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National Monitoring Programme for Biodiversity in Lebanon

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NATIONAL MONITORING PROGRAMME FOR BIODIVERSITY IN LEBANON

Ghazi BITAR, Ghassan RAMADAN JARADI, Souad HRAOUI-BLOQUET, Myriam LTEIF

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ACRONYMS

ACCOBAMS: Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area
AEWA: African Eurasian Migratory Water Birds Agreement
CANA: Research Vessel
CARLIT: CARtografia LIToral
CBD: Convention on Biological Diversity
CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNRSL: Conseil National de la Recherche Scientifique- Liban
CoM: Council of Ministers
EcAp: Ecosystem Approach
EIA: Environmental Impact Assessment
ENPI: European Neighborhood and Partnership Instrument
ENVIMED: Environment in the Mediterranean
EOs: Ecological Objectives
EO1: Ecological Objective 1
EO2: Ecological Objective 2
EO3: Ecological Objective 3
EQR: Ecological Quality Ratio
ETM: éléments traces métalliques
FAO: Food and Agriculture Organisation
GEF: Global Environment Facility
GES: Good Environmental Status
GoL: Government of Lebanon
IEE: Initial Environmental Examination
IMAP: Integrated Monitoring and Assessment Programme
IUCN: International Union for Conservation of Nature
LEDO: Lebanese Environment and Development Observatory
LU: Lebanese University
MAP: Mediterranean Action Plan
MERMEX: Marine Ecosystems Response in the Mediterranean Experiment
MoA: Ministry of Agriculture
MoE: Ministry of Environment
MoPWT: Ministry of Public Works and Transport
MPA: Marine Protected Areas
NBSAP: National Biodiversity Strategy and Action Plan
NCMS: National Centre for Marine Sciences
NGO: Non-Governmental Organization
NIS: Non-Indigenous Species
NMPs: National Monitoring Programme
NMPB: National Monitoring Programme for Biodiversity
NMPBL: National Monitoring Programme for Biodiversity in Lebanon
NMPL: National Monitoring Programme in Lebanon
NMPLF: National Monitoring Programme for Ficheries in Lebanon
NMPLNIS: National Monitoring Programme for Non-Indigenous Species in Lebanon
NRCI: National Research Council (Italy)
RAC/SPA: Regional Activity Centre for Specially Protected Area
Ramsar: Convention on Wetlands of International Importance especially as Waterfowl Habitat
SEA: Strategic Environmental Assessment

SPA/RAC: Specially Protected Area Regional Activity Centre
UMR: UNEP/MAP-RAC/SPA
UNFCCC: United Nations Framework Convention on Climate Change
UNEP: United Nations Environment Programme
UNESCO: United Nation Educational, Scientific and Cultural Organization
UoB: University of Balamand

Introduction and general framwork

The Ecosystem Approach (EcAp) is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, as stated by the Convention of Biological Diversity. This process aims to achieve the Good Environmental Status (GES) in the Mediterranean through the elaborated 11 Ecological Objectives (EO) and their respective common indicators.

The Specially Protected Area Regional Activity Centre (SPA/RAC) is committed to implement the EcAp roadmap particularly related to Biodiversity (EO1) and Non-Indigenous Species (NIS) (EO2).

First phases of the EcAp process led to the accomplishment of 5 steps out of the 7 scheduled steps such as: 1) Definition of an Ecological Vision for the Mediterranean; 2) Setting common Mediterranean strategic goals; 3) Identification of an important ecosystem properties and assessment of ecological status and pressures; 4) Development of a set of ecological objectives corresponding to the Vision and strategic goals; and 5) Derivation of operational objectives with indicators and target levels.

The remaining 2 steps will include: 6) Revision of existing monitoring programmes for ongoing assessment and regular updating of targets; and 7) Development and review of relevant action plans and programmes.

The 19th Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean, (hereinafter the Barcelona Convention) adopted the Integrated Monitoring and Assessment Programme (IMAP), through a participatory process involving Contracting Parties and the scientific community.

The Specially Protected Areas Regional Activity Centre (SPA/RAC) in the framework of the Mediterranean Action Plan of the United Nations Environment Programme (UNEP/MAP) is involved in the implementation of the Ecosystem Approach (EcAp) in the Mediterranean Sea. In order to address the challenges related to the next steps of EcAp Roadmap implementation in an integrated manner and the implementation of IMAP, SPA/RAC is charged to assist the concerned countries in several activities among them the development of country-specific EcAp monitoring programme for biodiversity (EO1) and NIS (EO2).

NATIONAL MONITORING PROGRAMME FOR BIODIVERSITY IN LEBANON (NMPB)

This national montoring programme includes these 3 Ecological Objectives (EOs):

- EO1: Biodiversity related to habitats and species: marine mammals (Cetacean and monk seal), marine turtles and sea birds.
- EO2: Non-indigenous species (NIS)
- EO3: Fisheries

NATIONAL MONITORING PROGRAMME FOR BIODIVERSITY IN LEBANON (NMPB) – EO1 (HABITATS BENTHIQUES)

By
Ghazi BITAR

I. Introduction

According to the United Nations /Convention of the Biological Diversity (UN-CBD), BD generally abbreviated as "biodiversity", is "the variety of life on earth" and includes the diversity of ecosystems, species and genes, and the ecological processes that support them.

By 2030, Lebanon's vision for biodiversity adopted in the NBSAP is to sets a significant challenge for Lebanon in taking the appropriate measures to halt the decline in biodiversity; these measures are presented under thirteen **(13) Priority Areas**: (1) Threatened Species, (2) Genetic Diversity, (3) Protected Areas, (4) Sustainable Management and use of Natural Ecosystems and Resources, (5) Ecosystem Restoration, (6) Access and Benefit Sharing, (7) Invasive Alien Species, (8) Communication, Education and Public Awareness, (9) Mainstreaming Biodiversity into National and Sub-National Policies and Plans, (10) Climate Change, (11) Research and Knowledge Transfer, (12) Institutional and Legal Framework, and (13) Resource Mobilization. The Action Plan to reach the Vision includes **18 National Targets** and their respective **91 National Actions**. The national targets reflect the identified priority areas and are based on the result of the review of the past NBSAP guided by the Aichi Biodiversity Targets. Progress towards the identified national targets entailed the development of the 91 national actions (institutional, technical, legislative, economic or other policy actions); which consist of a continuation of existing programs and practices and include new initiatives based on altering circumstances and evolving science (MoE/UNEP/GEF. 2016).

Marine biodiversity in Lebanon has 207 species of macrophytes (Lakkis, 2013) including 29 non-native species (NIS) (Bitar et al., Submitted), 1072 species of invertebrates including about 156 NIS, 309 species of fish reported in Lebanon of which 52 NIS (Bitar unpubl. data), 5 turtles, 77 birds and 7 mammals.

II. Issues of the marine habitats monioring programme

The objective of the marine habitats monitoring programme (EO1) is to assess the ecological status and their associated species as well as the threatened or concerved species listed in the appendices of the various conventions related to the conservation of marine environment. The habitats concerned are those located from the coast to the circalittoral level. The objective is the achievement or maintenance of the good ecological status of marine habitats and species while measuring the various parameters of the environment as well as the different impacts or pressures of human activities and finally considering the necessary measures to limit the pressures in question. This falls within the framework of the Good Environmental Status (GES).

III. Commun indicators (ICs) of the ecological objective 1 "biodiversity" relaed to marine habitats

CI 1 : Habitat distributional range, to also consider habitat extent as a relevant attribute
IC2: Condition of the habitat's typical species and communities.

This section is based partiulary on the work of G.Bitar and his personal observations for more than 35 years, the results of the Lebanese-French cooperation missions (CEDRE project (1999-2003) and Lebanese-Spanish (MoE, AECID, TRAGSA, 2009) as well as the results of the MedMPAnet project in Lebanon (RAC / SPA - UNEP / MAP., 2014) which aimed, inter alia, at the ecological characterization of marine habitats in order to develop an action plan for sites of interest for conservation.

The commun indicators of this programme include: the habitat's distributional range and the condition of typical species and communities for each habitat.
Les indicateurs du programme incluent : les habitats et l'aire de leurs répartitions ainsi que les conditions des espèces typiques de chaque habitat. The state of the target species, especially the species considered as threatened, to protect or of interest for the conservation are also mentioned.

For the characterization of the different types of the benthic habitats and their codes, we took as a refrence the «Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest» (UNEP-MAP - RAC/SPA, 2015).

III.1. Marine biodiversity in Lebanon

Currently, the total number of species recorded in Lebanon is about 1588 species divided into 207 Macrophytes (according to the tables of Lakkis, 2013, while the current number of these macrophytes: Chromobionta, Rhodobionta, Chlorobionta and Streptobionta is certainly higher) including 29 NIS (Bitar et al., 2017), 1072 invertebrates (not counting softwood nematodes) including about 156 non-indigenous species (NIS), 309 fish actually reported in Lebanon including 52 NIS (Bitar unpublished data). The invertebrate fauna (far from being exhaustive) is divided into 19 zoological groups: Foraminifera (2), Sponges (99), Cnidarians (64), Turbellariates (2), Nemertes (3), Nematodes (2), Endoproctes (1), Bryozoa (93), Phoronidians (1), Brachiopods (5), Sipuncliens (2), Polychaetes (190), Mollusks (373), Crustaceans (164), Pycnogonides (6), Echinoderms (29), Enteropneustes (1), Pterobranch (1) and Ascidians (38) (Bitar unpublished data).

III.2. Species with heritage value and interest for conservation

The species included in this paragraph are protected species, plus other species that deserve to be protected.
Each species is presented by its conservation status, geographical distribution, habitats, threats and the Lebanon distribution with some recorded observations. The protection degree of the different Conventions and Directives:

- Barcelona Convention (1995, with the Marrakech-2009 and Istanbul-2013 amendments): annex II, endangered or threatened species; annex III, species whose exploitation must be regulated.
- Bern Convention (1996, 1998): annex I, strictly protected flora species; annex II, strictly protected fauna species; annex III, protected fauna species.

- Directive 92/43 CE on the conservation of natural habitats and of wild fauna and flora, European Commission: annex I, natural habitat types whose conservation requires the designation of special areas of conservation; annex II, species requiring designation of Special Areas of Conservation; annex IV, species in need of strict protection; annex V, species whose taking from the wild can be restricted.
- Washington Convention. Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES): appendix I, species that are the most endangered and threatened with extinction CITES; appendix II, species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled; appendix III, species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.
- Mediterranean Flora 'Red Book' (UNEP/IUCN/GIS-Posidonia, 1990).

Besides the species, with conservation interest some of economic interest were included too.

III.2.1. MACROPHYTA

Table 1 shows a list of the macrophytes that are under Mediterranean protection and have been observed in Lebanon.

Table 1. Marine Macrophyta of special interest, observed in Lebanon. (MRB) Mediterranean Flora Red Book; (EU) Habitat Directive European Union (1992); (BaC) Barcelona Convention (1995); (BeC) Bern Convention (1996-98).

MACROPHYTA	MRB	EU	BaC	BeC
Ocrophya				
Cystoseira amentacea amentacea	-	-	II	-
Cystoseira dubia	-	-	II	-
Cystoseira foeniculacea	+	-	II	-
Sargasssum tricocarpum	-	-	II	-
Rhodophyta				
Lithothamnion corallioides	+	V	-	-
Phymatolithon calcareum	+	V	-	-
Magnoliophyta				
Cymodocea nodosa	+	-	II	I

***Cystoseira amentacea amentacea* (C. Agardh) Bory de Saint-Vincent, 1832.**

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009 amendment). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species.
Geographical distribution: This mediterranean species is represented in the three major areas of the Mediterranean by different geographical varieties of this *Cystoseira*. The association with *Cystoseira amentacea amentacea* is endemic in the eastern Mediterranean, whereas *Cystoseira amentacea stricta* is found in the north-western Mediterranean and the *spicata* variety in the Adriatic (UNEP-MAP-RAC/SPA., 2015).
Habitat: Grows in exposed places, in the upper limit of the infralittoral stage.

Threats: Pollution from urban, agricultural, industrial and port areas, coastal development, concreting and the destruction of vermetid platforms, overgrazing by herbivores, global change and non-indigenous species.
Observations: Species encountered at Nakoura and in the Palms Islands Natural Reserve but for several years, it has become very infrequent (Bitar, personal observation).

Cystoseira dubia Valiante, 1883

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009 amendment). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species.
Geographical distribution: Endemic species of the Mediterranean Sea. SW-Italy, Sicily, Adriatic Sea and Mediterranean Eastern basin.
Habitat: Infralittoral and upper circalittoral rock, and coastal detritic bottoms, between 25 and 170 m depth.
Threats: Hyper-sedimentation, sediment dumping, turbidity, trawling, pull up by trammel nets, global change and non indigenous species.
Observations: encountered generally in the northern sector of the country (Ras Chekaa) from 30 to 42 m deep. Uncommon on rocky substratum and rhodoliths.

Cystoseira foeniculacea (Linnaeus), Greville, 1830

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009 amendment). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species. Mediterranean Flora 'Red Book' (UNEP/IUCN/GIS- Posidonia, 1990).
Geographical distribution: Atlanto-Mediterranean species. NE-Atlantic (southern Spatin to Canary Islands) and Mediterranean Sea (*Cabioch et al.*, 1995; *Ribera et al.*, 1992).
Habitat: Infralittoral species on rocky substratum, from calm shallow waters (littoral pools) to sciaphilic lower horizon, 0-50 m depth (UNEP /IUCN/GIS Posidonie, 1990; *Cabioch et al.*, 1995; Gomez-Garreta, 2001).
Threats: Sediment dumping, hyper-sedimentation, organic pollution, land reclamation, littoral dynamic alterations (marinas, ports), global change and non-indigenous species.
Observations: Attached on the flat rock and cobbles; where it forms sparse 'forests'. *C. foeniculacea* is abundant in the lagoon created between the northern beach and the inlets, on cobbles which are moved by the swell. Encountered from the south of Saida to Nakoura; 5 to 15 m depth.

Sargassum trichocarpum J. Agardh, 1848

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009 amendment). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species.
Geographical distribution: Endemic species of the Mediterranean Sea. From the Iberian Peninsula to the Eastern Mediterranean basin (Ribera *et al.*, 1992).
Habitat: Infralittoral on rocky substratum, down to 30 m depth (Gomez-Garreta *et al.*, 2001).
Threats: Hyper-sedimentation, turbidity, sediment dumping, land reclamation, and pull up by trammel nets, global change and non-indigenous species.
Observations: Rare species, on rocky substratum in the lower infralittoral. Observed in the north (Enfeh-Ras Chekaa); 28-30 m.

***Lithothamnion corallioides (*P. L. Crouan & H.M.Crouan, 1867)**

Protection status: The maerl beds (including *L. corallioides*) have been included in the Mediterranean Action Plan for the Conservation of the Coralligenous and Other Calcareous Bio-concretions. Species whose taking from the wild can be restricted (Annex V, EU Habitats Directive 92/43). Mediterranean Flora 'Red Book' (UNEP/IUCN/GIS-Posidonia, 1990) as maerl habitat.
Geographical distribution: Atlanto-Mediterranean species. Eastern Atlantic (from Ireland to the Cape Verde Islands) and the Mediterranean Sea (www.algaebase.org).
Habitat: Circalittoral maerl forming species on coarse sand and fine gravel, and low muddy fraction subject to bottom currents also, on lower infralittoral.
Threats: Sediment dumping, hyper-sedimentation, pull up by fixed bottom nets, trawling.
Observations: Common in Lebanon (Palm Islands Nature Reserve, Ras Chekaa, Tyre and Nakoura (35 to 47 m depth. Normally with *Spongites fruticulosum* (c) and *Phymatolithon cf. calcareum* (r),

***Phymatolithon calcareum* (Pallas) (Adey & McKibbin, 1970)**

Protection status: The maerl beds (including *P. calcareum*) have been included in the Mediterranean Action Plan for the Conservation of the Coralligenous and Other Calcareous Bio-concretions. Species whose taking from the wild can be restricted (Annex V, EU Habitats Directive 92/43). Mediterranean Flora 'Red Book' (UNEP/IUCN/GIS-Posidonia, 1990) as maerl habitat.
Geographical distribution: Wide range of geographical distribution in the Atlantic, Pacific, Antarctic, and Mediterranean Sea.
Habitat: Circalittoral maerl forming species on coarse sand and fine gravel, and low muddy fraction subject to bottom currents, with Lithothamnion coralliodes and Spongites fruticulosum also, on lower infralittoral horizon.
Threats: Sediment dumping, hyper-sedimentation, pull up by fixed bottom nets, trawling.
Observations: Rare in the Eastern Mediterranean basin. In Lebanon, it has only been observed on the deeper maerl beds (Palm Islands Nature Reserve, Ras Chekaa; 40-67 m).

Cymodocea nodosa (Ucria) (Ascherson, 1870)

Protection status: Endangered or threatened species (Annex II, Barcelona Convention, Marrakech-2009 amendment); strictly protected flora species (Annex I, Bern Convention 1996-98). Also, the *Cymodocea* meadows are located in the natural habitats of community interest (Annex I, Habitat Directive 92/43): sandbanks which are slighly covered by sea water all the time (1110); and large shallow inlets and bays (1160).
Geographical distribution: Atlanto-Mediterranean species. NEAtlantic (Southern Spain to Mauretania) and the Mediterranean Sea.
Habitat: Infralittoral species on sand and muddy sand bottoms, from shallow waters to a 50 m depth; and coastal lagoons.
Threats: Sediment dumping, hyper-sedimentation, organic pollution, land reclamation, littoral dynamic alterations (marinas, ports), global change.
Observations: Common in the north secteur of Lebanon (Enfeh, Ras Chekaa, Hannouch, Selaata. On the other hand, it has been rare in the southern sector of Lebanon, it has been

observed at the front of the south beach of Tyre. *Cymodocea nodosa* colonizes the sandy and muddy sand bottoms. The meadows are developed in shallow waters (1-4 m depth). Noteworthy is the abundance of germinated seeds in June of 2012, that colonised the deeper sediments (as far as 31 m depth) (UNEP-MAP - RAC / SPA, 2015).
Other protected Macrophyta: Other protected Macrophyta (Annex II, Barcelona Convention) have been observed from Lebanon.

- **Titanoderma trochanter** (Bory de Saint-Vincent) Benhissoune, Boudouresque, Perret-Boudouresque & Verlaque 2002.
  This species was first encountered in May 1993 at Ramkine Island of the Palm Islands Natural Reserve with Lithophyllum tortuosum. Currently they are both very rare (Bitar, personal observations).
- **Zostera noltii Hornemann, 1832.**
  It was reported in Lebanon in 2000 (Lakkis & Novel-Lakkis, 2000) while it was never found since 1993 (Bitar, personal observations).

III.2.2. INVERTEBRATA

The important marine invertebrates observed in the Lebanon sea that are under protection are indicated in the table 2.

Table 2. Marine invertebrata of special interest. (**EU**) Habitat Directive European Union (1992); (**BaC**) Barcelona Convention (1995, 2009, 2013); (**BeC**) Bern Convention (1996-1998); (WC) Washington Convention or CITES (2013).

Species	BaC	BeC	EU	WC
Porifera				
Aplysina aerophoba	II	II	-	-
Aplysina sp. nov	II	II	-	-
Axinella polypoides	II	II	-	-
Spongia officinalis	III	III	-	-
Cnidaria				
Cladocora caespitosa	II	-	-	II
Phyllangia mouchezii	-	-	-	II
Mollusca				
Dendropoma petraeum	II	II	-	-
Erosaria spurca	II	II	-	-
Luria lurida	II	II	-	-
Tonna galea	II	II	-	-
Pinna nobilis	II		IV	-
Lithophaga lithophaga	II	II	IV	II
Echinodermata				
Paracentrotus lividus	III	III	-	-

Aplysina aerophoba (Nardo, 1833)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to be included in the list of endangered or threatened species *Aplysina* spp. plur.
Geographical distribution: Atlanto-Mediterranean species. Eastern Atlantic (from Southern Portugal to Cape Verde, Canary and Madeira Islands), Mediterranean Sea.

Habitat: It is a photophilic species that alive on infralittoral rocky bottoms, preferably in shallow waters, although it has been spoted at 40m depth.
Threats: Sediment dumping, anchoring, collection by divers.
Observations: Very common in the Northern Lebanon, particularly in the Enfeh area and less common in Ras Chekaa, Batroun and Tabarja. Very rare in the Southern sector, observed in Nakoura and Tyre. The species has been observed on photophilic/hemi-sciaphilic rocky substrata, between 0 to 30m depth, mainly in shallow waters (2-8 m depth).

***Aplysina* sp. Nov**

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it on the list of endangered or threatened species *Aplysina* spp. plur.
Geographical distribution: At present, only observed in Lebanon.
Habitat: This species has only been sampled in shallow caves (1-5m depth).
Threats: Organic pollution, erosion by diving, land reclamation, littoral works (marinas, ports), global change.
Observations: The species has only been observed in very located caves (Very common in Raoucheh cave and common in Ras El Bayada caves, rare in Kafar Abida cave).

Axinella polypoides Schmidt, 1862

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species
Geographical distribution: Atlanto-Mediterranean species. NE-Atlantic (Southern United Kingdom to Mauretania, Azores, Madeira and Canary Islands) and the Mediterranean Sea.
Habitat: Typical circalittoral species that colonizes horizontal and vertical surfaces on rocky substrata. Also, the species is present in infralittoral enclaves on crevices and overhangs. It has a bathymetric range from 15 to >300m depth, although it is more abundant in the upper circalittoral horizon (40-50m depth).
Threats: Sediment dumping, pull up by fixed bottom nets, trawling, anchoring, erosion and/or collection by divers.
Observations: *A. polypoides* is present in a coralligenous community, overhangs, vertical surfaces and crevices in the infralittoral lower horizon (25 to 47 m). Common in the south Secteur Tyre and Nakoura, rare in Ras Chekaa area and very rare in Saida.
The family of Axinellidae is well represented in the Lebanon area, where another 4 species are encountered: *Axinella Cannabina* (rare), *Axinella damicornis* (rare), *Cymbaxinella sp. nov* is located in the entrance of littoral caves (identified by J. Vacelet et T. Pérez). It was found at the first time by Bitar in Ras Chakaa (Bouknai cave) in the framework of CEDRE project and studied later in the framework of ECIMAR project (2007-2011). The Fourth *Axinella sp. Nov,* Small Axinellidae specimens are present in rocky crevices, between 13 to 25m depth.

Spongia officinalis Linnaeus, 1759

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996).
Geographical distribution: Species of temperate-warm affinities with a wide range of geographical distribution (Mediterranean, Eastern and Western Atlantic, Indian Ocean.

Habitat: On rock (normally in walls, overhangs and cave entrances), seagrass beds and coarse sandy bottoms, from shallow waters to 40m depth (occasionally, some individuals have been caught from 200 to 300m depth).
Threats: Siltation, hyper-sedimentation, pull up by fixed nets, trawling, recollection unregulated, diseases, global change.
Observations: Non abundant species but encountered all along the lebanese coast; 3-20m depth. All of the individuals have been observed in shallow waters (< 10m depth) and, normally, in caves, overhangs and rocky crevices.
Three other Spongiidae are already reported in Lebanon and have the same protection status: Hippospongia communis (Lamarck, 1814) found around 30-35 m depth at Tyre (Bitar, personal observation), *Spongia (Spongia) agaricina* Pallas, 1766 and *Spongia (Spongia) zimocca* Schmidt, 1862 caught in the nets of the fishermen of Tyre.

Cladocora caespitosa (Linnaeus, 1767)

Protection status: Endangered or threatened species (Annex II, Barcelona Convention, Istanbul 2013); Appendix II CITES (Washington Convention, 2013).
Geographical Distribution: Endemic species of the Mediterranean Sea. The species has also been signaled in the NE Atlantic from southern Portugal to Agadir (Morocco).
Habitat: Hermatypic coral that live in photophilic infralittoral bottoms (0-25 m depth), although it can reach 50 m depth in very clear waters. On rocky substrata, *Posidonia* rhizomes and coastal detritic.
Threats: Hyper-sedimentation, sediment dumping, trawling, collection by divers, competition with *Oculina patagonica*.
Observations: Very rare species in Lebanon, observed in several localities, 0-5 m depth (Bitar, personal observations). Competition with *Oculina patagonica* that can overgrow on *Cladocora.*

Phyllangia americana mouchezii (Lacaze-Duthiers, 1897)

Protection status: Appendix II CITES (Washington Convention, 2013).
Geographical Distribution: Eastern Atlantic (from Portugal to Senegal, Azores, Madeira and Canary Islands) and Mediterranean Sea.
Habitat: Ahermatypic coral that live in sciaphilic infralittoral and circalittoral bottoms (0-47m depth).

Threats: Erosion and collection by divers, mooring on circalittoral rocky bottoms, pollution in the caves.
Observations: Not rare species on coralligenous and common in caves habitats along the lebanese coast, between 2 to 47m depth.

Dendropoma petraeum (Monterosato, 1884)

Protection status: Endangered or threatened species. (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species.

Geographical distribution: Endemic species of the Mediterranean Sea, from Gibraltar Strait to Lebanon. Also, Atlantic coasts from Spain and Morocco.

Habitat: The species forms dense aggregates on rocky substratum with *Neogoniolithon brassica-florida*, normally in the exposed littoral fringe. Also, on infralittoral photophilic rock

at 3m depth.
Threats: Sediment dumping, organic pollution, trampling, bait collection (destruction of the biogenic formations), littoral works (marinas, ports).
Observations: The species is common along the Lebanese coast at 0 m depth; whereas it seems to be rare in some places. Currently it is *Dendropoma anguliferum* (Templado *et al.*, 2016).

Erosaria spurca (Linnaeus, 1758)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species
Geographical distribution: Eastern Atlantic from Gibraltar Strait to Angola (also, Canary, Madeira, Cape Verde, Ascension and Saint Helene Islands, Mediterranean Sea.
Habitat: On rocky infralittoral bottoms, under stones, and *Posidonia oceanica* meadows, between 0 to 20m depth, deeper (30m depth) in Levantine basin.
Threats: Impacts associated with the infralittoral habitat loss (hyper-sedimentation, sediment dumping, littoral works, organic pollution); collection by divers; competition with lessepsian Cypraeidae (e.g. *Purpuradusta gracilis*).
Observations: uncommon species, observed all along the lebanese coast. Most often the observed specimens have been empty and eroded shells especially on beaches.

Luria lurida (Linnaeus, 1758)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species
Geographical distribution: Eastern Atlantic from southern Portugal to Angola (also, Canary, Madeira, Cape Verde, Ascension and Saint Helene Islands, Mediterranean Sea.
Habitat: On rocky bottoms (overhangs, crevices) and under stones, between 0 to 50m depth.
Threats: Impacts associated with the infralittoral habitat loss (hyper-sedimentation, sediment dumping, littoral works, organic pollution); collection by divers; competition with lessepsian Cypraeidae (e.g. *Purpuradusta gracilis*).
Observations: Very rare species in Lebanon, 2-25 m depth.

Tonna galea Linnaeus, 1758

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). European Union proposal (COM (2009) 585) to include it in the list of endangered or threatened species
Geographical distribution: Species with warm affinities. Eastern Atlantic (from southern Portugal to South Africa), Western Atlantic (from northern Carolina to Brazil), Mediterranean Sea.
Habitat: Mainly in sandy bottoms near to detritic substrata and coralligenous communities on the continental shelf, usually from 15 to 80m depth.

Threats: Trawling, collection by divers.
Observations: Very rare, Observed in the Palm Islands Nature Reserve and Tyre, 7-15 m

depth.

Lithophaga lithophaga (Linnaeus, 1758)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). Species of community interest in need of strict protection (Annex IV, Habitat Directive 92/43 European Union). Species that are not necessarily now threatened with extinction but that may become in the future, unless trade is closely controlled (Appendix II, CITES, 2013)

Geographical distribution: Eastern Atlantic from southern Portugal to Angola (also, Canary and Madeira Islands), Mediterranean Sea; also reported in the Red Sea.
Habitat: Endolithic species in calcareous substrata (rock, corals, biogenic formations), from 0m to 50m depth; more frequent in shallow waters (0-5m depth).
Threats: Very appreciated resource whose collection might imply the destruction of the rocky substratum by divers.
Observations: Observed in Ras El Bayada between 3 and 15 m depth. the species seems common in the lebanese coast.

Pinna nobilis Linnaeus, 1758

Protection status: Endangered or threatened species (Barcelona Convention, Annex II); strictly protected fauna species (Annex II, Bern Convention 1996-98). Species of community interest in need of strict protection (Annex IV, Habitat Directive 92/43 European Union).
Geographical distribution: Endemic species of the Mediterranean Sea.
Habitat: Characteristic species on soft substrata, mainly in *Posidonia* and *Cymodocea* meadows; also, in coarse sand and muddy sand bottoms. From shallow waters to 40 m depth.
Threats: Impacts associated with the seagrass habitat loss (hyper-sedimentation, sediment dumping, littoral works, organic pollution, trawling); collection by divers; pull up by fixed nets.
Observations: Observed in Enfeh, Ras Chekaa, Tyre and Ras El Bayada, from 7 to 42m depth. At present, the species seems to be rare in Lebanon waters.

Paracentrotus lividus (Lamarck, 1816)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention); protected fauna species (annex III, Bern Convention, 1996).

Geographical distribution: Atlanto-Mediterranean species. Eastern Atlantic, from Brittany Islands to Mauritania (incl. Azores, Madeira and Canary Islands), and Mediterranean Sea.
Habitat: On rocky substrata and *Posidonia* meadows, from 0 to 80m depth, normally in shallow waters (< 20m depth).
Threats: Hyper-sedimentation, collection by divers.
Observations: This herbivore species was very abundant all along the Lebanese coast in the 1980s and was sought for consumption. Currently, it is very rare and threatened with extinction either by overexploitation, or under the effect of invasion of the Lebanese coast by invasive algae such as *Stypopodium shimperi* which is known by its toxic secretions or under the effect of the climate change.

Other protected Invertebrates

Other protected invertebrate species reported from Lebanon waters (Barcelona Convention). They are uncommon or rare. It is the case of:

Annex II: *Tethya aurantium, Charonia lampas, Charonia variegata* (ex. *C. tritonis*), *Pholas dactylus, Zonaria pyrum, Ocypode cursor* and *Centrostephanus longispinus.*

Annex III: *Maja squinado* and *Scyllarides latus*.

III.2.3. VERTEBRATA (FISH)

The marine fish species to be protected and observed in Lebanon are indicated in the table 3.

Table 3. Marine fish species of special interest in Lebanon. **(BaC)** Barcelona Convention (1995); **(BeC)** Bern Convention (1996-98).

FISH	BaC	BeC
Gymnura altavela	II	-
Rhinobatos cemiculus	III	-
Isurus oxyrinchus	III	III
Prionace glauca	III	III
Squatina squatina	III	III
Anguilla anguilla	III	-
Epinephelus marginatus	III	III
Sciaena umbra	III	III
Umbrina cirrosa	III	-
Thunnus thynnus	III	-
Xiphias gladius	III	-
Hippocampus guttulatus	II	II
Hippocampus hippocampus	II	II

Gymnura altavela (Linnaeus, 1758)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009); strictly protected fauna species (Annex II, Bern Convention 1996- 98); critically endangered species (IUCN Red List).
Geographical distribution: Amphi-Atlantic species (from Bay of Biscay to Angola; from Massachusetts to La Plata estuary); Mediterranean and Black Seas.
Habitat: Benthic species on coastal sandy and muddy bottoms, near to estuaries: Normally, from shallow waters up to 80m depth.
Threats: Gill nets, trawling, estuary degradation.
Observations: Rare species, occasional presence in Lebanon (Mouneimne, 2002), observed in Anfeh at 31 m depth (RAC/SPA – UNEP/MAP. 2014).

Rhinobatos cemiculus E. Geoffroy Saint-Hilaire, 1817

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009); strictly protected fauna species (Annex II, Bern Convention 1996- 98); critically endangered species (IUCN Red List).

Geographical distribution: Species of warm affinities. Eastern Atlantic from Bay of Biscay to Angola, Mediterranean Sea.
Habitat: Benthic species on sandy or muddy bottoms of the continental shelf, from shallow waters to 100m depth.
Threats: Bottom trawling on the coastal areas where the juveniles are present.
Observations: occasional presence (Mouneimne, 2002), observed in in Tyre and Saida between 25 to 30m depth (RAC/SPA – UNEP/MAP. 2014).

Isurus oxyrinchus Rafinesque, 1810

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). Critically endangered species (Abdul Malak *et al*. 2011).
Geographical distribution: Cosmopolitan, from Norway to South Africa, Mediterranean Sea (Louisy, 2002).
Habitat: Epipelagic shark that swim near the surface but also descends to 740 m (Louisy, 2002; Golani *et al*., 2006).
Threats: targeted fishing, capture as by-catch, pollution, habitat loss and human disturbance.
Observations: occasional presence in Lebanon (Mouneimne, 2002).

Prionace glauca (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). Vulnerable species (Abdul Malak *et al*. 2011).
Geographical distribution: Circumglobal in temperate and tropical waters. Highly migratory species, Mediterranean Sea (www.fishbase.org)
Habitat: pelagic-oceanic, depth range 1 - 1000 m.
Threats: targeted fishing, capture as by-catch, human disturbance.
Observations: occasional presence in Lebanon (Mouneimne, 2002).

Squatina squatina (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). Critically endangered species (Abdul Malak *et al*. 2011).
Geographical distribution: Atlantic from Norway to Morocco, Mediterranean Sea
Habitat: Demersal, inhabit sandy or muddy bottom, depth range 5 - 150 m, Temperate (Golani et al., 206; www.fishbase.org)
Threats: capture as by-catch, ghost fishing, bottom trawling.
Observations: occasional presence in Lebanon (Mouneimne, 2002).

Anguilla anguilla (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995);
Geographical distribution: Atlantic Ocean: Atlantic coast from Scandinavia to Morocco; Baltic, Black and Mediterranean Seas; rivers of North Atlantic, Baltic and Mediterranean seas. Continuous introductions to Asia and South and Central America. Spawning area in western Atlantic (Sargasso Sea) (www.fishbase.org).

Habitat: Marine, freshwater, brackish, demersal, catadromous, depth range 0 - 700 m
Threats: pull up by fixed bottom nets, trawling, beach seine
Observations: its capture intervenes rather in closed brackish water (Mouneimne, 2002).

Epinephelus marginatus (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). European Union proposal (COM (2009) 585) to include it in the Annex V, whose capture from the wild can be restricted. Endangered species (IUCN Red List, 2004).
Geographical distribution: Amphi-Atlantic species. Eastern Atlantic (Brittany Islands to South Africa), Western Atlantic (Bermuda's Islands to Brazil), Mediterranean Sea.
Habitat: Demersal species on hard bottoms and submarine caves, from 0 to 200m depth.
Threats: Over-exploitation by spear-fishing of the great individuals (male populations).
Observations: *E. marginatus* seems to be more or less common in the Lebanon coast. Nevertheless, the population observed in shallow water corresponds to juvenile specimens (size < 20cm). This means a possible recovery of the size classes, when the marine protected areas would become operative (RAC/SPA – UNEP/MAP. 2014).

Sciaena umbra (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). European Union proposal (COM (2009) 585) to include it in the Annex V whose capture from the wild can be on the restricted list of endangered or threatened species. Vulnerable species (Abdul Malak *et al*. 2011).
Geographical distribution: Eastern Atlantic (from English Channel to Senegal, Canary Islands), Mediterranean and Black Seas (Bauchot, 1987).
Habitat: Demersal species in coastal waters, on seagrass, rocky and sandy bottoms, from shallow waters up to 180m depth (Bauchot, 1987).
Threats: Spear-fishing; alteration or destruction of the seagrass meadows (juvenile areas).
Observations: Very rare, one specimen was observed in Enfeh, at 18m depth (RAC/SPA – UNEP/MAP. 2014) and onother in Raoucheh cave (Bitar, personal observation). This species seems to be in regression (heavy spear-fishing, competition with lessepsian species).

Umbrina cirrosa (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); protected fauna species (annex III, Bern Convention, 1996). Vulnerable species (Abdul Malak *et al*. 2011).
Geographical distribution: Eastern Atlantic: Bay of Biscay and Gibraltar to southern Morocco, Mediterranean Sea
Habitat: Demersal; inhabit rocky, soft and hard flat bottoms to depth100m, Subtropical
Threats: Spear-fishing; alteration or destruction of the seagrass meadows (juvenile areas).
Observations: Rare, observed in Enfeh (RAC/SPA – UNEP/MAP. 2014), low abundance in trammel and beach seine (Mouneimne, 2002).

Thunnus thynnus (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); endangered species (Abdul Malak *et al*. 2011)
Geographical distribution: Tropical and temperate Atlantic and Pacific Oceans, Mediterranean Sea.
Habitat: pelagic-oceanic; oceanodromous, depth range 0 - 985 m.
Threats: Over-exploitation, capture as by-catch, ghost fishing.
Observations: quoted by Gruvel (1931) under the *Orcynus thynnus.*

Xiphias gladius (Linnaeus, 1758)

Protection status: Species whose exploitation must be regulated (Annex III, Barcelona Convention, 1995); Near Threatened species (Abdul Malak *et al*. 2011)
Geographical distribution: Cosmopolitan in all tropical and temperate oceans, Mediterranean Sea
Habitat: pelagic-oceanic, oceanodromous, depth range 0 - 800 m (www.fishbase.org).
Threats: Over-exploitation, capture as by-catch, ghost fishing
Observations: It can be caught accidentally when it approaches the coast (Mouneimne, 2002).

Hippocampus guttulatus Cuvier, 1829

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009); strictly protected fauna species (Annex II, Bern Convention 1996- 98); Near Threatened species (Abdul Malak *et al*. 2011).
Geographical distribution: Atanto-Mediterranean from the British Isles to Morocco, Azores, Madeira and Canary Islands.
Habitat: Seagrass or algae in roky or flat bottom to depth of 30m.
Threats: pull up by fixed bottom nets, trawling, beach seine, collection by divers.
Observations: Occasional in the catches of the beach seine (Mouneimné, 2002)

Hippocampus hippocampus (Linnaeus, 1758)

Protection status: Endangered or threatened species (Barcelona Convention, Annex II, Marrakech 2009); strictly protected fauna species (Annex II, Bern Convention 1996- 98); Near Threatened species (Abdul Malak *et al*. 2011).
Geographical distribution: Atlanto-Mediterranean from Biscay to Gulf of Guinea
Habitat: Between stones mainly in seagrass medows to depth of 10 m, recorded in deeper water on muddy bottom (Golani *et al*., 2006).
Threats: pull up by fixed bottom nets, trawling, beach seine, collection by divers.
Observations: Occasional in the catches of the beach seine (Mouneimné, 2002).

III. 2. 4. Other species of interest

In this part, we only consider the indigenous flora and fauna species without a conservation status however that deserve to be monitored all along the lebanese coast, specially in the marine protected areas (MPAs) and its surroundings that can be considered as reference zones. It is also important to monitor all these species in one or more areas subject to anthropogenic pressure to get an idea about the trend of species and especially the target species.

- **Endemic species and others that only existe in Lebanon**

The endemic Rhodobionta of the eastern Mediterranean *Lithophyllum tortuosum* ex. *Tenarea undulosa* which exists only in the Natural Reserve of the Palm Islands. This endangered species is facing an extremely high risk of extinction which has not be found for several years (Bitar, personal observation). **11** species, discovered only in Lebanon, including **7** sponges (*Cinachyrella levantinensis, Ciocalypta carballoi, Liosina blastifera, Niphates toxifera, Gastrophanella phoeniciensis, Microscleroderma lamina* and *Eurayspongia raouchensis*) and **4** *Bryozoaires* (*Celleporina bitari Parasmittina serruloides, Parasmittina spondylicola, Schizoretepora hassi*).

- **Endangered or threatned species**

Neogognolithon brassica-florida, Titanoderma trochanter (Macrophyta), *Sabella spallanzanii* (Polychaeta), *Dendropoma petraeum, Vermetus triquetrus, Stramonita haemastoma, Hexaplex trunculus* (Mollusca), *Perforatus perforatus, Pachygrapsus marmoratus* (Crustacea), *Paracentrotus lividus, Arbacia lixula* (Echinoderm).

- **Species with economic value***:*

Sepia officinalis, Octopus vulgaris (Mollusques Céphalopodes), *Maja goltziana* (Crustacé Décapode) , *Epinephelus costae, Epinephelus aeneus, Mycteroperca rubra, Caranx crysos, Sarpa salpa, Diplodus cervinus, Diplodus sargus, Diplodus vulgaris, Pagrus auriga, Lithognathus mormyrus, Oblada melanura, Mullus surmuletus, Oedalechilus labeo, Cheilopogon exsiliens, Belone belone, Xyrichthys novacula, Sparisoma cretense, Scorpaena maderensis, Scorpaena porcus, Auxis rochei* (poissons).

III.3. BENTHIC BIONOMY AND HABITATS

III.3.1. Introduction

Identification and typification of the marine habitats, and their benthic assemblages is a consistent tool to explain the delimitation of the marine protected areas and located anthropogenic impacts. Thus, the development of a standard habitat classification is required for evaluating of the nature conservation and a long-term monitoring of the sites (Costello & Emblow, 2005).
According to previous work (Bitar, 2011; RAC/SPA–UNEP/MAP. 2014), some characteristics of Lebanon's benthic habitats are peculiar and difficult for the application of the usual Mediterranean habitat/biocenosis classifications. Among these limitations are:

- Scarcity of studies about Lebanon's marine habitats;
- many habitats are quite different from to the rest of Mediterranean sectors (Western Mediterranean Sea, Aegean Sea, Adriatic Sea, Ionian Sea);
- relative homogeneity of the infralittoral fauna and flora (late summer thermocline at 40-50 m depth);
- influence of some lessepsians species (as Siganidae, *Chama-Spondylus* bioconstructions) on the habitat; and the seasonal changes are very pronounced in the flora composition.

Therefore, the comparisons with equivalent habitats from other Mediterranean sectors

represent some difficulties, on spatial and temporal scales. To solve this problem, we have done an approximation of the seascape ecology (Pittman *et al.*, 2011; Fuller, 2013), since it seems fundamental to understand how abiotic patterns influence species distribution, mainly, throughout the rocky bottoms. One pragmatic approximation has been to consider the seascapes as geo-morphological units with the associated communities, based in the sessile epibenthic assemblages. A seascape represents the combination of the physical habitat (mainly geo-morphological features) and the more conspicuous or dominant flora/fauna.

The main benefit of using habitat classification based on geo-morphological features makes possible to compare the results from surveys of one or more sites with other studies, independently of the season (with the variation of the megabenthic species). This classification aims to provide a standard nomenclature for describing and mapping marine habitats, mainly in areas where very little is known about the benthic environment.

The biocenosis, habitats and associations (with facies) have followed the classification of UNEP-MAP-RAC/SPA., 2006, 2015, mainly based on the Pérès & Picard (1964), and Bellan-Santini *et al* (1994), according to the division in stages: supralittoral, middlittoral, infralittoral and circalittoral; and after by substrata (hard and soft). Each biocenosis and association/facies have been assigned a code (as UMR); but to some of them, it has not been possible to give them this code. We have included the more abundant species and characteristic of the observed megabenthos (phyto and zoobenthos, fishes) with a subjective appreciation of the abundance: (cc) very common, (c) common, and (r) rare. The species observed in the different communities are included in the Annex II (inventory of species).

For the characterization of different types of benthic habitats and their codes, we took as a reference the «Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest» (UNEP-MAP – RAC / SPA, 2015).

III.3.2. HARD SUBSTRATA

We have applied the seascape/biocenosis concepts to hard substrata, classifiying them as: littoral rock (supra and midlittoral), infralittoral rock (upper, middle and lower horizons) and circalittoral rocky bottoms.

III.3.2.1. Littoral rock

The littoral rock embraces the supralittoral and midlittoral stages, with the littoral fringe ($\geq$0m in calm waters and high barometric pressure).

Biotope: The nature of substrata has been limestone (e.g. Enfeh, Ras Chekaa, Beirut (Raoucheh), Ras El Bayada) or sandstone rocks (Saida, Tyre, Nakoura). The hydrodynamism (by waves) has varied from moderate to high. The abrasion platform is more or less wide, although there are variations among the zones (between 1 to 30m width). Vermetid platform of Byblos (Jbeil) is very wide.

Conservation interest: The vermetid bio-builder (*Dendropoma petraeum* with *Neogoniolithon brassica-florida*) develops intertidal plateaus on the abrasion platform. On these platforms there are associations of Conservation interest (*Sargassum vulgare, Cystoseira compressa, Cystoseira amentacea (uncommon)* and *Palisada perforata*.

Potential threats: Due to human activities, the littoral rock is the most threatened marine habitat. The main anthropogenic impacts are trampling, shell-fish and algae collection (normally for baits), hydrocarbon and sewage pollution, littoral disturbance (building, ports, sediment filling). Climate change, non-indigenous species, Vermetid platforms are the main threatened habitat.

Associated biocenosis:

- Supralittoral rock (UMR: I.4.1)
- Upper midlittoral rock (UMR: II.4.1)
- Lower midlittoral rock (UMR: II.4.2)
- Midlittoral caves (UMR: II.4.3)
- Littoral fringe (abrasion platform with littoral pools)

III.3.2.1.1. Biocenosis of the supralittoral rock (UMR: I.4.1)

Structure of the community: Only the lower stratum is present, with the lichen *Verrucaria amphibia* (r), the gastropods *Melarhaphe* (= *Littorina*) *neritoides* (cc) and *Echinolittorina* (= *Littorina*) *punctata* (cc), and the crustaceans *Ligia italica* (cc), *Euraphia depressa* (r) and *Pachygrapsus marmoratus* (r).

Association: Association with *Enthophysalis deusta* and *Verrucaria* spp. (UMR: I.4.1.2).

III.3.2.1.2. Biocenosis of the upper midlittoral rock

Structure of the community: It is exclusively recognized in the lower stratum. In the summer season, it can only be observed in this lower stratum with endolitic Cyanophyta (cc) and white patches of *Lithophyllum papillosum*; as sessile epifauna, the cirripeds *Chthamalus stellatus* (cc) and *Ch. montagui* (cc). In winter and spring periods, the ephemeral rhodophytes *Bangia atropurpurea, Porphyra leucosticta* and *Nemalion helmintoides* are present.

- ***Mobile fauna***: The gastropods *Echinolittorina punctata* (cc) and *Patella rustica* (cc); the isopod *Ligia italica* (c) and the crab *Pachygrapsus marmoratus* (c).

Facies and associations:

- Facies with *Chthamalus stellatus* (cc) *et Chthamalus montaqui* (c). *Patella rustica* is also common.

III.3.2.1.3. Biocenosis of the lower midlittoral rock (UMR II.4.2)

Structure of the community: It occurs in the middle and the lower strata. In the summer season, it only appears on the lower strata with endolitic Cyanophytes (cc) and the epilithic

Rivularia atra (c), the encrusting *Ralfsia verrucosa* (r) and *Neogoniolithon brassica-florida* (c), and the turf of gelidiales *Gelidium* cf. *pusillum* and *Parviphycus pannosus* (c).

The soft macroalgae *Ulva compressa* (cc) is a characteristic species. The cirripeds *Chthamalus stellatus*, and *Ch. montagui* are present, mainly in exposed shores.

- ***Mobile fauna***: The gastropods *Echinolittorina punctata* (cc), *Patella ulyssiponensis* (cc), *P. caerulea* (c), *Phorcus turbinatus* (r); the polyplacophore *Acanthochitona fascicularis* (r); the crustaceans *Ligia italica* (c) and *Pachygrapsus marmoratus* (c). Also, the blennidae spp. has been observed.

Facies and associations:

- Association with *Lithophyllum papillosum* and *Polysiphonia* spp. (UMR: II.4.1.4), *Bangia atropurpurea* (UMR II.4.1.1), *Porphyra leucosticta* (UMR II.4.1.2) and *Nemalion helmintoides* (UMR II.4.1.3).
- Association with *Ceramium* sp. and *Corallina elongata* (UMR: II.4.2.4).
- Association with Jania rubens.
- Association with *Ulva compressa* (UMR: II.4.2.6).
- Association with Gelidiales spp. (UMR: II.4.2.9). Although, the characteristic species is *Gelidium* cf. *pusillum*, in the Levantine rocky shores *Parviphycus pannosus* is another gelidial observed.
- Pools and lagoons associated with vermetids (UMR: II.4.2.10). The vermetid *Dendropoma petraeum* and the corallinale *Neogoniolithon brassica-florida* form small plates in the lower midlittoral

III.3.2.1.4. Biocenosis of midlittoral caves (UMR: II.4.3)

Structure of the community: Only the lower stratum with the encrusting rhodophytes *Hidenbrandia rubra* and *Phymatolithon lenormandii. Actinia schmidti* is present.

Association and facies: Association with *Phymatolithon lenormandii* and *Hildenbrandia rubra* (UMR: II. 4. 3. 1). The littoral of Enfeh, Ras Chekaa, Raoucheh and Ras El Bayada presents some interesting midlittoral caves. In some of these coastal caves, there are two species of sponges (*Gastrophanella phoeniciensis* and *Microscleroderma lamina*) which are interpreted as remains of an ancient thermophilic fauna that has survived in the eastern Mediterranean (Perez et al., 2004). A return of two or three monk seals is reported by fishermen from Beirut near the Raoucheh Caves.

III.3.2.1.5. Littoral fringe

The littoral fringe is the uppermost horizon of the infralittoral algae. It can be identified by the abrasion platform, the shallow littoral pools and surf zone. Under high barometric pressures, this zone can remain above the sea level for some days.

Structure of the community: The abrasion platform presents middle and lower strata, dominated by chlorophytes, rhodophytes and Mytilidae.

- ***Upper stratum***: In the surf zone, some ramified macroalgae (*Sargassum, Cystoseira, Palisada, Laurencia, Acanthophora*) can develop a complex habitat.

- ***Middle stratum:*** The abrasion platform is dominated by chlorophytes (*Ulva compressa, U. rigida, Cladophora* and *Chaetomorpha* spp.) and the rhodophytes *Hypnea musciformis* (June in Enfeh and Ras Chekaa). In the littoral pools, the chromobiontes (ochrophytes) *Dictyota fasciola* (cc), *Cystoseira compressa* (cc) and *Padina boergenseni* (cc) are frequent.

- ***Lower stratum***: The surf zone is mainly colonized by *Jania rubens* and *Valonia utricularis* (r) The sessile fauna is dominated by the mytilid *Brachidontes pharaonis* and *Vermetus triquetrus*.

- ***Mobile fauna***: With *Patella caerulea* (c), *Pachygrapsus marmoratus* (c) and *Eriphia verrucosa* (c). In the littoral pools the decapod crustaceans *Palaemon serratus* and the Blenniidae fishes are common.

Facies and associations: They are concentrated in the uppermost part of the infralittoral rock (0-0,5m depth) with the associations/facies:

- Vermetids with *Dendropoma* and *Neogoniolithon* (UMR III.6.1.3): The vermetid *Dendropoma petraeum* (c) and the calcareous algae *Neogoniolithon brassica-marina* (=*Spongites notarisii*) (cc), form a small cushion and plate structures. *Vermetus triquetrus* is another frequent vermetid. The vermetid formations appear developed in all of the area but they are covered by algae, and many of the vermetids bio-concretions are dead.
- Littoral pools sometimes associated with vermetids (infralittoral enclave): These infralittoral enclaves are frequent in the sandstones and limestones rocks. The macroalgae are abundant: as chlorophytes (*Cladophora* spp., *Ulva* spp. *Chaetomorpha* spp.), ochrophytes (*Dictyota fasciola, Padina boergesenii*) and rhodophytes (*Jania rubens, Hypnea musciformis, Hypnea cornuta, Hypnea* sp.). The decapode *Palaemon serratus* is frequent.
- Association with Ulvales: In some places, normally subject to some organic pollution, the chlorophytes are dominant with Ulvales, Bryopsidales and Cladophorales (*Ulva intestinalis, U. compressa, U. rigida, Chaetomorpha* spp., *Bryopsis* spp.).
- Association with *Hypnea cornuta:* This lessepsian (non-indigenous) species present in calm areas of the platform.
- Association with *Acanthophora nayadiformis*: This lessepsian (non indigenous) species present in calm areas of the platform.
- Association with *Sarconema filiforme*: non-indigenous species present in calm areas of the platform
- Association with *Jania rubens*: The rhodophyte *Jania rubens* can dominate the littoral fringe (0-1m depth) in the surf zone. Usually it is accompanied by the rhodophytes *Corallina elongata* (c), *Palisada perforata* (c) and *Laurencia obtusa* (r), and the chorophytes *Cladophora* spp. (c).
- Association with *Sargassum vulgare* (UMR III.6.1.20) and *Cystoseira compressa* (UMR III.6.1.25): in calm and unpolluted shallow waters (0-2m depth), the ocrophytes *Sargassum vulgare* and *Cystoseira compressa* can be dominant, together with *Jania rubens* and the ceramiale *Palisada perforata*.
- Facies with Mytilids *Brachidontes pharaonis* (UMR III.6.1.4): This lessepsian mussel dominates the abrasion platform and it forms a marked belt in the lower part of the midlittoral, with Ulvales (*Ulva* spp.) and *Chaetomorpha* spp. *Brachidontes* replaced *Mytilus galloprovincialis*, who has disappeared from the Lebanese coast.

- Association with *Cladophora herpestica*: This lessepsian species is located on the surface and at the edge of the abrasion platform.
- Association with *Bryopsis pennata*: lessepsian species located in the edge of the platform.
- Association with *Cystoseira amentacea var. amentacea* (UMR: III.6.1.2): rare Association (Ramkine Island, Enfeh, Wadi Zeini and Nakoura).

III.3.2.2. Infralittoral rock (UMR: III.6)

The infralittoral rock represents a complex of habitats depending on the nature and topography of the substratum, surface slope, wave exposure, illumination, sediment cover and scour, seasonal temperature changes, thermocline depth, etc. That means a zonation of the communities, with a unique biocenosis: the infralittoral algae (UMR: III.6.1).

According to wave exposure and light extinction, we have considered three horizons in the infralittoral rock: upper, middle and lower (Riedl, 1971).

- Upper horizon: From the mean sea level up to 8m depth. Here the intense wave action prevents the sedimentation.
- Middle horizon: From 8m to 29m depth, with the dominance of the photophilic algae on horizontal surfaces
- Lower horizon: From 29 to 42m depth, with the dominance of sciaphilic algae on horizontal surfaces.

The topography of the rocky bottoms changes with the depths. So, in shallow depths (0-8m), normally, the rocky profile is vertical with big boulders on the base. In the middle horizon, the topography of the rock varies from sloping to horizontal with/without sandy channels, according to the zones. For example, in the Enfeh-Ras Chekaa sector, what prevails is the slopping and high rock; whereas, in the Saida-Nakoura one, it is and horizontal and lower with coarse sediment patches.

According with this zonation, the biocenosis of the infralittoral algae dominates the three horizons, with four groups (depending on the hydrodynamism (exposed/ sheltered) and light intensities: (photophilic/sciaphilic):

- exposed photophilic macroalgae;
- exposed sciaphilic macroalgae;
- sheltered photophilic macroalgae;
- sheltered sciaphilic macroalgae.

III.3.2.2.1. Upper horizon of the infralittoral rock

Biotope: Following the abrasion platform, the rock profile falls vertically to 2-8 m depth, depending of the zones (shallower or deeper), normally, with big boulders on the bottom. The wave exposure is high and the presence of vertical surfaces and overhangs favours the sciaphilic communities.

Conservation interest: There are some species of conservation interest. The erect ochrophyte *Sargassum* and *Cystoseira* create a photophilic complex habitat. The sciaphilic assemblage with *Schottera* and *Plocamium* is diverse, harbouring many species. Also, the impact of lessepsian species is low (*Brachidontes pharaonis* are dominant in some places).

Potential threats: The upper infralittoral rock is threated by many anthropogenic impacts, such as sewage pollution (industrial and domestic), littoral development (building, ports), sediment filling, land reclamation and global change. Also, it must be considered the serious impact of dynamite on the living resources must be taken into consideration, as well as on fish and on the harvest of *Lithophaga lithophaga*, and the spearfishing of some targed species (such as the large Serranidae).

III.3.2.2.1.1. Exposed photophilic algae

The width of this horizon depends on the hydrodynamism, and it can reach about 6-8m depth in a very exposed littoral. The light intensity is very high.

Structure of the community: The middle and lower stratum predominate in the community, although some ochrophytes (*Sargassum vulgare, Cystoseira compressa*) and large hydrozoans (*Pennaria disticha, Macrorhynchia philippina*) can create an upper stratum.

- **Middle-lower stratum:** With the algal turfs of geniculate Corallinales (*Jania rubens, Corallina elongata*). In some places, the mytilid *Barchidontes pharaonis* and/or hydroids are dominant. In Enfeh, some *Sagassum vulgare* and *Cystoseira compressa* patches have been observed. Among the sessile fauna, the poriferans (*Chondrilla nucula, Chondrosia reniformis, Crambe crambe, Cliona parenzani, Phorbas topsenti*), the hydrozoans (*Pennaria disticha, Macrorhynchia philippina*) and the cirripeds (*Balanus trigonus* and *Perforatus perforatus*) have been frequent. Another common sessile fauna has been the anthozoan *Oculina patagonica*, bryozoan *Schizoporella sanguinea* and ascidian *Phallusia nigra*. Noteworthy is the rarity of sea urchins (*Paracentrotus lividus, Arbacia lixula*) due to the surcollection by divers or to the global change and some non-indigenous species.

The presence of bare rock is very frequent, with *Lithophyllum incrustans* and small Ceramiales, accompanied by *Cliona parenzani* and *Balanus* spp. In some altered sites with organic pollution, the chloropyta (*Ulva* spp., *Codium taylori*) and rhodophyta (*Pterocladiella capillacea*) dominate the rocky substratum.

- **Mobile fauna:** As for the mobile fauna, the decapods *Eriphia verrucosa* (c) and the pagures *Clibanarius erythropus* (cc) and *Calcinus tubularis* (c), with the lessepsian gastropoda *Cerithium scabridum* (cc), Ergalatax junione (c) and *Conomurex persicus* (c) are frequent; the sea urchins *Arbacia lixula* and *Paracentrotus lividus* are rare. Among the fishes are *Diplodus* spp. (*D. sargus,*
- *D. vulgaris*) (cc), *Thalassoma pavo* (cc), *Coris julis* (c), *Siganus rivulatus* (cc), *Sparisoma creense* (cc), Chromis chromis (cc), *Symphodus tinca* (c), *Symphodus roissali* (r), *Serranus scriba* (r) and Blennidae (cc).

Facies and associations

- Overgrazed facies with encrusting algae (UMR: III.6.1.1): In some places, the rocky substratum is bare and empty of erected soft macroalgae, only some encrusting corallinales are present (*Lithophyllum incrustans* and *Neogoniolithon* spp.) with some *Amphiroa rigida* talus. Although the typical facies with *Lithophyllum incrustans* and *Arbacia lixula* is present, normally this overgrazing is due to the herbivorous pressure of the fishes *Siganus rivulatus* (cc) and *S. luridus* (c), whereas the sea urchins (*Arbacia lixula* and *Paracentrotus lividus*) are currently rare in Lebanon.

Another reason could be the erosion by the coarse sand of the rock due to the heavy storms. The bare rock can appear up to a depth of 8m.

The macrofauna is poorly represented, and some encrusted and well anchored animals are present. Like the poriferans *Crambe crambe* (c) and the boring sponges *Cliona* spp. (c); the cirripeds *Perforatus perforatus* (c) and *Balanus trigonus* (c), the ascophoran bryozoan *Schyzoporella errata* (c); and the ascidian *Phallusia nigra* (r).

- Association with *Corallina elongata* (UMR: III.6.1.5): Along the lebanese coast. Also in the middle horizon.
- Association with *Sargassum vulgare* (UMR: III.6.1.20): The association is frequent along the lebanese coast.
- Association with *Cystoseira compressa* (UMR: III.6.1.25): Although it is present in the same sites of *S. vulgare*, *C. compressa* has been less frequent than *Sargassum.*
- Association with *Dictyopteris polypoioides* (UMR: III.6.1.21): currently localized particularly in the northern sector of Lebanon.
- Association with *Jania* spp.: well represented in lebanese coast.
- Association with *Pterocladiella capillacea* and *Ulva* spp. (UMR: III.6.1.26): This association is located in stations with organic pollution. The rhodophyte *Pterocladiella capillacea* and the chlorophites *Ulva intestinalis* and *U. lactuca* are dominant in shallow waters (0-4m depth). Also, the lessepsian chorophyte *Codium taylori* is present.
- Facies with the Mytilidae *Brachidontes pharaonis* (UMR: III.6.1.4): It is very common facies in Lebanon, between 0 to 8m depth. In some places, the lessepsian mytilid *Brachidontes pharaonis* can completely cover the rocky surfaces.
- Facies with large hydrozoans (UMR: III.1.27): In the exposed surfaces the hydroids *Pennaria disticha* (cc) and *Macrorynchia philippina* (c) are present along the lebanese coast.
- Facies with Balanidae spp.: These facies dominated by *Perforatus perforatus* and *Balanus trigonus* is common in the Lebanese coast on horizontal and subhorizontal surfaces, between 1 to 15m depth. Noteworthy is the high frequency of empty tests.

III.3.2.2.1.2. Exposed sciaphilic algae

Structure of the commnity: It predominates on the vertical rock between 0-6m depth, with the middle and lower strata.

- *Middle stratum:* With the dominance of rhodophytes *Corallina elongata* and *Plocamium cartilagineum.* The sessile fauna is abundant, with the poriferans (*Chondrosia reniformis, Clathrina cf. coriacea, Niphates toxifera*), hydrozoans (*Pennaria disticha, Aglaophenia* spp.), some lessepsian bivalves (*Chama pacifica, Malleus regula, Spondylus spinosus*) and ascidians (*Herdmania momus, Phallusia nigra*). ***Lower stratum***: With the rhodophytes *Schottera nicaeensis* and *Lithophyllum incrustans*); the ochrphyte *Lobophora variegata* (c) is present in some places. Also, the sessile fauna is abundant, with encrusting poriferans (*Crambe crambe, Phorbas topsenti*), cirripeds (*Perforatus perforatus, Balanus trigonus*), bivalves (*Brachidontes pharaonis*) and ascidians (Didemnidae spp.).

- Mobile fauna: As for the mobile fauna, the polychaete *Hermodice carunculata* is very frequent. Also, the decapods (*Charybdis helleri, Atergatis roseus, Calcinus tubularis*), gastropodes (*Ergalatax junionae*) and fishes (Blennidae, *Pempheris vanicolensis, Scorpaena maderensis, Tripterygion melanurum*) are common in this habitat.

Associations:

- Association with *Corallina elongata* (UMR: III.6.1.5): On vertical walls, this corallinacea dominate the substrata, between 0 to 6m depth. Another rhodophyte should be present, *Plocamium cartilagineum* (c). The sessile fauna is not abundant with the poriferans *Chondrilla nucula* (c), *Chondrosia reniformis* (c), *Crambe crambe* (cc) and *Niphates toxifera* (r); the hydrozoans *Aglaophenia* spp. and *Pennaria disticha* (c); the cirriped *Perforatus perforatus*; the bryozoan *Schichoporella errata* (c); and the ascidians Didemnidae spp. (c) and *Phallusia* nigra (c).
- Association with *Schottera nicaeensis* (UMR: III.6.1.29): This association is located on more sciaphilic surfaces of the upper infralittoral horizon, in shallow water (0-2m depth), with the rhodophytes *Schottera nicaeensis* (c), *Plocamium cartilagineum* (c), *Corallina elongata* (c), *Lithophyllum incrustans* (cc) and *Mesophyllum lichenoides* (c). The poriferans *Chondrosia reniformis* (c), *Crambe crambe* (cc), and calcareous sponges (c) are present.

III.3.2.2.2. Middle horizon of the infralittoral rock

Biotope: The rock profile changes with the zones. It is steep in sector and gentler in another sector, normally flat rock with coarse sand patches and channels. Nevertheless, in some areas, the rock profile is more irregular and higher.

The wave exposure is moderated and the presence of vertical surfaces and overhangs favours the sciaphiilic communities. The bathymetric range varies from 2m depth (in sheltered places) to 28m depth on horizontal surfaces.

Conservation interest: There are some species of conservation interest. The erect ochrophyte *Cystoseira foeniculacea* create a photophilic complex habitat. The sciaphilic assemblage with *Peyssonnelia spp*. and *Lobophora variegata* is diverse, together with poriferans *(Axinella* sp., *Chondrosia reniformis, Aplysina aerophoba*, *Petrosia ficiformis*, etc.), and can harbour many species. Even, the *Chama-Spondylus* reefs create a complex habitat where many invertebrates find shelter (gastropods, crustaceans, polychaetes, and ophiurids). Furthermore, the presence of juveniles of some target species (*Diplodus cervinus, Epinephelus costae, E. marginatus* and *Mycteroperca rubra*) proves the potential of this biotope to recover these overfished species.

Potential threats: The infralittoral rock is threated by many anthropogenic impacts, such as sewage pollution (industrial and domestic), littoral development (building, ports), sediment filling, land reclamation and global change. T he impact of dynamite on the living resources must be taken into consideration, as well as the spearfishing of the target species (such as big Serranidae) and the loss of monofilament nets and traps (‘ghost fishing’).

***Associated biocenosis**:*

- Part of the biocenosis of infralittoral algae (UMR III.6.1), corresponding to sheltered sciaphilic macroalgae.
- Coralligenous enclaves (UMR: IV.3.1).

- Interesting is the presence of submarine freshwater springs in severel areas of the coast.

III.3.2.2.2.1. Sheltered photophilic algae

In the Lebanon area, it is difficult to establish associations and/or facies due to the important seasonal changes in the macroalgae assemblages, together with the deeper thermocline (48m depth) and the herbivorous pressure (Siganidae, *Conomurex*). The width of this horizon depends of the hydrodynamism and illumination reaching a 28m depth (e.g. in the Ras Chekaa, Tyre and Nakoura areas). The macroalgae are dominant, but this is not always the rule.

Structure of the communities: The major part of the communities presents a middle and lower stratum. Whereas, the upper one has been very rare, only represented by *Cystoseira foeniculacea* in shallow biotopes (5-17m depth) and *Axinella* sp. in deeper ones (18-29m depth).

- *Middle stratum*: Mainly, with erect rhodophytes (*Jania longifurca, Amphiroa beauvoissi, Galaxaura rugosa*), ochrophytes (*Stypocaulon scoparium, Padina* spp. *Colpomenia sinuosa, Dictyota dichotoma*) and the chlorophyte *Codium parvulum*. Also, the sessile epifauna forms part of this middle stratum, such as the poriferans (*Aplysina aerophoba, Niphates toxifera, Petrosia ficiformis, Ircinia* and *Sarcotragus spp.*), polychaetes (Sabellida spp.), actiniarians (*Anemonia viridis, Aiptasia mutabilis*); bivalves (*Chama pacifica, Conomurex persicus, Pinctada imbricate radiata, Malleus regula*) and ascidians (*Phallusia nigra, Herdmania momus*).

- *Lower stratum*: With the encrusting corallinales (*Lithophyllum incrustans, Neogonioliton mamillosum*), the poriferans (*Crambe crambe, Phorbas topsenti, P. tenacior, Cliona* spp.), cirripeds (*Balanus trigonus, Perforatus perforatus*), bryozoans (*Schizoporella errata*) and ascidians (Didemnidae spp.).
- *Mobile fauna*: With the polychaete *Hermodice carunculata*, the gastropods *Cerithium scabridum* (cc), *Conomurex persicus* (cc), *Ergalatax junionae* (c) *Fusinus verrucosus*, and fishes (*Chromis chromis, Diplodus* spp., *Thalassoma pavo, Sparisoma cretense, Siganus* spp., *Serranus scriba, S. cabrilla, Scorpaena maderensis, Torquigener flavimaculosus*, Blenniidae spp., Gobiidae spp….). The echinoderms are very rare, such as the echinoids *Arbacia lixula* and *Paracentrotus lividus*; and the holothurians (*Holothuria tubulosa, H. forskali, H. impatiens*), only the lessepsian *Synaptula reciprocans* has been more frequent.

Facies and associations: Due to the complexity of the rocky substrata, the differences between zones and periods, it has been very difficult to establish the different associations (some of them as seasonal aspects). Nevertheless, some assemblages can be distinguished, and others are probably new or non-indigenous species and specific to the Levantine infralittoral.

- Association with *Colpomenia sinuosa* (UMR: III.1.1.22): represents a seasonal aspect of the infralittoral algae biocenosis in cold months (December to June), between 1 to 14m depth (RAC/SPA - UNEP/MAP, 2014).
- Association with *Stypocaulon scoparium* (UMR: III.6.1.23): This association is common in the lebanese coast but in competition with non-indigenous species.

- Association with *Ganonema farinosum* (UMR: III.6.1.24): In Lebanon, this non-indigenous association was first found in April 1993 at El Heri (Bitar *et al.*, 2000, as *L. farinosa*; Bitar, 2010). *Ganonema farinosum* is established in Lebanon (Bitar *et al*., 2017). This species appears in warm months (June to September), forming gaudy masses between 1 to 3m depth.
- Association with *Cystoseira* sp.: This interesting association was observed in some localities such as Nakoura (9-11m depth) and the lagoon located behind the Tyre's northern inlets (7-9m depth). Probably the *Cystoseira* sp. may be *C. foeniculacea* (= *C. discors*) cited by Bitar & Kouli-Bitar (2001). Rarely, the thali present secondary branches (herbivorous pressure?) and the individuals are more or less isolated. Curiously, the *Cystoseira* was observed fixed on cobbles in the lagoon, where they were moving due to the action of the waves. The epiphytes *Dictyota fasciola* and the hydroid *Pennaria disticha* were observed tangled on the thali (RAC/SPA - UNEP/MAP, 2014).
- Association with erect Corallinales: This association is spread along the coast, although much more concentrated around the inlets, between 3 to 25m depth. The main species are the ramified corallinales *Amphiroa rigida* (cc) and *Jania rubens* (cc), both replaced by *A. beauvoisii* and *J. longifurca* in deeper waters (from 15m depth). Also, the encrusting Corallinales *Lithophyllum incrustans* (in shallow waters) and *Neogoniolithon mamillosum* (in deeper ones) are very common. In some areas, *Jania longifurca* develop dense grasses on rock, between 10-15m depth. The sponges *Cambe crambe, Aplysina aerophoba, Niphates toxifera, Ircinia variabilis, Sarcotragus spinosulus* and *S. fasiculatus*, and the bivalve *Spondylus spinosus* were the more common sessile fauna in this association. This association could be similar to the overgrazing facies with encrusting corallinales, due to the herbivorous pressure on soft algae by the siganids fishes and *Conomurex persicu*s (RAC/SPA - UNEP/MAP, 2014).
- Association with *Dictyota dichotoma*: more frequent in the northern sector of the Lebanese coast. It has been observed at 5m at Batroun and Kafar Abida (Bitar, personal observation). Currently in competition with exotic species.
- Association with *Padina boergesenii*: This frequent association is present between 0 to 28m depth. The lessepsian *Padina boergenseni* is the prevailing species, although *P. pavonica* is also present. Other accompanied macroalgae have been the ochrophyte *Dictyota dichotoma* (c), and the corallinales *Jania corniculata* (r) and *Amphiroa beauvoissi* (r). The poriferans (*Aplysina aerophoba, Petrosia ficiformis, Crambe crambe*) and the ascidians (Didemnidae spp., *Herdmania momus*) are common (RAC/SPA - UNEP/MAP, 2014).
- Association with *Galaxaura rugosa*: This invasive association along the coast is present between 3 to 35m (RAC/SPA - UNEP/MAP, 2014). It is accompanied by the corallinales *Amphiroa* spp. and *Neogoniolithon* sp.; the poriferans *Axinella* sp. (c), *Crambe crambe* (cc) and *Ircinia* sp. (c); the hydroids *Macrorynchia philippina* (c), *Pennaria disticha* (c) and *Eudendrium* sp. (c); and the ascidian *Phallusia nigra*. As for the mobile fauna, the gastropod *Conomurex persicus* and the gobid fish *Gobius buchichii* are common (RAC/SPA - UNEP/MAP, 2014).
- Association with *Laurencia* cf. *chondrioides*: Currntly, this invasive association is more frequent in the south sector between Saida and Nakoura. Saadiyat as its northern limit of distribution. To date, it has never been observed between Beirut and Tripoli (Bitar *et al*., 2017). It was abundant from the sea-surface down to 23 m depth (RAC/SPA - UNEP/MAP, 2014).

- Association with *Ulva lactuca*: The species found first in april 1991 (Bitar, 1999 as *U. fasciata*) is invasive along the whole Lebanese coast on Vermetid reefs and in shallow habitats. *Ulva lactuca* was the first invasive exotic marine macrophyte to be identified in Lebanon (Bitar *et al*., 2017).
- Association with *Codium parvulum*: The lessepsian chlorophyte *Codium parvulum* colonizes stressed rocky habitats with a low number of sessile species and the presence of fine sediments. *Amphiroa rigida* (cc), *Schizoporella errata* (c) and *Phallusia nigra* (c) are escort species. Currently, *C. parvulum* is invasive along the whole Lebanese coast, between 1 and 35 m depth (Bitar *et al*., 2017).
- Association with *Stypopodium schimperi*: was first found in May 1991 at Barbara (Bitar *et al.,* 2000). Since 2000, it has become very abundant along the whole Lebanese coast, from the sea surface down to 45 m depth, at the expense of native benthic assemblages (Bitar *et al*., 2000; Bitar, 2010; RAC/SPA - UNEP/MAP, 2014). Currently, it is in competition with *Galaxaura rugosa* and *Codium parvulum* (Bitar, personal observation).
- Association with *Lophocladia lallemandii*: it was first found in Lebanon in 1973 (Basson *et al.,* 1976). We found it in the infralittoral zone, from the sea-surface down to 25 m depth (Bitar, 2010; RAC/SPA - UNEP/MAP, 2014). *Lophocladia lallemandii* is well established in Lebanon (Bitar *et al.,* 2017).
- Association with *Asparagopsis taxiformis*: The non-indigenous association is common but not invasive on the whole Lebanese coast, down to 5 m depth (Bitar *et al.,* 2017).
- Facies with *Chama pacifica* and *Spondylus spinosus*: Although these lessepsian bivalves can be present from 1 to 31m depth along the lebanese coast, it is between 5 to 26m depth where they could be prevailing on the bottoms. Those develop original facies, without comparison along the whole Mediterranean, with another lessepsian bivalve *Malleus regulus* (cc). The heterogeneous substrata of the valves allow the growing of a high number of sessile organisms such as the algae (Ceramiales, Corallinales as *Amphiroa beauvoisii*), poriferans (*Crambe crambe, Phorbas tenacior, Petrosia ficiformis, Haliclona fulva, Sycon* sp., *Niphates toxifera, Aplysina aerophoba, Ircina* sp.), hydrozoans (*Aglaophenia* spp., *Eudendrium* spp., *Macrorhynchia philippina, Pennaria disticha*), serpulids, cirripeds, etc. are fixed. Another common species are the encrusting bryozoans (*Schizoporella, Reptadeonella*) and ascidians (Didemnidae spp.) (RAC/SPA - UNEP/MAP, 2014).

III.3.2.2.2.2. Sheltered sciaphilic algae

The sheltered sciaphilic algae community is well developed in Lebanon, but with the predominance of the *Peyssonnelia* spp. and *Lobophora variegata*. *Flabellia petiolata* is very rare and located in deep bottoms. It appears in shallow infralittoral enclaves (shadow surfaces: crevices, vertical walls, overhangs) and deep infralitoral rocky surfaces (from 26m depth).

Structure of the community**:**

- Medium stratum: Some geniculated corallinales such as *Amphiroa beauvoisii* (cc) and *Jania longifurca* (c) dominate this stratum, with the gelidial *Gelidium bipectinatum* (c), the ochrophyte *Stypopodium schimperi* (c) and the chlorophyte *Cladophora pellucida* (r). The massive poriferans are not abundant, with *Petrosia ficiformis* (c), *Ircinia variabilis* (c) and

Spongia officinalis (r); on the other hand, the lessepsian bivalve *Malleus regula* and the solitary ascidian *Herdmania momus* are frequent.

- **Lower stratum**: It is dominated by the encrusting corallinales *Mesophyllum* sp. (c) and *Neogoniolithon mamillosum* (c), and *Peyssonnelia* spp. (cc); with the ochrophyte *Lobophora variegata* (c). The encrusting poriferans (*Crambe crambe, Phorbas topsenti, Cliona parenzani, Lyosina blastifera*) and ascidians (Didemnidae spp.) are frequent.

- **Mobile fauna**: The polychaete *Hermodice carunculata* is common particularly, in the northern sector; some crustacean decapods such as *Charybdis helleri* (c), *Atergatis roseus* (c) and *Calcinus ornatus* (c); the holothurian *Holothuria sanctori* (r). The fishes *Pempheris vanicolensis* (cc), *Sargocentron rubrum* (cc), *Scorpaena maderensis* (c) and *Tripterygion melanurum* (c).

Associations and facies

- Association with *Lobophora variegata* (UMR: III.6.1.12): The ochrophyta *Lobophora variegate, present along the Lebanese coast,* dominate some hemi-photophilic and sciaphilic rocky surfaces, between 2 to 18m depth, with the corallinales *Jania longifurca* (c) and *Amphiroa beauvoisii* (c), and gelidial *Gelidium bipectinatum* (c).
- Association with *Peyssonnelia* spp. (UMR: III.6.1.34): This association is well developed on sciaphilic rock (as far as 35m depth on horizontal surfaces). The main algae are the rhodophytes *Peyssonnelia* spp. (cc) (*P. squamaria* and *P. rubra*). As for the sessile fauna, the poriferans are frequent such as *Crambe crambe* (cc), *Chondrosia reniformis* (c), *Petrosia ficiformis* (cc), *Ircinia* sp (c), and the ascidians Didemnidae spp. (c) and *Phallusia nigra* (c).

III.3.2.2.3. Lower horizon of the infralittoral rock

Biotope: The dominant rock profile is mostly flat, with coarse sand and gravel patches and channels. The sciaphilic species dominate on horizontal surfaces due to the light absorption; and the bottom current is moderate. The presence of vertical surfaces and overhangs favours the coralligenous community. The bathymetric range varies from 28 to 44m depth.

Conservation interest: There are some species of conservation interest, mainly the ochrophytes *Cystoseira dubia* and *Sargassum trichocarpum* (protected by the Barcelona Convention); with the candlestick sponge *Axinella* sp. Moreover, the presence of small adults of some target species (*Epinephelus costae, E. marginatus* and *Mycteroperca rubra*) proves the potential of this biotope to help with the recovery of these overfished species.

Potential threats: The lower infralittoral rock is threated by sediment filling. The high impact of dynamite on the living resources must also be considered; the spearfishing on some target species (such as the big Serranidae); the loss of monofilament nets and traps (ghost fishing) and global change.

Associated biocenosis**:**

- Part of the biocenosis of infralittoral algae (UMC III.6.1), corresponding to shelter photophilic and sciaphilic macroalgae.
- Coralligenous infralittoral enclaves (UMR: IV.3.1).

III.3.2.2.3.1. Biocenosis of sheltered sciaphilic algae

This assemblage appears on horizontal surfaces at 28m depth, and it reaches the circalittoral communities at a depth of about 44m. The profile of the rock is flat with gravel channels/patches and/or small boulders, cobbles and pebbles. In these gravel patches, the rhodolites are present from a depth of 32m.

Structure of the communities: There are some differences between the northern and southern sectors, maybe until the seasonal period of sampling (early *vs.* late summer). In Ras Chekaa, the sciaphilic deep community is dominated by ochrophytes (*Arthrocladia villosa, Cystoseira dubia, Sargassum trichocarpum, Sporochnus pedundulatus*) and rhodophytes (Halymeniales, Rhodymeniales Gelidiales spp.). Whereas, in the southern sector (Tyre-Nakoura), the encrusting rhodophytes (*Neogoniolithon, Mesophyllum, Peyssonnelia* spp.) with *Axinella* sp. are dominant. Perhaps, *A. villosa* represents a seasonal aspect which disappears during the summer period.

- Upper stratum: In the northern sector (Enfeh-Ras Chekaa), the ochrophyte *Arthrocladia villosa* (cc), with *Cystoseira dubia* (r), *Sargassum trichocarpum* (r) and *Sporochnus pedunculatum* (r), forms an upper stratum. Whereas this one does not appear on the southern sector (Tyre-Nakoura), where *Axinella* sp. and *Eudendrium* sp. are the mainly erect species, but they are very sparse and does form typical facies.

- Middle stratum: Formed by ochrophytes *Dictyota dichotoma* (c), *Padina pavonica* (cc), *Stypopodium schimperi* (r); rhodophytes *Amphiroa* spp. (*A. beauvoisii, A, cryptarthrodia*) (c), *Rhodymenia ardissonei* (c), *Galaxaura rugosa* (r), halimeniales (c) (*Halymenia floresia, H. latifolia*), *Scinaia furcellata* (r); and the chlorophyte *Codium parvulum* (r). The massive poriferans are rare, such as *Haliclona mediterranea* (r), *Petrosia ficiformis* (r), *Agelas oroides* (r) and *Niphates toxifera* (r); on the contrary, the hydrozoans (*Aglaophenia* sp.) and the ascidia *Hermania momus* are common.
- Lower stratum: With the rhodophytes *Peyssonnelia* spp. (cc), *Neogoniolihon mamillosum* (c), *Mesophyllum alternans* (c), *Gelidium bipectinatum* (c) and *Botryocladia botryoides* (r); and the ochrophyte *Lobophora variegata*. The poriferans *Crambe crambe, Sycon* sp., *Phorbas topsenti, Haliclona fulva* and *Cliona viridis*, also, the Didemnidae spp. are the more common species. Some shallower species are present in this association, such as *Spirobranchus lamarcki* (c), *Balanus trigonus* (c), *Malleus regula* (c) and *Chama pacifica* (r).

- Mobile fauna: The gastropods prosobranchia, as *Goniobranchus annulatus*, and the decapod crustaceans (*Pilumnus hirtellus*) are rare; as well as, the echinoderms *Echinaster sepositus* and *Synaptula recoprocans*. Within the fishes, *Boops boops* (cc), *Chromis chromis* (c), *Coris julis* (c), *Sargocentron rubrum* (cc), *Serranus cabrilla* (c), *Sparisoma cretense* (c) and *Torquigener flavimaculosus* (c). Some more littoral species such as *Diplodus sargus* (r), *Serranus scriba* (r), *Siganus luridus* (r) and *Thalassoma pavo* (c) can reach these depths.

Associations and facies

- Association with *Arthrocladia villosa* (UMR: IV.2.2.4): This association is included in the circalittoral stage on coastal detritic communities (UMR: IV.2.2.4) under relatively high bottom currents. Nevertheless, in the Ras Chekaa area (for example), apart from the gravel and pebbles, it also develops on flat rocky substrata,

accompanied by another erected ochropytes, such as *Cystoseira dubia* (r), *Sargassum trichocarpum* (r) and *Sporochnus pedunculatus* (r); in the middle stratum, *Dictyota dichotoma* (c), *Padina pavonica* (r) and *Stypopodium schimperi* (r) are frequent in the Ras Chekaa sector, between 27 to 42m depth.

- Association with encrusting corallinales: In deeper rocky infralittoral habitats (26 to 40 m depth) the encrusting rhodophyte are dominant with the species *Mesophyllum* spp. *Neogoniolithon* spp., and *Peyssonnelia* spp.; and the erect *Amphiroa cryptarthrodia* and the ochrophyta *Stypopodium schimperi*. The poriferans are abundant, particularly the species of the Axinellidae family (*Axinella polyploides*, *Axinella* sp., *Crambe crambe*). Interesting is the presence of more littoral species such as *Pennaria disticha*, *Macrorhynchia philippina* and *Phallusia nigra* in the proximity of the cold-water springs (station T-21, at 38m depth).

III.3.2.3. Upper circalittoral rock

Biotope: Apart from the coralligenous infralittoral enclaves (overhangs, caves entrances) and caves, the circalitoral rocky bottoms have been rare between 44 to 47m depth (maximum depth in the present study) on vertical surfaces in the Tyre area for example. The dominant rock profile in all studied zones has been flat, with coarse sand and gravel patches and channels. The sciaphilic species dominate on horizontal surfaces due to the light absorption; and the bottom current is moderate. The presence of vertical surfaces and overhangs favours the coralligenous community. The bathymetric range varies from 28 to 42m depth.

Conservation interest: The coralligenous and cave communities are considered as priority habitats under protection (Barcelona Convention, European Union Habitat Directive), due to the high fragility because of human impacts.

Potential threats: The coralligenous and caves communities are very fragile to human impacts, mainly the mechanical impacts by non-trained scuba divers (erosion by flippers, rubbing), and boat anchoring on the rock. Also, the erosion produced by the fixed nets that pull up the candle sponges and madreporarians; the spearfishing with tanks on some target species (such as big Serranidae); and the collection of some vulnerable species (sponges, anthozoans) as 'souvenirs'.

Associated biocenosis:
- Coralligenous (UMR: IV.3.1)
- Semi-dark cave (UMR: IV.3.2).

III.3.2.3.1. Biocenosis of the "coralligenous" (UMR: IV.3.1)

The biocenoses on circalittoral hard substrata are the coralligenous and the semi-dark caves. Both appear in high sciaphilic enclaves in shallow waters (overhangs, caves entrances, crevices), on vertical surfaces at 32m depth and horizontal ones from 43m depth.

Structure of the community: The coralligenous represent the most complex community on the Mediterranean. There are various strata (upper, middle, lower, epibiosis) with a diverse biota. Nevertheless, the typical associations and facies described for the Mediterranean are not present in Lebanon, except the association with *Cystoseira dubia*.

- ***Upper stratum***: The more apparent species in the coralligenous community from Lebanon is the candlestick sponges *Axinella polyploides, Axinella dissimilis* and *Axinella* sp. The ochrophyte *C. dubia* is very sparse to form small 'forests'; also, *Arthrocladia villosa* and *Sporochnus pedunculatus*, from the lower infralittoral rock, are present in the coralligenous.

- ***Middle stratum***: Many erect rhodophytes form the middle stratum with massive poriferans, large hydrozoans, anthozoans, erect bryozoans and solitary ascidians. Within the rhodophyta, there are some Ceramiales (*Acrosorium* sp.), Rhodymeniales (*Rodymenia ardissonei*), Gelidiales (*Gigartina bipictinatum*) and Halymeniales (*Halymenia floresia, H. latifolia, Cryptonemia* cf. *lomation*); and the ochrophyta *Dictyota dichotoma* and *Stypopodium schimperi*.

  With regard to the epifauna, the massive poriferans are rare with *Agelas oroides, Acanthella acuta, Corticium candelabrum, Cymbaxinella damicornis, Dysidea avara Haliclona mediterranea* and *Petrosia ficiformis*. In the same way, the erect bryozoans *Adeonella calvetti, Caberea boryi* and *Reteporella* sp. have been rare. However, the large hydrozoans *Aglaophenia* and *Eudendrium* spp., the anthozoans *Madracis phaerensis* and *Phyllangia americana mouchezii*, the polychaete *Filograna* sp. and the solitary ascidian *Hermania momus* are common. The lessepsian bivalves *Chama pacifica, Malleus regula* and *Spondylus spinosus* are present, but they are rare.

- ***Lower stratum***: With the rhodophytes *Lithophyllum stictaeforme* (cc), *Mespohyllum alternans* (c), *Peyssonnelia* spp. (cc) and *Botryocladia botryoides*. The encrusting poriferans *Crambe crambe* (cc), *Haliclona fulva* (c), *Spirastrella cunctatrix* (r) and *Phorbas tenacior* (r); bryozoans (*Schizomavella* spp.) and the ascidians Didemnidae spp. (cc) and *Cystodytes dellechiajei* (cc).

- ***Mobile fauna***: Within the polychaete *Hermodice carunculata* (r), the gastropod *Conomurex persicus* (r), the decapod crustacean *Pilumnus hirtellus* (c), and the asteroids *Echinaster sepositus* (r) and *Coscinasterias tenuispina* (r). The fishes are more abundant, with *Coris julis* (cc), *Sargocentron rubrum* (cc), *Serranus cabrilla* (c), *Gobius vittatus* (c) and *Scorpaena maderensis* (c). Some infralittoral species are present, such as *Chromis chromis* (c), *Sparisoma cretense* (c), *Siganus luridus* (c), *Torquigener flavimaculosus* (c) and *Thalassoma pavo* (r).

Associations and facies:

- Coralligenous in infralittoral enclaves (UMR: III. 6. 1. 35).
- Association with *Cystoseira dubia* (UMR: IV. 3. 1. 3).
- Facies with *Axinella* spp.
- Coralligenous on blocks (platforms) (UMR: IV.1.15)

Coralligenous in infralittoral enclaves (UMR: III.6.1. 35)

In the infralittoral enclaves of this community (overhangs, cave entrances, crevices), there is the littoral rocky coralligenous community with encrusting calcareous algae (*Lithophyllum stictaeforme* (r), *Mesophyllum alternans* (c), *Neogoniolithon mamillosum* (c)) and *Peyssonnelia* spp. (cc); also, the chlorophyte *Palmophyllum crassum* (r).

The sessile fauna is dominated by the poriferans *Crambe crambe, Chondrosia reniformis*

and *Clathrina* sp.*;* the hydrozoan *Aglaophenia* spp.; the bryozoans *Schyzoporella* and *Reptadeonella* spp.; the ascidians Didemnidae spp. and *Herdmania momus*. The mobile fauna is represented by the fish: *Sargocentrum rubrum* (cc), *Pempheris vanicolensis* (cc) *and Trypterygion melanurum* (r).

Association with *Cystoseira dubia* (UMR: IV.3.1.3)

This association has been observed in Ras Chekaa on some flat rocky outcrops surrounded by coastal detritic bottoms with rhodolithes (maerl facies), between 43-44m depth. Other accompanying ochrophyta species have been observed *Arthrocladia villosa* and *Sporochnus pedunculatus*, normally on pebbles.

Facies with Axinellidae spp.

This association is present in the high rocky outcrops from for example northern Tyre, quite near of the cold-water springs, where the candlestick *Axinella polypoides* is common between 40-42m depth.

The sessile fauna is abundant with the other poriferans *Crambe crambe* (cc), *Dysidea avara* (r), *Oscarella lobularis* (r) and *Haliclona fulva or Haliclona (Rhizoniera) sarai* (c); the hydrozoan *Eudendrium glomeratum*; the sclerantinians *Phyllangia americana mouchezii* (cc) and *Madracis phaerensis* (c); and the ascidians *Cystodytes dellechiajei* (cc), Didemnidae spp. (cc) and *Herdmania momus* (c).

Another interesting facies with *Axinellidae* spp. is located at the entrance of the Chack El Hatab cave (at Hannouch, south of Ras Chekaa). Here there is a *Cymbaxinella* sp.

Coralligenous on blocks (platforms) (UMR: IV.1.15)

On the flat rock from Nakoura for example, between 44-45m, there are small boulders (ø = 30-50cm) covered by encrusting calcareous rhodophytes (*Lithophyllum stictaeforme, Mesophyllum alternans, Neogoniolithon* sp.), poriferans (*Crambe crambe, Phorbas tenacior, Spirastrella cunctratix*); bryozoans (*Frondipora verrucosa, Schizomavella* spp.) and ascidians (Didemnidae spp., *Cystodytes dellechiajei*).

These blocks are surrounded by gravel and coarse sand with rhodoliths (maerl facies). Noteworthy is the abundance of an ochrophyte *Lobophora* sp. (M. Verlaque's pers. com.) on the top of these blocks.

We do not think that these blocks must be coralligenous platforms, due to the depth (the coralligenous on subhorizontal surfaces appears from 43m depth in other prospected areas), but rather, rocky boulders cover by encrusting organisms.

III.3.2.3.2. Biocenosis of the semi-dark caves (UMR: IV.3.2)

This biocenosis has been observed between 0 to 5m depth in Enfeh, Ras Chekaa, the Raoucheh tunnel and Ras El Bayada. The entrance of the caves is colonized by an impoverished coralligenous community (except in the Chack El Hatab cave) the encrusting algae *Mesophyllum sp* (c), *Lithophyllum stictaeforme* (c), *Peyssonnelia spp* (cc) and *Palmophyllum crassum* (r).

Structure of the community:

- ***Medium stratum***: With the massive sponges *Chondrosia reniformis* (cc), *Petrosia ficiformis* (c), *Myrmekioderma spelaeum* (c), *Eurypongia raouchensis* (c) and *Clathrina* spp.; (*C. coriacea, C.* cf. *clathrus, C.* cf. *lacunosa)*; the scleractinian *Phyllangia americana mouchezii* (c) and the actinian *Telmatactis cricoides* (r); some specimens of *Chama pacifica* (r); the bryozoan *Margaretta cereoides* (cc); and the ascidians *Herdmania momus* (c), *Phallusia nigra* (c) and *Pyura dura* (r).

- ***Lower stratum***: With the encrusting species *Aplysina sp.* (cc), *Crambe crambe* (c), *Haliclona fulva* (c), *Sycon* sp. (c), *Diplastrella* spp. (r), *Hexadella racovitzai* (r); the madreporarian *Phyllangia americana mouchezii* (cc); the bryozoans *Schizoretepora hassi* (c), *Cellaria, Crisia* and *Scrupocellaria* spp. (c), and the ascidians Didemnidae spp., *Symplegma brakenhielmi* (r) and *Cystodytes dellechiajei* (cc).

- ***Mobile fauna***: With the polychaete *Hermodice carunculata* (c); the decapodes *Charybdis helleri* (c) and Galatheidae sp. (r). The observed fishes have been: *Pempheris vanicolensis* (cc), *Sargocentrum rubrum* (cc), *Apogon imberbis* (r) and *Tripterygion melanurum* (r).

Noteworthy is the original and rich sessile fauna of Lebanon's caves, particularly in the Chack El Hatab and Raoucheh. The first one presents some interesting endemics sponges such as the lithistid *Microscleroderma lamina* and *Gastrophanella phoeniciensis.*

As for Raoucheh's tunnel, the diversity of poriferans (*Aplysina, Chondrosia, Cliona, Crambe, Clathrina, Diplastella, Disporella, Eurypongia, Gastrophanella, Haliclona, Hexadella, Ircinia, paraleucilla, Petrosia, Phorbas, Spongia, Sycon* spp.) and ascidians (*Aplidium, Botrylloides, Cystodytes, Didemnum, Diplosoma, Hedmania, Phallusia, Polysyncraton, Pseudodistoma, Pyura, Symplegma*) is very high.

This cave perhaps represents one of the richest filter-feeding communities in the Levantine coast, due to the strong currents and high abundance of organic matter.

III.3.2.3.3. Biocenosis of the caves and ducts in total darkness (in enclave in the upper stages)

Only observed in the inner part of two caves: the Chack El Hatab cave at Hannouch and Bouknai cave at Ras Chekaa, where the illumination is absent and freshwater springs are present.

Structure of the community: It is present only on the lower stratum with *Serpulidae* spp. (cc) and *Madracis phaerensis* (c).

Associations and facies: in the inner part of Bouknai cave facies of *Protula* sp. and one *Cerianthus* have been observed in October 1999 (Bitar, personal observation).

III.3.2.3.4. Submarine cold and hot freshwater springs

The submarine cold and hot fresh water springs are very interesting due to the organisms'

adaptations around them. Several of theses springs are found in different localities in the Lebanese coast. We had the opportunity to explore three regions: Chekka, Tyre and Ras El Bayada.

Cold freshwater springs

In Chekka, freshwater sources are between 3 and 14 meters deep.
In the freshwater springs which are on the rocky bottom there is: macrophytes (*Codium taylori* (c), *Corallina* (c), *Amphiroa* (c), *Pterocladiella* (r)) ; sponges (*Chondrosia reniformis* (r), *Crambe crambe* (c), *Phorbas topsenti* (r), *Sarcotragus spinosulus* (r), *Ircinia variabilis* (r)) ; cnidarians (*Macrorhynchia philippina* (c), *Madracis pharensis* (r)) ; molluscs (*Pinctada imbricata radiata* (c), *Malleus regula* (c), *Chama pacifica* (c), *Spondylus spinosus* (c)) ; crustaceans (*Balanus trigonus* (c), *Perforatus perforatus* (c)) ; echinoderms (*Holothuria* sp. (r), *Synaptula reciprocans* (r), *Paracentrotus lividus* (r), *Arbacia lixula* (r)) ; ascidians (*Phallusia nigra* (r), *Herdmania momus* (c), *Clavelina* sp. (r)) ; fish (*Coris julis*, *Thalassoma pavo*, *Siganus rivulatus*, *Chromis chromis*, *Scorpaena maderensis*).
However, in the freshwater springs that are on a sandy bottom of *Cymodocea nodosa*, we find: molluscs: *Conomurex percicus* (c), *Bulla* sp. (r), *Fusinus* sp. (r), *Rhinoclavis Kochi* (r), *Acanthocardia* sp. (c), *Mactra* sp. (r), *Neverita josephinia* (c) ; holothuroid: *Synaptula reciprocans* (r)*;* fish (*Bothus* (r), *Oblada melanura* (c), *Coris julis* (r), *Thalassoma pavo* (c), *Siganus rivulatus* (cc), *Chromis chromis* (c), *Scorpaena maderensis* (r)) (Bitar, personal observations).

Around the cold-water springs of the Ras El Bayada (12 to 15m depth) and Tyre (32-40m depth)., one deep red Cyanobacteria dominates (*Oscillatoria* sp.) and cover some organisms such as the poriferan *Phorbas topsenti*.

In Ras El Bayada, some encrusting species such as rhodophytes (*Peyssonnelia* spp. and *Lithophyllum* spp.) and the poriferan *Crambe crambe* and *Chondrilla nucula* are abundant. Also, the hydroids *Macrorhynchia philippina* (cc) and *Pennaria disticha* (cc) with the ascidian *Phallusia nigra* (c).

In Tyre, in a deeper station, it is noted the common occurrence of infralittoral species such as hydrozoa (*Pennaria disticha*, *Macrorhynchia philippina*), holothuroid (*Synaptula reciprocans*), ascidian (*Phallusia nigra*). The other species are: sponges (c) (*Agelas oroides*, *Petrosia (Petrosia) ficiformis*, *Crambe crambe*, *Axinella polypoides*), cnidarians (c) (*Phyllangia mouchezii*, *Madracis pharensis*, *Eudendrium* spp.), polychaetes (*Hermodice caranculata* (r), *Spirobranchus tetraceros* (c)), molluscs (*Chama pacifica* (c), *Spondylus spinosus* (c), *Lithophaga lithophaga* (r), calcareous algae (*Peyssonnelia spp.* (c)), fish (*Dasyatis pastinaca* (r), *Mycteroperca rubra* (r), *Epinephelus marginatus* (c), *Sargocentrum rubrum* (cc)).

Hot-water springs

Located in the north of Tyre, between 38-42m depth. The colonies of the bacteria *Beggiatoa* are characteristic and they growth quite near to the hot spring hole. The biodiversity around the hotsprings is poorer than that of the cold-water ones, dominating the encrusting rhodophytes.

Around the spring an impoverished community of sciaphilic algae is present with rhodophytes (Ceramiales, *Peyssonnelia* spp., *Amphiroa beauvoisii*), ochrophytes (*Stypopodium schimperi*), poriferans (*Petrosia ficiformis*), hydrozoans (*Aglaophenia* and *Eudendrium* spp.) and ascidians (*Cystodytes dellechiajei*).

III.3.3. SOFT SUBSTRATA

The soft substrata are dominant from 0m in the littoral sand beaches to deeper muddy sand bottoms (at 50m depth). The granulometry has been very varied: cobbles, pebbles, gravel, sand (coarse, fine) and mud. The more predominant sediments have been: well sorted sand in shallow waters (0-15m depth); coarse and shell gravel (8-32m depth); maerl beds (32-47m depth); and muddy sand (15-50m deph).

III.3.3.1. Infralittoral soft bottoms

Biotope: In shallow waters (< 15m) the well sorted sand is frequent, particularly from the littoral beaches (example Chekaa, north and south of Tyre). The wave action procures clean sandy bottoms without mud, from 0 to 15m depth; then, the mud fraction increases to 50m depth (maximum isobath reached). In rocky shore areas, the coarse sand and fine shell gravel bottoms are the dominant, normally forming patches and channels in the rocky substratum. Although the separation in the infralittoral and circalittoral soft substrata communities is not clear, we have considered the presence of deep maerl beds (from 32-33m depth) as the limit of these stages.

Conservation interest: From the conservation point of view, there is one community of special interest, the *Cymodocea nodosa* meadows (Barcelona Convention). At present, this community is more frequent in the northern secteur of Lebanon where it forms sparce meadows. The causes are not elucidated, but the competition with another magnoliophyte *Halophila stipulacea* (lessepsian species), together with the increasing temperature and anthropic impacts may be some possible causes for this rarefaction. It occurs between 3 and 31m depth sometimes accompanied by *Halophila* (; Bitar, personal observation).

Potential threats: The *Cymodocea* meadows are subject to various threats. One of the more important ones is the hyper-sedimentation from sediment discharge (e.g. Selaata harbour; concrete factories) and global change. Other impacts could be related to untreated domestic waters and littoral constructions (such as marinas, ports, beach replenishment, littoral gains).

Associated biocenosis:

- Biocenosis of well sorted sand (UMR: III.2.2).
- Biocenosis of muddy sand (UMR: III.3).
- Biocenosis of Coarse sands and gravels, under the influence of bottom currents (UMR: III.3.2).

III.3.3.1.1. Biocenosis of well sorted fine sands

The biocenosis of well sorted fine sand is developed from the open beaches, mainly in Enfeh-Chekaa and Tyre, between 0 to 15m depth.

Structure of the community: The upper stratum with *Cymodocea nodosa* in some shallow locations, 1-3m depth. As for the middle and lower strata, it is represented by Cerianthidae sp. (r).

- ***Infauna***: Mainly with the bivalves *Acanthocardia tuberculata* (cc), *Glycymeris* spp. (cc), *Mactra stultorum* (c), *Gafrarium savignyi* (c); and the echinoidea, *Echinocardium mediterraneum* (c).

- ***Mobile fauna***: With the decapod *Diogenes pugilator* (cc); the gastropodes *Rhinoclavis couchii* (c), *Conomurex persicus* (c), *Nassarius reticulatus* (c) and *N. sufflatus* (c); the holothurian *Holothuria tubulosa* (r), *Synaptula reciprocans* (c); and the fishes *Lithognathus mormyrus* (c), *Mullus surmuletus* (r), *Bothus podas*, *Xyrichthys novacula*, *Pomatoschistus* sp. *(c).*

Association and facies

- Association with *Cymodocea nodosa* on well sorted fine sands (UMR: III.2.2.1).

Association with *Cymodocea nodosa* in fine sand

Distribution: *Cymodocea nodosa* a été observé dans plusieurs localités du nord au sud: Ile Ramkine, Enfeh, El Heri, Ras Chekaa, Hannouch, Selaata, Batroun, Barbara, El Zahrani, and Rachidiye (au sud de Tyre). *C. nodosa* exhibited a lower value in morphology, shoot density, and biomass. This could be related to the extreme environmental conditions which are the limit of the distribution of the *C.* in this sector for the Mediterranean Sea (RAC/SPA - UNEP/MAP, 2014, Bitar, personal observation).

III.3.3.1.2. Biocenosis of muddy sands

This community is spread, between 8 to 47m depth, particularly around Enfeh and Selaata with *Cymodocea nodosa* and *Caulerpa prolifera* patches.

Structure of the community

- ***Middle and lower strata***: With the chlorophytes *Caulerpa prolifera* (c), *Caulerpa racemosa* (r), *C. scapelliformis* (r) and *Flabellia petiolata* (r) and the magnoliophyte *Halophila stipulacea* (r); isolated mats of *Cymodocea nodosa* have been observed in this community. Some isolated individuals from Cerianthidae spp. have been observed.

- ***Infauna***: With the polychaete *Ditrupa arietina* (cc); the bivalves *Acanthocardia tuberculata* (c), *Ctena decusata* (c), *Lucinella divaricata* (c) and *Fulvia fragilis* (c); the echinoida *Echinocardium mediterraneum* (r).

- ***Mobile fauna***: With the crustacean decapods *Diogenes pugilator* (cc) and *Myra fugax* (r); the gastropoda *Rhinoclavis kochi* (cc), *Conomurex persicus* (c), *Murex forskoehlii* (c), *Nassarius sufflatus* (c) and *Semicassis granulata* (c); the holothuroids *Holothuria tubulosa* (r) and *Synaptula reciprocans* (r); the fishes *Dasyatis pastinaca* (c), *Pagellus acarne* (c), *Serranus hepatus* (cc), *Bothus podas* (r), *Xyrichthys novacula* (c) and *Spicara smaris* (c).

Association and facies

- Association with *Cymodocea nodosa* on muddy sands (UMR: III.2.3.4)
- Association with *Caulerpa prolifera* (UMR: III.2.3.6)
- Association with *Caulerpa taxifolia* var. *distichophylla*
- Association with *Halophila stipulacea*

Association of *Cymodocea nodosa* on muddy sands

Cymodocea nodosa on muddy sand has been frequently observed in the Enfeh-Ras Chekaa sector in sites deeper than 14m, but it does not form meadows only dispersed mats, resulting from seed recruitment. In June 2012, many germinated seeds have been observed, between 14 to 44m depth, it means that the fructification period occurs in later spring. In the Saida-Nakoura sector, *C. nodosa* has been observed on one site (in front of Rachidiye, southern Tyre) forming a small patch with isolated plants at 30-31m depth (RAC/SPA - UNEP/MAP, 2014).

Association with *Caulerpa prolifera*

The *Caulerpa prolifera* meadows have only been observed in the Enfeh – Ras Chekaa sector, between 17 to 44m depth and in northern Saida Island at 31m. *C. prolifera* meadows are dispersed and dense from 20 to 27m depth (RAC/SPA - UNEP/MAP, 2014; Bitar personal observation).

Association with *Caulerpa taxifolia* var. *distichophylla*

In Lebanon, *C. taxifolia* var. *distichophylla* was first found in October 2016 at El Madfoun and Byblos, between 16 and 48 m depth, where it constituted small patches (10-40 cm in diameter) on sand and gravels. It is the first time that this invasive species has been recorded from Lebanon (Bitar *et al*., 2017).

Association with *Halophila stipulacea*

In Lebanon, this non-indigenous association was first collected in 1966, off Saida, by Dr J. H. Powell (Lipkin, 1975). *Halophila stipulacea* is mainly distributed in the northern part of Lebanon, between 1 and 40 m depth. No dense meadows were found in Lebanon (Bitar *et al.*, 2017).

III.3.3.1.3. Biocenosis of coarse sands and gravels (under the influence of bottom currents)

The biocenosis of coarse sand and gravels under the influence of bottom currents is widespread in the Ras Chekaa, Nakura and Tyre zones. Both on infralittoral and circalittoral bottoms (mainly, between 7 to 44m depth), it appears in rocky channels and pools, between blocks, around maerl beds and rock ridges.

Structure of the community: The upper and middle strata are absent. In the lower stratum appear some rhodolithes and Ceramiales (cc) with the poriferans *Ciocalypta carballoi* (c) and *Cinachyrella levantinensis* (r);

The invertebrate mobile fauna has been poor, with the polychaete: *Hermodice carunculata*; the gastropods *Bittium* sp (c) and *Conomurex persicus* (r); the bivalves *Venus verrucosa* (c) and *Mimachlamys varia* (r); and the holothurian *Synaptula reciprocans* (r). Noteworthy is the frequency of empty shells of *Brissus unicolor* on this bottom.

Nevertheless, and due to the proximity of rocky and sandy bottoms, the fishes have been common, such as *Dasyatis pastinca* (c), *Boops boops* (c), *Coris julis* (cc), *Plotosus lineatus* (c), *Thalassoma pavo* (c), *Diplodus vulgaris* (c), *Serranus cabrilla* (cc), *Sargocentron rubrum* (c), *Spicara smaris* (c), *Torquigener flavimaculosus* (r) and *Gobius geniporus* (r), The more characteristic fish has been *Gobius bucchichi* (cc).

Associations and facies: Association with rhodolithes (UMR: III.3.2.2)

Association with rhodolithes

Although this community is enclosed in the biocenosis of coarse sands and gravels under the influence of bottom currents, this original and rare habitat in the Mediterranean deserves to be considered separately. The substratum is formed by free living rhodoliths (some of them ∅ = 7cm) of the Corallinacea (Melobesiae), mainly the species *Neogoniolithon brassica-florida* and *Lithophyllum incrustans*, with small cobbles, shell gravel and coarse sand.

This maerl bed has been located in northern Tyre, where the inlets and beach form a lagoon. A complex community is associated with this habitat, between 6 to 9m depth, mainly sessile fauna are bivalves (*Chama, Spondylus, Malleus, Pinctada*), hydroids (*Macrorynchia, Pennaria*), sponges (*Crambe*), ascidians (*Phallusia, Rhodosoma, Styelidae*) and macroalgae (*Cystoseira, Dictyota, Amphiroa, Lobophora, Lithophyllum…*) Noteworthy is the presence of juvenile fishes (p.e. *Mycteroperca rubra*), as a nursery area.

III.3.3.2. Upper circalittoral soft bottoms

It has been difficult to establish the separation between infra and circalittoral soft bottom communities. The criterion has been pragmatic, when the rhodolith cover in the coarse sand and gravel exceeded the 10%, it was considered maerl bed (according with Steller *et al.* 2003). This occurs at a depth of about 32-33m.

Biotope: The coarse sand and gravel are very spread around the areas where the intensity of the bottom currents, preventing the presence of mud. Nevertheless, from 40m the muddy sediment becomes frequent on gravel bottoms, revealing the muddy detritic bottoms. In the summer time (2013) the thermocline (28ºC) has reached 42m depth.

Conservation interest: The maerl facies represents the most important communities on soft bottoms from the conservation point of view. It is protected by the Barcelona Convention and the European Union habitat Directive (annex V).

Potential threats: The maerl beds are subject to various threats. One of the most important threats is the hyper-sedimentation from sediment discharge (e.g. Selaata harbour; concrete factories). Another impact is related to fixed nets that pull up the rhodolithes and associated species (e.g. *Cystoseira dubia*).

Associated biocenosis:

- Biocenosis of the muddy detritic bottom (UMR: IV.2.1).
- Biocenosis of the coastal detritic bottom (UMR: IV.2.2).
- Also, the muddy sands are present at this stage with the *Caulerpa prolifera* facies.

III.3.3.2.1. Biocenosis of the muddy detritic bottom

The biocenosis of the muddy detritic bottom has been present in patches on the maerl bed, between 35-47m depth. The most characteristic association has been *Flabellia petiolata* and *Caulerpa scapelliformis*; this later species is also present on muddy bottoms.

Structure of the community

- ***Upper and lower strata***: The *Flabellia petiolata* and *Caulerpa scapelliformis* thali form an upper stratum, although very dispersed; some *Arthrocladia villosa* and *Halymenia floresia* individuals are present.

- ***Lower stratum***: Some living rhodolithes (*Lithothamnion corallioides*) with small *Ceramiales* spp. are present.

- ***Mobile fauna***: The mobile fauna has been rare, only the fish *Serranus hepatus* is common. Also, the polychaete *Hermodice carunculata* (r), the lessepsian holothurian *Synaptula reciprocans* (r) and the fishes *Serranus cabrilla* (c) and *Coris julis* (r) have been observed.

Associations and facies: Association with *Flabellia petiolata* and *Caulerpa scapelliformis*.

This interesting association has been observed in Anfeh, and Ras Chekaa-Selaata, between 42-44m on maerl bed degraded by the mud.

III.3.3.2.2. Biocenosis of the coastal detritic bottom

The coastal detritic bottoms appear at 32m depth, where the coarse sand and fine gravel sediment are dominated by the rhodolithes (cover > 10% of the bottom surface).

Structure of the community

- ***Upper stratum***: With *Arthrocladia villosa* (cc) and *Sporochnus pedunculatus* (c); some thalli of *Cystoseira dubia* are present and fixed on rhodolithes.

- ***Middle stratum***: Mainly, with soft rhodophytes such as *Halymenia floresia* (c) and *Rhodymenia ardissonei* (c); the ochrophytes *Dictyota dichotoma* (c) and *Stypopodium schimperi* (r). The ascidian *Herdmania momus* (c) can agglomerate with some rhodolites.

- ***Lower stratum***: With the corallinales *Lithothamnion corallioides* (cc), *Spongites fruticulosa* (c), Mesophyllum sp. (c) and *Phymatolithon calcareum* (r); the soft rhodophytes *Cryptonemia lomation* (c), *Botryocladia botryoides* (c), *Peyssonnelia* spp. (cc) and Ceramiales (cc), the sponge *Crambe crambe* (c); the madreporarian *Madracis phaerensis* (r); and the bivalve *Striarca lactea* (c).

- ***Mobile fauna***: With the polychaete *Hermodice carunculata* (r); the gastropods *Bittium* sp. (cc) and *Conomurex persicus* (r); the brachyuran *Pilumnus hirtellus* (r); the echinoderms *Echinaster sepositus* (r) and *Synaptula reciprocans* (r). The most abundant fishes have been *Coris julis* (c), *Sparisoma cretense* (r), *Serranus cabrilla* (c), *Pagellus erythrinus* (r), *Torquigener flavimaculosus* (c) and Gobiidae [with *Gobius geniporus* (c), G. *kolombatovici* (r) and *G. vittatus* (c)]

Associations and facies

- Maerl facies *(Lithothamnion corallioides* and *Phymatoliton calcareum*) (UMR: IV.2.2.2)
- Association with *Arthrocladia villosa* (UMR: IV.2.2.4)

Maerl facies

The deep maerl beds have appeared in Nakoura and Tyre, between 32-45m depth (RAC/SPA - UNEP/MAP, 2014) and to the west of Ramkine Island at 67m depth (Bitar, personal observation during a deep dive). The substratum is formed by shell gravel and coarse sand, with the rhodolithes *Lithothamnion corallioides* (c), *Mesophyllum* sp. (c) and *Spongites fruticulosus* (c). The lessepsian chlorophyte *Caulerpa scapelliformis* is present.

The epifauna has been scarce with the gastropod *Conomurex persicus* (c), the holothurian *Synaptula reciprocans* (r) and the echinoid *Cidaris cidaris* (c) (only faraway to the west of Ramkine Island).

Association with *Arthrocladia villosa*

This association has been present in the Ras Chekaa area, between 32-42m depth. The upper stratum is formed by *Arthrocladia villosa* (cc) and *Sporochnus* pedunculatus (c). Other ochrophytes are present, *Dictyota linearis* (c) and *D. dichotoma* (c).

III.4. List of habitats to be monitored

In hard substrata

Littoral rock

1. Biocenosis of midlittoral caves (UMR: II.4.3)
2. Vermetid Platform: Vermetids with *Dendropoma* and *Neogoniolithon* (UMR III.6.1.3).

Infralittoral rock (UMR: III.6)

1. Association with *Cystoseira amentacea var. amentacea* (UMR: III.6.1.2).
2. Association with *Sargassum vulgare* (UMR: III.6.1.20.
3. Association with *Cystoseira compressa* (UMR: III.6.1.25.
4. Association with *Dictyopteris polypoioides* (UMR: III.6.1.21.
5. Facies with *Perforatus perforatus*.
6. Association with *Peyssonnelia* spp. (UMR: III.6.1.34).
7. Coralligenous infralittoral enclaves (UMR: IV.3.1).
8. Association with *Arthrocladia villosa* (UMR: IV.2.2.4).

9. Association with encrusting corallinales: In deeper rocky infralittoral habitats (26 to 40 m depth) *Mesophyllum* spp., *Neogoniolithon* spp., and *Peyssonnelia* spp.

Upper circalittoral rock

1. Biocenosis of the "coralligenous" (UMR: IV.3.1) (4).
2. Biocenosis of the semi-dark caves (UMR: IV.3.2).
3. Biocenosis of the caves and ducts in total darkness (in enclave in the upper stages).
4. Submarine cold and hot freshwater springs.

In soft substrata

Infralittoral soft bottoms

1. Association with *Cymodocea nodosa* on well sorted fine sands (UMR: III.2.2.1).
2. Association with *Cymodocea nodosa* in fine sand.
3. Association with *Cymodocea nodosa* on muddy sands (UMR: III.2.3.4).
4. Association with rhodolithes (UMR: III. 3. 2. 2).

Upper circalittoral soft bottoms

1. Association with *Flabellia petiolata* and *Caulerpa scapelliformis*.
2. Maerl facies (*Lithothamnion corallioides* and *Phymatoliton calcareum*) (UMR: IV.2.2.2).
3. Association with *Arthrocladia villosa* (UMR: IV.2.2.4).

IV. Implementation of the monitoring and operational plan

IV.1. Means used

Traveling to the monitoring sites can be done using rented, personal or CNRS cars. The study of the supra and mediolittoral zones and vermet platforms is carried out on foot, that of the shallow areas by snorkelling. Offshore trips to study the submarine and circalittoral submarine zones are conducted by the national oceanographic vessel CANA / CNRS. While the coastal surveys can be carried out using either small craft fishing boats rented or with a small boat of the Navy. The CNRS has just got a catamaran boat "CADMOS-CNRS" of 7m length which will be well equipped for all field studies near the coast.

IV.2. Tools and methods used

Monitoring tools and methods used according to the objectives:

- **Exploration on foot** of the coastline, particulary the vermets platforms.
- **Snorkeling** in the shallow areas.
- **Scuba diving** for the exploration of associations and infralittoral and circalittoral facies. For point observations, a plastic plate with polyester paper is used to record the nature of the bottom, habitat type, macrofauna and macroflora encountered. Some species with taxonomic or unidentified doubts on the spot are collected. The stattions location of stations is identified using GPS.
- **Sampling in the *Cymodocea nodosa* meadow** with a surface of 40 X 40 cm: for morphological and morphometric study as well as density and biomass

- **Visual census of fish**: for counting fish by the metric tape transect method. Usually, the transects were 125 m2 (25m x 5m). The parameters studied are: number, size, abundance and biomass.
- **Hydroplane**: for bottom mapping and habitat characterization. Hydroplane allows extensive exploration of the area concerned. It is equipped with a rope of 100 m and a chain of 3 m and dragged by small inflatable boat (zodiac). Once the diver is at the bottom, he records on a plastic plate his observations of the species end populations encountered. A Go Pro video camera installed at the diver's head films everything that happens during the dive. On board the boat, one person takes care of the navigation and two others who note the position (with a GPS), the depth (with an echo sounder), the time and the safety of the diver. The GPS data is afterwards downloaded to the computer.
- Possible use of a **Van Veen tipper**.
- **Photography** is used in all cases.
- **Drop cameras** "and **photo quadrates** are to be use
- **CTD** and **Secchi disk**: for hydrological profiles and water transparency.
- The CNRS has just got a **ROV**, a **multibeam sonar** and a **sediment sounder**.
- Establishment of **monitoring systems** in priority habitats is to be consider
- **Samples processing**: After binding in formalin or alcohol samples (fauna and flora) are observed with a binocular and microscope for taxonomy.
- **Parameters and indices used**: relative abundance (three levels of semiquantitative value are used: 1 = rare, 2 = common and 3 = abundant), dominance or frequency, specific richness, diversity indices, equitability, Margalef index / nb. habitats, vulnerability, heritage value, aesthetic value, economic importance, rarity, naturalness index and environmental value. For visual fish census: a software called ecoCEN is used. This is a special software for the management of fish underwater visual census data. This helps to organize the data. However, for statistical analysis, R. R open source statistical software can be used.

IV.3. Monitoring systems used

The only system applied until now has just been started by a Lebanese PhD student (A. Baderddine) which is the CARLIT metric (CARtografia LIToral) which is used to calculate the ecological qualities EQR (Ecological Quality Ratio) which are transcribed into ecological status. in accordance with the requirements of the Marine Strategy Framework Directive (2008/56 / EC), with the objective is the protection and conservation of this environment and to prevent its deterioration in order to achieve a "good ecological status of the marine environment". It uses macroalgae and sessile invertebrates (vermets and Mytilidae) as environmental descriptors. This method is based on the exhaustive mapping of the distribution and abundance of mid-upper and upper-level communities as well as the geomorphology of the coast.

IV.4. Systems to be developped

All the devices needed to evaluate the good environmental status of marine habitats and which are already used in other marine research centers and universities, especially in all the countries of the Mediterranean region.

V.5. Operational implications requested and proposed for the proper monitoring of the programme

IV.5.1. Human ressources

- The first priority in terms of need is the training of Lebanese specialists in oceanology in general and especially in taxonomy because before conducting monitoring activities and taking measures for protection and adaptation, they must know what to protect; hence it is necessary to progress the inventory of national biodiversity and complete the list of species of our genetic and biological heritage. This list is far from being hexaustive. One more reason is that the 3 well-known specialists in Lebanon are currently retired. The specialists must also be good divers.

• Confirmed divers to accompany scientists and specialists in field work.

• At least two sailors to work on the boat and to help divers.

IV.5.2. Requested equipment

In order to simultaneously complete the taxonomic work and the monitoring of marine habitats from all depths, there is need to:

• Complete set of diving equipment for 4 people to work safely.

• Dredges for rocky and soft bottoms, underwater cameras, drop cameras, quadrats cameras and surveillance systems. The rest of the equipment and research facilities are at the National Marine Science Center at Batroun.

IV. 5.3. Sites to be monitored (figure 1)

Three sites or areas of monitoring are proposed:

- Tripoli – Ras El Chakaa sector (including the Palm Islands Natural Reserve and the Chak El Hatab cave known by the Lithistides cave located a little south of Ras El Chakaa).
- Beirut sector (from the port to Raoucheh area).
- Tyr – Ras El Bayada sector

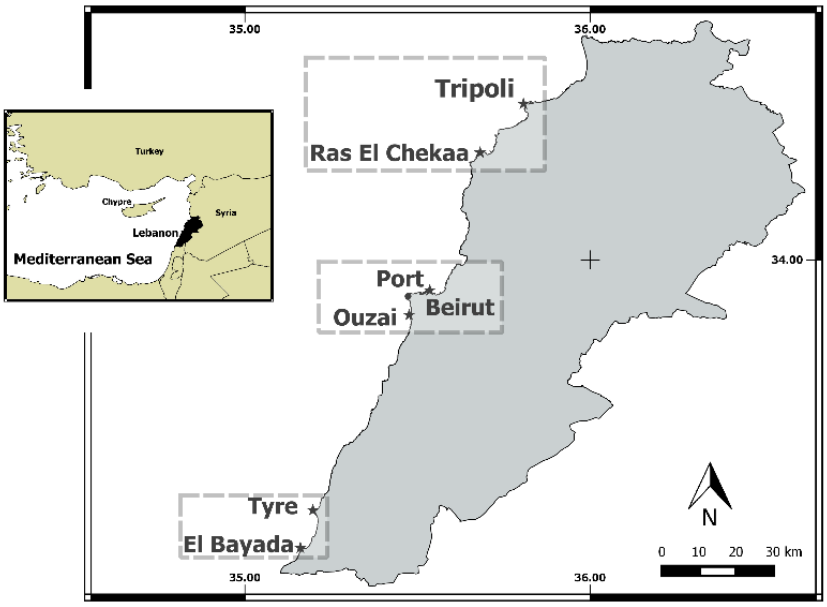

Figure 1. Monitoring sites

IV.5.4. Exploration and sampling strategy

Given the geographical location of Lebanon, near the Suez Canal which considered as a vector of introduction of indopacific exotic species and given the impact of global change we propose an annual monitoring for marine habitats.

IV.5.5. Storage, sharing and access to scientific data

The MoE through the LEDO (Lebanese Environment and Development Observatory) centralized all basic data of marine and other environmental information. But since 2002, the LEDO no longer functional. Currently, each university centralizes its own data, as is the CNRSL and its NCMS. For the marine environment, the Marine Science Center has been monitoring for a long time a network of about 30 stations along the Lebanese coast covering physical, chemical and bacteriological parameters. The CNRS and its National Marine Science Center in collaboration with the MoE could take charge of the management and the banking of all the data of the marine environment. It is up to them too to take the necessary measures so that the scientific community can have access to these data.

IV.5.6. Link with other programmes or ecological objectives

The data obtained from this benthic habitat monitoring programme will also be able to meet the objectives of the "non-indigenous species" programme.

IV.5.7. Responsible bodies for the implementation

The MoE, all the ministries concerned, the CNRSL, the NCMS, the universities, the research institutes, the national committees, the donors, the private sectors, as well as the important assistance and associated expertise of the UNEP-MAP/ SPA/RAC, IUCN ... and specialist researchers (especially taxonomists) from universities and regional and international marine research centers.

Not to mention the implication of retired specialists who have accumulated a lot of data on the characteristics of species and habitats including the history and evolution of non-indigenous species and their impacts on local habitats.

IV.5.8. Financial sustainability (budget)

Without counting the unavailable material (rocky and soft bottom dredges, core drill, drop cameras, Photo quadrats and surveillance systems), the necessary budget is distributed according to the following table:

Needs	**Costs in dollars/year**
Diving equipment for 4 people	14 000
Two underwater cameras (with cameras and accessories) and two Go Pro cameras	6 000
Chemicals, pliers, glassware, systematics books, stationery and others,	8 000
Field work 1. On foot, snorkeling and scuba diving up to the circalittoral stage 2. Hydroplane 3. ROV, Drop Camera 4. Visual census of fish 5. Multibeam sonar 6. CTD Data analysis	500 000

IV.5.9. Conclusions and recommendations on the implementation of the national monitoring programme

In the report on the vulnerability and impacts of climate change on marine and coastal biodiversity in Lebanon (Bitar 2008), priority "urgent" actions have been proposed. We quote (in italics) those related to this monitoring programme:

- *Biodiversity Action: Before taking measures of protection and adaptation, we must know what must be protected; hence it is necessary to advance the inventory of national biodiversity and complete the list of the genetic and biological heritage. This requires the training of young researchers in the taxonomy of the different zoological and floristic groups belonging to: plankton, nekton (fish and mammals) and benthos.*

- *Habitats (coastal and marine) Action and mapping of ecosystems, biocenoses, associations and facies: It is true that planktonic communities are well studied in Lebanon, but nekton and especially benthos deserve special attention. The different benthic biocenoses must be identified, mapped at all levels and depths without forgetting the fauna and flora associated with different facies and associations. These types of studies must be implemented as soon as possible because many habitats are already weakened by pollution, warming and exotic species. Similarly, the benthic communities of the Lebanese coasts in particular, and the Levantine coast in general, should be considered as a regional priority throughout the Mediterranean given their biological characteristics that distinguish them from other*

communities in the western Mediterranean. To give more details, and to visualize the target biocenoses, this action plan is subdivided into several sub-actions concerning:

o Dunes, beaches including coastal degradation and erosion in relation to warming, rising of the sea level and human activities.

o The vermetus platforms (Dendropoma petraeum) and Neogoniolithon brassica-florida. These characteristic zones of the Lebanese coast, which are considered by the scientific community as sites to be protected, are demolished in several localities by town planning and the construction of factories and seaside resorts. Likewise, they are threatened by sea levels rising.

o The biocenosis of photophilous algae of the infralittoral layer with its associations and its facies. With particular attention to the associations of Cystoseires and especially that of Cystoseira amentacea which is a good indicator of clean water, and which has disappeared in many localities. It is the same for the two species of high levels Tetanoderma byssoides and Tenarea tortuosa.

o Herbaria with Cymodocea nodosa and Halophila spipulacea.

o Coralligenous biocenosis which is spongiform and without gorgonians and red coral.

o The maërl observed once by scuba diving at Ramkine Island (one of the islands of the Palm Island Reserve) at 67 m depth. The bottom is rich in characteristic calcareous algae Lithothamnion calcareum and Mesophyllum corallioides in the presence of sea urchins Stylocidaris affinis.

o Semi-dark and dark caves. The exploration of the caves all along the Lebanese coast is a priority, dozens of species of new sponges never found in the seas of the world were found there. This suggests declaring the already explored caves of Chak El Hatab (north of Selaata), Raoucheh in Beirut and El Bayada north of Nakoura as marine sites of special interest or protected areas. The cave of Raoucheh located on the cliff in front of 2 big rocks is in the form of a long tunnel very rich especially in sponges but unfortunately it is threatened by the garbage poured by the people who frequent this region; an explanatory letter has already been sent to the Municipality of Beirut to save this natural heritage.

o The harbor environment and the soiling sites. Ports are reservoirs of exotic species that arrive there fixed on the hulls of boats that travel long distances between different seas or oceans. The hulls of boats as well as any construction or installation at sea are substrates for so-called fouling..

- Exotic and invasive species Action : This action is very important to follow in relation to the warming. The aim is not only to identify them and to follow their temporal distribution but also to know their biology and especially their ecology in the host environment which differs from that of the environment of origin.

- Action studies impact, monitoring and long-term preservation of species and biocenoses and especially bioindicators. This will allow to take measures to assess vulnerability, adaptive capacity and subsequently mitigation.

- Marine reserves action: Marine protected areas remain a priority because they play, among other things, the role of the reference areas of any comparative study between clean and polluted zones. In this respect, the creation of other marine reserves should be considered in a

framework similar to that of the SPA/RAC MedMPA project. Transboundary marine areas (with Syria) are strongly recommended.

It is necessary to consider the benthic habitats of the Lebanese coasts in particular, and of the Levantine coast in general, as a regional priority at the level of the whole Mediterranean Sea, given their biological characteristics and the habitats that distinguish them from other habitats of the western Mediterranean.

Proposed localities for monitoring benthic habitats and species respond well to the main objective of this program. Monitoring of the spatial and temporal coverage may be changed according to unforeseen needs.

Establishment of monitoring systems in priority habitats.

The CARLIT device and other suggested devices should be continued along the Lebanese coast in the long term.

It is necessary to extend the coverage of the programme to include also the study of the deep environments and especially the exploration of the different canyons of the Lebanese coast. In this respect, a field mission of the "Deep Sea Lebanon" project is already well completed in October 2016 and is implemented by OCEANA with the assistance of SPA/RAC, IUCN and CNRSL.

The most important obligation and priority is the capacity building of national taxonomists (divers at the same time) of the different floristic and faunal groups. Similarly, there is a need to fill in the gaps that exist in the habitats and species that live in the soft bottom and that require the use of skips and dredges for sampling. In the same way the technical team on board the boats must have a good knowledge of the basics for the good progress of the various research operations.

The data collected under this programme are also useful for the purposes of the Ecological Objective 2: monitoring programme of the non-indigenous species.

The the implementation of this monitoring programme can start by the end of 2018.

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