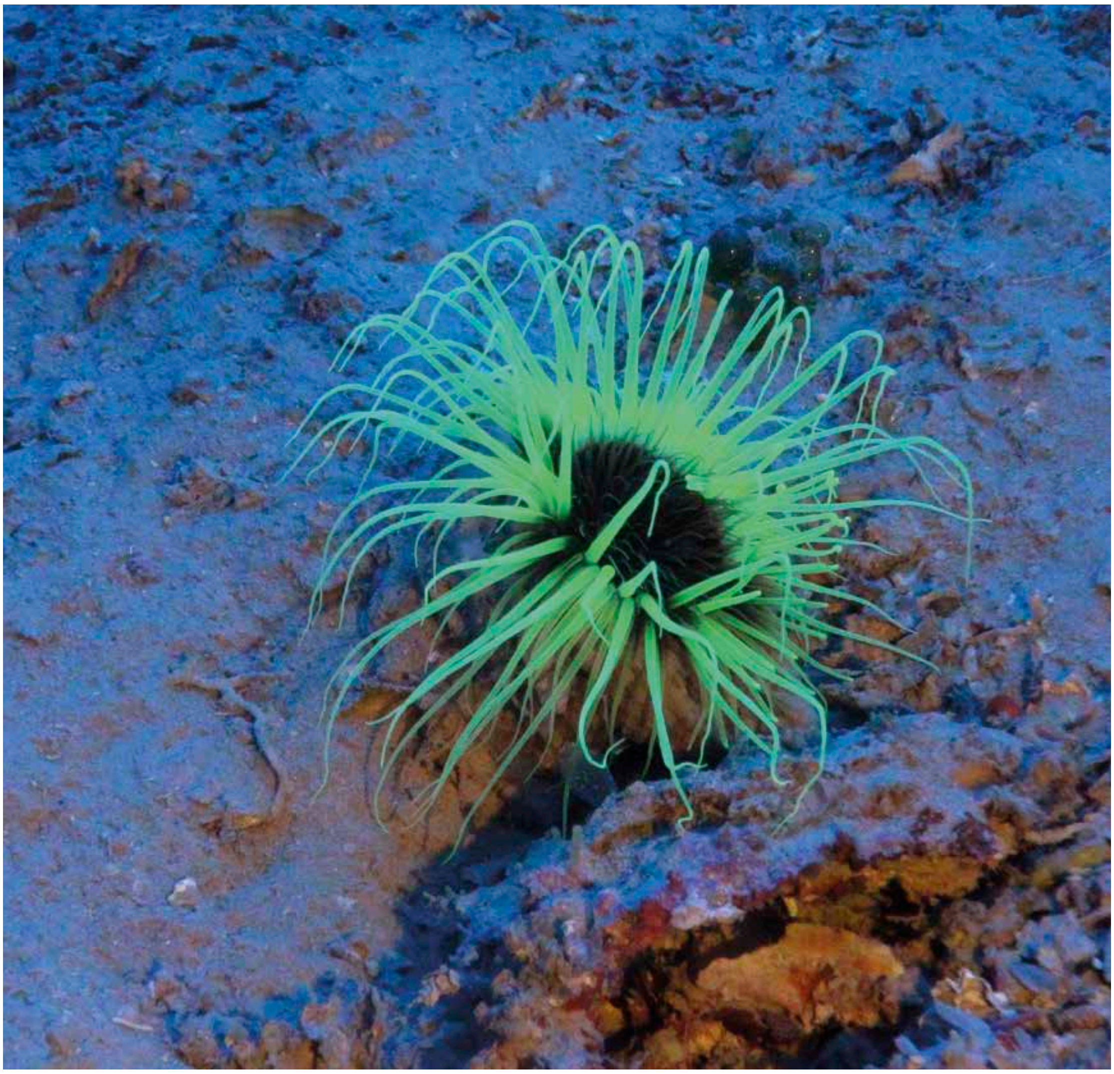
REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

DEEP SEA LEBANON

RESULTS OF THE 2016 EXPEDITION EXPLORING SUBMARINE CANYONS

Towards Deep-Sea Conservation in Lebanon Project



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Based on an official request from Lebanon's Ministry of Environment back in 2013, Oceana has planned and carried out an expedition to survey Lebanese deep-sea canyons and escarpments.

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Introduction

Biodiversity of the Eastern Mediterranean Sea

The Mediterranean Sea is a semi-enclosed basin, surrounded by 21 African, Asian, and European states. It extends over an area of 2.5 million km^2 and is connected to the Atlantic Ocean though the Strait of Gibraltar, to the Black Sea through the Dardanelles and Bosforus Straits, and to the Red Sea through the artificially opened Suez Canal. When compared to the average depth of the world's oceans (3733 m), the Mediterranean Sea is relatively shallow, with a mean depth of ca. 1650 m[1], yet it is the deepest of the enclosed seas. The entire Mediterranean Sea is considered a biodiversity hotspot, hosting up to 18% of the global total of macroscopic species (in less than 1% of the global ocean surface), with 25% to 30% of them considered endemic.[2,3]

The Eastern basin of the Mediterranean is defined as lying to the east of the Strait of Sicily. It encompasses the Adriatic, Aegean, Ionian, and Levantine Seas, and includes the deepest waters of the Mediterranean (5121 m), in the Hellenic Trench.[4] The nutrient concentration of the Mediterranean is relatively low, and it is more oligotrophic or ultra-oligotrophic in the Eastern basin, where the exhausted surface layer is thicker and deeper due to stronger stratification.[5] In the Levantine Sea, the easternmost region of the Mediterranean, temperatures are also more extreme than in the rest of the Mediterranean, such that it is also referred to as the 'warm-water corner of the Mediterranean'.[6] This characteristic appears to have become more pronounced during recent decades, possibly due to climate change.[7,8,9] The relatively warmer waters of the Levantine may be responsible for the fact that, even though community composition throughout the Mediterranean Sea is relatively homogenous, some important habitat-forming species are absent from Levantine waters (e.g., *Posidonia oceanica* seagrass and sea fans such as *Paramuricea clavata* and *Eunicella* spp.).[10,11,12]

Within the Levantine Sea, the waters of Lebanon host a wide variety of ecosystems, in an area representing 0.005% of the global marine surface. These ecosystems range from shallower features such as coralligenous habitat, seagrass meadows and vermetid reefs, to deep-sea ones such as underwater canyons.[13] Lebanese offshore waters are characterised by a narrow continental shelf, which is perpendicularly crossed by various canyon systems that connect coastal zones to deep-sea habitats. These geographic features range approximately from 50 to 1600 m deep in Lebanese waters, and are important 'keystone structures' due to their role in supporting deep-sea communities acting as nursery and shelter habitats, benefiting fisheries, enhancing carbon sequestration, and providing other ecosystem goods and services to human society.[14]

The array of marine habitats in Lebanese waters supports a diversity of marine life, with total species richness estimated in the thousands, and new species continuing to be discovered.[13,15] Among the species known to occur in the region are various iconic species that are considered to be at risk of extinction. For example, threatened cetaceans such as sperm whales (*Physeter macrocephalus*), fin whales (*Balaenoptera physalus*), and striped dolphins (*Stenella coeruleoalba*) are found in Lebanese waters, and monk seal (*Monachus monachus*) has been irregularly spotted. Three species of threatened sea turtles (i.e., *Caretta caretta*, *Chelonia mydas* and *Dermochelys coriacea*) have been reported to occur, with the first two being relatively common.[13] Various threatened sharks and rays are also reported from the area, including Critically Endangered species such as shortfin mako (*Isurus oxyrinchus*) and common guitarfish (*Rhinobatos rhinobatos*).[16]

Threats to Lebanese marine life

Lebanese marine ecosystems face, from a general perspective, similar pressures and threats as the entire Mediterranean. Major economic and social activities are concentrated along the coast, which represents 8% of the territorial area of the country.[17] The coastal zone suffers severe anthropogenic pressure, as it hosts 55% of the total Lebanese population, concentrated in coastal urban areas.[18] As a result, many commercial interests influence this area and compete for space. Thus, the status of the Lebanese coast has been described as declining due to over-exploitation and pollution from different origins, making the current uses of coastal areas unsustainable.[19] These activities include, among others: marine aggregate (i.e., sand and gravel) extraction, sewage and oil dumping, unsustainable and illegal fisheries, habitat degradation, recreational uses, coastal urbanisation, invasive species, and larger-scale impacts such as the effect of climate change.[18]

Active industrial and commercial areas are concentrated on the coast. In total, Lebanon has four commercial ports, 15 fishing ports, 12 oil pipelines and three power stations run on fuel.[18] Coastal development, including the construction of resorts and industrial development, has progressed in coastal areas in a chaotic and unregulated manner, particularly during the period of the Lebanese Civil War.[17] This development has affected landscapes and threatened biodiversity, while structures like marinas have disrupted regular water flux, increasing sand deposition. Most solid waste along the Lebanese coast is discarded, including non-biodegradable plastic (i.e., plastic bags, other plastic debris, lost fishing gear), with deleterious effects on marine fauna.[13] Untreated domestic sewage and industrial effluents represent the main sources of chemical pollution, while episodic pollution events have also resulted in significant impacts to marine life. For example, airstrikes on a Jiyeh oil storage depot during the 2006 conflict with Israel resulted in a major oil spill, which constituted the largest oil-release accident in the Eastern Mediterranean.[20] A large portion of the coastline was severely damaged, including a nature reserve in the north of Lebanon.

Octopus vulgaris

According to the most recent report on fisheries stock status from the General Fisheries Commission for the Mediterranean (GFCM), over 90% of the assessed commercial fish stocks in the Mediterranean are overexploited.[21] The precise status of Lebanese stocks is not known, largely due to a paucity of information; traditionally, there has been a lack of logbooks, and landings data are typically scarce and underestimated.[22] Nevertheless, overexploitation is a recognised problem[15] and surveys of local fisherman have suggested that some native fish species have decreased in size and abundance as a result of overfishing.[23]

The artisanal or traditional fisheries sector represents the dominant fishery sector in Lebanon, and the main gears used include trammel nets, gill nets, longlines, purse seines (used together with *lampara* – floating lamps used at night to attract larval and juvenile fishes to the nets[24]) and beach seines.[22] Some of the most destructive types of fisheries are not carried out in Lebanese waters (i.e., bottom trawling), as the seabed is not suitable for it.

The fishing fleet comprises around 2600 registered fishing boats (based on the most recent available data, from 2015[21]) with total lengths of less than 12 m.[22] There are more than 80 species of commercial interest, and an average of 3574 t were landed annually from 2000-2013[21]). Moreover, the general disorder that prevailed during the period of the war resulted in an anarchic use of marine resources, and some illegal practices reportedly still take place (i.e., dynamite fishing, spear fishing, and undersize mesh), contributing to the depletion of fish stocks and habitat destruction.[13,22]

The Levantine part of the Eastern Mediterranean is particularly susceptible to the invasion of alien species from subtropical environments, due to its aforementioned warm temperatures.[10] The opening of the Suez Canal in 1869 constituted a corridor for the spreading of thermophilic species, largely affecting local biodiversity.[8] Other activities such as aquaculture, shipping and leisure boating are increasing the magnitude of this problem, which is also worsening under climate change, particularly in the Eastern Mediterranean basin.[13,25] The spread of invasive species in the region has resulted in observable impacts on the productivity of Lebanese coastal marine ecosystems. For example, 37% of total catches in the region of Tyre (south Lebanon) in 2008 were alien species, whereas this proportion did not exceed 14% in the entire Eastern Mediterranean in 2012.[22]

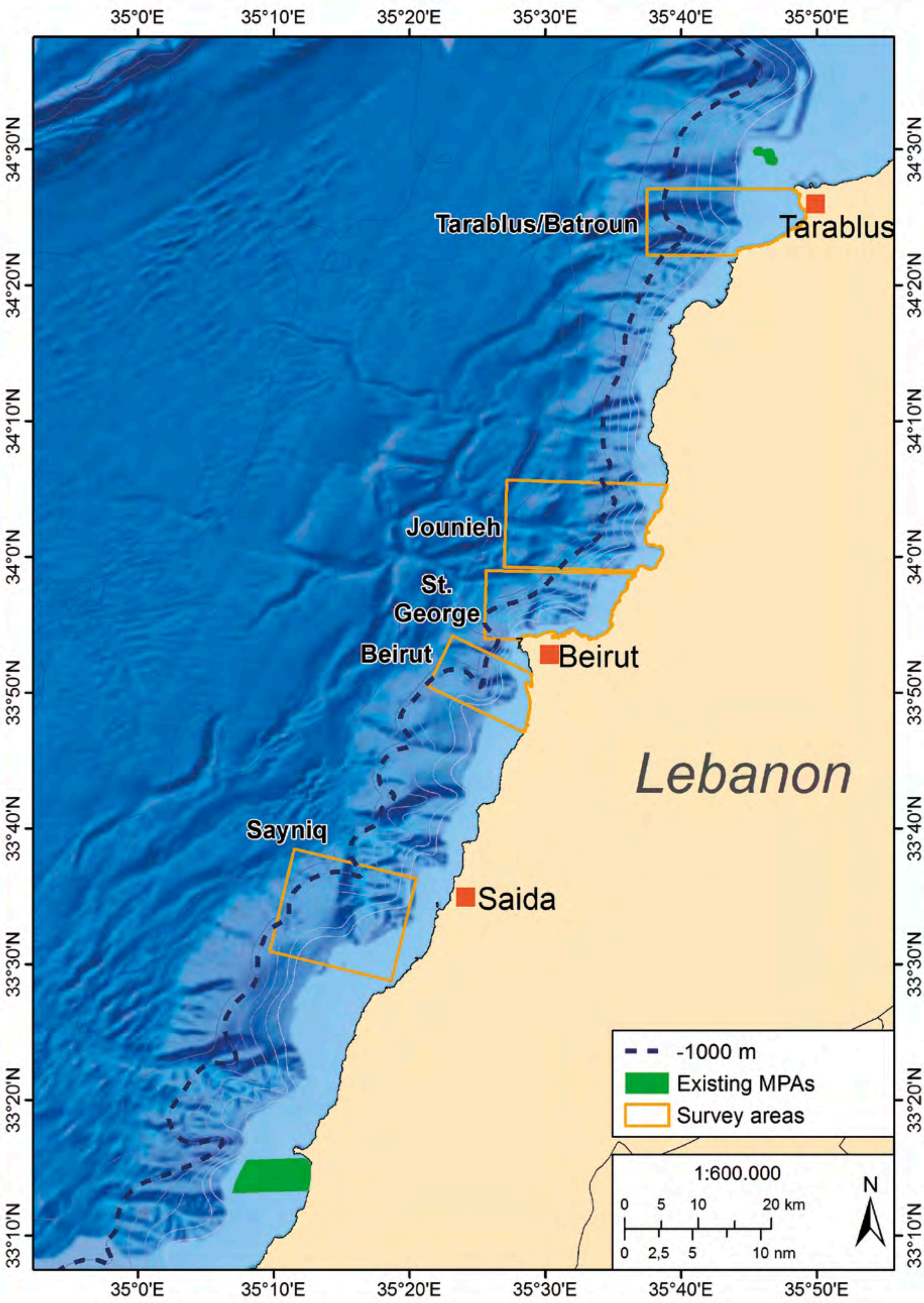
Current marine protection

The Lebanese government has signed or ratified various international conventions and agreements that directly affect the protection of its waters. These conventions include: the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention); the Convention on Biological Diversity (CBD); the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on Wetlands (Ramsar Convention); the African-Eurasian Migratory Waterbird Agreement (AEWA); the Agreement on Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS); and the UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention).

At the national level, Lebanon has protected two marine areas, covering only 0.22% of national waters (Map 1): *Palm Islands Park and Nature Reserve* and *Tyre Coast Nature Reserve.* The former was created in 1992 and covers an area of 5 km^2. It is formed by a group of three islets (Palm, Sanai and Ramkin) that lie roughly 5.5 km northwest of Tripoli and are important for marine turtles that are Red Listed as threatened by the International Union for Conservation of Nature (IUCN),[26] as such loggerhead turtle (*C. caretta*; Vulnerable) and green turtle (*C. mydas*; Endangered), and migratory birds. Endangered monk seals (*M. monachus*) were also regularly recorded in the area in the past, but such sightings have since become very rare[27]. It was recognised as a Ramsar Site in 2001[27]. The *Tyre Coast Nature Reserve* was declared in 1998. It occupies an area of 3.8 km^2 and consists of private agricultural land, freshwater springs and the last remaining sandy beach ecosystem in the country[28]. As with the Palm Islands, its geographical location places it along a major migratory route for birds, and for nesting sea turtles[28]. It has been designated as a Ramsar Site[29], an Important Bird Area (IBA), and a UNESCO World Heritage Site.

The artisanal or traditional fisheries sector represents the dominant fishery sector in Lebanon.

Map 1. Marine Protected Areas in Lebanon.



Peltaster placenta

Despite the demonstrated effectiveness of MPAs as a tool for marine protection[30], the percentage of marine area under this designation remains below internationally agreed targets, globally, in the Mediterranean Sea. According to the CBD Aichi Target 11, at least 10% of coastal and marine waters should be protected by 2020;[31] however, in the Mediterranean Sea, only 7.14%[21] has been legally protected (and only 4.29% if the extensive Pelagos Sanctuary is excluded). Most marine ecosystems represented in the Mediterranean network of MPAs are those associated with shallow, coastal waters, while valuable deep-sea ecosystems are typically excluded, which leads to an MPA network which is neither coherent nor ecologically representative. This situation is especially prevalent in the Eastern and Southern basins of the Mediterranean, which are characterised by small and dispersed MPAs along the coast.[32] Nevertheless, the deep-sea canyons from the Lebanese and Syrian regions have already been identified as an Ecologically or Biologically Significant Area (EBSA) by the CBD, namely *East Levantine Canyons*, thus acknowledging their important role in ecosystem functioning, their uniqueness and rarity, and their special importance for life-history stages of the species that they host, among other characteristics.[33]

A general obstacle to MPAs designation and management is a lack of detailed information about marine habitats and species. In the Mediterranean, such information is still relatively deficient, despite advancements in marine research technology and recent efforts to prioritise the study of marine ecosystems. In the Levantine area, the need for marine data is particularly pronounced for the northeastern basins of the Levantine area, in comparison with the central and western basins[11]. This lack of data is even more pronounced when it comes to deep-water ecosystems, which are known to contribute significantly to the total biodiversity of the Mediterranean.[34]

Closing this knowledge gap is the primary aim of the *Deep-sea Lebanon* project. Providing first-hand information about deep-sea ecosystems to the Lebanese authorities will help to increase the protection of Lebanese waters, and specifically of ecosystems found in deep areas. Ultimately, this increased protection will also contribute to reaching Aichi Target 11 by 2020, and to strengthening the natural marine biodiversity corridor in the Eastern basin.

Closing the knowledge gap about the deep-sea was the primary aim of the expedition.

Methods

Oceana carried out a research cruise in Lebanese waters during a period of nearly four weeks (3-27 October 2016), across a total of five areas covering some of the main underwater canyons that lie off the coast of the country. Surveys of these zones were carried out on board *Sea Patron*, a fully-equipped vessel of 42 m overall length and 11.4 m extreme breadth.

Potential sites were selected prior to the expedition, based on available scientific information and consultation with project partners. Several areas had previously been highlighted as priorities for consideration as potential MPAs. For example, the Beirut escarpment, St. George canyon, and Jounieh canyon were included in Lebanon's Marine Protected Area Strategy[35] as proposed deep-sea sites for protection, based partly on their inclusion within the 2011 MedNet proposal by Oceana.[36] In September 2015, representatives of Oceana, IUCN, UNEP-MAP RAC/SPA[37], the Lebanese Ministry of Environment, and the Lebanese National Council for Scientific Research (CNRS) held a meeting in which they jointly agreed the areas that would be surveyed. These areas were selected to ensure the inclusion of high priority areas for data collection across northern, central, and southern Lebanese waters. The final areas surveyed were as follows (Map 2, from north to south): Tarablus/Batroun, Jounieh, St. George, Beirut escarpment, and Sayniq.

In each of the five areas, exploration of the seabed was principally carried out by non-intrusive (visual) methods, using a remotely operated vehicle (ROV) with a high-definition camera. In order to obtain more detailed information about the infaunal communities, sediment samples were collected with a Van Veen grab in soft bottom areas. In addition, oceanographic parameters were recorded with a conductivity, temperature, and depth (CTD) instrument. A detailed description of the sampling methods is explained below.

Figure 1. Remotely operated vehicle (ROV) on board the research vessel.

ROV SURVEYS

Data were collected using a Saab Seaeye Falcon DR ROV (Figures 1 and 2), equipped with two forward-facing video cameras: (1) a high-definition camera with 1920x1080 resolution, 1/2.9" Exmor R CMOS Sensor, minimum scene illumination of 3-11 Lux, and a 4-48 mm, f/1.8-3.4 zoom lens; and (2) a low-definition camera with resolution of 540 TVL, 1/2" interline transfer CCD sensor, sensitivity of 0.35 Lux, and a 1/2" aspherical, wide-angle, fixed-focus lens. During ROV transects, *Sea Patron* sailed at an average speed of 0.1-0.2 knots, filming both in high- and low–definition, and simultaneously recording position, depth, course and time. Scientists onboard *Sea Patron* viewed the video feed in real time, to carry out preliminary species identification and select species, habitats, and seabed features of interest for more detailed investigation. In total, 51 ROV dives were carried out, ranging in depth from 36 to 1050 m. These surveys yielded 71 h 15 min of video of the seabed, and 4601 still images. Samples of key habitat-forming species were also collected (by means of the robotic arm of the ROV) for detailed analyses to confirm preliminary species identifications based on the live video feed.

Figure 2. ROV-launching manoeuvre.

Exploration of the seabed was principally carried out using a remotely operated vehicle down to 1000 m depth.

Map 2. Areas surveyed during the 2016 Oceana expedition in Lebanese waters, and the survey methods applied.

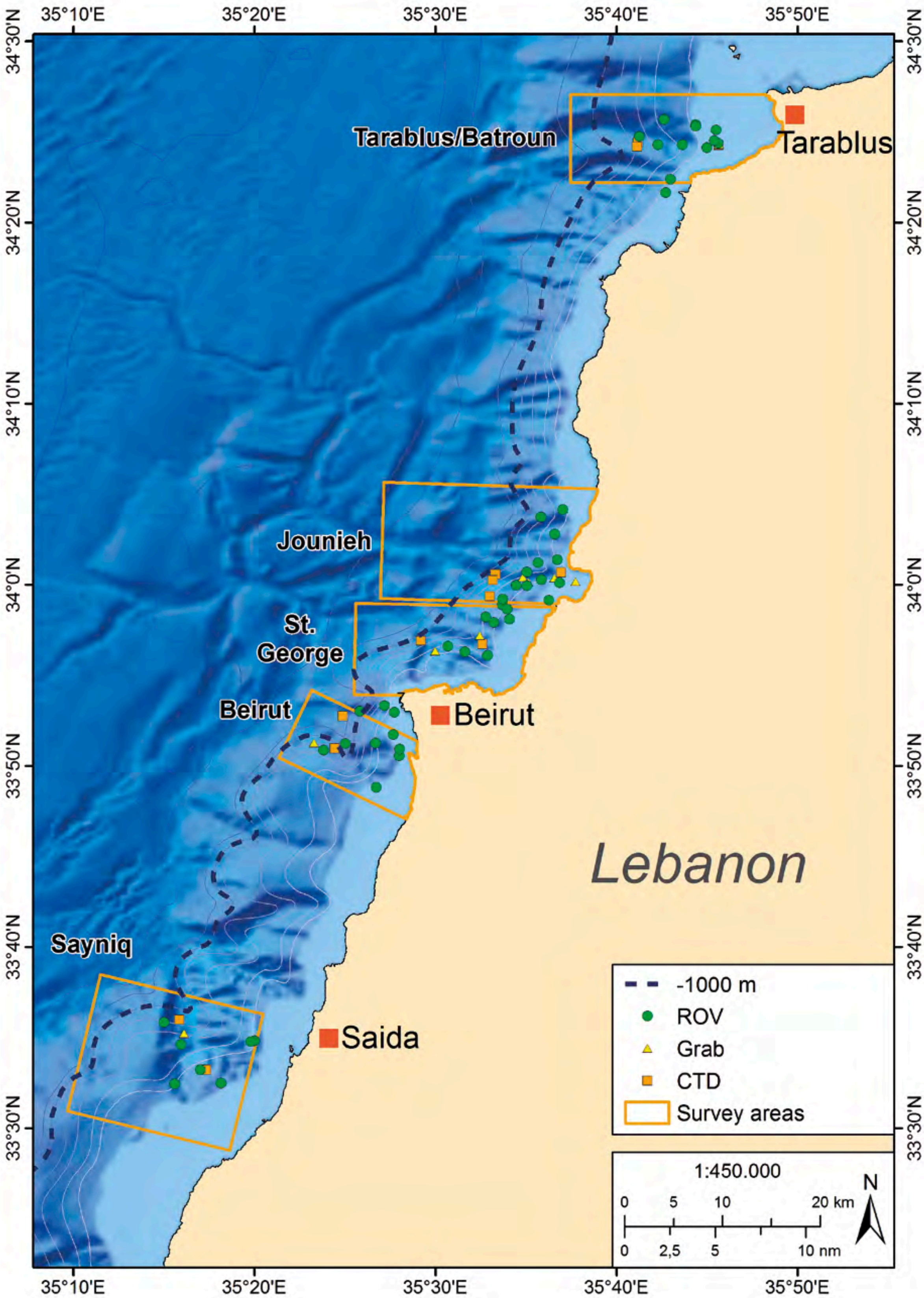


Figure 3. Preparation of the Van Veen grab for seabed sampling.

INFAUNAL SURVEYS

Infaunal community composition was examined by collecting samples in soft-bottom areas, with a 12 L Van Veen grab. In total, 12 grab samples were collected from a depth range of 76-1015 m and were processed on board. Specimens retained on 0.5 mm and 1 mm mesh sieves were kept for identification (Figure 3).

OCEANOGRAPHIC MEASUREMENTS

In order to take measurements of different oceanographic parameters, a Valeport MIDAS CTD + instrument was used, down to a maximum depth of 1076 m. The following parameters were recorded: conductivity, temperature, pressure, turbidity, dissolved oxygen, pH, salinity and chlorophyll-*a*. The CTD was deployed in all five of the sampling areas, recording parameters at 1 m depth intervals while the CTD unit was descending and ascending, yielding a total of approximately 7300 measurements for each parameter. Examples of the temperature results are presented in Figure 4.

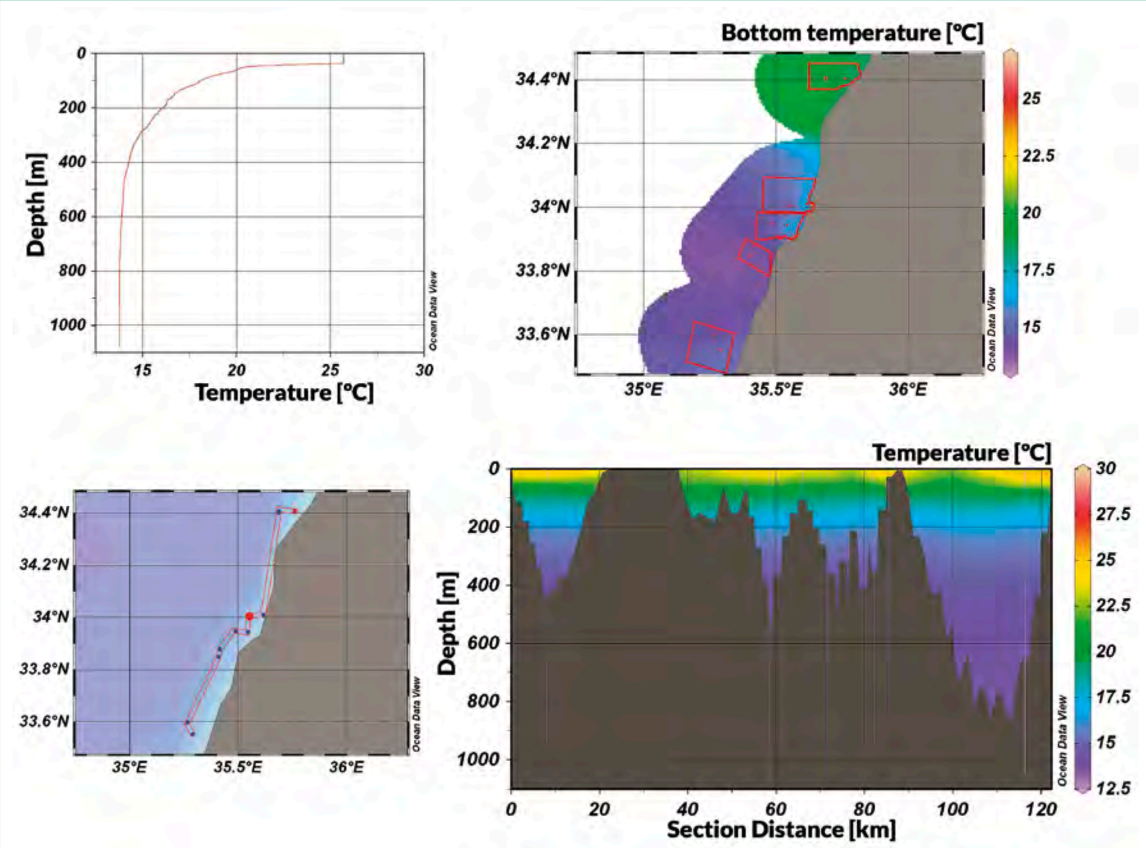


Figure 4. Outcome plot extracted from CTD device, showing the bottom temperature gradient across the areas sampled and the temperature gradient across the depths sampled.

DATA ANALYSES

Following the expedition, analysis of the footage recorded by the ROV was carried out by Oceana scientists. All of the visible species were identified to the finest taxonomic level possible. Specimens collected with the ROV and in grab samples (n=94 specimens; Figure 5), were also identified to the finest resolution possible. In cases where identification required additional expertise, specimens and/or footage were sent to taxonomic experts for confirmation. These experts included: Dr. Alfonso A. Ramos Esplá, whose identifications of ascidian species were compiled in a report;[38] Marie Grenier, Dr. Jean Vacelet and Dr. Thierry Pérez, who identified most of the sponge species documented, and prepared a technical report;[39] and Dr. Óscar Ocaña, Dr. José Templado and Ph. D. Ghazi Bitar, who identified specimens from various phyla[40].

Figure 5. Examples of specimens collected in a grab sample.

COLLABORATIONS

The research expedition was carried out with the full collaboration and support of project partners IUCN, UNEP-MAP RAC/SPA, the Lebanese Ministry of Environment, and CNRS, and with permanent representation onboard of the Lebanese military. Research work at sea was greatly supported by the following scientific collaborators on board *Sea Patron*: Dr. Abed El Rahman Hassoun and Ali Badreddine from CNRS, and Ph. D. Ghazi Bitar, representing UNEP.

The research expedition was carried out with the full collaboration and support of project partners IUCN, UNEP-MAP RAC/SPA, the Lebanese Ministry of Environment, and CNRS

Figure 6. Project collaborators, Ali Badreddine (CNRS, left) and Dr. Ghazi Bitar (UNEP-MAP RAC/SPA, right) on board *Sea Patron* during the *Deep-sea Lebanon* research cruise.

HABITAT TYPES

In total, six main habitat types were documented over a broad depth range (36-1050 m). These habitats and the key associated communities and species are described below and are presented according to increasing depth.

Coralligenous habitat and rhodolith/maërl beds

In all of the shallow-water surveyed areas, the presence of dead and live coralligenous habitat and rhodolith/maërl beds was documented (Map 3).

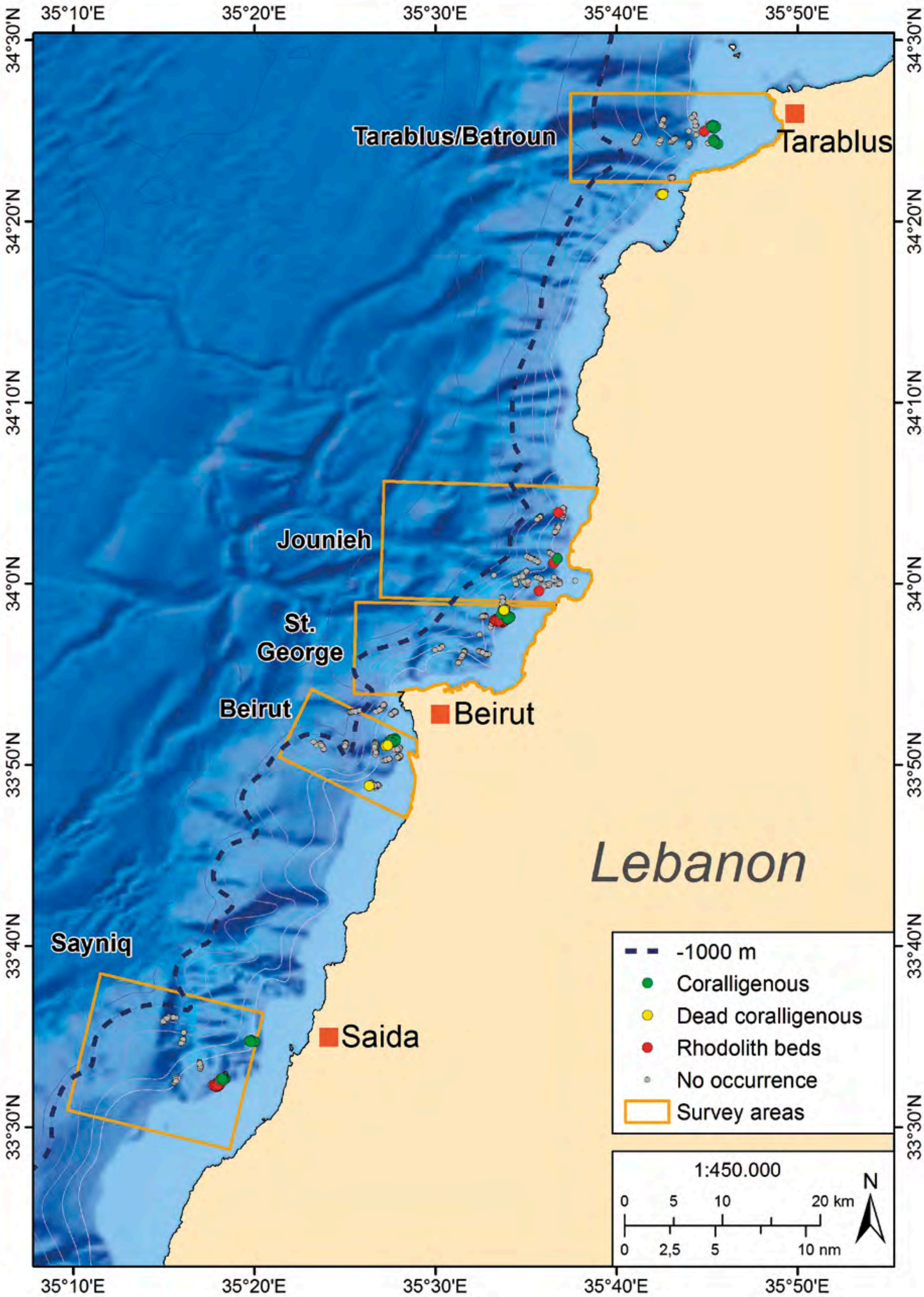
A belt of coralligenous habitat was found between approximately 70 m and 90 m depth (Figure 7), which coincided with the edge of the continental shelf and the heads of the submarine canyons, in all surveyed areas. In some cases, coralligenous habitat occurred at shallower depths (roughly 50-60 m), extending to where it joined with that found on the edge of the continental shelf.

Figure 7. Coralligenous concretions in Tarablus/Batroun, at 74 m depth.

Although some large sponges occurred on these algal concretions, the highest density of massive sponges was found on the rocks and coralligenous habitat on the shelf edge. The most common and representative sponge species was *Agelas oroides* (Figure 8), which usually occurred together with other sponges, such as *Fasciospongia cavernosa*, *Ircina* spp., *Spongia (Spongia) officinalis*, *Sarcotragus spinosulus*, *Clathrina clathrus*, and *Calyx nicaeensis*.

Figure 8. *Agelas oroides* on coralligenous formations at the edge of the continental shelf, in Tarablus/Batroun, 77 m depth.

Map 3. Distribution of coralligenous and rhodolith/maërl beds across sampled areas.



A diversity of fishes was found in association with these reef formations. Examples of documented fish species include *Anthias anthias*, *Coris julis*, *Muraena helena*, *Mycteroperca rubra, Seriola dumerilii*, and *Serranus cabrilla*, as well as various invasive fish species, such as *Pterois miles*, *Siganus luridus* and *Sargocentron rubrum*.

Significant concentrations of hatpin sea urchin (*Centrostephanus longispinus*) were found to occur on this type of seabed, with the result that it was the dominant species in some areas. This species is included in Annex II of the SPA/BD Protocol of the Barcelona Convention, the list of endangered or threatened species in the Mediterranean that require strict protection.[41]

In some areas (i.e., Tarablus/Batroun, St. George and Beirut), ancient calcareous formations were documented below the coralligenous habitat at the shelf edge. These formations may have been the result of coralligenous habitat that extended to a greater depth in the past. Although they may no longer contain living algae, they may nevertheless maintain the reef structure that is characteristic of coralligenous formations, and therefore provide substrate and shelter for numerous species.

Other noteworthy calcareous red algae formations were rhodolith/maërl beds found on sedimentary bottoms in the upper circalittoral zone, in the areas of Tarablus/Batroun, Jounieh, Sayniq and St. George. As in other parts of the Mediterranean, these beds represent valuable habitat for many species; other species of algae and animals attach themselves to the rhodoliths (see Figure 9), and numerous small- and medium-sized organisms live within the beds. These include, for example: species of green, brown, and red algae (e.g., *Valonia macrophysa*, *Lobophora variegata*, *Amphiroa rigida* and *Rhodymenia* sp.); bryozoans (e.g., *Adeonella pallaisi* and *Hornera frondiculata*); ascidians (e.g., *Halocynthia papillosa*, *Didemnum* sp. and *Pseudodistoma cyrnusense*); and a variety of other organisms, such as polychaetes, sponges, hydrozoans, and echinoderms.

Figure 9. *Valonia macrophysa* on a coralligenous bed in St. George, 60 m depth.

Sandy bottoms

Sandy bottoms were widely distributed throughout the infralittoral and upper circalittoral zones, in different regions of the continental shelf and in areas at the head of shallower canyons. They were also found in areas of mixed habitat, in combination with rhodoliths, in areas of scattered coralligenous habitat, and sites with isolated algae, small rocks and/or rubble, or with various types of biogenic or artificial remains.

Invasive species, such as white-spotted pufferfish (*Torquigener flavimaculosus*) and broadbanded cardinalfish (*Ostorhinchus fasciatus*) and, possibly, the Indian Ocean twospot cardinalfish (*Cheilodipterus novemstriatus*), were frequently recorded from this habitat type. They were intermixed with native species that are typical of sandy bottoms, including sea basses such as *Serranus cabrilla* and *S. hepatus*, gurnards such as *Lepidotrigla cavilone*, and lizardfishes such as *Synodus* spp.

In some sandy areas, a species of scleractinian coral was frequently observed which has not previously been described from the Mediterranean. Its identification is still pending, but it appears that it may belong to the genus *Anomocora*.[42] This coral was found detached on sandy and sandy-muddy bottoms, as well as attached to various hard substrates, either natural or artificial. It was not uncommon to observe small colonies of this species, which in many cases consisted of a large, elongate cup-shaped structure upon which other, smaller elongate cups had developed, possibly by means of budding. Remains of this species served as substrate for a variety of species of tunicates (particularly of the family Didemnidae), bryozoans, and hydrozoans.

Of the bryozoans present in this habitat type, several larger species stand out as being of particular interest, such as *Hornera frondiculata*, *Reteporella* spp., *Adeonella pallaisi* and *Caberea ellissii*.

Although massive sponges are more frequently associated with hard bottoms, they were also common on sandy substrate. In particular, these species included massive sponges belonging to the order Dyctioceratida (Family: Irciniidae), such as those within the genera *Ircinia* and *Sarcotragus*.

Echinoderms were also among the typical inhabitants of sandy-bottom areas. Species observed included Mediterranean feather star (*Antedon mediterranea*), smooth sea star (*Hacelia attenuata*), and Mediterranean red sea star *Echinaster (Echinaster) sepositus*. The most abundant echinoderm was the ophiuroid *Ophiopsila aranea*, which formed colonies of hundreds or thousands of individuals that lifted their arms above the sediment to capture food.

Another echinoderm from this habitat type that deserves mention is a sea star belonging to the genus *Luidia*. The precise species is pending identification, and does not correspond to either of the two species of this genus that are known from the Mediterranean Sea (*L. ciliaris* and *L. sarsi*).

Due to the high abundance of litter, metallic waste, and other objects of human origin on sandy bottoms, artificial hard substrates have been created that permit or augment the presence of certain organisms. These animals include species such as Mediterranean feather star (*Antedon mediterranea*), ascidians belonging to the families Pyuridae and Didemnidae, and fishes such as *S. cabrilla* and *Pagellus erythrinus*.

A species of scleractinian coral was frequently observed which has not previously been described from the Mediterranean. It may belong to the genus Anomocora.

In some areas of the deep bathyal zone, ancient reefs had formed hard substrate. These fossil reefs were found in Jounieh and Tarablus Batroun canyons

Sandy-muddy bottoms

The transition zone between the upper and lower circalittoral was where muddy bottoms typically began to appear mixed with sandy ones, before becoming the dominant habitat type across most of the Lebanese sea bottom.

In this mixed habitat type, bioturbation by small gobies of the genus *Lesueurigobius* was apparent. Two such species were observed to be present: Fries' goby (*L. friesii*) and Lesueur's goby (*L. sueri*). In other regions of the Mediterranean and nearby waters of the Atlantic Ocean, these fishes typically share the holes that they create with crustaceans such as *Goneplax rhomboides*. However, no such observation was made during these surveys.

This transition zone between sandy and muddy bottoms in the lower circalittoral and upper bathyal zones was the preferred area for extensive communities of red sea pens (*Pennatula rubra*). In some cases, these were mixed communities of red and slender sea pens (*Virgularia mirabilis*), although the latter species also formed monospecific facies.

As was the case with sandy bottoms, anthropogenic waste in this habitat type was observed to have altered some areas, both through establishing new biotopes and supporting the presence of species more typically associated with hard bottoms.

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Rocky bottoms

Rocky substrate was found in all of the sampled areas (Map 4). At the continental shelf edge, in the deep circalittoral, rocky formations were observed that delimited the beginning of the drop-off or submarine canyon, as was the case with coralligenous habitat. However, these formations could be found at greater depths, extending into the upper bathyal zone. Many of these formations were found to be covered with sponges such as *Crambe crambe*, *Phorbas fictitius*, and other non-identified demosponges that were white, cream, yellow, orange, or red in colour.

In the deep bathyal zone, rocky formations were scarce, although they were occasionally observed on muddy substrate. In most cases they were found on the steepest walls of the canyons, where the fine sediment could not fully cover them. In these areas, some deep-sea coral species (e.g., *Caryophyllia (Caryophyllia) calveri*) had settled, together with various serpulid polychaetes, numerous scyphozoan polyps of the genus *Nausithoe*, crustaceans (e.g., *Bathynectes maravigna* and *Munidopsis marionis*), and, more rarely, gorgonians (i.e., *Swiftia pallida*) or sponges. In one of the deepest surveyed areas of the Jounieh canyon, even a glass sponge was observed (i.e., *Farrea bowerbanki*).

In some areas of the deep bathyal zone, ancient reefs had formed hard substrate (Map 4). These fossil reefs were found in Jounieh and Tarablus/ Batroun canyons (and possibly in other areas surveyed, such as St. George, where hard substrates documented looked similar to these formations), and provided a substrate that was functionally equivalent to areas of rocky bottom.

The most commonly recorded fish species in rocky areas were swallowtail seaperch (*Anthias anthias*) (Figure 10), parrot seaperch (*Callanthias ruber*), and deepwater cardinalfish (*Epigonus constanciae*). Although their depth ranges were distinct, in some cases these species were found to overlap.

Map 4. Distribution of rocky bottoms and fossil reefs in surveyed areas.

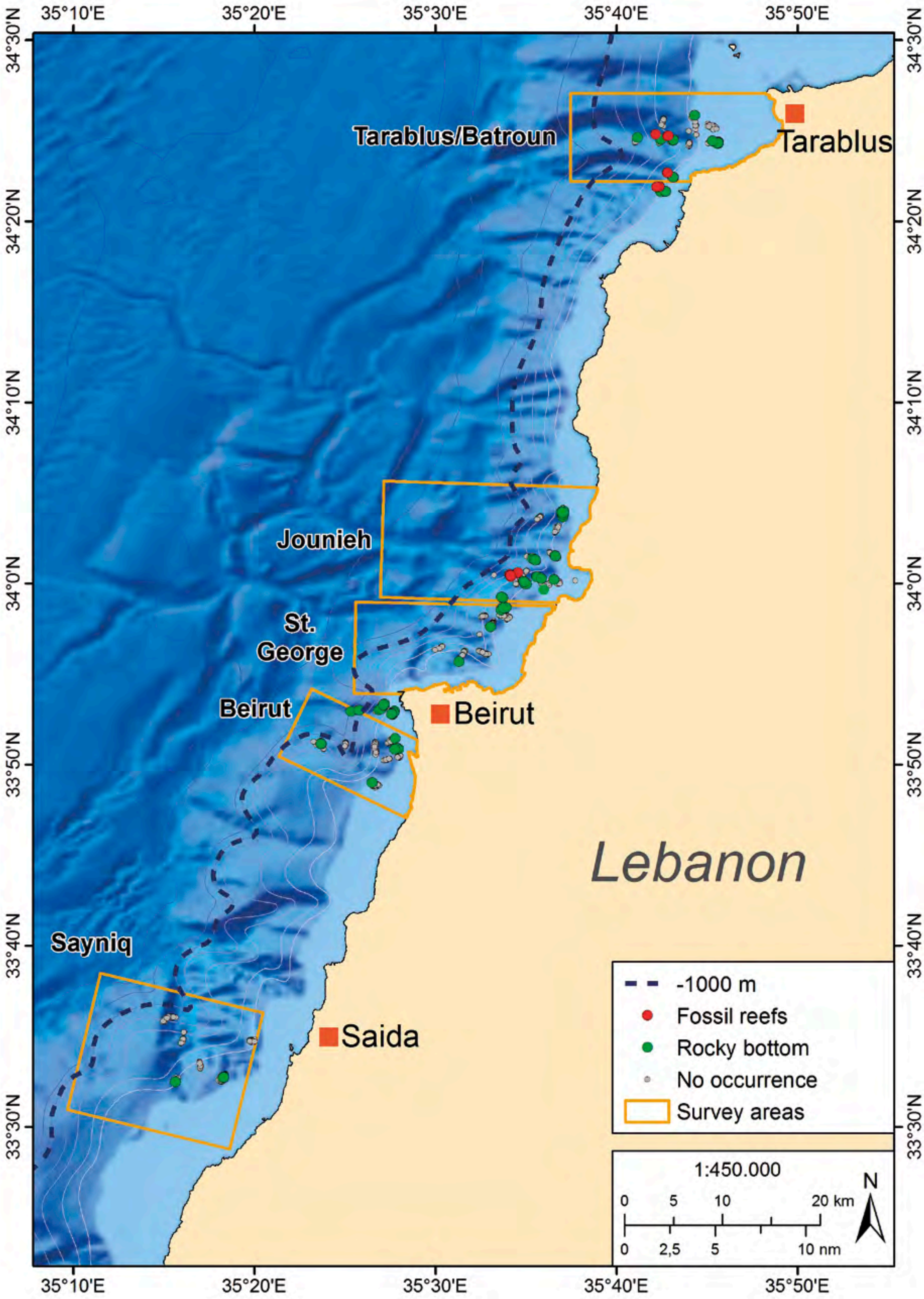


Figure 10. Swallowtail seaperch (*Anthias anthias*) and parrot seaperch (*Callanthias ruber*) over rocky bottom, with the brachiopod *Megerlia truncata* and star coral (*Madracis pharensis*).

Crustaceans, such as pandalid shrimp of the genus *Plesionika* (particularly *P. narval*) were also present in rocky areas in high densities, in some cases mixed with *P. edwardsii*. Less commonly, individuals of small European locust lobster (*Scyllarus arctus*) and golden coral shrimp (*Stenopus spinosus*) were also observed.

Canyon heads

In addition to the canyon heads that begin immediately beyond the coralligenous formations, others dropped off suddenly from areas of soft bottom, such as in the case of the Beirut escarpment. The Beirut slopes were characterised by rocks covered with star coral (*Madracis pharensis*), deep-sea oyster (*Neopycnodonte cochlear*) and/or the brachiopod *Megerlia truncata*, and various sponges that overlaid large areas of rocks.

Among the fishes found in these areas, leopard-spotted goby (*Thorogobius ephippiatus*) were frequently observed, along with some isolated iris wrasse (*Lappanella fasciata*) individuals.

Various echinoderms occurred on both soft and rocky bottoms at the head of the canyons, such as smooth sea star (*Hacelia attenuata*) and long-spine slate pen sea urchin (*Cidaris cidaris*).

Bathyal muds

The bathyal zone was predominantly covered by muds, which gave rise to different facies and communities. These habitats were dominated by echinoderms, large foraminifera, brachiopods, tube worms, tube-dwelling anemones, and some sea pens.

The foraminifera *Pelosina* cf. *arborescens* was distributed throughout a wide bathymetric range and was the most abundant species on these beds. Not surprisingly, large foraminifera were intermixed with the tubes of some sabellid worms, which may have been *Spiochaetopterus* sp.

The brachiopod *Gryphus vitreus* was observed to be distributed both in a dispersed manner, and in small groups, at depths below 450 m.

The ceriantharians, particularly *Cerianthus membranaceus*, were documented throughout the range of depths surveyed. They were found to be abundant on substrates as disparate as coralligenous habitat and bathyal muddy bottoms.

Although sea pens were more abundant in the domain between the circalittoral and bathyal zones, their distributions also extended to greater depths. *Pennatula rubra* continued to be the most abundant of the sea pen species in these areas, while some individuals of tall sea pen (*Funiculina quadrangularis*) were observed starting at depths of 500 m, and remains of dead *F. quadrangularis* were found at approximately 300 m depth.

After the foraminifera, the most dominant organisms on these soft bottoms were echinoderms. For example, the long-spine slate pen sea urchin (*Cidaris cidaris*) was found across a very wide range of depths, from the circalittoral down to the deep bathyal zone. Other sea urchins were also known to occur on bathyal muds, such as irregular sea urchins *Bryssopsis lyrifera*; although it is difficult to observe these animals, given that they live within the sediment, their remains were visible on the substrate. Holothurians were also frequently observed. The two most common species were *Mesothuria intestinalis* and the small elasipodid holothurian *Penilpidia ludwigi*. Densities of the latter species could reach several tens, or even more than one hundred individuals per square metre.

The most abundant fish species associated with this habitat type were shortnose greeneye (*Chlorophthalmus agassizi*), grenadiers (e.g., *Coelorinchus caelorhincus*, *Nezumia* spp., *Hymenocephalus italicus*; Figure 11), blackfin sorcerer (*Nettastoma melanurum*), Mediterranean spiderfish (*Bathypterois dubius*), silver roughy (*Hoplostethus mediterraneus*), and blackbelly rosefish (*Helicolenus dactylopterus*).

Flatfishes were also commonly observed, and included species such as Rüppell's scaldback (*Arnoglossus rueppellii*), megrims (*Lepidorhombus* spp.), spotted flounder (*Citharus linguatula*), and *Symphurus* spp.

Among the crustaceans documented on bathyal muds, shrimp belonging to the genus *Plesionika* were abundant (particularly *P. edwardsii*), as were deep-water rose shrimp (*Parapenaeus longirostris*).

The Beirut slopes were characterised by rocks covered with star coral (Madracis pharensis)

Figure 11. Common Atlantic grenadier (*Nezumia aequalis*) and glasshead grenadier (*Hymenocephalus italicus*) in Jounieh canyon, at 593 m depth.

SPECIES

In total, 619 taxa were identified: 352 to the level of species, 121 to genus, and 146 to order or higher. In the Annex 1 to this report, Table A1 provides a full list of recorded species by survey area, and Figure A1 shows the number of recorded species by broad taxonomic groups.

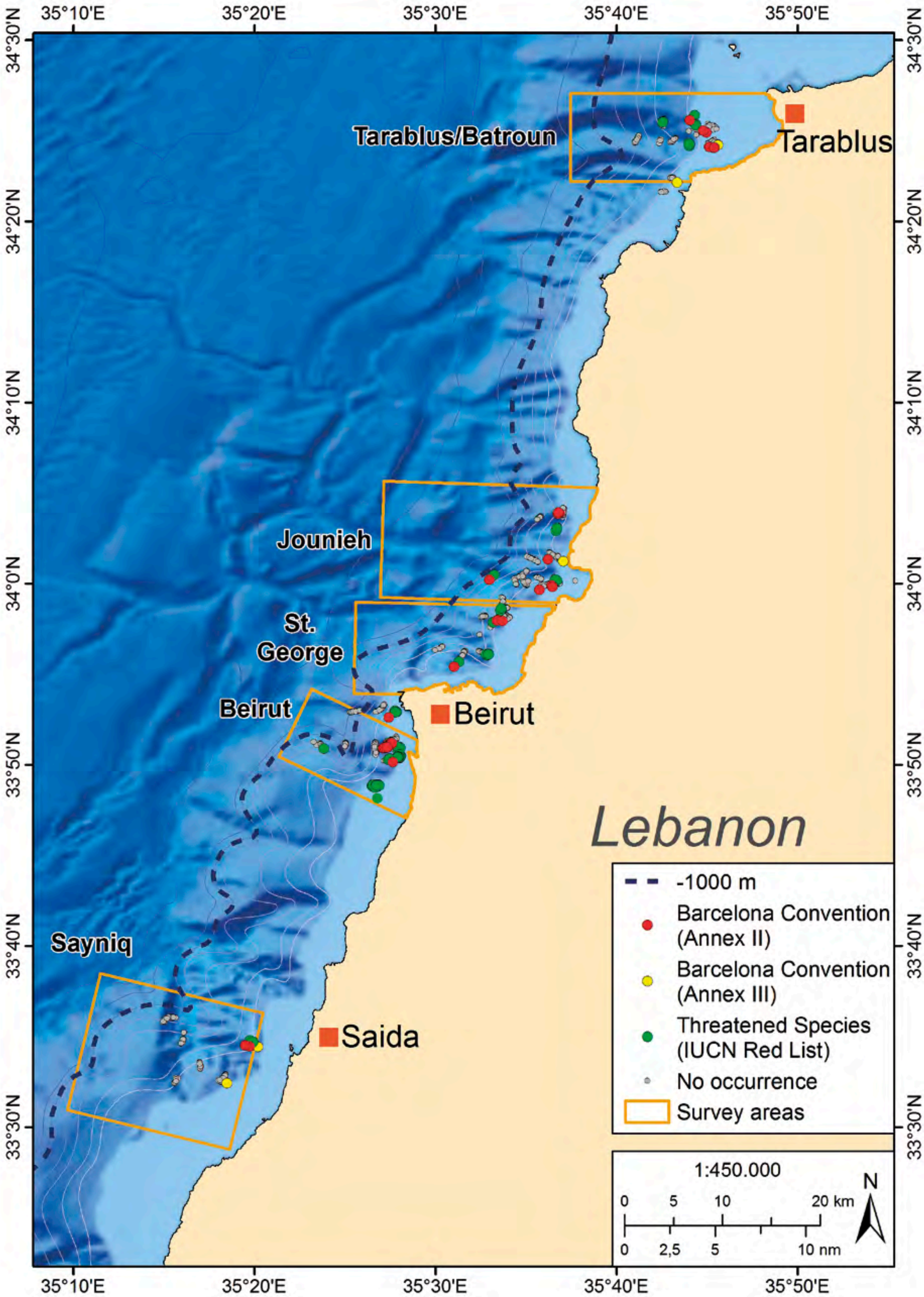
Dozens of species identified during these surveys had never previously been recorded from Lebanon. Key species of interest among these first-ever records include the glass sponge *Farrea bowerbanki*, rabbitfish (*Chimaera monstrosa*), velvet-belly lanternshark (*Etmopterus spinax*), and cnidarians such as the gorgonian *Swiftia pallida*, sea pens (e.g., *Pennatula rubra*, *Virgularia mirabilis*, and *Funiculina quadrangularis*), and species of the subclass Hexacorallia, such as *Sideractis glacialis* and tree coral (*Dendrophyllia ramea*). In addition, three species were discovered that are likely to be new to science: the sponge *Axinella* sp. (Figure 12)[39], the sea star *Luidia* sp., and the stony coral cf. *Anomocora* sp.

Observed species also included those that have been assessed as threatened or at risk of becoming threatened. Seven of the identified species have been listed under Annex II of the SPA/BD Protocol of the Barcelona Convention, while six species are Red Listed by IUCN as threatened (Table A2). These species were distributed throughout the five sampling areas (Map 5). In addition, three recorded species are listed under Annex III of the SPA/BD Protocol,[43] which requires that their exploitation be managed (i.e., *Epinephelus marginatus*, *Scyllarus arctus*, and *Spongia (Spongia) officinalis*) (Table A2). Nineteen of the organisms identified from these surveys are considered exotic; all of them are of Indo-Pacific origin (Table A1). Exotic species were present in all five surveyed areas (Map 6), although, in general, fewer such species were identified during the expedition than expected. One possible explanation relates to the deep-sea range of the surveyed areas, since Lessepsian species tend to be associated with shallow or pelagic waters.[44,45,46,47]

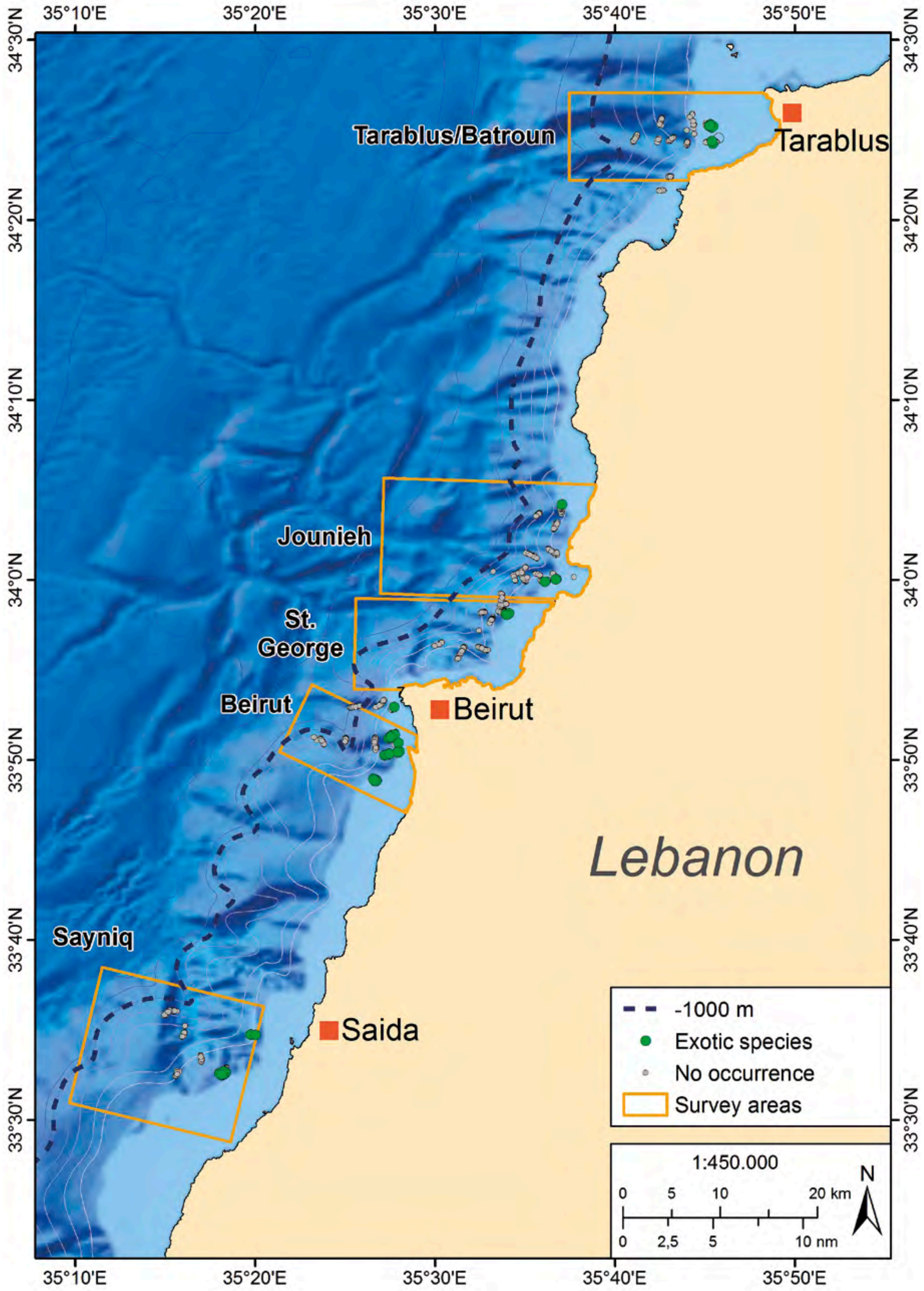
Figure 12. Sponge sample (cf. *Axinella* sp. nov.) collected with the ROV.

Seven of the identified species have been listed under Annex II of the SPA/BD Protocol of the Barcelona Convention.

Map 5. Distribution of identified species that are listed as threatened, either on the IUCN Red List or Annex II of the SPA/BD Protocol of the Barcelona Convention.



Map 6. Exotic species identified in the sampling areas.



Beyond the known exotic species, some of the species identified during this expedition appeared to have more taxonomic affinity to Atlantic species than to other Mediterranean or even Lessepsian species. As has already been proposed for several sponges found in Lebanese waters, some of this fauna could be "remnants of an ancient thermophilous fauna that survived in the easternmost part of the Mediterranean"[48]. This opinion is shared by several Mediterranean marine scientists,[49] some of whom have been involved in this project.

This fact could explain the occurrence of species like smooth sea star (*Hacelia superba*) in deep-sea areas of Lebanon (see section below on *Echinoderms*).

In addition to the benthic species recorded, other species were observed by chance at the water's surface, from the deck of the survey vessel. These included common clubhook squid (*Onychoteuthis banksii*), black wing flyingfish (*Hirundichthys rondeletii*), Atlantic tripletail (*Lobotes surinamensis*), and bottlenose dolphin (*Tursiops truncatus*).

Of all the identified taxa from ROV surveys, fishes and crustaceans were the two broad animal groups with the highest recorded species richness, as well as high abundance. Their numbers were exceeded by relatively few types of animals: colonial species (e.g., the foraminifera *Pelosina* cf. *arborescens*, star coral (*Madracis pharensis*), and the brachiopod *Megerlia truncata*); turf formed by hydrozoans and bryozoans on stones and rubble in the circalittoral zone (or even on sandy bottoms); and polychaetes in the bathyal zone (both sabellids on soft substrates and serpulids on rocky substrates). Among the taxa documented from infaunal samples, molluscs represented the most abundance and diverse group of animals.

Fishes

Fishes were the best represented taxonomic group among the species surveyed with ROV, with 84 identified species, 11 further taxa identified to the level of genus, and various others still pending identification. Nearly all of the recorded fishes belonged to the class Actinopterygii, with the exception of a small number of individuals of chondrichthyans.

Among the noteworthy species from bathyal mud bottoms were different species of grenadiers (e.g., *Coelorinchus caelorhincus*, *Hymenocephalus italicus*, and *Nezumia* spp.), silver roughy (*Hoplostethus mediterraneus*) and shortnose greeneye (*Chlorophthalmus agassizi*). On sedimentary bottoms of the circalittoral zone and the upper bathyal zone, the most abundant fishes were species of serranids (e.g., *Serranus cabrilla*, *S. hepatus*) and gobies (i.e., *Lesueurigobius* spp.). The latter group formed large colonies with numerous burrows excavated in the sediment, leaving the seabed with widespread evidence of bioturbation. On soft bottoms in deep waters, common species included blackfin sorcerer (*Nettastoma melanurum*), Mediterranean spiderfish (*Bathypterois dubius*), blackbelly rosefish (*Helicolenus dactylopterus*; Figure 13), silver roughy (*Hoplostethus mediterraneus*) and various flatfishes (order Pleuronectifores).

Figure 13. Blackbelly rosefish (*Helicolenus dactylopterus*), Beirut, 650 m depth.

Figure 14. Velvet-belly lanternshark (*Etmopterus spinax*) in Beirut canyon, 953 m depth.

Figure 15. Longnosed skate (*Dipturus oxyrinchus*) in St. George canyon, 425 m depth.

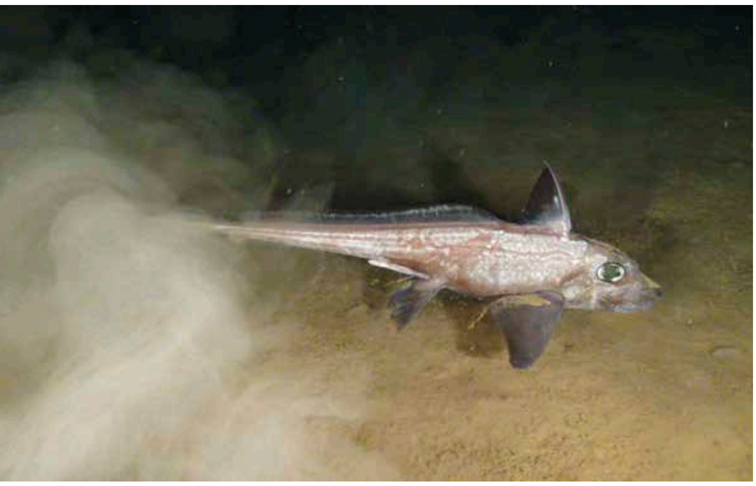


Figure 16. Rabbitfish (*Chimaera monstrosa*) in St. George canyon, 893 m depth.

The most common fishes in rocky areas were gregarious species (e.g., *Anthias anthias*, *Callanthias ruber*) and deepwater cardinalfish (*Epigonus constanciae*), as well as leopard-spotted goby (*Thorogobius ephippiatus*). The latter species was essentially restricted to the rocky bottoms at the edge of the continental shelf and canyon heads, mainly between 100 m and 200 m depth. Other frequently recorded species included large-eyed dentex (*Dentex macrophtalmus*), which demonstrated great mobility between bathyal hard and soft bottoms, as well as gurnards and longspine snipefish (*Macroramphosus scolopax*), which typically occurred on soft bottoms of the upper bathyal zone.

Within the water column, abundant fishes included those belonging to the family Stomiidae, (e.g., *Chauliodus sloani* and *Stomias boa*) and lanternfishes – especially jewel lantern fish (*Lampanyctus crocodilus*). Spine eels (e.g., *Nemichthys scolopaceus*) were also observed.

Many of the exotic fish species observed were found in association with coralligenous habitat, partly reflecting the shallower depth range of this habitat type. Examples include dusky spinefoot (*Siganus luridus*), redcoat (*Sargocentron rubrum*), common lionfish (*Pterois miles*) and bluespotted cornetfish (*Fistularia commersonii*). However, others were also found in sandy-bottom areas, such as broadbanded cardinalfish (*Ostorhinchus fasciatus*), white-spotted pufferfish (*Torquigener flavimaculosus*), Randall's threadfin bream (*Nemipterus randalli*) and *Equulites klunzingeri*.

Other species with more sporadic distributions were *Scorpaena* spp., *Capros aper*, *Serranus scriba*, *Lophius piscatorius*, *Pagellus bogaraveo* and *Electrona rissoi*.

Only three species of chondrichthyans were recorded during surveys: velvet-belly lanternshark (*Etmopterus spinax*), longnosed skate (*Dipturus oxyrinchus*) and rabbitfish (*Chimaera monstrosa*) (Figures 14-16). All of these species were observed in the central zone of Lebanon, in canyons close to Beirut. The closest known records of this species are from Egypt[50] and Israel[51].

The checklist published by Goren and Galil (2015)[51] of deep-sea fish species (i.e., those found deeper than 500 m) includes many of the species found in Lebanese waters during this expedition, except for *Nezumia aequalis*, *Argentina sphyraena*, *Dalophis imberbis*, *Facciolella oxirhyncha*, *Lepidorhonbus boscii* and *L. whiffiagonis*. Some of these fishes were already known in the Levantine seas, but at a shallower depth range, while others constituted new records for Levantine fauna.

Crustaceans

Surveys revealed an abundance of crustaceans, with pandalid shrimp (*Plesionika* spp.) and deep-water rose shrimp (*Parapeaneus longirostris*; Figure 17) being the most abundant species. Striped soldier shrimp (*Plesionika edwardsii*) was by far the crustacean species with the most widespread distribution and the highest abundance. It was documented from approximately 250 m depth, on both rocky and muddy bathyal substrates. Meanwhile, narwal shrimp (*Plesionika narval*) was observed in shallower waters (approximately 100-250 m), in groups of several tens or hundreds of individuals. In some cases, these individuals were mixed with *P. edwardsii*.

Figure 17. Deep-water rose shrimp (*Parapeaneus longirostris*), Jounieh, 440 m depth.

On rocky bottoms, the most common species were the small galatheid crab *Munidopsis* cf. *marionis* and the crab *Bathynectes maravigna*. In contrast, on muddy bottoms, deep-water rose shrimp (*Parapeaneus longirostris*) and shrimp belonging to the genus *Plesionika* were by far the most abundant species. In addition, blue and red shrimp (*Aristeus antennatus*) occurred in areas deeper than 500 m, although they were less abundant than the other shrimp species mentioned above.

Various live individuals of the spider crab *Neomaja goltziana* (or its remains) were found at different depths, especially below 400 m and on sedimentary bottoms. A similar distributional pattern was observed in the case of the ‘orangutan’ crab (*Spinolambrus macrochelos*; Figure 18), although on slightly shallower bottoms.

Figure 18. *Spinolambrus macrochelos*, Jounieh, 441 m depth.

In isolation, species such as golden coral shrimp (*Stenopus spinosus*) and small European locust lobster (*Scyllarus arctus*) were also observed, on bathyal rocks together with dense aggregations of soldier shrimp (*Plesionika narval* and *P. edwardsii*). Additionally, in some areas the mesopelagic shrimp *Eusergestes arcticus* was observed to be abundant within the water column over deep sedimentary bottoms.

Other species that were observed to be locally abundant were hermit crabs, primarily of the genus *Pagurus*. These animals were frequently carrying symbiotic anemones.

No crustaceans were found in the grab samples taken during surveys, with the exception of some individual crabs belonging to the genus *Ebalia*.

Echinoderms

The dominant faunal species on bathyal muddy bottoms were echinoderms, particularly holothurians such as *Mesothuria intestinalis* and *Penilpidia ludwigi*, which were both abundant in that habitat type. Neither of these two species had previously been recorded from Lebanon. Another echinoderm, the long-spine slate pen sea urchin (*Cidaris cidaris*), was also widely distributed.

The small elasipodid *Penilpidia ludwigi* was previously known from the Aegean Sea and the Western Mediterranean[52], and here was observed forming aggregations with densities of tens to hundreds of individuals per square metre on the sea bottom in deep bathyal waters. These high concentrations of individuals were typically found at depths greater than 800 m.

Other significant aggregations of echinoderms occurred in the circalittoral zone. The main such aggregations were formed by: the brittle star *Ophiopsila aranea* on detritic bottoms; hatpin urchin (*Centrostephanus longispinus*) on coralligenous formations; and Mediterranean feather star (*Antedon mediterranea*; Figure 19) in elevated locations – such as on top of rocks or marine litter found on sandy bottoms of the circalittoral zone.

Figure 19. Mediterranean feather star (*Antedon mediterranea*) on a coralligenous concretion, Beirut, 64 m depth.

Sea stars did not usually form large aggregations, but they were nevertheless frequently observed on certain substrates, especially in the circalittoral and upper bathyal zones. Smooth sea star (*Hacelia attenuata*) and Mediterranean red sea star (*Echinaster (Echinaster) sepositus*) were found on both soft and hard bottoms, particularly at the edge of the continental shelf. Of these two species, the former was more commonly observed. Some individuals of *Ceramaster granularis* and *Peltaster placenta* were also found in these areas, although in smaller numbers.

Of particular interest were the occurrences of three species of sea stars that have not previously been recorded from the Mediterranean Sea. Surveys revealed *Hacelia superba* on bathyal rocky bottoms, *Leptasterias* sp. on ancient fossil reefs, also in the bathyal, and a species of the genus *Luidia* (Figure 20), which was abundant on sandy bottoms in the circalittoral zone. The latter species was distinct from the two other species of the genus that are known to occur in the Mediterranean (*L. ciliaris* and *L. sarsi*).

Figure 20. *Luidia* sp., St. George, 71 m depth.

Other species of echinoderms were observed sporadically. For example, the sea star *Hymenodiscus coronata* and white sea urchin (*Gracilechinus acutus*) occurred on bathyal muds, while blue spiny starfish (*Coscinasterias tenuispina*) and common brittlestar (*Ophiothrix fragilis*) were documented from circalittoral detritic bottoms with rubble. This expedition marked the first time that *H. coronata* was recorded from Lebanese waters.

Grab samples also contained various individuals of the small green urchin (*Echinocyamus pusillus*), which were collected from sedimentary bottoms, and the irregular sea urchin *Bryssopsis lyrifera*.

Cnidarians

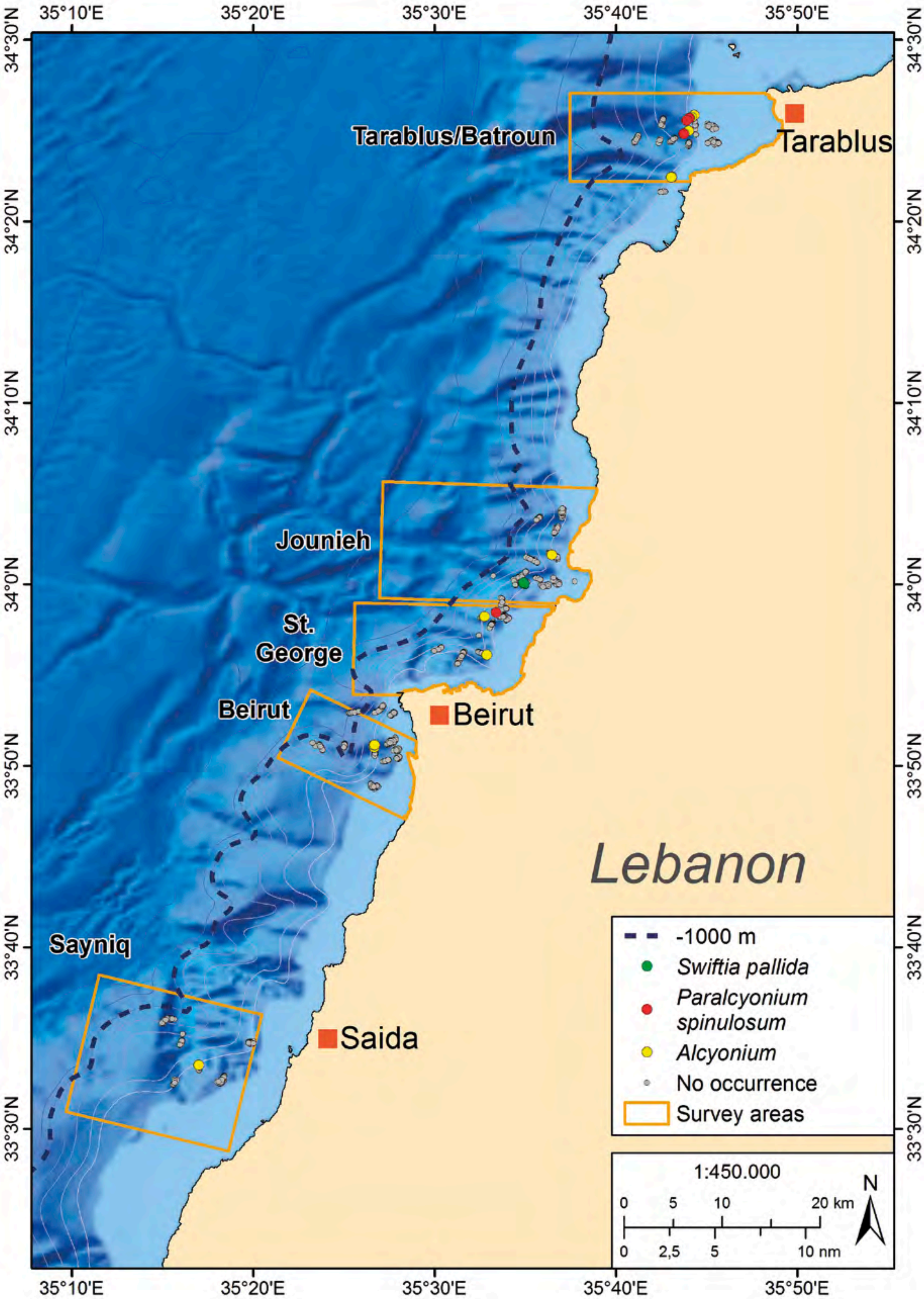
Lebanese waters do not host a great diversity or abundance of cnidarians, with the exception of hydrozoans, which were occasionally abundant. These included some species of the genera *Aglaophenia*, *Sertularella* and *Eudendrium* (on hard substrates), as well as species such as *Nemertesia antennina* and *Lytocarpia myriophillum* on soft bottoms or rubble. As for other cnidarians, some exceptional cases are outlined below, such as certain scleractinians on the continental shelf or canyon heads, some sea pens on sedimentary bottoms, and some scyphozoans on bathyal rocky bottoms.

Various octocorals were documented in Lebanese waters, with several genera present in all of the sampled areas (Map 7). With respect to anthozoans, prior to these surveys, gorgonians had not been recorded from Lebanese waters. The gorgonian species *Swiftia pallida* was observed in small groups of individuals, on bathyal rocks within Jounieh canyon (Figure 21). With respect to soft octocorals, individuals were recorded that belonged to two species of dead man's fingers: *Alcyonium palmatum* and *Paralcyonium spinulosum*. Both species were observed to occur in the circalittoral zone.

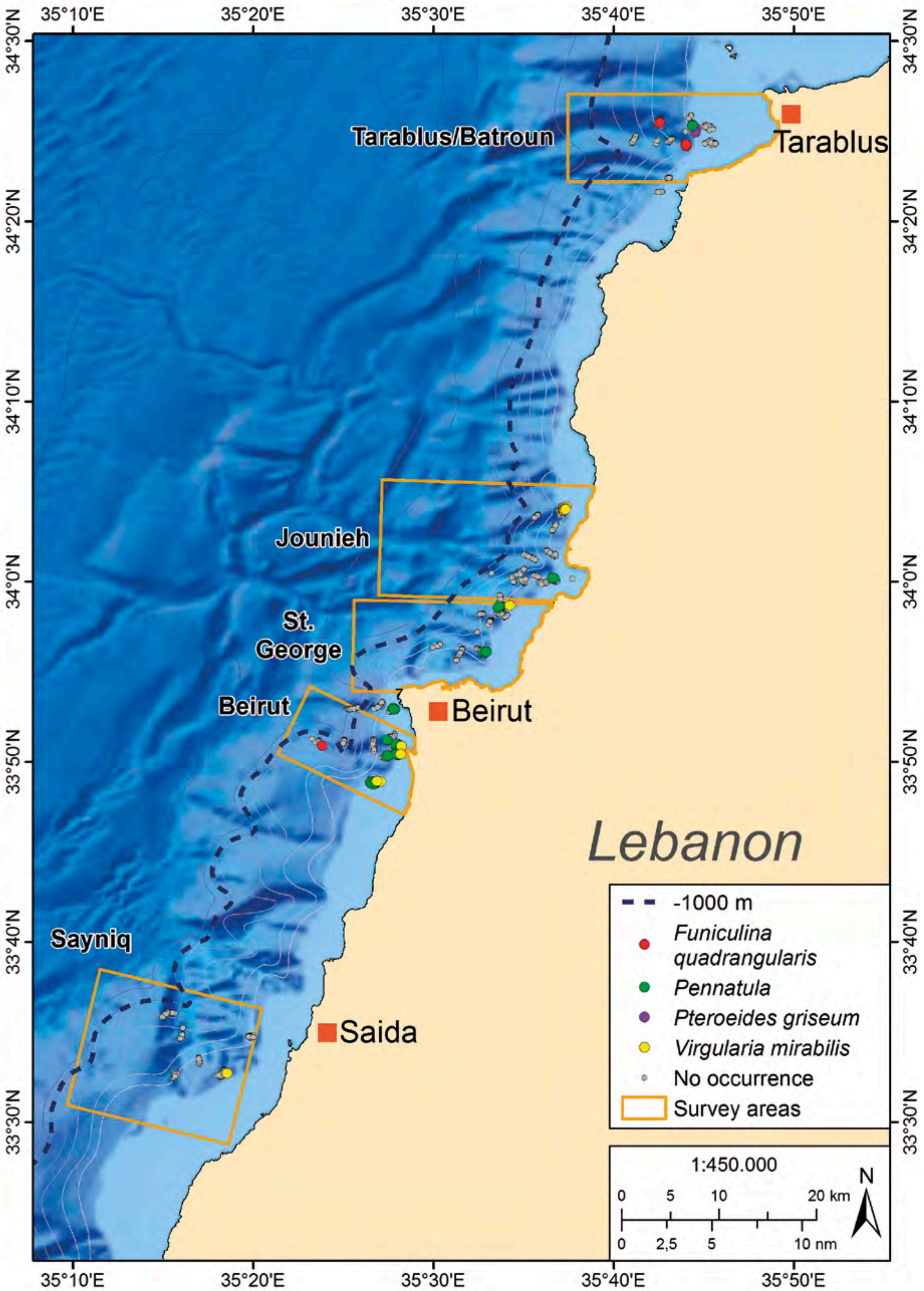
Another species of octocoral that was abundant is the red sea pen (*Pennatula rubra*), with large facies on sedimentary bottoms of the lower circalittoral and upper bathyal zones. Although it usually occurred as a single species, it was sometimes seen alongside slender sea pen (*Virgularia mirabilis*), which was generally less abundant than *P. rubra*, but was locally abundant in some places. Also recorded in these waters was tall sea pen (*Funiculina quadrangularis*), which was more sparsely distributed and at greater depths, and grey sea pen (*Pteroeides griseum*), which occurred on detritic bottoms together with *P. rubra*. Their distributions are presented in Map 8. These four species are considered as Vulnerable in the Mediterranean by IUCN, with populations of *F. quadrangularis* and *P. rubra* estimated to have decreased by approximately 40% during the last two decades.[53]

Figure 21. *Swiftia pallida*, Jounieh, 607 m depth.

Map 7. Distribution of octocorals across the sampled areas.



Map 8. Distribution of sea pens across surveyed areas, by species.



Surveys also revealed at least six different species of scleractinian corals: star coral (*Madracis pharensis*), *Caryophyllia (Caryophyllia) calveri*, Devonshire cup coral (*C. smithii*), tree coral (*Dendrophyllia ramea*), cockscomb cup coral (*Desmophyllum dianthus*), and a fifth species that may belong to the genus *Anomocora*. This species had not yet been described from the Mediterranean, and may potentially be a new species. All occurrences of scleractinians are represented in Map 9.

Star coral (*Madracis pharensis*) was the most abundant hard coral species. It formed dense aggregations on rocky bottoms of the deep circalittoral and upper bathyal zones, frequently at the edges of the continental shelf and canyon heads. In addition, it was found in small colonies, on scattered rocks on the continental shelf, and on anthropogenic waste.

The next most common hard coral species is still pending identification. Some individuals were found detached, on sandy bottoms, as well as attached to small rocks, and objects of artificial origin, such as litter, oil drums, tyres, cans, and metallic objects. It did not form large colonies and in many cases appeared as solitary corals scattered on the seabed. This species was only observed to occur on the deep continental shelf, typically below 40-50 m depth.

Corals belonging to the genus *Caryophyllia* were always found on hard substrates. Devonshire cup coral (*C. smithii*) was seen in shallower zones, and even in deep circalittoral waters, while *C. calveri* could be abundant on bathyal rocky bottoms at different depths. It is also possible that other species of this genus may be present in Lebanese waters, such as *C. inornata* and other deep-sea species. However, sampling would be necessary in order to verify their identification.

In the case of *Dendrophyllia ramea*, it was only observed in one location in the Tarablus/Batroun area, at 172.4 m (Figure 22), a record depth for this species. Small colonies were found on sedimentary substrate, similar to those which were recently discovered in the waters of Cyprus.[54]

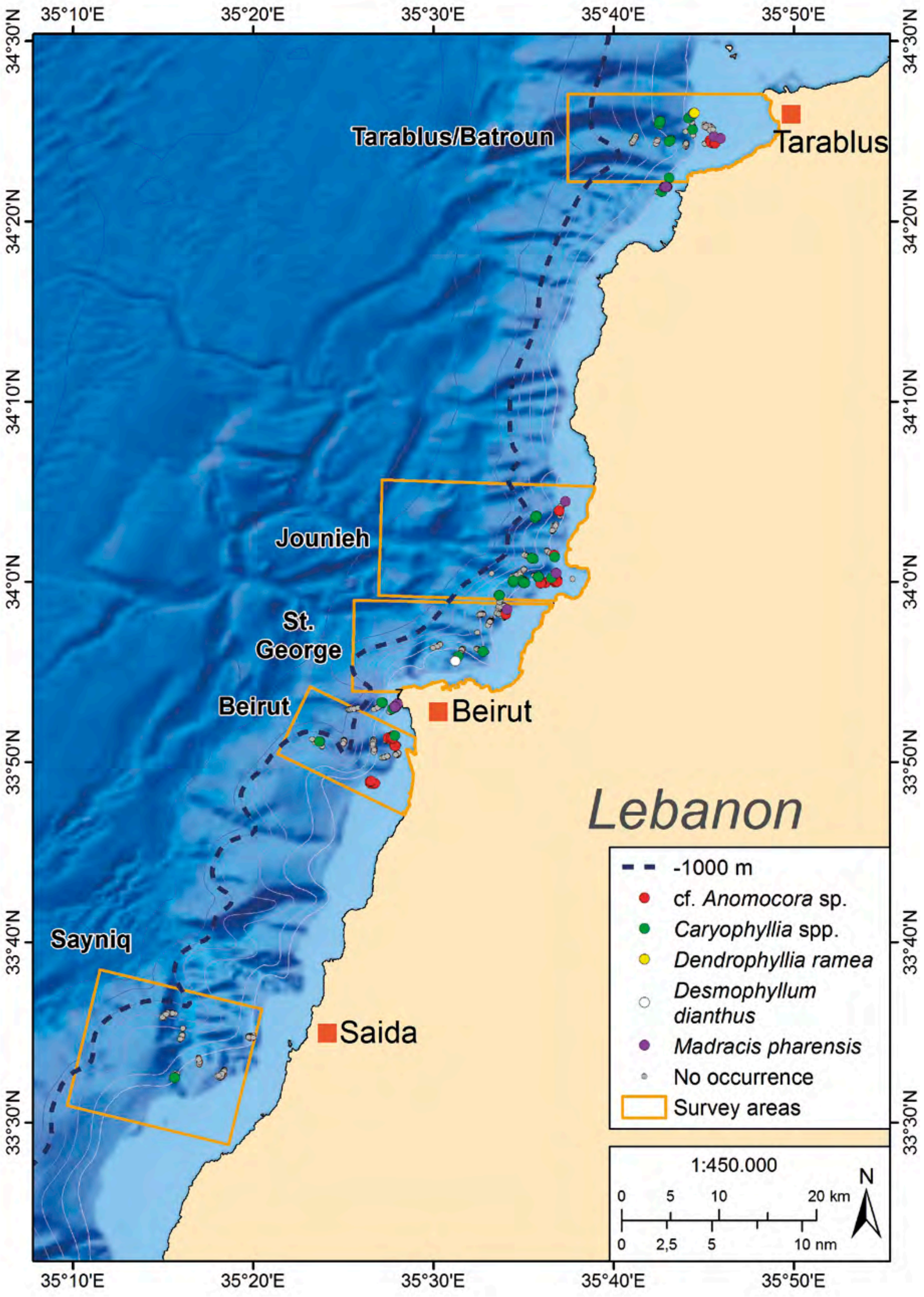
Figure 22. *Dendrophyllia ramea* on soft sediments in Tarablus/Batroun, 172.4 m depth.

Other hexacorals present in the areas surveyed included anemones, such as cloak anemone (*Adamsia palliata*), although they were not abundant. *Hormathia alba* was also recorded and was always associated with the shells that were carried by hermit crabs of the genus *Pagurus*. It is also worth highlighting the occurrence of some individuals of the corallimorpharian *Sideractis glacialis*.

Ceriantharians were distributed across a wide range of depths and habitat types, with some areas of high abundance. Most of these animals were found on bathyal muddy bottoms, but they were also common in coralligenous beds of the continental shelf edge. The most common species was the cylinder anemone (*Cerianthus membranaceus*; Figure 23); some lesser cylinder anemone (*C. lloydii*) was also found, as well as a few *Arachnanthus* sp. and *Pachycerianthus* sp.

Figure 23. Cylinder anemone (*Cerianthus membranaceus*), Beirut, 648 m depth.

Map 9. Distribution of scleractinian corals in the sampling areas.



Finally, jellyfishes were not observed to be abundant, except in the case of small scyphozoans in the polyp phase, on vertical walls of the bathyal zone (Figure 24). These animals belonged to the genus *Nausithoe*, and colonised the small overhangs and protrusions of deep-sea rocks and ancient fossil reefs.

Figure 24. Scyphozoans, vermetids and corals on deep-sea rocks, St. George canyon, 683 m depth.

Sponges

Large sponges were common on the continental shelf and, in particular, on the rocks and coralligenous formations at the shelf edge; in the latter areas, *Agelas oroides* was the dominant species (Figure 25). It was generally found together with other characteristic species, such as various sponges belonging to the family Ircinidae. In particular, these species included *Sarcotragus spinosulus* and *Ircinia variabilis*, as well as *Fasciospongia cavernosa* and *Chlathrina clathrus*. These sponges were the largest and most representative habitat-forming species and were present in all the sampling areas (Map 10).

At one location in the Sayniq canyon, *Calyx nicaeensis* was also present. This cup-shaped demosponge has a fragmented distribution across the Mediterranean Sea, and concerns have been raised about the need for urgent conservation measures to protect it.[55,56,57]

Figure 25. *Agelas oroides*, *Clathrina clathrus*, *Dysidea fragilis* and other sponges on rocky bottom, Jounieh, 77 m depth.

In some cases, other species were locally abundant, such as *Aaptos aaptos*, massive beige horny sponge (*Biemna variantia*), *Crambe crambe*, and various *Axinella* spp. One such *Axinella* species, found and collected in the Sayniq area at 525 m depth, was of particular interest as it appears to be a newly discovered species. Its morphology is similar in some aspects to the genus *Axinella*, but differs in other specific characteristics.[39]

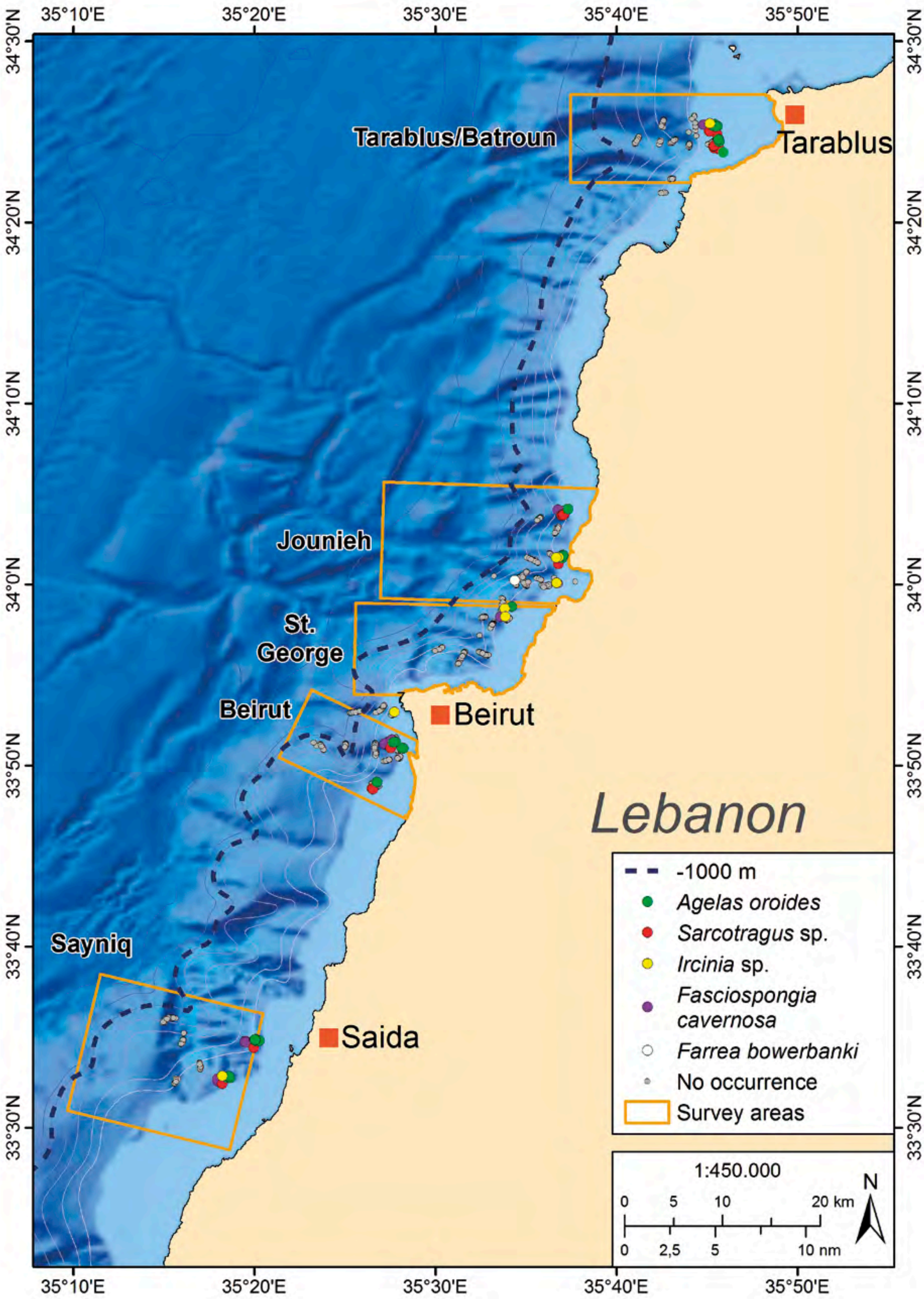
A variety of other sponges occurred on smaller rocks, rubble, and sandy bottoms. These species included *Chodrosia reniformis*, *Corticium candelabrum*, *Dysidea fragilis*, *Haliclona* spp., *Oscarella lobularis*, *Petrosia (Petrosia) ficiformis*, and *Ulosa stuposa.* Meanwhile, a diversity of other sponges covered deep rocky surfaces. Among these species were *Hexadella dedritifera*, *Phorbas fictitius*, simple-rayed membrane sponge (*Plakina monolopha*), *Pleraplysilla spinifera*, and many other unidentified species.

Another species of interest, the glass sponge *Farrea bowerbanki* (Figure 26), was observed on vertical walls formed by fossil reefs in deep waters of the Jounieh canyon.[39]

Figure 26. Hexactinellid sponge (*Farrea bowerbanki*) on fossil reef in Jounieh. canyon, 857 m depth.

It was possible to confirm the presence of additional sponges in surveyed areas, via samples that were collected from sediment grabs or with the hydraulic arm of the ROV. Species that were sampled in this way included *Hymedesmia* sp., *Plakortis simplex*, *Prosuberites longispinus*, *Timea geministellata*, *T. stellata*, and *Topsentia calabrisellae.*[57]

Map 10. Distribution of selected sponge species in the sampling areas.



Molluscs

There is still a lack of detailed knowledge regarding molluscs in the Eastern Mediterranean. Some groups are well represented, such as the cephalopod fauna, which comprises 81% of the known cephalopod species recorded for the entire Mediterranean.[58] However, there are no comprehensive lists for other mollusc groups in the Eastern Mediterranean or, specifically, in the Levantine Sea. Some previous studies carried out in Lebanon[11,59,60] have provided valuable information about molluscs, but the results from this expedition underscore the knowledge gap that still exists regarding in this regard, both in shallow and deep waters.

Via the ROV videos recorded during the expedition, it was possible to document the occurrence of a diversity of cephalopods, bivalves, gastropods, and scaphopods. Grab samples also provided additional data on bivalves, gastropods, and scaphopods which, due to their size or behaviour (e.g., living within the sediment) would have been impossible to identify via direct visual methods.

Among the cephalopods observed, it is worth highlighting the occurrence of species such as stout bobtail squid (*Rossia macrosoma*), fourhorn octopus (*Pteroctopus tetracirrhus*), common octopus (*Octopus vulgaris*), cuttlefish (*Sepia officinalis*), pink cuttlefish (*S. orbignyana*), neon flying squid (*Ommastrephes bartramii*) and greater argonaut (*Argonauta argo*). In the case of the latter species, only remains were observed on the seabed.

Octopus vulgaris and *Sepia officinalis* were found in sedimentary areas of the continental shelf, using anthropogenic waste (such as old tyres and plastic) to hide themselves. The other documented cephalopod species were observed on bathyal muddy bottoms, although some of the most abundant squid that could not be identified were found in the water column.

In some of the deepest areas surveyed, clusters of cuttlefish eggs were seen on both rocky bottoms and on pieces of marine litter (Figures 27, 28).

Figures 27 and 28. Up: Cuttlefish effs in Jounieh canyon, 522 m depth. Below: Sepiidae eggs in a tube, Beirut, 818 m depth.

Other cephalopods which occurred on bathyal muddy bottoms were gastropods such as *Galeodea* sp., *Naticarius stercusmuscarum*, *Semicassus granulata*, and an unidentified species belonging to the family Trochidae. A large giant tun individual (*Tonna galea*; Figure 29) was also observed in the Jounieh area. This species is listed as threatened, on Annex II of the SPA/BD Protocol of the Barcelona Convention.[41]

Figure 29. *Tonna galea*, Jounieh, 239 m depth.

One noteworthy finding was the presence of large quantities of deep-sea oysters (*Neopycnodonte cochlear*) at the continental shelf edge, in the canyon heads of Jounieh, St. George, Beirut and Sayniq (Map 11), and on the continental shelf (Figure 30). In some cases, they were found to be covering marine litter, such as tyres.

Map 11. Oyster aggregations (*Neopycnodonte cochlear*) in surveyed areas.

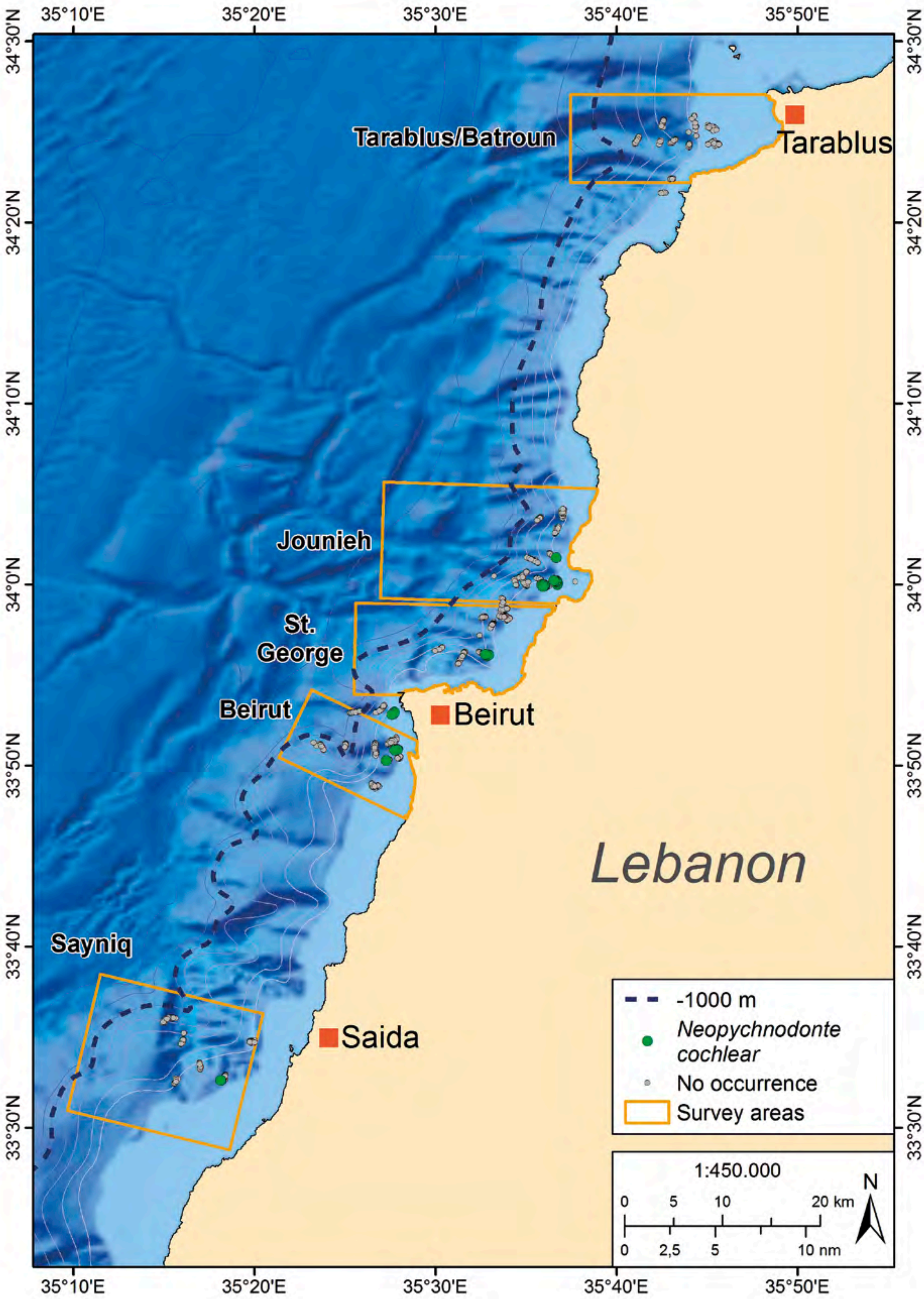


Figure 30. Deep-sea oyster (*Neopycnodonte cochlear*) in Jounieh, 70 m depth

In some areas of the continental shelf, individuals of rough penshell (*Pinna rudis*), a species included within Annex II of the SPA/BD Protocol of the Barcelona Convention, and muricids (e.g., *Murex forskoehlii* and *Bolinus brandaris*) were observed. At approximately 60 m depth, in continental shelf areas, some vermetid aggregations or reefs were found which were covered by sponges, polychaetes, and hydrozoans (Figure 31). These communities were on sedimentary bottoms where some scleractinian corals were also common.

Figure 31. Vermetid reef in Jounieh, 60 m depth.

Additional data about molluscan fauna were obtained via grab samples, which revealed considerable species richness within the seabed of the continental shelf. Dozens of mollusc species were identified from these areas, as well as from bathyal muds. Among these species were bivalves such as *Anadara* sp., European clam (*Corbula gibba*), *Nucula* spp., *Parvicardium* sp., *Similipecten similis*, and oval venus (*Timoclea ovata*), and gastropods such as *Antalis inaequicostata*, *Bittium* spp., *Clio pyramidata*, necklace shell (*Euspira catena*), *Taranis moerchii*, and *Turritella turboma.* Many of the molluscan species identified from the grab sampling had not previously been recorded in Lebanese waters, even from the coastal shelf.

Bryozoans

Through the ROV videos and grab samples, it was possible to detect the presence of some large bryozoan species, such as *Adeonella pallasii*, *Caberea ellisii*, *Hornera frondiculata*, and *Reteporella* sp. Other identified species were *Dentiporella sardonica*, *Exidmonea atlantica*, *Frondipora verrucosa*, *Margaretta cereoides*, *Rhynchozoon neapolitanum*, and *Scrupocellaria* cf. *scrupea*. All of these species were found on the continental shelf, both in coralligenous habitat and sedimentary bottoms.

Harmelin *et al.*[61] described 93 species of bryozoans in Lebanese waters, including some exotic ones; all of those species were collected at depths shallower than 42 m. Because this expedition focused on sampling in waters below that depth, new records were expected to be found. Only 13 species of the bryozoans found have been identified to the species level so far, and seven of these constitute new records. The species *Hornera frondiculata* was of particular interest since, despite its abundance, it had not previously been mentioned from either Lebanon or in a recent Israeli compilation.[62] Further samples are still pending analysis and revision and may add to the number of known Lebanese bryozoan taxa.

Brachiopods

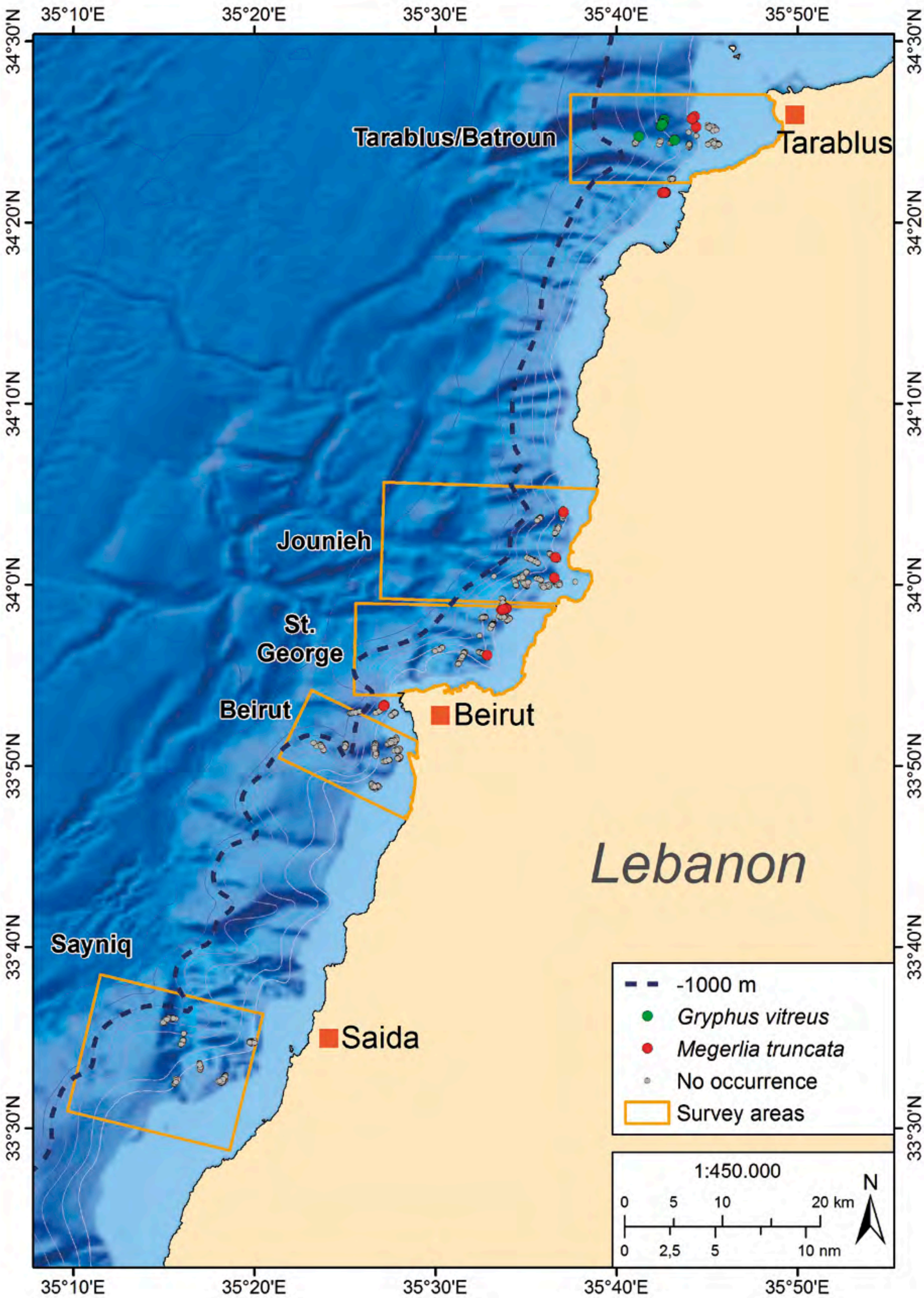
The most common brachiopod species on hard bottoms was *Megerlia truncata* (Figure 32). It could reach high densities on the edges of the continental shelf and in canyon heads, in some cases forming colonies together with various polychaetes or corals (e.g., *Madracis pharensis*). Specimens obtained from grab samples also revealed the presence of brachiopods, such as *Argyrotheca cuneata* and *Megathiris detruncata*.

Figure 32. *Megerlia truncata* on the border of St. George canyon, 173 m depth.

On bathyal bottoms, below 450 m depth, *Gryphus vitreus* was also documented. Although densities were not observed that were comparable to those discovered in other parts of the Mediterranean,[63,64,65,66] they were nevertheless locally important in some areas.

Both *M. truncata* and *G. vitreus* were distributed in all sampled areas (Map 12).

Map 12. Distribution of brachiopod species (*Megerlia truncata* and *Gryphus vitreus*) in sampled areas.



Tunicates

All of the observed tunicates were found on the continental shelf or in canyon heads, on hard substrates. In some cases, they were observed on dead corals or bryozoans or on anthropogenic waste. This was the case of those belonging to the families Didemnidae (Figure 33) or Pyuridae, while *Halocynthia papillosa* had a wider range of distribution and preferred natural substrates.

Figure 33. Didemnidae growing on dead *Sarcotragus spinosulus*, Tarablus/Batroun, 102 m depth.

Annelids

In some places, large concentrations of sabellid or serpulid annelids were found. In the case of sabellids, these aggregations occurred on sedimentary bottoms and were often mixed with large foraminifera. Meanwhile, serpulids were common on both hard bottoms of the continental shelf and upper circalittoral, and in escarpments, overhangs, and rocks in canyon heads and in the bathyal zone.

The majority of annelids observed could not be identified, with the exception of a small number of species, such as lacy tubeworm (*Filograna implexa*), bearded fireworm (*Hermodice carunculata*), sand mason worm (*Lanice conchilega*), red-spotted horseshoe (*Protula tubularia*), Mediterranean fanworm (*Sabella spallanzanii*), peacock worm (*Sabella pavonina*), and red tube worm (*Serpula vermicularis*).

Although it was not possible to take samples of some of the deep-sea polychaetes to verify their taxonomy, one of the most common polychaetes observed to have settled on deep-sea rocks and fossil reefs appeared to be the serpulid *Vermiliopsis monodiscus*. This tentative identification seems probable, given that this species has previously been described as inhabiting fossil corals in the Eastern Mediterranean.[67]

Also of interest was the wide distribution of the echiuroid *Bonnelia viridis*, in terms of both its geographic and bathymetric ranges. It was found to be abundant in the lower circalittoral and upper bathyal zones, but also was observed in high densities in some bathyal areas. It even occurred at depths of nearly 1000 m.

Foraminifera

Particular mention should be made of the foraminifera, as it is an important taxonomic group in Lebanese waters, due to its high abundance. Large astrorhizid foraminifera, such as *Pelosina* cf. *arborescens* (Figure 34), occupied extensive areas of all bathyal muddy bottoms surveyed (Map 13).

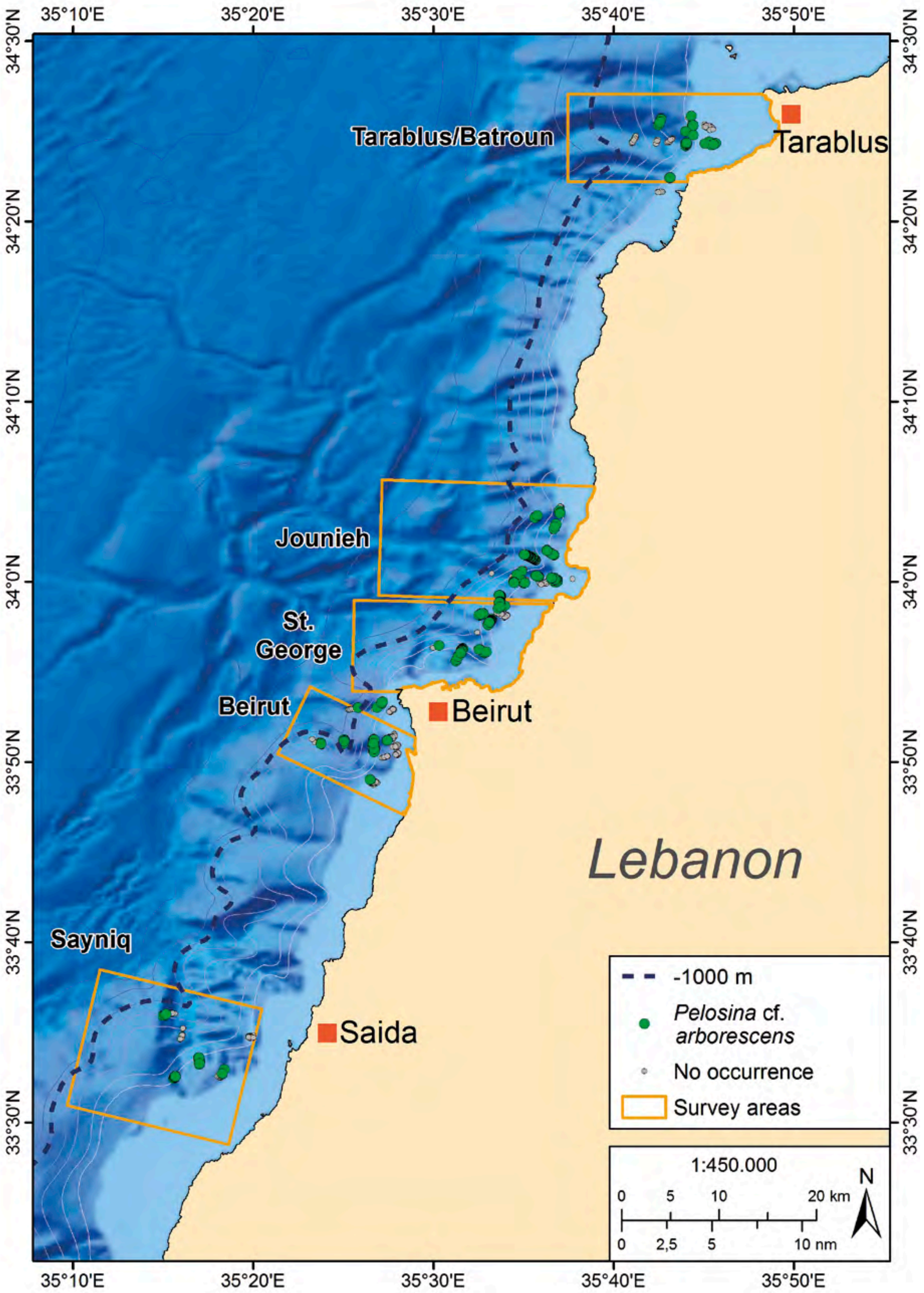
In areas of the continental shelf, *Miniacina miniacea* was also documented, while other species (e.g., *Ammodiscus cretacicus*, *Quinqueloculina* sp., and *Pyrgo inornata*) were recorded from grab samples.

Algae

Various species of algae were found in all of the surveyed areas. Due to the fact that most of the areas surveyed were below 50 m depth, most of these algae are sciaphilic, such as calcareous red algae. However, some green algal species, like *Valonia* sp. and *Caulerpa scalpelliformis* were also documented.

Figure 34. Giant foraminifera (*Pelosina* cf. *arborescens*) with slender rockfish (*Scorpaena elongata*).

Map 13. Observed distribution of the foraminifera *Pelosina* cf. *arborescens*.



TARABLUS/BATROUN

The area between Tarablus and Batroun was characterised by many different types of substrates, including rhodolith/maërl beds, coralligenous concretions (living and dead), hard rocky bottoms including fossil reefs, detritic sand, and mud beds.

This survey area was the only place where the scleractinian coral *Dendrophyllia ramea* was observed, on muddy bottoms at 172.4 m depth, the deepest location known for the species. Deep-sea populations of *D. ramea* such as these have only been discovered very recently in the Mediterranean; they have been documented from another Levantine area, on muddy bottoms in Cyprus.[54] From a conservation perspective, the presence of *D. ramea* in Lebanese waters is of particular interest. It is considered Vulnerable on the IUCN Red List of Mediterranean Anthozoans, on the basis of population declines in the Mediterranean,[53] and was recently granted strict protection under Annex II of the SPA/BD Protocol of the Barcelona Convention. Lebanon, like other signatory countries, is therefore required to take measures to safeguard this species in its waters.

Tarablus/Batroun was also the area with the highest abundance of typical Mediterranean habitat-forming species that are considered vulnerable or sensitive. For example, tall sea pen (*Funiculina quadrangularis*) and the brachiopod *Gryphus vitreus* were present in higher numbers in that area than in the other four. Other sea pens (i.e., *Pennatula rubra* and *Pteroeides griseum*) were also found there, in association with sandy bottoms.

Other species of special interest were recorded from the Tarablus/Batroun area. Small European locust lobster (*Scyllarus arctus*), which is listed in Annex III of the SPA/BD Protocol of the Barcelona Convention, was found on rocky bottoms at 287 m depth, together with other crustaceans (e.g., *Stenopus spinosus*, *Plesionika edwardsii* and *P. narval*). Large bryozoans (e.g., *Hornera frondiculata* or *Caberea* spp.) were commonly found in rhodolith/maërl beds, detritic sand and coralligenous beds, while a population of the Annex II-listed large mollusc rough pen shell (*Pinna rudis*) was found in detritic sediments.

JOUNIEH

The Jounieh area supported coralligenous habitat, rhodolith/maërl beds and sandy bottom with high biodiversity. Jounieh also hosted other interesting deep-sea substrata, such as rocks, fossil reefs and muddy bottoms.

Overall, Jounieh comprised the highest number of total species identified during the expedition. This canyon was found to host some interesting and rare species, like the Atlantic starfishes *Hacelia superba* and *Leptasterias* sp., the protected mollusc species *Tonna galea*, the recently discovered glass sponge *Farrea bowerbanki* and the octocoral *Swiftia pallida*. In the case of the latter species, its discovery marked the first time that a gorgonian had been found in Lebanese waters. Both the glass sponges and the gorgonians were found living on deep-sea rocks or fossil reefs.

ST. GEORGE

In shallow waters, St. George canyon hosted both coralligenous and rhodolith/maërl beds. Detritic bottom extended to the head of the canyon, where some rocks appeared that were covered by brachiopods and sponges. In deep waters, most of the canyon was covered by muds. However, in some steep zones, emergent rocks were visible, from which scyphozoans, serpulids, and solitary stone corals were hanging. On some parts of these rocks, structures like fossil reefs were documented.

Marine litter was abundant both on the shelf and inside the canyons. Many of the anthropogenic objects were colonised by fauna, especially deep-sea oysters (*Neopycnodonte cochlear*) on tyres.

Shrimp were among the common species in the St. George area, such as deep-water rose shrimp (*Parapeneus longirostris*) and striped soldier shrimp (*Plesionika edwardsii*). Exotic fish species, such as redcoat (*Sargocentron rubrum*) and dusky spinefoot (*Siganus luridus*) were also common in the area, especially among coralligenous beds.

Surveys in the area also revealed specific fauna of interest. For example, during one of the ROV dives in the St. George canyon, a large number of unidentified top shells (Trochidae) were filmed in areas close to 700 m depth, an exceptional aggregation only found in this location. Two of the three chondricthyans found during the research expedition (*Chimaera monstrosa* and *Dipturus oxyrinchus*), were recorded from the St. George canyon. Both of these species are considered to be Near Threatened by IUCN.[68]

Areas of muddy bottom were heavily covered by giant foraminifera (*Pelosina* cf. *arborescens*), which in some cases were mixed with unidentified sabellid worms and large bioturbations.

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BEIRUT

The head of the Beirut canyon had a steep gradient and rocky bottom with many corals, brachiopods, oysters and sponges covering the hard bed. Surveys of the area were complicated by both the rocky bottom and the fact that the walls of the canyon head were densely covered by fishing lines and nets and other garbage.

The most common fishes in this canyon were swallowtail seaperch (*Anthias anthias*), parrot seaperch (*Callanthias callanthias*), iris wrasse (*Lappanella fasciata*) and leopard-spotted goby (*Thorogobbius ephippiatus*).

Coralligenous habitat in the Beirut area was occupied by many large sponges and was the site of the largest concentration of hatpin sea urchin (*Centrostephanus longispinus*) recorded in Lebanon. This species is protected in the Mediterranean, as it is listed in Annex II of the SPA/BD Protocol of the Barcelona Convention.

The only shark recorded during the research cruise, the velvet-belly lanternshark (*Etmopterus spinax*), was found at nearly 1000 m depth. This small species of lantern shark has not been previously recorded from Lebanese waters.

The largest sea pen fields documented during this survey were also recorded in the head of the Beirut canyon. The threatened red sea pen (*Pennatula rubra*) was the most abundant species, although slender sea pen (*Virgularia mirabilis*) was also present. The latter species was abundant in specific sites, and also in mixed aggregations with *P. rubra*.

The potentially newly discovered sea star species belong to the genus *Luidia* was also very abundant around the Beirut canyons, specifically on sandy/detritic bottoms.

The potentially newly discovered sea star species belong to the genus Luidia was also very abundant around the Beirut canyons.

SAYNIQ

The Sayniq canyon has a very well-represented deep-sea muddy bottom community, with many species that are characteristic of this kind of substrate.

While the deep-sea elasipodid *Penilpida ludwigi* was common around all of the Lebanese canyons surveyed, it was most abundant in Sayniq, together with other holothurians (e.g., *Mesothuria intestinalis*) and the giant foraminifera *Pelosina* cf. *arboresecens*. Striped soldier shrimp (*Plesionika edwardsii*) was also abundant and was widely distributed in the canyon.

Coralligenous habitat was also important in the head of the canyon and along the continental shelf break. The benthic community associated with coralligenous formations in these areas was characterised by large sponges (e.g., *Agelas oroides*, *Fasciospongia cavernosa*, and *Spongia (Spongia) officinalis*). In addition, the rare sponge species *Calyx nicaeensis* was also found in this area, and the dusky grouper (*Epinephelus marginatus*), which is listed in Annex III of the SPA/BD Protocol of Barcelona Convention.

The Mediterranean fanworm (*Sabella spallanzanii*), a worm species that has been decreasing in Lebanese waters, appeared to still be abundant in the Sayniq canyon.

In the sandy bottom close to the coralligenous beds, two introduced species were found: the algae *Caulerpa scalpelliformis*, and reticulated leatherjacket (*Stephanolepis diaspros*). *C. scalpelliformis* is a species that has been known from Levantine waters since 1929[69] and has been recorded in Lebanon at depths of up to 44 m.[70] In the case of the surveys presented here, the species was recorded between 66 m and 82 m depth. Similarly, *S. diaspros* was also first recorded in Palestinian waters in the 1920s.[71] Since then, it has expanded along the shores of the Eastern Mediterranean, even reaching the Central Mediterranean.[72]

Human Impacts

MARINE LITTER

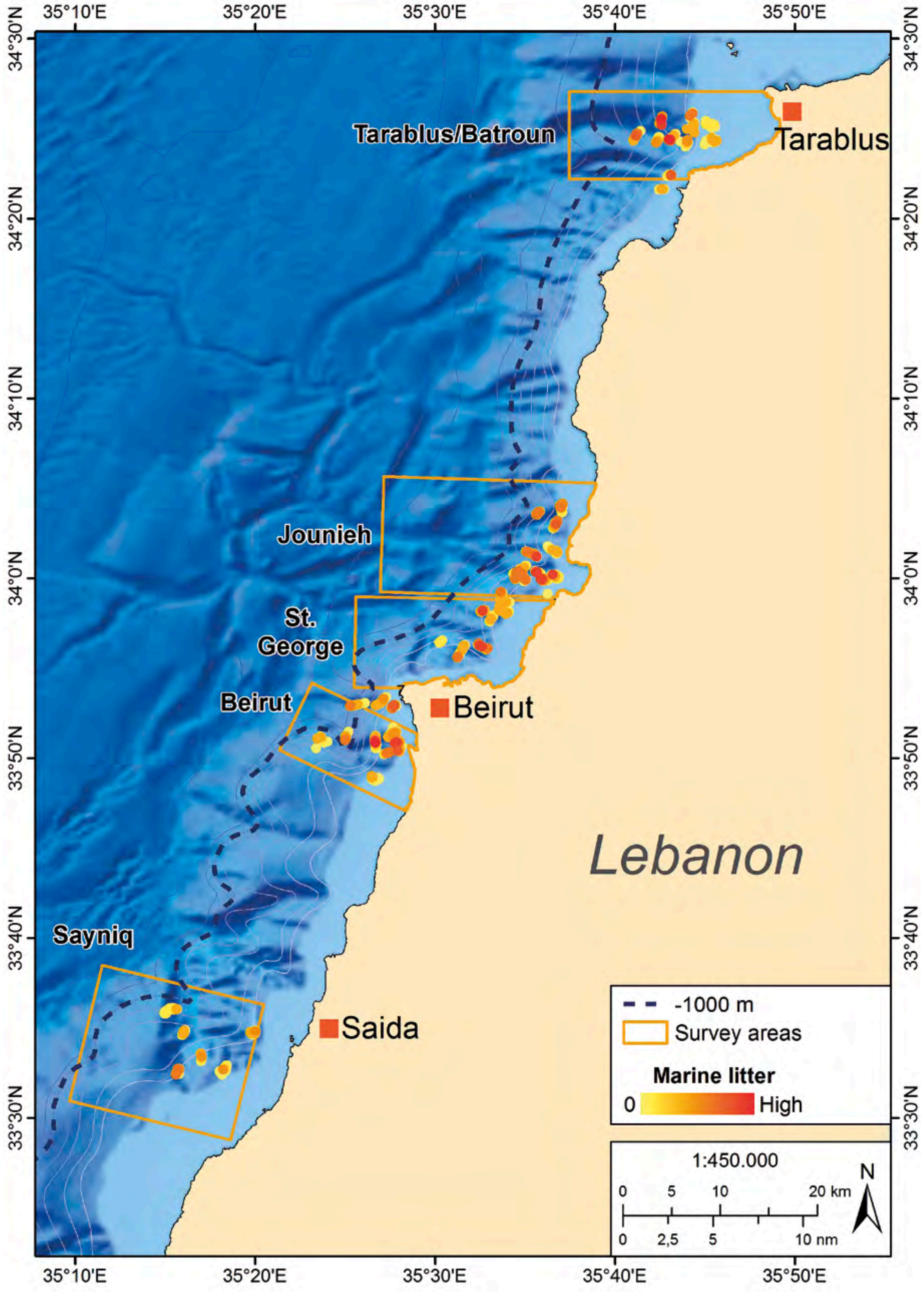
The most visible human impact on the Lebanese seabed was the widespread presence of marine litter on the seafloor. Abundant quantities of garbage and other debris that had been thrown into the sea were observed in all of the areas surveyed (Map 14). Household waste was discovered in all of the canyons, and at all depths, forming true underwater landfill sites in some zones. In these deep areas, it was usual to find a multitude of plastic debris, urban waste, and oil drums (Figure 35).

Figure 35. Barrel in Jounieh canyon, 596 m depth.

Meanwhile, in many parts of the continental shelf, marine litter was encountered in sites that appeared to be disposal areas for tyres (Figure 36), metallic waste such as appliances, and fishing nets (see below).

Figure 36. Tyres and glass bottles on detritic bottoms (St. George, 70 m depth).

Map 14. Distribution and abundance of marine litter in surveyed area.



FISHERIES

All of the fishing activity observed in the areas surveyed was related to small-scale or artisanal fisheries. The fishing techniques that are most damaging to benthic ecosystems (i.e., bottom trawling) do not occur in Lebanese waters, and as a result, no direct impacts of such fishing activities were observed on the seabed. However, indirect impacts were widespread, in the form of lost or discarded fishing gear, including lines, nets, and traps (Figure 37).

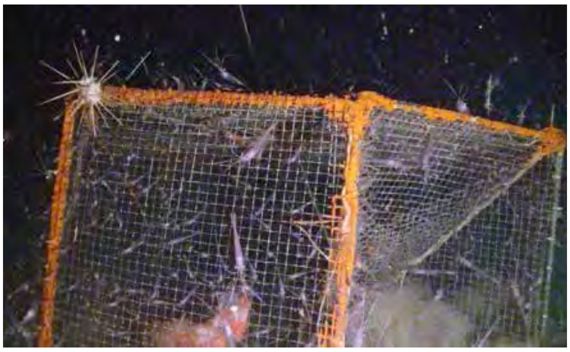


Figure 37. Lost fishing trap in St. George canyon, 307 m depth.

The highest density of lost fishing gear was found in areas of coralligenous habitat, the shelf edge, and canyon heads (Figure 38). This finding indicates a worrying concentration of effort on some of the most productive – but sensitive – habitats and ecosystems.

Figure 38. Fishing lines at the head of Tarablus/ Batroun canyon.

Indirect fisheries impacts were widespread, in the form of lost or discarded fishing gear.

Remains of fishing lines were most numerous in coralligenous areas, while abandoned nets formed dense covers over some rocky canyon heads (Figure 39). For example, around Beirut, such nets not only covered extensive areas of seabed, but also hindered surveys, because of the associated risk of entangling the ROV.

Figure 39. Lost fishing net in the area of Tarablus/ Batroun, 267 m depth.

OTHER OBSERVATIONS

Marine archaeological remains were encountered on only one occasion during the surveys, when an amphora was observed on the seabed of the Jounieh canyon (Figure 40).

Figure 40. Amphora found in Jounieh, 88 m depth.

Discussion and conclusions

The importance of the biodiversity of the deep-sea canyons off the Lebanese coast is well recognised, with various recommendations for their conservation, including from Oceana's MedNet proposal[36], Lebanon's Marine Protected Area Strategy,[35] and the CBD process to identify ecologically or biologically significant marine areas (EBSAs) in the Mediterranean Sea.[33] The importance of deep-sea canyons has also been emphasised under the UNEP-MAP RAC/SPA 'Dark Habitats Action Plan'[73] for the conservation of these and other sensitive Mediterranean ecosystems that require protection.

Designating MPAs to protect such deep-sea areas would represent an important step towards strengthening the marine protected area network within Lebanon, and with the Mediterranean Sea as a whole, by extending coverage to key offshore areas that harbour unique biodiversity and serve as important connections between coastal and deep-sea ecosystems. Proper management is also urgently needed, particularly in the case of those species protected under the Barcelona Convention, and species considered by IUCN as threatened that have been found to inhabit these waters.

Advancing the protection of these canyons, however, depends on having high-quality, scientific data about the marine life that they support. Until now, such data have been lacking. Prior habitat mapping studies of the canyons had relied mainly on technologies such as multibeam echo sounders, but biological surveys had only been carried out within the first few hundred metres of depth. The *2016 Deep-Sea Lebanon Expedition* sought to close this knowledge gap. The research expedition represented the first time that an ROV was used to document benthic habitats and communities at greater depths.


Rhodolith bed

MAIN EXPEDITION FINDINGS

The four-week expedition revealed a diversity of marine life in the five areas surveyed, with 619 identified taxa within six broad habitat types and various associated communites.

The highlights of the expedition findings with respect to habitat types include:

- Extensive areas of coralligenous habitat extending along the Lebanese coast, on the continental shelf and at the heads of the canyons surveyed, locations where rhodolith beds were also documented. The coralligenous formed well-developed reefs, which in turn supported a high diversity of species. It also appeared to be the most affected by lost or discarded fishing gears, probably due both to its proximity to the coast, and to its relatively high productivity, which attracts fishers. Both coralligenous habitat and rhodolith beds are considered as vulnerable and essential to hundreds of species, and all Mediterranean states are committed to their conservation, as signatories of the Barcelona Convention.
- Rocky bottom areas supporting important benthic communities. In areas surrounding canyon heads, rocks were covered with organisms such as corals, sponges, oysters, and brachiopods, while in deep-sea areas, some rocky bottoms were related to ancient fossil reefs built by corals, worms and other organisms. In these places, particular species of interest were found, including stony corals (e.g. *Desmophyllum dianthus* and *Caryophyllia* spp.), glass sponges (*Farrea bowerbankii*) and gorgonians (*Swiftia pallida*) were also documented.

Key findings include coralligenous concretions and vulnerable habitat-forming species.

- Muddy and sandy-muddy bottoms that supported vulnerable habitat-forming species. For example, sea pens (i.e., *Pennatula rubra* and *Virgularia mirabilis*) were widely distributed in areas where sandy bottom was mixed with mud, while tall sea pen (*Funiculina quadrangularis*) occurred in certain bathyal muddy areas. Most of these species are assessed as threatened in the Mediterranean by IUCN, and so protection and management measures should be put in place.

Among the observations regarding individual species, the expedition revealed:

- Three species that may be new to science: a sponge belonging to the genus *Axinella*, a sea star belonging to the genus *Luidia* (which appears to be different from its two known Mediterranean congeners), and a stony coral which is pending identification, but likely belonging to the genus *Anomocora*. Additional specimens obtained during the expedition are still pending identification and may yet reveal additional species of scientific interest.
- Multiple species that have not previously been recorded from the Mediterranean (e.g., *Hacelia superba*, *Leptasterias* sp.), and dozens of known Mediterranean species for which there were no previous Lebanese records (e.g., *Farrea bowerbanki*, *Chimaera monstrosa*, *Swiftia pallida*, *Dendrophyllia ramea*).
- Thirteen species that are considered threatened in the Mediterranean Sea, including: seven species for which strict measures of protection are required under Annex II of the SPA/BD Protocol of the Barcelona Convention (*Centrostephanus longispinus*, *Dendrophyllia ramea*, *Desmophyllum dianthus*, *Pinna rudis*, *Tonna galea*, *Tursiops truncatus* and *Sarcotragus foetidus*); three species whose exploitation is regulated under Annex III of the SPA/BD Protocol of the Barcelona Convention (*Epinephelus marginatus*, *Spongia (Spongia) officinalis* and *Scyllarus arctus*); two species assessed by IUCN as Endangered in

the Mediterranean Sea (*Epinephelus marginatus* and *Desmophyllum dianthus*), five assessed as Vulnerable (*Dendrophyllia ramea*, *Funiculina quadrangularis*, *Merluccius merluccius*, *Tursiops truncatus*, and *Pennatula rubra*). Two additional species were observed that are considered Near Threatened (*Chimaera monstrosa* and *Dipturus oxyrhincus*).


Filograna implexa

KEY COMMUNITY TYPES AND THEIR ECOLOGICAL IMPORTANCE

Discussed below are the most important community types found during the expedition, from a conservation perspective. We therefore focus on those communities that: are considered threatened or vulnerable; are protected under international agreements; or play significant ecosystem roles, either by building habitat or providing other ecosystem services.

Coralligenous concretions and rhodolith/maërl beds.

Rhodolith/maërl beds occur across the entire Mediterranean basin, from 25 m to 150 m depth, with some exceptional observations from deeper areas in the Balearic Sea.[74,75] Coralligenous concretions are also present throughout the Mediterranean. They are found within a depth range of 12 m to 120 m[76] and, like rhodoliths/maërl beds, also reach deeper depths in the Balearic Sea[2], due to the transparency of those waters. Both habitat types are considered hotspots of biodiversity; hundreds of marine species depend on their three-dimensional structures, for refuge, hard substrate upon which to settle, and food and nursery grounds.[1,3,77] Together with *Posidonia oceanica* meadows, these calcareous concretions are among the most biodiverse habitats of the Mediterranean Sea, and also represent key habitat for threatened and commercial species. During the Lebanese expedition, these communities were documented in all of the survey areas, in shallower waters, and were associated with a diversity of other marine life.

Coralligenous concretions and rhodoliths/maërl beds are vulnerable to anthropogenic impacts, such as damage from trawling and other fishing activities, pollution, sedimentation, warming and invasive species.[4,78] Both habitat types are listed as habitats of interest under the Barcelona Convention, and so sites with presence of these habitats are to be considered for the creation of marine protected areas (MPAs). Also, under the Barcelona Convention, the *Action Plan for the Conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea* was adopted in 2008, and then updated in 2017.[79] Under the Action Plan, signatories of the convention are urged to improve knowledge of these habitats (through data collection and monitoring), and to establish legislation (including the creation of MPAs) and science-based management plans to avoid any damage to these habitats.

As highlighted within the Action Plan, some of the best examples of legislative measures to protect these important habitats are found in European Union laws. For example, trawling above coralligenous habitats and rhodolith/maërl beds is one of the main threats to these habitats in the Mediterranean. Therefore, fishing with trawl nets, dredges, shore seines and similar nets over these vulnerable communities has been prohibited by law in EU Mediterranean waters since 2006.[80] This prohibition should be applied to the entire Mediterranean basin, to enhance the protection of these important habitats at the regional scale.

In addition to addressing the direct threat from fisheries, the Action Plan points to the need to grant coralligenous habitat and maërl beds the same degree of legal protection as *Posidonia oceanica* meadows. Listing Mediterranean rhodolith/maërl beds as protected habitats under Annex I has been under debate in several scientific fora (e.g., in the framework of the Spanish LIFE+INDEMARES and LIFE-IP INTEMARES projects). Outside of the EU, the Action Plan notes that similar efforts to strengthen legal protection of coralligenous and maërl should be made, using the tools of the Barcelona Convention.

Sponges are key species that provide a wide variety of ecosystem services that are essential for the health of the marine environment, and for human society.

Given the importance of these habitats for both biodiversity and for fisheries, Lebanon should prioritise their conservation. Specifically, in line with the Action Plan, the distribution of coralligenous and maërl assemblages in Lebanese waters should be mapped as soon as possible and management plans should be put in place to avoid any activities that may potentially damage these habitats or the communities that they support. One key element of these plans would be the creation of marine protected areas to limit localised threats to these important systems, including impacts from fisheries and other activities that directly or indirectly damage them, such as anchoring. It is also important to consider measures to reduce the of impacts of more distal threats to coralligenous and maërl communities, such as land-based sources of increased turbidity and sedimentation (e.g., eroded river basins, untreated wastewater, and coastline degradation).

Sponge aggregations

In the Mediterranean, there are hundreds of sponge species that can create important communities on deep-sea beds, both in hard and soft bottoms. During the expedition, sponge communities were observed in all of the survey areas, and in particular, were found on the rocks and coralligenous formations at the shelf edge.

Sponges are key species that provide a wide variety of ecosystem services that are essential for the health of the marine environment, and for human society. These contributions include: linking nutrients from the water column to benthic communities; playing a decisive role in the nitrogen and silicon cycles (which are important for marine nutrients and organic production); building and consolidating substrata; reducing deep-sea sediment erosion; and forming high-density aggregations that serve as habitat for many different species, including commercial species and their prey.[81,82,83,84,85,86]

In addition to the services they provide *in situ*, sponges themselves are important resources for humans. They produce compounds with antimicrobial,[87] allelopathic,[88] and other pharmacological effects.[89] Many of these compounds have been discovered in sponges of the genera *Ircinia*,[90] *Spongia*,[91,92] *Fascispongia*,[93] *Agelas*,[94,95] *Sarcotragus*, and *Axinella*;[96] these taxa were the most commonly observed ones during the research expedition. Compounds of potential relevance for cancer treatment have been confirmed in many of these species.[97]

Most of the sponge species that were documented during the expedition were living in association with coralligenous habitat. Therefore, many of the recommendations for protecting coralligenous would also be beneficial for the protection of sponge aggregations. Those sponge aggregations that were not linked with coralligenous assessmblages should be considered as vulnerable marine ecosystems (VMEs), and appropriate measures be taken for their protection (either under the General Fisheries Commission for the Mediterranean, or under the Dark Habitats Action Plan[73] of UNEP-MAP RAC/SPA). In addition, in the case of one particular species (*Sarcotragus foetidus*), its protected status under Annex II of the SPA/BD Protocol of the Barcelona Convention means that Lebanon must take legal steps to ensure the protection of both the species and its habitat.

Scleractinians (Stony corals)

Only a few Mediterranean coral species belong to the scleractinians (also known as madreporarians or stony corals), which are the type of corals that forms the extensive reefs of the tropics. In the Mediterranean, the great majority of these species are only represented by small colonies or in isolation (or as part of reefs created by other species).

Five main types of stony coral communities were found in Lebanese waters during this survey (cf. *Anomocora* sp., *Madracis pharensis*, *Dendrophyllia ramea*, *Caryophyllia (Caryophyllia) calveri* and *Desmophyllum dianthus*).

One type occurred in relatively shallower waters in the circalittoral zone, composed by small colonies of a scleractinian coral that has not yet been described and may be new to science (possibly *Anomocora* sp.). This species was found on soft sandy bottoms or, in some cases, attached to natural and artificial hard bottoms between 60 m and 90 m depth.

Another scleractinian species, star coral (*Madracis pharensis*), is a colonial, mainly encrusting coral with a wide distribution in the tropical and temperate waters of the Atlantic Ocean, from the Caribbean to the Mediterranean[98]. This species mainly occurs in shallow waters. In the Western Atlantic, it is generally zooxanthellated, while in the Mediterranean, it typically lacks zooxanthellae.[99] In Lebanese waters, it represents one of the most characteristic communities growing on hard bottoms in the region of the continental shelf break, in canyon heads, and in the upper part of the bathyal zone. *Madracis pharensis* has also been found close to hydrothermal vents in Greece, covering a high proportion of the primary rock, and representing one of the main and characteristic species of constructing corals[100]. In the deep circalittoral and upper bathyal areas off Lebanon, this species must also be considered as one of the main bio-constructors, which frequently occurs together with oysters (*Neopycnodonte cochlear*) and sponges and provides an important habitat for many species. The primary threats to this species are those related to global climate change, such as ocean acidification and the increased incidence of coral diseases.[101]

Tree coral (*Dendrophyllia ramea*) is a tree-shaped coral found in the upper bathyal zone. This species is distributed in the Mediterranean Sea and in the eastern Atlantic Ocean, where it occurs around the African coast and the Iberian Peninsula.[102,103] It has also been recorded from the Indian Ocean, in Mozambique.[104] In the Western Mediterranean and the Eastern Atlantic, it lives on hard rocky surfaces, from very shallow waters until the shelf break, and on top of seamounts.[105,106,107] In the Eastern Mediterranean, the species has only been recently described from Greece,[108] Cyprus,[54] and now Lebanon. Contrary to what has been observed in Western Mediterranean communities of *D. ramea*, the eastern ones seem to prefer soft bottoms, in deep waters close to the shelf break. Therefore, they may be vulnerable to fishing gears that directly impact the seabed, such as bottom trawls, bottom longlines, set nets, and traps, whether actively used or discarded on the seabed. This species may also be affected by other types of marine litter, as well as by


Calyx nicaeensis

sedimentation resulting from terrestrial run-off[109]. The three-dimensional structure created by this coral allow many species to live within or near the colonies. Also, many associated species can live in their branches. In the nearby Cypriot colonies, up to 44 such species of epibionts were found.[110] In the Mediterranean, *D. ramea* is considered threatened. It is Red Listed as Vulnerable,[53] and is also listed on Annex II of the SPA/BD Protocol of the Barcelona Convention. Therefore, its protection is a legal obligation, and Lebanon is legally obliged to ensure the maximum possible protection and recovery of the species, including prohibiting damage and destruction of its habitat.[41] Legal measures should therefore be introduced for the area where it was documented (i.e., Tarablus/Batroun).

Caryophyllia (Caryophyllia) calveri and cockscomb cup coral (*Desmophyllum dianthus*) are solitary corals from the deep bathyal zone that sometimes grow in small colonies. They are the main erect fauna found on vertical walls and on fossil reefs in deep-sea waters, even tolerating high levels of sediment 'rain' from above. While *C. calveri* does not usually occurs in large numbers, *D. dianthus* can form dense colonies and even forms part of the coral community on deep-sea reefs.[111] *D. dianthus* has a wide distribution, across the Atlantic Ocean, the Mediterranean Sea, and the Pacific coast of Chile.[112] In contrast, *C. calveri* is only found in the North-East Atlantic and Mediterranean Sea.[113] Both species are considered vulnerable to different human activities, including bottom trawling, fishing lines, climate change, mining, dumping of waste, energy development and exploitation, deployment of submarine cables and pipelines, etc.[114] Population declines in *D. dianthus* have resulted in it being Red Listed as Endangered,[53] and in its 2017 listing on Annex II of the SPA/BD Protocol of the Barcelona Convention. As with *D. ramea*, Lebanon is required to grant this species the maximum possible protection, and so legal measures of protection should be introduced for the area where it was observed (i.e., St. George).

Many of the community types of stone corals described above are included in the UNEP-MAP Reference List of Marine Habitats proposed for the selection of sites to be included in the national inventories of places of natural interest for their conservation,[115] including:

- Bathyal rock with *Desmophyllum dianthus*
- Bathyal rock with *Madracis pharensis*
- Bathyal rock with *Caryophyllia (Caryophyllia) calveri*
- Bathyal mud with *Dendrophyllia ramea*

In the Lebanese deep-sea, some scleractinian species clearly formed habitats that supported diverse benthic communities. In particular, tree coral (*D. ramea*) provided important three-dimensional structures on the seabed, while star coral (*M. pharensis*) formed large communities. The latter coral is not usually considered to be a major habitat-forming species in the Mediterranean. However, in Lebanese waters it appeared to play a bioconstructing role similar to that of *Cladocora caespitosa* (the main scleractinian reef-builder in other parts of the Mediterranean), but in deeper waters, and over a wide bathymetric range. It should therefore be included under the Dark Habitats Action Plan of UNEP-MAP RAC/SPA,[73] and managed accordingly.

Deep-sea oysters formed the most important mollusc aggregations found, with up to 1000 individuals/m².

Other stony coral species also represented part of important communities, while some species may be new to science, such as the potential *Anomocora* species found during the expedition, which could be endemic to the area. The ecosystem role of species such as these, about which so little is known, remains to be discovered.

Gorgonian/sea fan communities

More than 20 species of gorgonian have been described from the Mediterranean Sea.[116] This expedition marked the first time that sea fans had been discovered in Lebanon.

Swiftia pallida is a gorgonian known as northern sea fan, which is distributed throughout the entire Mediterranean Sea (from the Alboran Sea to the Levantine Sea)[117] and in the Atlantic Ocean (mainly in the eastern part from Norway[118] to Morocco and the Macaronesian Archipelagos).[107] It has also been found in the Western Atlantic, in deep waters off of North America.[119] In general, its distribution appears to be limited by water temperature; in the Mediterranean it is normally found between 200 m and 700 m depth, while in northern areas it can be found in much shallower water. It can be fixed to rocky bottoms, as well as on gross detritic beds with cobbles, and tolerates some degree of sedimentation.[117]

S. pallida is vulnerable to a range of human impacts, as has been shown across various regions where it occurs. In Scotland, this species has been recognised as one of the more vulnerable gorgonians to temperature increases,[120] and could therefore disappear from part of its current range of distribution in response to climate change.

The species has also been shown to be sensitive to oil leaks and spills. After the Deepwater Horizon accident in the Gulf of Mexico, different species of sea fans – including *S. pallida* – exhibited "signs of stress response, including excessive mucous production and retracted polyps" as described by White *et al.* (2012).[121] These toxic oil effects can be long-lasting. When areas impacted by oil leakage were revisited several years later, the most affected sea fans showed high levels of colonisation by hydrozoans, contributing further to the decline of the colonies.[122] In Norway, *S. pallida* is considered one of the sea fan species that must be prioritised for protection, under the Monitoring Guidelines for oil drilling.[123]

This community type is included in the reference list of Mediterranean Marine Habitats proposed for the selection of sites to be included in the national inventories of places of natural interest for their conservation,[115] as 'Bathyal rock with *Swiftia pallida*'.

Gorgonians are very uncommon in the Levantine Sea, and here – as with the rest of the Mediterranean – it is a community type that must be protected and managed, under the Dark Habitats Action Plan.[73] Such measures may include the identification and protection of threatened populations, the designation of MPAs, and measures designed to address specific identified threats. Given the known sensitivity of *S. pallida* to impacts associated with exposure to oil, the planned exploratory drilling for oil and gas in Lebanese waters is reason for particular concern.

Sea pen fields

Sea pens play an important role in forming 'animal forests' on soft bottoms, thereby providing habitat for a variety of associated species, including those of commercial value. The most widely and densely distributed sea pen aggregations in Lebanese waters are those of red sea pen (*Pennatula rubra*) on soft bottoms between the shelf break and the head of the canyons. In some locations they also appeared in mixed aggregations with slender sea pen (*Virgularia mirabilis*). In the Mediterranean Sea, *P. rubra* can reach densities of more than 9000 colonies per square kilometre.[124] In Syrian waters, communities dominated by *P. rubra* and the echinoid *Shizaster canaliferus* have been identified as the ones with the highest levels of biomass (30g/m²) and with a high associated species richness.[125] Alongside its high ecological value, *P. rubra* is also considered threatened in the Mediterranean; it is Red Listed as Vulnerable because of inferred population declines of approximately 40% over 20 years.[53] These declines are due in large part to the impacts of fishing activities, with red sea pen known to be among the species discarded as bycatch from trawl fisheries.[126,127,128]

In deepest areas, the tall sea pen (*Funiculina quadrangularis*) was found on muddy beds down to 604 m. This species is known to play an important role as a habitat builder on soft bottoms, and supports commercial species such as the crustaceans *Nephrops norvegicus* and *Parapenaeus longirostris*.[129,130,131] Tall sea pen is considered to be a vulnerable marine ecosystem (VME) indicator species[132] and has been assessed as Vulnerable in the Mediterranean by IUCN.[133]

All of these pennatulaceans are key species included as habitat builders under the Mediterranean Action Plan for protecting dark habitats.[73,117] In the Lebanese deep-sea, the largest aggregations of sea pens identified were formed by red sea pen (*P. rubra*), and must be considered one of the key deep-sea community types in Lebanon. The tall sea pen (*F. quadrangularis*) is also a priority for protection in Lebanese waters, and in the wider Mediterranean, due to its importance for both biodiversity and commercial fisheries, and its vulnerability to human impacts. Conservation and management of this species should be carried out in line with both the Dark Habitats Action Plan and measures being developed within the General Fisheries Commission for the Mediterranean, to protect those species identified as VME indicators from adverse impacts caused by fishing activities.

Oyster aggregations/concretions

The most important mollusc aggregations found in Lebanese waters were the dense mantles of deep-sea oyster (*Neopycnodonte cochlear*), with a distribution ranging from 60 m to 250 m depth. These aggregations were observed in some cases over the shelf, covering rocks and artificial objects, and were also very frequently observed on hard bottoms in the heads of canyons.

These oysters can settle on hard substrata, both natural and artificial, reaching concentrations of up to 1000 individuals per square metre.[134] They have been found in dense groups forming reefs and banks in the Mediterranean (e.g., on the Chella bank;[105] in the Gulf of Lions;[135] in the Alboran Sea[136]; and in this study, in Lebanon), and in wide aggregations that carpet the seabed (e.g., on the Gorringe Bank; on Atlantic seamounts;[137] and in the Azores)[138,139] and serve as substrate for other species. The most common species found in association with these aggregations include large bryozoans, other molluscs, polychaetes, and various echinoderms.

In the aggregations observed in Lebanon, the oysters also formed mantles together with corals (primarily *Madracis pharensis*), polychaetes and sponges. In these aggregations, a variety of species of mobile organisms were observed, such as echinoderms (e.g., *Cidaris cidaris*, *Hacelia attenuata*, and *Echinaster (Echinaster) sepositus*), fishes (e.g., *Anthias anthias*, *Callanthias ruber*, *Thorogobius ephippiatus*, and *Lappanella fasciata*), as well as sessile organisms, such as worms, sponges, bryozoans, and corals.

These bioherms significantly increase the complexity of the hard and mixed sediment bottoms. Therefore, it is recommended to implement conservation measures to prevent damage to the seafloor where this habitat occurs, including banning demersal fisheries that can have detrimental effects upon them.[140] For example, *N. cochlear* has been found in discards from trawlers fishing in Tunisian waters.[141] Beyond these direct impacts, water quality management is also necessary for the conservation of this community type, given that “polluted water discharges and dredge disposal may have lethal or sub-lethal effects” upon the oysters.[140]

Oyster aggregations in Lebanese waters play a similar role to coral reefs, in that they contribute to both increased biodiversity and habitat complexity, whether as reefs of living oysters, or of their remains. *N. cochlear* is an opportunistic species, which in some cases establishes itself in sites where other species have undergone declines and creates substrate upon which other organisms may settle (e.g., sponges, polychaetes, and corals). As such, they should be considered as key habitat-forming species under the Dark Habitats Action Plan,[73] and be managed and protected accordingly.

Echinoderm-dominated communities

Various echinoderms are known to form large aggregations on the seabed, providing different ecosystem services that are key for the entire ecosystem.[142] In Lebanese waters, the largest such concentrations of echinoderms observed during the expedition were, on the one hand, those formed by sea urchins and, on the other hand, those made up of deep-sea cucumbers.

With resepect to sea urchins, the main aggregations were formed by hatpin sea urchin (*Centrostephanus longispinus*) around and in coralligenous beds, and by long-spine slate pen sea urchin (*Cidaris cidaris*) on soft bottoms in deeper areas.

C. longispinus has not typically been described as creating large aggregations.[143,144] This species appears to avoid sunlight; therefore, it normally appears in areas below 30 m depth. Its distribution is also restricted by water temperatures, as it only resists a limited thermal range of between approximately 12°C and 20°C.[145] The species is likely to play a key role in maintaining the health of coralligenous concretions, as has been documented in other *Centrostephanus* species worldwide.[146] In the Mediterranean, this species is included on the Annex II list of endangered or threatened species, and therefore requires legal measures to ensure the protection of both it and its habitat.[41]

The other main aggregating urchin species, *C. cidaris*, is another echinoid species that lives far from sunlight. This urchin can be found much deeper than *C. longispinus*; in the Mediterranean it is normally found in soft and hard bottom areas between 50 m depth and close to 600 m depth,[147] although its depth distribution has been mentioned to extend below 2000 m.[148] It is the most conspicuous sea urchin in Lebanese waters. This species is considered an important factor influencing marine species aggregations and distributions, and an important player as a bioeroder of deep-sea ecosystems, including those formed by cold-water corals.[149,150]

The other important echinoderms in deep areas are sea cucumbers. Both *Mesothuria intestinalis* and *Penilpidia ludwigi* were very abundant in the Lebanese canyons studied. Holothurians are known to create large aggregations that play a crucial role for deep-sea ecosystems;[142,142,151,152] sea cucumbers excrete inorganic nitrogen and phosphorus, enhancing the productivity of benthic biota.[153] Therefore, they are key elements for the cycling of different nutrients, and put sources of food back into circulation and available to other species. These include other echinoderms, such as sea urchins that feed on holothurian fecal casts,[154] reintroducing nutrients into the food web.

As explained by Purcell *et al.* (2016)[153] impacts affecting the abundance of holothurians could “decrease sediment health, reduce nutrient recycling and the capacity of ecosystems to buffer against ocean acidification, diminish biodiversity of associated symbionts and reduce the transfer of organic matter from detritus to higher trophic levels”.

The roles played by echinoderms in deep-sea ecosystems are poorly understood, both in general, and in Lebanese waters. In a limited number of cases, the value and importance of such habitats has been determined, such as the identification of crinoid beds as ‘essential fish habitat’ for commercial species,[155] or of certain holothurian species that are clearly very important for food and biogeochemical cycling. For many other echinoderms, however, little is known. Their function and contribution to deep-sea areas deserves further study, and should be taken into account to improve the management of these ecosystems in Lebanese waters and elsewhere.

Fossil reefs

Coral aggregations act as a reef, providing shelter and substrate for many species, both when the polyps are still alive, and when only a fossil or subfossil structure remains.[156]

Although no living deep-sea coral reefs were found in the Lebanese canyons surveyed during the present expedition, some hard bottoms in deep-sea areas were the result of fossilised corals, worms and other species. These fossil reefs act very similarly to rocky bottoms, allowing species to settle and proliferate. The intricate morphology of fossil reefs allows rare species to settle, increasing new biodiversity levels and giving rise to new biological associations. Hard bottoms, whether bioherms or lithoherms, are scarce on


Lepidorhombus whiffiagonis

marine bottoms, but they provide substrate for the development of some of the most productive ecosystems in the world.

Cold water corals like *Lophelia pertusa*, *Madrepora oculata* and *Desmophyllum dianthus* are commonly found in the Mediterranean Sea forming patches or thickets of fossil or subfossil scleractinians.[157,158,159] Dead corals and coral framework could promote further settlement and species, including new corals that can give birth to new coral reefs throughout different successional stages of reef building.[160]

Lebanese fossil reefs surveyed during the expedition were found to host hexactinellid species like *Farrea bowerbanki*, other living corals like *D. dianthus* and *Caryophyllia (Caryophyllia) calveri*, soft corals like the gorgonian *Swiftia pallida*, scyphozoans like *Nausithoe* sp., worms like *Vermiliopsis monodiscus*, etc. and vagile fauna of crustaceans, echinoderms, fish, and other organisms that live within the reef structure.

Although fossil reefs are no longer living reefs, they clearly nevertheless still act as reefs, by providing valuable hard substrate in deep-sea areas (where such substrata are very scarce), and supporting a diversity of species. As such, their ecological importance must be taken into account. Lebanon and other Contracting Parties to the Barcelona Convention should ensure that fossil reefs are managed under the same framework as other 'dark habitats', to ensure that threats to these systems are minimised or avoided altogether.

SURVEY AREAS

The surveyed areas were broadly similar in terms of the marine habitats and communities that they supported. Nevertheless, they varied in terms of total biodiversity, and in the particular species and communities of interest that occurred within them. Table 1 provides a comparison of the five areas surveyed, showing selected main features of ecological and conservation interest. In general, key observations included:

Beirut

- Some key community types were highly abundant in the area, including sea pen fields that were the most widespread and abundant of all those observed. The aggregations formed by oysters and stony corals in the canyon heads were also most common in the Beirut area.
- The area appeared to be important for some key species of interest, with a high abundance of scleractinians, bryozoans, and echinoderms (including the largest aggregation of the protected hatpin urchin (Centrostephanus longispinus) and the potential new species of starfish). The potential new species of coral discovered during the expedition (cf. *Anomocora* sp.) was also found in this area.

Jounieh

- The highest diversity of species was recorded from in the Jounieh area, with nearly 300 species identified.
- All of the key community types described were present in the area, with fossil reefs (in the deepest areas) and sponge aggregations being of particular importance.
- Many of the rarest species observed during the expedition were documented from Jounieh, such as the glass sponge Farrea bowerbankii and two starfish species that are typically considered to be Atlantic (i.e., Hacelia superba and Leptasterias sp.).

- Jounieh provided the first-ever record of a gorgonian (Swiftia pallida) from Lebanese waters.
- Similar to the Beirut area, some key habitat-forming species were highly abundant, such as sea pens.

Sayniq

- The area accounted for the second-highest number of identified species.
- Among the key community types in the area, coralligenous formations, maërl beds, and sponge aggregations were particularly well represented.
- Particular species of interest included the large bryozoans (*Hornera frondiculata*) and rare, new, and protected sponge species.

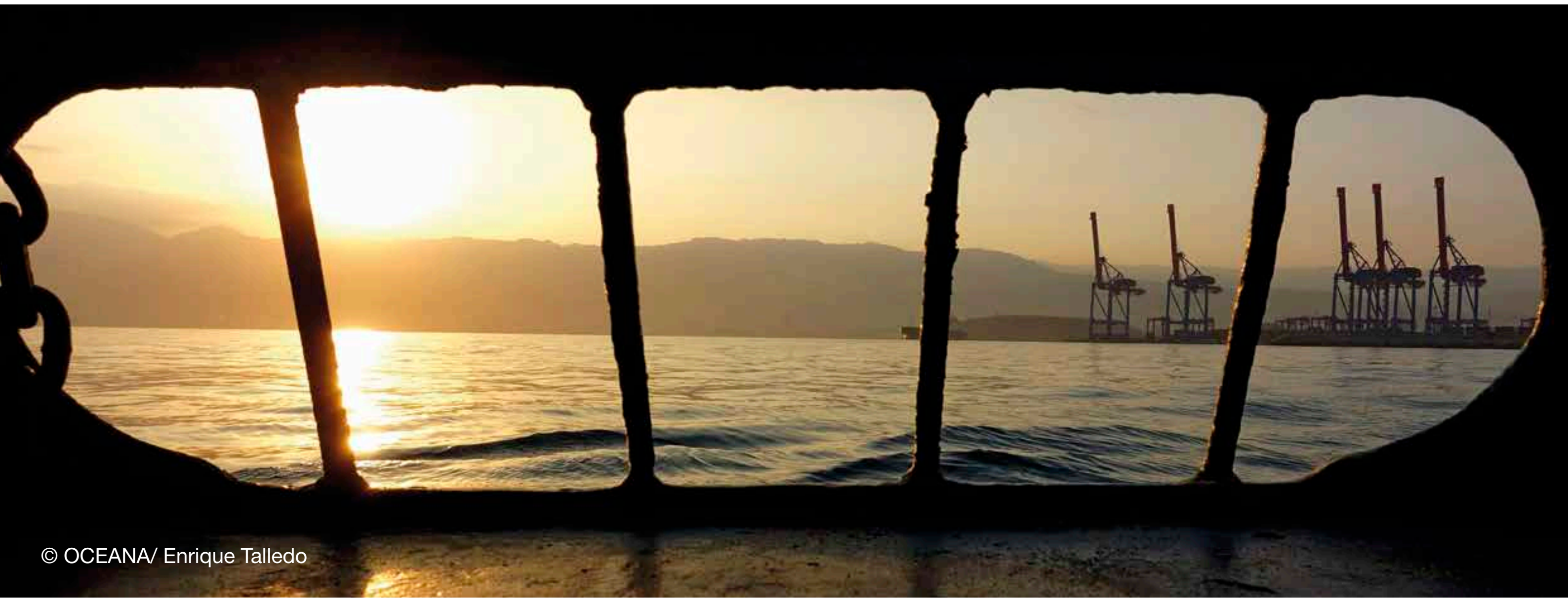
St. George

- The most extensive and diverse coralligenous and maërl habitats were found in the St. George area.
- Two chondrichthyan species that are classified as Near Threatened (*Chimaera monstrosa* and *Dipturus oxyrhincus*) were observed only from this area.
- St. George was also the only area in which the Annex II-listed species of coral *Desmophyllum dianthus* was observed, in association with the deep-sea fossil reefs.

Tarablus/Batroun

- The Tarablus/Batroun area was characterised by a diversity of key habitat types, and a variety of protected and/or threatened species.
- The occurrence of hard substrata was relatively high in the area, partly reflecting the high abundance of habitat-forming species.
- The area was important for more than half of the protected and/or threatened species documented. These species included the threatened and Annex II-listed tree coral (*Dendrophyllia ramea*). This species was found to occur in deep areas and on muddy bottoms, an occurrence that was only recently first observed in deep-sea areas near Cyprus.

The three categories of features included in Table 1 are summarised in Figure 41, showing the sites of highest importance for key communities, protected and/or threatened species, and species of particular interest. When combined, this information indicated a series of sites of highest conservation interest, spread across the five survey areas (Map 15; see Annex 2 for further details).



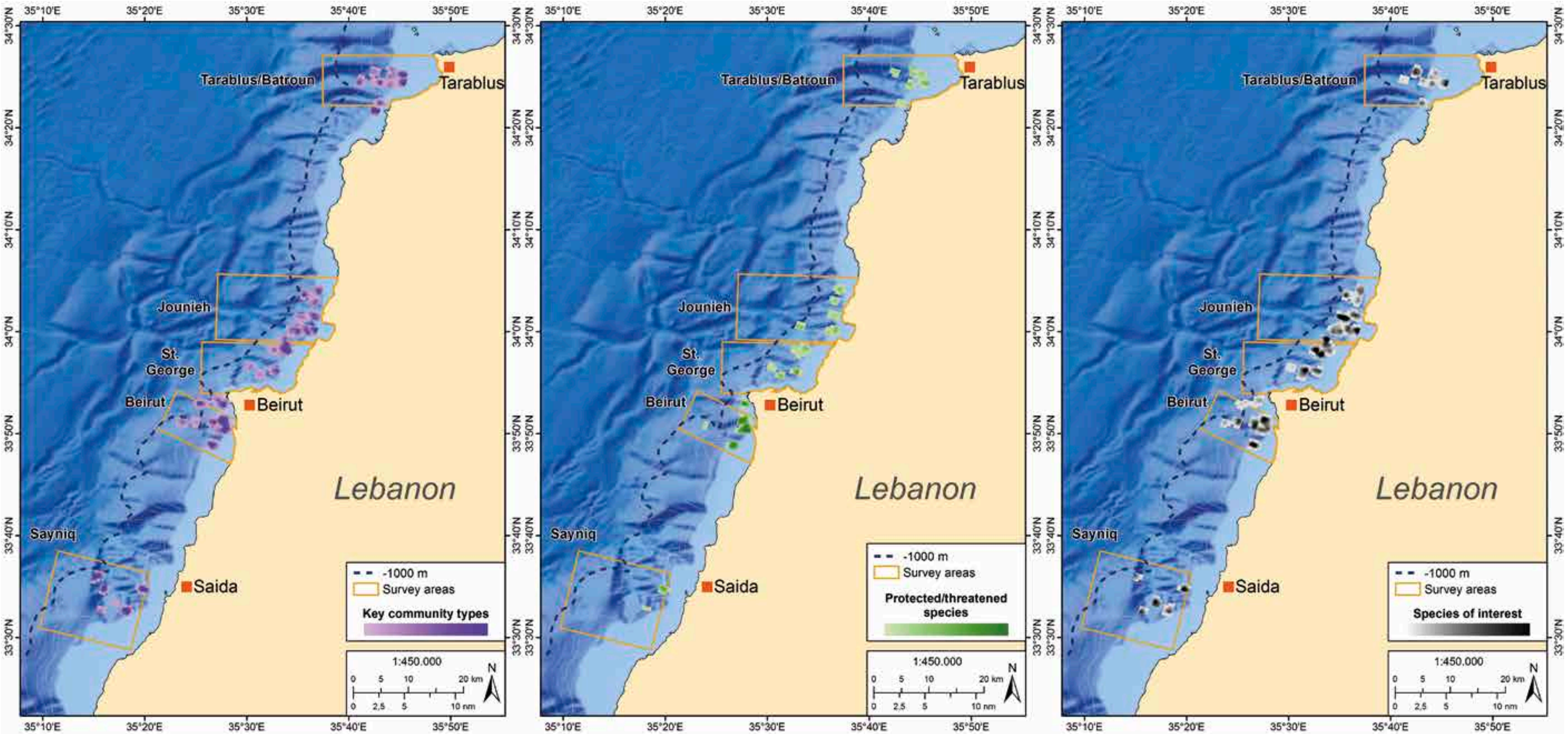


Figure 41. Relative conservation interest of the study areas, according to: a) key community types; b) protected and/or threatened species; and c) other species of general scientific interest.

Table 1. Main features of interest in each of the study areas.

		Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun
Total number of identified taxa		214	299	250	210	214
Key community types						
	Coralligenous formations	Low	Medium	High	High	Medium
	Coralligenous formations (dead)	Low	Low		Low	High
	Fossil reefs		High		Low	Medium
	Rhodolith/maërl beds		Low	Medium	High	Medium
	Echinoderm-dominated communities	High	Low	High		Low
	Gorgonian/sea fan communities		Low			
	Oyster aggregations/concretions	High	Medium	Low	Medium	
		High	Medium	Low	Low	Medium
	Sea pen fields	High	Low		Medium	Low
	Sponge aggregations	Low	High	High		Low
	Vermetid reefs	Low	Low			

Relative abundance (estimated): High; Medium; Low

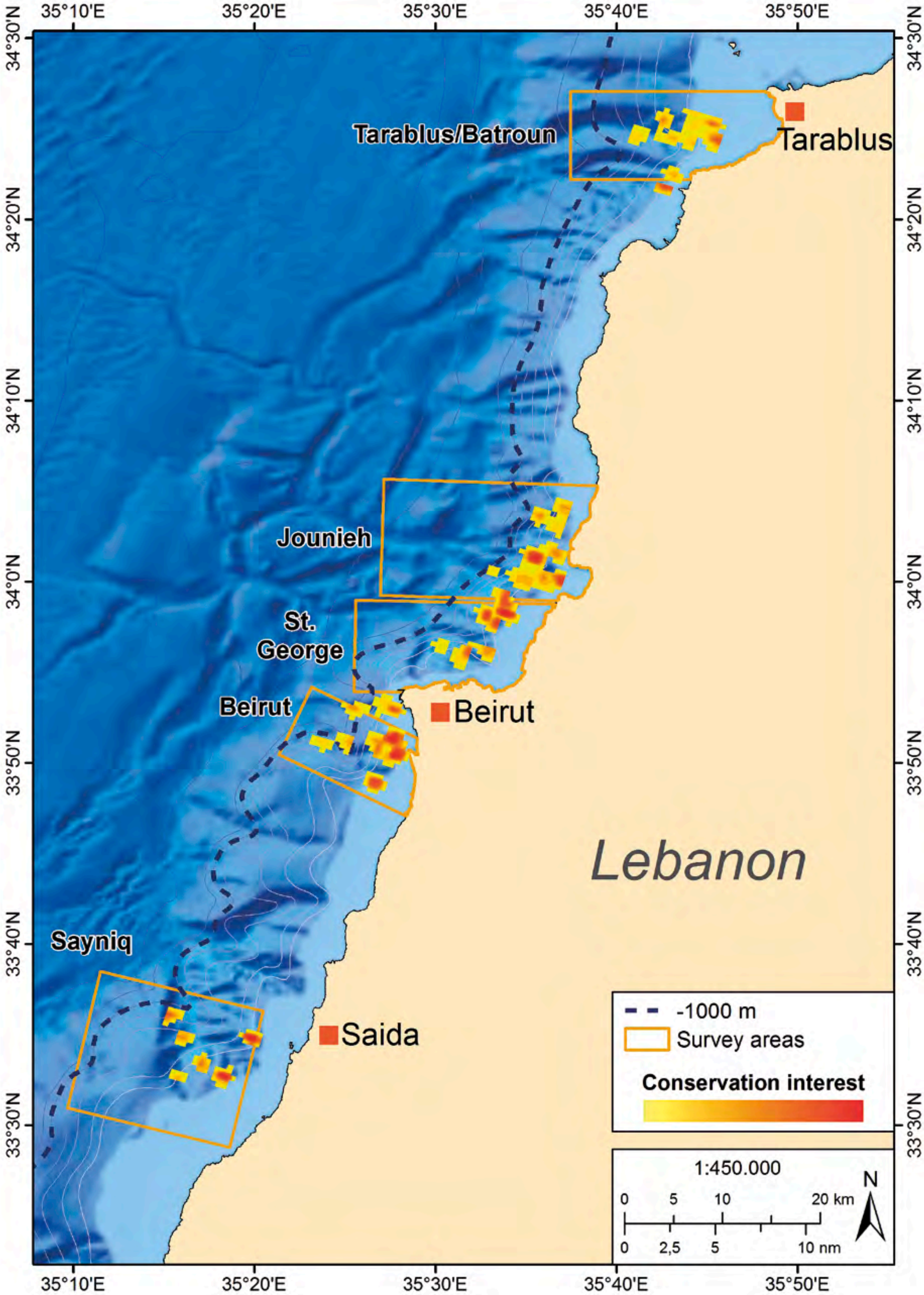
		Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun
Protected/threatened species						
Chordata	*Chimaera monstrosa*				1	
Chordata	*Dipturus oxyrhincus*				1	
Chordata	*Epinephelus marginatus*			>1 and <10		
Chordata	*Merluccius merluccius*		>1 and <10		1	
Chordata	*Tursiops truncatus*		1			
Cnidaria	*Dendrophyllia ramea*					>1 and <10
Cnidaria	*Desmophyllum dianthus*				>1 and <10	
Cnidaria	*Funiculina quadrangularis*	1				>1 and <10
Cnidaria	*Pennatula rubra*	≥10	≥10		>1 and <10	>1 and <10
Crustacea	*Scyllarus arctus*					1
Echinodermata	*Centrostephanus longispinus*	≥10	≥10		1	>1 and <10
Mollusca	*Pinna rudis*					>1 and <10
Mollusca	*Tonna galea*		1			
Porifera	*Sarcotragus foetidus*		>1 and <10			>1 and <10
Porifera	*Spongia (Spongia) officinalis*		>1 and <10	>1 and <10		>1 and <10

Abundance (number of individuals per area): ≥10; >1 and <10; 1

		Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun
Species of interest						
Annelida	*Sabella spallanzanii*			>1 and <10		
Brachyopoda	*Gryphus vitreus*					≥10
Bryozoans	*Adeonella pallaisi*		>1 and <10	1		≥10
Bryozoans	*Caberea* sp.	≥10	≥10		1	>1 and <10
Bryozoans	*Hornera frondiculata*		>1 and <10	≥10	>1 and <10	>1 and <10
Bryozoans	*Reteporella* spp.	≥10	>1 and <10	>1 and <10		1
Chordata	*Etmopterus spinax*	1				
Cnidaria	cf. *Anomocora* sp.	≥10	≥10			
Echinodermata	*Hacelia superba*		1			
Echinodermata	*Leptasterias* sp.		1			
Echinodermata	*Luidia* sp.	≥10		1	1	
Foraminifera	*Pelosina* cf. *arborescens*	≥10	≥10	≥10	≥10	≥10
Porifera	*Axinella* spp.	>1 and <10	1	≥10	>1 and <10	>1 and <10
Porifera	*Axinella* sp. nov (possible)			1		
Porifera	*Calyx nicaeensis*			>1 and <10		
Porifera	*Farrea bowerbankii*		1			

Abundance (number of individuals per area): ≥10; >1 and <10; 1

Map 15. *Sites of highest conservation interest.*



MAIN THREATS

Threats observed

Marine litter

Across all of the areas studied, surveys revealed the pervasive threat of marine litter, in all habitat types, and at all depths. In some cases, the sources of this waste were likely coastal, with ocean currents carrying litter offshore, while in other cases it was apparent that large objects such as appliances, tyres, and barrels had been dumped directly at sea. These observations reflect the broader and significant challenges that Lebanon faces regarding the disposal and management of the country's solid waste.[161] The environmental benefits of improved waste management policies and practices would be far-reaching, not only limited to terrestrial and coastal systems, but extending to deep-sea areas such as those surveyed here, and beyond.

Fisheries

While direct impacts of fishing activities on benthic communities were limited (largely due to the lack of bottom-contact fisheries), discarded fishing nets, lines, and traps were also commonly found, particularly around coralligenous habitat, the shelf edge, and the heads of canyons. Although deep-sea benthic habitats and species are currently out of the reach of Lebanese fisheries, they are nevertheless clearly affected by anthropogenic activities.

Alien species

Five percent of the species that currently inhabit the Mediterranean Sea are of alien origin.[162] Many of these species have entered from the Red Sea; more than 60% of the 614 multicellular non-indigenous species with populations established in the Mediterranean have reached this sea via the Suez Canal.[163] As a result, the Levantine Sea is one of the most affected areas in the region. According to the Marine Mediterranean Invasive Alien Species database, which is maintained by UNEP-MAP RAC/SPA, 215 marine species have been recorded from Lebanon that are either alien or cryptogenic (i.e., of unknown origin).[164]

This expedition was focused on deep-sea areas, while most alien species in the Mediterranean are associated with shallow waters. However, even in the deeper areas surveyed, various alien species were documented: the algae *Caulerpa scalpelliformis*; the fish species cf. *Cheilodipterus novemstriatus*, *Equulites klunzingeri*, *Fistularia commersonii*, *Nemipterus randalli*, *Ostorhinchus fasciatus*, *Pterois miles*, *Sargocentron rubrum*, *Siganus luridus*, *Stephanolepis diaspros* and *Torquigener flavimaculosus*; and the mollusc species *Fulvia fragilis*, *Mactra olorina*, and *Murex forskoehlii*.

Non-native species are of particular concern in cases where they become invasive, establishing viable populations outside of their natural ranges and causing changes to the structure and function of local ecosystems, such as by displacing native species, altering habitats, or modifying foodwebs.[165,166] Such changes can have significant ecological and economic consequences, with resulting impacts on both biodiversity and ecosystem services.[167] Of the alien species observed during the expedition, five are considered to have invasive characteristics (*Fistularia commersonii*, *Fulvia fragilis*, *Sargocentron rubrum*, *Siganus luridus*, and *Stephanolepis diaspros*). Both *F. commersonii* and *S. luridus* have been identified as species with high impacts on ecosystem services or biodiversity.[167]

In 2016, 46 scientists from the Mediterranean region signed a manifesto expressing their concern about bio-invasions and their effects on the Mediterranean marine ecosystem, and calling on parties to the Barcelona Convention to take immediate action.[168] UNEP-MAP has also expressed its concern about the impact of invasive alien species, and highlighted the need for Mediterranean countries to take action to avoid their intentional or unintentional release, and associated harmful impacts on the ecosystem.[169] Given the scale of the problem, effective solutions will depend on joint actions implemented by Mediterranean countries, including Lebanon, to both prevent the introduction of further exotic species in the future, and to limit the impacts of those that have already established themselves in Mediterranean waters.

Other threats

Erosion

Ecosystem complexity in the deep-sea environment is higher in areas with epifauna that provide living three-dimensional structures, as well as where the remains of these organisms occur. This complexity can help to reduce erosion and resuspension in important habitats, thereby decreasing impacts on these bottoms and increasing the general resilience of the marine ecosystem. For example, the presence of sponge spicules within soft sediment have been demonstrated to reduce erodibility.[86] The protective benefits of these ecosystems can be useful in the face of erosive impacts (such as resuspension of sediment due to fisheries impacts, or shipping activities) and must be considered, along with land-based measures, as a means of reducing environmental degradation.

In other areas, like the North Sea, changes in the abundance of benthic species have been associated with changes in sediment erosion. In particular, the reduction of epibenthic fauna in favour of infauna has been shown to cause increased sediment erosion, as a result of decreased benthic structural complexity.[170]

Oil exploration

Oil reserves in the Eastern Mediterranean have been estimated at between roughly 1.7-2.5 billion barrels. This amount is relatively small in comparison with the most important oil fields in surrounding areas, like the North African Mediterranean (over 65 billion barrels).[171,172] Of the estimated Eastern Mediterranean reserves, the most important predicted resources are those of gas, accounting for an estimated 122 trillion cubic feet.

In Lebanese waters, hydrocarbon resources are estimated at 660 million of barrels of oil and approximately 25-30 trillion cubic feet of gas.[173] To date there have not been any large commercial discoveries, and reserves are not proven. Drilling exploration is expected to commence in 2019.

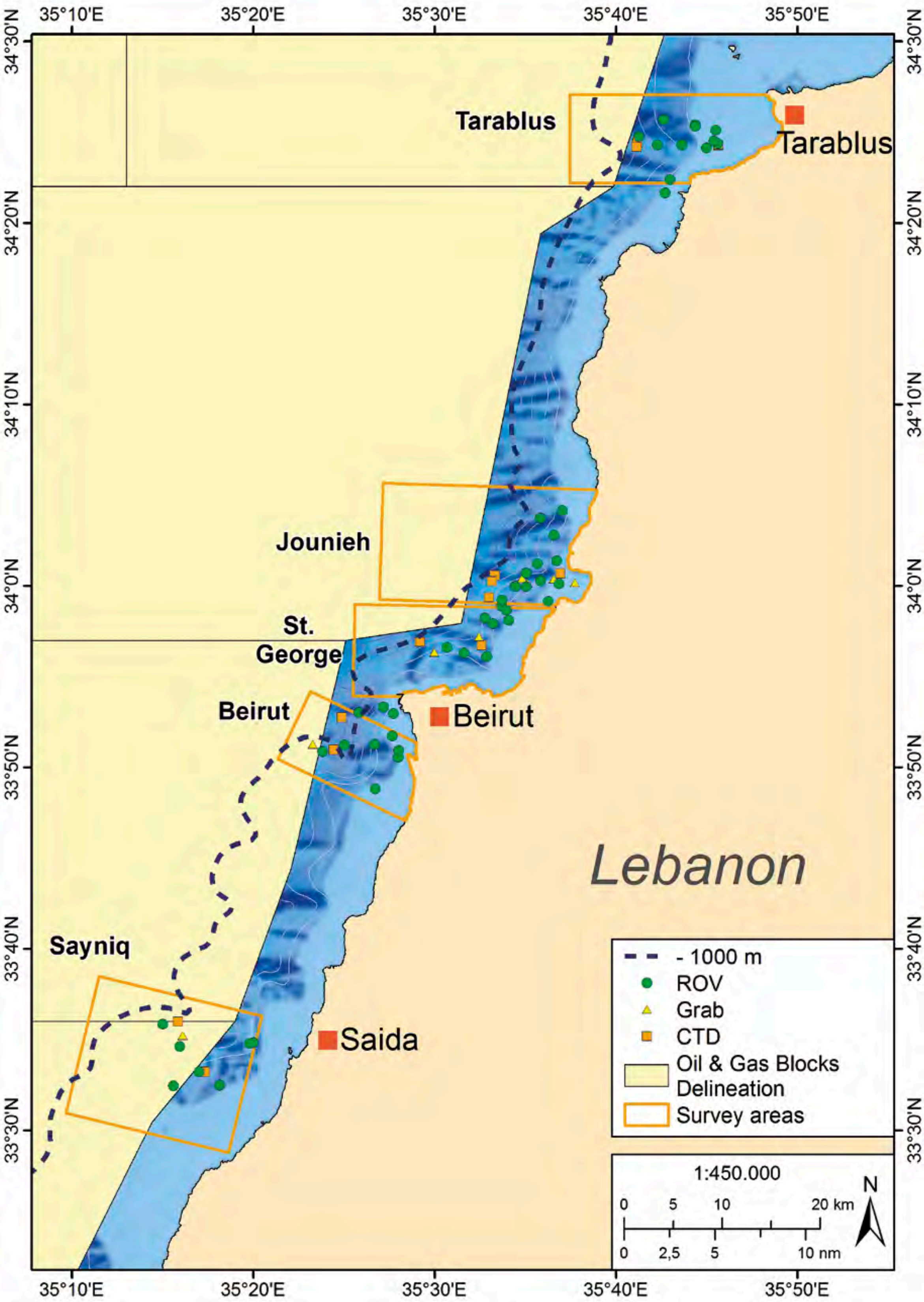
The exploratory area covers 17 901 m^2, divided into ten blocks. As shown on Map 16, most of these blocks are deeper than the areas surveyed during this expedition. Only two of the areas surveyed, Sayniq and Beirut, overlap directly with the exploratory area. In these areas, exploratory drilling would directly affect both muddy bottoms (in which dozens of species were documented, especially arthropods, fishes and echinoderms), and some patches of rocky bottoms (in which some stony corals were documented, as well as commercial species such as shrimps, dentex, rosefish, seabreams, and forkbeards).

Oil and gas exploration, apart from contributing to global climate change, can also affect other species and habitats in areas not surveyed biologically yet. The impact of leaks, as proven in other accident and routine spills could pollute extensive areas and destroy or damage vulnerable ecosystems.

CONCLUSIONS

The data obtained from the *2016 Deep-Sea Lebanon Expedition* provided a wealth of information about deep-sea benthic communities along the Lebanese coast. This information provides a scientific foundation for the development of a plan to manage and protect vulnerable ecosystems, habitats, and species in Lebanese waters, in the face of current and future threats. This plan should be developed in line with the relevant Action Plans developed by UNEP-MAP RAC/SPA, with measures being developed to protect VMEs within GFCM fisheries, and with Lebanon's legal obligations to protect species listed on Annex II of the SPA/BD Protocol of the Barcelona Convention. One critical element of this plan will be the declaration of new MPAs under the framework of a Lebanese network of MPAs. These areas may be designated to protect important geological features (e.g., submarine canyons), habitats, or community types, in order to ensure the coherence and connectivity of marine protection in Lebanese waters, and to help safeguard the natural corridor of the Eastern Mediterranean basin.

Map 16. Oil and gas exploitation blocks, in relation to survey locations.



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Annex 1

TABLE A1. LIST OF SPECIES IDENTIFIED

Species are listed according to survey area, and to sampling method. (#) Species spotted incidentally from/at the deck of the research vessel; (+) Exotic species; (*) Possible new species; (~) Possible dead coralligenous formations.

CHLOROPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Caulerpa scalpelliformis +	61.3	82.4			X			X	
Chlorophycea indet.	36.0	483.7		X	X	X		X	
Codium bursa	64.4	64.4			X			X	
Palmophyllum crassum	67.2	67.2				X		X	
Ulva sp.	58.5	58.5				X		X	
Valonia macrophysa	59.9	59.9				X		X	

OCHROPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Dictyota dichotoma	62.7	71.4			X			X	
Lobophora variegata	49.2	71.4			X	X		X	
Sargassum vulgare	62.7	68.6			X			X	
Zanardinia typus	68.6	68.6			X			X	

RHODOPHYTA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Amphiroa rigida	48.4	63.6				X		X	
cf. Corallinales indet.	59.9	61.3		X				X	
cf. Corallinales indet. (x)	86.6	255.4	X			X	X	X	
Corallinales indet.	36.0	122.6	X	X		X	X	X	X
Lithophyllum sp.	63.0	100.4	X		X			X	
Lithophyllum incrustans	46.1	80.4					X	X	
Lithothamnion sp.	61.3	71.4			X			X	
Mesophyllum lichenoides	63.6	68.9				X		X	
Mesophyllum sp.	36.0	85.5			X	X	X	X	X
Peyssonnelia rubra	66.4	66.4			X			X	
Peyssonnelia sp.	68.3	75.1			X			X	
Peyssonneliaceae indet.	36.0	90.9				X		X	
Phymatolithon calcareum	45.6	71.7			X		X	X	
Phymatolithon sp.	61.6	61.6			X			X	
Rhodophyta indet.	36.3	82.4			X	X		X	
Rhodophyta indet. (dead)	297.0	297.0				X		X	
Rhodymenia sp.	63.6	70.0				X		X	
Spongites fruticulosa	45.6	71.7					X	X	

FORAMINIFERA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Adelosina sp.	76.0	76.0		X					X
Ammodiscus cretaceous	76.0	76.0		X					X
Foraminifera indet.	99.3	102.9	X	X				X	
Heterostegina depressa +	63.0	63.0				X			X
Komokioidea indet.	53.7	175.2		X			X	X	
cf. Komokioidea indet.	61.9	80.7		X				X	
Miniacina miniacea	56.8	344.8	X	X	X	X	X	X	X
Miliolinella subrotunda	63.0	63.0				X			X
Pelosina cf. *arborescens*	53.7	905.0	X	X	X	X	X	X	
Pyrgo inornata	906.0	1015.0			X	X			X
Pyrgo sp.	63.0	63.0				X			X
Quinqueloculina sp.	64.0	76.0		X	X		X		X
Thurammina papillata	63.0	63.0				X			X

PHORONIDA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Phoronis australis	113.9	113.9			X			X	

PORIFERA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Aaptos aaptos	79.9	79.9			X			X	
Agelas oroides	47.0	180.0	X	X	X	X	X	X	
Amphilectus fucorum	64.1	64.1			X			X	
Antho sp.	87.5	96.5	X					X	
Axinella damicornis	36.0	82.1			X	X		X	
Axinella sp.	36.0	298.4	X	X	X	X	X	X	
Axinella sp.*	525.9	525.9			X			X	
Axinella verrucosa	82.1	82.1			X			X	
Biemna variantia	178.3	178.3				X		X	
cf. *Biemna variantia*	122.6	124.0				X		X	
Calyx nicaeensis	78.7	83.2			X			X	
cf. *Chelonaplysilla noevus*	171.3	171.3				X		X	
Chondrosia reniformis	53.7	74.5		X	X			X	
cf. *Chondrosia reniformis*	122.6	124.0				X		X	
Clathrina clathrus	73.4	85.5	X	X	X		X	X	
Clathrina coriacea	82.4	82.4			X			X	
Cliona rhodensis	64.1	64.1	X					X	
Corticium candelabrum	62.7	90.0	X			X		X	
Crambe crambe	36.0	78.7	X		X	X	X	X	
cf. *Crambe crambe*	46.4	133.6		X		X	X	X	

Demospongiae indet.	46.1	377.1	X	X	X	X	X	X	X
Diplastrella bistellata	127.7	127.7		X				X	
Dysidea fragilis	63.0	82.4	X		X			X	
Farrea bowerbanki	857.0	857.0		X				X	
Fasciospongia cavernosa	59.9	83.5	X	X	X	X	X	X	X
Haliclona cf. *(Gellius) angulata*	70.9	70.9	X					X	
Haliclona (Reniera) mediterranea	68.6	78.2			X			X	
Haliclona sp.	48.4	88.3		X	X	X	X	X	
Hexactinellida indet.	863.4	863.4		X				X	
Hexadella dedritifera	167.6	167.6			X			X	
cf. *Hexadella detritifera*	148.5	148.5					X	X	
cf. *Hexadella pruvoti*	133.6	174.9				X	X	X	
Hymedesmia sp.	76.0	76.0		X					X
Ircinia sp.	49.5	97.6	X	X	X		X	X	
cf. *Ircinia* sp.	53.7	133.6		X		X		X	
Ircinia variabilis	59.9	100.4		X		X		X	
Mycale sp.	172.7	172.7				X		X	
Myxilla sp.	207.8	207.8	X					X	
Oscarella lobularis	67.2	68.9	X					X	
Petrosia (Petrosia) ficiformis	36.0	37.4				X		X	
Phorbas fictitius	56.0	64.1	X	X				X	
Plakina monolopha	127.7	207.8	X	X				X	
Plakortis simplex	173.0	173.0					X	X	
Pleraplysilla spinifera	78.5	100.4	X	X	X			X	
Porifera indet.	46.4	773.7	X	X		X	X	X	
Prosuberites longispinus[39]	76.0	76.0		X					X
Sarcotragus foetidus	71.2	102.1		X			X	X	
Sarcotragus sp.	60.7	88.9	X	X			X	X	
Sarcotragus spinosulus	46.1	116.1	X	X	X		X	X	X
Scalarispongia scalaris	71.7	78.7			X		X	X	
Spongia (Spongia) officinalis	65.0	82.4		X	X		X	X	
Thenea sp.	525.9	533.5		X				X	
Timea geministellata	90.0	90.0					X	X	
Timea stellata	90.0	90.0					X	X	
Topsentia calabrisellae[39]	76.0	76.0		X					X
Ulosa stuposa	70.6	71.7	X					X	

CNIDARIA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. *Abietinaria abietina*	126.0	126.0				X		X	
Actinaria indet.	65.8	674.4	X			X		X	
Actiniidae indet.	529.3	529.3		X				X	
Adamsia palliata	86.6	113.9	X					X	

Aglaophenia octodonta	107.1	107.1	X					X	
Aglaophenia pluma	60.2	74.0		X		X		X	
Aglaophenia sp.	61.3	72.6		X	X			X	
Alcyonacea indet.	207.8	207.8	X					X	
Alcyonium palmatum	138.6	377.1	X	X	X	X	X	X	
Alcyonium sp.	175.2	215.4	X				X	X	
cf. *Anomocora* sp.*	48.4	144.5	X	X		X	X	X	
Anthozoa indet.	729.2	729.2	X					X	
Arachnanthus sp.	537.4	776.5	X	X				X	
Caryophyllia (Caryophyllia) calveri	433.7	773.7	X	X	X	X	X	X	
Caryophyllia (Caryophyllia) cf. *inornata*	287.1	287.1					X	X	
Caryophyllia (Caryophyllia) cyathus	151.3	177.7	X				X	X	
Caryophyllia (Caryophyllia) smithii	61.6	175.2	X	X			X	X	
Caryophyllia (Caryophyllia) sp.	127.2	729.2	X	X		X	X	X	
Ceriantharia indet.	822.0	822.0	X					X	
Cerianthus lloydii	885.3	885.3	X					X	
Cerianthus membranaceus	55.7	977	X	X	X	X	X	X	
cf. *Cerianthus membranaceus*	703.6	703.6		X				X	
Cerianthus sp.	61.9	849.0		X	X	X		X	
Cnidaria indet.	448.3	529.3		X				X	
Dendrophyllia ramea	172.4	172.4					X	X	
Desmophyllum dianthus	682.8	682.8				X		X	
cf. *Edwardsiella* sp.	521.1	521.1		X				X	
Epizoanthus sp.	441.3	664.0		X				X	
Eudendrium sp.	48.4	175.2	X	X	X	X	X	X	
Funiculina quadrangularis	506.2	604.4	X				X	X	
cf. Haloclavidae indet.	438.4	438.4				X		X	
Hormathia alba	473.3	979.8		X	X			X	
cf. *Hormathia digitata*	510.7	510.7				X		X	
cf. *Hydroidolina* sp.	91.1	91.1		X				X	
Hydrozoa indet.	49.2	703.6	X	X	X	X	X	X	X
cf. Hydrozoa indet.	845.7	845.7			X			X	
Lytocarpia myriophyllum	70.9	126.6	X		X			X	
cf. *Lytocarpia myriophyllum*	122.9	122.9			X			X	
Madracis pharensis	61.3	221.9	X	X		X	X	X	X
Nausithoe sp.	192.4	771.7	X	X		X	X	X	
cf. *Nausithoe* sp.	531.0	531.0		X				X	
Nemertesia antennina	46.1	121.2				X	X	X	
Nemertesia sp.	68.1	119.2	X		X			X	
Pachycerianthus sp.	860.3	860.3			X			X	
cf. *Pachycerianthus* sp.	244.7	244.7		X				X	
Paralcyonium spinulosum	173.2	192.4				X	X	X	

Pennatula rubra	65.0	206.1	X	X		X	X	X	
Pennatula sp.	126.0	198.3				X	X	X	
Pteroeides griseum	171.5	172.7					X	X	
Scleractinia indet.	175.2	175.2					X	X	
Sertularella sp.	65.2	90.0	X				X	X	
Sideractis glacialis	457.3	457.3		X				X	
Swiftia pallida	531.0	606.6		X				X	
Virgularia mirabilis	66.1	131.9	X	X	X	X		X	

	Min. depth	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
ANNELIDA									
Annelida indet.	254.6	359.7				X		X	
Bonellia viridis	59.9	977.8	X	X	X	X	X	X	
Branchiomma bombyx	93.6	93.6		X				X	
Ditrupa arietina	76.0	858.9	X	X	X			X	X
cf. *Ditrupa arietina*	846.2	846.2			X			X	
Errantia indet.	344.8	344.8				X		X	
Filograna implexa	60.7	185.6	X	X	X		X	X	
cf. *Filograna implexa*	63.6	63.6			X			X	
Hermodice carunculata	53.2	167.6	X	X	X	X	X	X	
Lanice conchilega	255.4	405.3				X	X	X	
cf. *Lanice conchilega*	295.0	774.5		X			X	X	
Myxicola aesthetica	69.5	74.5					X	X	
Myxicola infundibulum	66.4	66.4		X					
Polychaeta indet.	56.8	976.7	X	X	X	X	X	X	X
Protula intestinum	77.3	77.3	X					X	
Protula sp.	110.0	379.4	X			X		X	
Protula tubularia	120.4	644.9		X		X		X	
cf. *Protula tubularia*	192.4	491.0		X		X		X	
Sabella cf. *discifera*	172.7	172.7					X	X	
Sabella pavonina	70.6	177.7		X		X		X	
Sabella sp.	77.3	77.3	X					X	
Sabella spallanzanii	80.1	82.1			X			X	
Sabellidae indet.	63.6	472.2	X	X	X	X	X	X	X
Seraphsidae indet.	65.5	92.2	X	X		X		X	
Serpula sp.	138.6	138.6				X		X	
Serpula vermicularis	74.5	602.4	X	X		X	X	X	
Serpulidae indet.	60.2	906.0	X	X	X	X	X	X	X
Spirorbis sp.	63.8	63.8			X			X	
cf. *Vermiliopsis monodiscus*	435.6	674.4		X		X		X	

ARTHROPODA/ CHELICERATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. Pycnogonida	618.7	618.7		X				X	

BRACHIOPODA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Argyrotheca cuneata	63.0	101.0		X	X	X	X		X
Brachiopoda indet.	73.1	167.6			X	X		X	
Gryphus vitreus	462.3	975.0					X	X	
Megathiris detruncata	76.0	220.0		X			X		X
Megerlia truncata	122.3	221.9	X	X		X	X	X	X
Novocrania anomala	63.0	101.0			X	X	X		X

BRYOZOA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Adeonella pallasii	65.2	107.1		X	X		X	X	X
Adeonella sp.	63.0	121.2	X	X	X	X		X	X
Alcyonidium sp.	68.1	68.1	X					X	
cf. *Amathia* sp.	71.4	71.7					X	X	
Bryozoa indet.	63.0	545.3	X	X	X	X	X	X	X
Bugula sp.	171.5	171.5					X	X	
Caberea boryi	138.6	138.6				X		X	
Caberea ellisii	56.8	75.4	X	X		X	X	X	
Caberea sp.	61.6	113.6		X	X	X		X	
Cellaria cf. *fistulosa*	64.4	102.9		X			X	X	
Cellepora sp.	63.0	63.0				X			X
Celleporina sp.	76.0	76.0		X					X
Crisia sp.	56.8	119.2	X	X	X		X	X	
Dentiporella sardonica	76.0	76.0		X					X
cf. *Escharina* sp.	76.0	76.0		X					X
Exidmonea atlantica	76.0	76.0		X					X
Frondipora verrucosa	64.0	101.0			X		X		X
Hornera frondiculata	70.0	124.0	X	X	X		X	X	X
cf. *Licornia vieirai*	101.0	101.0					X		X
Margaretta cereoides	64.0	76.0		X			X		X
Parasmittina sp.	101.0	101.0					X		X
Pentapora fascialis	83.2	83.2			X			X	
Reteporella grimaldii	55.7	117.6	X	X	X		X	X	X
Reteporella sp.	60.7	122.6	X	X	X	X	X	X	X
cf. *Reteporella* sp.	59.9	59.9		X				X	
Rhynchozoon neapolitanum	63.0	97.3	X		X			X	

Schizomavella (Schizomavella) cf. *mamillata*	63.6	63.6	X					X	
Schizomavella sp.	56.0	69.5		X		X	X	X	
Schizoporella sp.	74.5	74.5					X	X	
Schizoretepora sp.	76.0	76.0		X					X
Scrupocellaria cf. *scrupea*	76.0	76.0		X					X
Scrupocellaria sp.	101.0	101.0					X		X
Smittina cervicornis	63.6	67.2				X		X	
Smittina sp.	68.1	120.4	X			X		X	

CHAETOGNATHA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
cf. *Sagitta* sp.	784.6	784.6			X			X	

NEMERTEA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Phoronis australis	979.0	979.0					X	X	

ECHINODERMATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Antedon mediterranea	59.9	107.1	X	X	X	X	X	X	
cf. *Antedon mediterranea*	133.6	133.6				X		X	
Asteroidea indet. (buried)	84.4	84.4		X					
Astropecten sp.	327.6	327.6			X			X	
Brissopsis lyrifera	76.0	517.0			X				X
Centrostephanus longispinus	56.0	94.2	X	X	X	X	X	X	X
Ceramaster granularis	73.4	148.5					X	X	
Chaetaster longipes	70.6	70.6		X				X	
Cidaris cidaris	62.7	949.7	X	X	X	X	X	X	X
Coscinasterias tenuispina	67.5	98.0	X	X				X	X
Echinaster (Echinaster) sepositus	49.2	133.6	X		X	X	X	X	
cf. *Echinaster (Echinaster) sepositus*	58.8	139.5				X		X	
Echinocardium sp.	64.0	64.0					X		X
Echinocyamus pusillus	101.0	101.0					X		X
Echinodermata indet.	45.6	979.2	X	X	X	X	X	X	X
Echinoidea indet.	65.2	133.6	X	X		X		X	
Genocidaris maculata	76.0	76.0		X					X
Gracilechinus acutus	520.3	834.7		X				X	
Gracilechinus cf. *elegans*	755.7	755.7	X					X	
Hacelia attenuata	65.2	221.9	X	X		X	X	X	
Hacelia sp.	121.2	121.2		X				X	

Hacelia superba	260.4	260.4		X				X	
Hymenodiscus coronata	617.8	930.3		X	X		X	X	
Leptasterias sp.	827.7	827.7		X				X	
Luidia sp.*	69.7	99.8	X		X			X	
Luidia ciliaris	71.2	71.2				X		X	
Mesothuria intestinalis	544.2	979.2	X	X	X		X	X	
cf. *Ophiopsila aranea*	59.9	59.9		X				X	
Mesothuria sp.	650.5	780.7		X				X	
Ophiopsila aranea	56.0	85.8	X	X				X	X
Ophiothrix fragilis	63.0	77.1	X	X	X			X	X
cf. *Ophiothrix* sp.	177.7	177.7				X		X	
Ophiuroidea indet.	60.2	60.2	X					X	
Peltaster placenta	86.9	269.1	X			X	X	X	
Penilpidia ludwigi	791.7	1,005.4	X		X	X	X	X	
Stylocidaris affinis	86.1	148.5		X			X	X	
cf. *Stylocidaris* sp.	431.4	431.4		X				X	
Tethyaster subinermis	194.0	367.3	X					X	

ARTHROPODA/ CRUSTACEA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Amphibalanus amphitrite	82.0	82.0		X					X
Amphipoda indet.	63.0	939.2	X		X	X		X	X
Anomura indet.	60.5	833.8	X	X	X	X	X	X	
Aristeus antennatus	302.0	827.9	X	X		X	X	X	
Balanus sp.	56.8	65.8				X		X	
Bathynectes maravigna	465.2	766.1	X	X	X		X	X	
cf. *Bathynectes maravigna*	521.1	521.1		X				X	
cf. *Bathynectes* sp.	674.4	674.4				X		X	
Brachyura indet.	77.3	781.5	X					X	
Cirripedia indet.	75.6	75.6		X				X	
Copepoda indet.	845.7	845.7			X			X	
Dardanus arrosor	212.0	212.0	X					X	
Decapoda indet.	289.7	1,012.4	X	X	X	X	X	X	
Ebalia deshayesi	95.6	95.6		X					X
Ebalia granulosa	74.0	74.0			X				X
Ethusa mascarone	90.0	90.0	X					X	
Eumalacostraca indet.	606.3	606.3	X					X	
Euphausiacea indet.	345.9	345.9				X		X	
Galathea squamifera	193.2	193.2					X	X	
Homola barbata	300.1	300.1					X	X	
Inachus sp.	56.0	73.7	X	X	X			X	
Liocarcinus depurator	76.2	76.2		X					
Macropipus tuberculatus	230.0	230.0		X				X	

cf. *Macropipus tuberculatus*	180.0	180.0			X			X	
Munida sp.	82.1	158.0			X	X	X	X	
Munidopsis marionis	551.2	800.7	X	X				X	
Munidopsis sp.	448.3	937.1		X		X	X	X	
Mysidacea indet.	291.1	979.5	X	X	X	X	X	X	
cf. Mysida indet.	691.3	695.2		X				X	
Neomaja goltziana	418.8	752.8	X			X	X	X	
cf. *Pagurus alatus*	850.4	850.4			X			X	
Pagurus alatus	284.3	979.8		X	X	X		X	
Pagurus prideaux	86.6	113.9			X			X	
cf. *Pagurus* sp.	396.8	396.8				X		X	
Parapenaeus longirostris	286.9	799.6	X	X	X	X	X	X	
cf. *Parapenaeus longirostris*	305.1	562.2		X		X		X	
Periclimenes sp.	59.9	604.4		X			X	X	
Plesionika antigai	354.9	373.2				X		X	
Plesionika edwardsii	256.2	618.7	X	X	X	X	X	X	
Plesionika gigliolii	318.9	598.5	X	X	X	X	X	X	
Plesionika heterocarpus	227.8	535.2	X	X	X	X	X	X	
cf. *Plesionika heterocarpus*	366.7	366.7				X		X	
Plesionika narval	119.5	300.1	X	X		X	X	X	
Plesionika sp.	239.3	599.9		X	X	X		X	
Scyllarus arctus	287.1	287.1					X	X	
Eusergestes arcticus	372.1	502.3	X					X	
Spinolambrus macrochelos	230.0	526.2		X	X	X		X	
Stenopus spinosus	287.1	287.1					X	X	

	Min. depth	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
MOLLUSCA									
Abra alba	74.0	906.0		X	X				X
Abra longicallus	74.0	1015.0	X	X	X	X	X		X
Abra nitida	64.0	101.0					X		X
Abra prismatica	74.0	76.0		X	X				X
Abra sp.	74.0	74.0		X	X				X
Acanthocardia paucicostata	82.0	82.0		X					X
Aequipecten opercularis	64.0	101.0	X	X	X		X		X
Anadara corbuloides	74.0	74.0			X				X
Anadara gibbosa	74.0	74.0			X				X
Anadara cf. *inaequivalvis* +	74.0	74.0			X				X
Anadara cf. *transversa* +	74.0	74.0			X				X
Anomia ephippium	90.0	175.2	X				X	X	
Antalis dentalis	74.0	1015.0			X	X	X		X
Antalis inaequicostata	64.0	101.0		X			X		X
Aporrhais pespelecani	74.0	74.0			X				X

Aporrhais serresianus	91.4	517.0	X		X			X	X
Arca noae	74.0	74.0			X				X
Argonauta argo	634.2	634.2					X	X	
Asperarca nodulosa	64.0	101.0		X			X		X
Astarte fusca	74.0	74.0			X				X
Astarte sp.	76.0	76.0		X					X
Astarte sulcata	74.0	76.0		X	X				X
Barbatia barbata	64.0	76.0		X	X		X		X
Basisulcata lepida	460.4	460.4					X	X	
Berthella cf. *stellata*	113.6	113.6				X		X	
cf. *Berthella* sp.	111.1	111.1				X		X	
Bittium latreillii	63.0	265.0		X	X	X	X		X
Bittium reticulatum	74.0	74.0			X				X
Bittium sp.	66.4	107.1	X	X	X		X	X	X
Bivalvia indet.	72.8	906			X			X	X
Bolinus brandaris	74.0	212.0	X	X	X			X	X
Bolma rugosa	76.0	76.0		X					X
cf. *Brachioteuthis riisei*	444.6	444.6		X				X	
Calliostoma sp.	76.0	906.0		X	X	X		X	X
Cardiidae indet.	74.0	173.0			X		X	X	X
Cardiomya costellata	74.0	76.0		X	X				X
Cassidae indet.	71.2	71.2	X					X	
Centrocardita aculeata	63.0	101.0		X	X	X	X		X
Cephalaspidea indet.	300.0	300.0		X					X
Cephalopoda indet.	403.6	647.2	X			X		X	
Cerithidea indet.	63.0	906.0		X	X	X			X
Cerithidium submammillatum	64.0	64.0					X		X
Cerithiopsidae indet.	63.0	76.0		X	X				X
Cerithiopsis sp.	74.0	74.0			X				X
Cerithium cf. *nodulosum* +	64.0	64.0					X		X
Circenita callipyga +	101.0	101.0					X		X
Clanculus corallinus	668	668		X					X
Clio pyramidata	63.0	544.2	X	X	X	X		X	X
Coccopigya viminensis	688.0	688.0		X					X
Copulabyssia corrugata	688.0	688.0		X					X
Corbula gibba	64.0	101.0			X		X		X
cf. *Crassopleura maravignae*	76.0	76.0		X					X
Creseis sp.	906.0	906.0			X				X
Creseis virgula	76.0	76.0		X					X
Ctena decussata	101.0	101.0					X		X
Cuspidaria cuspidata	74.0	220.0		X	X				X
Cuspidaria rostrata	74.0	74.0			X				X
Decapodiformes indet.	799.5	1,018.6		X			X	X	
Dentaliidae indet.	906.0	906.0			X				X

Digitaria digitaria	63.0	63.0				X			X
Dosinia lupinus	906.0	906.0			X				X
cf. *Dosinia lupinus*	76.0	76.0		X					X
Emarginula huzardi	63.0	76.0		X		X			X
Ennucula corbuloides	1015.0	1015.0				X			X
Ennucula tenuis	74.0	74.0			X				X
Entalina tetragona	911.0	911.0	X						X
Euspira catena	74.0	76.0		X	X				X
Flabellina sp.	138.6	138.6				X		X	
Flexopecten hyalinus	76.0	82.0		X					X
Fulvia fragilis +	74.0	76.0		X	X				X
Fusinus sp.	66.4	66.4			X			X	
Galeodea sp.	531.8	976.7			X		X	X	
Gastropoda indet.	56.0	833.8	X	X	X		X	X	X
Glans trapezia	76.0	76.0		X					X
Goodallia triangularis	74.0	74.0			X				X
Hadriania craticulata	76.0	76.0		X					X
Haedropleura flexicosta	76.0	76.0		X					X
Haminoeidae indet.	906.0	906.0			X				X
Homalopoma sanguineum	63.0	63.0				X			X
Japonactaeon pusillus	76.0	76.0		X					X
Jujubinus sp.	552.1	552.1					X	X	
Karnekampia sulcata	76.0	76.0		X					X
Kurtziela serga	906.0	906.0			X				X
Lepetellidae indet.	76.0	76.0		X					X
cf. *Licornia vieirai*	101.0	101.0					X		X
Lima lima	76.0	76.0		X					X
Limaria tuberculata	74.0	74.0			X				X
Limatula gwyni	74.0	74.0			X				X
cf. *Loligo vulgaris*	646.3	646.3		X				X	
Loligo vulgaris	90.8	90.8	X					X	
Macomangunus tenuis	76.0	76.0		X					X
Mactra olorina +	101.0	101.0					X		X
Mactra sp.	76.0	76.0		X					X
Malleus sp.	76.0	76.0		X					X
Melanella sp.	64.0	64.0					X		X
Metaxia metaxa	63.0	63.0				X			X
Mimachlamys varia	74.0	906.0		X	X				X
Mitra sp.	101.0	101.0					X		X
Mitrella coccinea	76.0	76.0		X					X
Mitrella minor	906.0	906.0			X				X
Murex forskoehlii +	70.0	70.0	X					X	X
Muricidae indet.	289.9	289.9					X	X	
Nassarius sp.	64.0	906.0		X	X	X	X		X

Naticarius stercusmuscarum	279.3	533.8					X	X	
Naticidae indet.	74.0	74.0			X				X
Neopycnodonte cochlear	55.7	178.3	X	X	X	X		X	
Nucula hanleyi	74.0	74.0			X				X
Nucula nitidosa	74.0	1,015.0		X	X	X			X
Nucula nucleus	74.0	1,015.0		X	X	X			X
Nucula sp.	82.0	82.0		X					X
Nucula sulcata	64.0	906.0		X	X		X		X
Nuculidae indet.	74.0	74.0			X				X
Nudibranchia indet.	82.7	82.7			X			X	
Ocinebrina sp.	63.0	63.0				X			X
Octopus vulgaris	65.5	358.0	X	X	X			X	
Ommastrephes bartramii	877.2	877.2	X					X	
Ommastrephes sp.	820.1	820.1			X			X	
Onychoteuthis banksii #						X			X
Pagodula echinata	300.0	300.0		X					X
Palliolum sp.	64.0	64.0					X		X
Papillicardium papillosum	63.0	101.0				X	X		X
Parvicardium exiguum	74.0	76.0		X	X				X
Parvicardium minimum	64.0	76.0		X	X		X		X
Parvicardium scabrum	74.0	74.0			X				X
Parvicardium sp.	74.0	74.0			X				X
Pecten jacobaeus	74.0	74.0			X				X
Pectinidae indet.	74.0	76.0		X	X				X
Petalopoma elisabettae	76.0	76.0		X					X
Pinna rudis	58.8	61.3					X	X	
Pododesmus patelliformis	90.0	192.9	X					X	
Pseudamussium peslutrae	161.0	161.0					X		X
Pteroctopus tetracirrhus	260.4	260.4		X				X	
Pyramidellidae indet.	76.0	76.0		X					X
Retusidae indet.	906.0	906.0			X				X
Ringicula sp.	906.0	906.0			X				X
Rissoidae indet.	75.1	83.5			X			X	
Rossia macrosoma	666.8	666.8		X				X	
cf. *Rossia macrosoma*	396.8	396.8				X		X	
Roxania sp.	906.0	906.0			X				X
Saccella commutata	64.0	1015		X	X	X	X		X
Scaphopoda indet.	76.0	879.4	X	X	X			X	X
Semisaccis granulata	170.4	170.4			X			X	
Sepia officinalis	67.8	91.4	X	X				X	
Sepia orbignyana	172.7	358.3				X	X	X	
Sepiidae indet.	521.1	811.1	X	X			X	X	
Siliquariidae indet.	74.0	74.0			X				X
Similipecten similis	74.0	76.0		X	X				X

Spondylus gussonii	756.5	756.5					X	X	
cf. *Spondylus gussoni*	477.0	477.0			X			X	
Striarca lactea	74.0	76.0		X	X				X
Taranis moerchii	668.0	668.0		X					X
Tellinidae indet.	465.7	465.7		X				X	
cf. *Tenagodus* sp.	76.0	76.0		X					X
Teuthida indet.	458.7	488.2		X				X	
Thracia convexa	76.0	76.0		X					X
Thyasira cf. *subovata*	101.0	101.0					X		X
Thyasira flexuosa	668.0	668.0		X					X
Thyasira sp.	64.0	64.0					X		X
Thylaeodus semisurrectus	63.0	63.0				X			X
Timoclea ovata	64.0	161.0		X	X		X		X
Tonna galea	239.3	239.3		X				X	
Tritia cf. heynemanni	302.0	302.0				X			X
Trochidae indet.	674.9	701.7				X		X	
Turritella turbona	63.0	76.0		X	X	X			X
Tylodina perversa	76.0	76.0			X				X
Veneridae indet.	76.0	76.0		X					X
Venus verrucosa	101.0	906.0			X		X		X
Vermetidae indet.	59.9	74.0	X	X	X			X	X
Volvarina mitrella	76.0	76.0		X					X

CHORDATA	Min. depth	Max. depth	Beirut	Jounieh	Sayniq	St. George	Tarablus/ Batroun	ROV	Grab
Anguilliformes indet.	794.8	794.8			X			X	
Anthias anthias	70.6	293.6	X	X	X	X	X	X	
Argentina sphyraena	304.6	581.3	X	X	X	X	X	X	
Arnoglossus laterna	179.7	216.5			X			X	
Arnoglossus rueppelii	226.1	366.7	X	X	X	X	X	X	
Arnoglossus sp.	458.7	458.7	X					X	
Aulopus filamentosus	193.5	193.5		X				X	
Bathypterois dubius	780.7	931.4	X	X	X		X	X	
Benthocometes robustus	531.8	531.8			X			X	
Callanthias ruber	132.7	221.9				X	X	X	
Capros aper	238.5	418.5	X			X		X	
Carangidae indet.	82.4	82.4			X			X	
Chauliodus sloani	590.3	892.4		X	X	X		X	
cf. *Cheilodipterus novemstriatus* +			X						
Chelidonichthys cuculus	87.2	87.2		X				X	
Chelidonichthys lastoviza	78.5	180.0	X		X		X	X	
Chimaera monstrosa	881.5	881.5				X		X	

Chlorophthalmus agassizi	187.6	887.0	X	X	X	X	X	X
Citharus linguatula	68.1	223.3	X	X		X		X
Coelorinchus caelorhincus	267.7	788.0	X	X	X	X	X	X
Coelorinchus sp.	418.8	930		X				X
Conger conger	164.5	164.5				X		X
Coris julis	46.1	82.4		X	X		X	X
Coryphaenoides cf. *mediterraneus*	1014.7	1014.7		X				X
Cottoidei indet.	471.9	471.9		X				X
Dalophis imberbis	869.6	869.6		X				X
Dentex macrophthalmus	151.3	460.7	X	X	X	X	X	X
Dipturus oxyrinchus	421.8	421.8				X		X
Electrona risso	464.4	464.4		X				X
Epigonus constanciae	255.4	359.7		X			X	X
Epinephelus marginatus	82.1	82.1			X			X
Equulites klunzingeri +	71.2	71.2	X					X
Etmopterus spinax	952.8	952.8	X					X
Facciolella oxyrhyncha	799.3	799.3	X					X
Fistularia commersonii +	56.8	56.8		X				X
Gobiidae indet.	71.2	128.0	X	X		X		X
Gobius gasteveni	82.7	82.7			X			X
Gobius geniporus	58.8	71.7				X	X	X
Gobius niger	110.0	110.0	X					X
Gobius sp.	61.9	81.9	X		X			X
Gobius vittatus	77.1	77.3	X		X			X
Helicolenus dactylopterus	177.7	842.6	X	X	X	X	X	X
Hoplostethus mediterraneus	363.1	991.6	X	X	X	X	X	X
Hymenocephalus italicus	358.8	979.5	X	X	X	X	X	X
Hymenocephalus sp.	415.1	491.0		X				X
Lampanyctus crocodilus	477.2	833.0	X	X			X	X
Lappanella fasciata	124.0	174.9	X	X			X	X
Lepidopus caudatus	432.5	747.5	X	X		X		X
Lepidorhombus boscii	582.7	582.7	X					X
Lepidorhombus whiffiagonis	285.2	424.7	X	X		X	X	X
Lepidotrigla cavillone	89.4	114.2	X					X
Lesueurigobius friesii	72.6	340.3	X	X	X			X
Lesueurigobius sp.	60.7	320.9		X	X		X	X
Lesueurigobius suerii	90.0	241.9	X					X
Lobotes surinamensis #						X		
Lophius budegassa	474.2	474.2					X	X
Macroramphosus scolopax	107.1	332.7	X	X	X	X	X	X
Macrouridae indet.	363.1	925.8		X		X		X
Merluccius merluccius	294.2	388.4		X		X		X
Mullus surmuletus	173.0	173.0					X	X
Muraena helena	46.4	46.4					X	X

Mycteroperca rubra	81.8	81.8			X			X	
Myctophidae indet.	420.2	881.5		X	X	X	X	X	
Nemichthys scolopaceus	672.1	672.1					X	X	
Nemipterus randalli +	68.6	100.7	X					X	
Nettastoma melanurum	487.4	1045.3	X	X	X	X	X	X	
Nettastomatidae indet.	682.0	881.5	X	X		X		X	
Nezumia aequalis	536.6	1,005.4	X	X	X		X	X	
Nezumia sclerorhynchus	536.3	898.0	X	X		X		X	
Nezumia sp.	538.0	948.0	X	X	X		X	X	
Ophisurus serpens	192.1	192.1	X					X	
Ostorhinchus fasciatus +	65.5	89.4	X	X				X	
Pagellus bogaraveo	177.7	504.8			X	X	X	X	
Pagellus erythrinus	69.2	92.0	X	X				X	
Pagellus sp.	65.5	65.5	X					X	
Parablennius pilicornis	48.4	48.4				X		X	
Parablennius rouxi	81.0	81.8			X			X	
Peristedion cataphractum	334.1	375.2	X	X				X	
Phycis blennoides	645.1	942.7		X	X	X	X	X	
Phycis phycis	148.5	192.9	X				X	X	
Pisces indet.	63.3	979.0	X	X	X	X	X	X	
Pleuronectiformes indet.	80.1	375.2	X	X		X		X	
Pterois miles +	49.5	85.5			X		X	X	
Sargocentron rubrum +	36.0	47.0				X	X	X	
Scorpaena elongata	127.7	441.8	X	X	X	X	X	X	
Scorpaena notata	61.9	344.8	X	X		X		X	
Scorpaena porcus	49.5	119.8	X				X	X	
Scorpaena scrofa	62.4	419.0	X	X		X	X	X	
Scorpaena sp.	80.7	88.0	X	X				X	
Scorpaeniformes indet.	435.3	435.3				X		X	
Seriola dumerili	62.7	133.6		X	X		X	X	
Serranidae indet.	113.6	113.6				X		X	
Serranus cabrilla	46.1	171.5	X	X	X	X	X	X	
Serranus hepatus	61.6	178.3	X	X	X	X	X	X	
Serranus scriba	61.6	61.6		X				X	
Serranus sp.	90.0	90.0	X					X	
Siganus luridus +	36.0	49.5				X	X	X	
Sparidae indet.	198.3	198.3				X		X	
Stephanolepis diaspros +	63.6	63.6			X			X	
Stomias boa	399.3	861.4		X	X	X	X	X	
Stomiidae indet.	448.3	448.3				X		X	
Stomiiforme indet.	696.0	696.0			X			X	
Symphurus ligulatus	778.7	849.9	X	X	X			X	
Symphurus nigrescens	122.6	226.1			X			X	
Symphurus sp.	408.1	408.1	X					X	
Synchiropus phaeton	304.6	474.6	X	X	X	X	X	X	

Syngnathus acus	65.5	65.5					X	X	
Synodus saurus	69.2	69.2	X					X	
Synodus synodus	266.9	266.9	X					X	
Thorogobius ephippiatus	94.2	341.4	X	X		X	X	X	
Torquigener flavimaculatus +	63.0	110.2	X		X		X	X	
Tripterygion melanurum	70.0	70.0			X			X	
Tursiops truncatus #				X					

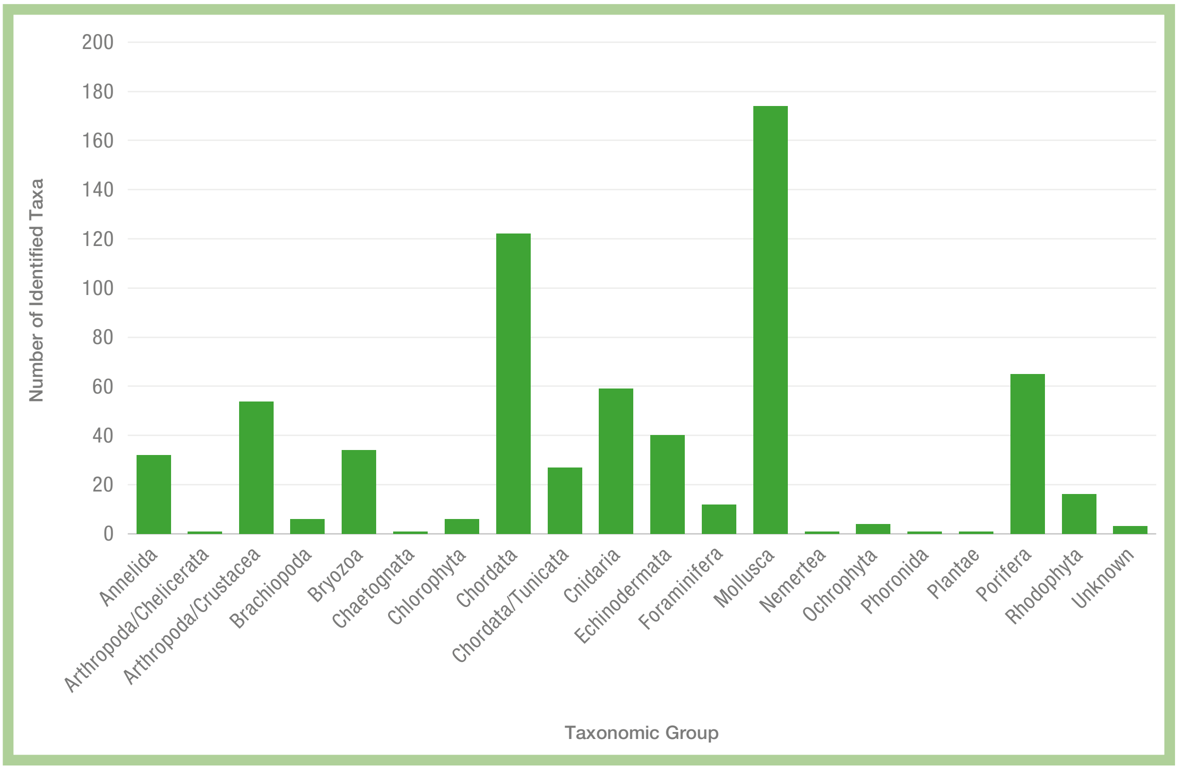
CHORDATA/TUNICATA	**Min. depth**	**Max. depth**	**Beirut**	**Jounieh**	**Sayniq**	**St. George**	**Tarablus/ Batroun**	**ROV**	**Grab**
Aplidium sp.	60.5	60.5	X					X	
Aplousobranchia indet.	69.2	72.0	X				X	X	
Ascidia conchilega	157.8	157.8		X				X	
Ascidia cf. *mentula*	70.9	102.1	X				X	X	
Ascidia sp.	77.1	95.6	X					X	
Ascidiacea indet.	56.0	551.2	X	X	X			X	
Ascidiella cf. *aspersa*	69.2	119.2	X					X	
cf. Ascidiidae indet.	78.5	83.5	X					X	
cf. Botryllinae indet.	63.0	63.0	X					X	
Botrylloides sp.	38.8	39.1				X		X	
Cystodytes sp.	56.0	57.7		X				X	
Cystodytes dellechiajei	67.5	82.0	X		X		X	X	
Diazona violacea	80.1	126.3	X	X	X	X		X	
Didemnum fulgens	70.6	83.5	X	X	X			X	
Didemnum sp.	53.2	116.1	X	X	X	X	X	X	
Halocynthia papillosa	70.6	163.1	X	X	X	X	X	X	
Microcosmus cf. *vulgaris*	69.2	69.2	X					X	
Pseudodistoma cf. *cyrnusense*[38]	65.2	71.7					X	X	
Polysyncraton lacazei	71.7	71.7					X	X	
cf. *Polysyncraton* sp.	83.5	83.5		X				X	
cf. *Polyzoinae indet.*	81.8	81.8			X			X	
Pycnoclavella cf. *communis*	69.0	71.0	X			X		X	
Pycnoclavella sp.	39.1	71.4	X			X		X	
cf. *Pycnoclavella* sp.	38.8	53.2				X		X	
Pyura dura	63.0	64.1	X					X	
Pyuridae indet.	107.1	107.1	X					X	
Rhopalaea cf. *hartmeyeri*[38]	60.2	93.4	X	X			X	X	
Rhopalaea sp.	68.1	78.5	X					X	
Styela cf. *canopus*	78.0	107.0	X					X	
Styela sp.	119.2	119.2	X					X	
Styelinae indet.	56.0	84.1		X	X			X	
Tunicata indet.	66.4	66.4			X			X	

TABLE A2. LIST OF THREATENED SPECIES IDENTIFIED

Species are listed that are either included on Annex II or III of the SPA/BD Protocol of the Barcelona Convention, and/or have been assessed by IUCN as threatened (i.e., Vulnerable (VU), Endangered (EN), or Critically Endangered (CR)) or Near Threatened (NT) in the Mediterranean Sea.

Phylum	Species	Listed on Annex II (SPA/ BD Protocol)	Listed on Annex III (SPA/ BD Protocol)	IUCN Red List Threat Status in the Mediterranean	Reference
Arthropoda/Crustacea	*Scyllarus arctus*		X		43
Chordata	*Chimaera monstrosa*			NT	26
Chordata	*Dipturus oxyrhincus*			NT	26
Chordata	*Epinephelus marginatus*		X	EN	26, 43
Chordata	*Merluccius merluccius*			VU	26
Chordata	*Tursiops truncatus*	X		VU	26, 41
Cnidaria	*Dendrophyllia ramea*	X		VU	26, 53
Cnidaria	*Desmophyllum dianthus*	X		EN	26, 53
Cnidaria	*Funiculina quadrangularis*			VU	26, 53
Cnidaria	*Pennatula rubra*			VU	26, 53
Echinodermata	*Centrostephanus longispinus*	X			41
Mollusca	*Pinna rudis*	X			41
Mollusca	*Tonna galea*	X			41
Porifera	*Sarcotragus foetidus*	X			41
Porifera	*Spongia (Spongia) officinalis*		X		43

FIGURE A1. NUMBER OF IDENTIFIED TAXA, ACCORDING TO BROAD TAXONOMIC GROUP



Annex 2

Annex 2. Methodology for assesing relative conservation interest of survey areas

Spatially-referenced data from the underwater surveys, at a resolution of 500 m x 500 m, were combined for the key communities, protected and/or threatened species, and particular species of interest (see Table 1), as follows:

1) Key communities were scored for their relative abundance, according to the same categories shown in Table 1 (high: 3 points; medium: 2 points; and low: 1 point). They were also scored according to whether they were included in the UNEP-MAP RAC/SPA *Action Plan for the conservation of habitats and species associated with seamounts*, *underwater caves and canyons*, *aphotic hard beds and chemo-synthetic phenomena in the Mediterranean Sea* or the *Action Plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea* (2 points if included; 1 point if not included). These two scores were multiplied, yielding a maximum value of 6 points. (See Figure 41a).
2) Protected and/or threatened species were also scored according to whether they were Red Listed (Endangered: 3 points; Vulnerable: 2 points; Near Threatened: 1 point) and/or listed under Annex II or Annex III of the SPA/BD Protocol of the Barcelona Convention (Annex II: 3 points; or Annex III: 2 points). These two scores were added together (for a value of up to 6 points), and multiplied by a third score, which was based on their relative abundance, according to the same categories shown in Table 1 (≥10 individuals: 3 points; >1 and <10 individuals: 2 points; 1 individual: 1 point). The maximum value was 18 points. (See Figure 41b).
3) Other species of particular interest were scored according to whether they were new species recorded from Lebanon (3 points), rare species for the Mediterranean (2 points), or other species of general scientific interest (1 point). They were also scored for their relative abundance, according to the same categories shown in Table 1 (≥10 individuals: 3 points; >1 and <10 individuals: 2 points; 1 individual: 1 point). These two scores were multiplied, yielding a maximum value of 9 points. (See Figure 41c).
4) Each of the three indices was rescaled to fall between 0 and 1. The three indices were then added together, yielding the final index of conservation interest, shown in Map 15.

Annex 3

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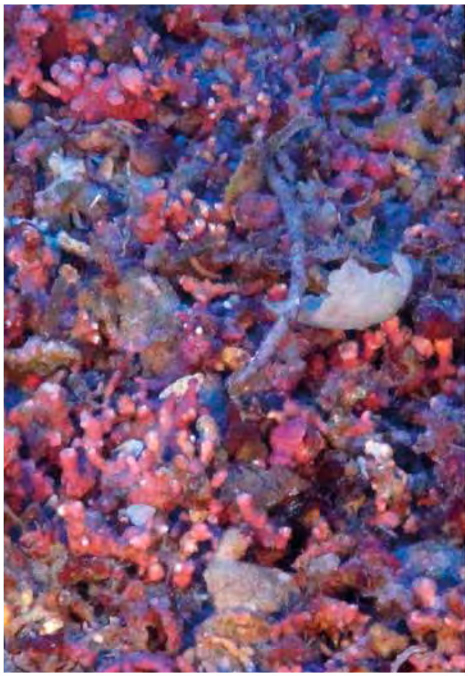

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