part of their genetic data is the sequence alignment shown in Table 2 of their publication [100]. They have given 9 COI haplotypes for *P. miles* and 7 haplotypes for *P. volitans*. However, the 81 basepair COI sequence which represents their *P. miles* specimens (Haplotype_1) does not match with “any” sequence in the GenBank when searched in NCBI Blast (Basic Local Alignment Search Tool) platform. Although COI sequences show interspecific divergence and used to discriminate species, it is a conserved gene, and any unrelated two fish species should show some homology in their COI sequences. On the other hand, the *P. volitans* COI sequences presented by [100] (Haplotypes 10–16) partially align, not with *P. volitans*, but various sequences of Bacteria, Yeast, Fungi, Plants, etc. in the GenBank, indicating a match by chance. Moreover, the interspecific genetic divergence value they presented (0.038178) cannot be correct, since the sequences they have shown for the two species are unrelated. In conclusion, it is very obvious that the COI sequences given by [100] are not related to the COI barcodes for any *Pterois* species. Also, it is hard to understand why authors have not compared their sequences with the previously published sequences found in the databases, or why they have not mentioned any of the genetic studies performed on the Mediterranean *Pterois* specimens. There is clear evidence that *P.miles* and *P.volitans* are two sibling species with extreme morphological resemblance, whose identification based primarily on simple meristic counts is often impossible [101, 102]. All previous records of *P.volitans* throughout the Mediterranean Sea [100, 103–105] are therefore refuted, all considered as misidentifications of *P.miles*. 
The record of *Trachurus declivis* given from Mersin coasts (northern Levant) [106] is merely a misidentification of a xanthochromatic specimen of the native *T. trachurus*, both of which have quite distinct lateral line formations. In *T. declivis*, the lateral line bends downwards more suddenly; commences in a line with the 5th ray of 2nd dorsal and is entirely comprised within a space equal to that occupied by four finrays vs. the bend begins in a line with the commencement of the 2nd dorsal fin, and from its more gradual obliquity, extends over a space equal to that occupied by nine finrays in *T. trachurus* [107]. Moreover, dorsal accessory lateral line terminates below 5th to 11th (usually 7th to 9th) soft dorsal-fin ray in *T. declivis* [108] vs. 23rd to 31th soft dorsal fin ray in *T. trachurus* [109].

The Indo-Pacific soldier bream *Argyrops filamentosus* (Valenciennes, 1830) recorded from the Mediterranean Sea [110] is also a misidentified species. Associated with no photographs of a captured specimen, the morphometric characters presented by the authors provide enough data for revealing the error. The proportions of head length, predorsal length, prepelvic length, caudal peduncle depth and preorbital length in standard length of *A. filamentosus* [111] are by no means a match to the Mediterranean specimen. Although the preserved material was not examined herein for a precise identification, the morphometric characters most likely indicate the native *Pagrus caeruleostictus*.

An unvalid record of *Upeneus tragula* was given from Antalya Bay [112], based on a night-dive underwater photograph of a juvenile individual, but the photograph clearly belongs to a native *Mullus cf. surmuletus*. *Priacanthus hamrur* collected of Hatay (northeastern Levant) was misidentified as *P. sagittarius* [113], a species previously recorded from Turkey. Based on the recent review on Mediterranean Champsodontidae [114], previous records of *Champsodon capensis* and *C. vorax* [115, 116] are now considered as misidentifications of *C. nudivittis*. *Ruvettus pretiosus*, a circumtropical fish native to the Mediterranean Sea, was incorrectly treated as an alien species [117], naturally excluded herein.

Mitigation programmes of biological invasions require reliable national lists purified from errors [4], even so, inattentive taxonomic approaches are still present. A recent checklist of alien fish inventory of Turkey [118] includes huge number of erroneous entries, in which even taxa endemic to the Mediterranean Sea were inexplicably treated as alien species. Inclusion of the following native species to the alien inventory is evidently a mistake and should be excluded: *Petromyzon marinus, Alopias superciliosus, Mustelus punctulatus, Carcharhinus altimus, C. brevipinna, C. limbatus, Centrophorus granulosus, C. uyato, Squatina aculeata, Dasyatis marmorata, Mobula japanica, Notacanthus bonaparte, Enchelycore anatina, Dysomma brevirostre, Apterichtus caecus, Pisodonophis semicinctus, Nettastoma melanurum, Facciolella oxyrhyncha, Lepidon lepidon, Apletodon incognitus, Syngnathus rostellatus, Cephalopholis taeniops, Pomadasys incisus, Seriola fasciata, Corcyrogobius liechtensteini, Sphyraena viridensis and Sphoeroides pachygaster*.

**Cryptogenic species**

The cyanobacter *Trichodesmium erythraeum*, the sipunculans *Apionsoma misakianum* and *Aspidosiphon mexicanus*, the bryozoan *Bugula neritina* and the amphipod crustacean *Monocorophium sextonae* that were classified as established alien species in the 2011’s species list, were moved to the cryptogenic category due to debate on their origins and alien status [4, 119–121]. In addition to the cryptogenic species listed in 2011 [7], we assigned here three more ascidian (*Botryllus schlosseri, Clavelina lepadiformis* and *Molgula manhattensis*) and one bryozoan (*Bugulina fulva*) species to the cryptogenic status, based on the recent detailed assessment [4]. The distributions of these species as well as their habitat and depth preferences were previously presented [122, 123].
Impacts of invasive alien species

Developing mitigation measures against invasive species depends on a good understanding of their ecological, economic or health related influences, which has so far been documented only for a relatively low number of species. All alien species introduced to an ecosystem doubtless modifies the marine food webs to varying degrees, but available data denotes multifaceted impacts of invasive taxa transforming the decision-making process by governments or managers into a hard to solve situation. A recent comprehensive pan-European review proposed 87 marine taxa with high impact on ecosystem services or biodiversity [124], in which both negative and positive impacts were reported for 63 species, while 17 had only negative and 7 only had positive impacts. The most recent compilation of invasive species impacts observed at the Turkish coastline included information for over 40 species [7] and we present herein additional data obtained during the last decade.

A total of 105 invasive alien species have been reported from the coasts of Turkey, with documented and observed impacts on the major categories like biodiversity (all species), habitats (30 species), economy (both negative and positive contributions, 39 species) and human health (12 species). The impacts on these categories vary among taxonomic groups (Fig 15). Only Polychaeta (1 species, Eurythoe complanata), Cnidaria (3 species, Rhopilema nomadica,Macrobrachia philippina and Cassiopea andromeda) and Pisces (7 species, Siganus spp., Lagocephalus spp., Torquigener flavimaculosus and Pterois miles) create problems in human health when touched (venomous chaetae, nematocysts or spines) or eaten (tetradotoxin in the flesh). Two groups (Cnidaria and Polychaeta) had impacts on all major categories.

Ecosystem and biodiversity impacts. There has been a considerable range expansion of Caulerpa cylindracea towards the northern Aegean Sea [125], with an increasing trend of its abundance. The maximum and mean algal coverage were estimated as 60% and 20%, respectively, between depths of 1 and 45 m at Ayvalık Islands Natural Park [126], but recent surveys proved a drastic raise of its coverage, extending to 100% in several localities (pers. obs. MB).

Fig 15. The number of invasive alien species affecting to native biodiversity, habitats, human health and economy (positive or negative).
The Ayvalık region is a touristic hotspot in Turkey, in which daily boat trips are a common recreational activity, but the serious damage caused by boat anchors leave scars behind, swiftly settled by *C. cylindracea* (Fig 16A).

Owing to the conspicuous role in the recipient ecosystems and taking the place of keystone species, the alien alga, *Stypopodium schimperi*, is considered as an invasive species in the

![A—Caulerpa cylindracea observed at Ayvalık Islands Natural Park, forming dense populations at scars in the vicinity of Posidonia oceanica meadows (Photo: M.Bilecenoglu), B—Stypopodium schimperi forms dense populations at Turkish coasts (Photo: E. Taşkin), C—The famous “small pebble beach” at Kâş, Antalya Bay is currently covered entirely with Amphistegina lobifera tests (Photo: M.B.Yokey), D—Several coastal fish species found shelter among long spines of *Diadema setosum* (Photo: M.Bilecenoglu), E—The Red Sea goatfish, *Parupeneus forsskali*, is currently the dominant alien mullid in several localities, often observed in association with *Siganus* spp. (Photo: M.Bilecenoglu), F—The venomous *Plotosus lineatus* is a marine health hazard (Photo: B.Selli).](https://doi.org/10.1371/journal.pone.0251086.g016)
eastern Mediterranean Sea [127]. Remarkable range expansion of the species towards the north Aegean Sea is evident in the last decade, which forms very dense populations along the shallow coastal strip (Fig 16B). The dead matte forms extended strips through the supralittoral zone, negatively influencing the existing faunal assemblages.

*Amphistegina lobifera* is the most abundant alien foraminifer species in the Mediterranean Sea, infamous for its ability to change the whole habitat type and coastal structure (Fig 16C). The species accumulates extensive sand and forms uncountable dense populations at the northern Levant, reaching to densities of up to 310000 ind.m$^{-2}$ [7]. Current research indicated the immense impact of *A. lobifera* is continuing, whose tests form thick deposits of almost 60 cm in certain localities of Antalya Bay [128].

The Levantine population of *Penaeus kerathurus*, a native and commercially exploited species, has been severely hammered by intense fishing pressure and the invasion of its habitat by alien penaid species [129]. The penaeid shrimp catch composition in the region mainly consists of the alien species, such as *Penaeus pulchricaudatus*, *P. semisulcatus*, *P. hathor*, *Metapenaeopsis aegyptia*, *M. mogiensis consobrina*, *Trachysalambria palaestinensis*, *Metapenaeus monoceros* and *M. stebbingi* [130, 131], clearly indicating that *P. kerathurus* is being outcompeted.

The invasive longspine sea urchin *Diadema setosum* has recently been observed to provide refuge for coastal fish species (including the important keystone species, *Chromis chromis*, Fig 16D) against predators through their impenetrable long and venomous spines the northern Levant Sea [132]. This may be regarded as an ecologically positive impact, which should be closely monitored throughout its distribution range.

### Socio-economic impacts.

Among the invasive species, 39 species had direct impacts on the economy. Some species such as shrimps and edible fish (like *Nemipterus randalli*, *Siganus* spp., *Planiliza haematocheilus*, *Etrumeus golanii* and *Sphyraena* spp.) have positive contributions to fisher’s incomes, while a few such as *Rhopilema nomadica* and *Mnemiopsis leidyi* create a nuisance for commercial fisheries by clogging nets [7] or consume eggs or larvae of highly economic pelagic fish [133]. Eight invasive species have both positive and negative contributions to local economy. They are the species of high commercial value, which synchronously affect populations of other commercially important species. For example, the rapa whelk (*Rapana venosa*) is being intensively fished (positive impact), but have devastated beds of the native, highly economic mussel (*Mytilus galloprovincialis*) (negative impacts).

Several alien taxa have been commercially exploited in Turkey but obtained revenue can only be estimated for a few species. Capture fisheries of *R. venosa*, *C. sapidus*, *U. moluccensis* and *P. haematocheila* are regulated by the official fishery notifications (no. 5/1 and 5/2, valid until 31.08.2024), which set limitations on fishery methods, fishing seasons and minimum capture lengths. Started during the late 1980’s, there has been a growing up demand of the Rapa whelk from the Asian market and several processing plants were therefore established. According to official fishery statistics, almost 12,000 tons of *R. venosa* was produced on the coasts of the Sea of Marmara and Black Sea (Turkey) during 2019 and exported (as processed/frozen meat) to South Korea, Japan, China, Taiwan, USA and Vietnam, where over 18 million USD of income was obtained.

The Red Sea goatfish, *Parupeneus forsskali*, has an established population in the eastern Mediterranean Sea. First sightings off the northern Levant shores [15] were followed by other observations from Lebanon and Israel [134, 135]. An extreme population explosion was encountered in Turkey during the last few years, where the species become the dominant alien Mullid in certain localities (such as Antalya and Fethiye Bays, Fig 16E). The species has rapidly become a commercial catch for artisanal fishermen, sold with prices ranging 70 to 90 Turkish
Lira (equivalent to 7–10 Euros). Competition with native *Mullus* spp. is quite likely, yet to be proved by further research.

**Human health impacts.** The long spine urchin, *Diadema setosum*, was first recorded in the Mediterranean Sea from Kaş, Turkey [136], which has rapidly invaded the northern Levant and southern Aegean Sea shores during the last decade. Unlike other native sea urchins, *D. setosum* can be even found over sandy substrates of very shallow depths (i.e., 0.1 m), making the species a potential threat to touristic activities. Several daily boat trips in Turkey only let the customers to swim once the long spine sea urchins from the area has been totally removed by the crew, especially at regions heavily infested by the species (for example Fethiye Bay). The slender venomous spines can inflict painful injuries, although a precise number of annual envenomation is not available.

All fin spines of *Pterois miles* are associated with venom glands, capable of producing intense pain. Given its enormous rate of invasion, the species possess high risk both to recreational and artisanal fishermen, as well as to tourists especially during the high season. No lionfish injuries have been reported from the Mediterranean Sea until 2018 [137], but there are at least two non-fatal injuries from Turkey appeared in local newspapers.

The established population of *Plotosus lineatus* is confined to Iskenderun Bay (Fig 16F), currently with no signs of westwards expansion. It is considered to be a dangerous fish, because of venom glands associated with the serrate spines on the dorsal and pectoral fins and skin secretions containing proteinaceous toxins [137], which is responsible from 10% of all venomous fish injuries reported by Israeli fishermen [138]. Its possible westwards range expansion is therefore a threat to human health.

Negative impacts of *Lagocephalus sceleratus* have quite well been documented in the Mediterranean Sea, yet unforeseen health related cases are still encountered. Following the first observations of biting cases from Antalya shores (i.e., a tourist was bit in the back, whilst a fisher suffered problems in one of his fingers; [139]), a traumatic amputation caused by a severe *L. sceleratus* bite in a child was observed, who eventually lost the distal part of her finger [140].

**Legislation**

Environmental legislation in Turkey is mainly determined by the constitution, national laws, by-laws, regulations, notifications, international conventions and protocols. Protection of species and natural assets within their own ecosystems started legally in 1937 with the Forest Law and Terrestrial Hunting Law, but the Turkish Governments began focusing on environmental issues by the early 1980s. Since then, major steps have been taken towards harmonizing Turkey’s legislation both with EU acquis and with international standards, but still a huge effort is required to achieve the expected levels.

On national basis, Turkey does not currently have any laws specifically targeting marine alien or invasive species, but some indirect judgments are available mostly on biodiversity and environment issues, potentially linked to bioinvasions. The most prominent example is the Constitution of Turkey (adopted by the Parliament on 18.10.1982, law no. 2709), which mentions that the State shall ensure the protection of the historical, cultural and natural assets and wealth, and shall take supportive and promotive measures towards that end. The main legal framework is set out in Environment Law (no. 2872, dated 11.08.1983), emphasizing on the importance of protection of the environment, where all the activities threatening the biodiversity are prohibited.

General Directorate of Fisheries and Aquaculture (of Ministry of Agriculture and Forestry) is the main state organization responsible for the administration and regulation of fisheries
and aquaculture. All activities are based on the Fisheries Law No. 1380 enacted in 1971, in which regulations and circulars are prepared to regulate fisheries. Article 25 of the Fisheries Law includes statements that may be linked to alien species (all alive import and export of aquatic products are subject to permission the relevant Ministry). For the first time in Turkey’s history, a recent incentive notification with short-term validity has been published in the official gazette (dated 02.12.2020, no: 31322), which permits artisanal fishermen to bounty hunt *Lagocephalus sceleratus* for a price of 5 TL per fish caudal fin (0.52 Euros) during 02 to 31 December 2020. The notification supports hunting of one million *L. sceleratus* in total, but the targeted amount could not be reached and remained roughly at 46,000 individuals. The Ministry has unofficially announced that the same incentive approach will continue in 2021, by also including other alien pufferfish species.

There are two other laws defining border controls on plant and animal species entering/exiting Turkey (Agricultural Plant Protection and Agricultural Quarantine Law and Animal Health and Surveillance Law), where any kind of transfer is subjected to Ministry of Agriculture and Forestry regulations. Relevant laws concentrate mainly on terrestrial taxa and are loosely related to marine alien species, but they provide prominent baseline for import and export of species at the customs.

The Turkish National Biodiversity Strategy Action Plan was first published in 2008, in compliance with the Article 6 of CBD. Following the Decision 10/2 of Cop X/2, the NBSAP was reviewed and an updated version covering the 2018–2028 periods has been prepared [141]. Among the listed seven national objectives, the first one and its associated action directly focuses on alien and invasive species: *National Objective (1)—Pressures and threats on biodiversity and ecosystems will be determined, reduced to the lowest level or removed totally; Action 1.2. Studies on improving the measures for identifying, monitoring, and controlling the entrance routes of invasive species and alien species and preventing entrance and habitation thereof will increasingly be continued.*

Since invasive alien species are a global threat that clearly requires international cooperation and actions, there are many international agreements (binding/non-binding) and regulations referring directly or indirectly to alien species [142]. Those ratified by Turkey are as follows: Convention on Biological Diversity, Ramsar Convention (The Convention on Wetlands of International Importance especially as Waterfowl Habitat), CITES (The Convention on International Trade in Endangered Species of Wild Fauna and Flora), The International Convention for the Control and Management of Ships’ Ballast Water and Sediments (BWM Convention), Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), and Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (Barcelona Convention). According to the Turkish legislation, ratification of the above-mentioned conventions is not sufficient alone without the implementation regulations (yet to be prepared by the responsible Ministries) have come into force.

**Management**

No successful story has yet been written in the effective management of marine invasive alien species in the Mediterranean, and the world’s seas as well. Although certain studies have been carried out for the killer alga *Caulerpa taxifolia* to cease its invasion (manual removal and application of a cloth soaked in copper salts) in the western Mediterranean (see [143]), all of them ended in disappointment. Despite of several international conventions ratified; Turkey has been progressing very slowly to manage on-going invasions by alien species. The recent fishery notification entered into force aims to create a pressure on the existing stocks of *L. sceleratus*, which is responsible from the huge negative impact on artisanal fisheries (by damaging
fishing gears), as well as on food web dynamics (through predator-prey relationships) and human health. Since the bounty hunting is limited to 1 million of fish and only valid between 02 to 31 December 2020, the expected impact (if any) will only be of minor magnitude and evidently far from effective management of alien species. However, it would be also on the agenda to create a management plan later with the experiences to be gained from this initiative.

Among all other alternatives, the pre-border management (i.e., the management of vectors) seems to be the most effective way of alien species management [144]. Turkey signed and ratified (Law Number: 6531, date: 8.4.2014) the International Convention For the Control and Management of Ship’s Ballast Water and Sediments, 2004 (BWM). This is an important step towards preventing translocations of species by shipping activities. According to the D1 standard of the BWM Convention, vessels need to perform ballast water exchange (at least 95% capacity) at least 50 nautical miles from the nearest land and in waters at least 200 m deep. According to the D2 standard, vessels may only discharge ballast water that contains viable organism within specified limits (by treating ballast water) [145]. This might considerably decrease risks of species introductions via ballast water of ships, which was previously poured into sea near ports where tolerant introduced species can easily survive and establish [146, 147].

In the eastern Mediterranean, where Turkey is located, a little can be done for the management of invasive alien species as long as the Suez Canal is widely open. As stated in this study, the Red Sea species comprised more than half (57%) of the number of established and casual species reported from Turkey and this ratio varies considerably among seas. In accordance with the expansion of the Suez Canal, which was fully completed in 2016 [6]; sea-level change through the canal over years [148]; decrease in the salinity level of hyperhaline lakes (Bitter Lake) through the canal, and the reduction of the fresh-water outflows of the Nil River after the construction of the Aswan Dam, which acted as a freshwater barrier at the gateway (Port-Said) to the Mediterranean [149]; and global climate changes [150] a significant increase in the number of introduced species will likely to occur, yet to be meticulously and closely monitored. Therefore, alien species management in Turkey, in a sense, is associated very closely with the management of the Suez Canal itself. It is not possible to protect the Mediterranean habitats from the Red Sea originated species invasions without deploying smart engineering solutions on the canal such as saltwater-freshwater barriers. The importance of international cooperation in the management of Lessesbian species is increasing than ever before, as their increasing profound impacts and incalculable costs on the biodiversity and socio-economy cannot be overcome by any individual country. Regardless under which umbrella it would be (e.g., Barcelona Convention, UN Biodiversity Convention), the Mediterranean countries should sit around a table to start a discussion on the effective management of the Suez Canal and to create solution plans with alternatives. In this context, the time has come to pass a proposal to compensate the ecosystem services lost by the countries due to the invasion of Red Sea species from the country operating the Suez Canal.

**Conclusion—The way forward**

The coasts of Turkey, which accounted for almost 65% of the total number of alien species reported from the Mediterranean Sea till now, will be undoubtedly subjected to new alien species entrance from now on. For this reason, in defiance of critically evaluated available information on the taxonomy and distribution characteristics of alien species, producing an up-to-date alien species inventory on the coasts within a certain time period (preferably once in every decade) will allow us a better understanding of the diversity, trends and establishment success of alien species. Surrounded by four seas of different oceanographic features, it is
essential to prepare and implement different management plan for each sea of Turkey, taking
cognizance of the vectors and invasion strategies of the introduced species. As a result of inves-
tigations by academic institutions scattered along the coastal cities of Turkey, a mass of inform-
ation has been produced so far on the alien species distribution pattern in certain areas such
as İskenderun Bay and İzmir Bay. In addition, the relatively long-term, on-going monitoring
projects such as the Integrated Pollution Monitoring Studies covering all seas of Turkey
financed by the Ministry of Environment and Urbanization in the last decade have enabled
keeping the information up to date. However, in order to monitor and surveil alien species at
least in hot-spot areas, implementation of long-term specific projects in an eastern Mediterra-
nean country like Turkey, which lose habitats and native biodiversity hence causing a few bil-
lion US dollar financial loss annually, is a prerequisite rather than arbitrariness. In addition,
part from those on the identification and distribution of alien species, future multi-oriented
studies towards the invasion bio-ecology of alien species and their impacts on the prevailing
ecosystems (especially in the food chain) are needed for allowing us a better understanding of
irreversible changes these species have created in the Mediterranean ecosystems.

Acknowledgments
We would like to thank to Bülent Şelli (Imbat Underwater Imaging Center) for sharing his
photo (Plotosus lineatus) with us.

Author Contributions
Conceptualization: Melih Ertan Çınar, Murat Bilecenoğlu, M. Baki Yokeş.

Data curation: Melih Ertan Çınar, Murat Bilecenoğlu, M. Baki Yokeş, Bilal Öztürk, Ergün
Taşkin, Kerem Bakir, Alper Doğan, Şermin Açık.

Funding acquisition: Murat Bilecenoğlu.

Investigation: Melih Ertan Çınar.

Methodology: Melih Ertan Çınar, Murat Bilecenoğlu.

Visualization: Melih Ertan Çınar, Murat Bilecenoğlu, Kerem Bakir.

Writing – original draft: Melih Ertan Çınar, Murat Bilecenoğlu.

Writing – review & editing: Melih Ertan Çınar, Murat Bilecenoğlu, M. Baki Yokeş, Bilal
Öztürk, Ergün Taşkin, Kerem Bakir, Alper Doğan, Şermin Açık.

References
1. Coll M, Pirolli C, Steenbeek J, Kaschner K, Lasram FBR, Aguzzi J, et al. The biodiversity of the Medi-
terranean Sea: estimates, patterns, and threats. PloS one. 2010; 5(8):e11842. https://doi.org/10.1371/
journal.pone.0011842 PMID: 20689844

2. Rilov G, Galil B. Marine bioinvasions in the Mediterranean Sea—history, distribution and ecology. Bio-
logical invasions in marine ecosystems: Springer; 2009. p. 549–75.

3. Çınar ME. Alien polychaete species worldwide: current status and their impacts. Journal of the Marine
Biological Association of the United Kingdom. 2013; 93(5):1257. https://doi.org/10.1017/
S0025315412001646

4. Zenetos A, Çınar ME, Crocetta F, Golani D, Rosso A, Servello G, et al. Uncertainties and validation of
alien species catalogues: The Mediterranean as an example. Estuarine, Coastal and Shelf Science.
2017; 191:171–87. https://doi.org/10.1016/j.ecss.2017.03.031

5. Zenetos A, Galanidi M. Mediterranean non indigenous species at the start of the 2020s: recent
changes. Marine Biodiversity Records. 2020; 13(1):1–17. https://doi.org/10.1186/s41200-020-
00191-4
6. Galil B, Boero F, Fraschetti S, Piraino S, Campbell M, Hewitt C, et al. The Enlargement of the Suez Canal and Introduction of Non-Indigenous Species to the Mediterranean Sea. Limnology and Oceanography Bulletin. 2015; 24(2):43–5. https://doi.org/10.1002/lob.10036

7. Çınar ME, Bilecenoglu M, Ozturk B, Katagan T, Yokes MB, Aysel V, et al. An updated review of alien species on the coasts of Turkey. Mediterr Mar Sci. 2011; 12(2):257–315. https://doi.org/10.12681/mms.34

8. Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, Raso JG, et al. Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union’s Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. Mediterr Mar Sci. 2012; 13(2):328–82. https://doi.org/10.12681/mms.327

9. Galil BS, Marchini A, Occhipinti-Ambrogi A. East is east and West is west? Management of marine bioinvasions in the Mediterranean Sea. Estuarine, Coastal and Shelf Science. 2018; 201:7–16. https://doi.org/10.1016/j.ecss.2015.12.021

10. GDoMA. Maritime statistics in Turkish Straits System. General Directorate of Maritime Affairs. 2019 [15 February 2020]. Available from: https://denizcilikistatistikleri.ua.b.gov.tr/turk-bogazlari-gemi-gecis-istatistikleri

11. Çınar ME, Bilecenoglu M, Ozturk B, Katagan T, Yokes MB, Aysel V. Alien species on the coasts of Turkey. Mediterr Mar Sci. 2005; 6(2):119–46. https://doi.org/10.12681/mms.187

12. Çınar ME. The alien ascidian Styela clava now invading the Sea of Marmara (Tunicata: Ascidiae). ZooKeys. 2016;(563):1–10. https://doi.org/10.3897/zookeys.563.6836 PMID: 27047235

13. Yokes MB. First record of the Indo-Pacific slender ponyfish Equulites elongatus (Günther, 1874)(Perciformes: Leiognathidae) from Turkey. Bioinvasions Rec. 2015; 4(4):305–8. https://doi.org/10.3391/bir.2015.4.4.13

14. Yokes MB, Andreou V, Bakir R, Bonanomi S, Camps J, Christidis G, et al. New Mediterranean Biodiversity Records (November 2018). Mediterr Mar Sci. 2018; 19(3):673–89. https://doi.org/10.12681/mms.19386

15. Çınar ME, Bilecenoglu M, Öztürk B, Can A. New records of alien species on the Levantine coast of Turkey. Aquatic invasions. 2006; 1(2):84–90.

16. Bilecenoglu M, Alfaya JE, Azzurro E, Baldacconi R, Boyaci Y, Circosta V, et al. New Mediterranean Marine Biodiversity Records (December, 2013). Mediterr Mar Sci. 2013; 14(2):463–80. https://doi.org/10.12681/mms.676

17. Matsuura K, Golani D, Bogorodsky SV. The first record of Lagocephalus guentheri Miranda Ribeiro, 1915 from the Red Sea with notes on previous records of L. lunaris (Actinopterygii, Tetraodontiformes, Tetraodontidae). Bulletin of the National Museum of Nature and Science, Series A. 2011; 37(3):163–9.

18. Leydet KP, Hellberg ME. The invasive coral Oculina patagonica has not been recently introduced to the Mediterranean from the western Atlantic. BMC Evolutionary Biology. 2015; 15(1):79. https://doi.org/10.1186/s12862-015-0356-7 PMID: 25940207

19. Engin S, Larson H, Irmak E. Hazaeus ingressus sp. nov. a new goby species (Perciformes: Gobiidae) and a new invasion in the Mediterranean Sea. Mediterr Mar Sci. 2018; 19(2):316–25. https://doi.org/10.12681/mms.14336

20. Mutlu E, Çagatay IT, Olguner MT, Yilmaz HE. A new sea-nettle from the Eastern Mediterranean Sea: Chrysaora pseudooceallata sp. nov. (Scyphozoa: Pelagiidae). Zootaxa. 2020; 4790(2):229–44. https://doi.org/10.11646/zootaxa.4790.2.2 PMID: 33055839

21. UNEP/MAP. Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea. Athens, Greece: UN Environment/MAP 2017. 12 p.
Directive (MSFD). Part I. Spatial distribution. Mediterr Mar Sci. 2010; 11(2):381. https://doi.org/10.12681/mms.87

27. Carlton JT. Biological invasions and cryptogenic species. Ecology. 1996; 77(6):1653–5.

28. Savigny J. Mémoires sur les animaux sans vertèbres. Seconde Partie. Description et classification des animaux invertébrés, non articulés, connus sous les noms de Mollusques, de Radiaries, de Polypes, etc. Paris1816. 239 p.

29. Skinner L, Oliveira G, Barboza D, Tenório A, Soares D. First record of the Ascidiaeae Rhodosoma turcirum in the south-west Atlantic Ocean. Marine Biodiversity Records. 2013; 6:e37. https://doi.org/10.1017/S1755267213000092

30. Bitar G, Kouli-Bitar S. Nouvelles données sur la faune et la flore benthiques de la côte Libanaise. Migration Lessepsienne. Thalassia Salentina. 2001; 25:71–4. https://doi.org/10.1285/i15910725v25p71

31. Shenkar N, Loya Y. Non-indigenous ascidians (Chordata: Tunicata) along the Mediterranean coast of Israel. Marine Biodiversity Records. 2009; 2:e166. https://doi.org/10.1017/S1755267209990753

32. Zenetos A, Corsini-Foka M, Crocetta F, Gerovasileiou V, Karachle PK, Simbouna N, et al. Deep cleaning of alien and cryptogenic species records in the Greek Seas (2018 update). Management of Biological Invasions. 2018; 9(3):209–26. https://doi.org/10.3391/mbi.2018.9.3.04

33. Leppäkoski E, Shiganova T, Alexandrov B. European enclosed and semi-enclosed seas. In: Rilov G, JA C, editors. Biological invasions in marine ecosystems. Berlin, Heidelberg: Springer; 2009. p. 529–47.

34. Çınar ME. Serpulid species (Polychaeta: Serpulidae) from the Levantine coast of Turkey (eastern Mediterranean), with special emphasis on alien species. Aquatic invasions. 2006; 1(4):223–40. https://doi.org/10.3391/ai.2006.1.4.6

35. Çınar ME, Katagan T, Öztürk B, Dagli E, Açık S, Bitlis B, et al. Spatio-temporal distributions of zoobenthos in Mersin Bay (Levantine Sea, eastern Mediterranean) and the importance of alien species in benthic communities. Marine Biology Research. 2012; 8(10):954–68. https://doi.org/10.1080/17451000002140194

36. Langeneck J, Lezzi M, Del Pasqua M, Musco L, Gambi MC, Castelli A, et al. Non-indigenous polychaetes along the coasts of Italy: a critical review. Mediterr Mar Sci. 2020:238–75. https://doi.org/10.12681/mms.21860

37. Çınar ME. Description of a new fireworm, Eurythoe turcica sp. nov. (Polychaeta: Amphinomidae), from the Levantine coast of Turkey (eastern Mediterranean), with re-descriptions of Eurythoe parvecarunculata Horst and Amphimone djiboutiensis Gravier based on type material. Journal of Natural History. 2008; 42(29–30):1975–90. https://doi.org/10.1080/00222930802140194

38. Arias A, Barroso R, Anadón N, Paiva P. On the occurrence of the fireworm Eurythoe complanata complex (Annelida, Amphinomidae) in the Mediterranean Sea with an updated revision of the alien Mediterranean amphinomids. ZooKeys. 2013; 337:19–33. https://doi.org/10.3897/zookeys.337.5811 PMID: 24146576

39. Ben-Eliahu M. Contributions to the knowledge of Suez Canal migration. Polychaeta errantia of the Suez Canal. Israel Journal of Zoology. 1972; 21(3–4):189–237. https://doi.org/10.1080/00212210.1972.10688363

40. Abdelnaby FA. Polychaetes from Suez Gulf (Gabel El Zeit), Egypt. Egyptian Journal of Aquatic Biology and Fisheries. 2019; 23(5):43–53. https://doi.org/10.21608/EJABF.2019.62805

41. Stulpinaite R, Hyams-Kaphzan O, Langer MR. Alien and cryptogenic Foraminifera in the Mediterranean Sea: A revision of taxa as part of the EU 2020 Marine Strategy Framework Directive. Mediterr Mar Sci. 2020; 21(3):719–58. https://doi.org/10.12681/mms.24673

42. Toueg R. History of the Inner Harbour in Caesarea. Haifa: MA thesis, Department of Maritime Civilizations, University of Haifa, Haifa, Israel (In Hebrew, English abstract); 1996.

43. Avital A. Geological history of the Plio-Pleistocene-Holocene offshore based on cores off Ashqelon, Southern Israel: MSC thesis, Ben Gurion University of the Negev (In Hebrew, English abstract); 2002.

44. Lazar S. Recent and late Pleistocene carbonate-rich sediments in the Mediterranean shelf of Israel: sedimentary, biogenic and genetic analysis. 2007.

45. Merkado G, Holzmann M, Apothéloz-Perret-Gentil L, Pawlowski J, Abdou U, Almogi-Labin A, et al. Molecular Evidence for Lessepsian Invasion of Soritids (Larger Symbiont Bearing Benthic Foraminifera). PLOS ONE. 2013; 8(10):e77725. https://doi.org/10.1371/journal.pone.0077725 PMID: 24204936

46. Meriş E, Yokeş MB, Aysar N, Kyak NG, Öner E, Nazik A, et al. Did Amphistegina lobifera Larsen reach the Mediterranean via the Suez Canal? Quaternary International. 2016; 401:91–8. https://doi.org/10.1016/j.quaint.2015.08.088
47. Merç E, Öner E, Avşar N, Nazik A, Güneyli H, İslamoğlu Y, et al. Did the Red Sea–Mediterranean connection over the Dead Sea Fault Zone end in the Late Pliocene? Quaternary International. 2016; 401:123–31. https://doi.org/10.1016/j.quaint.2015.08.067

48. Schmidt C, Morard R, Prazeres M, Barak H, Kucera M. Retention of high thermal tolerance in the invasive foraminifera Amphistegina lobifera from the Eastern Mediterranean and the Gulf of Aqaba. Marine Biology. 2016; 163(11):228. https://doi.org/10.1007/s00227-016-2998-4

49. Colombo A. Raccolte zoologiche eseguite dal R. Pirascafa Washingto n nella campagna abissale talassografica dell’anno. Rivista Marittima. 1885; 18:22–53.

50. Ostroumoff A. Otchet o dragirovk ax i planktonn yix ulovax ekspeditsii “Selyanik a”. Bulletin de l’Académie Impériale des Sciences de St-Pétersbourg. 1896; 5:33–92.

51. Uysal A. Türkiye suları Ascidia’l arı.

52. Taşkın E, Akbulut A, Yıldız A, Şahin B, Şen B, Uzunöz C, et al. Checklist of the flora of Turkey (algae). İstanbul: Ali Nihat Gökyı ktu Vakfı 2019. 807 p.

53. Taşkın E, Çakır M, Akçali B, Sungur Ö. Benthic marine flora of the Marmara Sea (TURKEY). Journal of Black Sea/Mediterranean Environment. 2019; 25(1):1–28.

54. Verlaque M, Ruitton S, Mineur F, Boubouresque C-F. CIESM atlas of exotic species in the Mediterranean. 2019; 25(1):1–28.

55. Ökseneberg B, Enzenross R, Enzenross L. First record of Rhizocephala (Crustacea: Cirripedia) from the eastern Mediterranean Sea, eastern Mediterranean Sea). Zootaxa. 2005; 1036(1):43–54. https://doi.org/10.11646/zootaxa.1036.1.4

56. Çinar ME. Syllis ergentii, a new species of Syllidae (Annelida: Polychaeta) from Izmir Bay (Aegean Sea, eastern Mediterranean Sea). Zootaxa. 2005; 1036(1):43–54. https://doi.org/10.11646/zootaxa.1036.1.4

57. Çinar ME, Bakır K, Öztürk B, Katağan T, Doğan A, Açıkgöz S, et al. Macrobenthic fauna associated with the invasive alien species Brachidontes pharaonis (Mollusca: Bivalvia) in the Levantine Sea (Turkey). J Mar Biol Assoc Uk. 2017; 97(3):613–28. https://doi.org/10.1017/jmboa.2017.58

58. Romero R, Öztürk E, Özgür Özbek E, Öztürk B. editors. The Turkish Part of the Mediterranean Sea Marine Biodiversity, Fisheries, Conservation and Governance. 43. İstanbul: Turkish Marine Research Foundation; 2016. p. 152–66.

59. Özak AA, Demirkale İ, Yanar A. First record of two species of parasitic copepods on immigrant puffer-fishes (Tetraodontiformes: Tetraodontidae) caught in the eastern Mediterranean Sea. Turkish Journal of Fisheries and Aquatic Sciences. 2012; 12(3):675–81.

60. Ọsikeneberg B, Enzenross R, Enzenross L. First record of Rhozocephala (Crustacea: Cirripedia) from Turkish waters with notes on Lessepsian migration. Stuttgarter Beiträge zur Naturkunde Serie A (Biologie). 1997; 557:1–7.

61. Ọsikeneberg B, Enzenross R, Enzenross L. First record of Rhozocephala (Crustacea: Cirripedia) from Turkish waters with notes on Lessepsian migration. Stuttgarter Beiträge zur Naturkunde Serie A (Biologie). 1997; 557:1–7.

62. Golani D. First record of the muzzled blenny (Osteichthyes: Blenniidae: Omobranchus punctatus) from the Mediterranean, with remarks on ship-mediated fish introduction. J Mar Biol Assoc Uk. 2004; 84(4):851–2.

63. Ọzbek EÖ, Ọzkaya M, Özgür B, Golani D. First record of the blenny Parablennius thyssanius (Jordan & Seale, 1907) in the Mediterranean. Journal of Black Sea/Mediterranean Environment. 2014; 20 (1):53–9.

64. Artüz ML, Fricke R. The marine teleost fishes of the Sea of Marmara; an updated and annotated checklist. Zootaxa. 2019; 4565(4):545–65. https://doi.org/10.11646/zootaxa.4565.4.9 PMID: 31716457

65. Bileceoğlu M. Comments on “The marine teleost fishes of the Sea of Marmara; an updated and annotated checklist” by Artüz & Fricke (2019). Zootaxa. 2020; 4751(3):597–600. https://doi.org/10.11646/zootaxa.4751.3.12 PMID: 32230414
68. Artüz ML, Fricke R. First and northernmost record of *Upeneus moluccensis* (Actinopterygii: Perciformes: Mullidae) from the Sea of Marmara. Acta Ichthyol Piscat. 2019; 49(1):53–8. https://doi.org/10.3750/AIEP/02527

69. Artüz ML, Golani D. First and most northern record of *Sargocentron rubrum* (Forsskål, 1775) from the Sea of Marmara. Thalassas: An International Journal of Marine Sciences. 2018; 34(2):377–81. https://doi.org/10.1007/s41208-018-0075-0

70. Artüz ML, Kubań N. First record of shrimp scad *Alepes djedaba* (Carangidae) from the Sea of Marmara, Turkey. Cybium. 2014; 38(4):319–20. https://doi.org/10.26028/cybium/2014-384-013

71. Çeviker D. Recent immigrant Bivalves in the northeastern Mediterranean off Iskenderun. La Conchiglia. 2001; 298:39–46.

72. Zenetos A, Gofas S, Russo G, Templado J. CIESM Atlas of Exotic Species in the Mediterranean: Molluscs: CIESM Publishers; 2004. https://doi.org/10.1016/S0025-326X(03)00370-9 PMID: 14725883

73. Mifsud C, Ovalis P. A Galeommatid bivalve new to the Mediterranean Sea. Triton. 2012; 26:6–8.

74. Engl W, Çeviker D. New migrant species from southeast Turkey *Psammotrota praerupta* (Salisbury, 1934) and *Antigona lamellaris* Schumacher, 1817. La Conchiglia. 1999; 299:17–20.

75. Aysel V, Güner H, Dural B. Türkiye Marmara denizi florası II. Phaeophyta ve Rhodophyta. Ege Üniversitesi Su Ürünleri Fakültesi Dergisi. 1993; p. 10–15.

76. Zeybek N, Güner H, Aysel V. The marine algae of Türkiye. The fifth Optima Meeting; İstanbul1993. p. 8–15.

77. Melis R, Bernasconi MP, Colizza E, Di Rita F, Schneider EE, Forte E, et al. Late Holocene palaeoenvironmental evolution of the northern harbour at the Elaiussa Sebaste archaeological site (south-eastern Turkey): evidence from core ELA6. Turkish Journal of Earth Sciences. 2015; 24(6):566–84. https://doi.org/10.3906/yer-1504-10

78. Parker FL. Eastern Mediterranean foraminifera. Reports of the Swedish deep-sea Expedition. 1958; 8 (4):219–83.

79. Kurt Sahin G. Marphysa cinari, a new species of Eunicidae (Polychaeta) from the coasts of Turkey (eastern Mediterranean) and re-descriptions of Marphysa kinbergi McIntosh, 1910 and Marphysa disjuncta Hartman, 1961. Journal of Natural History. 2014; 48(33–34):1989–2006. https://doi.org/10.1080/00222933.2014.905125

80. Arias A, Paxton H. *Onuphis and Aponuphis* (Annelida: Onuphidae) from southwestern Europe, with the description of a new species. Zootaxa. 2015; 3949(3):345–69. https://doi.org/10.11646/zootaxa.3949.3.3 PMID: 25947812

81. Lezzi M, Giangrande A. New species of *Streblosoma* (Thelepodidae, Annelida) from the Mediterranean Sea: *S. pseudocolumbus* sp. nov., *S. nogueirai* sp. nov. and *S. hutchingsae* sp. nov. Journal of Natural History. 2018; 52(43–44):2857–73. https://doi.org/10.1080/00222933.2018.1556357

82. Sun Y, Wong E, Keppel E, Williamson JE, Kupriyanova EK. A global invader or a complex of regionally distributed species? Clarifying the status of an invasive calcareous tubeworm *Hydroides distans* (Verrill, 1873) (Polychaeta: Serpulidae) using DNA barcoding. Marine Biology. 2017; 164(1):28. https://doi.org/10.1007/s00227-016-3058-9

83. Bakir AK, Kataran T, Aker HV, Ozcan T, Sezgin M, Ates AS, et al. The marine arthropods of Turkey. Turk J Zool. 2014; 38(6):765–831.

84. Zenetos A, Cinar M, Pancucci-Papadopoulou M, Harmelin J, Furnari G, Andaloro F, et al. Annotated list of marine alien species in the Mediterranean with records of the worst invasive species. Mediterr Mar Sci. 2005; 6(2):63–118. https://doi.org/10.12681/mms.186

85. Kovaliev A. On the problem of Lessepsian migrations of zooplanktonic organisms. Mediterr Mar Sci. 2006; 7(2):67–72. https://doi.org/10.12681/mms.171

86. Unal E, Shmelева A, Zagorodnyaya J, Kideys A, editors. Zooplankton structure and copepod species of the Sea of Marmara in spring 1998. Proceedings of Symposium on Marmara Sea; 2000; İstanbul: Turkish Marine Research Foundation.

87. Uysal Z, Kideys AE, Shmelева AA, Zagorodnyaya JA, Gubanova AD. Checklist of copepods (Calanoida and Podoplea) from the northern Levantine basin shelf waters. Hydrobiologia. 2002; 482(1–3):15–21. https://doi.org/10.1023/A:1021253721682.

88. Altuğ G, Akta˘n Y, Oral M, Topaloğlu B, Dede A, Keskin Ç, et al. Biodiversity of the northern Aegean Sea and southern part of the Sea of Marmara, Turkey. Marine Biodiversity Records. 2011; 4:e65. https://doi.org/10.1017/S1755267211000662

89. Topaloğlu B, Öztürk B. First record of *Marsupenaeus japonicus* (Bate, 1888)(Crustacea: Decapoda: Penaeidae) from the western coast of the Turkish Black Sea. Journal of the Black Sea/Mediterranean Environment. 2017; 23(3):229–34.
90. Artüz ML, Artüz OB. First and Northernmost Record of Diadema setosum (Leske, 1778) (Echinodermata: Echinoidea: Diadematidae) in the Sea of Marmara. Thalassas: An International Journal of Marine Sciences. 2019; 35(2):375–9. https://doi.org/10.1007/s41208-019-00137-3

91. Sala E, Kızılıkaya Z, Yıldırım D, Ballesteros E. Alien marine fishes deplete algal biomass in the eastern Mediterranean. PloS one. 2011; 6(2):e17356. https://doi.org/10.1371/journal.pone.0017356 PMID: 21364943

92. Öztöprak B, Doğan A, Dağı E. Checklist of Echinodermata from the coasts of Turkey. Turk J Zool. 2014; 38(6):892–900.

93. Kocata A. İzmir Körfezi kayalık sahillerinin bentik formları üzerinde kalitât ve quantitatıf araştırmalar. Ege Üniversitesi Fen Fakültesi Monografiler Serisi. 1978; 12:1–93.

94. Albayrak S. Prosobranch gastropods of the Imbros Island (NE Aegean Sea). Acta Adriat. 2001; 42(2):35–42.

95. Yapıçi S. Unusual observation of the alien sea urchin Diadema setosum (Leske, 1778) in the Aegean Sea: recent and recorded occurrences. Thalassas. 2018; 34(2):267–9. https://doi.org/10.1007/s41208-017-0060-z

96. Hablützel PJ, Wilson AB. Notes on the occurrence of Syngnathus rostellatus (Teleostei: Syngnathidae) in the Mediterranean. Marine Biodiversity Records. 2011; 4:e57. https://doi.org/10.1017/S1755267211000558

97. Bariche M, Keltou P, Kalogiros S, Bernardi G. Genetics reveal the identity and origin of the lionfish invasion in the Mediterranean Sea. Scientific Reports. 2017; 7(1):6782. https://doi.org/10.1038/s41598-017-07326-1 PMID: 28754912

98. Dimitriou AC, Chartosia N, Hall-Spencer JM, Kleitou P, Jimenez C, Antoniou C, et al. Constructing the genetic population demography of the invasive lionfish Pterois miles in the Levant Basin, Eastern Mediterranean. Mitochondrial DNA Part A. 2019; 30(2):249–55. https://doi.org/10.1080/24701394.2018.1482284 PMID: 29873574

99. Stern N, Jimenez C, Huseynoglu MF, Andreou V, Hadjioanou L, Petrou A, et al. Genetic data suggest multiple introductions of the lionfish (Pterois miles) into the Mediterranean Sea. Diversity. 2019; 11(9):149. https://doi.org/10.3390/d11090149

100. Turan C, Uyan A, Gürelk M, Doğdu SA. DNA Barcodes for Identifications of Two Lionfish Species Pterois miles (Bennett, 1828) and Pterois volitans (Linnaeus, 1758) in the Mediterranean. FishTaxa. 2020; 16:29–36.

101. Méndez IAG, Rivera-Madrid R, Díaz-Jaimés P, Aguilar-Espinoza M, Arias-González JE. Applying an easy molecular method to differentiate Pterois volitans from Pterois miles by RFLPs. Conservation Genetics Resources. 2017; 9(3):493–7. https://doi.org/10.1007/s12686-017-0700-x

102. Wilcox CL, Motomura H, Matsumuna M, Bowen BW. Phylogeography of Lionfishes (Pterois) Indicate Taxonomic Over Splitting and Hybrid Origin of the Invasive Pterois volitans. Journal of Heredity. 2017; 109(2):162–75. https://doi.org/10.1093/jhered/esx056 PMID: 28637254

103. Ayas D, Ağlıkaya GŞ, Yaşğioğlu D. New occurrence of the red lionfish Pterois volitans (Linnaeus, 1758) in the north eastern Mediterranean (Yeşilovacık Bay). Düzce Üniversitesi Bilim ve Teknoloji Der. 2018; 6(4):871–7.

104. Gürelk M, Ergüden D, Uyan A, Doğdu SA, Yaşğioğlu D, Öztürk B, et al. First record red lionfish Pterois volitans (Linnaeus, 1785) in the Mediterranean Sea. Natural and Engineering Sciences. 2016; 1(3):27–32.

105. Gürelk M, Ergüden D, Uyan A, Doğdu SA, Yaşğioğlu D, Öztürk B, et al. First record red lionfish Pterois volitans (Linnaeus, 1785) in the Mediterranean Sea. Natural and Engineering Sciences. 2016; 1(3):27–32.

106. Gürelk M, Ergüden D, Doğdu SA, Turan C. First record of greenback horse mackerel, Trachurus declivis (Jenyns, 1841) in the Mediterranean Sea. J Appl Ichthyol. 2016; 32(5):976–7. https://doi.org/10.1007/s12686-016-0755-2

107. Jenyns L. Fish. The zoology of the voyage of HMS Beagle, under the command of Captain Fitzroy, RN, during the years 1832 to 1836. Smith, Elder, London. 1841:65–96.

108. Smith-Vaniz W. Carangidae. In: Carpenter K, Niem V, editors. FAO species identification guide for fishery purposes The living marine resources of the Western Central Pacific Volume 4 Bony fishes part 2 (Mugilidae to Carangidae). Rome: FAO. 1999. p. 2659–83.

109. Smith-Vaniz W. Carangidae. In: Whitehead P, Bauchot M, Hureau J, Nielsen J, Tortonee E, editors. Fishes of the north-Eastern Atlantic and the Mediterranean, 2. Paris: UNESCO; 1986. p. 815–44.

110. Gürelk M, Ergüden D, Doğdu S, Turan C. First record of the Indo-Pacific soldier bream Argyrops filamentosus (Valenciennes, 1830) from the Mediterranean Sea. J Appl Ichthyol. 2016; 32(6):1224–5. https://doi.org/10.1007/s12686-016-0755-2
111. Iwatsuki Y, Heemstra PC. Taxonomic review of the genus *Argyrosomus* (Perciformes; Sparidae) with three new species from the Indo-West Pacific. Zootaxa. 2018; 4438(3):401–42. https://doi.org/10.11646/zootaxa.4438.3.1 PMID: 30313129

112. Gökşenlu M. A new goatfish species of the genus *Oplegnathus* (Mullidae) in the Gulf of Antalya. Acta Aquatica: Aquatic Sciences Journal. 2018; 5(2):56–8.

113. Chartosi G, Anastasiasiadis D, Bazzari H, Crocetta F, Deidun A, Despalattini M, et al. New Mediterranean Biodiversity Records (July 2018). 2018; 19(2):398–415. https://doi.org/10.12681/mmns.18099

114. Stern N, Gouws G, Golani D, Goren M, Gon O. Champsodonta (Pisces: Trachinoides) in the Eastern Mediterranean: how many species are there? Journal of Natural History. 2019; 53(47–48):2869–81. https://doi.org/10.1080/00222933.2020.1758820

115. Dalyan C, Yemimken E, Eryilmaz L. A new record of gaper (*Champsodon capensis* Regan, 1908) in the Mediterranean Sea. J Appl Ichthyol. 2012; 28(5):834–5. https://doi.org/10.1111/j.1439-0426.2012.02019.x

116. Gökşenlu M, Özvarol Y. Additional records of *Champsodon vorax* and *Champsodon capensis* (Actinopterygii: Perciformes: Champsodontidae) from the eastern Mediterranean Sea. Acta Ichthyol Piscat. 2013; 43(1):79. https://doi.org/10.3750/AIP2013.43.1.12

117. Uysal İ, Turan C. Impacts and risk of venomous and sting marine alien species in Turkish marine waters. Biharean Biologist. 2020; 14(1):41–8.

118. Turan C, Gürlek M, Bağusta N, Uyan A, Doğu SA, Karan S. A checklist of the non-indigenous fishes in Turkish marine waters. Natural and Engineering Sciences. 2018; 3(3):333–58.

119. Saber H, Wafa F-S, Asma H, Malika BH. Long term characterization of *Trichodesmium erythraeum* blooms in Gabès Gulf (Tunisia). Continental Shelf Research. 2016; 124:95–103. https://doi.org/10.1016/j.csr.2016.05.007

120. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

121. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

122. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

123. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

124. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

125. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

126. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.

127. Acik S. Alien Sipuncula species in the Mediterranean Sea. J Mar Biol Assoc Uk. 2018; 98(1):33–9.
133. Kideys AE. The comb jelly Mnemiopsis leidyi in the Black Sea. Invasive Aquatic Species of Europe Distribution, Impacts and Management: Springer; 2002. p. 56–61. https://doi.org/10.1126/science.1073002 PMID: 12202806

134. Bariche M, Bilecenoglu M, Azzurro E. Confirmed presence of the Red Sea goatfish Parupeneus forsskali (Fourmanoir & Guézé, 1976) in the Mediterranean Sea. Bioinvasions Rec. 2013; 2(2):173–5. https://doi.org/10.3391/bir.2013.2.2.15

135. Sonin O, Salameh P, Edelist D, Golani D. First record of the Red Sea goatfish, Parupeneus forsskali (Perciformes: Mullidae) from the Mediterranean coast of Israel. Marine Biodiversity Records. 2013; 6: e105. Epub 2013/09/04. https://doi.org/10.1017/S1755267213000791

136. Yokes B, Galil BS. The first record of the needle-spined urchin Diadema setosum (Leske, 1778)(Echinodermata: Diadematidae) from the Mediterranean Sea. Aquatic Invasions. 2006; 1(3):188–90. https://doi.org/10.3391/ai.2006.1.3.15

137. Galili B. Poisonous and venomous: marine alien species in the Mediterranean Sea and human health. In: Mazza G, E T, editors. Invasive species and human health. 10. U.K.: CABI International; 2018. p. 1–15.

138. Gweta S, Spanier E, Bentur Y. Venomous fish injuries along the Israeli Mediterranean coast: scope and characterization. The Israel Medical Association Journal. 2008; 10(1):783. PMID: 19070287

139. Ünal V, Gönçüoğlu Bodur H. The socio-economic impacts of the silver-cheeked toadfish on small-scale fishers: A comparative study from the Turkish coast. Su Ürünleri Dergisi. 2017; 34(2):119–27.

140. Sümen SG, Bilecenoglu M. Traumatic finger amputation caused by Lagocephalus sceleratus (Gmelin, 1789) bite. Journal of the Black Sea/Mediterranean Environment. 2019; 25(3):333–8.

141. GDoNCNP. National biodiversity action plan 2018–2028. General Directorate of Nature Conservation and National Parks. Ankara: Republic of Turkey Ministry of Agriculture and Forestry; 2019. 118 p.

142. De Poorter M. International legal instruments and frameworks for invasive species. In: Clout MN, PA W, editors. Invasive species management: a handbook of principles and techniques New York: Oxford University Press; 2009. p. 108–40. https://doi.org/10.1111/j.1399-5448.2009.00612.x PMID: 19930225

143. Meinesz A, Belsher T, Thibaut T, Antolic B, Mustapha KB, Boudouresque C-F, et al. The Introduced green alga Caulerpa taxifolia continues to spread in the Mediterranean. Biological Invasions. 2001; 3(2):201–10. https://doi.org/10.1023/A:1014549500678

144. Lehtiniemi M, Ojaveer H, David M, Galil B, Gollasch S, McKenzie C, et al. Dose of truth—Monitoring marine non-indigenous species to serve legislative requirements. Marine Policy. 2015; 54:26–35. https://doi.org/10.1016/j.marpol.2014.12.015

145. IMO. International convention for the control and management of ships' ballast water and sediments: International Maritime Organization, London; 2004.

146. Çinar ME, Katagan T, Öztürk B, Egemen Ö, Ergen Z, Kocatas A, et al. Temporal changes of soft-bottom zoobenthic communities in and around Alsancak Harbor (Izmir Bay, Aegean Sea), with special attention to the autecology of exotic species. Marine Ecology. 2006; 27(3):229–46. https://doi.org/10.1111/j.1439-0485.2006.00102.x

147. Ergen Z, Çinar ME, Dagli E, Kurt G. Seasonal dynamics of soft-bottom polychaetes in Izmir Bay (Aegean Sea, eastern Mediterranean). Scientia Marina. 2006; 70(S3):197–207. https://doi.org/10.3989/scimar.2006.70s3197

148. Biton E. Possible implications of sea level changes for species migration through the Suez Canal. Scientific Reports. 2020; 10(1):21195. https://doi.org/10.1038/s41598-020-78313-2 PMID: 33273688

149. Spanier E, Galil BS. Lessepsian migration: a continuous biogeographical process. Endeavour. 1991; 15(3):102–6.

150. Hiddink JG, Ben Rais Lasram F, Castrill J, Davies AJ. Keeping pace with climate change: what can we learn from the spread of Lessepsian migrants? Global Change Biology. 2012; 18(7):2161–72. https://doi.org/10.1111/j.1365-2486.2012.02698.x