

CORRECTED PROOF

Data Paper

Unpublished Mediterranean and Black Sea records of marine alien, cryptogenic, and neofaunal species

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Citation: Ragkousis M et al. (2023) Unpublished Mediterranean and Black Sea records of marine alien, cryptogenic, and nonnative species. *BioInvasions Records* 12 (in press)

Received: 6 August 2022

Accepted: 6 January 2023

Published: 13 February 2023

Thematic editor: April Blakeslee

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Abstract

To enrich spatio-temporal information on the distribution of alien, cryptogenic, and nonnative species in the Mediterranean and the Black Sea, a collective effort by 173 marine scientists was made to provide unpublished records and make them open access to the scientific community. Through this effort, we collected and harmonized a dataset of 12,649 records. It includes 247 taxa, of which 217 are Animalia, 25 Plantae and 5 Chromista, from 23 countries surrounding the Mediterranean and the Black Sea. Chordata was the most abundant taxonomic group, followed by Arthropoda, Mollusca, and Annelida. In terms of species records, *Siganus luridus*, *Siganus rivulatus*, *Saurida lessepsianus*, *Pterois miles*, *Upeneus moluccensis*, *Charybdis (Archias) longicollis*, and *Caulerpa cylindracea* were the most numerous. The temporal distribution of the records ranges from 1973 to 2022, with 44% of the records in 2020–2021. *Lethrinus borbonicus* is reported for the first time in the Mediterranean Sea, while *Pomatoschistus quagga*, *Caulerpa cylindracea*, *Grateloupia turuturu*, and *Misophria pallida* are first records for the Black Sea; *Kapraunia schneideri* is recorded for the second time in the Mediterranean and for the first time in Israel; *Prionospio depauperata* and *Pseudonereis anomala* are reported for the first time from the Sea of Marmara. Many first country records are also included, namely: *Amathia verticillata* (Montenegro), *Ampithoe valida* (Italy), *Antithamnion amphigeneum* (Greece), *Clavelina oblonga* (Tunisia and Slovenia), *Dendostrea cf. folium* (Syria), *Epinephelus fasciatus* (Tunisia), *Ganonema farinosum* (Montenegro), *Macrorhynchia philippina* (Tunisia), *Marenzelleria neglecta* (Romania), *Paratapes textilis* (Tunisia), and *Botrylloides diegensis* (Tunisia).

Key words: non-native species, non-indigenous, distribution, invasive alien species, geo-referenced records, Mediterranean Sea, Black Sea

Introduction

Biological invasions have been a major focus of marine scientists and managers in the Mediterranean and Black Seas because of their severe impacts on marine biodiversity and ecosystem services (Micheli et al. 2013; Katsanevakis et al. 2014a, b; Azzurro et al. 2019; Tsirintanis et al. 2022). Furthermore, an increasing number of neontive species (i.e., range-expanding species that track human-induced environmental change; *sensu* Essl et al. 2019) have invaded the Mediterranean Sea through the Gibraltar Strait or the Black Sea through the Dardanelles Strait and the Sea of Marmara (e.g., Azzurro et al. 2022). Facilitated by climate change, alien and neontive species have contributed to great shifts in native ecosystems (Katsanevakis et al. 2018; Albano et al. 2021; Steger et al. 2021), the gradual tropicalization of the Mediterranean Sea (Bianchi and Morri 2003; Por 2009; Bianchi et al. 2018; Peleg et al. 2020), and mediterraneanization of the Black Sea (Kideys et al. 2000; Boltachev and Karpova 2014; Eyuboglu 2022). The latest reviews report a 40% increase in the established alien species in the Mediterranean Sea since 2010 and a steady increase in the Black Sea over the last five decades (Băncilă et al. 2022; Zenetos et al. 2022). Thus, the need arises for an improved theoretical and practical understanding of range shifts and biological invasion dynamics through space and time, the mechanisms of related impacts, and the functional role of alien and neontive species as drivers of change in the Mediterranean and Black Seas. This will contribute to effective regional conservation planning (Mačić et al. 2018) and prioritizing and implementing effective mitigation actions (Giakoumi et al. 2019), aiming to protect biodiversity and safeguard marine ecosystem services.

Although appropriate spatio-temporal data and information on the ecological characteristics of species are a prerequisite for effective management, they are often deficient in the Mediterranean and Black Seas (Levin et al. 2014). Hence, updated geo-referenced alien species records are valuable for assessing new species invasion progress and temporal dynamics (Katsanevakis et al. 2020a). Alien species records are often published when considered “first records” within a geographical region but rarely when a species is observed within its already documented invasion range. Consequently, spatio-temporal data of great value to researchers and managers remain unpublished and scattered in various repositories or personal files. Such information becomes even more valuable considering that the Mediterranean is warming at exceptionally high rates in comparison to the global ocean (Schroeder et al. 2016; Cramer et al. 2018; Pisano et al. 2020), whereas native species are becoming locally extinct (Rilov 2016; Albano et al. 2021) and may suffer high mortalities due to elevated temperatures and marine heatwaves (Garrabou et al. 2022). Consequently, even more suitable conditions are created for species of warm-water affinity to invade and replace native fauna (Bianchi et al. 2019).

A recent collective effort to compile such spatio-temporal information was made by Katsanevakis et al. (2020a). In that effort, 126 marine scientists from 16 countries contributed 5376 records of 239 alien and cryptogenic taxa from the Mediterranean, including one Mediterranean first record and nine first country records. Following that effort and expanding the geographical scope to cover the Black Sea, an invitation to submit unpublished alien, cryptogenic, and neonative species records was sent to marine scientists from all Mediterranean and Black Sea countries. This effort aimed to compile a second large open-access collective dataset, complementing existing information on alien and cryptogenic species in the region.

Dataset compilation

Overall, 173 scientists from 23 countries submitted their data, compiling a dataset of 12,649 records (see Supplementary material Table S1). Each Excel sheet line represents a specific record in space and time with relevant information. The required fields for each record were species name, species status, latitude, longitude, country, year, the observer of the record, the type of observation, and how it had been documented. “Status” refers to biogeographic status and was based on Zenetos et al. (2022) for Mediterranean records, Băncilă et al. (2022) for Black Sea records, and species-specific literature for debatable cases. “Status” took four possible values: “Alien” (*sensu* Essl et al. 2018), “Neonative” (*sensu* Essl et al. 2019), “Cryptogenic” (i.e., of uncertain biogeographic status; Carlton 1996; Essl et al. 2018) and “Data deficient” (for taxa for which an assessment of biogeographic status is unfeasible because of the lack of data; Essl et al. 2018). The “Observer” column has the name of the marine scientist(s) who identified the species. Records that a citizen-scientist had shared through an online platform like “Is it Alien to you? Share it!!!” (Giovos et al. 2019), personal communication, or a questionnaire are listed within brackets in the same column or within the “Comments” column. Only records adequately verified by scientists have been included; citizen science records that were not verified by marine experts were excluded.

“Type of observation” refers to the identification process for each record. Observations can be visual with or without photographic evidence (e.g., during SCUBA surveys or photo/video taken by a citizen), collected specimens by scientists, or even, for some fish species with no identification difficulties, answers to questionnaires by fishers.

Moreover, additional optional fields were available to include further information, exact or approximate date, depth of observation/collection, habitat, number of individuals observed or per cent substratum cover, and additional comments.

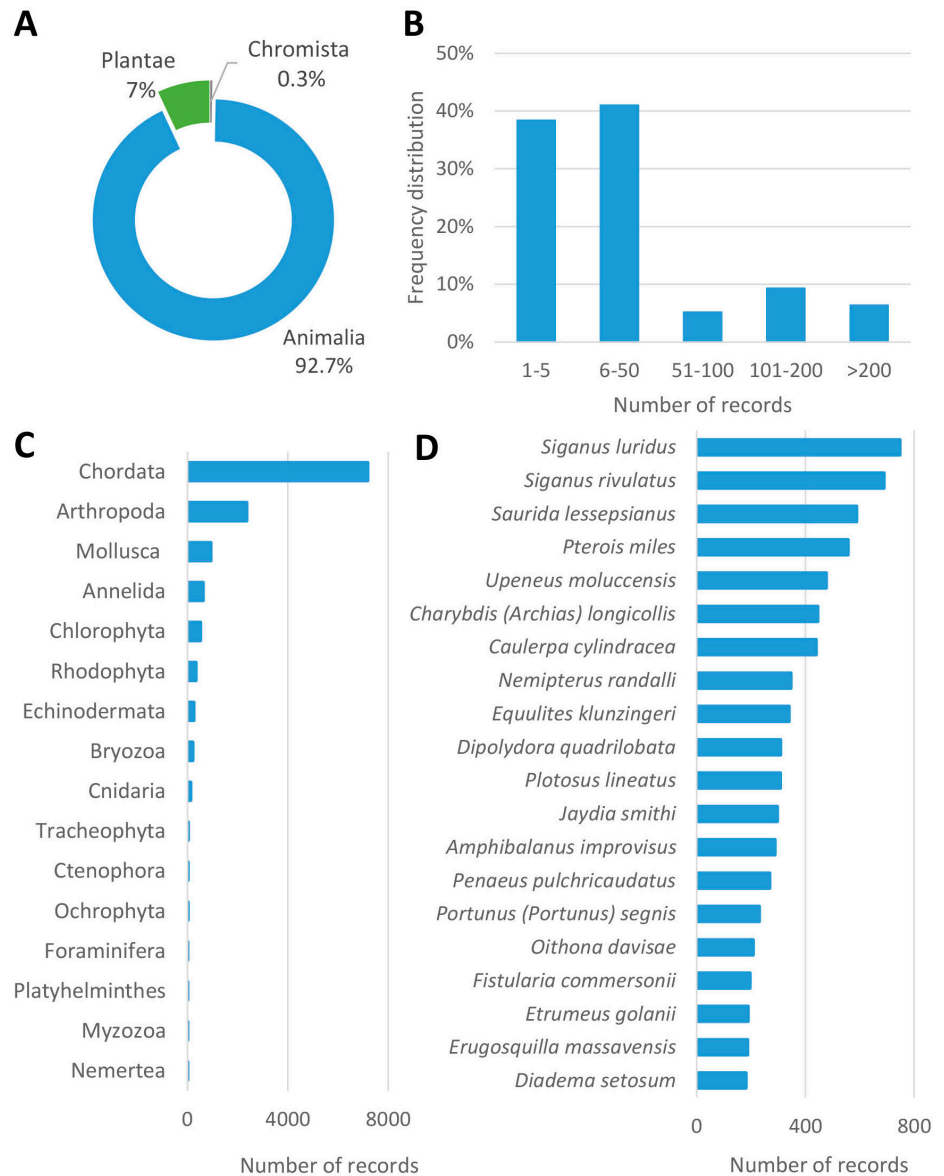


Figure 1. Taxonomic coverage of the dataset: (A) distribution pool by Kingdom; (B) frequency distribution of the number of records per species; (C) records by Phylum; (D) records by species (for the twenty most frequently observed species).

Taxonomic coverage

The compiled dataset included 247 taxa, of which 217 (88.38%) were Animalia, 25 (9.54%) Plantae, and 5 (2.08%) Chromista. Alien taxa were the majority (198); 31 species were classified as cryptogenic, 17 as neonative, and one as data deficient. Most records belonged to Animalia (92.7%), followed by Plantae (7%), and Chromista (0.3%) (Figure 1A). Most taxa (41%) were recorded between 6 and 50 times, while 37.3% less than six times (Figure 1B). In terms of Phyla, Chordata had the most records (7,180), followed by Arthropoda (2,359), Mollusca (925), and Annelida (621) (Figure 1C). Ninety per cent of the taxa were reported from 5 countries (Israel, Greece, Romania, Cyprus, and Italy). The five species with the highest number of records were all Osteichthyes, namely *Siganus luridus*

(Rüppell, 1829) (748), *Siganus rivulatus* Forsskål & Niebuhr, 1775 (689), *Saurida lessepsianus* Russell, Golani & Tikochinski, 2015 (589), *Pterois miles* (Bennett, 1828) (557), and *Upeneus moluccensis* (Bleeker, 1855) (477) (Figure 1D). Identification was based on collected specimens for 61% of the records in the dataset, only visually for 29.1% (either *in situ* or through photos/video), and through questionnaires to fishers for 9.8%.

Spatial and temporal coverage

The temporal coverage of observations extended from 1973 to June 2022. Records between 2014 and 2021 constituted 95.2% of the dataset, with most from 2020 (3,026), followed by 2021 (2,520) and 2014 (1,410) (Figure 2A). Regarding spatial coverage, records came from 23 countries, with 11,119 records from the Mediterranean and 1,530 from the Black Sea (the latter also includes the Sea of Marmara and the Istanbul Strait). The highest number of records were reported from Israel (5,304), Greece (2,900), Romania (1,365), Cyprus (744), and Italy (727) (Figure 2B). The species reported in most countries were *Callinectes sapidus* Rathbun, 1896 (11), *Caulerpa cylindracea* Sonder, 1845 (10), *Brachidontes pharaonis* (P. Fischer, 1870) (9), *Siganus luridus* (9), and *Pinctada radiata* (Leach, 1814) (9) (Figure 2C).

The records were unevenly distributed in the study area, as their spatial distribution is not only driven by the actual distribution patterns of the targeted taxa but is also influenced by the spatial variability of sampling effort and methodology and the uneven distribution of participating experts. A high concentration of records in the dataset is observed along the coast of Israel, in the South Aegean Sea and Cyprus, along the Romanian coast, but also, to a lesser extent, in Malta, Slovenia, and the Venice lagoon (Italy). Conversely, records were scarce along the Mediterranean coast of France, North Africa (except Tunisia), and the Black Sea coastlines of Turkey and Russia (Figure 3).

Remarkable new records of alien species

Among the records in the dataset, 20 are of particular importance. Most notably, the fish *Lethrinus borbonicus* Valenciennes, 1830 is reported for the first time in the Mediterranean (Tunisia), and the fish *Pomatoschistus quagga* (Heckel, 1837), the macroalgae *Caulerpa cylindracea* Sonder and *Grateloupia turuturu* Yamada, and the copepod *Misophria pallida* Boeck, 1865 are reported for the first time from the Black Sea (Crimea; Turkey; Romania). In addition, the red alga *Kapraunia schneideri* (Stuercke & Freshwater) Savoie & G.W. Saunders is reported for the first time in the Levant Sea (Israel; second time in the Mediterranean Sea). The polychaetes *Pseudonereis anomala* Gravier, 1899 and *Prionospio depauperata* Imajima, 1990 are reported for the first time in the Sea of Marmara (Turkey). Moreover, 12 first country records are included in the dataset: *Ampithoe valida* S.I.

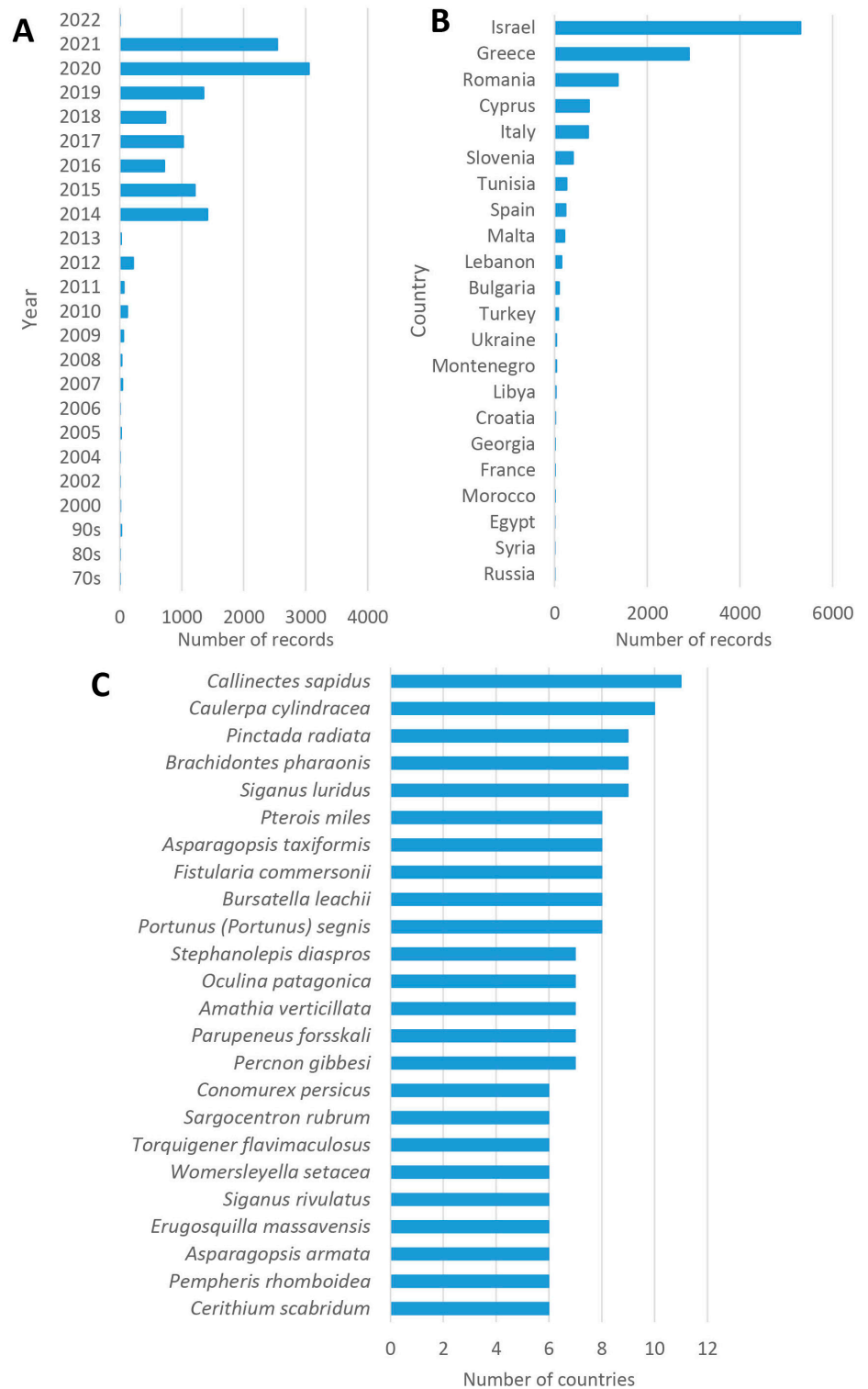


Figure 2. Spatio-temporal coverage of the dataset: (A) temporal distribution of records; (B) records per country; (C) country-coverage of species (for species recorded in more than 5 countries).

Smith, 1873 (Italy), *Amathia verticillata* (delle Chiaje, 1822) (Montenegro), *Antithamnion amphigeneum* A. Millar (Greece), *Clavelina oblonga* Herdman, 1880 (Slovenia and Tunisia), *Epinephelus fasciatus* (Forsskål, 1775) (Tunisia; third record in the Mediterranean Sea), *Dendostrea cf. folium* (Linnaeus, 1758) (Syria), *Ganonema farinosum* (J.V.Lamouroux) K.-C.Fan & Y.-C.Wang

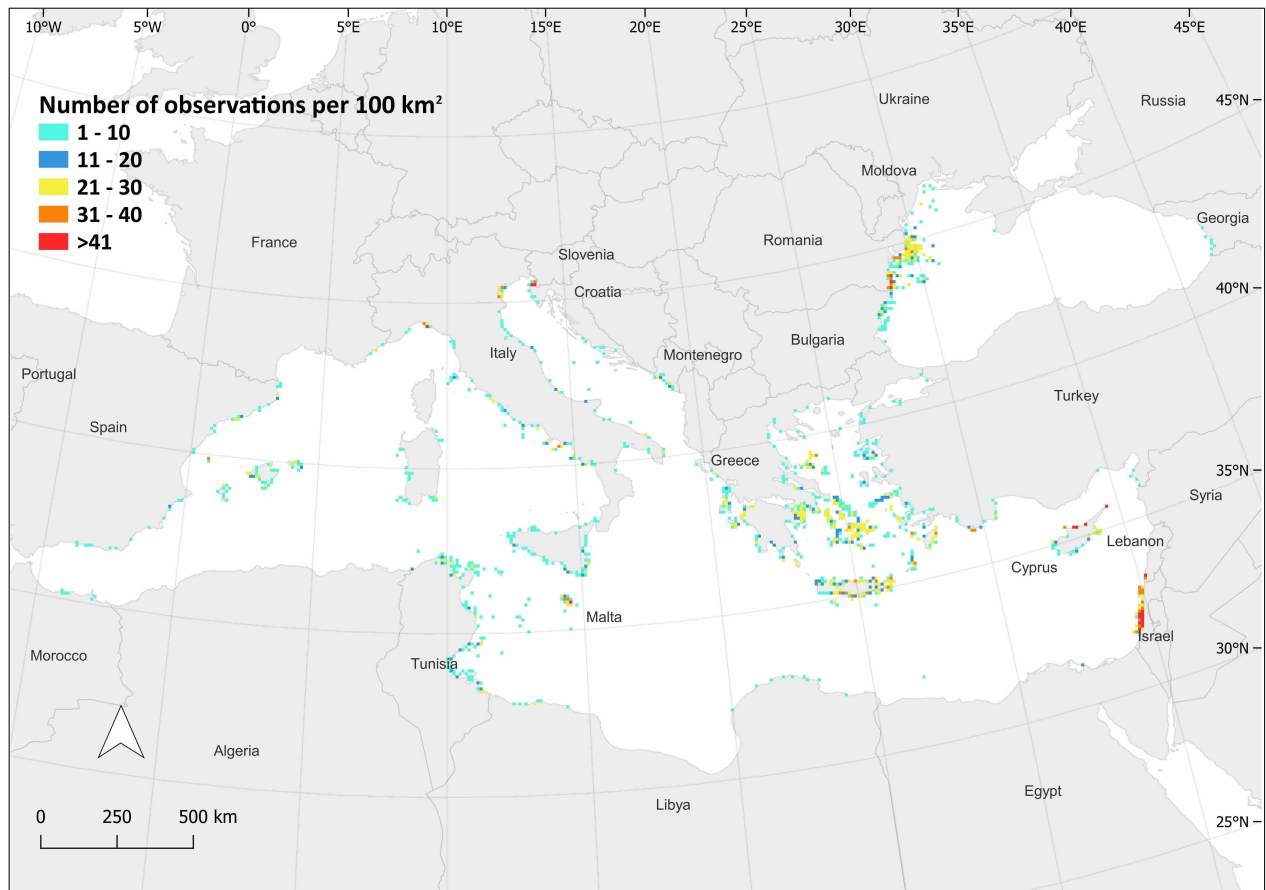


Figure 3. Number of alien, cryptogenic and neontative records per 10 km × 10 km grid cell, included in the dataset.

(Montenegro), *Marenzelleria neglecta* Sikorski & Bick, 2004 (Romania), *Macrorhynchia philippina* Kirchenpauer, 1872 (Tunisia), *Paratapes textilis* (Gmelin, 1791), and *Botrylloides diegensis* Ritter & Forsyth, 1917 (Tunisia).

The snubnose emperor *Lethrinus borbonicus* is the first representative of its genus in the Mediterranean Sea (Golani et al. 2021). It originates from the Western Indian Ocean, including the Red Sea and Arabian (Persian) Gulf to Reunion, and primarily occurs in sandy areas near reefs at depths of around 40 m (Carpenter and Allen 1989). The herein-reported specimen (Figure 4A) was captured on 20 March 2020 near the Marine Protected Area (MPA) of Zembra Island (eastern Tunisia) (37.11883°N; 10.7755°E) by a local fisher using gillnets at 75 m depth on a sandy bottom. It measured 203 mm in total length and weighed 122.6 g. The integrative taxonomic approach carried out on the sample confirmed the putative morphological identification. In particular, a 611 base pairs fragment of the *cytochrome c oxidase subunit I* (COX1) gene was amplified (GenBank accession number: OL441769), yielding a > 99% similarity with sequences of *L. borbonicus* from the Gulf of Suez (accession number: LC543919–LC543921), but also a 98–99% overlap with samples attributed to the congeneric species *L. lentjan* and *L. mahsena*. However, the inner surface of the pectoral fin base of the Zembra's specimen was covered with scales, thus excluding *L. lentjan*, and the specimen was characterized by 5½ longitudinal



Figure 4. Remarkable new records included in the dataset: (A) *Lethrinus borbonicus*, a first record in the Mediterranean Sea, observed in Tunisia, recorded by Jamila Ben Souissi; (B) first record of *Pomatoschistus quagga* in the Black Sea, recorded by Evgeniia Karpova and Elena Slynko.

scale rows between the lateral line and the base of middle dorsal spines, thus excluding *L. mahsena* (that has $4\frac{1}{2}$) (Carpenter and Allen 1989). Shipping is a potential pathway of introduction of this species around the Zembra MPA.

The quagga goby *Pomatoschistus quagga* is a small, benthic goby, often associated with seagrasses in the coastal zone of the northern and western parts of the Mediterranean Sea, including the Adriatic and Aegean Seas (Kovačić 2003). Among individuals of the genus *Pomatoschistus* caught with a hand net in June 2018 in the bay of Sevastopol in the Black Sea ($44.574698^{\circ}\text{N}$; $33.404630^{\circ}\text{E}$), and after fixing it in 96% ethanol, one quagga goby was identified through an integrative taxonomic approach (Figure 4B). In particular, a 524 base pairs fragment of the 16S ribosomal ribonucleic acid (16S rRNA) was amplified (GenBank accession number: MK457224), yielding > 97% similarity with three congeneric species, namely *P. bathi*, *P. minutus*, and *P. quagga*. However, its morphological features clearly pointed to *P. quagga*. In fact, it differed significantly from *P. minutus* in the number of scales of the lateral rows (32 *versus* more than 55) and it was characterized by the infraorbital row b that did not extend anteriorly below the infraorbital row a (*versus* *P. bathi* that is characterized by the infraorbital row b ending anteriorly under the infraorbital row a) (Kovačić 2008). This sighting constitutes the first record of *P. quagga* in the Black Sea. The preferred habitat of *Pomatoschistus* species, and specifically their epibenthic shallow-water lifestyle in open areas with soft substrates, implies that these

fish rarely enter new water bodies. Like *Pomatoschistus bathi* Miller, 1982, the most probable vector for penetration of the quagga goby into the Black Sea is the natural introduction of planktonic larvae by the surface current, following the changing climate and the mediterraneanization of the Black Sea (Boltachev et al. 2016). Thus, the species should be considered as neonative in the basin.

Misophria pallida is a hyperbenthic neritic copepod species in the Order Misophroidea (Family Misophriidae Brady, 1878), widely distributed in the NE Atlantic, Mediterranean, and Red Sea. Despite Misophrioids apparent wide occurrence, they are quite rare with Boxhall (1984) stating that “most copepod workers have probably never seen one”. Misophrioids present a peculiar combination of both podoplean body segmentation and gymnoplean-like characters, providing pieces of evidence for their ancestral evolution. Herein, we report the first record of *M. pallida* (Figure 5) in the Black Sea (44.75887°N; 30.11173°E) in six samples collected in June 2020 at depths of 50–55 m on mixed sediments (mud and shells). In total, 21 males, 12 females (five of which were ovigerous), and six juveniles were identified. This suggests that the species could develop large populations in Black Sea offshore deep habitats. We assume that the species entered the Black Sea only recently, possibly following an unusual climate-driven event that affected the subsurface circulation of the Mediterranean inflow into the Black Sea or through shipping. The recent first record of the hydrozoan *Podocorynoides minima* (Trinci, 1903) in the Black Sea, made in the summer of 2020, which could also have entered from the Mediterranean Sea (Muresan et al. 2021), supports our assumptions.

Two macroalgae reported from the Sea of Marmara, *Caulerpa cylindracea* and *Grateloupia turuturu*, are here first recorded from the Black Sea. Both species are included in the proposed inventory of alien marine species with reported moderate to high impacts on biodiversity and ecosystem services in the Mediterranean Sea (Tsirintanis et al. 2022). The green alga *C. cylindracea* ranks first among the ten worst invasive species in terms of reported negative impacts on biodiversity. It was first reported in the Mediterranean Sea from Tunisia in 1985 (Hamza et al. 1995). It is now widespread throughout the Mediterranean Sea, becoming one of the most invasive species of the basin (Verlaque et al. 2015; Katsanevakis et al. 2016; Zenetos et al. 2017; Morri et al. 2019), although its population dynamics are not yet fully understood (Piazzi et al. 2016). Çinar et al. (2021) have monitored the distribution of *C. cylindracea* along the Aegean coasts of Turkey since 1993 and noticed its considerable range expansion towards the northern Aegean Sea (Güreşen et al. 2015). The species was detected on 28 February 2020 in the Dardanelles Strait, Turkey (40.0464°N; 26.3463°E) on rocky substratum (Figure 6A). The rhodophyte *Grateloupia turuturu* was first detected in the Mediterranean Sea in southern France in 1982 (Riouall et al. 1985) and has spread across the Mediterranean basin (Verlaque et al. 2015). It reached

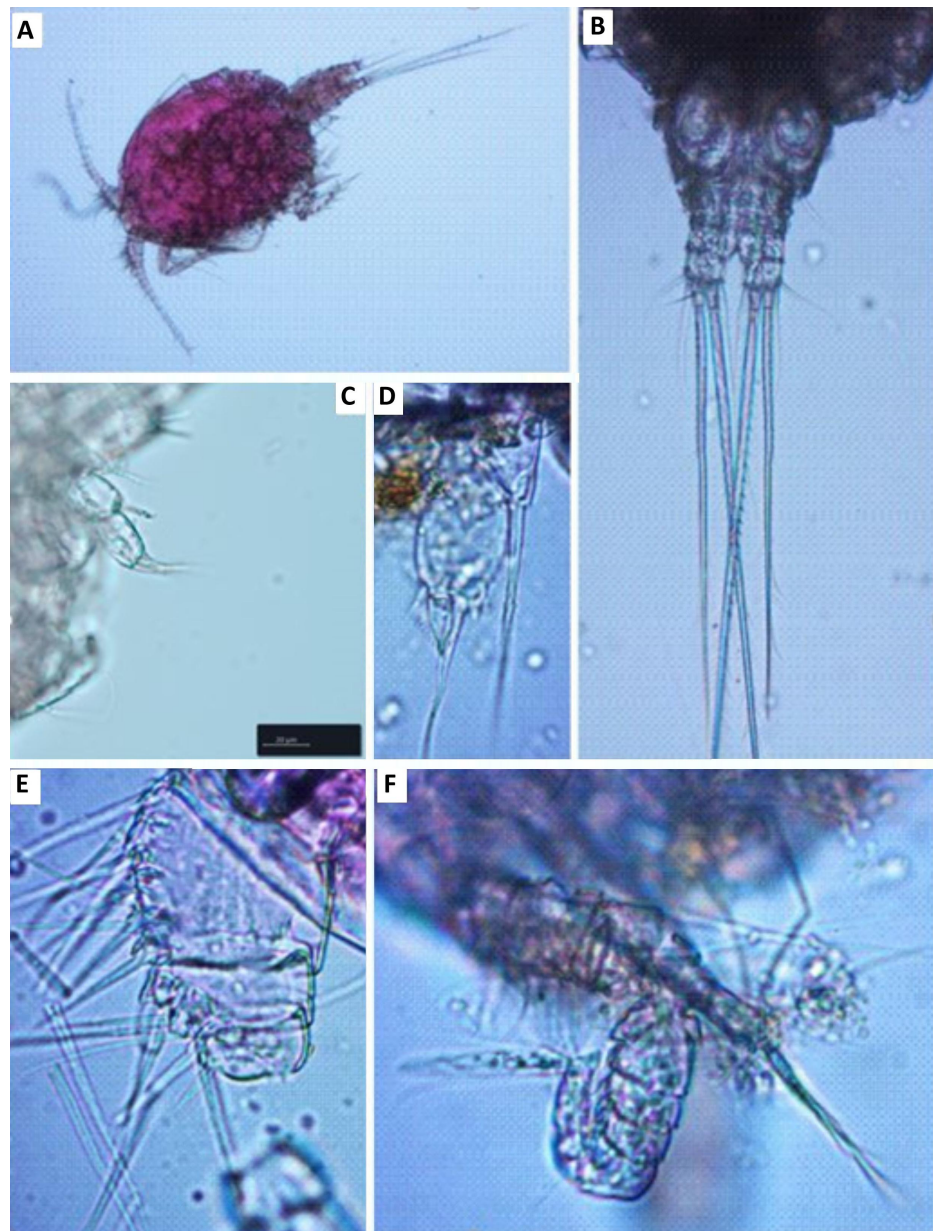


Figure 5. First record of *Misophria pallida* in the Black Sea, recorded by Muresan Mihaela: (A) *M. pallida* male; (B) male abdomen and furca; (C) male P5 and P6; (D) detail P5 (protopodal segment with outer basal seta and 2 setae on inner distal margin); (E) geniculate part of A1 male; (F) details of 13 segmented A1 male.

the Turkish coasts of the Aegean Sea in 2015 (Çinar et al. 2021). This red alga was often misidentified as *Grateloupia doryphora* (Montagne) M.Howe (Verlaque et al. 2015). *Grateloupia turuturu* was detected on 26 June 2021 in the Sea of Marmara (40.4008°N; 27.9145°E) on rocky substrata where it was abundant at 0–1 m depth (Figure 6B).

Kapraunia schneideri (previously *Polysiphonia schneideri*) (see Díaz-Tapia et al. 2013), is a marine red alga that has a mainly central-western Atlantic and Caribbean distribution (Guiry and Guiry 2019). Since its erection, this species was collected from the northwestern Atlantic in Connecticut and the central-eastern Atlantic in southwestern Spain (Stuercke and Freshwater 2010; Díaz-Tapia et al. 2013). The first reported introduction of this Atlantic

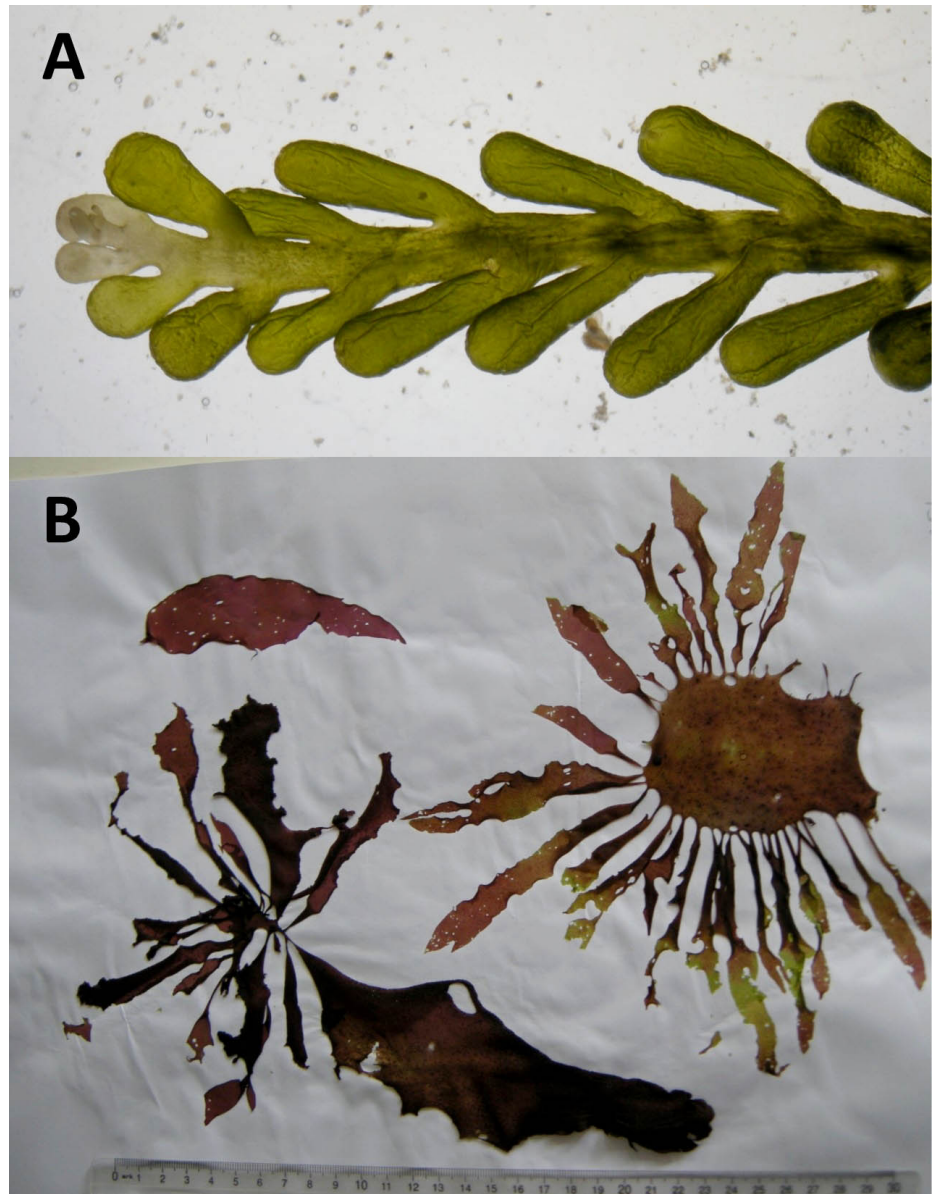


Figure 6. Remarkable new records included in the dataset: (A) *Caulerpa cylindracea*, a first record for the Black Sea reported by Ergün Taşkın; (B) *Grateloupia turuturu*, also a first record for the Black Sea reported by Ergün Taşkın.

native species from the Mediterranean was from the north Adriatic Sea, specifically the Venice Lagoon, in 2016 (Wolf et al. 2018). However, in February 2014, specimens were collected from wave breaker rocks inside the marina of the city of Ashkelon, located on the southern Levantine Mediterranean shore of Israel (31.68080°N; 34.55400°E). These sterile specimens were initially identified as *Polysiphonia denudata* (Dillwyn) Greville ex Harvey based on cross-sections of the thallus showing six pericentral cells surrounding each central siphon. Further study of the reproductive and vegetative morphology of some newly collected specimens from the same site indicated that the tetrasporangia of this species are not spirally arranged and that the basal portion of the axes is ecorticated. Other vegetative features that agree with the species description of *K. schneideri*

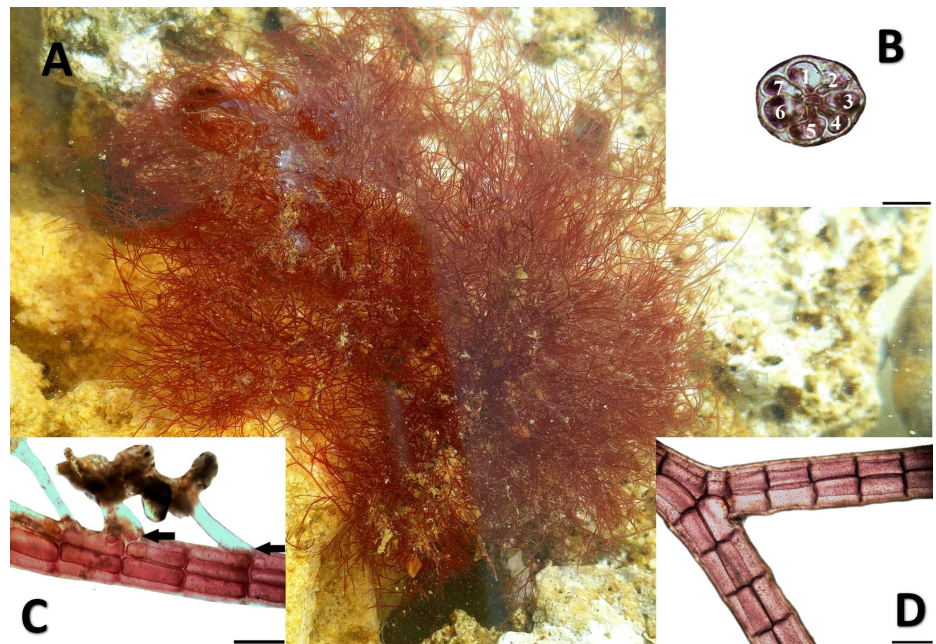


Figure 7. *Kapraunia schneideri*: (A) *in situ*; (B) Seven pericentral cells per segment of thallus; (C) Indicating rhizoids cut off from pericentral cells (arrows); (D) Segmented thallus; Sterile plant, scale bars 100 μm ; a first record in the Levantine Sea, Israel and second in the Mediterranean Sea, recorded by Razy Hoffman.

(Stuercke and Freshwater 2010; Díaz-Tapia et al. 2013) are: plants are up to 8 cm long, attached to rocks by rhizoids (Figure 7A) that grow from short, decumbent basal parts; rhizoids are cut off from pericentral cells (Figure 7C), and segments (Figure 7D) have six or seven (Figure 7B) pericentral cells. Molecular identification of specimens collected from the marina of Ashkelon in February 2020 (GenBank accession number: OP797406) confirmed the morphological identification. The fact that *K. schneideri* was found in harbours and marinas in the Venice Lagoon, in Barbate (Spain), and Ashkelon (Israel) (present work) points to vessels and recreational boats as the vectors of introduction of this species in the Mediterranean Sea.

Pseudonereis anomala is a nereidid species of Indo-Pacific origin, also found in the Red Sea. In the Mediterranean, it was first reported from the coast of Alexandria, Egypt, by Fauvel (1937) and has since expanded widely to become the most successful alien nereidid species in the Mediterranean Sea (Kurt et al. 2021). Ten *P. anomala* individuals were extracted from an assemblage dominated by *Mytilus galloprovincialis* Lamarck, 1819 and sampled just below the water surface on 21 December 2018, near the South entrance of the Istanbul Strait (41.02870°N; 28.98830°E). The morphological features of the specimens examined agreed with the original and subsequent descriptions of *P. anomala* (Figure 8A). This species is mainly characterized by homogomph falcigers in the notopodia, dorsal cirrus subterminally, a dorsal ligule foliose (twice longer than wide) and markedly longer than median ligule in posterior chaetigers, areas VI with cones only, and few paragnaths on areas VII-VIII (up to 20 paragnaths

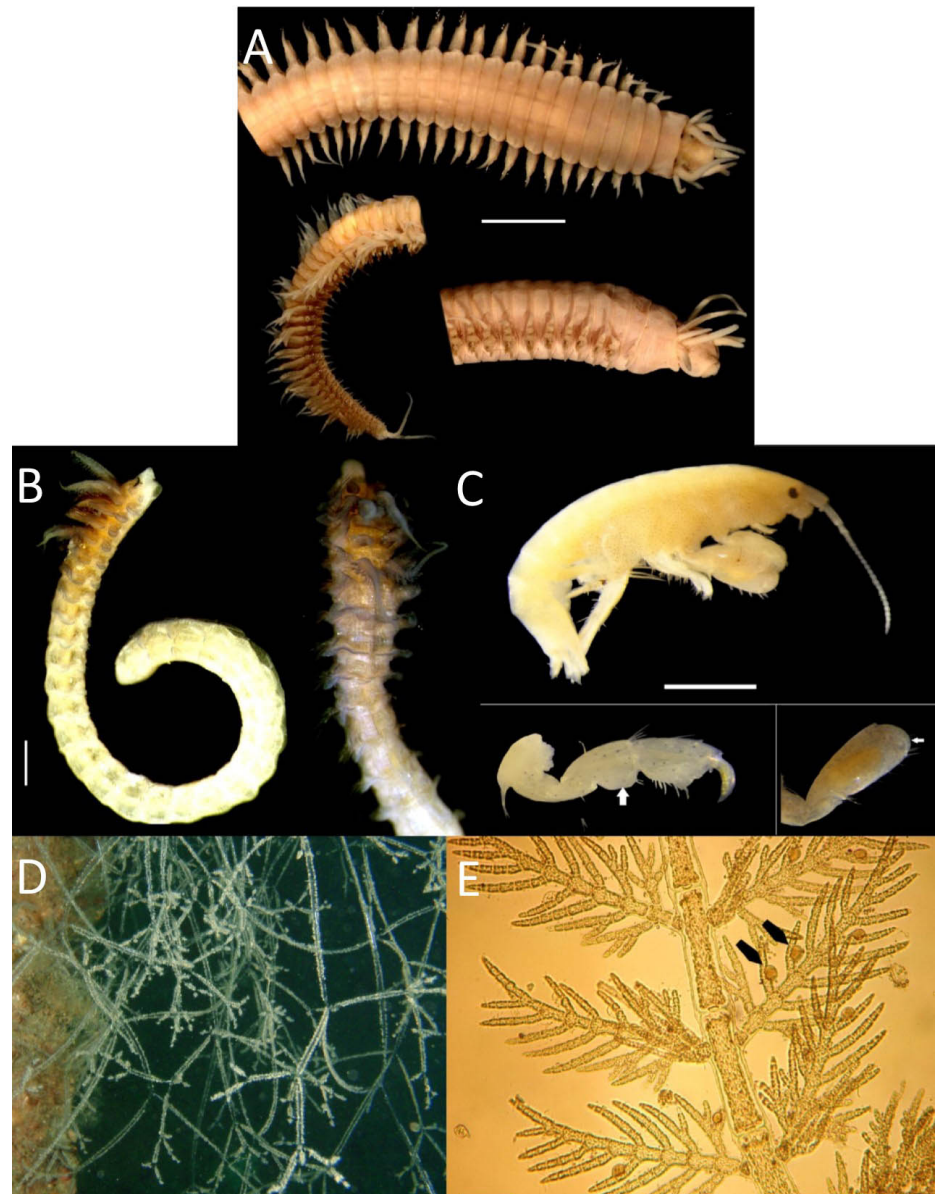


Figure 8. Remarkable new records included in the dataset: (A) *Pseudonereis anomala* and (B) *Prionospio depauperata*, first records in the Sea of Marmara by Ertan Dağlı; (C) *Ampithoe valida* from the Venice Lagoon, top: male specimen (scale bar: 1 cm), low left: gnathopod 1 (the arrow indicates carpal lobe), low right: gnathopod 2 (the arrow indicates the process stemming from the central part of the propodus palm), first record from Italy by Agnese Marchini and Renato Sconfietti; (D) *Amathia verticillata*, a first record for Montenegro by Slavica Petović; (E) *Antithamnion amphigeneum*, a first record from Greece by Konstantinos Tsiamis, whorl-branches (pinnae) with gland cells born adaxially (black arrows). Scale bar = 40 μ m.

in a single band). *Pseudonereis anomala* is a new species to the marine fauna of Marmara Sea and the Straits System (Bosphorus).

Prionospio depauperata was described from the coast of Japan by Imajima (1990). It was reported for the first time in the Mediterranean Sea in Izmir Bay (Dagli and Çinar 2009) and later found along the Levantine coast of Turkey (Çinar et al. 2014). On 13 December 2019, eight further specimens were collected near the south entrance of the Istanbul Strait (41.02130°N; 28.97630°E) at 15 meters depth, fixed and identified morphologically. The morphological features of the specimens examined agree with the original

and subsequent descriptions of *P. depauperata* (Figure 8B). This species is mainly characterized by pinnate branchiae on chaetigers 2 and 5 and apinnate branchiae on chaetigers 3 and 4, large posterior eyes, dorsal crests extending from chaetigers 7 to 16, and no dorsolateral skin folds. It is a new species to the marine fauna of the Marmara Sea and the Bosphorus Straits System.

Ampithoe valida Smith, 1873 (Figure 8C) is known from the Atlantic coast of North America (Pilgrim and Darling 2010). Faasse (2015) has reported this species in the western Mediterranean, from specimens collected in 2000 in Balaruc-les-Bains (Bassin de Thau), France. Here we report its presence in the northern Venice Lagoon (45.50550°N; 12.39050°E), accounting for the first record from Italy, based on two male individuals collected in June 2017 from the subtidal fouling community of a wooden pole. The European distribution of *A. valida* reflects the routes of introduction of Pacific oysters. The Ria de Aveiro (Cunha et al. 1999), Arcachon Bay (Gouilleux 2017), Berre Lagoon (Faasse 2015), as well as the Venice Lagoon (present work), are all brackish sites where Japanese oysters have been introduced for aquaculture, and which share several alien species of NW-Pacific origin, probably introduced along with imported shellfish stocks. The individuals collected present the diagnostic characters well described in Conlan and Bousfield (1982) and Gouilleux (2017), and especially the large posterior carpal lobe in gnathopod 1 and the transverse palm of male gnathopod 2, bearing a central process (Figure 8C). Previous records of the morphologically similar congener *Ampithoe ferox* (Chevreux, 1901) in Mediterranean aquaculture sites (e.g., Marchini et al. 2007) may be due to misidentifications of introduced populations of *A. valida*, and the first introduction event of this American amphipod could be backdated by several years.

Amathia verticillata is a bryozoan probably native to the Caribbean ecoregion (Galil and Gevili 2014) that uses its ability to produce vegetative fragments and shipping as its main pathway of introduction (as fouling) (Nascimento et al. 2021). First described from Italian waters (delle Chiaje, 1822) and long considered native of the Mediterranean Sea, *A. verticillata* is known from several localities in the basin (e.g., Galil and Gevili 2014). While surveying the Boka Kotorska Bay, Montenegro (42.431767°N; 18.691783°E) on the 1st of August 2016, extensive colonies of this cryptogenic bryozoan were observed and collected for identification (Figure 8D). This is the first record of *A. verticillata* in Montenegro.

Antithamnion amphigeneum is a minuscule filamentous red alga which is an alien in the Mediterranean Sea, originating from the Indo-Pacific region. The species was first reported for the Mediterranean Sea from Algeria in 1989, possibly introduced through shipping (Verlaque et al. 2015). Since then, it has also been recorded from Spain, Morocco, Monaco, France, Italy, and most recently from Montenegro (Mačić and Ballesteros 2016, and references therein). The species was found as an epiphyte on the

alien alga *Dictyota cyanoloma* Tronholm, De Clerck, A.Gómez-Garreta & Rull Lluç (Figure 8E), located in the upper sublittoral zone at a semi-exposed shore in March 2013, near the port of Argostoli (Kephallonia Island, Ionian Sea). This finding represents the first record of the species in Greece and the Ionian Sea and its easternmost distribution record in the Mediterranean Sea.

Clavelina oblonga is an ascidian originally described from Bermuda, whose native range is considered the tropical western Atlantic Ocean (Rocha et al. 2012). The species has a long invasion history, at least since 1929 in the Mediterranean, which has led to confusion regarding its biogeographical status (Carlton 2009). Here we report for the first time on the occurrence of *C. oblonga* in Slovenia (45.48778°N; 13.58532°E) and Tunisia (34.30650°N; 10.15590°E) (Figure 9A, B). The observations occurred on 3 July 2018 and 31 July 2019, respectively. In Slovenia, most specimens were found within a mussel farm site, while in Tunisia many colonies were observed on artificial structures within Skhira port. The observers reported colonial ascidians united by stolons, forming closed clusters; zooids had thorax and abdomen regions up to 2–3 cm long. The tunic was transparent without the white bands—like *Clavelina lepadiformis* (Müller, 1776)—around oral and atrial siphons, dorsal and ventral parts, and base of thorax, and only showed fine white dots. Branchial sac had 15–18 rows of stigmata. *Clavelina oblonga* is associated with bivalve mariculture, which is believed to be the original pathway of introduction into the Mediterranean Sea, later expanding its distribution naturally (Ordóñez et al. 2016).

The blacktip grouper *Epinephelus fasciatus*, one of the most common and widespread species of the genus in the tropical Indo-West Pacific (Heemstra and Randall 1993), was first recorded in the Mediterranean Sea in Syria in 2002 (Foulquie and Dupuy de la Grandrive 2003) and then once more in 2011 off the coast of Lebanon (Bariche and Heemstra 2012). Here we report the third occurrence of *E. fasciatus* in the Mediterranean Sea (Figure 9C), which constitutes the first record of this species from Tunisia. On 31 May 2020, a single individual of the blacktip grouper was caught along the Kelibia coast, northern Tunisia (36.8289°N; 11.1357°E). It was entangled in gillnets at a depth of 35 m over a sandy bottom covered by seagrasses. The specimen measured 201 mm in total length and weighed 102 g. The fresh colouration of the body was pale yellowish-red with orange-red bars, the margin of inter-spinous dorsal fin membranes black, and the dark reddish-brown dorsal part of the head and nape are characteristic features of the species. The present record in the vicinity of a port suggests that the introduction of the species in Tunisia was via maritime shipping.

Dendostrea cf. folium is a Lessepsian species belonging to the Ostreidae family, found on hard substrata in the infralittoral zone (Zenetos et al. 2011). This species was reported for the first time in the Mediterranean from Greece in 2010 as *Dendrostrea frons*, and is expanding its range

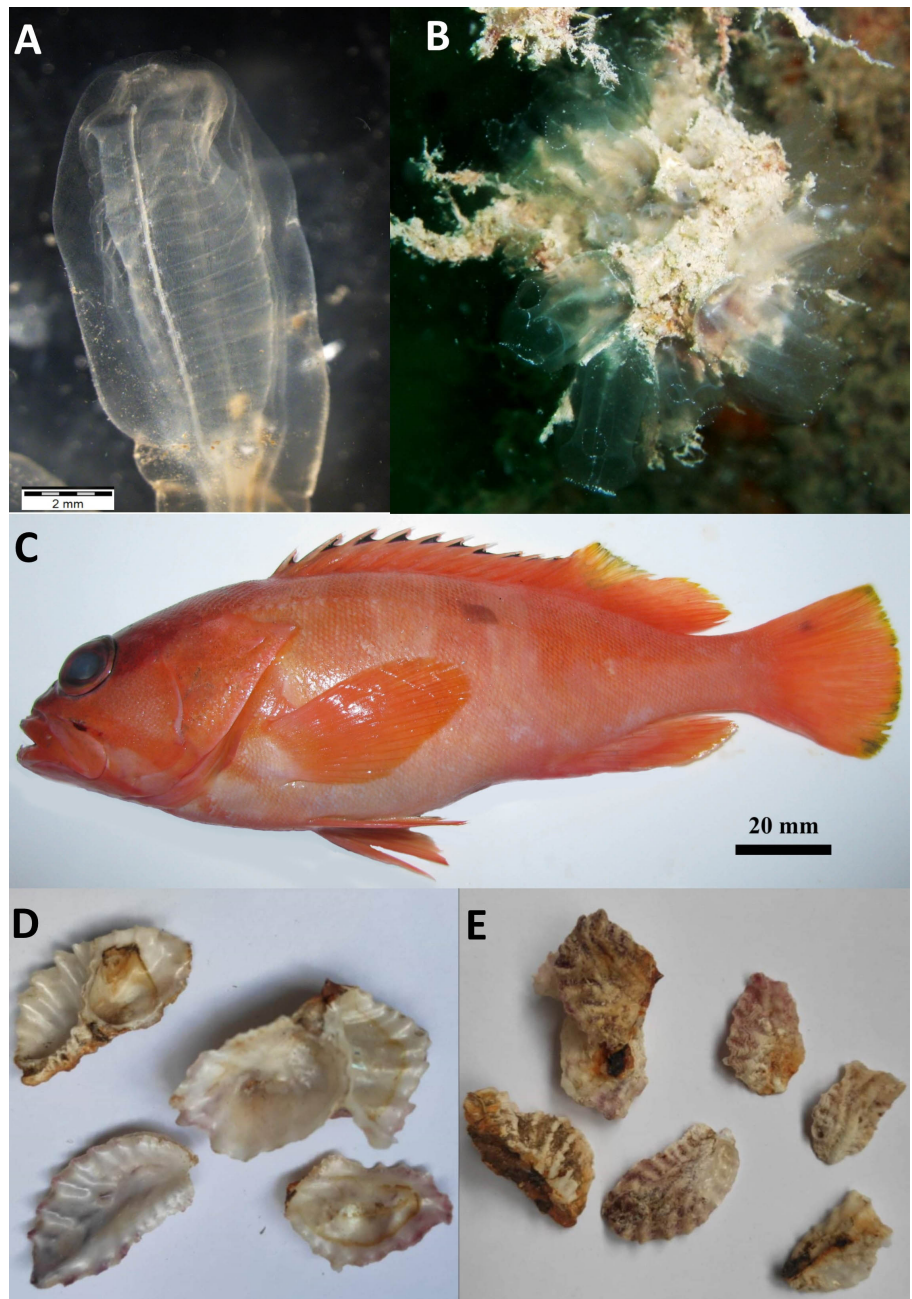


Figure 9. Remarkable new records included in the dataset: (A) *Clavelina oblonga*, a first record from Slovenia reported by Domen Trkov and Ana Fortič; (B) *Clavelina oblonga*, a first record from Tunisia reported by Alfonso Ramos; (C) *Epinephelus fasciatus*, a first record from Tunisia reported by Raouia Ghanem; (D and E) upper and lower valvae of *Dendostrea cf. folium* from Syria, a first record reported by Izdihar Ammar and Alaa Alo.

(Zenetos et al. 2011; Crocetta et al. 2013; Karachle et al. 2016; Ivkić et al. 2019). Based on molecular analysis and although it is a species that exhibits high morphological variability, it seems to be the only representative of its genus in the Mediterranean (Crocetta et al. 2015). Here we report the first record from Syria. Many samples were collected at 0.5 m depth, North of the Latakia port (35.567553°N; 35.739105°E) in April 2019 and near Al-bassit marina (35.865836°N; 35.866614°E) in August 2021, where they were attached to rock and fishing gear (Figure 9D, E). All samples are currently in the High Institute of Marine Research collection (Latakia).

The red alga *Ganonema farinosum* has a heteromorphic life history with alternation of erect gametophyte and filamentous tetrasporophytes. The gametophyte is erect and bushy, light purple to reddish brown, axes cylindrical, subdichotomously branched, moderately calcified, and up to 25 cm high (Lin et al. 2014; Verlaque et al. 2015). The species was described from the Red Sea (Suez) by Lamouroux (1816, as *Liagora farinosa*), and it is widespread from the Indo-Pacific through western Africa and the eastern Atlantic Ocean. It was recorded for the first time in the Mediterranean Sea from Alexandria (Egypt) in 1808 (Hamel, 1931, as *Liagora farinosa*) and later mainly in the eastern Mediterranean: Greece (1931), Israel (1964), Syria (1976), Lebanon (2000), Cyprus (2000), Turkey (1978), but also in south Italy (1969), south Spain (1987), Albania (2011), and Malta (Verlaque et al. 2015; Crocetta et al. 2021). Verlaque et al. (2015) suggested the introduction or the co-occurrence of introduced and native populations in the Mediterranean, given that the oldest Mediterranean record dates before the opening of the Suez Canal. Contrary to this, Cormaci et al. (2004) considered this species a Tethyan relict. Hence, the species is treated as cryptogenic due to its uncertain biogeographic status. *Ganonema farinosum* has not been previously reported from the Adriatic Sea except for the Strait of Otranto (Katsanevakis et al. 2011). We may presume that this species could be transported in the form of floating spores by water currents and ballast waters or as fouling of ship hulls, but the northward expansion of this thermophilic species could also be a consequence of climate change. In some tropical waters, *G. farinosum* is utilized for human consumption (Trono 2001), but in the Mediterranean, although well established, it has no importance to humans (Verlaque et al. 2015). Here we report on the first record of *G. farinosum* (Figure 10A) from Montenegro (42.09259°N; 19.07768°E), found in October 2018 in the port of Bar area, on an artificial hard substratum, at 7 m depth. This new record is the northernmost record of the species in the Adriatic.

The red gilled mud worm *Marenzelleria neglecta* is an oligohaline polychaete whose invasion history in the Baltic Sea received much attention at the turn of the last millennium (Leppäkoski and Olenin 2000; Zettler et al. 2002). First recorded (as *Marenzelleria viridis*) in the North Sea in 1983 (Essink and Kleef 1988), the species appeared in the Baltic Sea in 1985 (Bick and Burckhardt 1989). After only a dozen years, the red gilled mud worm expanded its distribution into almost the whole Baltic Sea. Though the native region of *M. neglecta* is not known with certainty, genetic data suggest that it most likely originates from the Atlantic coast of North America (Bastrop et al. 1998). In the Ponto-Caspian region, the species was reported for the first time in 2014 in the Don River delta and Taganrog Bay of the Sea of Azov and spread rapidly (Syomin et al. 2017; Mikhailova et al. 2021). The first specimens from Romanian waters that we report here (Figure 10B) were collected on 27 May 2021 from black detritic mud at 0.5 m

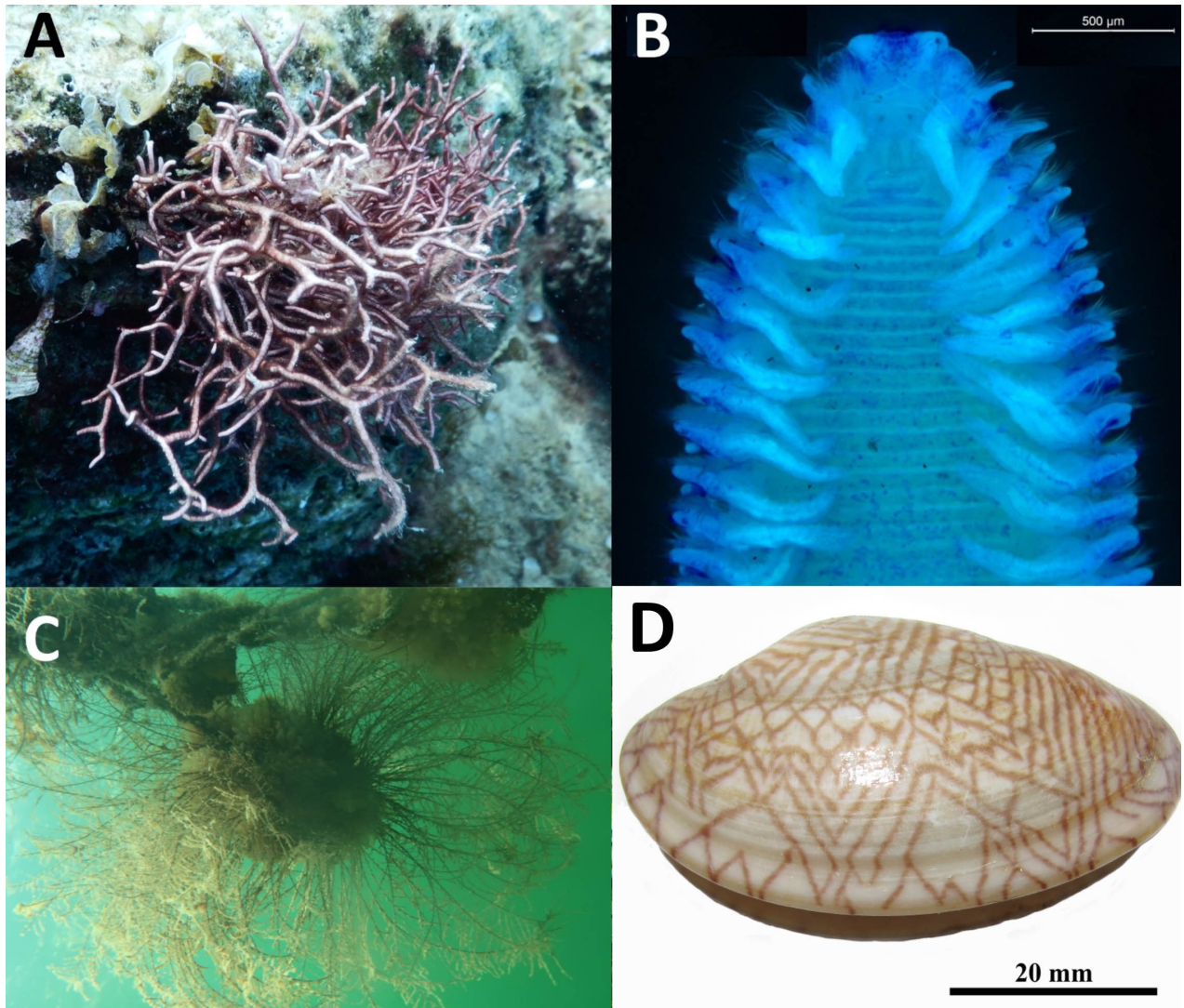


Figure 10. Remarkable new records included in the dataset: (A) *Ganonema farinosum*, a first record for Montenegro reported by Vesna Mačić; (B) *Marenzelleria neglecta*, a first record from Romania reported by Victor Surugiu; (C) *Macrorhynchia philippina*, a first record for Tunisia reported by Raouia Ghanem; (D) *Paratapes textilis*, a first country record from Tunisia reported by Wafa Rjiba.

depth in the upper reaches of the Mangalia Gulf (43.81180°N; 28.51840°E), at a salinity of 5.9 PSU. In the Sea of Azov, *M. neglecta* is already well established and locally has become a major component of the benthic fauna, reaching high densities (6823 ind. m⁻²) and large biomass (31.2 g m⁻²) (Syomin et al. 2017). The most probable vector of its introduction into the Sea of Azov and the Caspian Sea is by ship ballast water through the Volga-Baltic and Volga-Don canals (Syomin et al. 2017; Mikhailova et al. 2021). The secondary spread along the Black Sea shores is probably due to larval dispersal by the quasi-permanent anti-clockwise Main Rim Current. Therefore, the species is expected to occur soon on the Bulgarian Black Sea coast. On 26 May 2022, and while this work was ongoing, Teaca et al. (2022) published their study on “The First record of *M. neglecta* and the Spread of *Laonome xeprovala* in the Danube Delta–Black Sea Ecosystem”. The samples containing *M. neglecta* that we report on were collected less than two weeks prior to the records described in their work, and though far in terms

of distance, our results completely agree. Teaca et al. (2022) found *M. neglecta* in the northern part of the Romanian Black Sea coast, where it accounted for 36% of the total density of macrobenthos (50 to 1400 ind m⁻²). The fact that the species was found in high densities in the northern part of the Romanian coast (Teaca et al. 2021, 2022), while only one specimen was found in the south, indicates that the northern part offers much more suitable habitat conditions for *M. neglecta*.

The feathery stinging hydroid *Macrorhynchia philippina* is distributed in tropical and subtropical regions (Rees and Vervoort 1987) and is common in the Red Sea (Vervoort 1993). The species has been observed in the Mediterranean along the coast of Lebanon at 0–40 m depth (Bitar and Bitar-Kouli 1995; Zibrowius and Bitar 2003; Morri et al. 2009) and has since expanded northwards to the Turkish coast (Çinar et al. 2006). About twenty colonies were observed and photographed, for the first time, on southern Tunisian coasts at Bibane lagoon (33.260283°N; 11.236798°E) on a wreck at 2 m depth (Figure 10C). This species has probably been introduced via shipping.

Paratapes textilis was first recorded as *Tapes undulatus* in the Mediterranean in 1939 from Egypt (Moazzo 1939) and then from Palestine Authority in 1935 (Haas 1948). Subsequently, it was reported from Israel (1948), southern Turkey (Niederhöfer et al. 1991), Syria (Kucheruk and Basin 1999), and Cyprus (Zenetos et al. 2009). The first specimen from Tunisia (Figure 10D) was caught by trawling off Kelibia coasts in Tunisia (36.82341°N; 11.13739°E) at 50 m depth. The specimen was characterized by the absence of lateral teeth in the hinge, colour externally beige and pale yellow with a characteristic zig-zag pattern in brown, and internally white.

The colonial ascidian *Botrylloides diegensis* is native to the North Pacific but has already colonized several European areas, namely the English Channel, where it was well established in marinas of the United Kingdom, the Atlantic coast of France, and the Italian Adriatic (Viard et al. 2019). In October 2019, colonial ascidians of the genus *Botrylloides* Milne Edwards, 1841 were observed for the first time in the shallow waters of Bahiret el Bibane lagoon (33.22909°N; 11.172793°E) on a rocky substratum (Figure 11A). Subsequently, during surveys carried out at the same location in May 2020, similar colonies were observed on *Pinna nobilis* Linnaeus, 1758 shells and collected for identification. As morphological identification of botryllid taxa could be deceiving, and several alien species are now spreading in the Mediterranean basin (Rocha et al. 2019; Viard et al. 2019; Della Sala et al. 2022; Virgili et al. 2022), the specimen was identified through DNA barcoding. A 631 base pairs fragment of the *cytochrome c oxidase subunit I* (COX1) gene was amplified (GenBank accession number: OP802711), yielding a > 98% similarity with sequences of both *B. diegensis* and *B. leachii*. However, the latter species was excluded based on the recent work of Viard et al. (2019), thus the reported ascidians are the first records of *B. diegensis* found in Tunisia.

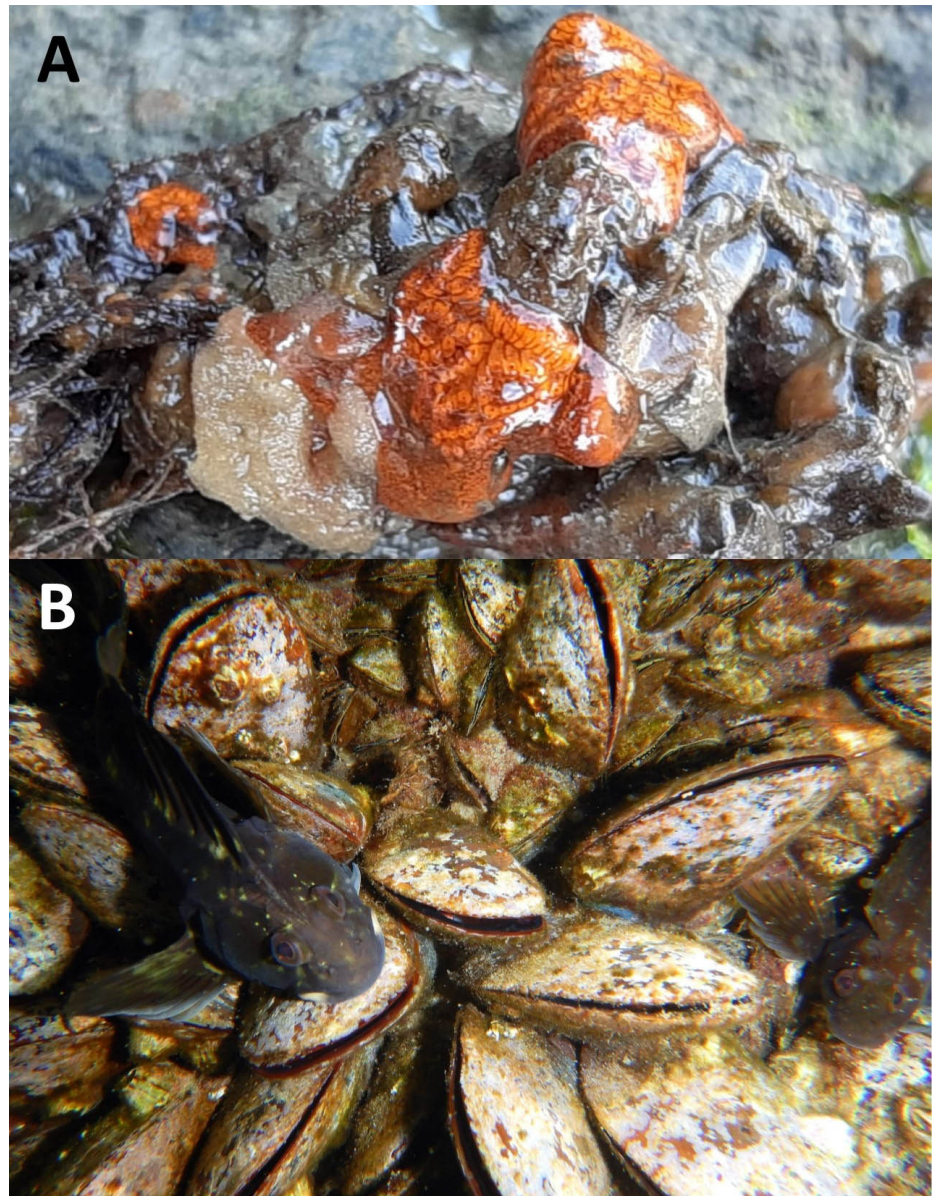


Figure 11. Remarkable new records included in the dataset: (A) *Botrylloides diegensis*, a first record for Tunisia reported by Raouia Ghanem; (B) *Perna perna* as ecosystem engineer providing shelter and a new habitat for the local fish *Scartella cristata* and barnacle species, and free surface for settlement, establishment and prosperity of the encrusting coralline red alga *Hydrolithon* sp.; this bivalve's aggregate was observed in 8.10.2020 at 1 m depth in Haifa. The fish is ca. 7 cm in length. Photo by Moti Mendelson.

One last very interesting observation included in the dataset, that does not constitute a first record, belongs to the widely invasive bivalve *Perna perna* (Linnaeus, 1758), initially observed and collected by a citizen scientist during the summer of 2020 in Haifa, located in north Israel (Douek et al. 2021), and spread all along the Levantine Mediterranean shore of Israel like wildfire. At the end of 2020, less than six months since its first record from Israel, this species of western Indian Ocean origin (Gardner et al. 2016; Fofonoff et al. 2018) reached the southernmost beach of Israel in Zikim (31.60630°N; 34.49940°E), by the border with Gaza Strip (Figure 11B). Although it is not the first introduction of this invasive mytilid mussel on

the Israeli shoreline, the previous introduction (Barash and Danin 1992) was regarded as an ephemeral occurrence, and the species remained cryptic until recently (Douek et al. 2021). Moreover, seven years of steady ongoing seasonal “Bioblitz” surveys of the marine fauna and flora of the shallow and deep subtidal in Haifa, conducted by the Israeli Nature and Parks Authority, proved that the species is indeed a new invader because it was not observed or collected until 2020. The extensive and dense beds observed near Haifa port may point to vessels as the vector of introduction (Douek et al. 2021). In Haifa, Zikim and Tel Aviv, this invasive species is an ecosystem engineer, providing a habitat for marine fauna and epiflora, as depicted in Figure 11B. Moreover, although a recently published study reported that a marine heatwave-induced mass mortality event “laid waste to the entire mussel population” in July 2021 and suggests that *P. perna* outbreaks in Israel might be short-lived (Galil et al. 2022), further observation from April 2022 testify that, at least in part, the population seems to be slowly recovering in Zikim.

Discussion

Just two years after Katsanevakis et al. (2020a) paper came out, we managed to collect more than double the records of alien, cryptogenic and neonative species, complementing existing data with an additional 12,649 open-access records. This effort was motivated by the need to demonstrate that a huge amount of valuable information exists, and new data are continuously accumulating that need to be retrieved, harmonized, and openly shared. Despite the requirements of the Barcelona Convention (e.g., UNEP/MAP 2017) and the EU (e.g., for the implementation of the Marine Strategy Framework Directive 2008/56/EC), a state-level monitoring network is still largely missing from the Mediterranean and Black Seas (Tsiamis et al. 2021). Regional collaboration and networking among scientists can be valuable in partially filling this gap.

This extensive and large-scale cooperation, aiming to collect data from a large geographic area, facilitates networking among colleagues in the biological invasions field, promoting future cooperation. Scientists have been very positive in sharing their data and working together despite regional geopolitical issues for the benefit of science and society. By continuing this effort regularly, we believe we will further promote invasion science in the region and increase opportunities for further research and analyses that will improve our understanding of ecosystem change and the impacts of biological invasions in the Mediterranean and the Black Sea.

As expected, our dataset is not unbiased in the spatial and taxonomic representation of biological invasions in the Mediterranean and the Black Sea. Species size and habitat distribution, the feasibility of visual identification, the location of participating scientists, varying sampling effort and methodology among countries, the uneven distribution of citizen science initiatives,

socioeconomic differences, and field methods used to obtain data may have introduced biases in our dataset. Still, the emerged patterns can highlight the invasive potential of certain species (e.g., *Caulerpa cylindracea*, *Charybdis (Archias) longicollis*, *Upeneus moluccensis*, *Pterois miles*, *Saurida lessepsianus*, *Siganus rivulatus*, *Siganus luridus*) that appear abundant and widespread. Moreover, the ever-growing use of advanced machine learning and artificial intelligence technology for big-data analysis can help overcome biases and produce novel applications to spatially and temporally map alien species advances in our seas using large datasets such as the one collated in the present study.

Acknowledgements

Razy Hoffman acknowledges Tamar Feldstein for confirming the identity of *Kapraunia schneideri* through molecular study and Moti Mendelson for the first documented record of the new invasion of *Perna perna* and the figures indicating this bivalve's colony. The School of Plant Sciences and Food Security of Tel Aviv University is also acknowledged for the use of microscopes and cameras. Fiona Tomas and María García thank the marine citizen Science platform "Seawatchers project" for holding the "Invasive algae" subproject. The Oddfish initiative, a Facebook page aimed at detecting the occurrence of rare and non-indigenous species in Mediterranean waters, contributed to the provision of validated records of species. Carmelo Fulco is thanked for providing photographic material. Charalampos Dimitriadis wants to thank Stefano Mariani, Erica Neave and Peter Shum for their assistance in the field surveys. Radhouan El Zrelli and Lotfi Jilani Rabaoui thank all the fishers of Gabès, in particular those of Chatt Sidi Abd Essalam for continuously reporting on the unusual records of introduced and rare marine species during their fishing activities in the Gulf of Gabès. Emanuele Mancini wants to thank the Laboratory of Experimental Oceanology and Marine Ecology of Civitavecchia (University of Tuscia) and the Environmental Office of the Civitavecchia Port Authority for the support given to the sampling operation and development of the research and in particular to Calogero Burgio and Giorgio Fersini. Emanuele Mancini and Fabio Colleparado Coccia thank the fishers Angelo Grillo, Domenico Accardo, Gastone Orsini, Maurizio Lampacresce and Andrea Monaco for their support during the sampling operation. Daniele Grech is grateful to Capo Caccia-Isola Piana Marine Protected Area, the professional diver Ugo Montaldo and Alessandra Bellucci for their support and field assistance. Jamila Rizgalla would like to thank; Anwaige A. Almasawri, Raby El Jaly, Hamed El Shari, Ahmed Bobaker, Big Blue, and FB group Sartma (Reda Salah Bozayd, Boshwegeer Ali). Dori Edelist would like to acknowledge Dr. Oren Sonin, the trawl fishers of Israel, who contributed to this study, and surveyors Elad Lando and Eugene Vassa. Martina Gaglioti wishes to thank EMSEA Med Working group for the current affiliation and SSI (Scuba Schools International) for the financial and logistic support for her fieldwork activities and observations conducted in the last few months. Ioannis E. Batjakas and Thodoros E. Kampouris wish to thank Elias Papadopoulos and Azure Diving Center, for providing photographic material and further information regarding the *P. miles* individual from Chalikidiki.

Funding declaration

Stelios Katsanevakis, Michail Ragkousis, Maria Sini, Markos Digenis and Vasilis Gerovasileiou were supported by the Hellenic Foundation for Research and Innovation (HFRI) under the "First Call for HFRI Research Projects to support Faculty members and Researchers and the procurement of high-cost research equipment grant" (Project ALAS – "ALIens in the Aegean – a Sea under siege" (Katsanevakis et al. 2020b); Project Number: HFRI-FM17-1597). Konstantinos Tsirintanis was co-financed by Greece and the European Union (European Social Fund-ESF) through the Operational Programme "Human Resources Development, Education and Lifelong Learning", 2014-2020, in the context of the Act "Enhancing Human Resources Research Potential by undertaking a Doctoral Research" Sub-action 2: IKY Scholarship Programme for PhD candidates in the Greek Universities. Maria Zotou was supported by the project "Coastal Environment Observatory and Risk Management in Island Regions AEGIS+" (MIS 5047038), implemented within the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020), co financed by the Hellenic Government (Ministry of Development and Investments) and the European Union (European Regional Development Fund, Cohesion Fund). Razy Hoffman was supported by Yad-Hanadiv Foundation, through the Israel Society of Ecology and Environmental Sciences and Israel Nature and Parks Authority, an integrated

program for establishing biological baselines and monitoring protocols for marine reserves in the Israeli Mediterranean Sea (Grant #10669). Tatiana Begun, Adrian Teaca and Mihaela Muresan were supported by the European Union's Horizon 2020 BRIDGE-BS project under grant agreement no. 101000240. Fiona Tomas was supported by the project "Invasion of the tropical alga *Halimeda incrassata* in the Balearic Islands: ecology and invasion dynamics (AAEE119/2017)", funded by the Vicepresidencia y Consejería de Innovación, Investigación y Turismo del Govern de les Illes Balears, with support from the European Union and FEDER funds, and the project "Una nueva alga invasora en el Mediterráneo: invasibilidad, detección y erradicación del alga tropical *Halimeda incrassata* (INVHALI)", funded by the Fundación Biodiversidad, del Ministerio para la Transición Ecológica y el Reto Demográfico. Simonetta Frascchetti, Laura Tamburello, Antonia Chiarore were supported by the project PO FEAMP 2014-2020 - DRD n. 35/2019, "Innovazione, sviluppo e sostenibilità nel settore della pesca e dell'acquacoltura per la Regione Campania" (ISSPA 2.51) and the EU EASME - EMFF (Sustainable Blue Economy) Project AFRIMED (<http://afrimed-project.eu/>, grant agreement N. 789059). Carlos Jimenez, Louis Hadjioannou, Vasilis Resaikos, Valentina Fossati, Magdalene Papatheodoulou, and Antonis Petrou were supported by MedPan Small Projects, Mava, and LIFE-IP. Louis Hadjioannou, Manos L. Moraitis and Neophytos Agrotis received funding from the European Union's Horizon 2020 research and innovation program within the framework of the CMMI/MaRITeC-X project under grant agreement No. 857586. Ernesto Azzurro was supported by the project USEIt - Utilizzo di Sinergie operative per la gestione integrata specie aliene Invasive in Italia, funded by the research programme @CNR. Antonietta Rosso and Francesco Sciuto were supported by the University of Catania through "PiaCeRi-Piano Incentivi per la Ricerca di Ateneo 2020–22 linea di intervento 2." This is the Catania Paleocological Research Group contribution n. 484. Diego K. Kersting was supported by the Beatriu de Pinós programme funded by the Secretary of Universities and Research (Government of Catalonia) and the Horizon 2020 programme of research and innovation of the European Union under the Marie Skłodowska-Curie grant agreement No 801370. Francesco Tiralongo was supported by the AlienFish project of Ente Fauna Marina Mediterranea (Scientific Organization for Research and Conservation of Marine Biodiversity, 96012 Avola, Italy), a citizen science project for monitoring and studying rare and non-indigenous fish in Italian waters. Adriana Vella, was supported by funds through the BioCon Innovate Research Excellence Grant from the University of Malta awarded to her. Noel Vella was supported by REACH HIGH Scholars Programme-Post Doctoral Grant for the FINS project. Some of the records provided by Victor Surugiu were obtained during surveys carried out within the framework of the project "Adequate management of invasive species in Romania, in accordance with EU Regulation 1143/2014 on the prevention and management of the introduction and spread of invasive alien species", SMIS 2014+ 120008, coordinated by the Romanian Ministry of Environment, Water and Forests in partnership with the University of Bucharest (2018–2022). Alan Deidun and Alessio Marrone were supported by the "Spot The Alien" citizen science campaign for the monitoring of the Alien species in the Maltese archipelago and by the Interreg Italia-Malta Harmony project. The authors from the National Institute of Biology (Slovenia) acknowledge the financial support of the Slovenian Research Agency (Research Core Funding No. P1-0237) and of the Ministry of Agriculture, Forestry and Food (project "Survey of the species richness and abundance of alien species in the Slovenian Sea"). Emanuele Mancini and Fabio Collepardo Coccia were supported by the project PO-FEAMP 2014-2020 "BIOBLITZ: research, knowledge and participation for the sustainable management of marine resources (BioBlitz Blu 2020)" coordinated by CURSA for MIPAAF, the Italian Ministry of Agricultural, Food and Forestry Policies, Measure 1.40 - Protection and restoration of biodiversity and marine ecosystems and compensation schemes in the context of sustainable fishing activities. Daniele Grech was supported by the PO-FEAMP 2014-2020 project ECOGESTOCK "Approccio ECOSistemico per la tutela e la GESTione delle risorse biologiche e STOCK ittici nelle acque interne", the citizen science project Progetto Fucales: chi le ha viste? and the Paralenz Every dive counts sponsor. Jamila Rizgalla was supported by the project Snowball for the monitoring of alien species in Libyan waters امتدطصا له امتغش له (have you seen it have you fished it?). Gerasimos Kondylatos and Dimitrios Mavrouleas were supported by the project "EXPLIAS" (MIS (OΠΣ): 5049912), design and piloting methods of commercial exploitation of invasive alien species with a view to contributing to their population control, coordinated by the National Technical University of Athens with the collaboration of the Hellenic Centre for Marine Research and the University of the Aegean and co-founded by Greece and the European Union. G. Kondylatos and Savvas Nikolidakis were supported by the project "SAMOS" (ID CODE: 32.2072004/001), a study for a submarine productive park in Marathokampos of Samos. Paraskevi K. Karachle, Aikaterini Dogrammatzi, Giorgos A. Apostolopoulos, Kassiani Konida and Melina Nalmpanti were supported by the project "4ALIEN: Biology and the potential economic exploitation of four alien species in the Hellenic Seas", funded by NRSF 2017-2020 (MIS (OΠΣ): 5049511). Fabio Crocetta and Riccardo Virgili were partially funded by the project PO FEAMP Campania 2014–2020, DRD n. 35 of 15th March 2018, Innovazione, sviluppo e sostenibilità nel settore della pesca e dell'acquacoltura per la regione Campania, Misura

2.51, WP5, Task 5.5 Presenza e distribuzione di specie non indigene del macrozoobenthos e del necton in Campania. Michel Bariche was partially funded by the University Research Board of the American University of Beirut (DDF 103951/2592). Constantinos G. Georgiadis, Dimitra Lida Rammou, Paschalis Papadamakis and Sotiris Orfanidis were supported by the MSFD monitoring program. Sonia Smeraldo was supported by the MPA-Engage project, led by the Institute of Marine Sciences of the Spanish National Research Council and funded by the Interreg MED program. Evgeniia Karpova acknowledge that the publication of this article was in part carried out within the framework of the state assignment of the FRC IBSS “Patterns of Formation and Anthropogenic Transformation of Biodiversity and Bioresources of the Azov–Black Sea Basin and Other Regions of the World Ocean” (No. 121030100028-0). Elena Slynko’s work was carried out within the framework of a State Assignment no. 121051100109-1 of IBIW RAS. Manuela Falautano and Luca Castriota were supported by ISPRA citizen science campaigns for the monitoring of alien species through the dedicated institutional project (alien@isprambiente.it). María Altamirano was supported by the project RUGULOPTERYX funded by Fundación Biodiversidad-Ministerio para la Transición Ecológica y el reto Demográfico (Spain) and the project UMA20-FEDERJA-006 with support from the European Union and FEDER funds and Junta de Andalucía. Records provided by L. Mangialajo were collected in the framework of projects funded by the Pew Charitable Trust, by the European Commission (AFRIMED, <http://afrimed-project.eu/>, grant agreement N. 789059) and by the Académie 3 de l’Université Côte d’Azur (projet CONVOST).

Disclaimer

The responsibility for correct identification and reporting rests with the observer of each record, as stated in the Supplementary material Table S1.

References

- Albano PG, Steger J, Bošnjak M, Dunne B, Guifarro Z, Turapova E, Hua Q, Kaufman DS, Rilov G, Zuschin M (2021) Native biodiversity collapse in the eastern Mediterranean. *Proceedings of the Royal Society B* 288: 20202469, <https://doi.org/10.1098/rspb.2020.2469>
- Azzurro E, Sbragaglia V, Cerri J, Bariche M, Bolognini L, Ben Souissi J, Busoni G, Coco S, Chryssanthi A, Fanelli E, Ghanem R, Garrabou J, Gianni F, Grati F, Koltari J, Letterio G, Lipej L, Mazzoldi C, Milone N, Pannacciulli F, Pešić A, Samuel-Rhoads Y, Saponari L, Tomanic J, Topçu NE, Vargiu G, Moschella P (2019) Climate change, biological invasions, and the shifting distribution of Mediterranean fishes: A large-scale survey based on local ecological knowledge. *Global Change Biology* 25: 2779–2792, <https://doi.org/10.1111/gcb.14670>
- Azzurro E, Smeraldo S, Minelli A, D’Amen M (2022) ORMEF: a Mediterranean database of exotic fish records. *Scientific Data* 9: 363, <https://doi.org/10.1038/s41597-022-01487-z>
- Băncilă RI, Skolka M, Ivanova P, Surugiu V, Stefanova K, Todorova V, Zenetos A (2022) Alien species of the Romanian and Bulgarian Black Sea coast: state of knowledge, uncertainties, and needs for future research. *Aquatic Invasions* 17: 353–373, <https://doi.org/10.3391/ai.2022.17.3.02>
- Barash A, Danin Z (1992) Fauna Palaestina: Mollusca I. Annotated list of Mediterranean molluscs of Israel and Sinai. The Israel Academy of Sciences and Humanities, Jerusalem, 372 pp
- Bariche M, Heemstra P (2012) First record of the blacktip grouper *Epinephelus fasciatus* (Teleostei: Serranidae) in the Mediterranean Sea. *Marine Biodiversity Records* 5: 1–3, <https://doi.org/10.1017/S1755267211000509>
- Bastrop R, Jürss K, Sturmbauer C (1998) Cryptic species in a marine polychaete and their independent introduction from North America to Europe. *Molecular Biology and Evolution* 15: 97–103, <https://doi.org/10.1093/oxfordjournals.molbev.a025919>
- Bianchi CN, Morri C (2003) Global sea warming and ‘tropicalization’ of the Mediterranean Sea: biogeographic and ecological aspects. *Biogeographia* 24: 319–327, <https://doi.org/10.21426/B6110129>
- Bianchi CN, Caroli F, Guidetti P, Morri C (2018) Seawater warming at the northern reach for southern species: Gulf of Genoa, NW Mediterranean. *Journal of the Marine Biological Association of the United Kingdom* 98: 1–12, <https://doi.org/10.1017/S0025315417000819>
- Bianchi CN, Azzola A, Bertolino M, Betti F, Bo M, Cattaneo-Vietti R, Cocito S, Montefalcone M, Morri C, Oprandi A, Peirano A, Bavestrello G (2019) Consequences of the marine climate and ecosystem shift of the 1980–90s on the Ligurian Sea biodiversity (NW Mediterranean). *The European Zoological Journal* 86: 458–487, <https://doi.org/10.1080/24750263.2019.1687765>
- Bick A, Burckhardt R (1989) First record of *Marenzelleria viridis* (Polychaeta, Spionidae) in the Baltic Sea, with a key to the Spionidae of the Baltic Sea. *Mitteilungen aus dem Zoologischen Museum in Berlin* 65: 237–247, <https://doi.org/10.1002/mmnz.19890650208>

- Bitar G, Bitar-Kouli S (1995) Impact de la pollution sur la répartition des peuplements de substrat dur à Beyrouth (Liban - Méditerranée Orientale). *Rapports et Procès-Verbaux des Réunions, Vol XIV (Nouvelle série), Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 34: 19
- Boltachev AR, Karpova EP (2014) Faunistic revision of alien fish species in the Black Sea. *Russian Journal of Biological Invasions* 5: 225–241, <https://doi.org/10.1134/S2075111714040018>
- Boltachev A, Karpova E, Vdodovich I (2016) Distribution, Biological and Ecological Characteristics of Alien Species *Pomatoschistus bathi* Miller 1982 (Gobiidae) in the Black Sea. *Turkish Journal of Fisheries and Aquatic Sciences* 16: 113–122, https://doi.org/10.4194/1303-2712-v16_1_12
- Boxshall GA (1984) The Functional Morphology of *Benthomisophria palliata* Sars, with a Consideration of the Evolution of the Misophrioida. *Crustaceana Supplement* 7: 32–46
- Carlton JT (1996) Biological invasions and cryptogenic species. *Ecology* 77: 1653–1655, <https://doi.org/10.2307/2265767>
- Carlton JT (2009) Deep invasion ecology and the assembly of communities in historical time. In: Rilov G, Crooks JA (eds), *Biological Invasions in Marine Ecosystems*. Ecological Studies 204, Springer-Verlag Berlin Heidelberg, pp 13–56, https://doi.org/10.1007/978-3-540-79236-9_2
- Carpenter KE, Allen GR (1989) Emperor fishes and large-eye breams of the world (family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. *FAO Fisheries Synopsis* 125(9): 118
- Çinar ME, Bilecenglu M, Öztürk B, Can A (2006) New records of alien species on the Levantine coast of Turkey. *Aquatic Invasions* 1: 84–90, <https://doi.org/10.3391/ai.2006.1.2.6>
- Çinar ME, Dagli E, Kurt Şahin G (2014) Checklist of Annelida from the coasts of Turkey. *Turkish Journal of Zoology* 38: 734–764, <https://doi.org/10.3906/zoo-1405-72>
- Çinar ME, Bilecenoğlu M, Yokeş MB, Öztürk B, Taşkin E, Bakir K, Doğan A, Açık Ş (2021) Current status (as of end of 2020) of marine alien species in Turkey. *PLoS ONE* 16: e0251086, <https://doi.org/10.1371/journal.pone.0251086>
- Conlan KE, Bousfield EL (1982) Studies on Amphipod Crustaceans of the Northeastern Pacific Region, I.2 Family Ampithoidae. *National Museum of Natural Sciences (Ottawa) - Publications in Biological Oceanography* 10: 41–75
- Cormaci M, Furnari G, Giaccone G, Serio D (2004) Alien macrophytes in the Mediterranean Sea: A review. *Recent Research Development in Environmental Biology* 1(2004): 153–202
- Cramer W, Guiot J, Fader M, Garrabou J, Gattuso JP, Iglesias A, Xoplaki E (2018) Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change* 8: 972–980, <https://doi.org/10.1038/s41558-018-0299-2>
- Crocetta F, Bitar G, Zibrowius H, Oliverio M (2013) Biogeographical homogeneity in the eastern Mediterranean Sea. II. Temporal variation in Lebanese bivalve biota. *Aquatic Biology* 19: 75–84, <https://doi.org/10.3354/ab00521>
- Crocetta F, Mariottini P, Salvi D, Oliverio M (2015) Does GenBank provide a reliable DNA barcode reference to identify small alien oysters invading the Mediterranean Sea? *Journal of the Marine Biological Association of the UK* 95: 111–122, <https://doi.org/10.1017/S0025315414001027>
- Crocetta F, Al Mabruk SA, Azzurro E, Bakiu R, Bariche M, Batjakas I E, Bejaoui T, Ben Souissi J, Cauchi J, Corsini-Foka M, Deidun A, Evans J, Galdies J, Ghanem R, Kampouris T E, Katsanevakis S, Kondylatos G, Lipej L, Lombardo A, Marletta G, Mejdani E, Nikolidakis S, Ovalis P, Rabaoui L, Ragkousis M, Rogelja M, Sakr J, Savva I, Tanduo V, Turan C, Uyan A, Zenetos A (2021) New Alien Mediterranean Biodiversity Records (November 2021). *Mediterranean Marine Science* 22: 724–746, <https://doi.org/10.12681/mms.26668>
- Cunha MR, Sorbe JC, Moreira MH (1999) Spatial and seasonal changes of brackish peracaridan assemblages and their relation to some environmental variables in two tidal channels of the Ria de Aveiro (NW Portugal). *Marine Ecology Progress Series* 190: 69–87, <https://doi.org/10.3354/meps190069>
- Dagli E, Çinar ME (2009) Species of the subgenera *Aquilaspio* and *Prionospio* (Polychaeta: Spionidae: *Prionospio*) from the southern coast of Turkey (Levantine Sea, eastern Mediterranean), with description of a new species and two new reports for the Mediterranean fauna. *Zootaxa* 2275: 1–20, <https://doi.org/10.11646/zootaxa.2275.1.1>
- Della Sala G, Coppola D, Virgili R, Vitale GA, Tanduo V, Teta R, Crocetta F, de Pascale D (2022) Untargeted Metabolomics Yields Insights Into the Lipidome of *Botrylloides niger* Herdman, 1886, An Ascidian Invading the Mediterranean Sea. *Frontiers in Marine Science* 9: 865751, <https://doi.org/10.3389/fmars.2022.865751>
- Díaz-Tapia P, Kim MS, Secilla A, Bárbara I, Cremades J (2013) Taxonomic reassessment of *Polysiphonia foetidissima* (Rhodomelaceae, Rhodophyta) and similar species, including *P. schneideri*, a newly introduced species in Europe. *European Journal of Phycology* 48: 345–362, <https://doi.org/10.1080/09670262.2013.842655>
- Douek J, Paz G, Gayer K, Mendelson M, Rinkevich B, Galil BS (2021) An outbreak of *Perna perna* (Linnaeus, 1758) (Mollusca, Bivalvia, Mytilidae) in the Eastern Mediterranean. *BioInvasions Records* 10: 136–148, <https://doi.org/10.3391/bir.2021.10.1.15>

- Essink K, Kleef HL (1988) *Marenzelleria viridis* (Verrill, 1873) (Polychaeta: Spionidae): a new record from the Ems estuary (The Netherlands/Federal Republic of Germany). *Zoologische Bijdragen* 38: 1–13
- Essl F, Bacher S, Genovesi P, Hulme PE, Jeschke JM, Katsanevakis S, Kowarik I, Kühn I, Pyšek P, Rabitsch W, Schindler S, van Kleunen M, Vilà M, Wilson JRU, Richardson DM, (2018) Which Taxa Are Alien? Criteria, Applications, and Uncertainties. *BioScience* 68: 496–509, <https://doi.org/10.1093/biosci/biy057>
- Essl F, Dullinger S, Genovesi P, Hulme PE, Jeschke JM, Katsanevakis S, Kühn I, Lenzner B, Pauchard A, Pyšek P, Rabitsch W, Richardson DM, Seebens H, van Kleunen M, van der Putten WH, Vilà M, Bacher S (2019) A conceptual framework for range-expanding species that track human-induced environmental change. *BioScience* 69: 908–919, <https://doi.org/10.1093/biosci/biz101>
- Eyuboglu O (2022) Measures and Gap Analysis on the Impact of Non-Indigenous Species on the Black Sea Ecosystem. *Pakistan Journal of Zoology* 53: 1419–1429, <https://doi.org/10.17582/journal.pjz/20200726170735>
- Faasse MA (2015) New records of the non-native amphipod *Ampithoe valida* in Europe. *Marine Biodiversity Records* 8: e87, <https://doi.org/10.1017/S1755267215000706>
- Fauvel P (1937) Les fonds de pêche près d’Alexandrie. XI. Annélides Polychètes. Ministère du Commerce & de l’Industrie, Le Caire. Direction des Recherches des Pêcheries. *Notes and Mémoires* 19: 1–60
- Foulquie M, Dupuy de la Grandrive R (2003) First assignment concerning the development of Marine Protected Area on the Syrian coast, from 8-15 November 2002. Regional Activity Centre for Specially Protected Areas, 33 pp
- Galil BS, Gevili R (2014) *Zoobotryon verticillatum* (Bryozoa: Ctenostomatida: Vesiculariidae), a new occurrence on the Mediterranean coast of Israel. *Marine Biodiversity Records* 7: 1–4, <https://doi.org/10.1017/S1755267214000086>
- Galil B, Mienis H, Mendelson M, Gayer K, Goren M (2022) Here today, gone tomorrow - the Levantine population of the Brown mussel *Perna perna* obliterated by unprecedented heatwave. *Aquatic Invasions* 17: 174–185, <https://doi.org/10.3391/ai.2022.17.2.03>
- Gardner JP, Patterson J, George S, Edward JP (2016) Combined evidence indicates that *Perna indica* Kuriakose and Nair 1976 is *Perna perna* (Linnaeus, 1758) from the Oman region introduced into southern India more than 100 years ago. *Biological Invasions* 18: 1375–1390, <https://doi.org/10.1007/s10530-016-1074-9>
- Garrabou J, Gómez-Gras D, Medrano A, Cerrano C, Ponti M, Schlegel R, Bensoussan N, Turicchia E, Sini M, Gerovasileiou V, Teixido N, Mirasole A, Tamburello L, Cebrian E, Rilov G, Ledoux JB, Ben Souissi J, Khamassi F, Ghanem R, Benabdi M, Grimes S, Ocaña O, Bazairi H, Hereu B, Linares C, Kersting DK, Rovira G, Ortega J, Casals D, Pagès-Escolà M, Margarit N, Capdevila P, Verdura J, Ramos A, Izquierdo A, Barbera C, Rubio-Portillo E, Anton I, López-Sendino P, Díaz D, Vázquez-Luis M, Duarte C, Marbà N, Aspillaga E, Espinosa F, Grech D, Guala I, Azzurro E, Farina S, Gambi MC, Chimienti G, Montefalcone M, Azzola A, Pulido Mantas T, Frascchetti S, Ceccherelli G, Kipson S, Bakran-Petricioli T, Petricioli D, Jimenez C, Katsanevakis S, Tuney Kizilkaya I, Kizilkaya Z, Sartoretto S, Rouanet E, Ruitton S, Comeau S, Gattuso JP, Harmelin JG (2022) Marine heatwaves drive recurrent mass mortalities in the Mediterranean Sea. *Global Change Biology* 28: 5708–5725, <https://doi.org/10.1111/gcb.16301>
- Giakoumi S, Katsanevakis S, Albano PG, Azzurro E, Cardoso AC, Cebrian E, Deidun A, Edelist D, Francour P, Jimenez C, Mačić V, Occhipinti-Ambrogi A, Rilov G, Ramzi Sghaier Y (2019) Management priorities for marine invasive species. *Science of the Total Environment* 688: 976–982, <https://doi.org/10.1016/j.scitotenv.2019.06.282>
- Giovos I, Kleitou P, Poursanidis D, Batjakas I, Bernardi G, Crocetta F, Doumpas N, Kalogirou S, Kampouris TE, Keramidis I, Langeneck J, Maximidi M, Mitsou E, Stoilas VO, Tiralongo F, Romanidis-Kyriakidis G, Xentidis NJ, Zenetos A, Katsanevakis S (2019) Citizen-science for monitoring marine invasions and stimulating public engagement: a case project from the eastern Mediterranean. *Biological Invasions* 21: 3707–3721, <https://doi.org/10.1007/s10530-019-02083-w>
- Golani D, Azzurro E, Dulčić J, Massutí E, Orsi-Relini L (2021) Atlas of Exotic Fishes in the Mediterranean Sea, 2nd edn. CIESM Publishers, Paris, Monaco, 365 pp
- Gouillieux B (2017) New records of benthic amphipods, *Jassa slatteryi* Conlan, 1990 and *Ampithoe valida* Smith, 1873 (Crustacea: Peracarida: Amphipoda) for the Bay of Biscay, France, with morphological notes. *Cahiers Biologie Marine* 58: 279–289, <https://doi.org/10.21411/CBM.A.F205EFDE>
- Güreşen A, Okudan EŞ, Dural B, Aysel V (2015) An updated checklist of marine flora on the continental shelf of Gökçeada island (northern Aegean Sea, Turkey). *Journal of Aquaculture Engineering and Fisheries Research* 3: 171–187, <https://doi.org/10.3153/JAEFR17020>
- Haas G (1948) Sur l’immigration de mollusques de l’Indo-Pacifique dans les eaux côtières de la Palestine. *Journal de Conchyliologie* 88: 141–144

- Hamel G (1931) Sur le *Cladostephus dubius* Bory. In: Travaux cryptogamiques dédiés à Louis Mangin. Laboratoire de Cryptogamie, Muséum National d'Histoire Naturelle, Paris, pp 309–312
- Hamza A, Bradai MN, Ghorbel M, Abdelmoula A (1995) New mentions of *Caulerpa racemosa* (Forsskål) J. Agardh in the Gabès Gulf (Tunisia). *Bulletin de l'Institut National des Sciences et Technologie de la Mer de Salammbô* 22: 81–87
- Heemstra PC, Randall JE (1993) FAO species catalogue Vol. 16. Groupers of the world (Family Serranidae, Subfamily Epinephelinae). An annotated and illustrated catalogue of the groupers, rockcod, hind, coral grouper and lyretail species known to date. FAO Fisheries Synopsis 125 (vol. 16). Rome, FAO, 382 pp
- Imajima M (1990) Spionidae (Annelida, Polychaeta) from Japan IV. The genus *Prionospio* (*Prionospio*). *Bulletin of the Natural Science Museum Tokyo Series A* 16(3): 105–140
- Ivkić A, Steger J, Galil BS, Albano PG (2019) The potential of large rafting objects to spread Lessepsian invaders: the case of a detached buoy. *Biological Invasions* 21: 1887–1893, <https://doi.org/10.1007/s10530-019-01972-4>
- Karachle PK, Angelidis A, Apostolopoulos G, Ayas D, Ballesteros M, Bonnici C, Brodersen MM, Castriota L, Chalari N, Cottalorda JM, Crocetta F, Deidun A, Đodo Ž, Dogrammatzi A, Dulčić J, Fiorentino F, Gönülal O, Harmelin JG, Insacco G, Izquierdo-Gómez D, Izquierdo-Muñoz A, Joksimović A, Kavadas S, Malaquias ME, Madrenas E, Massi D, Micarelli P, Minchin D, Önal U, Ovalis P, Poursanidis D, Siapatis A, Sperone E, Spinelli A, Stamouli C, Tiralongo F, Tunçer S, Yaglioglu D, Zava B, Zenetos A (2016) New Mediterranean Biodiversity Records (March 2016). *Mediterranean Marine Science* 17: 230–252, <https://doi.org/10.12681/mms.1684>
- Katsanevakis S, Zenetos A, Mačić V, Beqiraj S, Poursanidis D, Kashta L (2011) Invading the Adriatic: Spatial patterns of marine alien species across the Ionian Adriatic boundary. *Aquatic Biology* 13: 107–118, <https://doi.org/10.3354/ab00357>
- Katsanevakis S, Coll M, Piroddi C, Steenbeek J, Ben Rais Lasram F, Zenetos A, Cardoso AC (2014a) Invading the Mediterranean Sea: biodiversity patterns shaped by human activities. *Frontiers in Marine Science* 1: 32, <https://doi.org/10.3389/fmars.2014.00032>
- Katsanevakis S, Wallentinus I, Zenetos A, Leppäkoski E, Çinar ME, Öztürk B, Grabowski M, Golani D, Cardoso AC (2014b) Impacts of marine invasive alien species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions* 9: 391–423, <https://doi.org/10.3391/ai.2014.9.4.01>
- Katsanevakis S, Tempera F, Teixeira H (2016) Mapping the impact of alien species on marine ecosystems: the Mediterranean Sea case study. *Diversity and Distributions* 22: 694–707, <https://doi.org/10.1111/ddi.12429>
- Katsanevakis S, Rilov G, Edelist D (2018) Impacts of marine invasive alien species on European fisheries and aquaculture - plague or boon? In: Briand F (eds), CIESM Monograph 50 - Engaging marine scientists and fishers to share knowledge and perceptions - early lessons. CIESM Publisher, Monaco and Paris, pp 125–132
- Katsanevakis S, Poursanidis D, Hoffman R, Rizgalla J, Rothman SB-S, Levitt-Barmats Y, Hadjoannou L, Trkov D, Garmendia JM, Rizzo M, Bartolo AG, Bariche M, Tomas F, Kleitou P, Schembri PJ, Kletou D, Tiralongo F, Pergent C, Pergent G, Azzurro E, Bilecenoglu M, Lodola A, Ballesteros E, Gerovasileiou V, Verlaque M, Occhipinti-Ambrogi A, Kytinou E, Dailianis T, Ferrario J, Crocetta F, Jimenez C, Evans J, Ragkousis M, Lipej L, Borg JA, Dimitriadis C, Chatzigeorgiou G, Albano PG, Kalogirou S, Bazairi H, Espinosa F, Ben Souissi J, Tsiamis K, Badalamenti F, Langeneck J, Noel P, Deidun A, Marchini A, Skouradakis G, Royo L, Sini M, Bianchi CN, Sghaier Y-R, Ghanem R, Doumpas N, Zaouali J, Tsirintanis K, Papadakis O, Morri C, Çinar ME, Terrados J, Insacco G, Zava B, SoufiKechaou E, Piazza L, Ounifi Ben Amor K, Andriotis E, Gambi MC, Ben Amor MM, Garrabou J, Linares C, Fortič A, Digenis M, Cebrian E, Fourt M, Zotou M, Castriota L, Di Martino V, Rosso A, Pipitone C, Falautano M, García M, Zakhama-Sraieb R, Khamassi F, Mannino AM, Ktari MH, Kosma I, Rifi M, Karachle PK, Yapıcı S, Bos AR, Balistreri P, Ramos Esplá AA, Tempesti J, Inglese O, Giovos I, Damalas D, Benhissoune S, Huseyinoglu MF, RjibaBahri W, Santamaría J, Orlando-Bonaca M, Izquierdo A, Stamouli C, Montefalcone M, Cerim H, Golo R, Tsioli S, Orfanidis S, Michailidis N, Gaglioti M, Taşkın E, Mancuso E, Žunec A, Cvitković I, Filiz H, Sanfilippo R, Siapatis A, Mavrič B, Karaa S, Türker A, Monniot F, Verdura J, El Ouamari N, Selfati M, Zenetos A (2020a) Unpublished Mediterranean records of marine alien and cryptogenic species. *BioInvasions Records* 9: 165–182, <https://doi.org/10.3391/bir.2020.9.2.01>
- Katsanevakis S, Tsirintanis K, Sini M, Gerovasileiou V, Koukourouli N (2020b) Aliens in the Aegean - A sea under siege (ALAS). *Research Ideas and Outcomes* 6: e53057, <https://doi.org/10.3897/rio.6.e53057>
- Kideys AE, Kovalev AV, Shulman G, Gordina A, Bingel F (2000) A review of zooplankton investigations of the Black Sea over the last decade. *Journal of Marine Systems* 24: 355–371, [https://doi.org/10.1016/S0924-7963\(99\)00095-0](https://doi.org/10.1016/S0924-7963(99)00095-0)
- Kovačić M (2003) Hyperbenthic gobies in the Kvarner area, Adriatic Sea. *Journal of Fish Biology* 63: 1051–1055, <https://doi.org/10.1046/j.1095-8649.2003.00221.x>

- Kovačić M (2008) The key for identification of Gobiidae (Pisces: Perciformes) in the Adriatic Sea. *Acta Adriatica* 49: 245–254, <https://doi.org/10.32582/aa.49.3.207>
- Kucheruk NV, Basin AB (1999) Lessepsian migrant *Strombus persicus* bottom community-new one for eastern Mediterranean. In: Abstracts of the International Conference on Oceanography of the Eastern Mediterranean and Black Sea. Similarities and differences of two interconnected basins. Athens, February 23-26, 1999, pp 244
- Kurt G, Rezzag-Mahcene H, Kus S, Daas T, Villalobos-Guerrero TF (2021) First record of the Lessepsian nereidid *Pseudonereis anomala* Gravier, 1899 (Annelida: Nereididae) in the western Mediterranean Sea. *Cahiers de Biologie Marine* 62: 17–26, <https://doi.org/10.21411/CBM.A.4D8612>
- Leppäkoski E, Olenin S (2000) Non-native species and rates of spread: lessons from the brackish Baltic Sea. *Biological Invasions* 2: 151–163, <https://doi.org/10.1023/A:1010052809567>
- Levin N, Coll M, Fraschetti S, Gal G, Giakoumi S, Göke C, Heymans JJ, Katsanevakis S, Mazor T, Öztürk B, Rilov G, Gajewski J, Steenbeek J, Kark S (2014) Biodiversity data requirements for systematic conservation planning in the Mediterranean Sea. *Marine Ecology Progress Series* 508: 261–281, <https://doi.org/10.3354/meps10857>
- Lin SM, Huisman JM, Ballantine DL (2014) Revisiting the systematics of *Ganonema* (Liagoraceae, Rhodophyta) with emphasis on species from the northwest Pacific Ocean. *Phycologia* 53: 37–51, <https://doi.org/10.2216/13-201.1>
- Mačić V, Ballesteros E (2016) First record of the alien alga *Antithamnion amphigeneum* (Rhodophyta) in the Adriatic Sea. *Acta Adriatica* 57(2): 315–320
- Mačić V, Albano PG, Alpanidou V, Claudet J, Corrales X, Essl F, Evagelopoulou A, Giovos I, Jimenez C, Kark S, Marković O, Mazaris AD, Ólafsdóttir GÁ, Panayotova M, Petović S, Rabitsch W, Ramdani M, Rilov G, Tricarico E, Vega Fernández T, Sini M, Trygonis V, Katsanevakis S (2018) Biological invasions in conservation planning: A global systematic review. *Frontiers in Marine Science* 5: 178, <https://doi.org/10.3389/fmars.2018.00178>
- Marchini A, Sconfietti R, Krapp-Schickel T (2007) Role of the artificial structures on biodiversity: the case of arthropod fauna in the North Adriatic lagoons. *Studi Trentini di Scienze Naturali-Acta Biologica* 83: 27-31
- Micheli F, Halpern BS, Walbridge S, Ciriaco S, Ferretti F, Fraschetti S, Lewison R, Nykjaer L, Rosenberg AA (2013) Cumulative human impacts on Mediterranean and Black Sea marine ecosystems: assessing current pressures and opportunities. *PLoS ONE* 8: e79889, <https://doi.org/10.1371/journal.pone.0079889>
- Mikhailova AV, Popova EV, Shipulin SV, Maximov AA, Plotnikov IS, Aladin NV (2021) On the invasion of the genus *Marenzelleria* (Polychaeta, Spionidae) representatives into the Caspian Sea basin. *Russian Journal of Biological Invasions* 12: 373–376, <https://doi.org/10.1134/S207511172104007X>
- Moazzo PG (1939) Mollusques testacés marins du Canal de Suez. *Mémoires de l'Institut d'Égypte Cairo* 38: 1–283
- Morri C, Puce S, Bianchi CN, Bitar G, Zibrowius H, Bavestrello G (2009) Hydroids (Cnidaria: Hydrozoa) from the Levant Sea (mainly Lebanon), with emphasis on alien species. *Journal of the Marine Biological Association of the UK* 89: 49–62, <https://doi.org/10.1017/S0025315408002749>
- Morri C, Montefalcone M, Gatti G, Vassallo P, Paoli C, Bianchi CN (2019) An alien invader is the cause of homogenization in the recipient ecosystem: a simulation-like approach. *Diversity* 11: 146, <https://doi.org/10.3390/d11090146>
- Mureşan M, Teacă A, Begun T (2021) First record of the hydrozoan *Podocorynoides minima* (Trinci, 1903) in the Romanian Black Sea waters. *Biologia* 77: 1819–1828, <https://doi.org/10.1007/s11756-022-01051-5>
- Nascimento KB, Migotto AE, Fehlaue-Ale KH (2021) Molecular data suggest the worldwide introduction of the bryozoan *Amathia verticillata* (Ctenostomata, Vesiculariidae). *Marine Biology* 168: 1–9, <https://doi.org/10.1007/s00227-021-03837-8>
- Niederhöfer H, Enzenross L, Enzenross R (1991) Neue Erkenntnisse über die Ausbreitung von “Lesseps’schen Einwanderern” (Mollusca) a der türkischen Mittelmeerküste. *Club Conchilia Informationen* 23: 94–108
- Ordóñez V, Pascual M, Fernández-Tejedor M, Turon X (2016) When invasion biology meets taxonomy: *Clavelina oblonga* (Ascidiacea) is an old invader in the Mediterranean Sea. *Biological Invasions* 18: 1203–1215, <https://doi.org/10.1007/s10530-016-1062-0>
- Peleg O, Guy-Haim T, Yeruham E, Silverman J, Rilov G (2020) Tropicalization may invert trophic state and carbon budget of shallow temperate rocky reefs. *Journal of Ecology* 108: 844–854, <https://doi.org/10.1111/1365-2745.13329>
- Piazzi L, Balata D, Bulleri F, Gennaro P, Ceccherelli G (2016) The invasion of *Caulerpa cylindracea* in the Mediterranean: the known, the unknown and the knowable. *Marine Biology* 163: 1–14, <https://doi.org/10.1007/s00227-016-2937-4>
- Pilgrim EM, Darling JA (2010) Genetic diversity in two introduced biofouling amphipods (*Ampithoe valida* & *Jassa marmorata*) along the Pacific North American coast: investigation into molecular identification and cryptic diversity. *Diversity and Distributions* 16: 827–839, <https://doi.org/10.1111/j.1472-4642.2010.00681.x>

- Pisano A, Marullo S, Artale V, Falcini F, Yang C, Leonelli FE, Buongiorno Nardelli B (2020) New evidence of Mediterranean climate change and variability from sea surface temperature observations. *Remote Sensing* 12: 132, <https://doi.org/10.3390/rs12010132>
- Por FD (2009) Tethys returns to the Mediterranean: success and limits of tropical recolonization. *Biorisk* 3: 5e19, <https://doi.org/10.3897/biorisk.3.30>
- Rees WJ, Vervoort W (1987) Hydroids from the John Murray Expedition to the Indian Ocean, with revisory notes on *Hydrodendron*, *Abietinella*, *Cryptolaria* and *Zygophylax* (Cnidaria: Hydrozoa). *Zoologische Verhandlungen* 237: 1–209
- Riouall R, Guiry MD, Codomier L (1985) Introduction d'une espèce foliacée de *Grateloupia* dans la flore marine de l'étang de Thau (Hérault, France). *Cryptogamie. Algologie* 6(2): 91–98
- Rilov G (2016) Multi-species collapses at the warm edge of a warming sea. *Scientific Reports* 6: 36897, <https://doi.org/10.1038/srep36897>
- Rocha RM, Kremer LP, Fehlaue-Ale KH (2012) Lack of COI variation for *Clavelina oblonga* (Tunicata, Ascidiacea) in Brazil: Evidence for its human-mediated transportation? *Aquatic Invasions* 7: 419–424, <https://doi.org/10.3391/ai.2012.7.3.012>
- Rocha RM, Salonna M, Griggio F, Ekins M, Lambert G, Mastrototaro F, Fidler A, Gissi C (2019) The Power of Combined Molecular and Morphological Analyses for the Genus *Botrylloides*: Identification of a Potentially Global Invasive Ascidian and Description of a New Species. *Systematics and Biodiversity* 17: 509–526, <https://doi.org/10.1080/14772000.2019.1649738>
- Schroeder K, Chiggiato J, Bryden H L, Borghini M, Ben Ismail S (2016) Abrupt climate shift in the Western Mediterranean Sea. *Scientific Reports* 6: 23009, <https://doi.org/10.1038/srep23009>
- Steger J, Bošnjak M, Belmaker J, Galil BS, Zuschin M, Albano PG (2021) Non-indigenous molluscs in the Eastern Mediterranean have distinct traits and cannot replace historic ecosystem functioning. *Global Ecology and Biogeography* 31: 89–102, <https://doi.org/10.1111/geb.13415>
- Stuercke B, Freshwater DW (2010) Two new species of *Polysiphonia* (Ceramiales, Florideophyceae) from the western Atlantic. *Botanica Marina* 53: 301–311, <https://doi.org/10.1515/BOT.2010.036>
- Syomin V, Sikorski A, Bastrop R, Köhler N, Stradomsky B, Fomina E, Matishov D (2017) The invasion of the genus *Marenzelleria* (Polychaeta: Spionidae) into the Don River mouth and the Taganrog Bay: Morphological and genetic study. *Journal of the Marine Biological Association of the United Kingdom* 97: 975–984, <https://doi.org/10.1017/S0025315417001114>
- Teaca A, Begun T, Muresan M (2021) Annelid invaders in the Black Sea region: The distribution of *Streblospio gynobranchiata* and first occurrence of *Laonome xeprovala*. *Global Ecology and Conservation* 32: e01920, <https://doi.org/10.1016/j.gecco.2021.e01920>
- Teaca A, Begun T, Menabit S, Muresan M (2022) The First Record of *Marenzelleria neglecta* and the Spread of *Laonome xeprovala* in the Danube Delta-Black Sea Ecosystem. *Diversity* 14: 423, <https://doi.org/10.3390/d14060423>
- Trono GC Jr (2001) Seaweeds. In Carpenter KE, Niem VH (eds), *The Living Marine Resources of the Western Central Pacific, Vol. 1. FAO, Species Identification Guide for Fishery Purposes*, Rome, pp 19–99
- Tsiamis K, Palialexis A, Connor D, Antoniadis S, Bartilotti C, Bartolo GA, Berggreen Ulrik C, Boschetti S, Buschbaum C, Canning-Clode J, Carbonell A, Castriota L, Corbeau C, Costa A, Cvitković I, Despalatović M, Dragičević B, Dulčić J, Fortič A, Francé J, Gittenberger A, Gizzi F, Gollasch S, Gruszka P, Hegarty M, Hema T, Jensen K, Josephides M, Kabuta S, Kerckhof F, Kovtun-Kante A, Krakau M, Kraśniewski W, Lackschewitz D, Lehtiniemi M, Lieberum C, Linnamägi M, Lipej L, Livi S, Lundgreen K, Magliozzi C, Massé C, Mavrič B, Michailidis N, Moncheva S, Mozetič P, Naddafí R, Ninčević Gladan Ž, Ojaveer H, Olenin S, Orlando-Bonaca M, Ouerghi A, Parente M, Pavlova P, Peterlin M, Pitacco V, Png-Gonzalez L, Rousou M, Sala-Pérez M, Serrano A, Skorupski J, Smolders S, Srebalienė G, Stæhr Peter A, Stefanova K, Strake S, Tabarcea C, Todorova V, Trkov D, Tuaty-Guerra M, Vidjak O, Zenetos A, Žuljević A, Cardoso AC (2021) Marine Strategy Framework Directive Descriptor 2, Non-Indigenous Species, delivering solid recommendations for setting threshold values for non-indigenous species pressure on European seas. Publications Office of the European Union, Ispra, 22 pp, <https://data.europa.eu/doi/10.2760/035071>
- Tsirintanis K, Azzurro E, Crocetta F, Dimiza M, Froglija C, Gerovasileiou V, Langeneck J, Mancinelli G, Rosso A, Stern N, Triantaphyllou M, Tsiamis K, Turon X, Verlaque M, Zenetos A, Katsanevakis S (2022) Bioinvasion impacts on biodiversity, ecosystem services, and human health in the Mediterranean Sea. *Aquatic Invasions* 17: 308–352, <https://doi.org/10.3391/ai.2022.17.3.01>
- UNEP/MAP (2017) Action Plan concerning Species Introductions and Invasive Species in the Mediterranean Sea. United Nations Environment Program/Mediterranean Action Plan, Athens, Greece, 14 pp
- Verlaque M, Ruitton S, Mineur F, Boudouresque CF (2015) Macrophytes. In: Briand F (ed), *CIESM Atlas of Exotic species in the Mediterranean Sea, Vol. 4*, CIESM Publishers Monaco, 364 pp

- Vervoort W (1993) Report on hydroids (Hydrozoa, Cnidaria) in the collection of the Zoological Museum, University of Tel-Aviv, Israel. *Zoologische Mededelingen* 67(40): 537–565
- Viard F, Roby C, Turon X, Bouchemousse S, Bishop J (2019) Cryptic diversity and database errors challenge non-indigenous species surveys: an illustration with *Botrylloides* spp. in the English Channel and Mediterranean Sea. *Frontiers in Marine Science* 6: 615, <https://doi.org/10.3389/fmars.2019.00615>
- Virgili R, Tanduo V, Katsanevakis S, Terlizzi F, Villani G, Fontana A, Crocetta F (2022) The Miseno Lake (Central-Western Mediterranean Sea): An Overlooked Reservoir of Non-Indigenous and Cryptogenic Ascidiaceans in a Marine Reserve. *Frontiers in Marine Science* 9: 866906, <https://doi.org/10.3389/fmars.2022.866906>
- Wolf MA, Buosi A, Juhmani A-SF, Sfriso A (2018) Shellfish import and hull fouling as vectors for new red algal introductions in the Venice Lagoon. *Estuarine, Coastal and Shelf Science* 215: 30–38, <https://doi.org/10.1016/j.ecss.2018.09.028>
- Zenetos A, Konstantinou F, Konstantinou G (2009) Towards homogenization of the Levantine alien biota: additions to the alien molluscan fauna along the Cypriot coast. *Marine Biodiversity Records* 2: 1–7, <https://doi.org/10.1017/S1755267209990832>
- Zenetos A, Katsanevakis S, Poursanidis D, Crocetta F, Damalas D, Apostolopoulos G, Gravili C, Vardala-Theodorou E, Malaquias M (2011) Marine alien species in Greek Seas: additions and amendments by 2010. *Mediterranean Marine Science* 12: 95–120, <https://doi.org/10.12681/mms.55>
- Zenetos A, Çinar ME, Crocetta F, Golani D, Rosso A, Servello G, Shenkar N, Turon X, Verlaque M (2017) Uncertainties and validation of alien species catalogues: The Mediterranean as an example. *Estuarine, Coastal and Shelf Science* 191: 171–187, <https://doi.org/10.1016/j.ecss.2017.03.031>
- Zenetos A, Albano PG, Lopez Garcia E, Stern N, Tsiamis K, Galanidi M (2022) Established non-indigenous species increased by 40% in 11 years in the Mediterranean Sea. *Mediterranean Marine Science* 23(1), <https://doi.org/10.12681/mms.29106>
- Zettler ML, Daunys D, Kotta J, Bick A (2002) History and success of an invasion into the Baltic Sea: the polychaete *Marenzelleria* cf. *viridis*, development and strategies. In: Leppäkoski E, Gollasch S, Olenin S (eds), *Invasive Aquatic Species of Europe. Distribution, Impacts and Management*. Kluwer Academic, Dordrecht, The Netherlands, pp 66–75, https://doi.org/10.1007/978-94-015-9956-6_8
- Zibrowius H, Bitar G (2003) Invertebres marins exotiques sur la côte du Liban. *Lebanese Science Journal* 4: 67–74

Web sites and online databases

- Fofonoff PW, Ruiz GM, Steves B, Simkanin C, Carlton JT (2018) National Exotic Marine and Estuarine Species Information System. <http://invasions.si.edu/nemesis/> (accessed 19 December 2021)
- Guiry MD, Guiry GM (2019) AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. <https://www.algaebase.org> (accessed 1 January 2022)

Supplementary material

The following supplementary material is available for this article:

Table S1. Dataset of unpublished Mediterranean and Black Sea Records of alien, cryptogenic, and nonnative species.