



CHAPTER 3/

Deep-sea vulnerable benthic fauna

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The uniqueness of the Mediterranean oceanography, local hydrography, geochemical and geomorphological settings on a relatively small scale, make its deep sea very diverse and with contrasting patterns of biodiversity. Hotspots of diversity can be found around complex topographic structures attracting a high abundance and diversity of species; this is particularly pronounced in areas with chemical effluxes that produce a true oasis of life specialised for extreme environmental conditions[1].

Many sessile (non-moving) deep-sea animals can form important aggregations or biogenic structures with surrounding ecosystems of low resilience yet hotspots of biodiversity. These species have positive impacts on associated species richness and abundance, play a major role in organizing community structure, and have an important function in determining community stability and productivity.

The vulnerability of these communities and their ecosystem is mainly related to the life history characteristics of each species, affected by habitat loss or destruction combined with other impacts on their surrounding environment. Thus, a large number of deep benthic species or communities are endangered and included in national and international lists of threatened/protected species or as indicators for sensitive marine ecosystems. In some regions, measures are being developed to protect them, with spatial and temporal management measures through the creation of marine protected areas (MPAs), designation of fisheries restricted areas (FRAs) to protect vulnerable marine ecosystems (VME) or other non-spatial management measures (e.g. restricted oil and gas exploitation) among others.

Information about deep sea benthic invertebrate diversity and abundance in the Eastern Mediterranean Sea is scarce and, as a result, advances in management, including conservation, have been slow. To progress

in this direction, this section presents the results¹ of an extensive historical literature review on deep-sea vulnerable sessile benthic fauna for the Eastern Mediterranean based on published literature (spanning from as old as 1900 to as recent as 2018), grey literature (international and national project deliverable reports) and other critically examined unpublished records (Table 3.4). The contribution of grey literature and unpublished reports or otherwise inaccessible information collated here, greatly extends the known distribution of these species and communities, as well as our understanding of the deep Eastern Mediterranean biodiversity.

In addition, the present information also provides data collected from the analysis of photographic material (on-board and laboratory) of deep-sea experimental fishing catches, collected in the framework of research projects, including MEDITS surveys (Table 3.5), in the Eastern Ionian, Aegean, and Levantine Seas, covering a time span of 24 years (1995-2018). The assembled material included mostly photos from trawl survey catches and to a lesser extent from longline catches. Additional coral sample material was also collected from longline fishing targeting blackspot seabream *Pagellus bogaraveo* at two sites in the South Aegean and Libyan Sea (off South Crete), respectively^[2].

The compiled information has the potential to identify biodiversity vulnerable hotspot areas for conservation and mitigation of impacts based on the presence and aggregations of key species around the Eastern Mediterranean. Nonetheless, given the nature and time of these records, they represent highly conservative estimates of the distribution of these communities.

Vulnerable habitat-forming sessile fauna from literature review

The presence of vulnerable benthic invertebrates in the Eastern Mediterranean basin has been known from records as early as 1896. Much of the existing information however could be considered rather outdated, as 46% of all compiled records have been obtained earlier than the year 2000. Furthermore, the main bulk of the existing records has been collected by blind, non-selective and destructive techniques such as trawling (~70%), dredging (~13%) and other fishing gear (~7%), while less than 10% has been obtained via less impacting methodological approaches (i.e. ROVs and submersibles) which allow proper collection of important scientific information such as accurate position and depth of observation, abundance data, seabed type and state, associated biodiversity, etc.

The present literature review is focused on vulnerable habitat-forming benthic species that can form aggregations occurring in the deep sea (typically > 200 m water depth), provide structural complexity to the seabed and might contribute to habitat formation as well as have long life spans and slow growth rates. Additionally, it was further considered whether species were listed as threatened in the IUCN Red list and/or if they have been identified as being vulnerable to fishing impacts (i.e. fragility, rareness, or low turnover rates). Potential assemblages of this benthic fauna could provide an indication

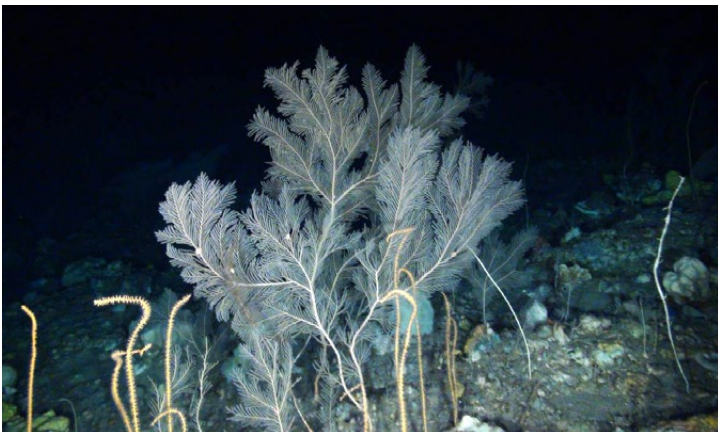
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Deep-sea biodiversity hotspots represented by habitat-forming sessile fauna such as deep-sea coral banks, gorgonian and black coral gardens, sea pen fields and sponge gardens have a high vulnerability to disturbance and a low recovery potential”

¹ The data that support the findings of this analysis are available from the corresponding authors on request.



Cold-water coral *Desmophyllum pertusum*. © Oceana.



Gorgonians (*Callogorgia verticillata* and *Viminella flagellum*). © Oceana.



Sea pen *Pennatula rubra*. Oceana/IUCN/UNEP-MAP RAC-SPA Deep Sea Lebanon Project. © Oceana.

of vulnerable biodiversity hotspots, that can constitute an important component of fisheries habitats, but also contribute to the biodiversity of the marine environment.

Deep-sea biodiversity hotspots represented by habitat-forming sessile fauna such as deep-sea coral banks, gorgonian and black coral gardens, sea pen fields and sponge gardens have a high vulnerability to disturbance and a low recovery potential.

The literature review revealed a total of 38 invertebrate taxa considered as key habitat-forming sessile fauna for the Eastern Mediterranean (Table 3.1): Scleractinian

coral species as indication of the potential presence of **coral reefs or banks** (the latter suggesting cases where scattered species or aggregations do not actually build up in extensive reef structure); soft coral species (e.g. gorgonians, black corals, alcyonids) indicating the potential presence of hard or soft bottom **gorgonian and black coral gardens**; sea pens indicating the potential presence of **sea pen fields**; sponges indicating the potential presence of hard or soft bottom **sponge gardens**, as well as specific assemblages of the same taxa (a bivalve mollusc, a brachiopod and a crinoid taxa species) indicating the potential presence of **other emergent fauna** fields.



Sponges
(*Poecillastra compressa*)
on maërl seabed.
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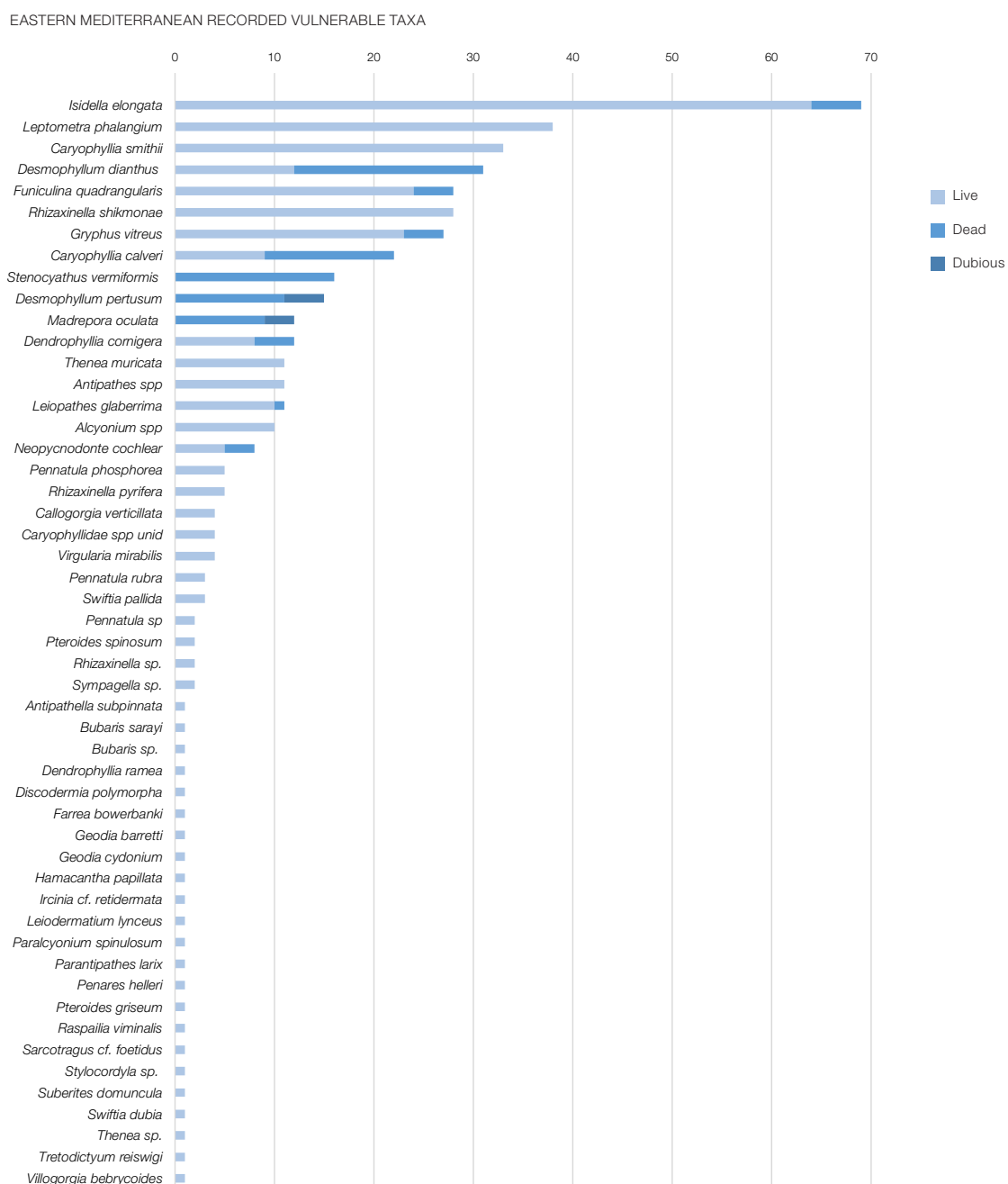
Table 3.1. List of the deep-sea habitat-forming vulnerable sessile taxa based on the literature review for the Eastern Mediterranean Sea. IUCN Conservation status of species and relevant international agreements, directives and conventions with listed annexes, applicable recommendations and regulations. DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered.

Key Habitat-Forming Vulnerable Fauna	Protection Status	IUCN Red List	Habitat Type
<i>Madrepora oculata</i>	CITES: II, Protocol SPA/BD (b): II, EU Regulation Trade: B	EN	Coral reefs/banks
<i>Desmophyllum pertusum</i> (= <i>Lophelia pertusa</i>)	CITES: II, Protocol SPA/BD (b): II, EU Regulation Trade: B	EN	Coral reefs/banks
<i>Desmophyllum dianthus</i>	CITES: II, EU Regulation Trade: B	EN	Coral reefs/banks
<i>Caryophyllia calveri</i>	CITES: II, EU Regulation Trade: B	DD	Coral reefs/banks
<i>Caryophyllia smithii</i>	CITES: II, EU Regulation Trade: B	LC	Coral reefs/banks
<i>Dendrophyllia cornigera</i>	CITES: II, EU Regulation Trade: B	EN	Coral reefs/banks
<i>Stenocyathus</i> sp.	-	DD	Coral reefs/banks
<i>Bebryce mollis</i>	-	DD	Coral gardens
<i>Swiftia</i> spp.	-	DD (<i>S. pallida</i>)	Coral gardens
<i>Villogorgia bebrycoides</i>	-	DD	Coral gardens
<i>Callogorgia verticillata</i>	Protocol SPA/BD (b): II	NT	Coral gardens
<i>Antipathes dichotoma</i>	CITES: II, Protocol SPA/BD (b): II, BERN: III, EU Regulation Trade: B	NT	Coral gardens
<i>Isidella / Acanella</i>	-	CR	Coral gardens
<i>Leiopathes glaberrima</i>	CITES: II, Protocol SPA/BD (b): II, BERN: III, EU Regulation Trade: B	EN	Coral gardens
<i>Parantipathes larix</i>	CITES: II, Protocol SPA/BD (b): II, EU Regulation Trade: B	NT	Coral gardens
<i>Alcyonium palmatum</i>	-	LC	Coral gardens
<i>Paralcyonium spinulosum</i>	-	LC	Sea pen fields
<i>Pennatula</i> spp.	-	VU	Sea pen fields
<i>Pteroeides</i> spp.	-	VU (<i>P. spinosum</i>)	Sea pen fields
<i>Virgularia mirabilis</i>	-	-	Sea pen fields
<i>Funiculina quadrangularis</i>	-	VU	Sea pen fields
<i>Kophobelemnion stelliferum</i>	-	LC	Sea pen fields
<i>Bubaris</i> spp.	-	-	Sponge gardens
<i>Farrea bowerbanki</i>	-	-	Sponge gardens
<i>Geodia</i> spp.	-	-	Sponge gardens
<i>Penares</i> spp.	-	-	Sponge gardens
<i>Leiodermatium lynceus</i>	-	-	Sponge gardens
<i>Discodermia polymorpha</i>	-	-	Sponge gardens
<i>Sympagella</i> sp.	-	-	Sponge gardens
<i>Tretodictyum reisiwigi</i>	-	-	Sponge gardens
<i>Hamacantha</i> spp.	-	-	Sponge gardens
<i>Thenea muricata</i>	-	-	Sponge gardens
<i>Stylocordyla</i> sp.	-	-	Sponge gardens
<i>Rhizaxinella</i> spp.	-	-	Sponge gardens
<i>Suberites</i> spp.	-	-	Sponge gardens
<i>Gryphus vitreus</i>	-	-	Other emergent fauna
<i>Neopycnodonte cochlear</i>	-	-	Other emergent fauna
<i>Leptometra phalangium</i>	-	-	Other emergent fauna

Based on the review of the existing literature², and expanding the initially proposed genera into species, there are 51 deep-sea vulnerable sessile taxa (3 of them only detected in dead or dubious records) accounting for a total of 441 records across the region of which 93 are in the Eastern Ionian Sea, 76 in the North Aegean, 86 in the South Aegean, 83 in the Libyan Sea and 102 in the Levantine Sea. The bamboo coral *Isidella elongata* was recorded as the most common species (69 records)

from the literature review, mostly in the Eastern Ionian but also in the North Aegean and Libyan Seas. Other deep-sea habitat-forming vulnerable taxa frequently detected include the crinoid *Leptometra phalangium* (38 records), the scleractinians *Caryophyllia smithii* (33 records) and *Desmophyllum dianthus* (31 records), the sea-pen *Funiculina quadrangularis* (28 records), the demosponge *Rhizaxinella shikmonae* (28 records) and the brachiopod *Gryphus vitreus* (27 records) (Fig. 3.1).

Fig. 3.1. Key-habitat forming sessile invertebrate taxa detected (live, dead or with dubious records) in published and grey literature between 1995-2018, and number of records per each in the Eastern Mediterranean Basin.



² excluding the Sea of Marmara



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Crinoid beds of *Leptometra phalangium*.**Table 3.2.** Minimum and maximum depth and seabed type of occurrence for the most frequently recorded species in literature sources from each sub-region.

Location	Taxa	Min Depth (m)	Max Depth (m)	Seabed Type
Eastern Ionian Sea	<i>Antipathes dichotoma</i>	516	600	Deep-sea muds
	<i>Desmophyllum dianthus</i>	400	968	Deep-sea muds, deep fossil coral reefs
	<i>Isidella elongata</i>	356	1,082	Deep-sea muds
	<i>Leiopathes glaberrima</i>	367	634	Deep-sea muds
North Aegean Sea	<i>Leptometra phalangium</i>	74	181	Circalittoral and deep-sea muds
	<i>Funiculina quadrangularis</i>	45	638	Circalittoral and deep-sea muds
	<i>Caryophyllia smithii</i>	74	439	Circalittoral and deep-sea muds
	<i>Isidella elongata</i>	150	760	Circalittoral and deep-sea muds
	<i>Alcyonium palmatum</i>	74	200	Circalittoral and deep-sea muds
	<i>Gryphus vitreus</i>	180	420	Deep-sea reefs / banks
	<i>Desmophyllum pertusum</i>	110	360	-
	<i>Dendrophyllia cornigera</i>	170	420	Deep-sea reefs / banks
	<i>Madrepora oculata</i>	110	360	-
	<i>Callogorgia verticillata</i>	60	200	Deep-sea reefs / banks
<i>Pennatula phosphorea</i>	45	427	Deep-sea muds	
South Aegean Sea	<i>Leptometra phalangium</i>	183	1,000	deep-sea muds
	<i>Caryophyllia smithii</i>	115	1,000	deep-sea muds
	<i>Funiculina quadrangularis</i>	51	711	deep-sea muds
	<i>Gryphus vitreus</i>	500	700	deep-sea muds
	<i>Dendrophyllia cornigera</i>	150	460	Reefs / banks
Libyan Sea	Fossil white coral reefs	284	1,208	coral framestone/rubble
	<i>Dendrophyllia cornigera</i>	560	620	Reefs / banks
	<i>Gryphus vitreus</i>	219	550	-
Levantine Sea	<i>Rhizaxinella shikmonae</i>	1,227	1,493	Deep-sea muds
	<i>Gryphus vitreus</i>	254	726	-
	<i>Thenea muricata</i>	254	620	-
	<i>Caryophyllia calveri</i>	301	804	-
	<i>Desmophyllum dianthus</i>	310	804	various
	<i>Alcyonium</i> spp.	138	617	-
	<i>Funiculina quadrangularis</i>	254	604	Deep-sea muds
	<i>Neopycnodonte cochlear</i>	55	179	-
	<i>Virgularia mirabilis</i>	66	131	-
	<i>Leiopathes glaberrima</i>	256	612	mixed facies
<i>Pennatula rubra</i>	65	206	-	

Vulnerable benthic fauna from photographic material of experimental fishing catches

Based on the analysis of photographic material (on-board and laboratory) of experimental fishing catches, a total of 355 occurrences were recorded and identified as 33 invertebrate taxa (9 Porifera, 19 Anthozoa, 2 Mollusca, 1 Brachiopoda, and 2 Echinodermata), which include habitat-forming and other emerging benthic fauna³ taxa that are Vulnerable Marine Ecosystem (VME) indicators for fisheries, are protected by international, EU or national legislation or are listed in the IUCN threatened categories (1 Critically Endangered, 3 Endangered, 2 Vulnerable species). Some of these taxa were identified only at higher taxonomic levels (e.g. genus, family) or as morphological categories (e.g. unidentified massive sponges), due to restrictions in taxonomic identification based on photographs. However, it should be noted that a considerable percentage of the occurrence records was obtained from old material (8% before 2000; 53% before 2010). Most of the occurrence records involved single (45%) or 2-5 individuals/colonies (36%).

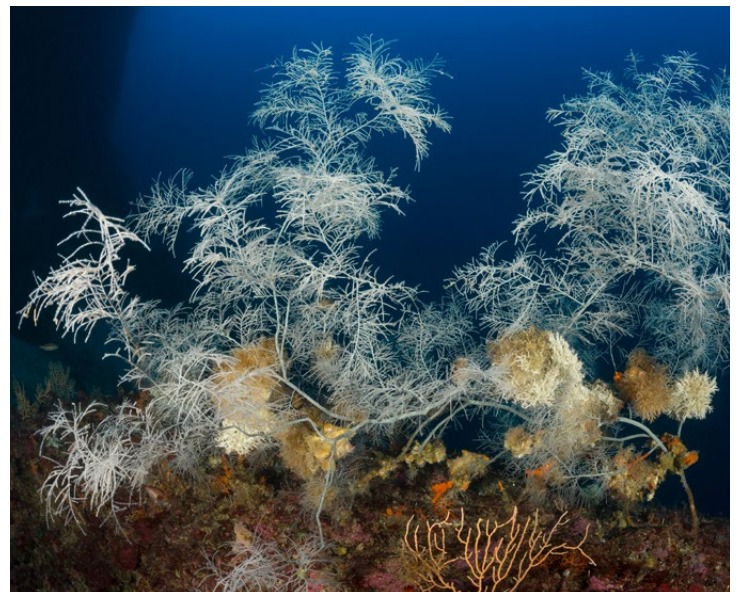
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These vulnerable marine ecosystems are considered hotspots of biodiversity and ecosystem functioning in the deep sea”

Vulnerable invertebrates were reported from a depth range of 163-897 m. Sponges were found in photographic material from trawl catches from a depth range of 165-766 m; anthozoans (stony corals, soft corals, sea pens and gorgonians) were found at trawls and longlines from relatively deeper waters, specifically 270-897 m depth.

Most invertebrate occurrences were found for the Eastern Ionian (46%) and North Aegean Seas (27%), while lower numbers were found for the South Aegean (16%) and Levantine Seas (11%), possibly reflecting the lower sampling effort. Anthozoan occurrences dominated (55%), followed by sponges (14%), molluscs (12%), echinoderms (11%) and the brachiopod *Gryphus vitreus* (8%).

The critically endangered “bamboo coral” *Isidella elongata* and the vulnerable sea pen *Funiculina quadrangularis* were the most frequently recorded anthozoans (81 and 65 occurrences respectively). In several cases, these two taxa presented considerable abundances (> 10 colonies) in fishing catches from particular areas, including MEDITS stations. The sponge *Thenea muricata* along with unidentified massive sponges were the most commonly recorded sponge taxa. It should be noted that in several cases there were smaller sponges, which could hardly be identified based only on photographs.



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³ *this term refers to fauna that can develop in clusters and offers hard substrate to smaller species such as the brachiopod *Gryphus vitreus*



Parazoanthus cf. *anguicomus* covering a sponge, probably *Thenea muricata*. © Oceana.



The gastropod *Tonna galea*. Oceana/IUCN/UNEP-MAP RAC-SPA Deep Sea Lebanon Project. © Oceana.

Table 3.3. Number of georeferenced records collected as bycatch from photographic material analysis of experimental fishing surveys. (See Annex 3.1 on data sources). Gastropod records include empty shells.

	Eastern Ionian Sea	North Aegean Sea	South Aegean Sea	Levantine Sea	Libyan Sea	Total records	Depth range (m)
Porifera (Sponges)	9	11	22	8		50	
<i>Agelas oroides</i>	1					1	499-533
<i>Axinella cannabina</i>		2				2	386
<i>Dysidea avara</i>			1			1	254-303
<i>Geodia</i> sp.			5			5	354-435
<i>Leiodermatium</i> sp. (rock sponge)	1					1	492
<i>Sarcotragus foetidus</i>	3		6			9	271-766
<i>Suberites</i> sp.		1	2			3	230-530
<i>Thenea muricata</i>	2	2	2	8		14	165-619
Unidentified massive sponges	2	6	6			14	165-716
Anthozoa (corals, sea pens, sea fans and anemones)	117	46	12	19		194	
<i>Alcyonium acaule</i>			1			1	270
<i>Antipatharia</i> spp.				3		3	256-600
<i>Antipathes dichotoma</i>	9					9	516-773
<i>Antipathes</i> sp.				2		2	612-617
<i>Caryophyllia calveri</i>				3		3	302
<i>Caryophyllia</i> sp.				4		4	256-318
<i>Dendrophyllia cornigera</i>	3					3	367-634
<i>Desmophyllum dianthus</i>	5			3		8	310-600
Elisellidae sp.	1					1	555
<i>Funiculina quadrangularis</i>	21	36	5	3		65	223-856
Gorgoniidae		2				2	210-292
Isididae	68	8	4		1	81	239-897
<i>Leiopathes glaberrima</i>	2					2	380-620
<i>Paracyathus pulchellus</i>	1					1	586
<i>Pennatula</i> sp.	2					2	519-571
Pennatulacea sp.				1		1	256
<i>Swiftia</i> sp.	1					1	343
Unidentified corals	3		2			5	322-740
<i>Villogorgia</i> sp.	1					1	499
Gastropod (Molluscs)	13	11	12	5		41	
<i>Ranella olearium</i>	1	4		1		6	428-609
<i>Tonna galea</i>	12	7	12	4		35	163-798
Brachiopoda (Lamp shells)						0	
<i>Gryphus vitreus</i>	18	6		6		30	223-813
Echinodermata (sea urchins, sea lillies)	5	23	11	0		39	
<i>Centrostephanus longispinus</i>	1		7			8	254-800
Crinoidea spp.	4	23	4			31	284-865
Total	162	97	57	38	1	355	

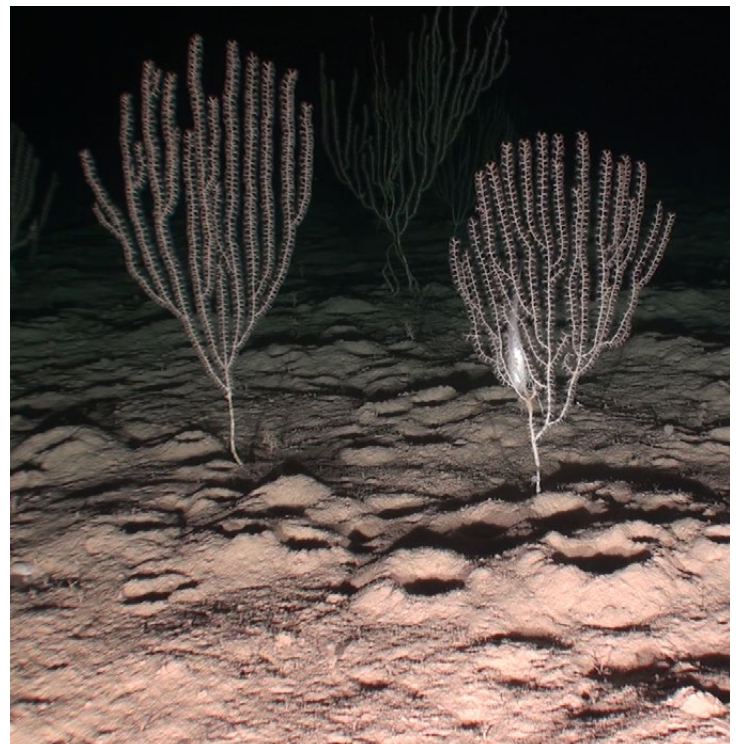
Table 3.4. Species collected as bycatch from photographic material analysis of experimental fishing surveys which are protected under relevant international agreements, directives and conventions with listed annexes, applicable recommendations, and regulations. IUCN Conservation status of species also indicated. DD = Data Deficient, LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered.

Taxa	Common name	IUCN	CITES	EC 338/97	Barcelona Convention	Bern Convention	GFCM
<i>Axinella cannabina</i>					II	II	
<i>Sarcotragus foetidus</i>	Black sponge				II	II	
<i>Antipathes dichotoma</i>	Black coral	NT	II	B	II	III	GFCM/43/2019/6
<i>Caryophyllia calveri</i>	Cup coral	DD	II	B			
<i>Dendrophyllia cornigera</i>	Yellow tree coral	EN	II	B	II		GFCM/43/2019/6
<i>Desmophyllum dianthus</i>	Cockscomb cup coral	EN	II	B	II		GFCM/43/2019/6
<i>Funiculina quadrangularis</i>	Tall sea pen	VU					
<i>Isidella elongata</i>	Bamboo coral	CR			II		GFCM/43/2019/6
<i>Leiopathes glaberrima</i>	Smooth black coral	EN	II	B	II	III	GFCM/43/2019/6
<i>Paracyathus pulchellus</i>	Papillose cup coral	DD	II	B			
<i>Pennatula sp.</i>	Greater sea pen	VU					
<i>Ranella olearium</i>	Wandering triton				II	II	
<i>Tonna galea</i>	Giant tun				II	II	
<i>Centrostephanus longispinus</i>	Hatpin urchin				II	II	

1

EASTERN IONIAN SEA

The overall analysis of the number of publications dealing with deep-sea biodiversity from the Eastern Ionian Sea (93), shows the presence of 17 sessile taxa at 84 locations (Fig. 3.2). Among these, the bamboo coral *Isidella elongata* (potentially also including misidentified *Acanella* species) ranked as the most common reported species. This was followed by the black corals *Antipathes dichotoma* and *Leiopathes glaberrima* together with the coral *Desmophyllum dianthus*. The maps generated by the database most likely represent maps of research effort rather than maps of the true extent of sessile species occurrences. Although the general lack of concrete and quantitative data does not allow a coherent identification of locations of special conservation interest, the scattered occurrence of several vulnerable taxa across the Eastern Ionian Sea is well-confirmed, indicating the widespread presence of deep-sea coral gardens, but also coral banks/reefs, sponge gardens and other vulnerable emergent fauna.



The bambo coral *Isidella elongata*.

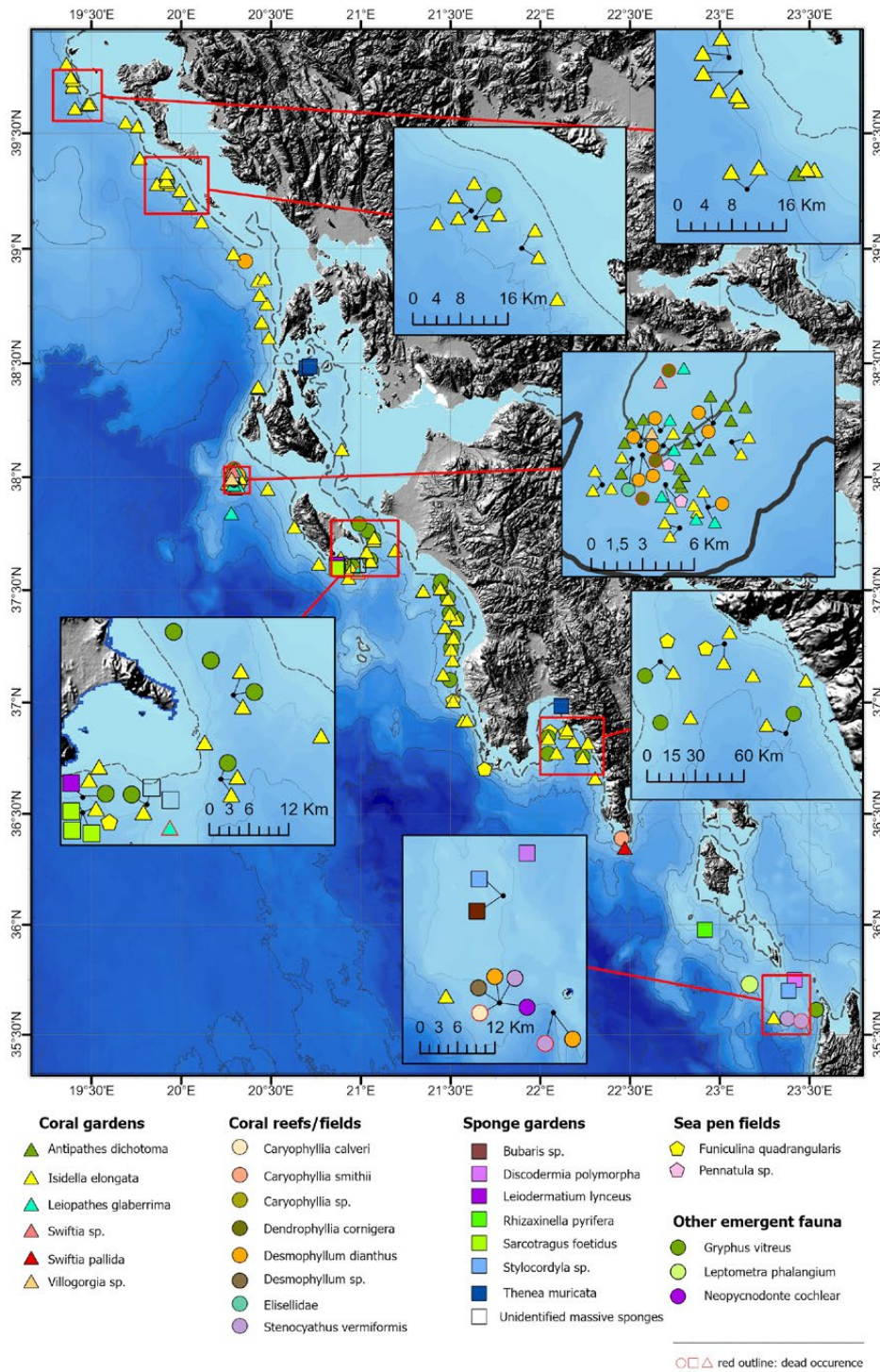


Fig. 3.2. Recorded presence of vulnerable sessile invertebrate taxa across the Eastern Ionian Sea.

The depth range and seabed type of occurrence, at least for the most frequently recorded taxa in the Eastern Ionian Sea (Table 3.2), clearly suggest that bamboo and black corals are the habitat-formers best adapted to life at these profound depths, deep-sea muds at depths between 300-1,000 m. The bamboo coral *Isidella elongata* is shown to be more or less continuous in the deep waters of the E. Ionian Sea and has a maximum recorded depth of 1,082 m, with deeper bottoms showing the highest abundances[3].

Cold-water corals such as *Madrepora oculata* are well documented in the other parts of the Mediterranean but not documented here. Only one deep-sea survey targeting potential cold-water coral reefs in the South Ionian Sea off NW Crete Island (Antikythera Strait) reported the discovery of subfossils of cold-water coral banks in the area (i.e. *Desmophyllum* - *Madrepora*)[4], with sporadic occurrences of other living corals (*D. dianthus* and *Caryophyllidae*). Further exploration in different types of seabeds and geomorphological formations (e.g. rock

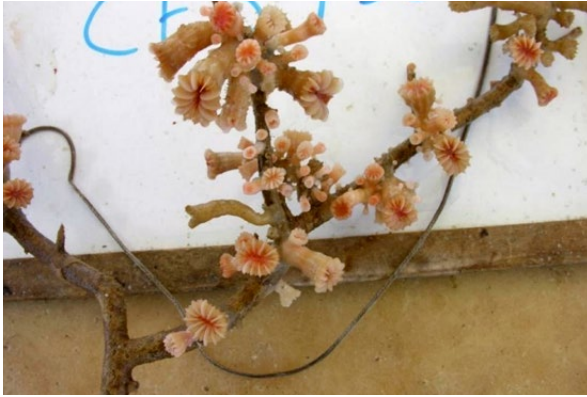


Plate 3.1. Multiple *Desmophyllum dianthus* colonies (> 140) caught on a single longline at a depth of 531 m in the framework of CORAL-FISH project (Photo by HCMR, Greece). The species can form colonies with younger individuals growing on the skeleton of older ones and might constitute the framework-building species in coral banks.



Plate 3.2. The brachiopod *Gryphus vitreus* was caught in high numbers in six stations in the Eastern Ionian Sea (> 60 individuals/station) and one station in the Levantine Sea (> 30 individuals) (Photos by HCMR and FRI, Greece).



Plate 3.3. Multiple specimens of the sponge *Thenea muricata* from the Patraikos Gulf, Eastern Ionian Sea. The sponge is characterized by root-like structures projecting from the base, by means of which it attaches itself to soft substrate (Photo by HCMR, Greece).



Plate 3.4. Multiple *Funiculina quadrangularis* specimens (yellow circles) and crinoids from MEDITS trawl catch from a depth of 512 m off Antipsara Island, North Aegean Sea (Photo by FRI, Greece).

dredging or ROV surveys on steep continental slopes, seamounts or relief hard grounds) would have provided better insights on the potential occurrence of other key assemblage sessile species, such as these deep-sea coral banks or sponge gardens.

The present analysis of photographic material (on-board and laboratory) from deep-sea experimental fishing catches, collected in the framework of past research projects, indicated the presence of an additional 162 unreported records. The taxa with the highest number of records in this area were *Isidella elongata* (68 records at 255-897 m depth), which has a wide dis-

tribution in the deep waters of the E. Ionian Sea, as shown by the literature review, and the sea pen *Funiculina quadrangularis* (21 records from Kefalonia Island to Peloponnesus and inner Korinthiakos Gulf, at a depth range of 364-856 m) which was not reported in deep E. Ionian waters from literature sources. Notable examples of high abundance of other sessile fauna as individuals or colonies collected in experimental fishing catches also included the cold-water coral ***Desmophyllum dianthus*** (3.1) caught on a single fishing longline, the brachiopod ***G. vitreus*** (3.2) and the sponge ***Thenea muricata*** (3.3) in trawl catches.

2

NORTH AEGEAN SEA

In general, the existing literature for the North Aegean Sea can be considered rather outdated, as most records (97%) are earlier than the year 2000, pointing to the general lack of more recent research efforts in the deep Aegean Sea (Table 3.4). Trawling, and less so fishing nets (bottom set gillnets and trammel nets), were the most common approach in the collection of these observations.

Data records from existing literature indicates the presence of 23 vulnerable sessile fauna, with a total of 76 records from 42 sites in the North Aegean Sea (Fig. 3.3). Among these, the most common species encounters have been the crinoid *Leptometra phalangium*, followed

by the sea-pen *Funiculina quadrangularis*, the cup coral *Caryophyllia smithii* and the gorgonian *Isidella elongata*. The soft coral *Alcyonium palmatum* and the brachiopod *G. vitreus* have also been recorded in the region. Reefs or banks built by cold-water corals, and particularly by the species *Desmophyllum pertusum*⁴ and *Madrepora oculata*, considered rare in the Eastern Mediterranean, appear at only a few sites (4 and 3 records respectively) from depths between 110-360 m in several areas of the North Aegean Sea. Recurrent observations through decades seem to strengthen the validity of these records.

The findings support the high biodiversity richness of this region, even if seldom studied, with deep-sea crinoid and sea pen fields, coral gardens, and other emergent fauna, at times in impressively dense aggregations.



Scleractinian coral *Lophelia pertusa*. Image courtesy of Lophelia II 2009 Deepwater Coral Expedition Reefs Rigs and Wrecks.

⁴ *Desmophyllum pertusum* (= *Lophelia pertusa*: Addamo et al., 2016).

© IFM-GEOMAR.



Dendrophyllia cornigera.

Aggregations of the crinoid *L. phalangium*, sometimes on very dense fields⁵ have been reported in several localities characterized by muddy or detritic bottoms at depths between 74-181 m. Suspension-feeding species such as crinoids, are known to occur along the shelf break and circalittoral environments in the Mediterranean and have been suggested as an indicator of highly productive areas that can sustain large biomasses of fish and recruits[5].

Sea pen fields of *Funiculina quadrangularis* and *Pennatula phosphorea*, were also relatively commonly reported at muddy bottoms between 45-638 m. Scattered colonies of *Isidella elongata* and the soft coral *Alcyonium palmatum* occurring at depth ranges between 150-760 m and 74-200 m respectively, also indicate the potential presence of soft bottom coral gardens in this

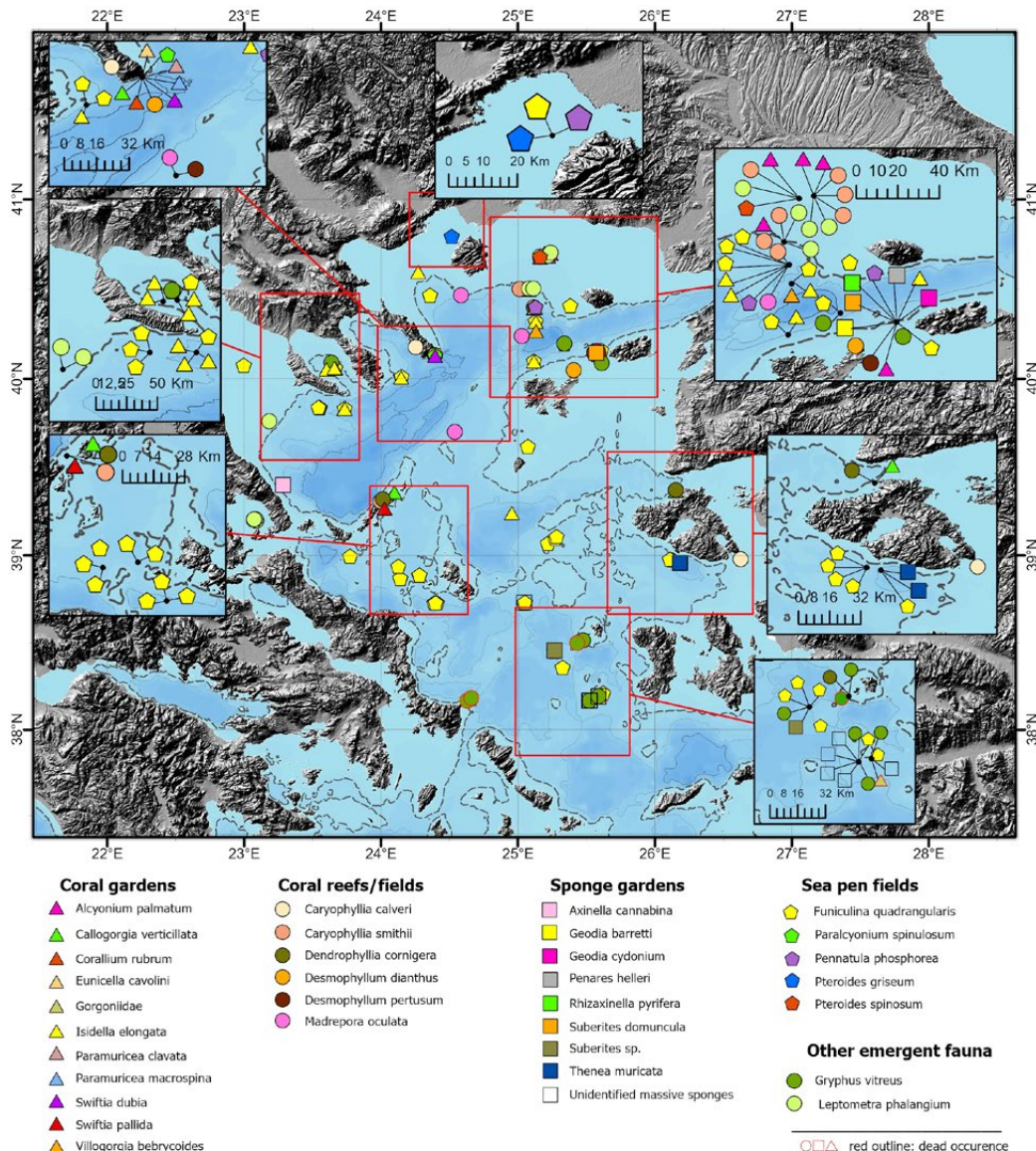


Fig. 3.3. Recorded presence of habitat-forming vulnerable sessile species across the North Aegean Sea (76 records, 42 sites).

5 Smith CJ, unpubl. data



Funiculina quadrangularis. © Simone Nicolini.

region. Older historical records indicate the presence of living colonies of the yellow coral *Dendrophyllia cornigera* off W. Kyra Panagia Island (Sporades Islands) and Antipsara Island, at depths of 170-420 m[6], a species that can also settle at shallower depths.

Fields or forests of other species reported the presence of the black coral *Parantipathes larix*, the sponge *Theenea muricata* or crinoid *L. phalangium*[7,8] although the reports lack information on the location and bathymetric range of the findings.

The present photographic material analysis from experimental fishing revealed a further addition of 97 records from a depth range of 210-630 m. The most common species recorded from trawl catches were the sea pen *Funiculina quadrangularis* (36) and crinoids (23). Notable examples of high numbers (more than 10) of vulnerable sessile individuals/colonies included: *Isidella elongata* (in 3 trawl catches in the Toroneos Gulf and off the Kassandra Peninsula, Chalkidiki), *F. quadrangularis* (3.4) (in 6 trawl catches in the centre of the N. Aegean), and crinoids (in 6 trawl catches).

SOUTH AEGEAN SEA

3

With some quite interesting exceptions, much of the existing knowledge (~93%) compiled for the South Aegean Sea from the literature review is rather outdated (earlier than the year 2000), and most relevant records (82%) come from observations aboard trawlers. The spatial distribution of available records (Fig. 3.4) are around the Cyclades islands and the Cretan Sea. In the Cyclades, records are random and highly scattered as they originate from variable timespans and methodological approaches, while the Cretan Sea presents more concentrated and systematic information, collected by means of experimental trawling in the frames of two HCMR research projects (CINCS and FGEII Project).

Both circalittoral and deep-sea muds of the Cretan Sea have been confirmed to host significant fields of the crinoid *Leptometra phalangium* at depths of between 51-1,000 m (up to 1,552 individuals have been reported from a single haul in the Cretan Sea), *Funiculina quadrangularis* sea-pen fields at depths of between 51-711 m, and sparse but widespread aggregations of the brachiopod *Gryphus vitreus* at depths of between 500-700 m. Along with these findings, the cup coral *Caryophyllia smithii* (115-1,000 m) is also frequently reported, suggesting that deep-sea muds in this region might host occasional mixed communities.

The new records of reef-forming *Dendrophyllia cornigera*, at the muddy crater of the Kolumbo submarine volcano (460 m) and surrounding the lower circalittoral off Serifos Island (150-200 m) further add to S. Aegean conservation interest. These locations are known to receive high pressure from artisanal fisheries using bottom gillnets, mostly targeting *Squalus* shark spp. and the blackspot seabream *Pagellus bogaraveo*⁶.

The present photographic material analysis revealed a further addition of 57 records from a depth range of 163-766 m. Notable examples of high numbers of vulnerable invertebrate individuals in the examined photographs included crinoids and the sponge *Theenea muricata*. The bamboo coral *Isidella elongata* was previously unknown in the area.

⁶ Salomidi M, unpubl. data

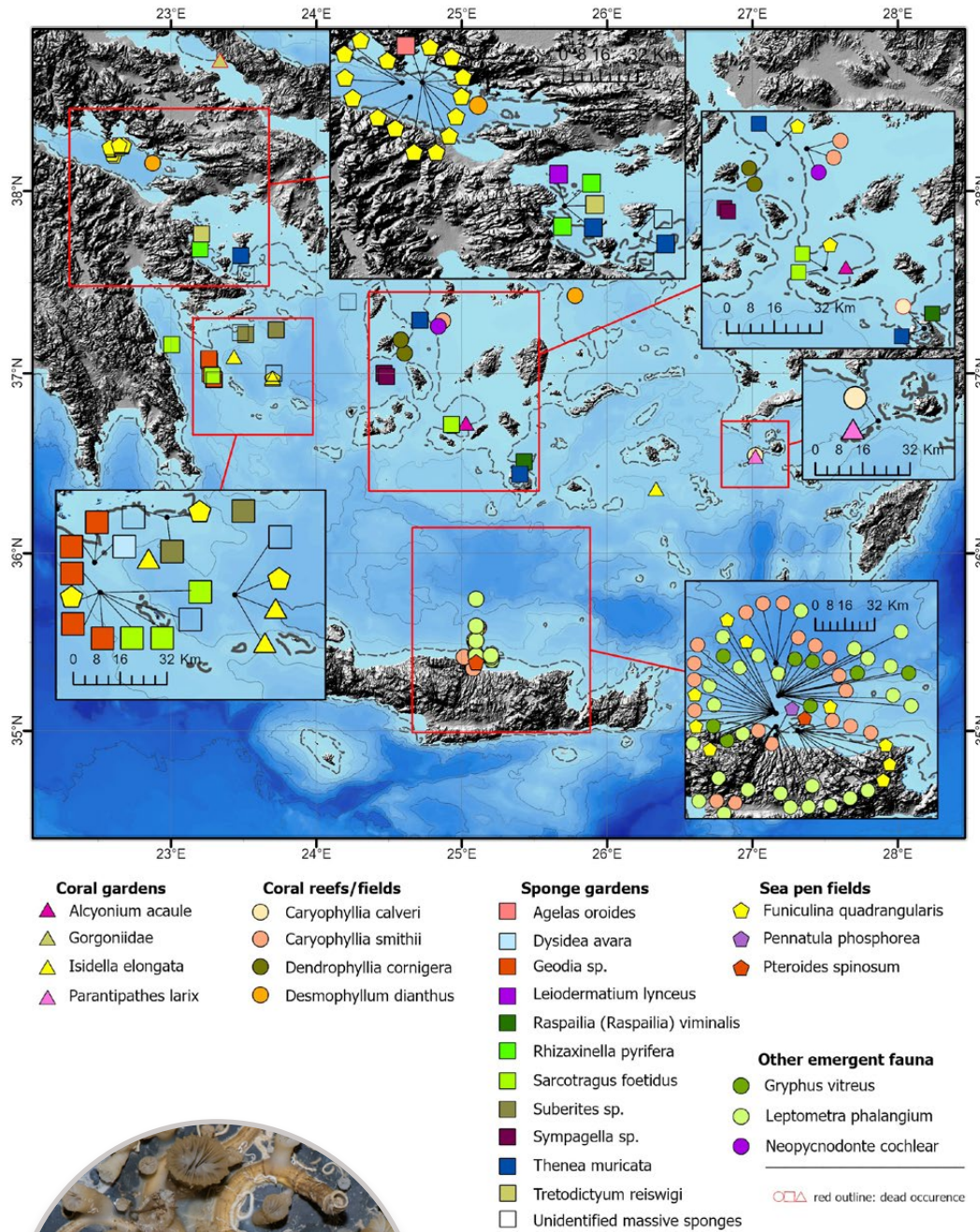


Fig. 3.4. Recorded presence of vulnerable sessile invertebrate taxa across the South Aegean Sea (86 records, 43 sites).



Desmophyllum dianthus covering the Arado WWII aircraft.

Also noteworthy for being of exceptional interest in this area is the 2013 case of a WWII aircraft wreck (sunk in 1944) accidentally raised by a trawler from a depth of ~400-500 m west off Ikaria Island, densely colonized by large individuals of *D. dianthus* and other deep reef-associated fauna (mostly serpulids)⁷.

⁷ Salomidi & Zibrowius, unpub. data

4

LIBYAN SEA

Most recorded vulnerable sessile invertebrate taxa in the Libyan Sea (88%) originate from a single research cruise that aimed particularly to explore the potential presence of cold-water coral banks along the margins south off Crete, Karpathos, and Rhodes islands, by the combined use of rock and epibenthic dredges on hard bottoms[4]. Information on deep-sea biodiversity from this region is therefore rather limited, with 15 key sessile species recorded from 34 sites (Fig. 3.5). Reef-forming species such as *Dendrophyllia cornigera* have been twice recorded alive from SE off Crete Island at depths of 520-620 m, while other cold-water corals (*Desmophyllum dianthus*, *D. pertusum*, *Caryophyllia calveri*, *Madrepora oculata* and *Stenocyathus vermiformis*) are so far known only in dead or subfossil aggregations.

Of special interest, a significant population of “exceptionally large specimens” of the deep demosponge *Rhizaxinella pyrifer* has been reported at 450 m depth of

the Napoli Mud Volcano[9], lying approximately equidistant from Crete Island and the Libyan coast. Scattered records of other key fauna include the presence of the brachiopod *Gryphus vitreus*, the antipatharians *Antipathes* spp. and *Leiopathes glaberrima*, the gorgonian *Isidella elongata*, the sea-pen *Funiculina quadrangularis*, as well as the demosponge *Rhizaxinella pyrifer*.

The occurrence of fossil and subfossil cold water coral aggregations in the Libyan Sea has been confirmed both on land (palaeo coasts in St. Paul’s Bay Limestone;[11], as well as on steep escarpments and elevations along the south margins of Crete, Karpathos and Rhodes Islands, suggesting cold-water corals forming banks and reefs might have had a wider area in previous times (12.4-12 ka cal BP)[4].

Although photographic material from fisheries catches from this area were not available, one *Isidella elongata* coral sample was caught with longlines targeting *Pageillus bogaraveo* (off South Crete), at a depth of approximately 400 m.

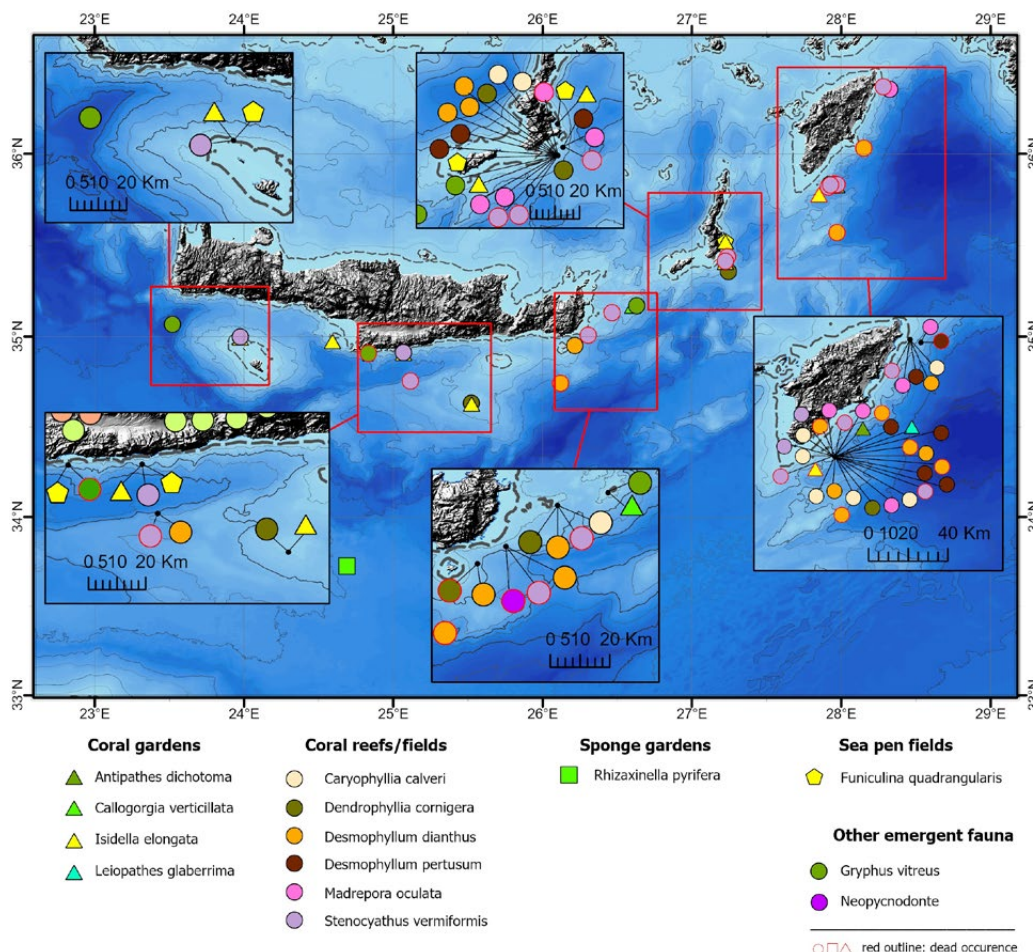


Fig. 3.5. Recorded presence of vulnerable sessile invertebrate taxa (classified under respective VME types) across the Libyan Sea (83 records, 34 sites).

5

LEVANTINE SEA

Although trawling remains the most important source of information (~70% of all compiled records), a significant part of the collected observations for the Levantine sub-region (~26%) also comes from the recent ROV deep survey off Lebanon (Deep-Sea Lebanon project, 2016) and the recent discoveries in Palmahim Disturbance on the continental margin offshore southern Israel[12].

The quantitative analysis of all historical literature reports 30 vulnerable sessile taxa within a total of 105 records from 76 sites for the Levantine Sea (Fig. 3.6). Among

them, the deep-sea sponge *Rhizaxinella shikmonae* was the most commonly reported of all the habitat-forming species, followed by the brachiopod *Gryphus vitreus*, the sponge *Thenea muricata* and the corals *Caryophyllia calveri* and *Desmophyllum dianthus* (the latter however includes three dubious ones in terms of taxonomic identification). More recently, numerous colonies of the habitat-forming hydroid *Lytocarpia myriophyllum* were reported for the first time around South and North-western Cyprus (Pendaskhnos, Kolpos Epistokopis and Vailiko-Mori), often in considerable densities, at a bathymetric range of 45-619 m[10]. This feather-like hydroid is the largest hydroid of the Mediterranean Sea and its colonies can reach up to 1 m in height, organized in tufts and anchored to detritic and sandy bottoms.

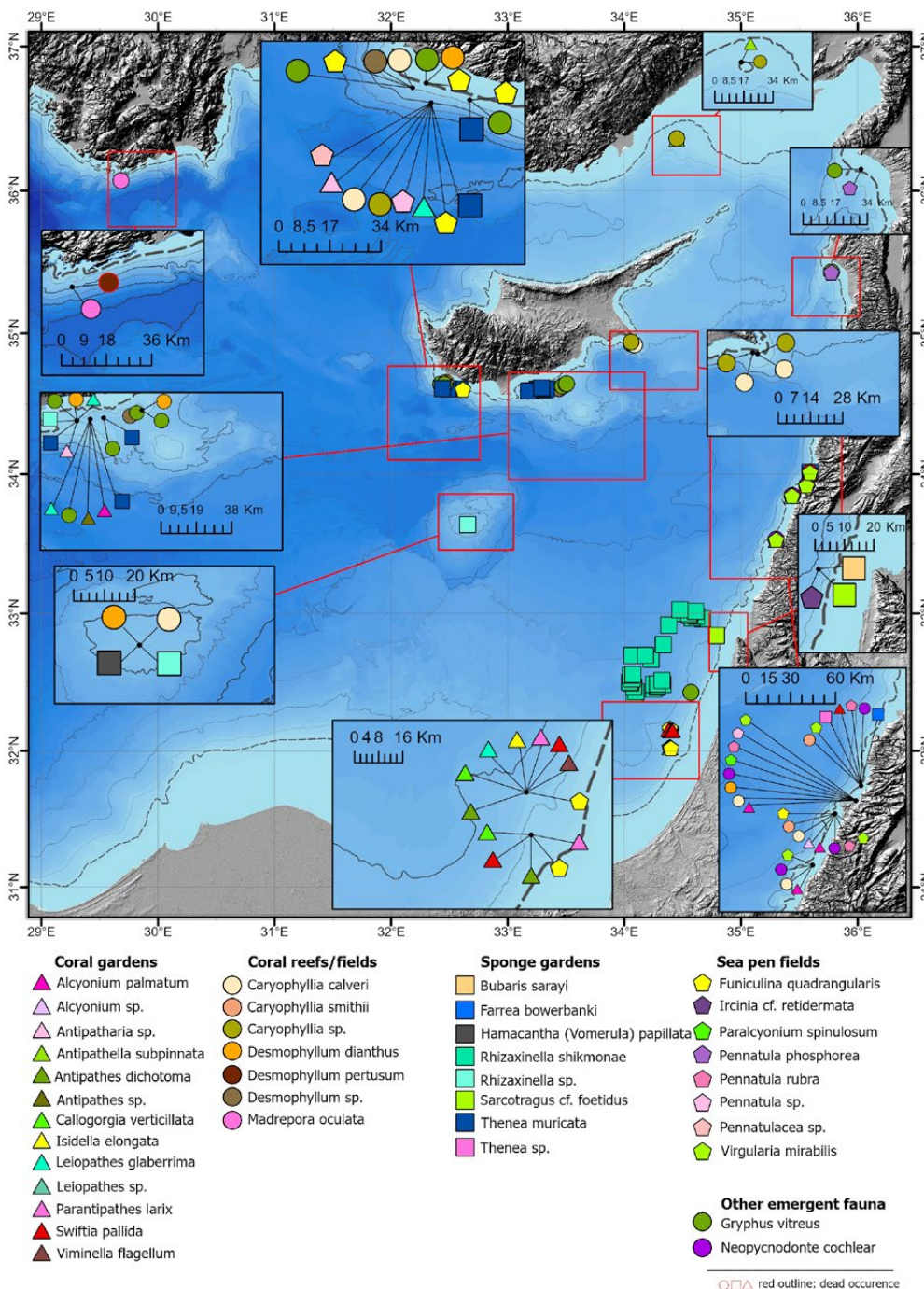
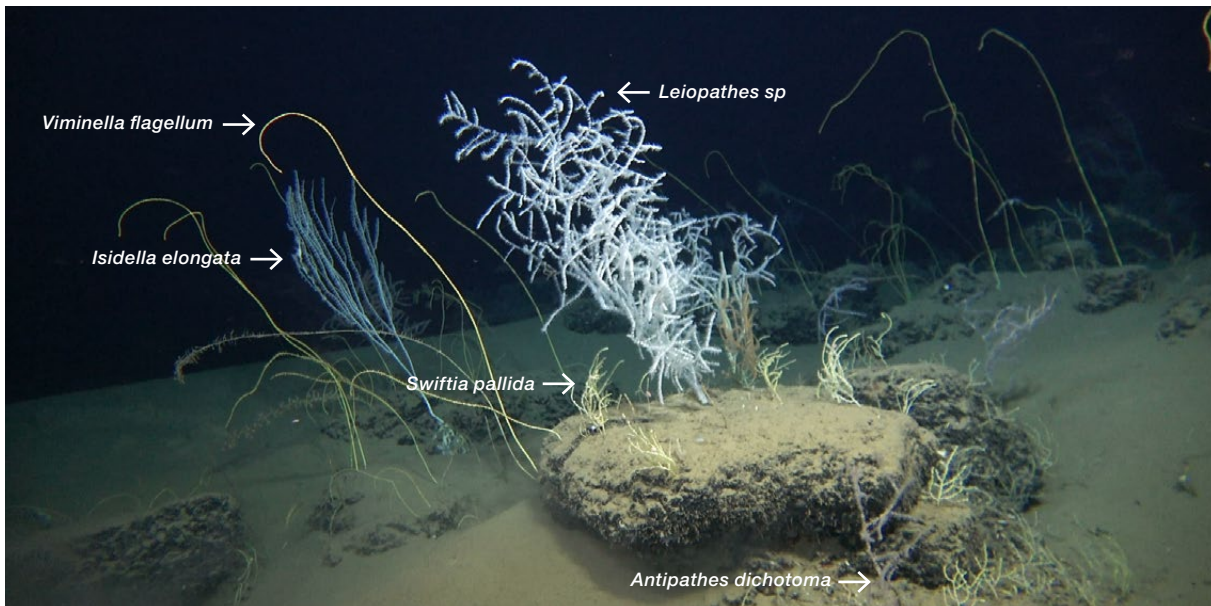


Fig. 3.6. Recorded presence of vulnerable sessile invertebrate taxa (classified under respective VME types) across the Levantine Sea (105 records, 76 sites).

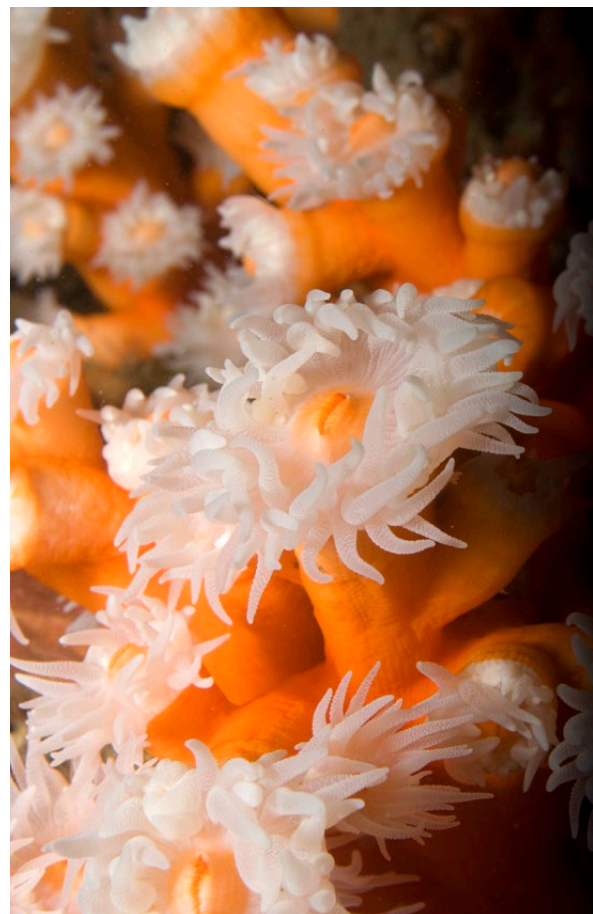


Deep-sea corals gardens on the northern face of Palmahim Disturbance (~650 m water depth). *Desmophyllum* corals were found to a maximum depth of ~1150 m. © Applied Marine Exploration Lab., Charney School of Marine Sciences, University of Haifa/ Israel Oceanographic and Limnological Research Institute.

Early expeditions to the Eratosthenes Seamount[13] have shown this area to host important communities of deep vulnerable sessile species. More recent studies from Cyprus, Israel, and Lebanon, both by experimental trawling and ROV surveys, highlight the Levantine deep muddy bottoms as important grounds for various key sessile fauna, and particularly the demosponges *Rhizaxinella shikmonae* and *Thenea muricata* (trawled from depths of between 1,227-1,493 m and 256-620 m respectively), the brachiopod *Gryphus vitreus* (254-726 m), and the sea-pen *Funiculina quadrangularis* (254-604 m). The scleractinian *Desmophyllum dianthus* has also been commonly reported from these same habitats, either as an associate of soft-bottom communities or colonizing natural or man-made fixed substrates (e.g. litter) scattered across muddy bottoms between 310-804 m.

Recent explorations have uncovered unique deep-sea communities off the Israeli shelf at the Palmahim Disturbance with the easternmost cold-water coral community in the Mediterranean. Overall, more than 7,400 coral colonies have been documented to date, including *Leiopathes*, *Antipathes dichotoma*, *Callogorgia verticillata*, *Viminella flagellum* and *Parantipathes larix*[12]. Of the compact mud growing upon the rock facies, both the critically endangered bamboo coral, *Isidella elongata*, and the vulnerable species of sea pen *Funiculina quadrangularis* are found in large numbers (hundreds of colonies) at the locality (Weissman et al. unpublished data).

A significant population of *Dendrophyllia ramea*, a species typically known from rocky circalittoral habitats in the Mediterranean, has been recently discovered off Protaras SE Cyprus forming a rather extensive coral



Polyyps of *Dendrophyllia ramea*. © Jose Elias Cabrera.



Pteroeides spinosum. © Francesco Pacienza.

field on circalittoral muds at depths of between 125-170 m[14]. Although not regarded as part of the truly deep-sea biodiversity, this finding is presented here for its exceptional interest, which highlights our thus far poor understanding of the eastern Mediterranean deep biota.

Apart from dead branches of the white corals *Madrepora oculata* and *Desmophyllum pertusum* dredged off Kastelorizo Island in 1956[15], other living coral banks of these species have not been reported from the Levantine, although unconfirmed sources do mention the presence of the cold-water coral *Desmophyllum pertusum* in deep-sea grounds of oil exploration interest⁸.

Although not included in this deep-sea compilation, several sea pen colonies of *Pteroeides spinosum* collected from the shallow coastal waters (20-25 m) of the northern coast of Egypt[16] also suggest potential occurrence of deeper sea-pen fields in this area.

The present work on the photographic material from experimental fishing observations indicated the presence of 11 species (1 Porifera, 7 Anthozoa, 2 Mollusca, and 1 Brachiopoda) encountered from 38 observations. The most common species, all from trawl catches, were the brachiopod *Gryphus vitreus*, the sponge *Thenea muricata* and the sea pen *Funiculina quadrangularis* (> 50 colonies in one trawl catch off Cyprus).

CONCLUDING REMARKS

According to the literature review on existing records of habitat-forming sessile species in the Eastern Mediterranean Sea, the presence of such fauna was revealed to be widespread, diverse, and, in cases, long-known for several decades.

Overall, 51 key species have been recorded at depths as shallow as 33 m (i.e. in the case of *Caryophyllia smithii*) and as deep as 2,000 m (i.e. in the case of the demosponge *Rhizaxinella pyrifer*) from the period 1995-2018 across various seabed types, suggesting both the ubiquity as well as the wide natural variation in the distribution of vulnerable fauna in this area.

The historical records reveal that bamboo corals, of the family Isididae, were previously documented as being common along the continental shelf and shelf slope, particularly in the E. Ionian Sea. Other widely and commonly reported benthic invertebrate taxa with habitat-forming characteristics include the crinoid *Leptometra phalangium*, the scleractinian corals *Caryophyllia smithii*, *C. calveri*, *Desmophyllum dianthus* and *Dendrophyllia cornigera*, the sea-pens *Funiculina quadrangularis* and *Pennatula phosphorea*, the demosponges *Rhizaxinella* spp. and *Thenea muricata*, the brachiopod *Gryphus vitreus*, the black corals (*Antipathes* spp., *Leiopathes grabberima*) and soft corals (*Alcyonium* spp.), as well as the mollusc *Neopycnodonte cochlear*.

⁸ Jimenez, unpubl. data.

Photographic documentation from experimental fishing surveys, even when not taken under a systematic and concrete sampling scheme, also provide valuable information, extending the known distribution range of rarely reported species. Notable examples include: the critically endangered bamboo coral which was found in several locations in the N. Aegean, S. Aegean and Libyan Sea, significantly extending the known distribution of the species[2], *Funiculina quadrangularis* in the E. Ionian Sea and off Cyprus, the rock sponge *Leiodermatium* sp. which was recorded for the first time in the E. Ionian Sea (off W. Peloponnesus at 492 m), and many records of the brachiopod *Gryphus vitreus* which is rarely reported from the Eastern Mediterranean Sea[17].

Areas of high abundances were also found, more specifically: high abundances of *Isidella elongata* in the Toroneos Gulf and off Sithonia, Chalkidiki (N. Aegean Sea), several sites in the E. Ionian Sea, Antikythira Strait and South Kasos Strait off Crete Island and Palmahin Disturbance. *Funiculina quadrangularis* in central N. Aegean Sea and off south coasts of Cyprus and Israel (Palmahin Disturbance); *Gryphus vitreus* in the E. Ionian Sea. In addition, specific areas harboured multiple taxa of conservation interest: off SE Kefalonia (e.g. *Antipathes dichotoma*, *Dendrophyllia cornigera*, *Desmophyllum dianthus*, *Funiculina quadrangularis*, *Isidella elongata*, *Leiopathes glaberrima*) and the south coasts of Cyprus (e.g. *F. quadrangularis*, *D. dianthus*, *Caryophyllia* spp. and many unidentified corals). These findings indicate areas of potential conservation interest, which require further examination of their present conservation status before adequate management and protection measures are planned.



Sponge *Agelas oroides*. Oceana/IUCN/UNEP-MAP RAC-SPA Deep Sea Lebanon Project. © Oceana.



Giant oyster (*Neopycnodonte cochlear*) off Tyre coast, Lebanon. Oceana/IUCN/UNEP-MAP RAC-SPA Deep Sea Lebanon Project. © Oceana.

“

Biodiversity hotspots of habitat forming fauna were found in the Toroneos Gulf and off Sithonia, Chalkidiki, several sites in the E. Ionian Sea, Antikythira Strait and South Kasos Strait off Crete Island and Palmahin Disturbance. These historical records also show rich faunal assemblages off SE Kefalonia and the south coasts of Cyprus”

Critical information is however needed to enable a better understanding and management of deep-sea sessile communities that will help in the future to assess the distribution, status, health, and potential threats faced by these important ecosystems. Since deep-sea ecosystems, and within them vulnerable sessile communities, extend beyond national boundaries and encounter similar threats, cooperative efforts among countries could be beneficial to maximize available resources, share expertise, and exchange data to rapidly increase the scientific understanding of the communities that are created by these habitat-forming species.

- **Locating and mapping of sessile habitat-forming species.** The historical dataset shows that the bulk of the information was acquired through trawling (~70% of all records), whereby only coordinates and depth of the start (at times also the end) of them are provided. Cases also exist where an important species presence is mentioned only across very large spatial scales and depth ranges. Some data from the NE Aegean and the Levantine coasts were difficult to retrieve although are probably available in local grey literature or otherwise inaccessible sources (e.g. published in Turkish, Israeli or Arabic) and there is very limited information from the Libyan Sea.
- **Obtaining specific information on populations and their specific threats using state-of-the-art advanced underwater technologies.** This is largely due to the lack of systematic studies, and particularly ones that would allow for the collection of scientifically sound quantitative information, such as visual transects by means of ROVs or submersibles (representing 10% of the studies to date) or multiparametric deep-sea observatory platforms.
- **Obtaining information and all habitat types.** The historical literature review shows that records from reefs/banks and other hard-bottom communities hardly account for 15% of all available data, as opposed to 85% obtained from the exploration of muddy bottoms. Studies should also investigate the fauna present in different ecosystems made by a variety of geomorphological formations such as seamounts, canyons or the continental shelf-break.
- **Understanding the status and vulnerability of sessile fauna.** A significant part of the historical records (~46%) pre-date the year 2000, and the overwhelming majority (83.5%) are older than 2010. Given the vulnerability of these species, and the constantly increasing pressures – especially as the trawling industry expands in previously unexploited grounds – their persistence today can by no means be considered certain.
- **Expand the collection of information from fisheries in a systematic manner.** Information from experimental fisheries surveys (e.g. MEDITS), other scientific surveys and commercial fisheries (including photographic documentation and use of morphological groups for sponges/corals in cases where species identification is not possible) could be useful measures for getting a greater understanding of the biology and ecology of species as well as evaluating the impact of fisheries on vulnerable benthic assemblages. This approach has been recently adopted by several Mediterranean countries for the identification of by-catch sponges and corals in commercial fisheries catches, within the framework of a pan-Mediterranean project⁹[18]. •

⁹ "Understanding Mediterranean multi-taxa 'bycatch' of vulnerable species and testing mitigation - a collaborative approach".

CHAPTER 3/

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