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Anthozoa of the Adriatic: New insights and a checklist for the southeastern Adriatic

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Abstract

Information about the Anthozoa in the Adriatic Sea has been available in the scientific literature since the second half of the 20th century. These data primarily cover the western coast and the northern and middle regions of the Adriatic, down to the city of Dubrovnik (Croatia), leaving the southeastern Adriatic (Montenegro, Albania, and the northwest waters of Greece) relatively under-studied in historical research. The aim of this paper is to present new information and a checklist of Anthozoa from the southeastern Adriatic by incorporating unpublished data, data from technical reports, and any other available information source. A total of 450 Anthozoa records were compiled, including 109 new records, and the updated checklist for this area currently comprises 62 species. The most numerous species and the most numerous records belong to the subclass Hexacorallia; this pattern is consistent throughout the Adriatic. The number of Octocorallia species was almost equal in Croatia, Italy, and Montenegro (24, 20, and 20, respectively), whereas it was significantly lower in Albania (9). Two species, *Pachycerianthus multiplicatus* Carlgren, 1912 and *Pachycerianthus solitarius* (Rapp, 1829), have been reported for the first time in the southeastern Adriatic, while several species are notably rare, and seven species have been documented only once. A total of 24 protected species were identified in this area. Furthermore, some species are endangered, and necrosis incidents have been reported in *Savalia savaglia* (Bertoloni, 1819) colonies. Although knowledge of anthozoans in the southeastern Adriatic has significantly improved in recent years, it is important to emphasise the need for more comprehensive studies to enhance the understanding and protection of these species.

Keywords: Anthozoa; checklist; southeastern Adriatic; biodiversity.

Introduction

The term Anthozoa, derived from Greek, translates to "flower animals" (*anthos* for flower and *zoon* for animal), aptly describing some key features of species within this class. Anthozoans are typically affixed to substrates, often displaying vibrant colours, and their polyps boast tentacles reminiscent of flower petals (Trainito & Baldacconi, 2016; Betti, 2017). Representing one of the oldest animal classes, anthozoans spend their entire life in the polyp phase, inhabiting various bottom types from the tidal zone to the bathyal. Despite their apparent simplicity, these organisms can form intricate three-dimensional structures, such as coral reefs. While more prevalent in tropical seas, the Mediterranean Sea also hosts coral reefs of *Cladocora caespitosa* (Linnaeus, 1767), bioconstructions of other species, and approximately 200 anthozoan species, some exceeding 200 years in life span (Trainito & Baldacconi, 2016; Corriero *et al*., 2019).

Information about Anthozoa in the Adriatic Sea has been available in the scientific literature since the second half of the 20th century (Broch, 1953; Pax & Muller, 1962; Zibrowius & Grieshaber, 1977). A checklist of Anthozoa for the Italian side of the Adriatic was presented by Morri *et al*. (2008), while data for the eastern part of the Adriatic, comprising around 116 species, has been compiled by Kružić *et al*. (2002, 2017), with additional details provided by Habdija *et al*. (2021). However, these data primarily cover the western coast, northern and middle regions of the Adriatic down to the city of Dubrovnik (Croatia), leaving the southeastern Adriatic (Montenegro, Albania and northwest waters of Greece) relatively under-studied in historical and current research.

For the southeast coast of the Adriatic (Montenegro), only few references on Anthozoa exist from the last century in the Boka Kotorska Bay (Karaman & Gamulin Brida, 1970; Stjepčević & Parenzan, 1980; Stjepčević *et al*., 1986), reporting 20 species. A more comprehensive check-list was provided by Petović & Marković (2021), indicating the presence of 36 species. A pivotal study conducted by Trainito in 2019 (UNEP/MAP-PAP/RAC-SPA/RAC & MSDT, 2019) focused on monitoring

assemblages of *Savalia savaglia* (Bertoloni, 1819) in the Boka Kotorska Bay, shedding light on the significance of micro-locations with high complexity and extraordinary biodiversity. Notably, recent discoveries of *Sarcodictyon catenatum* Forbes, 1847 and *Spinimuricea klavereni* (Carpine & Grasshoff, 1975) mark the first record of these species in the Adriatic Sea (UNEP/MAP-PAP/RAC-SPA/RAC & MSDT, 2019; Mačić *et al*., 2021).

In contrast, information from the coast of Albania is even scarcer, with historical records from the mid-20th century (Broch, 1953; Pax & Muller, 1962) mainly for deeper areas. Subsequent to these records, only a few recent papers have included Anthozoa in fauna lists (Kasemi *et al*., 2008; Gimenez *et al*., 2022). Further south, only a small part of the Adriatic waters belong to Greece, more precisely around the northern part of Corfu Island and the Diapontian Islands (IHO, 2021). In this area, a scarcity of surveys is evident, and all available records are from the last 15 years. Few surveys have been performed in deeper areas (Dounas *et al*., 2010; Taviani *et al*., 2015, 2019) and only one for three shallow locations on the Diapontian Islands (Salomidi *et al*., 2014). The deep areas of the South Adriatic have seen limited coverage, with a few studies reporting the presence of Anthozoa species (Angeletti *et al*., 2014; Taviani *et al*., 2015, 2019; Georges *et al*., 2024), leaving a substantial portion of this area still unexplored. Therefore, the objectives of this paper are to: i) present new information on Anthozoa from the southeastern Adriatic by incorporating unpublished data, data from technical reports, and any other available information source, ii) update the checklist of Anthozoa in the southeastern Adriatic, and iii) enhance knowledge regarding their distribution.

Materials and Methods

The southeastern Adriatic area and survey locations considered in this work are presented in Figure 1. Anthozoa specimens were primarily collected through SCUBA diving on rocky and sandy-muddy bottoms down to 40 m depth (101 dive locations marked as points in quadrats Q1 to Q24, Figure 2A with a few specimens obtained by experimental trawling fishery in the Boka Kotorska Bay (location in quadrat Q5 marked by line at position 42.482452° N, 18.754236° E to 42.466588° N,

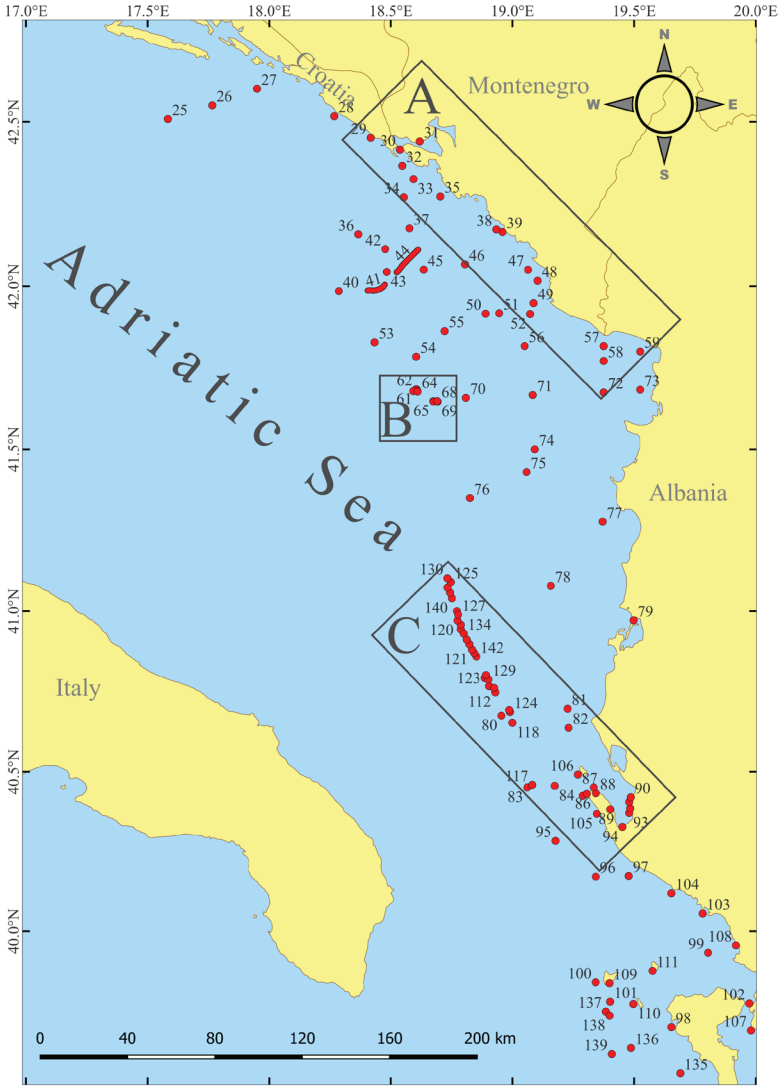

Fig. 1: Southeastern Adriatic area and survey locations considered in this work. Details for zones: A) Coastal part of Montenegro, B) Deep Adriatic, C) Karaburun Peninsula, Albania and deep Adriatic.

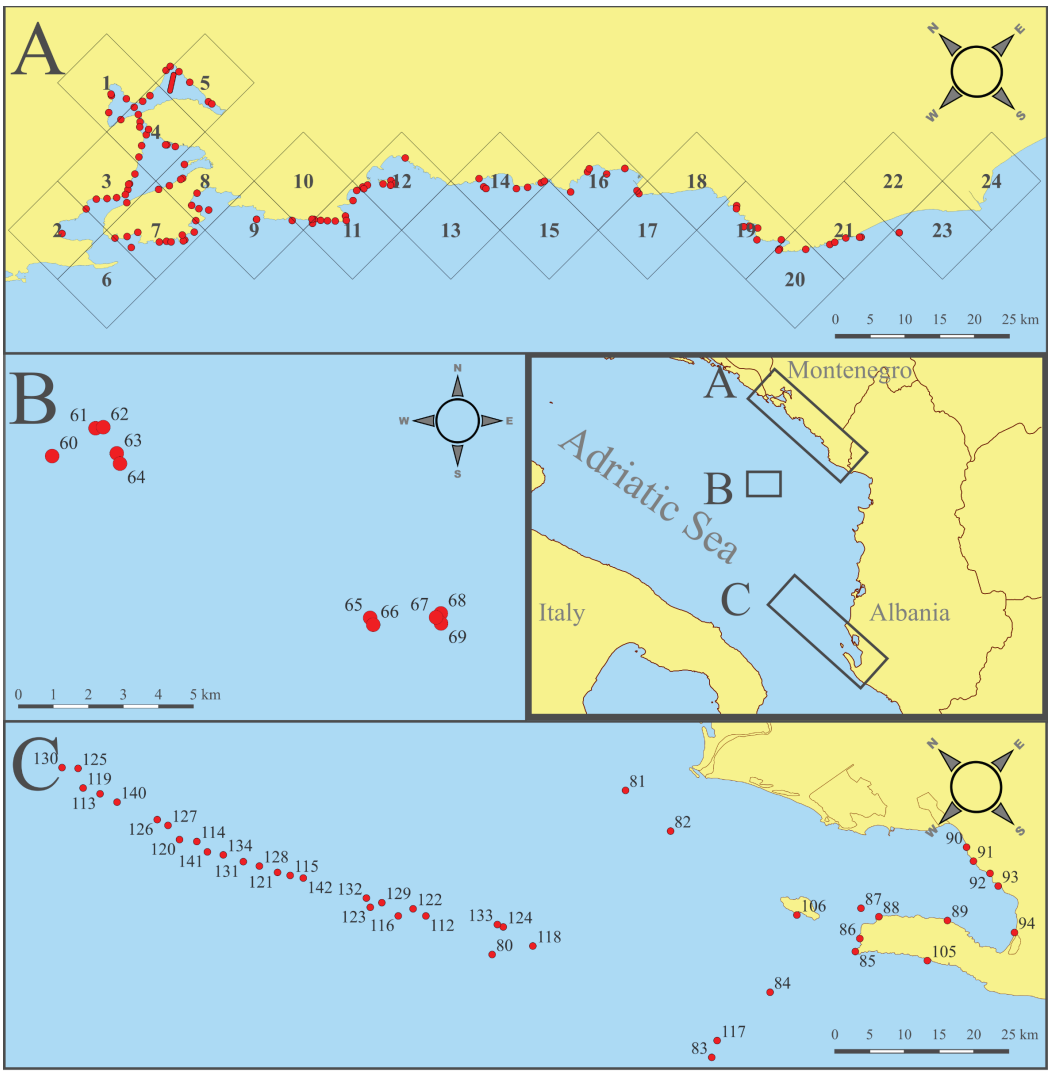

Fig. 2: Details of the surveyed areas in the southeastern Adriatic: A) Coastal dive locations of Montenegro are marked as points inside the respective quadrat (Q) from 1 to 24, B) Deep Adriatic, C) Karaburun Peninsula, Albania and deep Adriatic.

18.743114° E, Fig. 2A). Collected specimens from various activities between 2017 and 2023 are housed at the Institute of Marine Biology, University of Montenegro, but for many new records there is only photographic documentation. Given the extensive records along the Montenegrin coast, the area was divided into quadrats of 10 x 10 km, numbered from Q1 to Q24, as illustrated in Figure 2A along with points of dive locations inside the respective quadrats. The species found in this study (TS) and a number of new records for each species are presented in Table 1 along with other available Anthozoa checklists for the Adriatic. All findings (from TS and those from available literature) are numbered and depicted in Figures 1 and 2, with additional details provided in Annex 1, including location numbers and source references. Letters in brackets represent literature sources: A) Broch (1953); B) Pax & Muller (1963); C) Karaman & Gamulin Brida (1970); D) Stjepčević & Parenzan (1980); E) Stjepčević *et al*. (1986); F) RAC/SPA-UNEP/MAP (2014); G) DFS (2011); H) UNEP/MAP-SPA/RAC (2013); I) UNEP/MAP-RAC/SPA (2016); J) Angeletti *et al*. (2014); K) Mačić *et al*. (2018a); L) Petović *et al*. (2016); M) IBMK (2017); N) ENI Montenegro B.V. (2018); O) Petović *et al*. (2019); P) Mačić & Mačić (2019); Q) Mačić *et al*. (2018b); R) IBMK (2018); S) Mačić *et al*. (2018b); T) Mačić *et al*. (2019b); U) Đurović *et al*. (2018); V) Petović *et al*. (2018); W) Mačić & Petović (2020); X) UNEP/MAP-PAP/RAC-SPA/RAC & MSDT (2019); Y) Taviani *et al*. (2015); Z) Taviani *et al*. (2019); AA) Mačić *et al*. (2021); AB) Salomidi *et al*. (2014); AC) Gimenez *et al*. (2022); AD) Kasemi *et al*. (2008); AE) Dounas *et al*. (2010); AF) Kashta *et al*. (2010); AG) Georges *et al*. (2024); TS) this study. The new records from this study are presented in Appendix 1 in bold Appendix I.

The checklist was compiled by consolidating information from scientific literature, including peer-reviewed publications and project reports mentioning Anthozoa species in the southeast Adriatic, supplemented with new unpublished data. For this analysis, the area from Dubrovnik (Croatia) in the north to the island of Corfu (Greece) in the south was considered.

It should be noted that in numerous old references, the border between the Adriatic and Ionian seas is set in the narrowest part, from Otranto in Italy to the Karaburuni Peninsula in Albania. This is also the case in Morri *et al*. (2008), who considered the South Adriatic from Otranto to the Gulf of Malfredonia on the Italian coast and from the Karaburuni Peninsula in Albania to Dubrovnik on the

Table 1. List of Anthozoa species in the southeastern Adriatic. (Mne – all species reported up to now from Montenegro; Alb – all species reported up to now from Albania; It_S – species reported from the South Adriatic waters of Italy according to Morri *et al*., 2008; It_Adr – species reported from the Italian Adriatic Sea according to Morri *et al*., 2008; Cro – species reported from Croatian waters of southeastern Adriatic according to Kružić, 2017; Gre – species reported from Adriatic waters of Greece according to Dounas *et al*., 2010; Taviani *et al*., 2015, 2019; Salomidi, *et al.*, 2014; Georges *et al.*, 2024); TS – new records from this study.

Taxa	Mne	Alb	It_S	It_Adr	Cro	Gre	TS
Class Hexacorallia							
Order Actiniaria	12	5	7	36	41	0	
Actinia cari Delle (Chiaje, 1822)	+	+		+	+		
Actinia mediterranea (Schmidt,1971)	+	+		+	+		7
Anemonia viridis (Forsskål, 1775)	+	+	+	+	+		7
Anthopleura ballii (Cocks, 1851)				+	+		
Anthopleura thallia (Gosse, 1854)					+		
Bunodactis rubripunctata (Grube, 1840)				+	+		
Bunodactis verrucosa (Pennant, 1777)		+		+	+		
Condylactis aurantiaca (Delle Chiaje, 1825)	+			+	+		5
Cribrinopsis crassa (Andrès, 1881)				+	+		
Paranemonia cinerea (Contarini, 1844)				+	+		
Paranemonia vouliagmeniensis Doumenc, (England & Chintiroglou, 1987)					+		
Paranthus chromatoderus (Schmarda, 1852)					+		
Aiptasia mutabilis (Gravenhorst, 1831)	+		+	+	+		5
Aiptasiogeton hyalinus (Delle Chiaje, 1822)				+	+		
Exaiptasia diaphana (Rapp, 1829)				+	+		
Alicia mirabilis (Johnson, 1861)	+			+	+		4
Amphianthus dohrnii (Koch, 1878)		+	+	+	+		
Andresia partenopea (Andrès, 1883)	+			+	+		
Bunodeopsis strumosa (Andrès, 1881)				+	+		
Capnea sanguinea (Forbes, 1841)			+	+	+		
Diadumene cincta (Stephenson, 1925)				+	+		
Diadumene lineata (Verrill, 1869)				+	+		
Edwardsia claparedii (Panceri, 1869)				+	+		
Scolanthus callimorphus Gosse, 1853				+	+		
Gonactinia prolifera (Sars, 1835)				+	+		
Halcampoides purpureus (Studer, 1879)				+	+		
Anemonactis mazeli (Jourdan, 1880)				+	+		
Mesacmaea mitchellii (Gosse, 1853)				+	+		
Actinauge richardi (Marion, 1882)				+	+		
Calliactis palliata (Fabricius, 1779)	+		+	+	+		2
Calliactis parasitica (Couch, 1842)	+		+	+	+		1

Continued

Table 1 continued

Taxa	Mne	Alb	It_S	It_Adr	Cro	Gre	TS
Hormathia alba (Andrès, 1880)					+		
Hormathia coronata (Gosse, 1858)	+		+	+	+		
Peachia cylindrica (Reid, 1848)				+	+		
Phymanthus pulcher (Andrès, 1883)	+			+	+		2
Cereus pedunculatus (Pennant, 1777)	+			+	+		2
Cylista elegans (Dalyell, 1848)				+	+		
Sagartia undata (Müller, 1778)				+	+		
Sagartiogeton entellae (Schmidt, 1972)				+	+		
Actinothoe sphyrodeta (Gosse, 1858)					+		
Order Antipatharia	1	0	1	1	2	1	
Antipathes dichotoma (Pallas, 1766)					+		
Leiopathes glaberrima (Esper, 1792)	+					+	
Antipathella subpinnata (Ellis & Solander, 1786)			+	+	+		
Order Corallimorpharia	0	0	0	1	1	0	
Corynactis viridis (Allman, 1846)				+	+		
Order Scleractinia	16	8	12	26	27	4	
Desmophyllum dianthus (Esper, 1794)	+			+	+	+	
Desmophyllum pertusum (Linnaeus, 1758)	+	+	+	+	+		
Phyllangia americana mouchezii (Lacaze-Duthiers, 1897)	+		+	+	+		
Caryophyllia (Caryophyllia) calveri (Duncan, 1873)				+	+		
Caryophyllia (Caryophyllia) cyathus (Ellis & Solander, 1786)	+	+		+	+		
Caryophyllia (Caryophyllia) inornata (Duncan, 1878)	+		+	+	+		
Caryophyllia (Caryophyllia) smithii Stokes & Broderip, 1828	+	+	+	+	+		2
Ceratotrochus magnaghii (Cecchini, 1914)				+	+		
Hoplangia durotrix (Gosse, 1860)	+		+	+	+		
Polycyathus muellerae (Abel, 1959)	+			+	+		
Thalamophyllia gasti (Döderlein, 1913)				+	+		
Coenocyathus anthophyllites (Milne Edwards & Haime, 1848)				+	+		
Paracyathus pulchellus (Philipi, 1842)	+		+	+	+		1
Cladocora caespitosa (Linnaeus, 1767)	+	+	+	+	+		10
Cladocora debilis (Milne Edwards & Haime, 1849)	+			+	+		1
Leptopsammia pruvoti (Lacaze-Duthiers, 1897)	+		+	+	+	+	7

Continued

Table 1 continued

Taxa	Mne	Alb	It_S	It_Adr	Cro	Gre	TS
Astroides calycularis (Pallas, 1766)				+	+		
Balanophyllia (Balanophyllia) europaea (Risso, 1826)	+	+	+	+	+	+	10
Balanophyllia (Balanophyllia) regia Gosse, 1853				+	+		
Dendrophyllia cornigera (Lamarck, 1816)	+	+		+	+		
Dendrophyllia ramea (Linnaeus, 1758)				+	+		
Cladopsammia rolandi (Lacaze-Duthiers, 1897)		+			+		
Monomyces pygmaea (Risso, 1826)				+	+		
Guynia annulata (Duncan, 1873)			+	+	+		
Madrepora oculata (Linnaeus, 1758)	+		+	+	+		
Madracis pharensis (Heller, 1868)	+		+	+	+	+	7
Stenocyathus vermiformis (Pourtalès, 1868)		+					
Sphenotrochus (Sphenotrochus) andrewianus (Milne Edwards & Haime, 1848)				+	+		
Order Zoantharia	5	0	3	5	10	0	
Epizoanthus arenaceus (Delle Chiaje, 1836)	+		+	+	+		
Epizoanthus frenzeli (Pax, 1937)					+		
Epizoanthus mediterraneus (Carlgren, 1935)	+			+	+		
Epizoanthus paxii (Abel, 1955)	+			+	+		4
Epizoanthus steueri (Pax, 1937)					+		
Epizoanthus tergestinus (Pax, 1937)					+		
Epizoanthus univittatus (Lorenz, 1860)					+		
Epizoanthus vatovai (Pax & Lochter, 1935)					+		
Savalia savaglia (Bertoloni, 1819)	+		+	+	+		2
Parazoanthus axinellae (Schmidt, 1862)	+		+	+	+		7
Order Ceriantharia	3	0	1	2	2	0	
Cerianthus membranaceus (Gmelin, 1791)	+			+	+		5
Pachycerianthus multiplicatus (Carlgren, 1912)	+				+		1
Pachycerianthus solitarius (Rapp, 1829)	+			+			1
Arachnanthus oligopodus (Cerfontaine, 1891)			+				
Class Octocorallia							
Order Scleralcyonacea	10	5	4	9	10	2	
Corallium rubrum (Linnaeus, 1758)	+	+	+	+	+	+	
Cornularia cornucopiae (Pallas, 1766)				+	+		
Viminella flagellum (Johnson, 1863)	+						
Funiculina quadrangularis (Pallas, 1766)	+	+	+	+	+		
Isidella elongata (Esper, 1788)		+		+	+	+	

Continued

Table 1 continued

Taxa	Mne	Alb	It_S	It_Adr	Cro	Gre	TS
Pennatula phosphorea (Linnaeus, 1758)	+	+	+	+	+		1
Pennatula rubra (Ellis, 1761)	+			+	+		
Pteroeides griseum (Bohadsch, 1761)	+			+	+		1
Sarcodictyon catenatum (Forbes, 1847)	+						2
Veretillum cynomorium (Pallas, 1766)	+	+	+	+	+		
Virgularia mirabilis (Müller, 1776)	+			+	+		1
Callogorgia verticillata (Pallas, 1766)	+				+		
Order Malacalcyonacea	9	4	3	10	13	0	
Alcyonium coralloides (Pallas, 1766)	+			+	+		1
Alcyonium acaule (Marion, 1878)	+			+	+		1
Alcyonium palmatum (Pallas, 1766)	+	+	+	+	+		2
Clavularia crassa (Milne Edwards, 1848)				+	+		
Clavularia marioni (von Koch, 1890)					+		
Leptogorgia sarmentosa (Esper, 1789)	+			+	+		5
Maasella edwardsii (de Lacaze-Duthiers, 1888)				+	+		
Bebryce mollis (Philippi, 1842)	+						
Paramuricea macrospina (Koch, 1882)	+		+	+	+		
Spinimuricea klavereni (Carpine & Grasshoff, 1975)	+						1
Paramuricea clavata (Risso, 1826)				+	+		
Paramuricea placomus (Linnaeus, 1758)		+			+		
Eunicella cavolini (Koch, 1887)	+	+			+		
Eunicella singularis (Esper, 1791)	+	+		+	+		1
Eunicella verrucosa (Pallas, 1766)			+	+	+		
Order Octocorallia incertae sedis	1	0	1	1	0	0	
Rolandia coralloides (de Lacaze Duthiers, 1900)	+			+	+		
Total	57	22	32	90	106	7	32 species with 109 records

coast of Croatia. However, according to the International Hydrographic Organization (IHO, 2021), the limits of the Adriatic Sea are further south. Specifically, from the mouth of Lumi i Butrintit westward, a line to Akra (Cape) Kouloúra on the northeastern coast of Nisos Kerkira (Corfu Island) in Greece; from Akra (Cape) Kouloúra westward, along the northern coast of Nisos Kerkira, to Akra (Cape) Kefali, the northwestern extremity of this island; and from Akra (Cape) Kefali westward, a line to Capo (Cape) Santa Maria di Leuca, Italy. With this definition in mind, only small parts of Croatia and Greece belong to the southeastern Adriatic, and the list of species by country is provided only for Albania and Montenegro, whose coastlines completely belong to the southeastern Adriatic. Taxonomic information followed the World Register of Marine Species (WoRMS Editorial Board, 2024), and distribution data were digitised and presented using QGIS software.

Results

A total of 450 Anthozoa records were collected for the southeast Adriatic, contributing over 109 new records. The updated checklist for the Adriatic waters in front of Montenegro and Albania now comprises 62 species (Table 1). Hexacorallia is the most numerous group, with 37 species in Montenegro and 13 in Albania. Octocorallia include 20 species in Montenegro and nine in Albania. Considering all collected historic data and new findings, the Anthozoa fauna of the southeastern Adriatic Sea consists of 57 species in Montenegro and 22 in Albania. Two Octocorallia species have been reported from the southeastern Adriatic waters of Croatia, along with two Octocorallia and five Hexacorallia species from the Adriatic waters of Greece. Two species, *Pachycerianthus multiplicatus* Carlgren, 1912, and *Pachycerianthus solitarius* (Rapp, 1829), are reported for the first time from this area.

Pachycerianthus multiplicatus Carlgren, 1912

Morphology

These anemones exhibit a dark or whitish tube, reaching lengths of up to 1 m. They possess approximately 120 to 200 tentacles arranged in four crowns. Marginal tentacles display a white or whitish colour with brown stripes, while oral tentacles are light yellow. Tentacles typically measure around 15 cm, but can extend up to 30 cm. When disturbed, the tentacles curl into spirals instead of retracting.

Habitat

Found in mud or muddy sand, ranging from a few meters to over 100 m in depth. Originating from the northeast Atlantic, this species was first reported in the Mediterranean off the coast of Turkey in 2014 (Çinar *et al*., 2014). The introduction to the Mediterranean is likely through ship ballast waters. It was recorded in a *Cymodocea nodosa* (Ucria) Ascherson meadow at a depth of 6 m in 2018 (Fig. 3).

Distribution

Q4 (location: Cape Sv. Nedjelja), Montenegro, (42.458743°N, 18.674504°E).

Pachycerianthus solitarius (Rapp, 1829)

Morphology

This tube anemone features a slender body with a thin, mucous, and semi-transparent tube that generally does not protrude from the substrate. It boasts up to 120 very long, non-retractable marginal tentacles arranged in three concentric crowns. Colouration varies, with some specimens being light-coloured, whitish with darker (often purplish) oral tentacles, while others exhibit light/dark bands, sometimes with fluorescent spots. Dark specimens may have reddish marginal tentacles, and there are those with a light-coloured body, striped marginal tentacles, and completely white oral tentacles.

Habitat

Commonly found on soft bottoms, particularly on sand and mud, in areas between 2 and 100 m, away from strong currents. Discovered in the Boka Kotorska Bay in the vicinity of a *Mytilus galloprovincialis* Lamarck, 1819 farm (Fig. 3).

Distribution

Q5 (Location: Institute of Marine Biology (IBMK), Montenegro, (42.436559° N, 18.763686° E).

Rare Anthozoa species and new discoveries

Among the already reported Anthozoa species, several are notably rare, some documented only once in southeastern Adriatic and at specific locations. Actiniaria

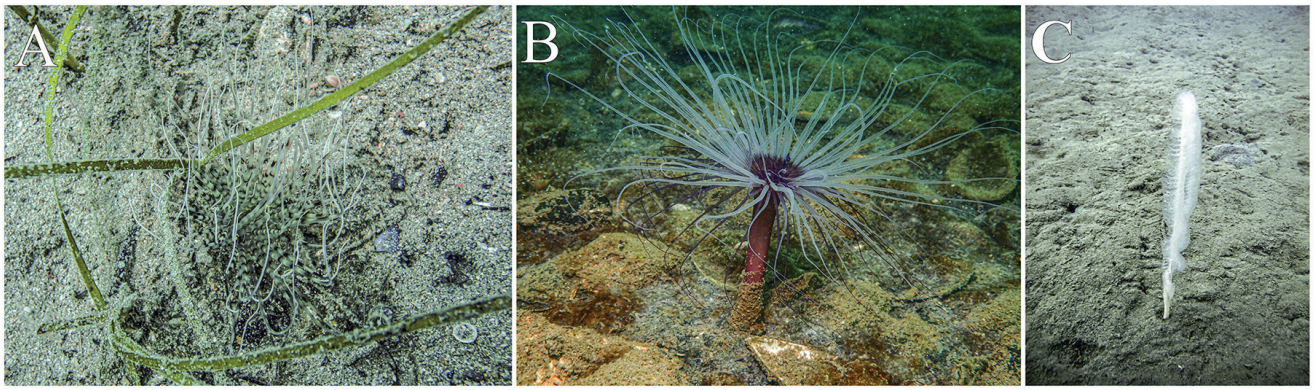

Fig. 3: Three rare anthozoan species photographed in Montenegro: A) *Pachycerianthus multiplicatus* Carlgren, 1912 in Cape Sv. Nedjelja (Q4) (42.458743°N, 18.674504°E) photographed on 4 September 2018; B) *Pachycerianthus solitarius* (Rapp, 1829) photographed in front of the Institute of Marine Biology in Kotor (Q5) (42.436559°N, 18.763686°E) on 31 July 2012; C) *Virgularia mirabilis* (Müller, 1776) photographed in Cape Mendra (Q20) (41.950847°N, 19.148166°E) on 24 June 2012).

species, such as *Amphianthus dohrnii* (Koch, 1878) and *Hormathia coronata* (Gosse, 1858), were recorded by Pax & Muller (1962), each at a single location. The malacalcyonacean *Paramuricea placomus* (Linnaeus, 1758) was mentioned solely by Broch (1953). Additionally, the scleralcyonacean *Virgularia mirabilis* (Müller, 1776) was reported once by Broch (1953) and once in this work, near Bar (Montenegro) at 51-44 m depth and Cape Mendra (Q20), respectively (Fig. 3, on 24 June 2012).

Other species reported only once include *Viminella flagellum* (Johnson, 1863), *Bebryce mollis* Philippi, 1842, *Cladocora debilis* Milne Edwards & Haime, 1849 (Trainito & Baldacconi, 2016), and *Stenocyathus vermiformis* (Pourtalès, 1868) (Taviani *et al*., 2019). *Andresia partenopea* (Andrès, 1883) was recorded twice (ENI Montenegro B.V., 2018; Mačić *et al*., 2018b). Many of these rare species inhabit deeper habitats, explaining their absence in our SCUBA diving surveys (except for *V. mirabilis*). Taxonomic verification of specimens, particularly of species such as *Paramuricea placomus*, would be valuable. We consider the old records referred to *P. placomus* as misidentifications because *P. placomus* "does not exist in the Mediterranean" (Topçu & Öztürk, 2013) and "is exclusively distributed in the North Atlantic and boreal coasts" (Ocaña Vicente *et al*., 2022). In contrast, our new reported data include numerous locations for easily recognisable species found in shallow habitats (up to 40 m). *Cladocora caespitosa* (Linnaeus, 1767) and *Balanophyllia europaea* (Risso, 1826) had the highest number of new records (10), followed by *Actinia mediterranea* Schmidt, 1971, *Anemonia viridis* (Forsskål, 1775), *Leptopsammia pruvoti* Lacaze-Duthiers, 1897, *Madracis pharensis* (Heller, 1868), and *Parazoanthus axinellae* (Schmidt, 1862), each with seven new records. Furthermore, *Condylactis aurantiaca* (Delle Chiaje, 1825) and *Aiptasia mutabilis* (Gravenhorst, 1831) were reported for the first time, mostly in the Boka Kotorska Bay, while *Cerianthus membranaceus* (Gmelin, 1791) was recorded both inside and outside the Boka Kotorska Bay (Annex 1). It is important to note that the reported locations for the last three species in the 10 x 10 km quadrats may represent multiple micro-locations within these quadrats (especially in the Boka Kotorska Bay), sometimes kilometres apart.

Discussion

Anthozoa species reported in the southeastern Adriatic represent only about 50% of the known Anthozoa of the entire Adriatic Sea (Habdija *et al*., 2021) (Fig. 5). The number of Octocorallia species is almost equal in Croatia, Italy, and Montenegro (24, 20, and 20, respectively), while in Albania, it is significantly lower, with only nine registered species. The most numerous species belong to the subclass Hexacorallia (Annex 1), and this pattern is consistent on both, the eastern and western Adriatic coasts (Fig. 4). The small number of species known from the Greek Adriatic waters (only seven) is due to the small number of surveys in this small marine part of Greece compared to larger areas in the Ionian and Aegean Seas, where research efforts have mostly focused. Recent studies (Smith *et al*., 2022; Salomidi *et al*., 2022) have suggested that more intensive surveys are needed in the Adriatic waters of Greece, as this area is located between two large-scale biodiversity hotspots for Anthozoa species, namely, the Kephallinia area (further south in the Greek Ionian Sea) and Cape Santa Maria di Leuca (southern Italy and border between Adriatic and Ionian Sea).

The number of Anthozoa species in the updated checklist from the southeastern Adriatic (57 species in Montenegro, 22 in Albania, seven in Greece, and two in Croatia) was double that of the southwestern Adriatic, where Morri *et al*. (2008) listed 32 species in Sector 7 (South Adriatic). It is important to note that there have been significant publications since 2008, especially in deep areas, and an updated checklist for the Italian part of the South Adriatic would likely include a higher number of species. The sandy coast on the Italian side and a large part of the Albanian sandy coast likely contributed to the relatively low biodiversity of Anthozoa. Nevertheless, research efforts on anthozoa in the southeastern Adriatic, especially in Albania, are extremely low. Further research is urgently needed across the southeastern Adriatic region, particularly in deeper areas, which are generally less surveyed but are crucial for biodiversity assessments (Angeletti *et al*., 2014; Corriero *et al*., 2019; Taviani *et al*., 2019; Chimienti *et al*., 2020a, 2020b). Confirming this statement is an example of the critically endangered

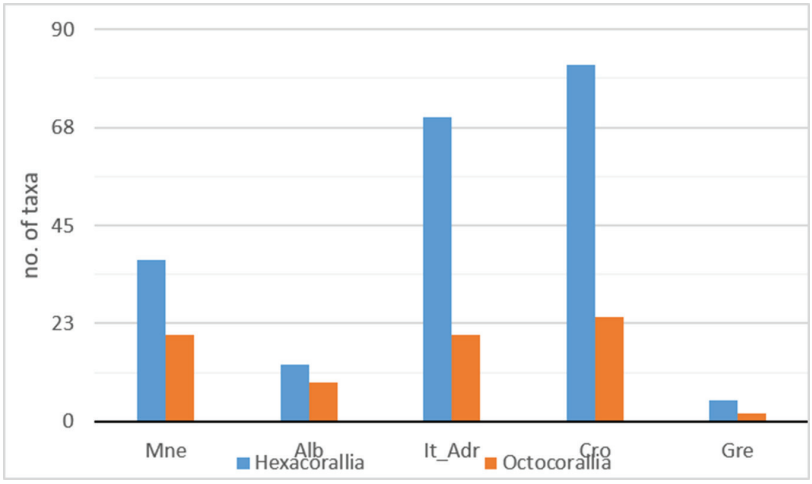

Fig. 4: Number of Anthozoa species recorded up to now in the Adriatic (Mne – Montenegro, Alb – Albania, It_Adr – Italian Adriatic waters, Cro – Croatia, Gre – Adriatic waters of Greece).

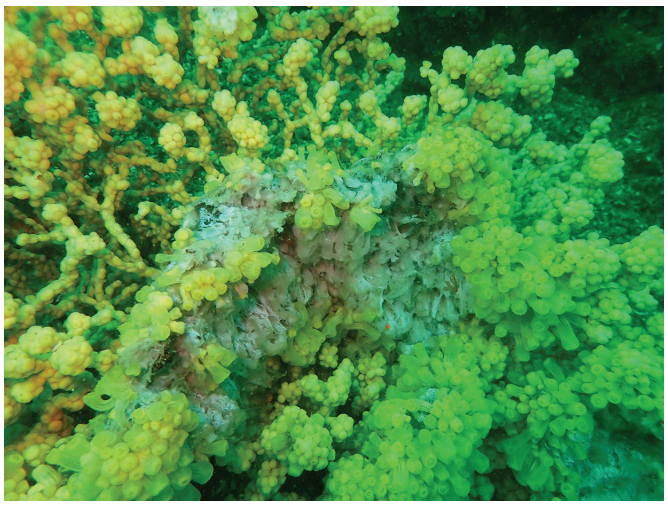

Fig. 5: Partial necrosis of *Savalia savaglia* (white parts) in Dražin vrt, Boka Kotorska Bay, Montenegro (42.483183°N, 18.715567°E), (Q4), at 15 m depth, photographed on 27 July 2023.

bamboo coral *Isidella elongata* (Esper, 1788), mentioned only once in the southeast Adriatic by Broch (1953) (in the vicinity of the Karaburun Peninsula, Albania). Recent studies by Georges *et al.* (2024) reported 31 new locations in the Adratic waters of Albania and Greece, 11 more in the Italian part of the South Adriatic, and many more in the Mediterranean Sea. In addition, the critically endangered bamboo coral (*I. elongata*) and vulnerable sea pen *Funiculina quadrangularis* (Pallas, 1766) are the most frequently recorded anthozoans among the deep-sea vulnerable benthic fauna in the Eastern Mediterranean basin (Salomidi *et al*., 2022).

To underscore the significance of further research on the Anthozoan fauna, it is important to mention that there are several Mediterranean endemic species present in this area, some of which are endangered, and 24 species are protected (Table 2).

One well-known protected species is the red coral *Corallium rubrum* (Linnaeus, 1758). In the Mediterranean Sea, red coral has been renowned since ancient times, utilised for various purposes such as jewellery, sacred ornaments, currency, and even as a medicine and aphrodisiac (Trainito & Baldacconi, 2016). Due to its slow growth and high intensity of harvesting using destructive tools known as Saint Andrew's cross, red coral is now a protected species with regulated harvesting practices (Official Gazette of the Republic of Montenegro, 76/06; Barcelona Convention, 2013). The Kotor Historical Archive (Montenegro) holds several documents about red coral, with the oldest one being a permission for coral harvesting from 1686 (Mačić & Mačić, 2019).

In the South Adriatic Sea, Pax & Muller (1962) refer to only two locations for red coral, one near Kotor in Montenegro and the other close to Vlora in Albania, with the majority of locations in the Adriatic concentrated in the central zone. Recent surveys by SCUBA diving in Montenegrin waters have not confirmed the presence of *C. rubrum* at depths down to 40 m. Kashta *et al*. (2010) reported red coral at two locations in Albania, near Vlora and further south at Ksamil, while Dounas *et al.* (2010) report it from the northwestern part of Corfu Island in Greece. Given its protected status under different international conventions, surveys targeting this species would be necessary to assess the state of its population in the South Adriatic.

Due to the aesthetic appeal of numerous calcified anthozoans, they have become threatened by illegal collection and trafficking, leading to their inclusion in the list by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). The collection and trade of these species are regulated, with some cases warranting complete prohibition (CITES, 2023). Additionally, recognising the vital role of these species as habitat builders, certain species receive protection under different international conventions such as the Barcelona Convention (2013) and national legislation (e.g., Official Gazette of the Republic of Montenegro, 76/06). Unfortunately, the Albanian Red List of wild flora and fauna (AMO, 2013) currently lacks any anthozoan species. This is likely due to limited data, underscoring the imperative need for further research.

However, coral collection is not the sole threat to these organisms. Factors such as rising water temperatures, seawater acidification, physical destruction, and pollution heavily impact these organisms (Otero *et al*., 2017; Gori *et al*., 2023). Understanding the species present in a specific area is a crucial prerequisite to comprehend the primary stressors affecting them and devising effective preservation strategies.

An exemplary illustration of scientific surveys integrated with effective management and protection is evident in two small marine protected areas within the Boka Kotorska Bay, specifically located at Dražin vrt and Sopot. These areas underwent comprehensive surveys and mapping because the impact of submarine freshwater springs (known as "vrulja") forms a unique habitat with a notably high density of *Savalia savaglia* populations in relatively shallow depths for this species, approximately 15-25 m (RAC/SPA-UNEP/MAP, 2013; UNEP/MAP-PAP/RAC-SPA/RAC & MSDT, 2019; Poliseno *et al*., 2022; Canessa *et al.*, 2024). Recognising the fragmented and rare nature of this habitat and the exceptionally dense *S. savaglia* colonies, these two small areas are demarcated by buoys, with anchoring and fishing prohibited. This

Table 2. Protected species of Anthozoa in the southeastern Adriatic according to Barcelona Convention (II - Annex II List of endangered or threatened species, III – Annex III List of species whose exploitation is regulated), Bern Convention (II - Annex II Strictly protected fauna species, III - Appendix III Protected fauna species) and Montenegro national legislation, as well as IUCN species category (NT – Near Threatened, LC – Least Concern, EN – Endangered, VU – Vulnerable, CR-Critically Endangered).

Species	Barcelona Convention	Bern Convention	MNE national legislation	IUCN Red List status
Antipathella subpinnata	II and III	III	*	NT
Antipathes dichotoma	II and III	III		NT
Astroides calycularis	II	II		NT
Balanophyllia (Balanophyllia) europaea				LC
Callogorgia verticillata	II			NT
Cladocora caespitosa	II		*	EN
Cladocora debilis	II			DD
Corallium rubrum	III	III	*	EN
Dendrophyllia cornigera	II			EN
Dendrophyllia ramea	II			VU
Desmophyllum dianthus	II			EN
Desmophyllum pertusum	II			EN
Eunicella cavolini			*	NT
Eunicella singularis			*	NT
Funiculina quadrangularis				VU
Isidella elongata	II			CR
Leiopathes glaberrima	II			EN
Madrepora oculata	II		*	EN
Paramuricea clavata				VU
Paranemonia vouliagmeniensis				EN
Pennatula phosphorea				VU
Pennatula rubra				VU
Savalia savaglia	II	II	*	NT
Viminella flagellum				NT

protective measure safeguards vulnerable *S. savaglia* colonies and the coralligenous biocoenosis from physical impact. Strategically placed information tables in these areas serve to raise awareness of the public about the imperative need for protection.

Protection from physical impact is more attainable in these cases than protection from the impacts of climate change. In the summer of 2023, necrosis was observed on numerous colonies at the Dražin vrt location, possibly induced by heat waves, but the presence of other impacts and pathogens cannot be excluded (Fig. 6). Coral necrosis incidents have also been reported in other areas (Garrabou *et al.,* 2022; Canessa *et al*., 2023; Bramanti *et al*., 2023; Georges *et al.,* 2024). However, we can only observe and hope that this damage will not extensively affect the colonies and that they will somehow manage to withstand marine heat waves in deeper areas that act as refuges (Bramanti *et al*., 2023; Georges *et al.,* 2024). In conclusion, although knowledge of anthozoans in the Adriatic Ocean has significantly improved in recent years, it is important to emphasise the need for more comprehensive studies to enhance the understanding and protection of these species.

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Appendix 1

Anthozoa species in the southeastern Adriatic Sea recorded up to now. Numbers refer to locations on Figures 1 and 2. More precisely dive and literature locations in Montenegro are presented as points in Quadrats (Q), numbered from 1 to 24, while other numbers (from 25 to 142) represent literature data. Letters in brackets represent literature sources: A) Broch (1953); B) Pax & Muller (1963); C) Karaman & Gamulin Brida (1970); D) Stjepčević & Parenzan (1980); E) Stjepčević *et al.* (1986); F) RAC/SPA-UNEP/MAP (2014); G) DFS (2011); H) UNEP/MAP-SPA/RAC (2013); I) UNEP/MAP-RAC/SPA (2016); J) Angeletti *et al.* (2014); K) Mačić *et al.* (2018a); L) Petović *et al.* (2016); M) IBMK (2017); N) ENI Montenegro B.V. (2018); O) Petović *et al.* (2019); P) Mačić & Mačić (2019); Q) Mačić *et al.* (2018b); R) IBMK (2018); S) Mačić *et al.* (2019b); T) Mačić *et al.* (2019b); U) Đurović *et al.* (2018); V) Petović *et al.* (2018); W) Mačić & Petović (2020); X) UNEP/MAP-PAP/RAC-SPA/RAC & MSDT (2019); Y) Taviani *et al.* (2015); Z) Taviani *et al.* (2019); AA) Mačić *et al.* (2021); AB) Salomidi *et al.* (2014); AC) Gimenez *et al.* (2022); AD) Kasemi *et al.* (2008); AE) Dounas *et al.* (2010); AF) Kashta *et al.* (2010); AG) Georges *et al.* (2024); AH) Mačić *et al.* (2022); TS) new records from this study.

SPECIES	LOCATIONS AND REFERENCES
Actinia cari Delle Chiaje, 1822	Q21(K); Q16(T); 102, 103, 104, 106, 107(AF)
Actinia mediterranea Schmidt,1971	Q5, Q4(E); Q8, Q10, Q19, Q21(K); Q12 (M), Q12 (O); Q4, Q7, Q8, Q11, Q12, Q19, **Q21(TS)**; 90, 93, 94(AD)
Actinia striata Rizzi, 1907	Q16(T)
Aiptasia mutabilis (Gravenhorst, 1831)	Q4 (H, X), Q16 (I, T), Q12, Q16 (M); Q3, Q4, Q8 (R); Q4, Q5, Q11, Q14, **Q21 (TS)**; 31 (B)
Alicia mirabilis Johnson, 1861	Q1(X); Q1, **Q3-5(TS)**; Q11(S)
Amphianthus dohrnii (Koch, 1878)	76 (B)
Andresia partenopea (Andrès, 1883)	Q11(S), 51 (O);
Anemonia viridis (Forsskål, 1775)	35(B); Q1, Q4(F); Q4, Q7, Q8, Q10, Q11, Q14, Q19, Q20(G); Q16(H); Q14, Q16(M); Q8, Q5(R); Q16(T, U); Q4, Q5, Q14, Q16, **Q19-21 (TS)**; 90, 91, 93, 94(AD)
Bunodactis verrucosa (Pennant, 1777)	102, 103, 104, 106, 107(AF)
Calliactis palliata (Fabricius, 1779)	Q4, **Q8(TS)**, 32(C)
Calliactis parasitica (Couch, 1842)	57, 75(B); Q1, Q4, Q5(C, F); Q1, Q5(D); **Q7(TS)**
Cereus pedunculatus (Pennant, 1777)	Q4(X), Q16(T); Q14, **Q21(TS)**
Condylactis aurantiaca (Delle Chiaje, 1825)	Q4(H); Q3, Q4(R); Q3-5, Q8, **Q14(TS)**
Hormathia coronata (Gosse, 1858)	36(C)
Phymanthus pulcher (Andrès, 1883)	Q19(F); Q1, Q4(X); Q4, **Q5(TS)**
Leiopathes glaberrima (Esper, 1792)	61, 62, 65-69(J); Q1, Q4(X); 60, 63, 67, 69, 100, 101(Y)
Alcyonium acaule Marion, 1878	Q4, Q5(E); **Q14(TS)**
Alcyonium coralloides (Pallas, 1766)	Q4(H, X, TS)
Alcyonium palmatum Pallas, 1766	26-28, 36, 47, 48, 50, 56-58, 71, 72(A); 25-29, 38, 42, 47, 50, 52, 59, 73, 71, 72, 74, 77, 78, 81(B); Q1, Q4, Q5(C); Q1, Q5(D); Q4, Q5(E); 39, 46, 49, 37, 45, 55, 43, 53, 54(L); 51(N); Q4(X); 56, **71(TS)**
Bebryce mollis Philippi, 1842	51(N)
Eunicella cavolini (Koch, 1887)	102, 106, 107, 108(AF); Q1, Q4(E)
Eunicella singularis (Esper, 1791)	Q1, Q4(E); **Q19(TS)**; 106(AF)
Leptogorgia sarmentosa (Esper, 1789)	Q4, Q19(F); Q4(H); Q16(I, U); Q1, Q4 (X); Q1, Q3, Q4, Q14, **Q19(TS)**; 89, 88, 86, (AC)
Paramuricea macrospina (Koch, 1882)	Q1, Q4(X); 61, 62, 65-69(J)
Paramuricea placomus (Linnaeus, 1758)	75(A)
Spinimuricea klavereni (Carpine & Grasshoff, 1975)	**Q1(TS)**; Q3, Q4(AA)

SPECIES	LOCATIONS AND REFERENCES
Balanophyllia (Balanophyllia) europaea (Risso, 1826)	Q1, Q5(D); Q5(E); Q1, Q4, Q7-9, Q11, Q12, Q14, Q19, Q20(F); Q4(H); Q9, Q11(I); Q12, Q14, Q16(M); Q12(O); Q1, Q3-5, Q7, Q8(R); Q11(S); Q16(T); Q1-8, Q16, **Q19(TS)**; 109-111(AB); 1(AD)
Caryophyllia (Caryophyllia) cyathus (Ellis & Solander, 1786)	Q4(X); 51(N); 99(Z)
Caryophyllia (Caryophyllia) inornata (Duncan, 1878)	Q1(X); Q4(H); Q9, Q11(I)
Caryophyllia (Caryophyllia) smithii Stokes & Broderip, 1828	Q1, Q4(E); Q4(H); Q11(I); Q12(O); Q4, **Q11(TS)**; 51(N), 99(Z)
Cladocora caespitosa (Linnaeus, 1767)	Q1 (C); Q1, Q5(D); Q1, Q4, Q5(E); Q1, Q4, Q7, Q14, Q19(F); Q4(H); Q11(I); Q14, Q16(M); Q12(O); Q3(R); Q11(S); Q16(U); Q1-5, Q7, Q14, Q16, Q19, **Q23(TS)**; 89, 88, 86 (AC), 102, 106, 107(AF); Q11(Q)
Cladocora debilis Milne Edwards & Haime, 1849	**Q4(TS)**
Cladopsammia rolandi Lacaze-Duthiers, 1897	86, 88, 89(AC)
Dendrophyllia cornigera (Lamarck, 1816)	61, 62, 65-69(J); 79(Z)
Desmophyllum dianthus (Esper, 1794)	51(N); 67, 100, 101(Y)
Desmophyllum pertusum (Linnaeus, 1758)	Q1, Q4(X); 61, 62, 65-69(J); 67(Y); 97, 99(Z)
Hoplangia durotrix Gosse, 1860	Q4(H); Q9, Q11(I)
Leptopsammia pruvoti Lacaze-Duthiers, 1897	Q7, Q12(F); Q9, Q11(I); Q7, Q11(K); Q12(O); Q4(X); Q7-12, **Q14(TS)**; 110(AB); 86, 88, 89(AC)
Madracis pharensis (Heller, 1868)	Q9, Q11(I); Q7, Q11, Q12(K); Q12(O); Q16(U); Q1, Q4, Q7, Q11, Q12, Q14, **Q19(TS)**; 109(AB); 85, 86, 88, 89(AC)
Madrepora oculata Linnaeus, 1758	Q5(E); 61, 62, 65-69(J); 60, 63, 67, 68, 97(Y); 64, 79, 96, 97(Z)
Paracyathus pulchellus (Philipi, 1842)	Q7(TS); 51(N)
Phyllangia americana mouchezii (Lacaze-Duthiers, 1897)	Q6, Q8, Q12(F); Q11(I); Q16(U), Q1, Q4(X)
Polycyathus muellerae (Abel, 1959)	Q4(F); Q7(W); Q11(I); Q11 (K)
Stenocyathus vermiformis (Pourtalès, 1868)	99(Z)
Sarcodictyon catenatum Forbes, 1847	Q1, Q4(X, AB); Q11(I)
Veretillum cynomorium (Pallas, 1766)	57, 73(A); 40, 78(B); Q1, Q4, Q5(C); Q1, Q5(D, E)
Viminella flagellum (Johnson, 1863)	51(N)
Virgularia mirabilis (Müller, 1776)	**Q20(TS)**; 48(A)
Callogorgia verticillata (Pallas, 1766)	61, 62, 65-69(J)
Corallium rubrum (Linnaeus, 1758)	Q4(E); 1(P); 30(B); 98(AE); 102, 105, 106(AF)
Funiculina quadrangularis (Pallas, 1766)	25, 27, 47, 70, 74(A); 25, 27, 47, 70, 74, 80, 83(B); 43, 53, 54(L); 51(N); 41, 44(AH)
Isidella elongata (Esper, 1788)	97(A); 112-142(AG)
Pennatula phosphorea Linnaeus, 1758	Q4(C, AB); Q1, Q4(X); 56,57,97(A); 56, 84, 95(B); 51(N)
Pennatula rubra (Ellis, 1761)	39, 46, 49(L); 51(N)
Pteroeides griseum (Bohadsch, 1761)	Q4(C); **Q20(TS)**; 46, 49(L)
Cerianthus membranaceus (Gmelin, 1791)	Q1, Q4(E); Q4(H); Q9, Q16(I); Q12(O); Q16(U); Q7(W); Q1, Q4, Q8, Q11, **Q16(TS)**; 3(X); 51(N)
Pachycerianthus multiplicatus Carlgren, 1912	**Q4(TS)**
Pachycerianthus solitarius (Rapp, 1829)	**Q5(TS)**
Parazoanthus axinellae (Schmidt, 1862)	Q4(C); Q1, Q4(E); Q4, Q11, Q12, Q14, Q19(F); Q9, Q11, Q12, Q16(I); Q11 (K); Q12(O); Q1, Q3-5, Q11, Q14, **Q19(TS)**; 27, 28, 34(B)
Epizoanthus arenaceus (Delle Chiaje, 1836)	Q4(H); 37, 45, 55(L)
Epizoanthus mediterraneus Carlgren, 1935	Q1, Q5(D, E)
Epizoanthus paxii Abel, 1955	Q4(X); Q1, **Q3-5(TS)**
Savalia savaglia (Bertoloni, 1819)	Q4(E,F); Q1, **Q4(TS)**