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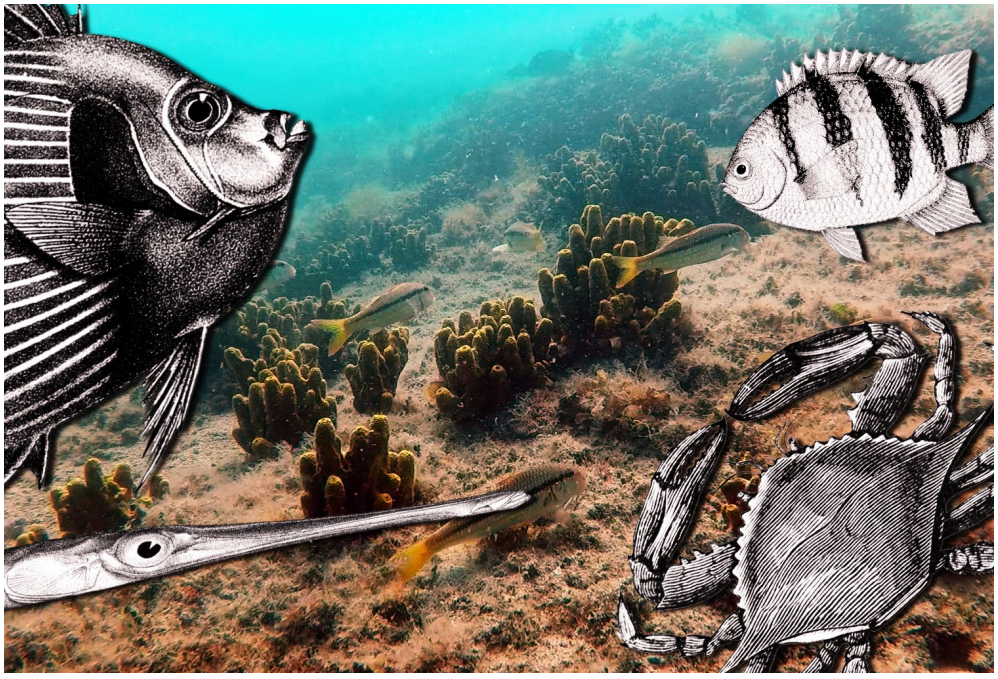

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HANDBOOK ON ALIEN DECAPOD CRUSTACEANS AND NEW FISHES OF THE ADRIATIC SEA

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Ecosystem biodiversity is being altered worldwide by species losses due to human activities, climate change and species gains through introductions. The Mediterranean Sea makes no exception and its marine biodiversity is currently undergoing substantial structural changes. The Adriatic Sea, central Mediterranean, as a semi-enclosed basin is heavily affected by anthropogenic actions such as intense fishing activity, aquaculture, shipping, pollution and tourism, is particularly prone to such invasions. During the last few decades, various factors – including climate change, anthropogenic activity and Lessepsian migration – have altered the composition of Adriatic flora and fauna: extensive investigations have revealed species not previously recorded or reported in the area. In this framework since 1999, the FAO AdriaMed project "Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea" (GCP/RER/010/ITA), has launched several activities, aimed at encouraging and sustaining a smooth process of international collaboration between the Adriatic Sea coastal countries. This was pursued through, inter alia, the identification and implementation of shared methodologies and research activities aimed at monitoring the fish diversity and exotic species occurrence in the Adriatic Sea. Within the framework of the FAO AdriaMed Working Group on Small Scale Fisheries, a survey based on the Local Ecological Knowledge methodology with interviews to fishers was launched. The objective was to monitor the occurence of non indigenous species in the Adriatic Sea, since 2014. This handbook stems from the survey experience and on the need identify and collect the recent information on the new species occuring in the Adriatic Sea.

The aim of this handbook is to compile and describe fish species whose presence in the Adriatic Sea was recorded only recently, and which are not included in the former available checklist of Adriatic fishes by Jardas (1996). For decapod crustaceans, only alien species found in the Adriatic Sea after the Second World War are dealt with.

The preparation of this publication was initiated by Jakov Dulčić Head of Laboratory- and Branko Dragičević, Senior Research Associate at the Laboratory of Ichtyology and Coastal Fishery- Institute of Oceanography and Fisheries of Split (Croatia). The publication was funded through the FAO AdriaMed Project.

External revision was provided by Dr Carlo Froglia, on the crustaceans section and Dr Ernesto Azzurro on the fish section (both from the Institute for Biological Resources and Marine Biotechnologies (IRBIM) – National Research Council (CNR) Italy). External editing was provided by Dr Evan Jeffries, FAO Consultant (English grammar and technical editing). Final editing and publication was facilitated by Chorouk Benkabbour (Communication specialist [publications], NFISI) and Ms Nicoletta Milone (Fisheries Information Officer, NFIFM).

Abstract

This document reviews and compiles the scientific information available on the new and non indigenous fish and decapod crustaceans species in the Adriatic Sea, central Mediterranean Sea. For fish, the new species are those whose presence in the Adriatic Sea was recorded recently, since the year 2000. For decapod crustaceans, only alien species found in the Adriatic Sea after the Second World War are dealt with. In total, 15 crustaceans and 52 fish species were selected and presented in this handbook. Following an introductory section, giving a general overview on the Adriatic Sea geographical characteristics, this document reviews, in its first part, the ichthyofauna and decapod crustaceans in the area. The second part of the document provides a description of each new species including synonyms, meristic formula, main morphologic features, bio-ecology, knonw geographical distribution, relevance and reference literature. This work was designed and implemented within the framework of the FAO-AdriaMed Project "*Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea*".

Contents

Acknowledgements

The idea of creating this handbook came about during local ecological knowledge (LEK) surveys with fishers in Montenegro (Rafailovići) and Albania (Durrës), carried out in the framework of the FAO AdriaMed Project 'Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea'. It partly relies on the book *Nove ribe Jadranskoga i Sredozemnog mora* (authors: J. Dulčić and B. Dragičević), which was used as a field guide to identify fish species and to differentiate between similar taxa on the basis of morphological details.

The Authors would like to thank all who have in any way contributed to the creation of this handbook, and acknowledge the important contribution of the FAO AdriaMed project, which provided conceptual and financial support for the publication of this work. The Authors owe great gratitude to Enrico Arneri and Nicoletta Milone who initiated and supported the idea of creating such a handbook. Special thanks go to the reviewers, Carlo Froglia and Ernesto Azzurro, for their helpful commentary and recommendations that contributed to the quality of the work.

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Jakov Dulčić
Branko Dragičević
Split, Croatia
September, 2022

This handbook is dedicated to all the researchers, carcinologists and ichthyologists who have contributed to knowledge of the fauna of the Adriatic Sea.

The authors

1. Introduction

1.1 THE ADRIATIC SEA

The Adriatic Sea, located in the north of the Mediterranean, is a semi-enclosed basin characterized by specific hydrological and biological properties. It is limited at its northern end by the lagoonary channel system around Venice and Trieste, while in the south it ends at the Strait of Otranto where it connects to the Ionian Sea. The Adriatic is generally considered a shallow sea, with an average depth of 231 m. The bottom, extending over an area of about 102 415 km^2, gradually decreases in depth from south to north. Most of the bottom (73 percent) lies on the continental shelf at depths of up to 200 m, while a significantly smaller portion is on the continental slope. This is one of the largest shelf areas in the Mediterranean Sea. Depths in the northern and middle Adriatic do not usually exceed 100 m, except for the area of the Jabuka/Pomo Pit (middle Adriatic) where the depth reaches 273 m. Greater depths are reached in the southern Adriatic, down to a maximum of 1 230 m in the South Adriatic Pit. The Adriatic Sea stretches some 800 km from its southernmost to its northernmost part, with an average width of 160 km. In the south, it is separated from the Ionian Sea by the 72 km-wide Strait of Otranto, where a submarine sill reaches depths of about 800 m (Ott, 1991; Jardas, 1996).

There are numerous islands along the eastern coast of the Adriatic, while there are relatively few on the western shore. Both coasts have unique morphological and topographical properties: the eastern coast is composed of limestone, with a steep and narrow shelf which deepens fast; while the western coast has a wider shelf because of sediments accumulation from the Po River, the largest river discharge in the Adriatic Sea. Variability of this inflow is a determining factor for a number of properties of the north Adriatic, including temperature, salinity and transparency. The sea floor of the Adriatic shelf is mostly covered with muddy and sandy sediments.

The Adriatic is considered a temperate warm sea, but there is a significant difference between its northern and southern parts. Its thermohaline properties are determined mainly by air-sea interaction, water exchange through the Otranto Strait, river discharges, mixing, currents, and the topography of the basin. The annual mean temperature at the surface is 18 °C in the south and 25 °C in the north. The extremes of surface temperature range from 6 °C to 29 °C, while temperatures of even the deepest layers are for the most part above 10 °C. The south Adriatic is 8–10 °C warmer than its middle and northern parts during winter. In other seasons the horizontal temperature distribution is more uniform. Generally, the open sea is warmer than the coastal waters (Jardas, 1996).

Salinity in the Adriatic is relatively high, and its ranges are significant. The southern part has salinity between 38.4 and 38.9‰, and levels are especially high in the intermediate layer. In the northern part and in the coastal zones salinity is lower, and also more variable. The lowest salinity is found close to the mouth of the Po River in the northern Adriatic. Generally, salinity decreases from south to north and from the open sea to the coast. Long-term measurements in the coastal and open waters of the middle and south Adriatic showed salinity increasing up to 1993/94 (Zore-Armanda *et al.*, 1999). This phenomenon probably played an important role in the appearance of some rare fish in the Adriatic, together with considerable year-to-year variability in sea surface temperature (SST) as detected across three different locations over time (Dubrovnik, Split, Trieste) (Dulčić *et al.*, 1999).

Currents in the Adriatic are generally low in speed and variable in direction, with the current field showing a simple cyclonic circulation regime. Generally, streamlines follow the isobath lines along both coasts, but wavelike patterns or meanders also appear, influenced by the topography of the middle Adriatic (the Palagruža Sill). The observed yearly-averaged circulation of the Adriatic Sea is characterized by an overall cyclonic circulation (Orlić *et al.,* 1992) consisting of two permanent gyres. The first cyclonic gyre is situated over the northern shallow shelf and the Jabuka Pit region of the middle basin. The second gyre covers the southern deep basin and is isolated from the northern part by the Palagruža Sill (Bergamasco *et al.,* 1999). An important hydrological process connecting the water mass of the Adriatic Sea with the rest of the Mediterranean is the Bimodal Oscillating System (BiOS) mechanism that changes the circulation of the North Ionian Gyre (NIG) from cyclonic to anticyclonic and vice versa on a decadal timescale (Civitarese *et al.*, 2010). This mechanism controls the influx of water that originates from the Ionian Sea and/or the central Mediterranean into the Adriatic Sea, respectively depending on whether the regime is cyclonic or anticyclonic. Beside its influence on hydrology, this mechanism also affects biodiversity. It has been shown that an increased abundance of some organisms in the Adriatic Sea – or their first appearance – might be related to BiOS regimes (inflow of water from the western Mediterranean/Atlantic or the eastern Mediterranean) (Civitarese *et al.*, 2010; Batistić *et al.*, 2014). The presence of various thermophilic species had previously been attributed to 'Adriatic ingressions', but the phenomenon is now better explained through BiOS mechanisms (Buljan, 1953; Pallaoro, 1988; Civitarese *et al.*, 2010). The influx of warmer, nutrient-rich and more saline Ionian waters has not only contributed to the presence of some rare and non-indigenous species in Adriatic waters, but has had a profound influence on Adriatic biodiversity in general.

The northern part of the Adriatic Sea is one of the richest fishing grounds in the Mediterranean. Thanks to rich river inflows over its shallow shelf and the mixing of bottom sediments, it is the most productive part of the Adriatic basin. The middle and southern Adriatic are less productive, but their exposure to the north Adriatic and to the periodically significant influence of Mediterranean waters enables periods of high productivity in these areas as well. The open waters of the Adriatic are important fishing areas, mainly for pelagic fisheries. In particular, the areas off Ancona and around Palagruža Sill are both known as rich fishing grounds for these fisheries.. The coastal area of the eastern Adriatic is traditionally an important fishing area for artisanal and recreational fisheries. These coastal areas are generally more productive than the open sea, due to the significant influence of the land and large fresh-water inflows in certain locations (Jardas, 1996).

The present-day flora and fauna of the Adriatic Sea are the result of numerous geological, geographical, climatic and biological processes which occurred during its formation. The influence of geographical, geomorphological, climatic and other environmental factors is crucial even today; indeed the peculiarities of Adriatic ichthyofauna stem from these factors. Although the Adriatic Sea is part of the Mediterranean, it is an independent biogeographical and ecological subunit, with its own unique composition and communities of marine life.

The Adriatic Sea is one of the best investigated biogeographic regions in the Mediterranean Sea, with numerous research facilities along its coastline. Even so, new taxa of marine flora and fauna, previously unknown in the Adriatic, are being recorded each year (Dragičević and Dulčić, 2010).

Ecosystem biodiversity is being altered worldwide by species losses due to human activities and species gains through introductions, and the marine biodiversity of the Mediterranean Sea is currently undergoing substantial structural changes (Coll *et al.*, 2010). Beside numerous other factors, it is rapidly changing through the arrival of increasing numbers of non-indigenous species. The bio-invasion of the Mediterranean encompasses nearly all

the major marine taxonomic groups, and is considered a significant threat to the structure and function of its biodiversity (Lipej and Dulčić, 2004; Zenetos *et al.*, 2010). Öztürk (2021) reported that more than 900 non-indigenous species have been introduced to the Mediterranean Sea. The Adriatic Sea, as an enclosed sea heavily affected by anthropogenic actions such as intense fishing activity, aquaculture, shipping, pollution and tourism, is particularly prone to such invasions. During the last few decades, various factors – including climate change, anthropogenic activity and Lessepsian migration – have altered the composition of Adriatic flora and fauna: extensive investigations have revealed species not previously recorded or reported in the area (Dulčić and Grbec, 2000; Lipej and Dulčić, 2004; Dulčić and Dragičević, 2011a; Pečarević *et al.*, 2013).

Eighty-nine decapod and two stomatopod species have been recorded as 'exotic' in the Mediterranean Sea (Galil *et al.*, 2015). The number of non-indigenous fishes recorded in the Mediterranean Sea is increasing, and the present number is probably higher than the 168 species (Zenetos *et al.*,2010; Kovačić *et al.*, 2021).

'Non-indigenous (alien, exotic) species' (NIS) is a term here used for species found outside their native distribution range and out of their natural expansion range, and whose presence in the Adriatic Sea is due to intentional or non-intentional introduction mediated by humans. Species introduced by various vectors (shipping, aquaculture, aquariology, artificial channels etc.) fall under this definition. It includes species which have come from the Red Sea through the Suez Canal (Lessepsian species), whereas it excludes Atlantic species which have arrived autonomously through the Gibraltar Strait into the Mediterranean Sea (Dulčić and Dragičević, 2011a). 'Invasive' is a term mostly (but not exclusively) used for non-indigenous species whose presence does or is likely to cause damage to the environment, economy, public health or other human values. A non-native species might be considered invasive in one region but not in another. Whether or not a species is considered as invasive depends largely on human values, and classification is often not straightforward.

The aim of this handbook is to present those species whose presence in the Adriatic Sea was recorded only recently, with year 2000 taken as a reference year. Namely, all fish species which were for the first time recorded in the Adriatic Sea in and after year 2000 were considered. Those species which were recorded before 2000, but their records published afterwards were not taken into account. When this handbook was conceived in 2018, the original idea was to present those fish species not described in, at that time, the latest monograph on the the checklist of Adriatic marine fishes by Jardas (1996). In 2020, Dulčić and Kovačić published a new monograph making the idea obsolete and urging the revision of the manuscript. For decapod crustaceans, only non-indigenous species found in the Adriatic Sea after the Second World War were taken into account.

1.2 ADRIATIC DECAPOD CRUSTACEANS

Many carcinologists have contributed to a long tradition of research and numerous investigations have been undertaken in the Adriatic Sea to gain an insight into the assemblages of its decapod crustaceans (Crustacea: Decapoda). Such investigations started very early: the first documented observations on Adriatic decapod fauna were made in 1524 by Giovio (syn.: Jovius). Ševčić (1993) defined three distinct periods of significant carcinological research activity in the Adriatic Sea: the "post-Linnean period" (1763–1846), the "Sinonimia-moderna period" (1847–1968), and the "current period" (1969–present). Intensive scientific surveys of the Adriatic Sea have revealed a constantly increasing number of decapod species that have been noted for the first time in this region. Among the most important publications on this issue are those of Olivi (1792), Heller (1863), Nardo (1847, 1869), Stalio (1877), Graeffe (1902) and Pesta (1918) (see all references in Ševčić, 1993), which

have made a considerable contribution to knowledge not only of the decapod crustaceans in the Adriatic and Mediterranean Sea, but also in a general context. Števčić (1990) published a complete checklist of Adriatic decapods that has since been twice updated (Števčić, 1995; 2002). An additional 20 species have been recorded for the first time since the most recent update. Descriptions of new species (the majority of new species added to the list of Adriatic forms were obtained by a revision of the already well-known genera occurring in the area) and immigration of species from other geographic regions are the main factors behind these additional records (Števčić, 2002). Froglia (1995, 2010) published checklists of Malacostraca recorded in the Italian seas which include species occurring in the Adriatic Sea. In recent years decapodologists working in the area have been very active, and have contributed to the increasing number of known Adriatic decapod species (Mizzan, 1993, 1995; Mizzan and Zanella, 1996; Ungaro, 2000; Ungaro and Marano, 2002; Vukanić, 2003; Ungaro *et al.*, 2005; Kasalica and Joksimović, 2005; Kasalica, 2006; Kasalica *et al.*, 2006). The enormous progress in knowledge comes from no fewer than 70 contributions published in a relatively short period of just under 40 years (see Števčić, 1993, 2002).

Many neobiota, among them many Decapoda, gained entry to Mediterranean littoral habitats in previous decades and established stable populations, partly by invading neighbouring regions. One interesting recent example is the spread in the Mediterranean of the Atlantico-tropical crab *Percnon gibbesi* (H. Milne Edwards, 1853), a highly mobile member of the Plagusiidae. In total, six neozoic decapod species – the swimming crabs *Callinectes danae* Smith, 1869, *Callinectes sapidus* Rathbun, 1896 and *Dyspanopeus sayi* (Smith, 1869); the brackish water-inhabiting panopeid crab *Rhithropanopeus harrisii* (Gould, 1841); the sea spider *Maja goltziana* d'Oliveira, 1888; and the penaeid shrimp *Penaeus japonicus* Bate, 1888 – have been observed in the Adriatic Sea (Števčić, 2002). The first four of these species are known to originate from the northwest Atlantic, whereas *Maja goltziana* was previously known in the tropical East Atlantic and the southern sector of the Mediterranean. The capture off the Gargano peninsula of a single individual of *Penaeus japonicus,* an Indo-Pacific species (Lumare and Casolino, 1986), was due to a massive seeding of the nearby Lesina coastal lake with juveniles hatched from adults imported from Japan (see: Lumare and Palmegiano, 1980; Lumare and Hiramatsu, 1982).

Kirinčić and Števčić (2008) presented a list of new records of decapod crustaceans for the Adriatic Sea following the latest supplement presented by Števčić (2002). All species mentioned are known in the Mediterranean Sea or the Eastern Atlantic Ocean. These are: *Plesionika gigliolii* (Senna, 1902); *Hippolyte prideauxiana* Leach, 1817; *Hippolyte varians* Leach 1814; *Brachycarpus biunguiculatus* (Lucas, 1846); *Scyllarus caparti* Holthuis, 1952; *Callianassa truncata* Giard and Bonier, 1890; *Pagurus chevreuxi* (Bouvier, 1896); *Munida tenuimana* Sars, 1872 sin. *Munida perarmata* A. Milne-Edwards & Bouvier, 1894; *Munida rutllanti* Zariquiey Alvarez, 1952; *Calappa tuerkayana* Pastore, 1995; *Pinnotheres marioni* Gourret, 1887; *Hemigrapsus sanguineus* (de Haan, 1835); *Eriocheir sinensis* H. Milne Edwards, 1854 (see Kirinčić and Števčić, 2008 for references). *Munida perarmata* A. Milne-Edwards and Bouvier, 1894 needs further confirmation (D'Udekem d'Acoz, 1999; Ungaro *et al.*, 2005) as first record. Additionally, *Paragalene longicrura* (Nardo, 1868) has also been found recently, a long time after its description in its *locus typicus* – in middle Dalmatia (Pallaoro, 2005), and a few additional specimens were collected in the southern and middle Adriatic (Pallaoro, pers. comm.). Froglia (2017) recently presented a full list of non-indigenous species of decapod crustaceans recorded in the Adriatic Sea.

During the last 25 years several species from North American and Asian waters have been reported in the Mediterranean Sea (Galil *et al.*, 2002). Eight such species were reported in the Adriatic Sea (see Kirinčić and Števčić, 2008; Froglia, 2010). These are *Marsupenaues japonicus*, *Scyllarus caparti*, *Dysanopeus sayi*, *Rhithropanopeus harrisii*, *Callinectes danae*, *Callinectes*

sapidus, *Hemigrapsus sanguineus*, and *Eriocheir sinensis*. The vector of introduction for these immigrant species is probably related to shipping (transported in ballast waters), except for *Penaeus japonicus* Spence Bate, 1888, which was a mariculture-related introduction, and *Scyllarus caparti* Holthuis, 1952, which was probably released from an aquarium (Kirinčić and Števčić, 2008). Among exotic species there is a distinction to be drawn between those with only one or a few records, and those with established populations. Species like *Dyspanopeus sayi* (Smith, 1869), *Rhithropanopeus harrisii* (Gould, 1841), *Percnon gibbesi* (H. Milne Edwards, 1853) and *Callinectes sapidus* Rathbun, 1869 have established populations in the Adriatic Sea. All other species can be considered alien because they are only occasionally found in the area. In addition, a specimen of *Farfantepeaneus aztecus* (Ives, 1891) was recorded in Montenegrin waters in 2013 (Marković *et al.*, 2014). It seems that since then this species has become established in the Adriatic, as several specimens were collected in the western Adriatic between Ancona and San Benedetto del Tronto (depth 20–40 m) in 2016 (Froglia, pers. comm.). The presence of this species in the Mediterranean is probably due to maritime traffic (i.e. ballast waters). No Lessepsian migrant crabs have yet been reported in the Adriatic Sea.

Decapod crustaceans which can be considered non-indigenous (alien, exotic) and whose presence was reported at least once in the Adriatic Sea since the Second World War are presented in this handbook.

1.3 ADRIATIC ICHTHYOFAUNA

1.3.1. A brief history of Adriatic ichthyology

Investigations on Adriatic ichthyofauna began in the eighteenth century with the book *Ichthyologia massiliensis* (Brünnich, 1768; cited in: Jardas, 1985). Several checklists of Adriatic fish species were provided by authors working during the nineteenth and twentieth centuries (e.g. Naccari, Nardo, Martens, Lanza, Carrara, Plučar, Stosich, Kolombatović, Brusina, Kosić, Zei, Bini, Tortonese, Šoljan, Grubišić, reviewed in Jardas, 1985). In 1877, the *Bibliografia cronologica della fauna del Mare Adriatico* by Giandomenico Nardo ('Chronological bibliography of the fauna of the Adriatic Sea', Nardo, 1877), provided a detailed revision of all the faunistic studies carried out in the Adriatic Sea and lagoons from the sixteenth century to the year 1875. Concise descriptions of these investigations are given with reference to species of fish, molluscs, crustaceans and "sea stones". The naturalist Stefano Chiereghin (1745–1820) wrote the manuscript *Descrizione dè Pesci, dè Crostacei e dè Testacei che abitamo le lagune e il Golfo Veneto* ('A description of the Fishes, Crustaceans and Molluscs inhabiting the lagoon and the Gulf of Venice'), which is today held in the Biblioteca Marciana of Venice. This work is based on 40 years of studies carried out in the lagoon of Venice and its gulf, from 1778 to 1818. It contains accurate drawings and detailed descriptions of 774 species of crustaceans, molluscs, echinoderms and fishes, 455 of which were being described for the first time, and is collected in 12 handwritten volumes. These were printed in 2001 in two volumes (text and plates), edited by Cinzio Gibin. Spiridion Brusina (1845–1908), the Croatian naturalist and one of the greatest Darwinists of his time, wrote some very interesting reports on fishes, sea mammals and gastropod molluscs (*Sharks of the Mediterranean and Black Sea* in 1888; *About fisheries in Dalmatia* in 1888; *Sea mammals of the Adriatic Sea* in 1889; *Fish, known as 'milk' in Dalmatia* in 1889; *Our sturgeons* in 1902). Juraj Kolombatović, the renowned Croatian naturalist, was most successful in his ichthyological research, the field in which he discovered and described nine new fish species (five goby species, three blenny species, and one species of the family Gadidae).

The first systematic study of Adriatic ichthyofauna began in the first quarter of the 19th century, when several fish species were described for the first time, but the most important and comprehensive lists were presented in the twentieth century. Tonko Šoljan (1948), an

internationally renowned scientist, ichthyologist and expert on Adriatic fisheries, wrote the significant monograph *Ribe Jadrana* ('Fishes of the Adriatic'), which has been translated into English and Italian. He also initiated and led the HVAR scientific expedition and contributed to Adriatic marine research and fisheries development. Grubišić (1982) wrote a book called *Ribe, rakovi i školjke Jadrana* ('Fishes, crabs and shells of the Adriatic') which presents a comprehensive overview of some economically important fishes, crustaceans and shells. Županović and Jardas (1989) presented a monograph on *Flora i Fauna Jadrana-Jabučka kotlina* ('Fauna and Flora of the Adriatic Sea-Jabuka Pit'). A complete list of Adriatic icthyofauna was presented by Jardas (1996) in *Jadranska ihtiofauna* ('Adriatic ichthyofauna'). Lipej and Dulčić presented an updated checklist of Adriatic Sea fishes in 2010. The first comprehensive list of new Adriatic ichthyofauna was presented in the book *Nove ribe Jadranskog i Sredozemnog mora* ('New fishes of the Adriatic and Mediterranean Sea') by Dulčić and Dragičević (2011a).

The Adriatic is therefore a well studied sea, with centuries of ichthyological tradition (Lipej and Dulčić, 2004). The number of fish species recorded in the area is increasing with new discoveries and advances in research. In the monograph about fish of the Adriatic published by Šoljan (1948), 365 fish species were described. Almost half a century later, Jardas (1996) described 407 fish species in his *Adriatic ichthyofauna*.

1.3.2. Current Adriatic ichthyofauna

The recent influx of non-indigenous fish species combined with the effects of climate change and a general increase in scientific studies and reports on marine species has significantly increased the number of fish species recorded in the Adriatic Sea, which reached 429 in 2004 (Lipej and Dulčić, 2004), 440 in 2010 (Lipej and Dulčić, 2010) and, according to the most recent literature, established nowdays at 449 (Lipej *et al.*, 2022). This number is very close to the numbers presented by Psomadakis *et al.* (2012) for the Ligurian (454 species), north Tyrrhenian (426) and south Tyrrhenian seas (447). However, it should be noted that the majority of the southern Adriatic basin has still not been sufficiently explored and knowledge of its deep demersal ichthyofauna is relatively poor (Lipej and Dulčić, 2004). There are also some unsolved systematic (taxonomic) and status issues regarding the historical presence of certain fish species that were thoroughly reviewed by Kovačić *et al.*, 2020.

About 58 percent of all species presently known in the Adriatic are of Atlanto-Mediterranean origin, 21 percent are of wider global occurrence, 15 percent are Mediterranean or Mediterranean and Black Sea endemics, while the origin of 5 percent of the species is outside Mediterranean Sea. Most of the Atlanto-Mediterranean species (49 percent) are restricted to the Eastern Atlantic, only 9 percent being amphiatlantic (Lipej *et al.*, 2022). The majority of species inhabit the benthic environment (71.9 percent), while others occur in the pelagic environment (20.7 percent) or are euryhaline (7.3 percent). The benthic littoral species are the most numerous Adriatic fishes, representing 40 percent of all species richness, whereas pelagic fishes are mainly eurybathic or epipelagic; only 3.6 percent of species are deep pelagic species (Lipej *et al.*, 2022).

Looking at the intra-Adriatic distribution, most species (56.5 percent) occur throughout the Adriatic Sea, while others are distributed in the middle and southern sectors (16.7 percent) or only in the southern part (15.8 percent). Species richness decreases from south to north, and significant changes can be observed in the faunal composition of the three major subsectors (northern, middle and southern Adriatic). The ichthyofauna of the northern Adriatic is typically characterized by boreal elements (genera such as *Sprattus, Scopthalmus*, *Merlangius*), while the middle and southern sectors are enriched by thermophilic species (genera such as *Thalassoma, Sparisoma, Epinephelus*). Some bathyphilic elements occur in the Jabuka Pit in the

middle Adriatic, and many others in the deep southern Adriatic. The southern sector of the basin is also characterized by other thermophilic elements, which are not found in the rest of the Adriatic (Jardas, 1996; Lipej and Dulčić, 2010; Dulčić *et al.*, 2017).

The most dominant families are Gobiidae (48), Labridae (17), Sparidae (23), Blenniidae (17) and Myctophidae (15) (Lipej et al, 2022). Judged by the number of fish species, the Adriatic is one of the world's richer seas – although on the basis of the density of populations and its capacity for exploitation, it can also be compared with poorer seas (Dulčić *et al.*, 2017).

The majority of the Adriatic fishes related to the benthic environment are benthic littoral species, representing 56 percent of all benthic fish diversity and 40 percent of total Adriatic fish diversity. Species occurring both in the littoral and in bathyal area represent 37 percent of all benthic fish diversity and 27 percent of total Adriatic fish diversity, and exclusive bathyal species represent 7 percent of all benthic fish diversity and 5 percent of total Adriatic fish diversity (Lipej *et al.*, 2022).

New techniques and greater research efforts (citizen science, advanced field techniques, deep sea trawling etc.) are increasingly revealing overlooked species or populations in the Adriatic Sea. Cooperation between ichthyologists, divers, underwater photographers and especially fishers offers new opportunities to monitor the occurrence of fish species in the marine environment. Partnerships of this kind have been recognized – at both political and scientific levels – as crucial for developing monitoring programmes. Other approaches involve *in situ* observations by means of traditional fishing surveys (Lipej and Dulčić, 2004, Dulčić *et al.*, 2017) or non-destructive techniques such as underwater visual censuses (Harmelin 1987; Harmelin-Vivien and Francour, 1992) and remotely operated vehicles (ROVs) for deep explorations (Lipej and Dulčić, 2004).

Visual censuses in coastal areas have allowed the identification of species previously overlooked in Adriatic studies, especially cryptobenthic fish species such as clingfishes (Gobiesocidae), gobies (Gobiidae) and blennies (Blenniidae) which are generally hidden under stones, or in cracks, crevices and cavities in rocky habitats. However, current lists of Adriatic fishes may also include species that no longer exist in the subregion, species that have become very rare, and/or species that are considered as critically endangered. This is well explained by the *Red book of the sea fishes of Croatia* (Jardas *et al.*, 2008), which summarizes the available knowledge on 123 fish taxa, representing roughly 27 percent of all Adriatic fish species. According to this book, three species – *Acipenser sturio, Argyrosomus regius* and *Squatina oculata* – are considered as regionally extinct. Five species (four sharks and one ray: *Squatina squatina, Isurus oxyrinchus, Lamna nasus, Carcharias taurus* and *Dipturus batis*) were listed as critically endangered (Jardas *et al.*, 2008). Another five sharks (*Carcharodon carcharias, Cetorhinus maximus, Galeorhinus galeus, Oxynotus centrina* and *Carcharhinus plumbeus*) were listed as endangered, together with three bony fishes (*Aphanius fasciatus, Epinephelus marginatus* and *Alosa fallax*) (Jardas *et al.*, 2008). The percentage of endangered species (in categories such as critically endangered, endangered and vulnerable) in the Adriatic Sea is considerably higher than in other Mediterranean subregions (Abdul Malak *et al.*, 2011). Unfortunately, only a quarter of all Adriatic fish species were evaluated in the Red Book, mainly because of a lack of data. This is especially true for mesopelagic and bathypelagic species, cryptobenthic, vagrant and generally rare species. Finally, some species have not been recorded for more than 50 years, which gives rise to some doubts about their actual occurrence in the Adriatic Sea. This is the case for the blenny *Salaria basilisca,* which was recorded only once in Piran, Slovenia (Dulčić *et al.*, 2006a).

1.3.3. Recent modifications of Adriatic ichthyofauna

Adriatic biota are currently subject to two rapid processes of change, which are often reported in the scientific literature under the terms "meridionalization" and "tropicalization". Meridionalization is generally interpreted as a temperature-related process, which consists of the northward expansion of native thermophilic fish previously distributed only in southern areas. Such changes in species distribution have been observed in different parts of the Mediterranean (see Francour *et al.*, 1994) and also in the Adriatic Sea (Dulčić *et al.*, 1999; Lipej and Dulčić, 2004). The abundance and distribution of thermophilic fish can be a useful indicator of warming-related effects, due to the mobility of these species and their inability to regulate their body temperature (Stebbing *et al.*, 2002). One of these is the triggerfish (*Balistes capriscus*), whose distribution was previously limited to the southern Adriatic Sea but which is now reasonably common along almost the entire eastern Adriatic coast (although it remains relatively rare in its northern part). Another frequently cited example of meridionalization is the ornate wrasse (*Thalassoma pavo*), a thermophilic fish which is expanding northwards and which was recorded in waters off Pula at the very tip of the Istrian peninsula in the northern Adriatic in September 2008. Other native and increasingly successful thermophilic fishes include the Mediterranean parrotfish (*Sparisoma cretense*), which has increased its abundance in the south-eastern Adriatic; the dolphin fish (*Coryphaena hippurus*), which regularly occurs in the middle and northern Adriatic; the blue runner (*Caranx crysos*), whose juveniles have recently been observed in the southern Adriatic which indicates the possibility of a permanent population (Dulčić *et al.*, 2014 c); and the bluefish (*Pomatomus saltatrix*), which has become abundant along both the eastern and western coasts.

At the Mediterranean level, the most important pathway for species introduction is the Suez Canal (Galil *et al.*, 2017; Zenetos *et al.,* 2017), which has already caused tremendous changes in the structure and composition of Eastern Mediterranean biota. This process, generally known as "Lessepsian" migration (after Ferdinand Marie De Lesseps, the French engineer responsible for the opening of the Suez Canal in 1869), is increasingly evident in the Adriatic Sea, especially its southern part. Again, temperature is considered as the most important abiotic factor influencing the arrival and increasing success of Lessepsian species (Dulčić and Lipej, 2015). Many organisms of Lessepsian origin have been recorded in the Adriatic Sea, including 15 Lessepsian fishes. Although most of those Lessepsian fishes have been recorded only once in the Adriatic, some species such as *Fistularia commersonii, Lagocephalus sceleratus, Stephanolepis diaspros, Siganus luridus, Bregmaceros nectabanus* and *Pterois miles* have multiple confirmed records and possibly have the potential to establish viable populations mainly in the southern Adriatic. This seems to be the case with the dusky spinefoot *S. luridus*, herbivorous species originally distributed in tropical and subtropical waters of the Indian and Pacific Oceans that is capable of developing abundant populations with considerable impacts on coastal habitats as is the case in many areas of the eastern Mediterranean including Ionian Sea. The dusky spinefoot has recently been observed in larger numbers in the southern Adriatic (Molunat Bay), indicating the establishment of a population in the area. Because of its poisonous spines, fishers need to handle *S. luridus* carefully to avoid painful stings. One other important invader is the silver-cheeked toadfish *L. sceleratus*, one of the most invasive species in the Mediterranean and Europe where it is rapidly expanding its distribution. This species is highly toxic for human consumption because it contains high levels of the poison tetrodotoxin. So far it has been reported several times in Adriatic waters (Dulčić and Dragičević, 2014; Azzurro *et al.*, 2018), and concern is growing over the further expansion of this new species. There is also *F. commersonii*, a tropical species native to the Indian Ocean and the Pacific Ocean that spreads in the Mediterranean Sea since its first confirmed record in 2000. Due to the speed of its geographic spread, it is seen as one of the most invasive species in the Mediterranean Sea. It is a voracious predator that mainly feeds on crustaceans, molluscs and small fish but poses no dangers to human

health. Despite the observation of juveniles (Dulčić *et al.*, 2013), indicating the presence of reproductive populations in or near the Adriatic Sea, very few confirmed sightings of this species occurred after 2013. *Stephanolepis diaspros* was recently reported in Slovenian waters by Kapiris *et al.* (2014), but there is no strong evidence to support the hypothesis of an established population of this species in the Adriatic Sea.

Notable newcomers include the lessepsian immigrants *Pterois miles* and *Bregmaceros nectabanus*, as well as species from the genus *Abudefduf*. The presence of the highly invasive *P. miles* is of concern due to the potential negative impacts of this species, and containment measures should be considered. Several records of this species have already been recorded in the period 2019-2021 (Di Martino and Stancanelli, 2021, Dragičević *et al.*, 2021). *Bregmaceros nectabanus* is another lessepsian species represented by several records in the Adriatic in recent years and its status should be evaluated through future research. Members of the genus *Abudefduf* have also recently been found in the Adriatic Sea. Namely, *A. saxatilis* in Italian waters and two specimens of the species precautionarily identified as *Abudefduf* cf. *saxatilis/vaigiensis/troschelii* in the area of Split and Cavtat (central and southern Adriatic, Croatian coast) (Lipej *et al.*, 2019, Dragičević *et al.*, 2021, Pavičić *et al.*, 2021).

The change in Adriatic fish diversity due to the expansion of thermophilic species (Azzurro *et al.*, 2011) and the retraction of boreal ones (Lasram *et al.*, 2010) is a rapid process which is often attributed to the gradual increase in water temperature. Beyond temperature, other physical factors can also contribute to the meridionalization and tropicalization of Adriatic ichthyofauna, such as increasing water salinity (this is known to suit tropical invaders) (Azzurro *et al.*, 2012). Biotic factors, such as the diminished biotic resistance of native populations due to anthropogenic stressors like pollution and overfishing can also be considered.

Other important vectors such as mariculture, ballast waters and ballast sediments have also played a significant role in introducing non-indigenous fish to the Adriatic Sea. Fortunately, there is still no evidence of population establishment by such aliens. To cite some examples, the introduction of *Paranthias furcifer* and *Holacanthus ciliaris* has been attributed to unintentional transport on a towed oil platform (originating from Mexico Bay) into Trogir Bay, while arrival of *Elates ransonettii* in Kaštela Bay (near the cargo port) is probably ship related (Dulčić and Dragičević, 2013a, 2013b; Dulčić *et al.*, 2010). Similar cases include the barred knifejaw *Oplegnathus fasciatus,* which was caught by a local fisher in waters close to the Transalpine Pipeline in Trieste, Italy (Crocetta *et al.*, 2015) and near Urinj in Croatia, which is close to several large ports (Dulčić *et al.*, 2016). Finally, aquarium-related introductions have also been documented, such as in the case of *Chrysiptera cyanea,* a tropical marine fish popular among aquarists, which has recently been observed in Slovenian waters by Lipej *et al.* (2014). Other new additions to the faunistic inventory of the Adriatic are the tripletail *L. surinamensis* (Dulčić *et al.*, 2014b), an Atlantic species which is being increasingly reported in the Mediterraenan Sea; the Norwegian skate *Dipturus nidarosiensis*, a deep-water fish observed for the first time in the Adriatic by Isajlović (2012) following its first Mediterranean record in Sardinia (Cannas *et al.*, 2010); and the big-eye thresher shark *Alopias superciliosus*, recently caught near Mamula island (Montenegro) and reported by Tsiamis *et al.* (2015). In the period from 2016 to 2022, new fish species whose presence in the Adriatic is probably linked to their natural range extension were *Gaidropsarus granti*, *Hexanchus nakamurai*, *Remora osteochir* and possibly *Rhizoprionodon acutus*, while the presence of *Bregmaceros nectabanus* and *Pterois miles* could be attributed to the phenomenon of Lessespisan migrations. *Speleogobius llorisi*, *Lepadogster purpurea* and *Zebrus pallaoroi* owe their discovery to increased research effort. The occurrence of *Abudefduf* spp. in the Adriatic Sea is interesting because different modes of introduction are possible, depending on the species.

For the period of 2010–2022, 25 new fish species have been added to the Adriatic ichthyofauna checklist (Table 1). These are mostly non-indigenous species and native Mediterranean species recorded in the Adriatic for the first time, plus some previously overlooked species. Other species which were considered rare or very rare in the Adriatic Sea, and newly described have been added.

Table 1. New additions to Adriatic ichthyofauna during the period 2010–2022, with their most probable vectors of introduction

Species	Pathway	Source of first record
*Siganus luridus**	Lessepsian migration	Poloniato *et al.*(2010)
*Holacanthus ciliaris**	Ship transport (oil transport)	Dulčić and Dragičević (2013b)
*Paranthias furcifer**	Ship transport (oil platforms)	Dulčić and Dragičević (2013a)
Lobotes surinamensis	Natural range extension	Dulčić and Dragičević, (2011b)
Enchelycore anatina	Atlantic influx	Lipej *et al.* (2011)
*Elates ransonnetti**	Ship transport	Dulčić *et al.* (2010)
*Lagocephalus sceleratus**	Lessepsian migration	Sulić-Šprem *et al.* (2014)
Caranx rhonchus	Northward spreading	Kožul and Antolović (2013)
Dipturus nidaroniensis	Deep-water studies	Isajlović (2012)
*Chrysiptera cyanea**	Aquarium release	Lipej *et al.* (2014)
Alopias superciliosus	Northward spreading	Tsiamis *et al.* (2015)
*Oplegnathus fasciatus**	Ship transport	Crocetta *et al.* (2015)
Pomadasys incisus	Natural range extension	Karachle *et al.* 2016
Gaidropsarus granti	Natural range extension	Bello, 2018
Rhizoprionodon acutus	Natural range extension	Kousteni *et al.* 2019
Hexanchus nakamurai	Natural range extension	Bakiu *et al.* 2018
Speleogobius llorisi	Increased research effort	Kovačić and Glavičić 2019
Lepadogaster purpurea	Increased research effort	Wagner *et al.* 2017
*Bregmaceros nectabanus**	Lessepsian migration	Dulčić *et al.* (2020)
Gouania adriatica	Newly described species	Wagner *et al.* (2021)
Gouania pigra	Increased research effort	Wagner *et al.* (2021)
Gouania hofrichteri	Newly described species	Wagner et al. (2021)
Remora osteochir	Natural range extension	Dulčić *et al.* (2021)
Abudefduf cf. *saxatilis/vaigiensis/troschelii**	Unknown	Lipej *et al.* (2020); Dragičević *et al.* (2021b)
Pterois miles	Lessepsian migration	Dragičević *et al.* (2021a)
Zebrus pallaoroi	Newly described species	Kovačić *et al.* (2021)

*Non-indigenous species

Other changes in the structure and composition of Adriatic fish communities have also been caused by intensive fishing, since the Adriatic is considered as one of the most productive and most exploited seas in the world (Jardas *et al.*, 2008). Although it is a small sea within the Mediterranean, covering only 5.5 percent of the total surface, it yields about 15 percent of total catches. Fishing activities in the Adriatic Sea are carried out both by large vessels and by a highly diversified small-scale fishing fleet which extends all along the Adriatic coast. These activities affect not only commercially exploited species, but also many non-target fish that are usually caught as bycatch. Many shark and batoid species are particularly vulnerable to fishing as they are frequently bycaught with various fishing gears. These include rare and endangered species such as the basking shark (*Cetorhinus maximus*), the six-gill shark (*Hexanchus griseus*), the common thresher shark (*Alopias vulpinus*) and angleshark (*Squatina squatina*), to name a few. About 120 fish species are of major or minor commercial importance in the Adriatic Sea; and more than 50 different kinds of fishing gears are used in the Croatian part alone, more than in any other part of the Mediterranean. Most of the fishing

gear is used for inshore (small-scale) fishing or in national waters (Jardas *et al.*, 2008). Due to unsustainable fishing efforts, a large number of stocks are currently overfished. Moreover, some important spawning and nursery grounds – such as the Blitvenica, the Jabuka Pit, the Croatian channels, the western Italian sector, and the eastern Adriatic coastal region – are heavily exploited by trawling (Jardas *et al.*, 2008). A positive example of action to protect important stocks in recent years is the proclamation of a fisheries restricted area in the Jabuka/Pomo Pit area through the joint efforts of Adriatic scientists and other stakeholders.

Documenting these rapid changes is a new challenge for Adriatic ichthyologists, as they often lack information on the appropriate temporal and spatial scales. The magnitude of efforts that would be needed to monitor and appropriately survey marine habitats is a major obstacle for current research (Polunin *et al.*, 2008): there is an urgent need to fill this gap and deepen our capability to track ongoing biodiversity changes in the Adriatic Sea, as well as in many other seas of the world. Recently, participatory approaches such as those using local ecological knowledge (LEK, i.e. the information that local people have about local ecosystems) have emerged as alternative information sources for ecological and fishery research, and could provide a valuable complement to traditional surveys (Azzurro *et al.*, 2011). Innovative approaches of this kind are expected to broaden our capacity to keep up to date with contemporary changes in Adriatic ichthyofauna, and to develop effective measures for its conservation.

NOTE:
Distribution maps are constructed on the basis of documented records (indicated by red dots) and estimated or known distribution (red areas – frequent occurrence, orange areas – rare occurrence). For some species maps were constructed only on the basis of documented records, although there is a possibility that these species are widespread or common in certain areas (mostly gobies).

List of abbreviations:

CL: carapace length
CW: carapace width
FL: fork length
SL: standard length
TL: total length

2. ALIEN DECAPOD CRUSTACEANS OF THE ADRIATIC SEA

Penaeus (*Farfantepenaeus*) *aztecus* (Ives, 1891)

Common name: Northern brown shrimp

Family: Penaeidae – penaeid shrimps

Synonyms: –

Description: Smooth carapace with rostrum armed with eight or nine teeth on dorsal margin and two on ventral margin. Long adrostral sulcus and carina, extending almost to posterior margin of carapace. No postorbital spine. Pronounced antennal and hepatic spines. First three pairs of pereiopods end with a chela. First pereiopod with spine on ischium and basis and second pereiopod with spine only on basis. Three short well-defined cicatrices on the sixth abdominal somite and one small on the fifth abdominal somite. Dorsolateral sulcus on the sixth abdominal somite and telson unarmed. Body colour is usually brown, sometimes with orange or yellowish tinge, but also reddish or greenish. Juveniles are usually light greyish with small brown or olive-green specks over entire body. Maximum size is 19.5 cm in total length (TL) for males and 23.6 cm for females. Similar to native *Melicertus kerathurus* which has transverse interrupted dark bands on first four segments of abdomen.

Biology and ecology: Adults inhabit littoral marine areas while juveniles inhabit estuaries. Found from the coast to depths of about 110 m, usually on soft, muddy or sandy bottoms. Nocturnal species hidden in burrows during the day.

Distribution: Western Atlantic coast from Massachusetts to the lower Yucatan Peninsula. Recorded in Aegean Sea, Ionian Sea, and Tyrrhenian Sea. Also recorded in western Mediterranean in France and southern coastal waters in Egypt and Tunisia. Adriatic Sea: First recorded in September 2013 in Montenegro; subsequently recorded in Italy, Croatia and Albania. Relatively high number of records indicate establishment of the species in the Adriatic Sea.

Note: The source of all thumbnail maps is listed at the end of the References section.

Origin: Non-indigenous species. Probably introduced in Adriatic through shipping activities or unaided dispersal from neighbouring areas.

Relevance: Important commercially in areas of Western Atlantic.

Literature: Tavares (2002), Deval *et al.* (2010), Marković *et al.* (2014), Scannela *et al.* (2016). Kampouris *et al.* (2018), Abdulrraziq *et al.* (2021), Ugarković and Crocetta (2021).

Penaeus (*Marsupenaeus*) *japonicus* (Spence Bate, 1888)

Common name: Kuruma prawn

Family: Penaeidae – penaeid prawns

Synonyms: *Marsupenaeus japonicus* (Spence Bate, 1888), *Penaeus canaliculatus japonicus* Spence Bate, 1888.

Description: Rostrum with seven to eleven teeth on upper margin and a single tooth on lower margin. Carapace smooth. Gastrofrontal crest present. Post-rostral crest medially grooved and bordered by deep grooves reaching posterior margin of carapace. Abdominal segments four to six keeled. Sixth abdominal segment bearing three lateral scars. Telson with pointed tip and three pairs of movable spines. First three pairs of walking legs chelate, only basical spines present on first and second walking legs. Thelycum tubular. Body pale yellow to pinkish bearing uninterrupted brown transverse bands. Walking legs and pleopods pale yellow proximally, blue distally. Uropods distally striped with yellow and blue. Setal fringe red. Maximum size for males is 17 cm TL, for females 27 cm TL. Similar to native *Melicertus kerathurus* which has both coxal and basial spines on first and second walking legs and transverse interrupted dark bands on first four segments of abdomen.

Biology and ecology: Lives on sandy and sandy-muddy bottoms in shelf areas at depths of up to 90 m, but usually less than 50 m. Nocturnal species with adults buried in substrate during daytime. Juveniles mostly inhabit coastal areas. It spawns during April–November period.

Distribution: West Pacific Ocean. Adriatic Sea: In 1985, only one specimen was caught offshore between Termoli and Varano lagoon (Italian coast), after intentional introduction of juveniles in the Lesina coastal lake for aquaculture.

Origin: Non-indigenous species, probably introduced by aquaculture.

Relevance: Commercial in native area, experimental farming in several European countries.

Literature: Lumare and Casolino (1986), Holthuis (1987), Galil *et al.* (2002).

Palaemon macrodactylus (Rathbun, 1902)

Common name: Oriental shrimp

Family: Palaemonidae

Synonyms: –

Description: Broad and straight rostrum reaching to tip of scaphocerite. On dorsal part of the rostrum up to 15 teeth (usually 10–12), one subterminal tooth and three to five ventral teeth. Shorter ramus of outer antennule fused to longer flagellum for one-fifth of the length of antennule. Broad palm. Carpus of pereopod two equal or slightly shorter than merus. Colour is greenish-brown or olive green, with brown chromatophores. Distinctive colourless dorsal stripe along thorax and abdomen. Maximum total length is 7 cm (common 2 cm).

Biology and ecology: Suprabenthic. Inhabits tidal creeks, estuaries, brackish waters and harbours. Tolerates wide range of environmental factors although mostly abundant in lower-salinity waters. Omnivorous, predominantly feeds on invertebrates.

Distribution: Native to coasts of north-western Pacific (Japan, Korea, northern China). Present outside its native area either through natural dispersion or as introduced species on west and east coast of North America, in South America (Argentina), southern Australia and European waters (Mediterranean and Eastern Atlantic), also found in the Black Sea. Adriatic Sea: First recorded in Venice lagoon in May 2012. Also found in certain brackish habitats in north Adriatic where an established population exists (Sacca di Goro, Lagoon of Grado and Marano, Venice Lagoon).

Origin: Non-indigenous species. Probably introduced by ballast water.

Relevance: Potential aquarium use.

Literature: Aiyun and Siliang (1991), Hayward and Ryland (1995), Davie (2002), Poore and Ahyong (2004), Mizzan and Vianello (2008), Lavesque *et al.* (2010), Ashelby *et al.* (2013), Cuesta *et al.* (2014), Cavraro *et al.* (2014), Redolfi Bristol *et al.*, (2021).

Homarus americanus (H. Milne Edwards, 1837)

Common name: American lobster

Family: Nephropidae-clawed crabs, lobsters

Synonyms: *Astacus americanus* Stebbing, 1893; *Homarus mainensis* Berrill, 1956;

Description: Cephalothorax covered by carapace with well developed median rostrum which bears one or more ventral teeths. The first of the five pairs of walking legs modified into two large, dimorphic chelipeds (cutter and a crusher claw). Second and third walking legs also ending in smaller claws. Six pairs of pleopods – the last pair modified into uropods which, with telson, form a tail fan. It has compound eyes situated on movable stalks. Males with sharp spines under the abdomen; females with blunt spines. Abdomen in males is narrower than the width of the carapace; in females these are equal or larger. The antennules and two large antennae act as the sensory organs. Maximum body length is around 64 cm, but usually around 25 cm. Similar to native H. gammarus which lacks ventral teeth on rostrum.

Biology and ecology: Benthic species which inhabits coastal and shelf waters. Usually in cold, shallow waters among rocks and vegetation which can be used as shelters although not restricted to it. They also burrow in mud. Typicaly at depths ranging from 4 to 50 m, but can be found at greater depths (up to 480 m). Juveniles usually feed on softer and easily accessible prey like scavanged flesh, mussels, polychaetes and macroalgae, while adults rely on hard-shelled taxa like other crabs, molluscs and echinoderms. Females carry eggs for 10 to 11 months. Ovigerous females are found throughout the year.

Distribution: Native to the northwest Atlantic coast from North Carolina to Labrador. It is abundant off Maine, southwest Nova Scotia, and the Gulf of St Lawrence coastline of the Maritimes. Introduced through live-food trade in Europe where it is occasionally wild-caught especially in Northern European waters (Sweden, Norway and Great Britain). Adriatic Sea: one individual was recorded in the Adriatic Sea in January 2018 near the west coast of Istria (Croatia), it is also first documented record of this species caught in the wild in the Mediterranean Sea.

Origin: Native western Atlantic species, previously unreported from the Mediterranean and Adriatic Sea.

Relevance: Highly commercial.

Literature: Holthuis (1991), Factor (1995), SwAM (2016), Pavičić *et al.* (2020).

Scyllarus caparti (Holthuis, 1952)

Common name: –

Family: Scyllaridae – slipper lobsters

Synonyms: –

Description: Carapace subquadrate with dentate lateral margins and slightly diverging anteriorly. Median carina of the carapace with three rounded teeth and two rows of tubercles. Rostrum small. Inner orbital margin bidentate. Antepenultimate antennal segment pointed with external margin deeply cut into two lobes. Anterior margin of thoracic sternum with two rounded lobes separated by a short fissure. Last thoracic sternite bearing obtuse median tubercle. Prominent median carina on abdominal segments two to four. Second pleuron is triangular. Body colour is brownish-grey. Maximum size is approx. 5 cm (TL).

Biology and ecology: Inhabits sandy and muddy bottoms at depths from 30–60 m. No data on the biology of the species.

Distribution: Tropical and subtropical East Atlantic. Adriatic Sea: In 1977, a single individual was collected near Ancona from a depth of 1 m. No subsequent records.

Origin: Non-indigenous species. Probably introduced through shipping activities (probably through clam trade).

Relevance: None.

Literature: Froglia (1979), Galil *et al.* (2002), Lavalli and Spanier (2007).

Herbstia nitida (Manning and Holthuis, 1981)

Common name: –

Family: Epialtidae

Synonyms: –

Description: Pyriform carapace. Two short rostral spines. Pre-orbital and post-orbital spines also short. Hepatic region with three or four sharp tubercles. Gastric region with three low tubercles in transverse line. Single low dorsal tubercle on cardiac and intestinal regions. Single projection at postero-median margin of carapace. Chelipeds long as carapace, not greatly enlarged in males. Merus and carpus with many low tubercles. Chela smooth. Walking legs with bristly meri. Posterior margin of dactyls with one to four triangular teeth. Carapace of creamy colour, mottled with rusty colour. Walking legs with orange-coloured transversal bands. Maximum size is 1.3 cm (CL).

Biology and ecology: Inhabits areas from intertidal to at least 73 m of depth, usually on rough bottoms composed of rock, coral and calcerous algae. Recorded in submarine cave in the Mediterranean (Adriatic record). No data on biology of the species.

Distribution: Present in East and South-East Atlantic (Gulf of Guinea). Adriatic Sea: In 2002 several young and adult individuals were collected inside a cave in Southern Italy (Otranto Channel). No subsequent records from the Adriatic Sea: these are the only records from the Mediterranean.

Origin: Non-indigenous species. Probably introduced by shipping activities.

Relevance: None.

Literature: Manning and Holthuis (1981), Pastore and Denitto (2002), Galil *et al.* (2002), Denitto *et al.* (2010).

Callinectes danae (Smith, 1869)

Common name: Dana swimming crab

Family: Portunidae – swimming crabs

Synonyms: –

Description: Carapace granulate. Four frontal teeth between orbits with middle two shorter. Nine antero-lateral teeth with hindmost as a large spine. Chelipeds longer than walking legs. Merus with three spines on inner margin and one subdistal external spine. No internal spine on carpus. Spines on claw. Walking legs compressed. Fifth walking leg with broad propodus and dactylus. Male first pleopods extend to sixth thoracic sternite. Carapace olive green, claw purple-tinged, other legs blue to olive. Maximum size is 14 cm (CW). Similar to *Callinectes sapidus* which has two frontal teeth.

Biology and ecology: Inhabits wide range of habitats from mangroves and moody estuaries to beaches, bare sand and open coastal waters up to 75 m depth. Tolerant of wide range of salinities. Feeds on molluscs, fishes and various bottom invertebrates including other Brachyurian crabs, also scavenges. Males are usually larger than females.

Distribution: Common in Western Atlantic especially in Brazil and Caribbean archipelago, up to North Carolina in the north. Adriatic Sea: A single individual was caught in the Venice lagoon in 1981. No subsequent records.

Origin: Non-indigenous species of Atlantic origin. Probably introduced by shipping activities.

Relevance: Has significant socio-economic importance in the Western Atlantic.

Literature: Mizzan (1993), Palomares and Pauly (2017).

Callinectes sapidus (Rathbun, 1896)

Comon name: American blue crab

Family: Portunidae – swimming crabs

Synonyms: *Callinectes sapidus acutidens* Rathbun, 1896; *Portunus diacantha* Latreille, 1825.

Description: Carapace broad, narrow distally with granulate dorsal surface. Front with two prominent triangular teeth. Antero-lateral margin with nine teeth including long hindmost tooth which is directed outwards. Chelipeds stout and longer than walking legs. Merus with three stout spines on inner margin, and one large external spine. Carpus without internal spine. Upper surface of palm with granulate carinae ending in spines. Walking legs compressed. Fifth walking leg with distal paddle-like segments. Male abdomen with fused segments three to five. In males first pleopods extend to fourth thoracic sternite. Carapace mottled greyish or bluish with spines orange-red. Fingers of chelipeds blue in male, red in female. Walking legs blue to white. Maximum size of males is 20 cm (CW). Similar to *Callinectes danae* which has four frontal teeth.

Biology and ecology: Hatches in estuaries and coastal regions (intertidal to 90 m), larval development occurs at sea. Megalopae migrate back into upper estuaries and there spend their life. Tolerant of large range of salinities and temperatures. Eats a range of animal foods, but also plants. May scavenge fishes and other animals, often from set nets. Females are highly fertile.

Distribution: Native to Western Atlantic, from Nova Scotia to Uruguay. Recorded off the Atlantic coasts of Europe as early as 1900, from the Baltic Sea to the Netherlands and France. First recorded in the Black Sea in 1967 and in Japan in 1974. First recorded in the Mediterranean Sea as *Neptunus pelagicus* in Venice, Italy in 1949. Reported in western (northern coasts) and eastern Mediterranean. Present in Aegean, Ionian and Levantine Sea. Scarce records from African coast of the Mediterranean. Adriatic Sea: Numerous records. Present throughout eastern Adriatic, abundant in Neretva estuary (Croatian coast). Established populations on Albanian coast (Patok and recorded all along the western Adriatic coast (Gargano lagoons, Italy).

Origin: Non-indigenous species of West Atlantic origin. Introduced probably through shipping activities.

Relevance: It can cause damage to local fishery and the ecosystem through competition and predation on native species, alteration of food webs and habitat modification. Also a valuable resource for the fishing industry.

Literature: Onofri *et al.* (2008), Beqiraj and Kashta (2010), Dulčić *et al.* (2011b), Castriota *et al.* (2012), Cilenti *et al.* (2015), Suaria *et al.* (2017), Mancinelli *et al.* (2017, 2021).

Charybdis japonica (A. Milne-Edwards, 1861)

Common name: Asian paddle crab

Family: Portunidae – swimming crabs

Synonyms: *Charybdis peitchihiliensis* Shen, 1932; *Charybdis sowerbyi* Rathbun, 1931; *Goniosoma japonica* A. Milne-Edwards, 1861

Description: Carapace covered with a dense mat of short hairs. Transverse granular lines on protogastric and mesogastric regions. Epibranchial line interrupted at the cervical groove and across midline. Front with six acute triangular teeth on carapace, medially broadest and prominent, laterally narrower. Anterolateral borders with six acute teeth, first with a slightly concave lateral border, sixth narrowest. Postero-lateral junctions rounded. Chelipeds densely hairy. Merus with three strong spines on anterior border, posterior border smooth. Carpus with a strong internal spine, outer border with three spinules. Palm with five spines on upper border. Merus of swimming legs with a subdistal posterior spine, propodus smooth on posterior border. Colour varies, usually pale to olive-green and brown to purple. Carapace with large greyish or white patches. Maximum size is approx. 12 cm (CW).

Biology and ecology: In its native range it occurs in intertidal and subtidal habitats in relatively shallow waters (up to 15 m). It occurs on sandy, muddy or rocky bottoms with seaweed. Opportunistic omnivore with a preference for sessile and slow-moving macroinvertebrates.

Distribution: Western Pacific Ocean from Korea and Japan to Indonesia. Invasive in New Zealand. Introduced to Western Australia. Adriatic Sea: One individual collected off Ancona (Italy) in 2006 (first Mediterranean record). No additional records.

Origin: Non-indigenous species. Probably introduced by ballast transport or as fouling organism.

Relevance: Edible, commercial in the areas where it is abundant.

Literature: Sakai (1976), Ng (1998), Smith *et al.* (2003), Mizzan and Vianello (2008), Fowler (2011), Froglia (2012, 2022).

Charybdis lucifera (Fabricius, 1798)

Common name: –

Family: Portunidae – swimming crabs

Synonyms: *Goniosoma quadrimaculatum* A. Milne-Edwards, 1861; *Portunus lucifera* Fabricius, 1798.

Description: Carapace wide and hexagonal in shape, curved posteriorly. Surface of the carapace naked with microscopic granules. Anterolateral margin with six teeth, first tooth pointed. Frontal margin with six rounded teeth. Lower orbital margin dentiform. Massive asymmetrical chelipeds. Merus with three spines on the anterior margin. Pointed spine on interior margin of carpus and three spines exteriorly. Carpus with a strong spine at the inner angle and three blunt spines on the outer surface. Fingers shorter than manus. First pleopods with inner spines and row of sparse small spines. Colour is yellowish-brown with white spots on branchial region. Chelipeds are scarlet-pink with light brown tips. No data on maximum size.

Biology and ecology: Inhabits rocky to muddy substrates in littoral to sublittoral zones up to 2 m depth.

Distribution: Indo-West Pacific Ocean from Red Sea to Japan, also in Australia. Adriatic Sea: In Summer 2006, one individual was collected 6 miles off the Venetian coast. This was also the first record for the whole Mediterranean. No additional records.

Origin: Non-indigenous species. Probably introduced by ballast transport or other shipping-related mode.

Relevance: Edible, commercial in the areas where it is abundant.

Literature: Aiyun and Siliang (1991), Davie (2002), Mizzan and Vianello (2008), Froglia (2010).

Dyspanopeus sayi (Smith, 1869)

Common name: Say mud crab

Family: Panopeidae – panopeid stone crabs

Synonyms: *Panopeus sayi* Smith, 1869.

Description: Subhexagonal carapace with minutely granular surface. Front is prominent with median notch which divides it into two sinuate lobes. Antero-lateral margin with two teeth close to the margin of ocular lobe and three differently shaped pointed teeth. Chelipeds massive and unequal, especially in large males. Walking pereiopods with long and slender dactylus. Carpus with acute tooth on inner distal margin. Palm smooth, with two ill-defined longitudinal crests on dorsal surface in females. Carapace and chelipeds from dark greenish to brown, with smaller darker dots. Chela with black fingers. Maximum size is up to 2.5 cm CL in males, females 1.5 cm CL.

Biology and ecology: Mainly found in shallow brackish waters on soft, mainly muddy bottoms with sparse stones and mussel beds. Feeds mostly on juvenile bivalves and barnacles. Highly fecund. Eggs are brooded in females' pleopods. Predated by *Callinectes sapidus*.

Distribution: Native to North-West Atlantic, from eastern Canada to Florida. Also recorded in North Sea and Mediterranean (Balearic and Adriatic Sea). Adriatic Sea: Recorded first in Venice lagoon in 1993 where it is now very abundant. Subsequently found in the Marano lagoon, and along the Romagna coast. It is spreading southward in the western Adriatic, one individual was collected off Cattolica in 2004 and in 2006 it was found to be common in the Lake of Varano (Gargano peninsula).

Origin: Non-indigenous species. Probably introduced through shipping activities (probably through clam trade).

Relevance: May affect local bivalve communities.

Literature: Froglia and Speranza (1993), Galil *et al.* (2002), Florio *et al.* (2008), Aubert and Sauriau (2015).

Rhithropanopeus harrisii (Gould, 1841)

Common name: Dwarf crab

Family: Panopeidae – panopeid stone crabs

Synonyms: *Panopeus wurdemannii* Gibbes, 1850; *Pilumnus harrisii* Gould, 1841.

Description: Carapace subovate with rare short hairs and two rows of minute tubercles. Two transverse lines of granules on the widest part of the carapace. Front straight and slightly notched with transversely grooved margin. Four teeth on antero-lateral margins. Posteriormost tooth smallest. Male abdomen with segments three to five fused. Chelipeds massive, unequal and mostly smooth. Walking legs somewhat hairy, long and slender. Dorsal surface is brownish-green, sometimes with darker spots, paler ventrally. Fingers of chelae whitish. Maximum size is 2 cm CL.

Biology and ecology: Inhabits shallow estuarine and brackish waters on sandy and muddy bottoms with sheltering possibilities. Euryhaline species, found also in freshwater. Omnivorous, feeds on leaf detritus as well as smaller crustaceans.

Distribution: Native to North-West Atlantic. Introduced to the Pacific coast of USA and Eastern Atlantic, from the Baltic Sea to the Netherlands, France, Portugal, Tunisia and Spain. Also in Black and Caspian Seas. Adriatic Sea: It was recorded for the first time in Italy's Po River Delta in 1994. Subsequently collected in Marano lagoon and brackish habitats along the Romagna coast.

Origin: Non-indigenous species. Probably introduced through shipping activities.

Relevance: None.

Literature: Mizzan and Zanella (1996), Hayward and Rylan (2000), Galil *et al.* (2002), Mizzan (2005).

Eriocheir sinensis (H. Milne Edwards, 1854)

Common name: Chinese mitten crab

Family: Varunidae

Synonyms: *Eriocheir leptognathus* Rathbun 1913; *Eriocheir rectus* Stimpson 1858.

Description: Carapace subquadrate with granulate ridges. Front and lateral margins granulated or with saw-like teeth. Front with four teeth with deeper median notch. Four lateral spines on both sides of carapace. A pronounced rhomboid-shaped gap between inner margins of third maxillipeds. Chelipeds equal, shorter than second walking legs. Large spine on inner anterior margin of carpus. Palm and basal part of fingers in males covered with dense mat of setae. Walking legs laterally depressed, distal upper margin of merus prominently spinose. Abdominal segments three to six fused in male. Carapace light brown or greyish-green to dark brown, sometimes with pairs of pale spots. Maximum size is approx. 10 cm (CW).

Biology and ecology: Juveniles settle in estuaries where they seek shelter among rocks. Adults migrate to freshwater and can migrate long distances upstream. Egg-laying and hatching takes place in estuaries or coastal regions. Makes burrows which can be up to 1 m long. Diet includes a wide range of plants, invertebrates, fishes and also detritus. Mostly preys on gastropods and bivalves. It has a good migrating potential.

Distribution: Native range includes southeast Asia and Japan. Centre of occurrence is the Yellow Sea. Introduced to European waters where it was first recorded in the German River Aller in 1912 and the UK in the 1930s. Subsequently spread through all North and Baltic Seas countries, the Atlantic seaboard of Europe and the Mediterranean and Black Seas. Adriatic Sea: Two adult males were collected in the Venice lagoon, Italy, in May 2005 and June 2013. Another adult male was caught in the lagoon of Marano in November 2014 and in 2020, a female specimen in Sacca di Goro lagoon, Italy.

Origin: Non-indigenous species. Probably introduced through shipping activities or aquarium release.

Relevance: Damages river banks through burrowing. Causes considerable damage to fisheries by consuming netted fish and by cutting nets. Consumed in China as a delicacy.

Literature: Gollasch (1999), Mizzan (2005), Francis (2012), Fiorin *et al.* (2013), Bettoso and Comisso (2015), Crocetta *et al.* (2020).

Percnon gibbesi (H. Milne Edwards, 1853)

Common name: Sally lightfoot crab

Family: Grapsidae – marsh crabs

Synonyms: –

Description: Carapace disc-like with tridentate front. Front deeply cut by antennular furrows. Margins of median tooth armed with two spines. Antero-alteral margins with four acute teeth. All walking legs with a row of spines on anterior margin of merus. Chelipeds with spinose merus and carpus. Palm with a small pilose area proximally on inner surface and also pilose groove proximally on upper surface. The carapace is brownish with paler patches. Golden yellow rings on joints of walking legs. Maximum size is approx. 3.7 cm CW. Somewhat similar to *Pachyrgapsus marmoratus* which has a square-shaped carapace and marbled colour pattern.

Biology and ecology: Usually found in shallow rocky intertidal zone. Lives under boulders or in narrow crevices, where it seeks shelter when threatened. Very agile. It is vulnerable to predation by fish and invertebrates. Can form thriving high-density populations in a short time interval. Mostly feeds on algae.

Distribution: Native range includes west coast of America (California to Chile), east coast of America (Florida to Brazil) and Eastern Atlantic (Madeira to Gulf of Guinea). First collected in the Mediterranean from Linosa Island in 1999. Subsequently spread throughout the whole Mediterranean Sea. Adriatic Sea: In 2010 its presence was recorded at six locations in Albanian coastal waters. Documented presence at Molunat Bay (Croatian coast, south Adriatic) in April 2014, and in August 2014 observed near Bari (west Adriatic). Subsequently observed near Dubrovnik and on Vis and Lastovo Islands (mid-southern Adriatic) with relatively abundant population in 2016. Since then it was recorded from Mljet, Korčula island and Palagruža archipelago islands in 2018 and 2019.

Origin: Non-indigenous species of Atlantic origin. Probably introduced by shipping activities (ballast waters) or passive transport of larvae or adult individuals.

Relevance: None.

Literature: Relini *et al.* (2000), Galil *et al.* (2002), Katsanevakis *et al.* (2011), Dulčić and Dragičević (2015), Ungaro and Pastorelli (2015), Stasolla *et al.* (2016), Suaria *et al.* (2017), Dulčić *et al.* (2019).

Hemigrapsus sanguineus (de Haan, 1835)

Common name: Asian shore crab

Family: Varunidae

Synonyms: *Grapsus* (*Grapsus*) *sanguineus* De Haan, 1835; *Heterograpsus maculatus* H. Milne Edwards, 1853.

Description: Carapace square-shaped and smooth. Lateral margins arched with three lateral spines. Front half sinuous. Suborbital stridulating organ is finely striated and crest-like. Chelipeds of males with fleshy vesicles at the base dactylus. Carpus with robust spine on inner anterior margin. Dactyls of walking legs shorter than propodi. Meri with subdistal spine on anterior margin. Carapace mottled greenish-brown or dark purple. Small reddish spots on the upper parts of the chelipeds. Walking legs with lighter bands. Maximum size is 3 cm (CL). Similar to native *Pachygrapsus marmoratus* which has marbled colour pattern.

Biology and ecology: Inhabits shallow rocky intertidal zones. Omnivorous with preference for herbivorous diet. Beside algae, feeds on larval and juvenile fish and small invertebrates. Fecundity is high (more than 40 000 eggs in a brood). Multiple broods per breeding season. Larvae pelagic for approx. a month before metamorphosis.

Distribution: Western Pacific from Sakhalin to Hong Kong and Japan. In 1998 recorded in North America, subsequently spread from Massachusetts to North Carolina. Established populations from Normandy to Germany in Northern Sea. Also reported in the Lake of Tunis and the Port of Radès in the Mediterranean Sea. Adriatic Sea: In 2001, a single individual was collected on the western coast of Istria. It was found under a boulder on a rocky platform at sea level at a location between Umag and Novigrad (northern Adriatic, Croatian coast).

Origin: Non-indigenous species. Probably introduced through shipping activities.

Relevance: None.

Literature: Bréton *et al.* (2001), Galil *et al.* (2002), Schubart (2003), Ben Souissi *et al.* (2004), Klassen (2012).

3. NEW FISHES OF THE ADRIATIC SEA

Hexanchus nakamurai (Teng, 1962)

Common name: Bigeyed sixgill shark

Family: Hexanchidae – cow sharks.

Synonyms: *Hexanchus griseus nakamurai* Teng, 1962; *Hexanchus vitulus* Springer & Waller, 1969.

Description: Body slender, with narrow head and 6 gill slits. Mouth ventral with 4 rows of front teeth in upper and 5 rows of comb-shaped teeth on each side in lower jaw. A single dorsal fin without spine. Eyes large. Caudal peduncle long and slender, distance from dorsal fin insertion to upper caudal origin at least twice the length of dorsal fin base. Body colour is plain gray, slightly darker dorsally. A light line extending along the lateral body trunk, the trailing fin edges are white in some specimens and the ventral surface is lighter. According to the available literature, grows up to 1.8 meters in total length (TL), but Adriatic specimen was larger (2.3 m). Similar to *H. griseus* which attains larger size, has shorter and broader head with blunt snout and 6 rows of lateral teeth in lower jaw.

Biology and ecology: Bathydemersal species occurring on continental and insular shelves and slopes from 90 to 600 m depth (occasionally up to 800 m), usually on or near bottom, but occasionally shallower in warmer waters. Ovoviviparous species with up to 26 embryos. About 40–45 cm long at birth. Probably feeds on bony fish and crustaceans.

Distribution: Patchily distributed species, present in warm temperate and tropical seas. In Western Central Atlantic present in Mexico, off Bahamas, northern Cuba, Nicaragua and Costa Rica. In Eastern Atlantic from France to Morocco, possibly Côte d'Ivoire and Nigeria. In Indian Ocean off eastern and southern Africa, India and Western Australia. In Western Pacific known from Japan, Taiwan, Philippines, New Caledonia and eastern Australia. Rare in the Mediterranean Sea where it was recorded in Aegean Sea, Italy, France and Greece. Adriatic Sea: one 230 cm (TL) long specimen of this species was captured near Himara (south Albanian cost) in October 2017. No subsequent records.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: Apparently uncommonly taken on line gear and in trawls and of relatively low importance to fisheries. Near threatened according to IUCN (2022).

Literature: Boeseman (1984), Ebert *et al.* (2013), Bakiu *et al.* (2018).

Alopias superciliosus (Lowe, 1841)

Common name: Bigeye thresher

Family: Alopiidae – thresher sharks

Synonyms: *Alopias profundus* Nakamura, 1935.

Description: Head with indented forehead, large eyes and long snout. Deep grooves extending along each side of the head starting from behind the eyes and reaching to end of gill openings. First dorsal fin closer to pelvic than to pectoral fins. Upper lobe of caudal fin very long and strap-like; its length is almost or equal to the length of the rest of shark (body). Lower lobe of caudal fin short but well developed. Purplish-grey above, cream to grey on the belly. Posterior edges of pectoral and pelvic fins dusky. Light colour of abdomen not expanded over pectoral fin bases. Common size is 300–350 cm TL (maximum 488 cm). Similar to *Aulopus vulpinus*, which lacks grooves on the head.

Biology and ecology: Inhabits epipelagic, oceanic and coastal areas. Occurs in coastal waters over continental shelves, sometimes close to the shore and in shallow waters, also on the high seas far from coast. Reaches depths of at least 500 m. Feeds on various pelagic fishes, but also demersal fishes and squids. Ovoviviparous. Stuns its prey with its long caudal fin.

Distribution: Circumglobal species, inhabits tropical and warm temperate seas of all oceans. Highly migratory species. Poorly documented in the Mediterranean, where it is considered rare. Nevertheless, in recent years the species has been reported on several occasions in the eastern basin off Israel, in the Levantine basin, in the Aegean Sea off Turkey, and in southern Greece off southern Crete. Adriatic Sea: In May 2012, a bigeye thresher shark, *Alopias superciliosus,* was caught by a local fisher near the island of Mamula in Montenegro (eastern coast). Also reported from Albania with documented record near Dhermi in 2016.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: Utilized for human consumption. Vulnerable species according to IUCN (2022).

Literature: Compagno (1984), Quero (1984), Stehman and Bürkel (1984), Tsiamis *et al.* (2015), Stamouli *et al.,* (2017), Bakiu and Soldo (2021).

Rhizoprionodon acutus (Rüppell, 1837)

Common name: Milk shark

Family: Carcharhinidae – requiem sharks

Synonyms: *Carcharias acutus* Rüppell, 1837; *Squalus sorrakowah* Cuvier, 1829; *Carcharias sorrahkowah* Bleeker, 1853.

Description: small shark with long and narrow snout. Eyes big and horizontally oval. Teeth smooth edged to finely serrated with oblique cusps except for the most anterior teeth which erect with narrow cusps. Usually over 16 enlarged hyomandibular pores on both sides of head, just behind mouth. Origin of the first dorsal fin in advance of appressed pectoral fin. Second dorsal fin small, low and behind larger anal fin. No interdorsal ridge. Colour grey, grey-brown or purplish brown above, pale below. Pectoral fins with a light margin. Common size is 110 cm TL (maximum 175 cm TL). In contrast to other species of *Carcharhinus* genus in the Mediterranean, origin of the second dorsal fin in *R. acutus* is behind the origin of anal fin.

Biology and ecology: Viviparous species, with a yolk-sac placenta. Usually 2 to 5 (maximum 8) in a litter after a gestation period of approx. 12 months. No seasonality in the reproductive cycle. Size at birth between 25 and 39 cm. Feeds with fishes, squids and other cephalopods. Occurs on the continental shelf. Benthopelagic marine species which occurs also in brackish and freshwaters. Depth range between 1 to 200 m. Maximum reported age is 8 years.

Distribution: Eastern Atlantic, from Mauritania to Angola. In Indo-West Pacific in Persian Gulf, Red Sea and East Africa to Indonesia, north to Japan, south to Australia. In the Mediterranean Sea recorded in Gulf of Taranto (Ionian Sea) in 1985 and off Zarzis (southern Tunisian coast). Adriatic Sea: one specimen has been caught near Sazani Island (Albanian waters) in February 2019. No subsequent records.

Origin: Non-native species in the Mediterranean Sea. Possibility of entrance both through Strait of Gibraltar and Suez Canal. Recently confirmed record for the Adriatic Sea.

Relevance: Commercially important species where it is more abundant. Vulnerable species according to IUCN (2022).

Literature: Branstetter (1984), Compagno (1984), Ben Amor *et al.* (2016), Kousteni *et al.* (2019).

Bregmaceros nectabanus (Whitley, 1941)

Common name: Smallscale codlet

Family: Bregmacerotidae

Synonyms: *Bregmaceros atlanticus* (non Goode & Bean, 1886)

Description: Elongated body, slightly compressed ventrally. Small head with a blunt snout and relatively large eyes. Long ray on top of the head, with base slightly behind the eye. Body densly pigmented along the dorsum with a thin brown dorsolateral longitudinal stripe below the second dorsal fin, abdomen nearly unpigmented. Pelvic fin jugular in positon, with three greatly elongated rays. Opercular spine is present and distally fimbriated. Maximum recorded size 7.6 cm SL. Meristic formula: D: 42–56; P: 15–19; A: 42 – 55; Vert: 47–52.

Biology and ecology: Small pelagic-neritic species occurring up to 850 m of depth, but usually up to 350. Undertakes vertical migrations. Data on reproductive or feeding habits are lacking.

Distribution: In Western Atlantic in southeast Caribbean. In Eastern Atlantic from Morocco to Namibia. Reported from South Africa, Indian Ocean and tropical western Pacific. It probably entered the Mediterranean Sea as an lessepsian migrant where it is distributed in eastern and central parts. The species has been misidentified as *Bregmaceros atlanticus* in all previous reports in the Mediterranean Sea before 2017. Adriatic Sea: Two individuals were collected in December 2019 off Mola di Bari (Italy, Adriatic Sea) at 100 m depth on a muddy bottom. One individual of smallscale codlet was collected by trawl off island Mljet in July 2020 at 138 m depth, while two individuals were collected in November 2020 by gillnet in Neretva Channel at a depth of 45 m representing the northernmost occurrence of this species in the Adriatic Sea.

Origin: Lessepsian migrant, previously not recorded in the Adriatic Sea. Probably introduced through active or passive dispersal from the neighbouring areas.

Relevance: None. Harmless.

Literature: Baird *et al.* (1973), Cohen (1990), Harold and Golani (2016), Dulčić *et al.* (2020), Orfanidis *et al.* (2021).

Dipturus nidarosiensis (Storm, 1881)

Common name: Norwegian skate

Family: Rajidae – skates

Synonyms: *Raja nidarosiensis* Storm, 1888.

Description: Rhomboidal body. Snout pointed and very long. Dorsal surface smooth, except on head and along anterior margins of disc where tiny spines are present. Small thornlets sometimes present around inner margin of eyes. Along tail, 40 to 50 small thorns, occasionally flanked by parallel rows in large females. Between the dorsal fins are usually one to three spines. Underside covered with rough prickles. Upper surface greyish-brown with black mucous pores. The ventral surface is dark brown, almost black, in some individuals without dots and spots. The disk is usually covered with a thick layer of firm black mucus which masks the real colour. Common size is 150–200 cm TL (maximum 230 cm). Similar to other congeneric (*Dipturus* spp.) species which have paler (whitish) or not uniformly coloured ventral surface.

Biology and ecology: Lives on the bottom on deep slope waters and submarine rises at depths from 200 to more than 1 000 m. Feeds on all kinds of bottom-living animals. Oviparous. Young individuals tend to follow large objects, sometimes their mother. Eggs are oblong capsules (20x10 cm) with stiff pointed horns at the corners which they deposit in sandy or muddy flats.

Distribution: Northeast Atlantic in the fjords of central and southern Norway, along the slopes off southern Iceland, western Scotland and west of Ireland as well as along the Mid-Atlantic Ridge and the Iceland-Faroe Ridge. It is considered uncommon in the Bay of Biscay and in northern Mauritania. Between 2005 and 2008, 14 individuals were caught off Sardinia in the western central Mediterranean Sea at depths of 600–1 420 m. Also recorded in Alboran Sea. Adriatic Sea: first recorded in 2008, when a single individual was caught in the south Adriatic. In the period from 2010 to 2016, at least seven specimens were collected in the southern Adriatic, several around the pit of Bari.

Origin: Eastern Atlantic species, probably native to Mediterranean, previously unreported for the Adriatic Sea.

Relevance: None. Near threatened according to IUCN (2022).

Literature: McEachran and Dunn (1998a), Cannas *et al.* (2010), Follesa *et al.* (2012), Isajlović (2012), Ramírez-Amaro *et al.* (2017), Isajlović *et al.* (2020).

Bathypterois dubius (Vaillant, 1888)

Common name: Mediterranean spiderfish

Family: Ipnopidae – deep-sea tripod fishes

Synonyms: *Bathypterois mediterraneus* Bauchot, 1962.

Description: Body elongated with snout flattened in the form of a spatula. Large oral cavity. Small eyes. Elongated spines on the lower part of the ventral fins and lower lobe of the caudal fin. Pectoral fins separated into two parts of which the upper part consists of two very elongated rays. It has an adipose fin. Almost the entire body is covered with scales except below the lower jaw. The body and head are black, while areas of overlapping scales are white. Fins are dark. Common size is 12–18 cm TL (maximum 21 cm TL). Meristic formula: D: 14–16; A: 8–10; V: 8+2 elongated; P: 11–13+2 elongated.

Biology and ecology: Bathydemersal species. Occurs in the depth range 260–2 800 m, usually 2 100–2 300 m. Found on continental slope and rise at temperatures from 4 °C to 12 °C. Usually solitary, but probably forms occasional aggregates. Leans on the sea bottom using spines of the ventral and caudal fin, resembling tripod. Feeds on mysids and benthopelagic copepods. Synchronously hermaphroditic.

Distribution: Eastern Atlantic from northeast Atlantic to off Sierra Leone. One record from the northwest Atlantic. Common in deep waters of Western and Eastern Mediterranean. Adriatic Sea: Four individuals were caught in South Adriatic Pit at a depth between 1 000 and 1200 m in 2000.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Merret (1990), Ungaro *et al.* (2002).

Saurida lessepsianus (Russell, Golani & Tikochinski, 2015)

Common name: Lessepsian lizardfish

Family: Synodontidae – lizardfishes

Synonyms: Recently described species. Previously misidentified as *S. undosquamis* (Richardson, 1848).

Description: Elongate and cylindrical body, somewhat depressed on the head and slightly compressed on caudal peduncle. Slightly raised lateral-line scales on the caudal peduncle, forming a slight ridge. Scales present on opercle and cheek. A prominent low bony ridge extending from behind nostrils to above middle of orbit. Eyes covered with fleshy adipose eyelid anteriorly and posteriorly. Pectoral fins moderately long. Caudal fin deeply forked, upper and lower lobes about equal in length. Top of head and back dark brown or coppery-brown with narrow black edge on some scales, forming a variegated pattern. Colour below lateral line is silvery-white with series of about nine indistinct small brownish blotches along the lateral line. Dorsal fin pale with four to 10 indistinct blackish spots on first two rays. Upper margin of caudal fin with three to eight distinct blackish spots. Common size is 30 cm TL (maximum 50 cm TL). Similar to *Synodus saurus*, which has much shorter inner pelvic rays than outer and lacks blackish spots on the upper part of the caudal fin. In *Aulopus filamentosus* the origin of the dorsal fin is in front or equal to pelvic fin origin. Meristic formula: D: 11–12; P: 13–15; A: 10–12; V: 9; LL: 47–51.

Biology and ecology: Mainly found on sandy or muddy substrates to about 100 m, but more common inshore at depths of 20 to 30 m. The spawning season is prolonged and occurs nearly all year round. Feeds mainly on fish.

Distribution: Originally distributed in the northern Red Sea, very common in the Gulf of Suez. Its current exotic range includes several eastern Mediterranean countries, being common in Tunisia, Libya, Syria, Lebanon, Israel, Turkey and Greece. Adriatic Sea: First recorded on Albanian coasts in the 1990s. In 2002, one individual was recorded close to the Albanian coast at a depth of 100 m. No further Adriatic sightings since 2002.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Important commercial fish where abundant. Common species in trawl fishery in the north-eastern Levant.

Literature: Rakaj (1990), Ungaro *et al.* (2004), Russell *et al.* (2015).

Enchelycore anatina (Lowe, 1839)

Common name: Fangtooth moray

Family: Muraenidae – moray eels

Synonyms: *Muraena anatina* Lowe, 1838; *Lycodontis anatinus* (Lowe, 1838).

Description: Body very elongated and compressed behind anus. Anus slightly before body midpoint. Long dorsal fin originates above branchial opening. Anal fin merged with caudal fin. Pectoral and pelvic fin absent. Head pointed, with a distinctly elevated occipital region. Tubular anterior nostril. Posterior nostril oval or round pore with a slight rim near upper anterior eye margin. Large mouth extending back behind eye. Jaw arched with many fang-like teeth visible even when mouth is closed. In both jaws an outer row of long teeth alternating with three to five smaller teeth. Premaxillary teeth very long and sharp. Few small uniserial teeth on the vomer. No scales on the body. Body dark brown with many yellow blotches and dots arranged in longitudinal rows. Snout and cheeks light brown with yellow dots. Common size is 50–100 cm TL (maximum 120 cm). Similar to Muraena helena, which has no arched jaw and both posterior and anterior nostrils have tubes. Gymnothorax unicolour is instead uniformly coloured and jaws are not arched.

Biology and ecology: Demersal species. Stays concealed among rocks and rubble where it ambushes its prey. Reaches depths of at least 60 m. Active predator feeding on crustaceans and fish. No data on reproduction of the species.

Distribution: Eastern Atlantic Ocean, Azores, Madeira, Canary, Cape Verde, Ascension and St. Helena islands. First recorded in the Mediterranean Sea in Israel, subsequently in Greece, Cyprus, Turkey, Lebanon and Italy. Adriatic Sea: First two individuals were observed (and determined from the photographs) in July 2010 near Sušac Island, Croatia. Another individual was observed in September of 2011, from Bijelac Islet near Lastovo Island (Croatian coast, middle Adriatic). One specimen recorded near Lopud Island (Croatian coast, south Adriatic) in 2015. Several specimens observed near Vis and Biševo islands in 2018 and 2019 and one specimen caught near Pelješac peninsula in 2021. Also reported from Mljet area. In 2019, a specimen was photographed in the western Adriatic near Tremiti islands (Italy). This species is considered established in the southern Adriatic.

Origin: Atlantic species, previously unreported in the Adriatic Sea.

Relevance: Edible, but not commercially important.

Literature: Bauchot (1986), Kalogirou (2010), Lipej *et al.* (2011), Dulčić *et al.* (2014c), Guidetti *et al.* (2012), Bartulović *et al.* (2017), Tiralongo *et al.* (2020).

Facciolella cf. *oxyrhyncha* (Bellotti, 1883)

Common name: Facciola's sorcerer

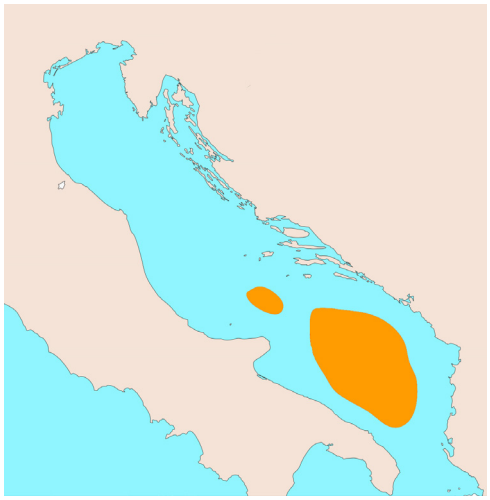
Family: Nettastomatidae – duckbill eels

Synonyms: *Leptocephalus oxyrhynchus* Bellotti, 1883; *Nettastoma melanurum* (non Rafinesque, 1810).

Description: Body very elongated and sub-cylindrical from head to anus, tapering to a pointed tail. Snout is long and slightly flat. Narrow interorbital space. Long jaws, upper jaw longer than the lower. Jaws reach well beyond posterior margin of eye. Teeth visible when mouth closed. Outer teeth are small and conical. Anterior nostril on the tip of the snout, the posterior nostril slit-like located at the level of the lower quarter of the eye. On the dorsal tip of the snout is a small fleshy extension. Gill opening crescent-like and located ventrally. Pectoral and pelvic fins absent. Body colour is light grey. Anterior part of the head from enlarged throat to snout is brownish-red. Maximum recorded size is 64 cm SL.

Biology and ecology: Demersal species found at depths from 30 to 731 m. The young are sometimes found in caves, while larger individuals usually reach deeper waters. Feeds mainly on smaller decapods.

Distribution: Eastern Atlantic from southern Portugal to Angola. In the Mediterranean known from the Ligurian and Tyrrhenian seas. Adriatic Sea: In August 2000, one leptocephali of this species was recorded in the south Adriatic close to Bari (Italian coast, south Adriatic) at depths between 440 and 526 m. During recent investigations in deep waters of the south Adriatic, approx. 30 individuals of leptocephali of *Facciolella* sp. were collected. Although morphologically similar to *F. oxyrhyncha*, genetic analysis suggested they belong to yet undescribed species. No adult individuals have been recorded so far in the Adriatic Sea.



Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Smith (1990), Stramigioli *et al.* (2002), Anibaldi *et al.* (2016).

Polyacanthonotus rissoanus (De Filippi & Verany, 1857)

Common name: Smallmouth spiny eel

Family: Notacanthidae – deep-sea spiny eels

Synonyms: *Notacanthus rissoanus* De Filippi & Verany, 1857; *Notacanthus rostratus* Collett, 1889.

Description: Body compressed and elongated with a tail tapering to a point. Head narrow and elongate. Snout slender and pointed. Body covered with small scales which are absent on underside, tip of snout and branchiostegal membranes. Anterior and posterior nostrils close together. Mouth small, inferior and end before anterior edge of eye orbit. Claw-like teeth. First spine of dorsal fin inserted well anterior to pectoral fin base. Dorsal fin consists of many small spines. Caudal fin reduced and connected with end of anal fin. Body uniformly whitish, tan or grey. Lateral line darker. Mouth bluish in front, black behind. Common size is 1–2.3 cm TL (maximum 9.5 cm TL). Distinct dorsal fin with numerous spines is a feature not shared by potentially similar species of elongated body type. Meristic formula: D: XXVI–XXXVI; A: XXXII+107; V: I+7–11.

Biology and ecology: Epibenthic. Feeds on small benthic crustaceans, polychaetes and similar. Inhabits depths from 500 to 2 800 m. Sexually dimorphic – mature males have black nostrils.

Distribution: Eastern Atlantic from Greenland, Iceland and Ireland to South Africa, including the Mediterranean Sea. Western Atlantic from Davis Strait to Cape Hatteras, North Carolina in the USA. Off Australia in Pacific Ocean. Adriatic Sea: In summer 2008 a single individual was collected from a depth of around 1200 m in south Adriatic. No subsequent documented records.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Sulak (1986), Smith and Heemstra (1986), Isajlović *et al.* (2009).

Gaidropsarus granti (Regan, 1903)

Common name: Grant's rockling

Family: Lotidae – hakes and burbots

Synonyms: *Onus granti* Regan, 1903

Description: Elongated body with rather narrow head. Relatively large mouth. Two dorsal fins, the first with elongated first finray followed by shorter finrays. Second dorsal fin similar in height to anal fin. Three barbels, one on chin and one on each anterior nostril. A band of small sharp teeth on the upper jaw with larger, curved teeth in the outer row. Fresh specimens are deep pink in colour with brown blotches that form asymmetrical patterns on the upper part of the body. Lower parts are cream colour, including head. Upper part of the body has three longitudinal brown stripes, one dorsal and two dorso-lateral with light band between them. Brownish head is interrupted by light spots and curved stripes. Maximum size is 36 cm SL. Meristic formula: D2: 58–60; A: 48(49) – 52; P: 20–22.

Biology and ecology: Inhabits rough grounds at depths ranging from 120 to 820 meters, sometimes in the vicinity of seamounts and underwater canyons. Also recorded on soft bottoms. Not commonly caught. Food items include palaemonid prawns and galatheids. No data on the reproduction.

Distribution: Eastern Atlantic around Canary Islands and the Azores. In the Mediterranean, it has been recorded in Alboran, Ligurian, Tyrrhenian, North Ionian, Levant and Adriatic Seas. Adriatic Sea: first record is from its south-western part (off Bari, Italy) in 1997. Subsequently sporadically recorded in the same area. One specimen recorded in 2018 near Island Žirje (eastern Adriatic, Croatian coast).

Origin: Its origin in the Mediterranean is debated (possibly overlooked native species or recent Atlantic immigrant), recently confirmed record for the Adriatic Sea.

Relevance: Minor importance in fisheries.

Literature: Cohen (1990), Orsi Relini and Relini (2014), Garcia (2015), Bello (2018), Spinelli and Castriota (2019).

Fistularia commersonii (Rüppell, 1835)

Common name: Bluespotted cornetfish

Family: Fistulariidae – Cornetfishes

Synonyms: *Fistularia depressa* Günther, 1880; *Fistularia petimba* (Lacepède, 1803).

Description: Body extremely elongated and slender. Long and tubular snout with small and slightly oblique mouth with small teeth. Lateral and upper ridges of snout serrate on proximal two thirds of length. Flat interorbital space with delicate ridges. Dorsal and anal fins posteriorly positioned and opposite to each other, without spines. Caudal fin forked, with two elongated and filamented middle rays. Skin smooth. No bony plates along the midline of the back. Body colour is uniform green or brownish dorsally. A pair of blue or green lines (or rows of spots) along the back of the body. Silvery-white ventrally. Common size is 20–100 cm TL (maximum 160 cm TL). Broadly similar to *Sygnathus* sp. and *Nerophis* sp., but these lack tail filament and attain much smaller maximum lengths. Meristic formula: D: 15; A: 14; P: 14–15; V: 6.

Biology and ecology: Benthopleagic species. Adults inhabit reefs to a depth of at least 132 m. Found also on sandy bottoms adjacent to reef areas, either solitary or in schools. Active predator. Feeds on small fishes, crustaceans and other small animals. One of the most important prey items in the Mediterranean are the fishes *Spicara smaris* and *Boops boops*.

Distribution: Originally distributed in Indo-Pacific Ocean and Red Sea, from East Africa to Rapa and Easter Island, north to southern Japan, south to Australia and New Zealand. In Eastern Central Pacific from Mexico to Panama. In the Mediterranean it was first reported from Israel in 2000, but Bariche *et al.* (2013) documented the capture of a single individual in Lebanon in 1975. This species experienced a population explosion along the eastern Mediterranean coasts and spread rapidly westward. Today the species is common in all the Levantine basin, and it is occasionally observed in most western Mediterranean countries. Adriatic Sea: In the winter of 2006, two individuals were caught in the waters off Tricase Porto (Italy, southwestern Adriatic) and off Sveti Andrija (Croatia, southeastern Adriatic). In December 2007, one individual was found washed up on the shore of Bar (Montenegro, southern Adriatic). Two juveniles were caught in Molunat Bay in October 2011 (Croatian waters). Two individuals were caught in Montenegrin waters in the winter of 2013 near Tivat and Budva. According to fishers, the species was observed near Molunat in 2016 (south Adriatic), but has not been recorded since.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Edible, but of minor commercial importance.

Literature: Smith and Heemstra (1986), Golani (2000), Azzurro *et al.* (2004), Dulčić *et al.* (2008), Joksimović *et al.* (2008), Azzurro *et al.* (2012), Bariche *et al.* (2009, 2013), Dulčić *et al.* (2013), Dulčić *et al.* (2014b).

Cyclopterus lumpus (Linnaeus, 1758)

Common name: Lumpfish

Family: Cyclopteridae – lumpfishes

Synonyms: *Cyclopterus minutus* Pallas, 1769; *Lumpus vulgaris* McMurtrie, 1831; *Cyclopterus lumpus hudsonius* Cox, 1920.

Description: Body round and deep. Dorsal spines form a distinct crest, covered by skin. Second dorsal and anal fins round and opposite to each other. Caudal fin rounded. Pelvic fins modified into a sucker disc. Longitudinal rows of bony tubercles along the body. Small denticles scattered along the body and on the head. Small terminal mouth reaching back in line of eyes. Colour is dark greenish-grey on the back with light grey belly. Darker tubercles can be visible on paler skin. Common size 10–50 cm TL (maximum 61 cm TL). Meristic formula: D1: VI–VII; D2: 9–11; A: I + 9–10; P: 20.

Biology and ecology: Usually solitary fish. Adults inhabit rocky bottoms but may also occur among floating seaweed. They migrate considerable distances in an annual cycle between deeper waters in winter and shallower waters in summer. Recorded at great depths (868 m). Epibenthic, but also pelagic species. Eggs are laid in large numbers on the rocky bottom. Males are egg-guarders. Juveniles can be found among algae in bays and fjords, migrating offshore as they mature. Adults feed on ctenophores, medusas, small crustaceans, polychaetes, jellyfish and small fishes.

Distribution: Western Atlantic Ocean from Nunavut, Hudson Bay to James Bay and Labrador in Canada to New Jersey in the USA. Also occasionally found in Chesapeake Bay and Bermuda. In Eastern Atlantic Ocean from Barents Sea, Iceland and Greenland to Spain. Adriatic Sea: In September 2004, a single adult individual was caught by a commercial trawl 7 NM south of Molunat Bay (south Adriatic). This is the only observation so far for the entire Mediterranean Sea.

Origin: Non-indigenous species. Probably introduced by ship transport.

Relevance: Valued for its eggs. Eaten in Nordic countries, marketed fresh or smoked. Flesh of male individuals is most popular and roe is sold fresh.

Literature: Stein (1986), Dulčić and Golani (2006).

Elates ransonnettii (Steindachner, 1877)

Common name: Dwarf flathead

Family: Platycephalidae – flatheads

Synonyms: *Platycephalus ransonnettii* Steindachner, 1876; *Elates thompsoni* Jordan & Seale, 1907.

Description: Body elongated with depressed head. Snout shape resembles duck's bill. Two well separated dorsal fins, first one with shorter base. Second dorsal fin originating at around body midpoint. First ray in second dorsal fin is the longest. Anal fin opposite to second dorsal fin and similar in shape. Caudal fin emarginated with upper ray filamentous. Pectoral fin base situated between dorsal fin origin and pelvic fin origin. Large mouth, lower jaw projected with small villiform teeth. Upper jaw edge not reaching the vertical of eye. Eyes situated dorsally. A long spine on the preoperculum. Body colour is tan to yellowish-cream with scattered black blotches and spots on the body, dorsal and caudal fins. Common size is 10–15 cm TL (maximum 19 cm TL). Broadly similar to *Callionymus* sp. which have pointed snout with small mouth. Meristic formula: D1: VI; D2: 12–14; A: 12–14; P: 19–20; V: 1+5; LL: 83–107; GR: 15–21.

Biology and ecology: Inhabits sandy or muddy bottoms from 5 to about 50 m. Feeds on benthic invertebrates and small fishes. Buries itself in the bottom and ambushes its prey.

Distribution: Western Central Pacific from Gulf of Thailand and the Philippines to Papua New Guinea and northern Queensland, Australia. In 2007, one individual was collected in the Mediterranean Sea (Gulf of Taranto, southern Italy). Adriatic Sea: In March 2010, a single individual was caught in Kaštela Bay (Croatian coast, middle Adriatic). It was caught at a depth of 15 m by a fish trap on a muddy bottom. This was the first reported observation of this species in the Adriatic Sea, and the second for the Mediterranean Sea.

Origin: Non-indigenous species, likely introduced through shipping activities.

Relevance: Minor commercial importance.

Literature: Paxton *et al.* (1989), Mastrotaro *et al.* (2007), Dulčić *et al.* (2010).

Coelorinchus mediterraneus (Iwamoto & Ungaro, 2002)

Common name: –

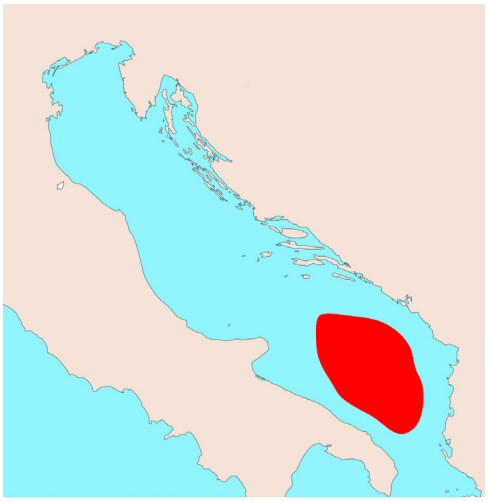
Family: Macrouridae – grenadiers or rattails

Synonyms: –

Description: Body elongated with relatively long tapering tail. Snout is long, broadly spade-shaped in dorsal view, relatively shallow, acutely pointed in lateral view tipped with narrow diamond shaped terminal scute. The front edges of the snout have bone support. The lower part of the head is without scales. The upper part of the head is mostly bare or with small scales. Relatively small mouth on the lower side of the head. Jaws with conical teeth of equal size. Photopores are poorly developed. Body colour is brownish-grey to almost black. Some parts of snout, operculum and pectoral fins are black. Maximum size is 24.5 cm TL. Similar to *Coelorinchus caelorhincus* which has a large dermal window of the light organ between pelvic fins, a broad, blunt trihedral terminal snout scute and extensively scaled underside of the head. Meristic formula: D: II+7–9; P: 16–19; V: 7.

Biology and ecology: Bathydemersal species occurring at depths from 800 to 1200 m. Feeds mostly on polychaetes and amphipods, but probably also on other smaller animals. Reproduction in Mediterranean is semi-continuous with higher activity in autumn and winter.

Distribution: Present in Northwestern Mediterranean on the continental margin. Distribution not well known due to previous confusion with *Coelorhynchus labiatus*. It is present in the eastern Aegean, Catalan and Ligurian Seas. Adriatic Sea: First recorded in 2001 in the south Adriatic. The species was described on the basis of the Adriatic specimen. Recent studies have shown that this species is abundant in the deep Adriatic Sea at depths from 800 to 1200 meters.



Origin: Recently described native Mediterranean species.

Relevance: None.

Literature: Iwamoto and Ungaro (2002), Fernandez-Arcaya *et al*. (2013).

Lepidion lepidion (Risso, 1810)

Common name: Mediterranean codling

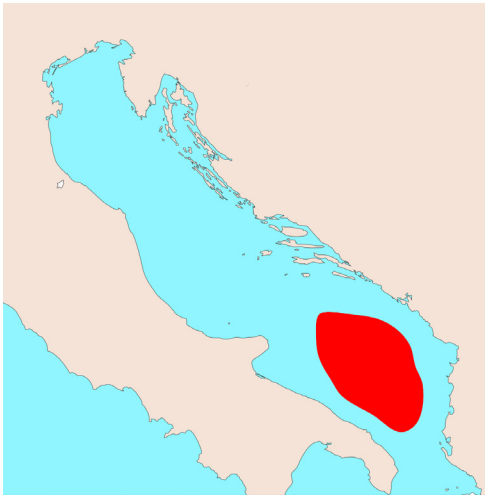
Family: Moridae – morid cods

Synonyms: *Gadus lepidion* Risso, 1810; *Lotta lepidion* (Risso, 1810); *Lepidion rubescens* Swainson, 1839.

Description: Body is elongated. Head is broad with relatively large eyes. Nostrils are located immediately in front of the eyes. Upper jaw in front of the lower. Barbel present on the lower lip. First dorsal fin greatly elongated. First two rays of the pelvic fins prolonged into filaments. Anal fin extends from the middle of the body to the tail. Head lateral line system with pit organs; pores are absent. Body is reddish and the belly is silvery. Maximum size is 34 cm TL. Meristic formula: D2: 54–59; A: 48–51.

Biology and ecology: Bathypelagic species inhabiting depths of 500 to 2 300 m. Most abundant in waters deeper than 750 m. Feeds mainly on benthic organisms.

Distribution: Endemic to the Mediterranean Sea, most common in its northwestern sectors. Adriatic Sea: In 1999, at depths below 1 000 m in the South Adriatic Pit, 284 individuals of this species were captured. The species can be considered as common in the deep Adriatic Sea.



Origin: Endemic Mediterranean bathypelagic species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Cohen *et al.* (1990), Ungaro *et al.* (2002).

Pterois miles (Bennett, 1828)

Common name: Devil firefish

Family: Scorpaenidae

Synonyms: *Pterois muricata* Cuvier, 1829; *Scorpaena miles* Bennett, 1828

Description: Body is relatively compressed, oblong, with large head. Head features distinct ridges, spines and fleshy tentacles most notably supraorbital ones. Dorsal fin is feathery; pectoral fin expanded, wing-like. Venomous spines in the dorsal, anal and ventral fins. The caudal fin is rounded. Teeth are villiform in the jaws and on vomer. Body colour is reddish to tan or grey in colour, with numerous brownish bars on body and head; tentacle above eye may be faintly banded. Maximum size is approx. 35 cm SL. Meristic formula: D: XIII+9–11; P: 13–15; A: III+6.

Biology and ecology: Inhabits coastal waters up to at least 85 m. Usually found on soft bottoms but also associated with reefs or other underwater structures. Fin spines highly venomous, and may cause harm to human, very rarely fatal. It is mainly nocturnal and usually hides during the day. It attains early maturity and has high growth ratres. It feeds mostly on fish and small crustaceans. Highly invasive species in invaded areas. Preyed upon by few predators such as groupers, moray eels and sharks in the native range. Known to be preyed upon by *Octopus vulgaris* in the Mediterranean.

Distribution: Native to the Indian Ocean, from the Red Sea and South Africa on the west to Indonesia on the east. As an invasive species it is present in many areas in eastern and central Mediterranean Sea i.e. Israel, Levant region, Cyprus, Malta, Turkey, Greece Tunisia and Italy. It is also present off the east coast of the United States and in the Caribbean Sea where it is considered as highly invasive species. It is morphologically very similar to *P. volitans*, which does not occur in the Red Sea. Adriatic Sea: First recorded in the Adriatic Sea near the coasts of Puglia (Italy) and Albania, in July 2019 and August 2020, respectively. Subsequently recorded near Vis island (middle Adriatic, Croatia) in August 2021. This record also constitutes the northernmost record of this species in the Mediterranean Sea to date.

Origin: Lessepsian migrant previously not recorded in the Adriatic Sea.

Relevance: Venomous species capable of causing a highly painful sting, very rarely fatal. Edible and important as an Aquarium species. Highly invasive outside native range.

Literature: Eschmeyer (1986), Savva *et al.,* (2020), Di Martino and Stancanelli (2021), Dimitriadis *et al.* (2020), Crocetta *et al.* (2021), Dragičević *et al.* (2021).

Cataetyx alleni (Byrne, 1906)

Common name: –

Family: Bythitidae – viviparous brotulas

Synonyms: *Pteridium alleni* Byrne, 1906; *Cataetyx leucos* (Osório, 1917); *Cataetyx brevis* (Koefoed, 1927).

Description: Body elongated and compressed with tapering tail. Cycloid scales on body and head. Strong spine on the operculum. Small spine near the eye. Ventral fins are reduced to one ray. The dorsal, caudal and anal fins are connected broadly into a single fin. The colour of the body is brownish, darker from snout to eyes, lighter ventrally. Two darker stripes present between eyes and upper edge of operculum. Maximum size is 12 cm TL. Meristic formula: D: 109–111; A: 79–83; P: 31–32.

Biology and ecology: Bathydemersal species occurring in depths ranging from 480 to 1 000 m. Euryphagic predator which feeds on smaller epibenthic and endobenthic crustaceans and polychaetes. Viviparous species with internal fertilization.

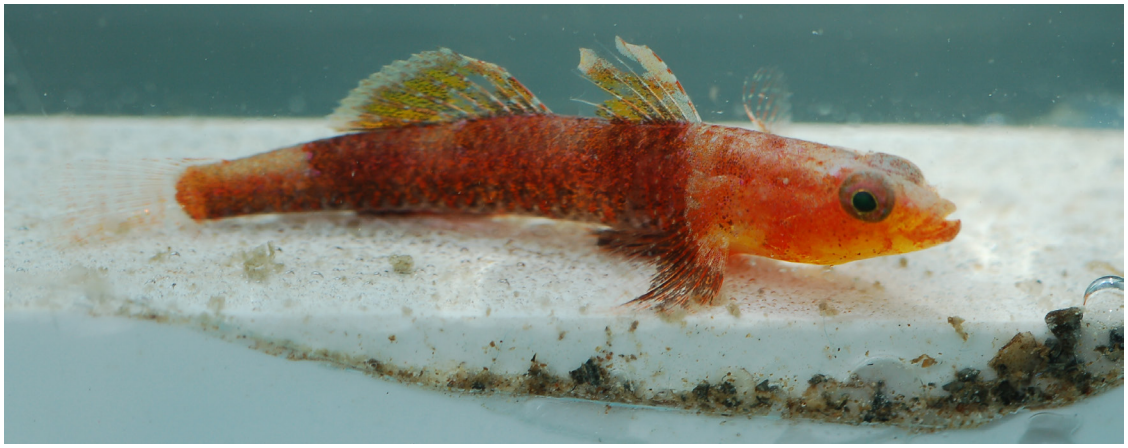
Distribution: Eastern Atlantic from France to Portugal and western Mediterranean. Adriatic Sea: First recorded in 1999 when large numbers of individuals were caught between depths of 1 076 to 1 196 m in the South Adriatic Pit.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Nielsen *et al.* (1999), Ungaro *et al.* (2002), Carrasssón and Matallanas (2002), Follesa *et al.* (2011).

Speleogobius Ilorisi (Kovačić, Ordines & Schliewen, 2016)



Common name: –

Family: Gobiidae – gobies

Synonyms: –

Description: Body moderately elongate, laterally compressed with a slender caudal peduncle. Head long, slightly depressed, with a nearly horizontal predorsal profile. Snout moderately long and pointed, equal or longer than eye. Eyes dorsolateral, extending above dorsal profile. Anterior nostril short, tubular, erect, without process from rim; posterior nostril pore-like, near orbit. Mouth oblique, posterior angle of jaws below anterior edge of eye, anterior tip of mouth in the horizontal level of eye. Body covered with ctenoid scales. In females, head and anterior body to pectoral fin base orange red. Rest of the body brown to reddish brown with three brown vertical bands alternating with pale reddish brown bands under both dorsal fins. Ventral midline and belly whitish. In males, head and anterior body to pectoral fin base ventrally yellow, laterally orange yellow and dorsally pale to reddish, Rest of the body brown to reddish with three brown vertical bands bellow dorsal fins alternating with pale reddish-brown bands. Ventral midline and belly without clear whitish area and mostly brown, different from female. In both genders caudal fin at base with continuing brown coloration from caudal peduncle, followed by three ill-defined orange vertical bands. Meristic formula: D1: VI; D2: I+6–7; A: I+6; P: 15; C: 11–12.

Biology and ecology: All individuals of the new species of *Speleogobius* were collected from circalittoral at depths from 46 to 69 m inhabiting red algae beds (rhodolith beds).

Distribution: Known only from Mediterranean Sea from Balearic Islands and Adriatic Sea where it has been recorded near Island Hvar (Croatia) in June 2018.

Origin: Newly described species – reported only from Balearic Islands and island Hvar (Adriatic sea).

Relevance: None.

Literature: Kovačić *et al.* (2016), Kovačić and Glavičić (2019).

Zebrus pallaoroi (Kovačić, Šanda & Vukić, 2021)

Common name: –

Family: Gobiidae – Gobies

Synonyms: –

Description: Body elongated, laterally compressed posteriorly with deep caudal peduncle. Head large and depressed. Snout is oblique, slightly longer than the eye. Mouth oblique and moderately large, posterior angle of jaws ending posteriorly below mideye. Teeth caniniform, erect in both jaws and enlarged in outer rows of both jaws. Anterior nostril nasal tube has a single process on the posterior rim, posterior nostril is a short tube. Eyes are moderately small, dorsolateral and slightly elevated above the dorsal profile. No spines on preopercle. Origin of the first dorsal fin is behind vertical line of the pectoral fin base. Pelvic fin disc is complete and rounded with well developed anterior membrane. Caudal fin is rounded and shorter than the head. Alive specimens are dark brown, almost blackish with conspicuous curved pale band on the head. When stressed may appear much paler, almost yellowish. There are 10–11 vertical dark brown bands present along the flanks, first in front of the first dorsal fin, last at the end of the second dorsal fin, at upper edge about equal or narrower than pale interspaces between. Maximum length is not known, probably about 5 cm. Meristic formula: A: I+8–9; D: VII+10–11; Vert: 27

Biology and ecology: Cryptobenthic species occurring in very shallow infralittoral waters by the shore up to 1 m of depth. Can occurr in holes, crevices and under the boulders. No data on the biology of the species.

Distribution: Known from the northern Ionian Sea, northern and western Aegean Sea and eastern Adiatic Sea. Adriatic Sea: The species was described on the type material from southern Adriatic (Montenegro), subsequently found in northern (Rt Ošto) and middle Adriatic (Split). Possibly wider distribution in the Adriatic but at present not known.

Origin: First record in the Adriatic Sea (recently described species).

Relevance: None. Harmless.

Literature: Kovačić *et al.* (2021); Kovačić *et al.* (2022a).

Gouania adriatica Wagner (Kovačić & Koblmüller, 2020)

Common name: Adriatic blunt-snouted clingfish

Family: Gobiesocidae – Clingfishes and singleslits

Synonyms: –

Description: Body slender and elongated, posteriorly laterally compressed. Head is compressed dorsoventrally and rounded in dorsal view. Canals and pores present on the head as a part of lateral line system. The snout is wide and blunt, and large compared to eyes. Eyes are small, dorsolateral with rounded lower edge. Teeth in upper and lower jaws caniniforms in outer row and with small conical teeth behind. Pharyngeal jaws with ceratobranchial 5 small, having several (about 5) small, conical teeth. Internostril space is gently convex. Cross-section of the body behind pectoral fin base is half oval with straight ventral side. Ventral adhesive disc small and of "double type", slightly larger in width than in length. Anterior margin of the disc is crenate with large invagination on lateral sides and in some specimens central invagination at midventral is visible; posterior margin is crenate or villous. Dorsal and anal fins small and rudimentary, reduced to low ridges with weak rays, located well posteriorly and connected to caudal fin. Caudal fin is rounded. Background coloration in alive specimens is flesh-coloured to yellow, slightly transparent with prominent head pigmentation and star-like pattern around eyes. Maximum length is approx. 48 mm TL. Similar to other species of *Gouania*, for proper identification see Wagner *et al*. (2021). Meristic formula: P: 15–17; C (principal rays): 12–13; Vert: 35.

Biology and ecology: Found in the intertidal among pebbles where it clings with adhesive disc. During low tides it can be found in layers of pebbles above the waterline. In the Adriatic Sea it is broadly sympatric with *Gouania pigra* and *Lepadogaster lepadogaster*.

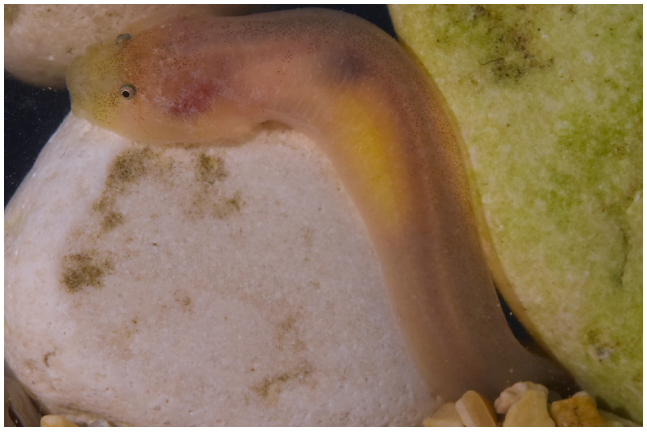
Distribution: Presently known to be distributed from northern Adriatic to northern Ionian Sea. Adriatic Sea: Recently described species known from localities in northern and southern Adriatic (Istria, Rijeka, Krk island and Pelješac in Croatia and Vlorë in Albania). Possibly wider distribution in the Adriatic but at present not known.

Origin: First record in the Adriatic Sea (recently described species).

Importance for humans: None. Harmless.

Literature: Wagner *et al.* (2021).

Gouania pigra (Nardo, 1827)



Common name: Piglet sucker

Family: Gobiesocidae – Clingfishes and singleslits

Synonyms: *Lepadogaster piger* Nardo, 1827, *Gouania piger* (Nardo, 1827)

Description: Body is very slender and elongated, compressed laterally. Cross-section of the body behind pectoral fin base is half oval to pentagonal with straight ventral side. Shallow and inconspicuous granules on the body. Head is moderately small, dorsoventrally compressed and wider than maximum body width. Snout wide and blunt, large compared to eyes. Mouth terminal with upper and lower lips ending about equally. Jaws with front row of caninifoms and small conical teeth behind. Dorsal and anal fins are rudimentary, located posteriorly, reduced to low ridges with weak rays. Caudal fin is rounded. Ventral adhesive disc small, of „double type“ and slightly larger in width than length. Background coloration of alive specimens is white to flesh-colored, slightly transparent and, in contrast to *G. adriatica*, without star shaped pigmentation aroun eyes. Sparse pigmentation on the body gives impression of irregular marbled pattern, but not pronounced as in other *Gouania* species. Maximum length approx. 48 mm TL. Similar to other species of *Gouania*, for proper identification see Wagner *et al.* (2021). Meristic formula: P: 13–16; C (pr incpal rays): 10–11; Vert: 39–40.

Biology and ecology: Inhabits intertidal pebble beaches. May be found above the waterline during low tide, and rarely occurs in fields of larger boulders. Data on biology and ecology are lacking.

Distribution: Possibly endemic to the Adriatic Sea. Recorded in northern (Istria, island Krk and Rijeka in Croatia) and southern Adriatic. The southernmost record is from Vlorë in Albania. Possibly wider distribution in the Adriatic but at present not known.

Origin: First record in the Adriatic Sea.

Relevance: None. Harmless.

Literature: Wagner *et al.* (2021).

Gouania hofrichteri Wagner (Kovačić & Koblmüller, 2020)

Common name: –

Family: Gobiesocidae – Clingfishes and singleslits

Synonyms: –

Description: Body is very slender, elongated and posteriorly laterally compressed. Cross-section of the body behind the base of the pectoral fin is triangular, ventrally flat and dorsally pointed. Granules on the body, prominent on posterior part and nape. Head is compressed dorsoventrally and moderately small, rounded in dorsal view and wider than maximum body width. Snout is wide, not pronounced and larger compared to eyes. Eyes are dorsolateral with rounded lower edge. Anterior and posterior nostrils long tubes are about equal in length. Mouth terminal with upper and lower lips ending about equally and upper lip larger than lower. Lateral line system on the head with canals with pores and with superficial neuromasts arranged in rows. Dorsal and anal fins are rudimental and located posteriorly, reduced to low ridges with weak rays. Caudal fin is rounded. Adhesive disc of „double“ type, very small, larger in width than in length. Background colour of alive specimen is bright to skin-colored. Behind of the head region sometimes with a clearly visible stripe or with marbled pattern. Small and evenly distributed iridophores sometimes visible in lateral view. Star-like pigmentation around eyes is lacking. Similar to other species of *Gouania*, for proper identification see Wagner *et al.* (2021). Meristic formula: P: 14–16; C (principal rays): 10–12; Vert: 38–40.

Biology and ecology: Inhabits intertidal pebble beaches. Probably exhibits passive emergence behavior (spends periods out of water). Data on biology and ecology of this species are lacking.

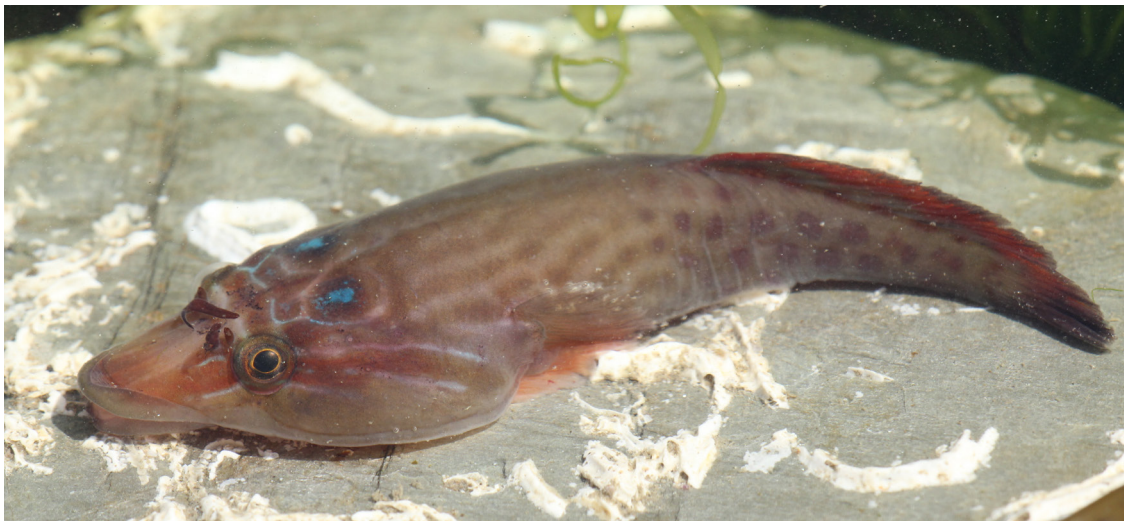
Distribution: Widespread in the eastern Mediterranean Sea, abundant in northern and suthern Ionian and Aegean Sea. Adriatic Sea: A single record in the Adriatic Sea from Pelješac island.

Origin: First record in the Adriatic Sea (recently described species).

Relevance: None. Harmless.

Literature: Wagner *et al.* (2021).

Lepadogaster purpurea (Bonnaterre, 1788)



Common name: Cornish sucker

Family: Gobiesocidae – clingfishs and singleslits

Synonyms: *Cyclopterus purpureus* Bonnaterre, 1788.

Description: Body anteriorly depressed. Elongated head in dorsal outline with pronounced, rounded and spatulate snout. Teeth small and conical, in deep patches towards front of each jaws. Pelvic fins modified into suction disc. Anterior nostrils with long tentacles. Flattened papillae in 4–6 rows across width of disc region A (anterior region); 5–6 rows across disc region B (posterior region). Colour is mostly red-brown in various patterns; often with a pair of blue ocelli behind eyes. Maximum size is 75 mm SL. Similar to *L. lepadogaster* which has 3–4 rows of papillae in both disc regions (A and B). Meristic formula: D: 17–21; A: 10–12; P: 20–23; C: 11–14.

Biology and ecology: Occurs on rocky and seaweed covered shores, particularly among boulders, but also found in pebble and cobble sized substrates. No data on feeding and reproduction.

Distribution: In Eastern Atlantic from Scotland to Senegal, also present around Canary and Madeira islands. In Mediterranean west of Cape Roux, Tunisia, Italy and Greece. Adriatic Sea: one specimen collected near island of Ilovik in 2014. Probably more common, but overlooked species.

Origin: Native Mediterranean species, recently confirmed record for Adriatic Sea.

Relevance: None.

Literature: Hofrichter and Patzner (2000), Wagner *et al.* (2017).

Abudefduf cf. *saxatilis*/vaigiensis/troschelii

Common name: –

Family: Pomacentridae – damselfishes

Synonyms: Depending on the particular species.

Description (shared by three species): Oval, deep and compressed body. Continuous dorsal fin with spinuous portion longer than soft ray portion. Soft protions of dorsal and anal fins prominent, opposite and of similar shape. Caudal fin is forked. Colour is yellowish to greenish dorsally, shading to white below. Five prominent vertical black bars originate from the basis of dorsal fin on the flanks ending on the belly. A faint sixth bar often represented by black spots may be present on the caudal peduncle in certain individuals of all three species, most notably in *A. saxatilis* and *A. troschelii*. Although particular morphological features allow distincition of species in many cases, due to similarities in morphology, caution in identification is advised. Meristic formula (shared by three species): D: XIII + 12–13; A: II + 10 – 12.

Biology and ecology: All three species are littoral species which occurr on the rocky bottoms and coral reefs, usually at depths less than 20 m. They usually form small to very large aggregations. Diurnal feeders which feed on small planktonic and benthic invertebrates, small fish and algae. Oviparous with distinct pairing during breeding. Eggs attached to various hard substrates and guarded by the adults.

Distribution: *Abudefduf saxatilis* is distributed in western Atlantic Ocean from Canada to Uruguay. Abundant on Caribbean reefs around mid-Atlantic islands, Cape Verde, and along the tropical coast of western Africa south to Angola in eastern Atlantic. *Abudefduf vaigiensis* is distributed in Indo-Pacific from Red Sea and eastern Africa on the west to French Polynesian islands on the east. Also present in southern Japan to northern Australia and New Zealand. *Abudefduf troschelii* is distributed in eastern Pacific from California and Mexico to northern Peru. Adriatic Sea: One individual identified as *Abudefduf saxatilis* was observed in September 2019 at Punta Sottile, in waters off Muggia (Gulf of Trieste). Additionally, two individuals identified as *Abudefduf* cf. *saxatilis/vaigiensis/troschelii* were recorded along Croatian coast. One near Split in September 2018 and one near Cavtat in 2020.

Origin: Species of this genus are non-native in the Mediterranean and the Adriatic Sea.

Relevance: Important in aquarium trade. Edible, but of limited commercial importance.

Literature: Allen (1991), Lipej *et al.* (2019), Dragičević *et al.* (2021), Pavičić *et al.* (2021).

Note: According to Dragičević *et al.* (2021), identification of particular species in *Abudefduf* genus which are based solely on external morphological characters is not sufficiently reliable due to variablitiy of such charaters among the species. Therefore, Adriatic records are precautionary considered *Abudefduf* cf. *saxatilis/vaigiensis/troschelii*. *Abudefduf troschelli* has not been yet documented in the Mediterranean Sea but is considered here due to similarity with *A. saxatilis* and *A. vaigiensis.*

Chrysiptera cyanea (Quoy & Gaimard, 1825)

Common name: Sapphire devil

Family: Pomacentridae – damselfishes

Synonyms: Abudefduf cyaneus (Quoy & Gaimard, 1825); Glyphisodon azureus Cuvier, 1830; Abudefduf sapphirus Jordan & Richardson, 1908.

Description: It has a slightly elongated, deep and oval body and small teeth in jaws in a single row. Small mouth. No teeth on vomer and palatines. Ctenoid scales moderately sized. Posterior margin of preopercle is smooth. No scales on infraorbitals. Body is bright sapphire blue and there is a dark stripe running through the eye and across the nose. Females develop a black spot at the base of the hindmost dorsal ray. Fins transparent. Dichromatic, with distinct colour difference between the adult male and female. Males have yellow snout and tail. Maximum size is 8.5 cm TL. Meristic formula: D: XIII+12-13; A: II+13-14; P: 18-19; GR: 17-19; LL:16-19.

Biology and ecology: Reef associated. Adults found amongst rubble and coral of sheltered lagoons and subtidal reef flats. Occurrs in groups which usually consists of a male and several females or juveniles. Mostly feeds on algae, pelagic tunicates and copepods. Oviparous with distinct pairing during breeding. Eggs are demersal and adhere to the substrate. Male guarders.

Distribution: Indo-West Pacific from South-Eastern Asia to eastern edge of the Indian Ocean and Western Australia. Adriatic Sea: in August 2013 one individual was recorded in the shallow water at Portorož beach (Slovenian coast, northern Adriatic). The fish was photographed at the site and subsequently captured with a hand net. Several other individuals were also observed at the site, but not collected. No other sightings have been reported so far in the Mediterranean Sea.

Origin: Non indigenous species, likely introduced via aquarium release or shipping.

Relevance: A popular aquarium fish.

Literature: Allen (1991), Lipej *et al.* (2014).

Remora osteochir (Cuvier, 1829)

Common name: Marlin sucker

Family: Echeneidae – remoras

Synoyms: *Echeneis osteochir* Cuvier, 1829; *Rhombochirus osteochir* (Cuvier, 1829)

Description: Body elongated, stout and depressed anteriorly. Scales very small, cycloid and irregulary scattered on the body. Skin covered by mucus. Head short, dorsally flattedned with oval and elongated sucking disc on the dorsal surface. Eyes relatively small. Mouth relatively small, lower jaw rounded and longer than the upper. Small and numerous villiform teeth in both jaws; outermost teeth in the lower jaw slightly enlarged. Dorsal and anal fins are relatively short with multibranched tips of rays. Caudal fin with slightly concave margin. Posterior parts of lamellae of cephalic disc are with numerous backward pointed spinules. Posterior margin of the sucking disc is behind the posterior margin of the pectoral fin. Colour is dark grey to black, darker dorsally than ventrally with dark margins of dorsal and anal fins. Maximum length approx. 400 mm SL. Meristic formula: P: 20–24; D: 20–26; A: 20–26; V: 6; Disc lamellae: 15–19, Vert.: 27.

Biology and ecology: Pelagic species which clings to other fishes with strong preference to billfishes. In the Mediterranean Sea it is usually associated with *Tetrapturus belone* and *Xiphias gladius*. Oviparous species with distinct pairing during breeding.

Distribution: Distributed worldwide in tropical and temperate areas of all oceans. Also present in the Mediterranean. Adriatic Sea: In December 2020, two specimens of *Remora osteochir* were found attached on a specimen of *Tetrapturus belone* in vicinity of Šolta island (middle Adriatic, Croatian coast).

Origin: First record for the Adriatic Sea.

Relevance: None. Harmless.

Literature: Paxton *et al.* (1989), McEachran and Fechhelm (2006), Dulčić *et al.* (2021).

Epinephelus coioides (Hamilton, 1822)

Common name: Orange-spotted grouper

Family: Serranidae – groupers

Synonyms: *Bola coioides* Hamilton, 1822; *Epinephelus nebulosus* (Valenciennes, 1828); *Epinephelus tauvina* (non Forrskål, 1775).

Description: Body moderately elongated and slightly compressed. Dorsal fin continuous. The posterior margin of dorsal, anal and pectoral fins is round. Caudal fin round. Large head with large mouth. Jaw extends back past the vertical line of posterior edge of eye. Teeth in two to three rows. Serrated preoperculum. Three flat spines near the upper-posterior corner of operculum. Body scales ctenoid except for nape, back, thorax, abdomen and above anal fin base which have cycloid scales. Short pelvic fins. Body covered with orange to reddish-brown spots on pale greyish background with several irregular shaped darker bars. Large individuals have many smaller spots. Common size is 30–50 cm TL (maximum 120 cm TL). Similar to other Mediterranean groupers, but they all lack orange to reddish-brown spots. Meristic formula: D: XI+13–16; A: III + 8; P: 18–20; V: I + 5; LL: 58–65; GR: 23–28.

Biology and ecology: Reef associated, often found in brackish waters over mud and rubble. Solitary species. Juveniles are common in shallow waters of estuaries. Feeds on small fishes, shrimps, and crabs. Protogynous hermaphrodite. Forms spawning aggregations.

Distribution: Indo-West Pacific from Red Sea to South Africa and eastward to Palau and Fiji, north to the Ryukyu Islands, south to the Arafura Sea and Australia. Also reported from the Mediterranean coast of Israel. Adriatic Sea: In May 1998, a young individual was caught in the Trieste Gulf (north Adriatic). No subsequent records.

Origin: Non-indigenous species, introduced through Lessepsian migration or by other human activities like shipping or aquarium/mariculture release.

Relevance: Commercial species in areas where abundant, also of potential importance for mariculture.

Literature: Ben-Tuvia and Lourie (1969), Parenti and Bressi (2001), Golani *et al.* (2002).

Mycteroperca rubra (Bloch, 1793)

Common name: Mottled grouper

Family: Serranidae – groupers

Synonyms: *Epinephelus ruber* Bloch, 1793; *Serranus emarginatus* Valenciennes, 1843; *Serranus fuscus* (non Lowe, 1838).

Description: Body oblong and slightly compressed. Depth of the body less than the head length. Convex interorbital area. Dorsal head profile evenly convex. Preopercle finely serrate. Three flat spines on the upper posterior corner of the operculum. Rear nostrils equal or slightly larger than anteriors. Caudal fin truncate or distinctly concave. The base of the soft-ray part of the dorsal fin is shorter than the spinous part. Pectoral fins rounded. Lower jaw projecting in front of the upper jaw. Canines at front jaws, teeth also present on palatines. Body colour usually reddish-brown, sometimes mottled with black or pale grey spots with black streak above maxilla. Juveniles with black saddle blotch on peduncle. Common size is 70–80 cm TL (maximum 144 cm TL). Similar to other Serranidae species which have seven to 10 anal rays and usually round caudal fin. Meristic formula: D: XI+15–17; A: III+11–12.

Biology and ecology: Adults found over rocky and sandy bottoms. Juveniles occur in shallower water, usually on rocky bottoms, seagrass beds and in estuaries. Feeds on molluscs (mostly cephalopods) and small fishes.

Distribution: Eastern Atlantic, from Portugal to southern Angola and Mediterranean Sea. Adriatic Sea: In 2000 one individual was caught near Dubrovnik (south Adriatic). Few subsequent records from the same area and near Lastovo island. Occasional records from Montenegro. In 2021 observed in large lake in island Mljet National Park. Possibly overlooked species due to similarity to other Serranids.

Origin: Native Mediterranean species, previously unreported in the Adriatic Sea.

Relevance: Commercial species of minor importance in the Mediterranean.

Literature: Heemstra and Randall (1993), Glamuzina *et al.* (2002), Dulčić and Dragičević (2011a).

Paranthias furcifer (Valenciennes in Cuvier and Valenciennes, 1828)

Common name: Creole-fish

Family: Serranidae – groupers

Synonyms: *Serranus furcifer* Valenciennes, 1828; *Serranus creolus* Valenciennes, 1828; *Centropristis nebulosus* Castelnau, 1855.

Description: Body oblong to elongated and slightly compressed. Head length shorter than body depth. Large and slightly oblique mouth. Jaws reach back to the vertical of centre of eye. Small canine teeth in both jaws, also present on palatine and vomer. Lower edge of preoperculum finely serrated. Three flat spines on posterior edge of operculum. A single continuous dorsal fin. Caudal fin deeply forked. Pectoral fin relatively long, reaching almost to the vertical of anus. Pelvic fin round, its base slightly behind pectoral fin base. Fine ctenoid scales on body. Upper head, back and flank brownish-red, becoming pinkish-red on ventral surface. Bright red spot at base of pectoral fin. Often three white spots below dorsal fin base and two blue lines on the cheek. Common size is 20 cm SL (maximum 40 cm SL). Distinguished from other members of Serranidae family by deeply forked caudal fin. Meristic formula: D: IX+17–19; A: III+8–10; P: 19–20; V: I+5; LL: 69–77.

Biology and ecology: Mid-water species, usually occurring several metres above the substrate. Can form feeding aggregations well above the reef. Feeds mainly on zooplankton. Gonochoristic species. Retreats instantly when alarmed. Inhabits coral reefs and areas with hard bottom, has been often observed in proximity of oil platforms.

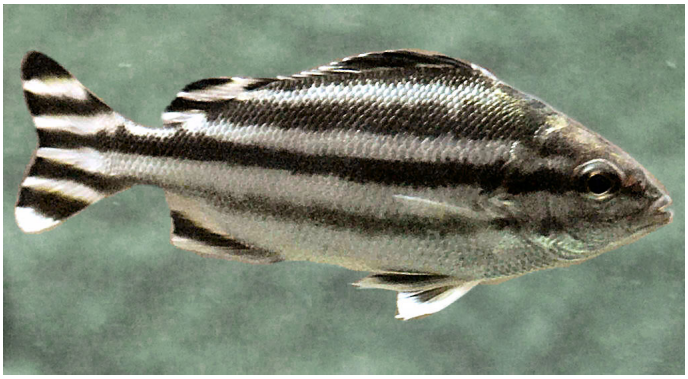
Distribution: Central and Eastern Atlantic, around Ascension Island, Gulf of Guinea islands, Principe, São Tomé and Annobon. Tropical and subtropical Western Atlantic from Bermuda to Florida, Gulf of Mexico, Campeche Bank, and throughout the Caribbean to Sao Paulo, Brazil. In Mediterranean it was recorded in 2007 in Lebanon waters, (Eastern Mediterranean) and in 2013 in Malta (the latter identified as *Paranthias* cf. *furcifer*). Adriatic Sea: In June 2011, a single individual was captured in Marina Bay (Croatian coast, eastern Adriatic Sea).

Origin: Non-indigenous species, likely introduced with an oil platform towed from the Gulf of Mexico.

Relevance: Edible, minor fisheries importance in its native range. It is also an aquarium fish.

Literature: Craig *et al.* (2011), Dulčić and Dragičević (2013a), Crocetta *et al.* (2015), Evans *et al.* (2020).

Terapon theraps (Cuvier, 1829)



Common name: Largescaled terapon

Family: Terapontidae – terapons

Synonyms: *Perca argentea* Linnaeus, 1758; *Perca indica* Gronow, 1854; *Therapon nigripinnis* Macleay, 1881.

Description: Body oblong and slightly compressed. Single continuous dorsal fin with distinct notch between the spinous and the soft portion. Anal fin opposite of soft dorsal fin part. Caudal fin forked. Small fine ctenoid scales on the body. Lateral line continuing onto caudal fin. Slightly oblique, terminal mouth. Jaws reach back to the vertical of the anterior margin of eye. Rows of villiform teeth, the outer row larger. No teeth on the vomer and palatine. Edge of preoperculum serrated. Two spines on the preoperculum, the lower much larger, extends beyond opercular margin. Body silvery-grey to dusky-green on the back with silvery-white belly. Four wide longitudinal black to brown stripes on the flank. The third stripe extends entirely to the caudal fin. Both caudal fin lobes with two horizontal stripes, a black spot on the tip of upper lobes. Large black spot between third and seventh dorsal spines. Juveniles with six or seven whitish or grey vertical bars. Common size is 10–15 cm SL (maximum 30 cm SL). Meristic formula: D: XI–XII + 9–11; A: III + 7–9; P: 14–15; V: I + 5; LL: 46–56; GR: 20–25.

Biology and ecology: Adults inhabit coastal and brackish waters. Juveniles may be associated with floating weeds, often far offshore. Eggs are guarded by the male parent. Feeds on invertebrates and small fish. Produces trumpet-like sound.

Distribution: Indo-West Pacific from East Africa, Madagascar, Seychelles, Red Sea, Arabian Peninsula and Persian Gulf to India and Andaman Islands. Also in Southeast Asia. Reaches south to the Arafura Sea and northern Australia. Two records from the Mediterranean Sea: beside one from the Adriatic Sea, one individual was collected in September 2008 in the Aegean Sea. Adriatic Sea: In August 2007, a single individual was captured by a trawler, 1.5 NM northeast of Piran (Slovenia, north Adriatic). For almost a year, the fish was kept alive in the Piran Aquarium.

Origin: Non-indigenous species likely introduced by anthropogenic activities or Lessepsian migration.

Relevance: Edible, of minor commercial importance in its native range.

Literature: Paxton *et al.* (1989), Lipej *et al.* (2008), Minos *et al.* (2012).

Pomadasys incisus (Bowdich, 1825)

Common name: Bastard grunt

Family: Haemulidae – grunts

Synonyms: *Anomalodon incisus* Bowdich, 1825; *Pristipoma bennettii* Lowe, 1838

Description: large head, about the same as the body depth. Slightly oblique and small mouth. Snout shorter than an eye orbit. Maxilla not reaching anterior edge of eye. Two pores on the tip of chin and a short, shallow groove behind. Deeply notched dorsal fin. Third anal spine longer than second or about equal to second. Relatively large scales. The coloration is back dark brown, silvery white on belly. Sometimes with large dark spots on back and flanks. Black blotch at upper angle of opercle. Maximum size is 35 cm (SL). Similar to some members of Sparidae which lack serrations on the margin of preopercle and 2 pores beneath chin. Meristic formula: D: XII+15–16; A: III+11–13; LL: 47–53.

Biology and ecology: Found on sandy and rocky bottoms in shallow waters up to 50 m of depth. Enters estuaries and lagoons. Feeds on invertebrates. Oviparous with distinct pairing during breeding.

Distribution: In eastern Atlantic from Angola to Gibraltar including Canary Islands, Madeira and Cape Verde. Present throughout the Mediterranean Sea, more common in its southern parts. It seems that its its presence in the northern parts of the Mediterranean is a result of northward spreading of the species. Adriatic Sea: single specimen recorded from Pelješac peninsula in 2015.

Origin: Native Mediterranean species, previously unreported from the Adriatic Sea.

Relevance: Minor commercial interest.

Literature: Ben-Tuvia & McKay (1986), Roux (1990), Bodilis *et al.* (2013), Karachle *et al.* (2016).

Caranx crysos (Mitchill, 1815)

Common name: Blue runner

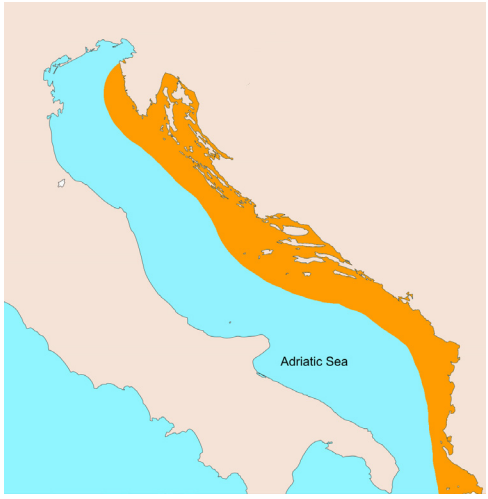
Family: Carangidae – jacks and pompanos

Synonyms: *Scomber crysos* Mitchill, 1815; *Caranx fusus* Geoffroy Saint-Hilaire, 1817; *Caranx pisquetus* Cuvier, 1833.

Description: Body elongated and moderately compressed. Snout slightly rounded. Adipose eyelid present, but weakly developed. Upper jaw with an irregular series of moderate canine teeth. Teeth in lower jaw in a single row. Maxilla ends below middle of eye. Anterior lobe of soft dorsal and anal fins moderately developed, their height smaller than head length. Pectoral fins elongated and longer than head. Scales small and cycloid. No scales on breast. Colour of the back light olivaceous to bluish-green, sides silvery-grey to golden. Juveniles with dark crossbars on sides. Common size is 30–40 cm TL (maximum 70 cm TL). Similar to *Pseudocaranx dentex*, whose maxila ends before the anterior margin of the eye. *Caranx rhonchus* is more slender, with well-developed adipose eyelid and with a yellow stripe on the flanks. Meristic formula: D1: VIII, D2: I+22–25; A: II+I+19–21, P: I+21–23; LL: 46–56.

Biology and ecology: A schooling species generally occurring close to the coast. Also present in brackish waters and on reefs from 0 to at least 100 m depth. Juveniles often found in association with floating *Sargassum*; may enter lagoons and estuaries. Adults feed on fishes, shrimps and other invertebrates.

Distribution: Eastern and central Atlantic, from Senegal to Angola, St. Paul's Rocks and Ascension Island. Reported from Mauritania. In Western Atlantic from Nova Scotia, Canada to Brazil, including the Gulf of Mexico, Caribbean and Argentina. Widespread in both the eastern and western Mediterranean, especially along the southern coasts. Recent distributional extension has been reported from the northern Mediterranean. Adriatic Sea: In August 2008, a single individual was reported from the north Adriatic (Červar porat, Istria, Croatian coast). This was the first record from the Adriatic Sea and the northernmost occurrence of this species in the Mediterranean Sea. Many subsequent records including Ulcinj and Boka Kotorska (Montenegrin coast, south Adriatic), Pelješac channel, Neretva River estuary, Split (Croatian coast, south Adriatic) and Rovinj (Croatian coast, north Adriatic). These observations suggest *C. crysos* is increasing in abundance and extending its distribution northwards.



Origin: Native Mediterranean species, previously unreported in the Adriatic Sea.

Relevance: Commercial species, also targeted by recreational fishers.

Literature: Dulčić *et al.* (2009b), Psomadakis *et al.* (2011), Dulčić *et al.* (2014c), Pavičić *et al.* (2014), Nerlović (2015).

Caranx rhonchus (Geoffroy Saint-Hilaire, 1817)

Common name: False scad

Family: Carangidae – jacks and pompanos

Synonyms: *Decapterus rhonchus* (Geoffroy Saint-Hilaire, 1817); *Caranx angolensis* Fowler, 1919.

Description: Body elongated and slightly compressed. Eye with well-developed adipose eyelid. Two separated dorsal fins. Last dorsal and anal ray transformed into a partially separate finlet. Pectoral fins short. Scales small and cycloid. Anterior, curved part of lateral line with scales and few skutes posteriorly, posterior straight part with skutes and few scales anteriorly. Teeth in both jaws on a narrow, irregular band with outer teeth slightly enlarged. Colour of the back is brownish to olivaceous, sides light olivaceous to whitish-silvery. A yellowish band visible on the flanks, sometimes extending from head to caudal fin base. A black spot on upper margin of gill cover. A black blotch with a narrow light distal margin present on second dorsal fin lobe. Common size is 20–35 cm TL (maximum 60 cm TL). Similar to *Pseudocaranx dentex*, whose maxilla ends before the anterior margin of the eye. *Caranx crysos* has more oblong body and weakly developed adipose eyelid. *Trachurus* sp. have enlarged scutes throughout the lateral line, *C. rhonchus* only posteriorly. Meristic formula: D: VIII+I+28–32; A: II+I+25–28.

Biology and ecology: Bentho-pelagic species. Usually near the bottom in 30–50 m but reported also to 200 m. At times appears near the surface. Schooling species. Also present in brackish lagoons and estuaries. Feeds on small fish and invertebrates. Spawning grounds are usually located in shallow waters. Eggs are pelagic.

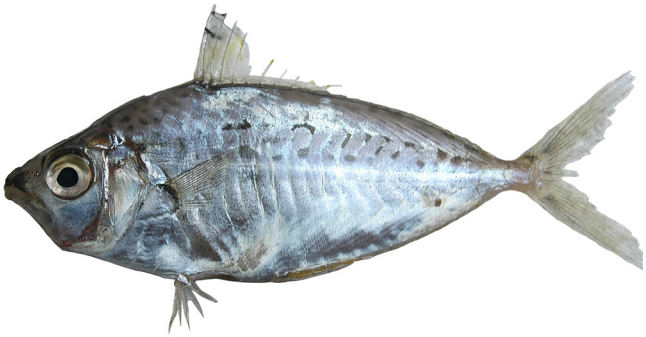
Distribution: Eastern Atlantic from Morocco to Angola, including the Mediterranean along the African coast. Reported also south to Namibia. Adriatic Sea: In 2011, one individual was recorded for the first time in the south Adriatic (Mali Ston Bay, Croatian coast). In summer 2013, larger quantities of *C. rhonchus* were reported from the area of Ulcinj (Montenegro) along with several records from other areas in Montenegro. Subsequent records from Dugi Otok and around island Brač (Croatian coast).

Origin: Native Mediterranean species, previously unreported in the Adriatic Sea.

Relevance: Edible, commercial species in areas where abundant.

Literature: Smith-Vaniz *et al.* (1990), Kožul and Antolović (2013).

Equulites klunzingeri (Steindachner, 1898)



Common name: Kluzinger's ponyfish

Family: Leiognathidae – ponyfishes

Synonyms: *Leiognathus klunzingeri* (Steindachner, 1898); *Equula klunzingeri* Steindachner, 1898; *Leiognathus mediterraneus* Rhasis Erazi, 1943.

Description: Body oblong and very compressed. A single dorsal fin with the second spine enlarged. Caudal fin forked. Anal fin long, more than half of standard length. The second spine in the anal fin is enlarged. Bony ridge on top of the head before dorsal fin origin. Mouth protrusible, tubular and directed downwards when protracted. Villiform teeth in the jaw. No vomer or palatine teeth. Body silvery-grey with white belly. Dark spots on the back and the upper flanks. Common size is 4–8 cm SL (maximum 11 cm SL). Meristic formula: D: VII + 15–16; A: III+15–16; P: 18–20; V: I+5, C: V+21+V, GR: 15–18.

Biology and ecology: Benthic species. Inhabits coastal waters on continental shelf to depths of 70 m. Feeds on bottom invertebrates. Reproduces in warmer months. Eggs and larvae are planktonic.

Distribution: Reported only from the Red Sea. Entered Mediterranean in the 1930s and subsequently established permanent populations in the Levantine basin, expanded westward through Greece and Turkey. Adriatic Sea: In 2000 a single individual was caught near the island of Mljet (Saplunara Bay, south Adriatic). No subsequent records.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Edible but of no commercial importance due to its small size.

Literature: Golani *et al.* (2002), Dulčić and Pallaoro (2002).

Lobotes surinamensis (Bloch, 1790)

Common name: Tripletail

Family: Lobotidae – tripletails

Synonyms: *Holocentrus surinamensis* Bloch, 1790; *Lobotes somnolentus* Cuvier, 1830; *Lobotes auctorum* Günther, 1859.

Description: Compressed, deep and oval body. Dorsal and anal fins rounded and symmetrical, resembling three-lobed fin together with caudal fin. Relatively small eyes, interorbital space narrow, upper profile concave and steep. Mouth large, slightly oblique and with protractile upper jaw. No teeth on roof of mouth. Preopercle with strong dentitions along its margin. Single dorsal fin with distinct spinous and ray part. Bases of dorsal and anal fins scaled. Pectoral fins shorter than pelvic fins. Adults are black, grey, brown or bronze with poorly defined spots and mottling. The young are often bright yellowish, becoming darker with age. Common size is 50 cm TL (maximum 110 cm TL). Meristic formula: D: XI–XII+14–16; A: III+11–12.

Biology and ecology: Adults inhabit bays, estuaries and lower reaches of large rivers. A sluggish fish often found offshore. Adults can be found near underwater objects (e.g. wrecked ships) up to 70 m depth. Occasionally drifts over reefs. Juveniles may occur in floating Sargassum and mimic a floating leaf. Can be found floating on its side near the surface in the company of floating objects. Feeds on benthic crustaceans and small fish.

Distribution: Present in tropical and subtropical waters of all oceans and in Mediterranean Sea. Possibly absent from eastern Pacific. Adriatic Sea: First recorded in June 2010 near island of Biševo. In December 2011 one individual was collected from Mali Ston Bay (Croatian coast, south Adriatic). In May 2013, one individual was captured by hand net at the surface in Raša Bay (southern coast of Istra Peninsula, north Adriatic). In October 2015, one adult specimen has been recorded from Manfredonia, Italy. In July 2016 one individual was recorded from Gulf of Trieste, Italy (north Adriatic). In 2019 recorded near Vir (middle Adriatic) and Pelješac peninsula in 2021 (southern Adriatic). Occasionally present, but rare in the Adriatic Sea.

Origin: Native Mediterranean species, previously unreported in the Adriatic Sea.

Relevance: Commercially important species where it is more abundant.

Literature: Tortonese (1990), Dulčić and Dragičević (2011b), Dulčić *et al.* (2014a), Dulčić *et al.* (2014c), Dailianis *et al.*, (2016), Bettoso *et al.* (2016).

Pagrus major (Temminck and Schlegel, 1843)

Common name: Red sea bream

Family: Sparidae – porgies

Synonyms: *Chrysophrys major* Temminck & Schlegel, 1843; *Pagrosomus major* (Temminck & Schlegel, 1843).

Description: Body oblong and moderately compressed with a single continuous dorsal fin. First two spines very small. Caudal fin forked. Pectoral fin pointed, its origin slightly in front of pelvic fin origin. Mouth terminal, jaws not reaching back to vertical of eye. Dorsal profile of head convex, larger individuals with bulged nape. Four to six canine teeth in upper and lower jaws. Two series of molar teeth in each lateral side of each jaw. Body covered with scales but not on dorsal and anal fin base. Dorsal surface brown-red becoming pinkish-silvery on the belly. Body covered with numerous bright blue spots. Common size is 10–50 cm TL (maximum 100 cm SL). Similar to *Pagrus pagrus* which lacks blue spots on the body, and to *Dentex* sp. which lack molars. Meristic formula: D: X + 10–12; A: III + 7–9; P: 15; V: I + 5; LL: 53–59.

Biology and ecology: Occurs from 10 to 50 m depths, often on hard bottoms, but also on softer bottoms. Usually found close to reefs. Adults migrate into shallower parts of their depth range to spawn. Juveniles occur mainly in the shallower areas. Feeds on various benthic invertebrates, but also on fishes.

Distribution: In Northwest Pacific from northeastern part of South China Sea (Philippines excluded) northward to Japan. Adriatic Sea: One individual was caught near the island of Molat in September 2004. Subsequently, two individuals, whose identification was based on photographs, were reported from Makarska in 2004 and the Zadar area (middle Adriatic) in 2007. No recent records. To our best knowledge, these are the only reports for the Mediterranean.

Origin: Non-indigenous species, introduced through mariculture activities.

Relevance: Commercial species in its native range. Used for mariculture in several world regions and farmed in some Mediterranean countries.

Literature: Eggleston (1974), Dulčić and Kraljević (2007).

Melanostigma atlanticum (Koefoed, 1952)

Common name: Atlantic soft pout

Family: Zoarcidae – eelpouts

Synonyms: –

Description: Body elongated, eel-like shape, covered with loose skin and mucous layer. Head relatively small and rounded. Snout short and blunt. Teeth small and conical. Single nostrils. No ventral fins. Dorsal and anal fins connected to the caudal fin. Body almost transparent. Upper part of body is pinky-grey, as well as flanks. Tail is darker. Snout, nasal area and mouth are dark. Belly is bluish-silvery. Maximum size is 15 cm TL. Meristic formula: D: 92–99; A: 77–84; P: 6–8.

Biology and ecology: Bathypelagic species inhabiting depth range from 400 to 1 853 m. Occurs in midwater over the continental slope, but can also be found on bottom. Mostly found from 365–550 m depth, but enters shallower water and estuaries in the northern part of its range. Feeds on foraminifera, copepods, and ostracods. Buries itself in the sediment, probably for reproduction purposes.

Distribution: North-western Atlantic, Canada, US coasts and Iceland. Eastern Atlantic from Scotland to Canary Islands. In Mediterranean Sea reported from Spain and Ligurian Sea. Adriatic Sea: In 2000, one individual was caught at a depth of 1 100–1 200 m in the South Adriatic Pit.

Origin: Native Mediterranean species, previously unreported in the Adriatic Sea.

Relevance: None.

Literature: Robins and Ray (1986), Silverberg *et al.* (1987), Ungaro *et al.* (2002).

Oplegnathus fasciatus (Temminck and Schlegel, 1844)

Common name: Barred knifejaw, Japanese parrotfish

Family: Oplegnathidae – knifejaws

Synonyms: *Scaradon fasciatus* Temminck and Schlegel, 1844.

Description: Body deep and compressed. Head small with pointed snout. Mouth small and terminate, jaw not reaching beyond the vertical of eye. Teeth in both jaws fused into sharp beak-like dental plates. A single spine on the operculum. Edge of preoperculum serrated. Single dorsal fin with a deep notch between anterior spinous portion and posterior soft ray portion. Deep incisions in the membranes of dorsal fin. Anal fin triangular. Caudal fin moderately forked with rounded lobes. Body covered with small ctenoid scales. Young individuals with seven black vertical bars on a bluish-grey background. First four bars approximately the same width as the intervals between them. Last three bars much narrower. Posterior (soft rays) portions of dorsal, anal and entire ventral fin are black. Large individuals become uniformly brownish-grey with faint or absent bars and black snout. Common size is 10 – 50 cm (maximum 80 cm TL). Meristic formula: D: XI–XII+16–18; A: III+12–13; P:17–18; V: I+5.

Biology and ecology: Inhabits rocky shore regions. Omnivorous species but feeds mainly on hard shells and crabs which it crushes with sharp-edged teeth. Juveniles associate with floating objects, usually drifting seaweed.

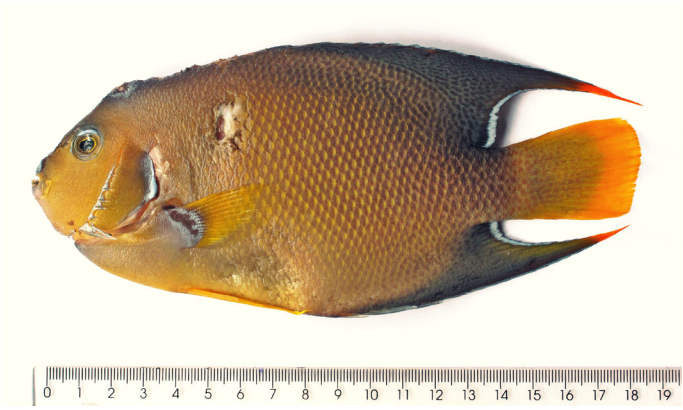
Distribution: Northwest Pacific from Japan to Taiwan. In Eastern Central Pacific around Hawaii. In the Mediterranean, two individuals wererecorded in Malta in 2009. Adriatic Sea: One individual was caught by a fisher in Trieste Bay (Italy, north Adriatic) in September 2015. In November 2015, one individual was caught by a trap for Norway lobster at around 1 NM off Urinj (Rijeka Bay, Croatian coast, north Adriatic). One individual was caught around 30 NM off Ravenna (Italy) in December 2017.

Origin: Non-indigenous species, likely introduced by shipping activities.

Relevance: Edible species. Commercially interesting for fisheries (especially in Japan) and aquaculture.

Literature: Schembri *et al.* (2010), Crocetta *et al.* (2015), Dulčić *et al.* (2016).

Holacanthus ciliaris (Linnaeus, 1758)



Common name: Queen angelfish

Family: Pomacanthidae – angelfishes

Synonyms: *Chaetodon ciliaris* Linnaeus, 1758; *Holacanthus coronatus* Desmarest, 1823; *Holacanthus lunatus* Blosser, 1909.

Description: Body deep and highly compressed. Relatively small and steep head. Small terminal protractile mouth with distinct lips and small brush-like teeth. Strong spine on angle of preoperculum. A single dorsal fin along the top of the body. Both dorsal and anal fin rays posteriorly form very long filaments, reaching in adults beyond caudal fin. Caudal fin moderately round. Pectoral fin round, pelvic fin pointed. Body covered with small ctenoid scales. Body's background is purplish to dark blue with yellow-edged scales. Dark ringed spot on the forehead resembles a crown. Nape, lower part of head and anterior part of belly deep blue. Yellow area on the side of head from eye to cheek. Dorsal and anal fins bluish-orange with distinct blue margin. Caudal, pectoral and pelvic fins yellow, the first often with posterior bluish-green edge. Juveniles are dark blue with yellow tail and blue vertical bars on the body. Common size is 20–30 cm (maximum 45 cm). Meristic formula: D: XIV+19–20; A: III+20–21; P:19; V: I+5; LL: 45–49.

Biology and ecology: Found on coral reefs. Generaly occurs solitarily or in pairs. Swims among seafans, seawhips, and corals. Feeds primarily on sponges, but also algae, tunicates, hydroids and bryozoans. Juveniles often serve as cleaners of other fishes at 'cleaning stations'. Eggs and larvae planktonic.

Distribution: Tropical western Atlantic from Florida and the Bahamas to Brazil. Adriatic Sea: In October 2011, a single individual of *H. ciliaris* was captured in Trogir Bay, eastern Adriatic by a spear gun. It was sheltering between larger stones at a depth of around 14 m in the vicinity of an oil platform. This capture represents the first record of this species in the Mediterranean Sea.

Origin: Non-indigenous species, likely introduced with an oil platform towed from the Gulf of Mexico.

Relevance: Popular as aquarium fish.

Literature: Allen *et al.* (1998), Dulčić and Dragičević (2013b).

Sphyraena chrysotaenia (Klunzinger, 1884)

Common name: Yellowstripe barracuda

Family: Sphyraenidae – barracudas

Synonyms: *Sphyraenella chrysotaenia* (Klunzinger, 1884).

Description: Body elongated. Two separated dorsal fins, first spinous. First spine is the longest, the rest progressively decreasing in size. Second dorsal fin origin in front of anal fin origin. Pelvic fin base located before the end of the pectoral fin. Caudal fin forked. Large head with pointed snout. Long and pointed jaws, lower slightly projected. Maxilla does not reach past front of eye. Large fang-like teeth variable in size, also on the palate. Large eyes. Small cycloid scales. Lateral line almost straight. Dusky band from snout through centre of eye and above pectoral base to caudal peduncle. The band may be yellowish on the head but rapidly fades to dusky colour. Caudal fin yellow, upper trailing edge usually black. Common size is 12–25 cm TL (maximum 35 cm TL). Similar to *Sphyraena sphyraena* and *S. viridensis*, which have pelvic fin located behind pectoral fin tip. Meristic formula: D1: V; D2: 9–10; A: I + 9; P: 13; V: I + 5; LL: 82–86.

Biology and ecology: Bentho-pelagic species which reaches depths of about 50 m. Forms large schools. Feeds mainly near bottom, mostly on smaller schooling fishes, to a lesser extent on crustaceans. Spawning season in the warmer months. Juveniles often observed in very shallow waters.

Distribution: Indo-Pacific from Red Sea, eastern Africa including Madagascar and the Seychelles to China and Northern Australia. In Mediterranean first recorded in Palestine, then successively in Lebanon, Libya, Malta, south Adriatic, Greece and Turkey. Very abundant in some sectors of the Levantine basin. Adriatic Sea: One specimen was caught in the Gornji Molunat Bay (southern Adriatic, Croatian coast) in August 2000. No subsequent records.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Commercially important species in the eastern Mediterranean, exploited by purse seine, trawl and artisanal fisheries.

Literature: Pallaoro and Dulčić (2001).

Gobius ater (Bellotti, 1888)

Common name: Bellotti's goby

Family: Gobiidae – gobies

Synonyms: *Gobius balearicus* Lozano-Rey, 1919

Description: Body is elongated and spindle like. Eyes are located on top of the head, and interorbital space is narrow. Has two dorsal fins, and second dorsal fin is almost symmetrical to anal. Ventral fins are joined to form almost round adhesive disc. Cheeks are conspicuous and have no scales. Alive colouration has only recently been described as follows: head and body is uniformly brown with white pattern on the dorsal side, on the head, fins and pectoral fin base; white interorbital transversal stripe on the head; white marks anteriorly on the right and left part of the lips; a longitudinal white stripe present on the predorsal area extending from the origin of the first dorsal fin and ending nearly behind eye; pectoral fin transparent with brown dots, pelvic fin transparent, dorsal, anal and caudal fin brown with whitish margin and scattered white dots. Maximum size about 7.1 cm SL. Meristic formula: D1: VI; D2: I+12–14; A: I+11; P: 18–19.

Biology and ecology: Demersal, subtropical species which occurs inshore and in lagoons, among seagrass. No data on biology of this species.

Distribution: Endemic to Mediterranean Sea. Records from Balearic Islands and Gulf of Lion to Nica. Also present in Sardinia and Greece. Adriatic Sea: Three individuals of this species were caught in Split area in 1890, and were preserved in ichthyological collection of the Natural History Museum, Vienna. Species identification was carried out in 2001.

Origin: Endemic Mediterranean species, previously unreported in the Adriatic Sea. Historical record, recently confirmed.

Relevance: None.

Literature: Miller (1986), Ahnelt (2001), Kovačić *et al.* (2022b).

Gobius couchi (Miller & El-Tawil, 1974)

Common name: Couch's goby

Family: Gobiidae – gobies

Synonyms: –

Description: Body is cylindrical, elongated and laterally flattened in posterior part. Head is relatively large and robust with a short snout. Cheeks are pronounced. Eyes are on top part of head and bulge. Mouth is rounded and at the top of the muzzle. Lips are thick and project forward. Dorsal fins are separated. Abdominal fins form a disk. All fins have rounded edges. Almost the entire body is covered with ctenoid scales, except gill cover and face completely without scales. Top part of body is dotted grey-brown to yellowish-brown colour. Lower part is lighter, whitish or irregular yellowish. Along the flanks, particularly on the back of the body, are oblique stains that are more elongated than high. Maximum size is 7.7 cm TL. Meristic formula: D1: V–VII; D2: I+12–14; A: I+11–13; P: 15–18.

Biology and ecology: Demersal species which occurs in coastal areas at depths from 0 to 20 m, usually from 5 to 10 m. Found inshore and intertidal, under stones on sheltered soft and rocky bottoms covered with photophilic algae. Feeds on polychaetes, algae, crustaceans, bivalves.

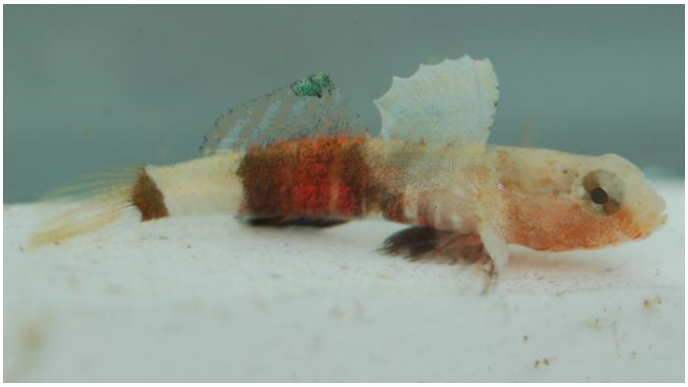
Distribution: North-eastern Atlantic and Western Mediterranean Sea. Adriatic Sea: In 1996 and 1997 a small number of individuals were observed and collected in the Kvarner region (north Adriatic). Previously considered rare, but probably common and widespread in the whole Adriatic.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Miller (1986), Kovačić (2001, 2012).

Lebetus guilleti (Le Danois, 1913)



Common name: Guillet's goby

Family: Gobiidae – gobies

Synonyms: *Gobius scorpioides guilleti* Le Danois, 1913; *Gobius scorpioides* (non Collett, 1874).

Description: Body elongated and laterally moderately flattened. Head relatively small. Eyes large and located on upper side of head. Interorbital space is narrow. Mouth curved with top lip shorter than lower. Pelvic disc is without anterior transverse membrane. Body colour consists of wide brown and whitish transverse stripes. Brown lines located below second dorsal fins in both sexes have a bright spot. Head greyish in males and brown in females. Maximum size is 2.5 cm SL. Meristic formula: D1: VI; D2: I+7–9; A: I+5–6; P: 15–17.

Biology and ecology: Demersal species found at depths down to 30 m, usually 8 – 10 m. Found inshore on coarse grounds, including coralline deposits. No data on the biology of this species.

Distribution: Eastern Atlantic from Kattegat in the north, including Scotland, Ireland, England and Denmark, to the Canary Islands in the south. Also present in Western Mediterranean. Adriatic Sea: Two small populations were located in the north Adriatic in 1999 and 2001, one south of Rijeka and the other along the western coast of Istria, near Rovinj. In 2014, few specimens observed near Ancona (western Adriatic coast, Italy).

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Herler and Kovačić (2002), Hope and Shucksmith (2010), Riolo and Betti (2015).

Didogobius splechtnai (Ahnelt & Patzner, 1995)

Common name: Splechtna's goby

Family: Gobiidae – gobies

Synonyms: –

Description: Body moderately elongated. Head slightly flattened on upper side. Relatively large eyes located on upper side of head. Interorbital space very narrow. The edge of the caudal fin is rounded. Body colour is mostly brown owing to four broad brown trunk bars running transverse across with whitish interspaces (head, under pectoral fins, under second dorsal fin and before caudal fin). Distinct dark spot at the end of first dorsal fin. Ventral part of pectoral fins with black markings extending from the centre of the fins to the tips. Maximum size is 2.3 cm SL. Meristic formula: D1: VI; D2: I+10; A: I+9; P: 15; V: I+5.

Biology and ecology: Found in caves with soft bottoms. Usually on the bottom of innermost cave areas, closer to rocky walls where it hides in secondary holes. Can be abundant within suitable habitats (medium and large-sized caves with soft bottoms). Also found in rocky shores in deep caves at water depths from 5–56 m resting in front of its hole and in small cavities near sea grass.

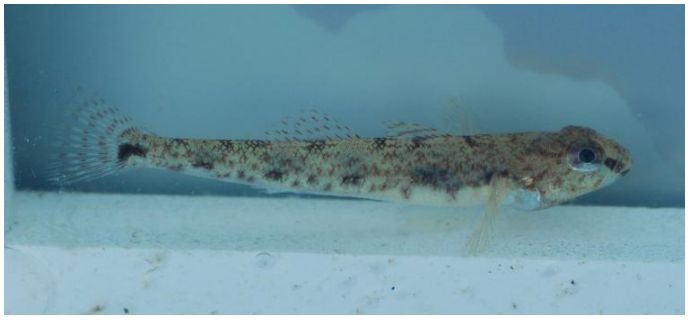
Distribution: Endemic to Mediterranean, so far recorded in Croatia, Spain, France and Italy. Adriatic Sea: One individual was caught with anaesthetics in 2001 near Pula (Croatian coast, north Adriatic) in an underwater cave at 11 m depth. No information about subsequent findings in the Adriatic.

Origin: Endemic Mediterranean species, recently confirmed record for the Adriatic Sea..

Relevance: None.

Literature: Ahnelt and Patzner (1995), Herler *et al.* (1999).

Pomatoschistus norvegicus (Collett, 1902)



Common name: Norway goby

Family: Gobiidae – gobies

Synonyms: *Gobius minutus norvegicus* Collett, 1902; *Gobius elongatus* (non Canestrini, 1862).

Description: Body moderately elongated, moderately cylindrical and flattened at caudal peduncle. Snout is rounded, shorter than diameter of eye. Eyes large and on top of head. Interorbital space is narrow. Upper and lower jaw almost same in size. Rear edge of mouth is in plane of first third of eye. Posterior edge of pectoral fins crosses plane of rear end of first dorsal fin base, but is ahead of beginning of base of second dorsal fin. Scales on back of first dorsal fin, no scales on breast. Dark spot in posterior part of first dorsal fin. Body colour is pale fawn, somewhat translucent, with faint darker reticulation and scattered ferruginous to orange dots. Males show characteristic colouration with a black spot in rear of first dorsal fin and 11 dark vertical striae on sides, pigmented breast and ventral disc. Females without first dorsal spot and chin blotch. Maximum size is 8 cm TL. Meristic formula: D1: VI; | D2: I+9–10; A: I+9–10.

Biology and ecology: Demersal species found at depth range from 18 to 325 m on muddy bottom and coarse shell deposits. Feeds on benthic invertebrates, also on smaller pelagic animals.

Distribution: Eastern Atlantic from Lofoten to western English Channel. In the Mediterranean it has been reported from Spain, and the Tyrrhenian and Aegean Seas. Adriatic Sea: First recorded in 1998 when five individuals were caught on the sandy bottom near Venice at a depth of 10–20 m. In June 2004, recorded at the mouth of river Ombla near Dubrovnik (Croatian coast, south Adriatic). Known only in north and south Adriatic, considered rare.

Origin: Native Mediterranean species, recently confirmed record for the Adriatic Sea.

Relevance: None.

Literature: Miller (1986), Stefanni (2000), Kovačić *et al.* (2012).

Vanneaugobius dollfusi (Brownell, 1978)

Common name: –

Family: Gobiidae – gobies

Synonyms: *Eleotris pruvoti* (non Fage, 1907).

Description: Body elongated with large head. Two dorsal fins, first ray of first fin is longer than others, very prominent in males. Edge of caudal fin is rounded. Abdominal fins are separated. Scales on body are ctenoid, on breast cycloid. Uppermost and lowermost scales on caudal fin more or less elongated, of triangular shape with pointed posterior tip and long ctenii which decrease in size towards tip of scale. Colour in live specimens is pale with orange pigmentation, semi-transparent. Preserved specimens lack transparency. Four irregular orange spots on flanks and one smaller on caudal peduncle. Black spot on base of first dorsal fin. Maximum size is 6 cm TL. Meristic formula: D1: V; D2: I+10; A: I+9; P: 15–16.

Biology and ecology: Demersal species found at depths down to 115 m, on sand with rocky outcrops. No data on the biology of the species.

Distribution: Eastern Atlantic off Agadir, Morocco. In the Mediterranean it has been reported from some localities in Greece. Adriatic Sea: Several individuals were collected near Split (1931), Veliki Drvenik island (1948), Mljet and Palagruža islands (1998), and Susak island (2006). In 2014, was recorded from Hvar island.

Origin: Native Mediterranean species, previously not described in check-list by Jardas (1996).

Relevance: None.

Literature: Miller (1990), Pallaoro and Kovačić (2000), Kovačić (2008), Glavičić and Kovačić (2016).

Siganus luridus (Rüppell, 1829)

Common name: Dusky spinefoot

Family: Siganidae – rabbitfishes, spinefoots

Synonyms: *Amphacanthus luridus* Rüppell, 1829; *Teuthis lurida* (Rüppell, 1829).

Description: Body deep, ellipsoid and compressed. Dorsal fin origin in line with pectoral fin base. Small first dorsal spine, directed forward and can be embedded in the skin. All spines are venomous including the one on the nape. Posterior portion of dorsal and anal fin margin is round. Caudal fin truncated. Pelvic fin origin is behind the base of pectoral fin. Head slightly concave above eyes with blunt snout. Mouth small with distinct lips. Maxilla not reaching vertical of eye. Single row of incisor teeth. Small scales embedded in skin. Colour is dark brown to olive-green with a touch of yellow on fins. Usually irregular complex patterns on the body, but coloration can vary, especially in living individuals observed underwater. Common size is 10–22 cm (maximum 30 cm TL). Similar to *Siganus rivulatus*, which has forked caudal fin. *Sarpa salpa* has yellow stripes on silvery body, forked caudal fin and fewer than seven spines in anal fin. Meristic formula: D: XIII–XIV, 10; A: VII, 8–9; P: 16–17; V: I+3+ I; GR: 18–22.

Biology and ecology: Juveniles form large schools while adults are usually in smaller groups. Prefers hard bottoms of compacted sand with rock or coral debris at depths between 2 and 40 m. Herbivorous species, feeds on a variety of algae. Spawning season is in warmer months. Its colonizing success is probably due to the utilization of unsaturated trophic niche of herbivorous fish species in the Mediterranean. Competitor of native *Sarpa salpa*.

Distribution: Western Indian Ocean and Red Sea, from Persian Gulf and East Africa to islands in the western Indian Ocean. Entered the Mediterranean through the Suez Canal. Recorded first in Israel, successively expanded in the Eastern and Central Mediterranean. Also reported from Southern Italy, Petraikos Gulf (Ionian Sea) and Provence (France). Adriatic Sea: First recorded in summer 2010 in Trieste Bay (Bagno Ducale, Italy). A second observation occurred in November 2010 in the Mljet Channel (Croatia). In December 2011 two juvenile individuals were caught in Molunat Bay (Croatian coast, south Adriatic). In September 2014, a single individual was caught by trammel net in Bigova (cape Trašte) (Montenegrin coast, south Adriatic). In summer 2016 numerous individuals were collected by fishers and large schools were observed near Molunat Bay (Croatian coast, south Adriatic). An established population is likely present along the south-eastern Adriatic. Also recorded in western Adriatic near Molfetta (Italy) in 2019.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: A commercially important species in the Levantine basin, usually caught by trammel nets and beach seines. Poisonous spines which can inflict a painful but non-lethal sting.

Literature: Ben-Tuvia (1964), Golani *et al.* (2002), Poloniato *et al.* (2010), Dulčić *et al.* (2011a), Dulčić *et al.* (2013), Đurović *et al.* (2014), Azzurro and Andaloro (2004), Schembri *et al.* (2012), Ounifi-Ben Amor *et al.* (2016), Azzuro *et al.* (2006, 2007a,b, 2017), Tiralongo *et al.* (2020).

Siganus rivulatus (Forsskål & Niebuhr, 1775)

Common name: Marbled spinefoot

Family: Siganidae – rabbitfishes, spinefoots

Synonyms: *Teuthis rivulata* (Forsskål & Niebuhr, 1775); *Scarus siganus* Forsskål, 1775

Description: Body compressed and oval, covered with small embedded scales. First dorsal fin origin above pectoral fin base. Dorsal fin spines preceded by procumbent spine. Caudal fin forked. Pelvic fin begins behind pectoral fin base. Head moderately concave with blunt snout. Mouth small with distinct lips, the upper overhanging and thick. Jaws with a row of close-set small incisor teeth. No teeth on palatine nor on vomer. Upper body colour grey, green or brownish, silvery below. Body colour patterns extend to the fins. Yellow-gold faded stripes on lower half of body. When frightened, fish become mottled or with six diagonal zones across side. Common size is 5–25 cm (maximum 27 cm TL). Similar to *Siganus luridus*, which has truncated caudal fin. *Sarpa salpa* has yellow stripes on silvery body, forked caudal fin and fewer than seven spines in anal fin. Meristic formula: D: XIII+10; A: VII+9 ; P: 15–16 ; V: I+3+I.

Biology and ecology: Inhabits shallow waters and generally occurs in larger schools (from tens to several hundred individuals). Occurs over sandy substrate, often covered by algae and seagrass. Feeds by grazing on algae, chiefly on fleshy green and red algae, mainly *Ulva* spp. and *Hypnea* spp. Spawning season in warmer months. Eggs and larvae are planktonic. Its success is probably due to utilization of unsaturated niche of herbivorous fish species in the Mediterranean.

Distribution: Western Indian Ocean including Red Sea and Gulf of Aden. In Mediterranean first recorded in Palestine, successively recorded in Syria, Cyprus, Aegean Sea, Libya, Tunisia and Ionian Sea. Recently recorded in southern Italy. Adriatic Sea: In Autumn 2000, two individuals were recorded near Cavtat (Bobara island, south Adriatic). No subsequent records.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: A commercially relevant species in the Levantine basin, usually caught in large quantities in trammel nets and purse seines. Good aquaculture potential. Poisonous spines which may inflict painful but non-lethal stings.

Literature: Smith and Heemstra (1986), Golani *et al.* (2002), Dulčić and Pallaoro (2004).

Stephanolepis diaspros (Fraser-Brunner, 1940)

Common name: Reticulated leatherjacket

Family: Monacanthidae – filefishes

Synonyms: *Stephanolepis ocheticus* Fraser-Brunner, 1940; *Stephanolepis weberi* Fowler & Steinitz, 1956.

Description: Body deep and compressed. Dorsal head profile slightly concave. Single strong spine in first dorsal fin with down-curved spinules along posterolateral edges. Second dorsal and anal fin opposite each other. Soft dorsal and anal fine rays elevated anteriorly. Caudal fin rounded. Pelvic fin is a moveable rudiment. Pointed snout slightly concave dorsally. Small terminal mouth with incisor teeth. Gill opening slit-like, below posterior part of eye. Body covered with rough skin composed of very small scales with delicate spinules. Adult males with second dorsal soft ray prolonged, filamentous. Body basically whitish with many large elliptical to irregular brown spots. Dorsal and anal fin yellow to orange. Common size is 7–15 cm (maximum 25 cm TL). Similar to *Balistes capriscus*, which has three dorsal spines. Meristic formula: D1: I; D2: 30–33; A: 30–33; P: 13–14.

Biology and ecology: Lives at depths from 0 to 50 m, on a coastal rocky substrate, usually with vegetation. Plucks small invertebrates from rocks. Eggs and larvae planktonic. Young individuals feed also in open water on sandy and muddy substrates. Juveniles found associated with jellyfishes.

Distribution: Western Indian Ocean from Persian Gulf to the Red Sea. Also in the Mediterranean Sea where is was first recorded in Palestine (1927). Subsequently spread throughout Eastern and Central Mediterranean reaching Sicily, Malta and Tunisia. Adriatic Sea: In August 2002 an individual of *S. diaspros* was found on the fish market in Ulcinj (Montenegrin coast, south Adriatic). According to fisher testimony, it was captured with a beach seine in the area of Hrid Djeran, at a depth of about 20 m on the rocky-sandy bottom. In September 2013, an individual was caught in the waters off Piran, Slovenia (north Adriatic) on a sandy muddy bottom at a depth of 20 m.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Edible, but of insignificant commercial value.

Literature: Randall (1995), Dulčić and Pallaoro (2003), Kapiris *et al.* (2014), Akyol and Özgül (2015).

Lagocephalus lagocephalus (Linnaeus, 1758)

Common name: Oceanic puffer

Family: Tetraodontidae – pufferfishes

Synonyms: *Lagocephalus lagocephalus lagocephalus* (Linnaeus, 1758); *Tetraodon lagocephalus* Linnaeus, 1758; *Lagocephalus oceanicus* Jordan & Evermann, 1903.

Description: Body elongate and almost ball-like anteriorly when inflated. Snout longer than distance between eyes. Nasal organ consisting of two holes on side of snout. Jaws beak-like, composed of four strong fused teeth with a central suture on each jaw. A slit-like gill opening in front of the pectoral fin base. A single and short dorsal fin posteriorly on the body. Anal fin similar and opposite. No pelvic fins. Tough scaleless skin, but with small spinules from chin to anus and on belly. Upper body and head dark green, brownish-grey or dark blue. Flanks silver with black spots. Belly white. Fins dark. Common size is 30–40 cm TL (maximum 61 cm TL). Similar to *Lagocephalus sceleratus*, which has spinules and black dots on the upper part of the body. *Sphoeroides pachygaster* instead has smooth skin overall. Meristic formula: D: 13–16; A: 11–13.

Biology and ecology: Benthopelagic and oceanodromous species. Occurs in subtropical waters. Inhabits depths of 10 to 1 000 m, but usually between 10 and 100 m. Primarily oceanic, but may occasionally enter estuaries. Capable of inflating when threatened.

Distribution: Circumglobal species found in tropical to temperate seas. It is found in the Atlantic, Indian and Pacific Oceans, in tropical and subtropical waters. In the western Atlantic, it is found in Newfoundland, Canada and southward to Brazil. In the eastern Atlantic, it is found from the Orkneys and the Azores and southward to South Africa; also present in the Mediterranean. In the eastern Pacific, this species occurs from southern California to Chile. Adriatic Sea: First recorded in the south Adriatic at 70 m depth (Molunat Bay, Croatian coast) in September 2004. Two additional individuals collected in June 2015, one near the Kornati archipelago and one near the island of Rab.

Origin: Circumglobal species present in the Mediterranean Sea, previously unreported in the Adriatic Sea.

Relevance: Potentially toxic species; not for human consumption or commercialization, according to EU regulations.

Literature: Schneider (1990), Dulčić and Pallaoro (2006), Tsiamis *et al.* (2015).

Lagocephalus sceleratus (Gmelin, 1788)

Common name: Silver-cheeked toadfish

Family: Tetraodontidae – pufferfishes

Synonyms: *Fugu sceleratus* (Gmelin, 1789); *Tetraodon bicolour* Brevoort, 1856; *Tetraodon blochii* Castelnau, 1861.

Description: Body elongated, ball-like anteriorly when inflated. Dorsal and anal fins opposite each other. Both fins with short base and pointed. Caudal fin emarginated, caudale peduncle long and tapering. Pectoral fin wide. Pelvic fin absent. Head large with blunt snout. Two teeth in each jaw with median suture. Gill slit in front of pectoral fin base. Two lateral lines. Small spinules on dorsal surface, reaching nearly to caudal fin base, and also on the ventral surface to the anus. Greenish-grey dorsally, sometimes with broad darker bands above. Numerous small brown or black spots dorsally. Underside white. Silver band from mouth to caudal fin and silver blotch in front of eye. Common size is 20–60 cm (maximum 110 cm TL). Similar to *Lagocephalus lagocephalus* which has no spinules on the dorsal surface. *Sphoeroides pachygaster* instead has smooth skin all over the body. Meristic formula: D: 11–19; A: 9–12; P: 16–18.

Biology and ecology: Usually over sandy bottom. Reaches depths of up to 250 m, but usually 100 m. Capable of inflating when threatened. Mainly feeds on cephalopods, but also on crabs and other benthic invertebrates, also on fishes. Eggs and larvae are planktonic. Contains potent toxin tetrodotoxin in internal organs (mainly gonads and liver), but also in muscles and skin.

Distribution: Widely distributed in the Indo-West Pacific, where it is native. Entered Mediterranean in 2003, through Suez Canal, and rapidly established permanent population in many areas in the eastern Mediterranean (Israel, Lebanon, Syria, Egypt, Turkey, Cyprus and Greece). It has also become established in Libya, Tunisia, Algeria and southern Italy. Adriatic Sea: In October 2012, the species was first reported from the Adriatic Sea: near Jakljan island (south Adriatic). Other individuals were subsequently captured in middle Adriatic in March 2013 near Tribunj and in April 2014 near Vodice. It was recorded in October 2014 near Trani (Italian coast, south Adriatic), in May 2015 near Dubrovnik (Croatia), and in July 2015 near Budva (Montenegrin coast, south Adriatic). Additional records of this species were also recorded through interviews with fishers in Montenegro. Recorded in 2018 near Peristeres Island (Greece) and in 2019 in Bay of Vlora (Albania) and, near Pašman island in Croatia in 2022.

Origin: Non-indigenous species of Lessepsian origin.

Relevance: Dangerous for human health if consumed, due to its high toxicity. Fatal poisonings have been reported. Negative effects on fisheries are mainly due to its intense predation on native species, and unwanted interference with small-scale fishing.

Literature: Sulić Šprem *et al.* (2014), Dulčić *et al.* (2014c), Dulčić and Dragičević (2014), Azzurro *et al.* (2014), Joksimović and Dulčić (2016), Carbonara *et al.* (2017), Yokeş *et al.* (2018), Kousteni *et al.* (2019).

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***Notes*:**

Beside the key literature references indicated for each species, the following references were used extensively as a source of information for general species descriptions, distinguishing characteristics among species, and distributional records.

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Map of the Adriatic region (Source: d-maps.com, URL: https://d-maps.com/m/mediterranean/adriatique/adriatique01.gif) modified by authors.

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