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SPA / RAC

# NATIONAL MONITORING PROGRAMME FOR MARINE BIODIVERSITY IN LEBANON

EcAp-Med II Project

With the financial support of

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# National Monitoring Programme for Marine Biodiversity in Lebanon

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**Study required and financed by:**

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# MINISTERIAL FOREWORD

Healthy and biologically diverse marine and coastal ecosystems are essential for human well-being, as they provide invaluable ecosystem services. Therefore, the application of the ecosystem approach to the human activities is very important to establish the balance between conservation and the sustainable use of the marine biodiversity.

Highly aware of the importance of the marine environmental issues in Lebanon, the Lebanese Government is engaged to establishing adequate measures that are consistent with the Ecosystem approach principles. However, there is a pressing need to continue the excellent Lebanese commitment to studying and protecting the marine biodiversity.

By working together, the Ministry of Environment of Lebanon and the Specially Protected Areas Regional Activity centre (SPA/RAC) elaborated the National monitoring programme for marine biodiversity following a collaborative approach involving national stakeholders, local scientists, national organizations and civil society.

This programme will help establishing an effective monitoring and reporting systems to better assess the environmental status of the marine ecosystem and to support decision making in the formulation of effective marine policies.

**Minister of Environment**

**Fady Jreissati**

# FOREWORD

The ecosystem approach (EcAp) is an overarching concept adopted at global level to guide the countries efforts to manage biological resources towards enhancing sustainable development and poverty alleviation. As defined by the UN Convention on Biological Diversity (UNCBD), EcAp is a "strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way».

In the Mediterranean region, the integration of the ecosystem approach in the regional and national policies and sectoral development strategies has become the number one priority for the region to promote the achievement of the Sustainable Development Goals.

In 2008, the Contracting Parties to the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean Sea, namely 21 Mediterranean countries and the European Union, decided to progressively apply the ecosystem approach to the management of human activities that may affect the Mediterranean marine and coastal environment, and initiate the EcAp process involving scientists and policy makers and other competent organizations and authorities. They agreed on an implementation roadmap driven by a shared vision: "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations".

In fact, the EcAp has become the guiding principle of the Mediterranean Action Plan mid-term strategy and overarching policy for the development and implementation of any action undertaken within Barcelona Convention, with the ultimate objective of achieving the Good Environmental Status (GES) of the Mediterranean.

Starting a new Project on the implementation of the ecosystem approach principles named EcAp-MED II (Mediterranean implementation of the Ecosystem Approach, in coherence with the EU MSFD) and funded by the European Union, was a challenge. The previous EcAp- MED I project was oriented based on regional knowledge to the preparation of specific ecological objectives and their related common indicators in different parts of the Mediterranean.

Preliminary evaluation at the first steps of the Project pointed out the existence of knowledge scarcity in terms of Mediterranean biodiversity in some areas and that numerous key potential areas were not regularly monitored, even if they were known by scientists and national stakeholders for their impact on the aggregation of biodiversity in their surroundings.

Considering this, SPA/RAC elaborated a strategy to assist Lebanon in the development of its national Monitoring and Assessment Programme (IMAP) related to biodiversity (EO1) and non-indigenous species (EO2). A collaborative process, involving the Lebanese Ministry of Environment, national stakeholders, experts and MPA managers, was undertaken to successfully i) identify national priorities for the next step of the IMAP implementation (2019-2021); ii) discuss the list of species and habitats of interest to be monitored and assessed; iii) agree on the list of key areas to be monitored including Marine Protected Areas (MPAs); and iv) develop the national Monitoring Programme on Marine Biodiversity in Lebanon.

This national monitoring programme is a first step towards the next phase (2019-2021) of the IMAP implementation that will help establishing more complete database of quality assurance data and contribute to the development of solid assessment reports, such as the 2023 Mediterranean Quality Status Report (2023 MED QSR), based on quantitative rather than qualitative information. This shows Lebanon's commitment to protect the marine environment through the implementation of the SPA/DB Protocol and the EcAp process of the Barcelona convention.

SPA/RAC and the Ministry of Environment of Lebanon have a longstanding and fruitful collaboration. This collaboration will be continued to overcome the future phase challenges and take a step further towards achieving the good environmental status of the Mediterranean Sea and coast.

**SPA/RAC Director**

**Khalil Attia**

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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

**CI:** Common Indicator

**CITES:** Convention on International Trade in Endangered Species of Wild Fauna and Flora

**CMS:** Convention of Migratory Species

**CNRS:** Conseil national de la recherche scientifique

**CNRSL:** Conseil National de la Recherche Scientifique-Liban

**CoM:** Council of Ministers

**EcAp:** Ecosystem Approach

**EIA:** Environmental Impact Assessment

**ENPI:** European Neighbourhood 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:** Eléments traces métalliques

**FAO:** Food and Agriculture Organisation

**GEF:** Global Environment Facility

**GES:** Good Environmental Status

**GoL:** Government of Lebanon

**GTML:** Marine Turtles Group in Lebanon

**IAS:** Invasive alien species

**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

**MEDASSET:** Mediterranean Association to Save Sea turtles

**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

**MSFD:** Marine Strategy Framework Directive

**NAP:** National Action Plan

**NBSAP:** National Biodiversity Strategy and Action Plan

**NCMS:** National Centre for Marine Sciences

**NGO:** Non-Governmental Organization

**NIS:** Non-Indigenous Species

**NMPs:** National Monitoring Programmes

**NMPB:** National Monitoring Programme for Biodiversity

**NMPBL:** National Monitoring Programme for Biodiversity in Lebanon

**NMPL:** National Monitoring Programme in Lebanon

**NMPLNIS:** National Monitoring Programme for Non-Indigenous Species in Lebanon

**NRCI:** National Research Council (Italy)

**NSN:** National Stranding Network

**OBSMER:** Observation at Sea

**PINR:** Palm Island Naturel Reserve

**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

**TCNR:** Tyre Coast Natural Reserve

**UL:** University of Lebanon

**UMR:** UNEP/MAP-RAC/SPA

**UNEP:** United Nations Environnent Programme

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# I. Introduction and general framework

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 (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).

This national monitoring programme includes these 2 Ecological Objectives (EOs):

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


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# II. NATIONAL MONITORING PROGRAMME FOR MARINE BENTHIC HABITATS

## 1. 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 National Biodiversity Strategies and Action Plan (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.

## 2. ISSUES OF THE MARINE HABITATS MONITORING 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 conserved 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).

## 3. COMMON INDICATORS (CIS) OF THE ECOLOGICAL OBJECTIVE (EO1) "BIODIVERSITY" RELATED TO MARINE HABITATS

CI 1: Habitat distributional range, to also consider habitat extent as a relevant attribute
CI 2: Condition of the habitat's typical species and communities.

This section is based particularly 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 common indicators of this programme include: the habitat's distributional range and the condition of typical species and communities for each 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 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).

### 3.1. 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).

### 3.2. 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.

#### 3.2.1. 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.

| 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 |

MRB) Mediterranean Flora Red Book; (EU) Habitat Directive European Union (1992); (BaC) Barcelona Convention (1995); (BeC) Bern Convention (1996-98).

*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 rhodolithes.

*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).

### 3.2.2. INVERTEBRATA

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

Table 2. Marine invertebrate of special interest

| 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 petraem* | 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 | - | - |

(EU) Habitat Directive European Union (1992); (BaC) Barcelona Convention (1995, 2009, 2013); (BeC) Bern Convention (1996-1998); (WC) Washington Convention or CITES (2013).

*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 C a pe 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 40 m 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 30 m depth, mainly in shallow waters (2-8 m depth).

*Aplysina sp.*

**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*.

**Geographical distribution:** At present, only observed in Lebanon.

**Habitat:** This species has only been sampled in shallow caves (1-5 m 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 (40-50 m 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 25 m 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 300 m 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 (< 10 m 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 signalled 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 (0-47 m 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 47 m 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 3 m 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 (30 m 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 50 m 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 80 m 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 (0-5 m 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 42 m 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 80 m depth, normally in shallow waters (< 20 m 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*.

### 3.2.3. 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

| 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 |

(BaC) Barcelona Convention (1995); (BeC) Bern Convention (1996-98).

***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 80 m 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 30 m 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 200 m depth.

**Threats:** Over-exploitation by spearfishing 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 < 20 cm). 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:** Spearfishing; alteration or destruction of the seagrass meadows (juvenile areas).

**Observations:** Very rare, one specimen was observed in Enfeh, at 18 m depth (RAC/SPA – UNEP/MAP. 2014) and another in Raoucheh cave (Bitar, personal observation). This species seems to be in regression (heavy spearfishing, 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 depth100 m, Subtropical.

**Threats:** Spearfishing; 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:** Atlanto-Mediterranean from the British Isles to Morocco, Azores, Madeira and Canary Islands.

**Habitat:** Seagrass or algae in rocky or flat bottom to depth of 30 m.

**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).

#### 3.2.4. 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, especially 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 exist 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 *Eurypongia raouchensis*) and 4 Bryozoaires (*Celleporina bitari Parasmittina serruloides*, *Parasmittina spondylicola*, *Schizoretepora hassi*).

- Endangered or threatened 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* (fish).

### 3.3. BENTHIC BIONOMY AND HABITATS

#### 3.3.1. Introduction

Identification and classification 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, midlittoral, 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).

### 3.3.2. HARD SUBSTRATA

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

#### 3.3.2.1. Littoral rock

The littoral rock embraces the supralittoral and midlittoral stages, with the littoral fringe (>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 hydro-dynamism (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 30 m 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, shellfish 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)

##### 3.3.2.1.1. 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).

##### 3.3.2.1.2. 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 i n 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.

##### 3.3.2.1.3. 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.

#### 3.3.2.1.4. 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.

#### 3.3.2.1.5. 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 (0-1 m 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 (0-2 m 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).

#### 3.3.2.2. 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 8 m depth. Here the intense wave action prevents the sedimentation.
- Middle horizon: From 8 m to 29 m depth, with the dominance of the photophilic algae on horizontal surfaces
- Lower horizon: From 29 to 42 m depth, with the dominance of sciaphilic algae on horizontal surfaces.

The topography of the rocky bottom's 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.

##### 3.3.2.2.1. 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).

###### 3.3.2.2.1.1. 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 8 m.

  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 (0-4 m 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 8 m 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 15 m depth. Noteworthy is the high frequency of empty tests.

#### 3.3.2.2.1.2. Exposed sciaphilic algae

Structure of the community: It predominates on the vertical rock between 0-6 m 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 6 m 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 (0-2 m 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.

#### 3.3.2.2.2. 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 2 m depth (in sheltered places) to 28 m 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. The 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 several areas of the coast.

#### 3.3.2.2.2.1. 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 (48 m depth) and the herbivorous pressure (Siganidae, *Conomurex*). The width of this horizon depends of the hydrodynamism and illumination reaching a 28 m 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 community: 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 (5-17 m depth) and *Axinella sp.* in deeper ones (18-29 m 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, Di-*

*plodus 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 14 m 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 3 m depth.
- **Association with *Cystoseira sp.*:** This interesting association was observed in some localities such as Nakoura (9-11 m depth) and the lagoon located behind the Tyre's northern inlets (7-9 m 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 25 m 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 10-15 m 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 persicus* (RAC/SPA - UNEP/MAP, 2014).
- **Association with *Dictyota dichotoma*:** more frequent in the northern sector of the Lebanese coast. It has been observed at 5 m 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 28 m 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 35 m (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 31 m depth along the lebanese coast, it is between 5 to 26 m 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).

#### 3.3.2.2.2. 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 26 m 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 18 m 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 35 m 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).

#### 3.3.2.2.3. 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 mode-

rate. The presence of vertical surfaces and overhangs favours the coralligenous community. The bathymetric range varies from 28 to 44 m 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).

#### 3.3.2.2.3.1. Biocenosis of sheltered sciaphilic algae

This assemblage appears on horizontal surfaces at 28 m depth, and it reaches the circalittoral communities at a depth of about 44 m. 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 32 m.

Structure of the community: 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 suchas *Pennaria disticha*, *Macrorhynchia philippina* and *Phallusia nigra* in the proximity of the cold-water springs (station T-21, at 38 m depth).

#### 3.3.2.3. 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 47 m 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 42 m 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).

##### 3.3.2.3.1. 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 32 m depth and horizontal ones from 43 m 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 43-44 m depth. Other accompanying ochrophyta species have been observed *Arthrocladia villosa* and *Sporochnus pedunculatus*, normally on pebbles.
- **Facies with *Axinella 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 40-42 m 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*. are 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 44-45 m, there are small boulders (ø= 30-50 cm) 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 43 m depth in other prospected areas), but rather, rocky boulders cover by encrusting organisms.

#### 3.3.2.3.2. Biocenosis of the semi-dark caves (UMR: IV.3.2)

This biocenosis has been observed between 0 to 5 m 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), *Eurayspongia 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, Eurayspongia, 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.

#### 3.3.2.3.3. 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 there are freshwater springs and the illumination is absent.

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).

#### 3.3.2.3.4. Submarine cold and hot freshwater springs

The submarine cold and hot freshwater springs are very interesting due to the organisms 'adaptations around them. Several of these 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 persicus* (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 15 m depth) and Tyre (32-40 m 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 38-42 m 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*).

### 3.3.3. Soft substrata

The soft substrata are dominant from 0 m in the littoral sand beaches to deeper muddy sand bottoms (at 50 m 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 (0-15 m depth); coarse and shell gravel (8-32 m depth); maerl beds (32-47 m depth); and muddy sand (15-50 m depth).

#### 3.3.3.1. Infralittoral soft bottoms

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

Biotope: In shallow waters (< 15 m) 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 15 m depth; then, the mud fraction increases to 50 m 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 32-33 m 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 sector of Lebanon where it forms scarce 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 31 m 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).

#### 3.3.3.1.1. 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 15 m depth.

Structure of the community: The upper stratum with *Cymodocea nodosa* in some shallow locations, 1-3 m 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)**.

  Distribution: *Cymodocea nodosa* was observed in several localities from north to south of Ile Ramkine, Enfeh, El Heri, Ras Chekaa, Hannouch, Selaata, Batroun, Barbara, El Zahrani, and Rachidiye (South of 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).

#### 3.3.3.1.2. Biocenosis of muddy sands

This community is spread, between 8 to 47 m 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):** *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 44 m 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 30-31 m depth (RAC/SPA - UNEP/MAP, 2014).

- **Association with *Caulerpa prolifera* (UMR: III.2.3.6):** The *Caulerpa prolifera* meadows have only been observed in the Enfeh – Ras Chekaa sector, between 17 to 44 m depth and in northern Saida Island at 31 m. *C. prolifera* meadows are dispersed and dense from 20 to 27 m 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).

#### 3.3.3.1.3. 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 verrucose* (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):** 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 = 7 cm) 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 9 m 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.

#### 3.3.3.2. 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 32-33 m.

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 40 m the muddy sediment becomes frequent on gravel bottoms, revealing the muddy detritic bottoms. In the summertime (2013) the thermocline (28ºC) has reached 42 m 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.

#### 3.3.3.2.1. 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 42-44 m on maerl bed degraded by the mud.

#### 3.3.3.2.2. Biocenosis of the coastal detritic bottom

The coastal detritic bottoms appear at 32 m 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):** The deep maerl beds have appeared in Nakoura and Tyre, between 32-45 m 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.
- **Association with *Arthrocladia villosa* (UMR: IV.2.2.4:** 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).

### 3.4. 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).

## 4. IMPLEMENTATION OF THE MONITORING AND OPERATIONAL PLAN

### 4.1. 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 7 m length which will be well equipped for all field studies near the coast.

### 4.2. Tools and methods used

Monitoring tools and methods used according to the objectives:

- Exploration on foot of the coastline, particularly 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 stations 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 $m^2$ (25 m x 5 m). 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 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.

### 4.3. 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.

### 4.4. Systems to be developed

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

### 4.5. Operational implications requested and proposed for the proper monitoring of the programme

#### 4.5.1. Human resources

- 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 exhaustive. 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.

#### 4.5.2. 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 Centre at Batroun.

#### 4.5.3. Sites to be monitored

Three sites or areas of monitoring are proposed (see figure 1):

- 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

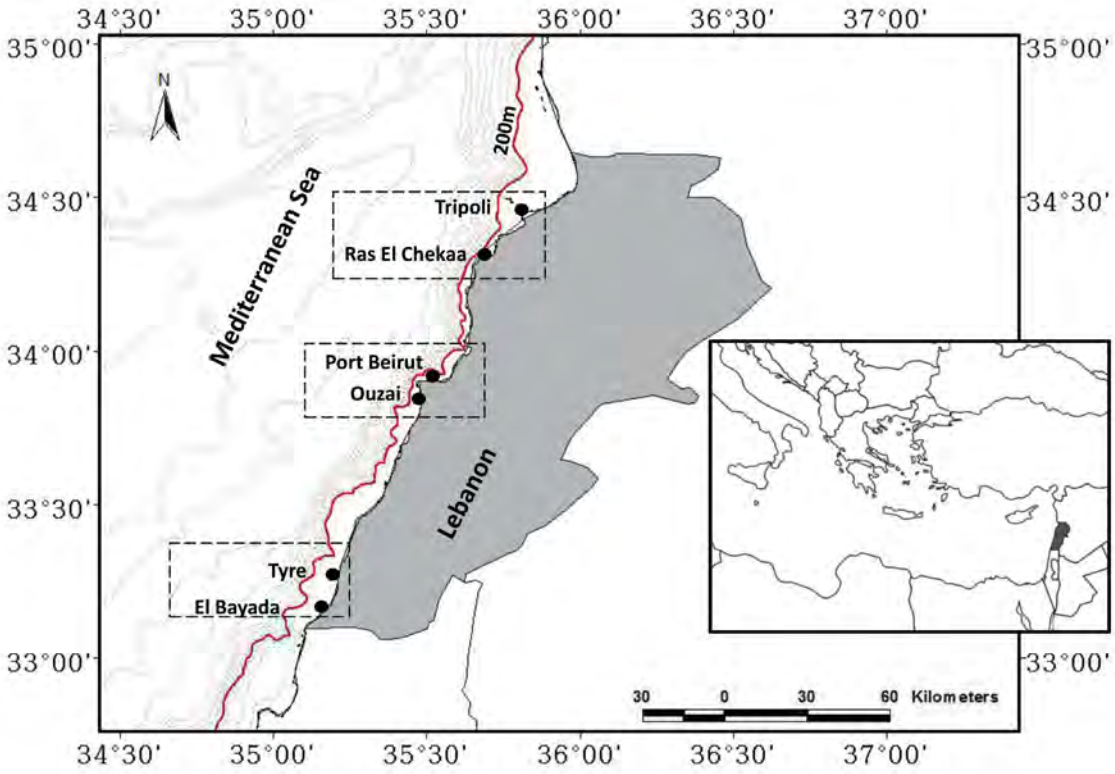


Figure 1. Monitoring sites

#### 4.5.4. Exploration and sampling strategy

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

#### 4.5.5. 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 Centre 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 Centre 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.

#### 4.5.6. 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.

#### 4.5.7. 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 centres.

Not to mention the implication of retired specialists who have accumulated a lot of data on the characte-

ristics of species and habitats including the history and evolution of non-indigenous species and their impacts on local habitats.

Needs

- ◊ Unavailable material (rocky and soft bottom dredges, core drill, drop cameras, Photo quadrats and surveillance systems)
- ◊ Diving equipment for 4 people
- ◊ Two underwater cameras (with cameras and accessories) and two Go Pro cameras
- ◊ Chemicals, pliers, glassware, systematics books, stationery and others,
- ◊ For the field work
  - On foot, snorkelling and scuba diving up to the circalittoral stage
  - Hydroplane
  - ROV, Drop Camera
  - Visual census of fish
  - Multibeam sonar
  - CTD
- ◊ Data analysis

### 4.5.8. 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:
  - Dunes, beaches including coastal degradation and erosion in relation to warming, rising of the sea level and human activities.
  - 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.
  - 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 T*enarea tortuosa*.
  - Meadows with *Cymodocea nodosa* and *Halophila spipulacea*.
  - Coralligenous biocenosis which is spongiform and without gorgonians and red coral.
  - 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*.
  - 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.
  - The harbour 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.

## References


1. Abdul Malak, D. et al. 2011. Overview of the Conservation Status of the Marine Fishes of the Mediterranean Sea. Gland, Switzerland and Malaga, Spain: IUCN. vii + 61pp.
2. Basson, P.W., Hardy, J.T. & Lakkis, V. 1976. Ecology of marine macroalgae in relation to pollution along the coast of Lebanon. Acta Adriatica, 18: 307-325.
3. Bellan-Santini, D. Lacaze, J.C. & Poizat, C. 1994. Les biocénoses marines et littorales de Méditerranée: Synthèse, menaces et perspectives. Muséum National d'Histoire Naturelle, Collection Patrimoines Naturels, Vo. 19, 246 pp.
4. Bitar, G. 2010. La flore marine benthique introduite de la côte libanaise. Etat actuel de trois espèces envahissantes. INOC-Tischreen University, International conference on Biodiversity of the Aquatic Environment, pp. 107-114.
5. Bitar, G. 2011. Les peuplements benthiques et ichthyologiques du littoral libanais. Impacts des espèces exotiques et du réchauffement climatique sur la biodiversité et les habitats marins. Rapport final des recherches sur la biodiversité marine benthique effectués dans le cadre de l'« Etablissement d'un projet de surveillance et d'environnement durable de la côte libanaise: Projet CANA-CNRS » (Contrat Réf.: 111/ 2010). 45 p., Annexe, 22 p.
6. Bitar, G., Harmelin, J.G., Verlaque, M. & Zibrowius, H. 2000. Sur la flore marine benthique supposée Lessepsienne de la côte libanaise. Cas particulier de Stypopodium schimperi. In: RAC/SPA (eds), Proceedings of the First Mediterranean Symposium on Marine Vegetation, Ajaccio, 3-4 Oct. 2000, RAC/SPA, PNUE, pp. 97-100.
7. Bitar, G. & Kouli-Bitar S. 2001. Nouvelles données sur la faune et la flore benthiques de la côte libanaise. Migration lessepsienne. Thalassia Salentina, Italie. 25:71-74.
8. Bitar, G., Ramos-Esplá A.A., Ocaña O., Sghaier Y.R., Forcada A., Valle C., El Shaer H., Verlaque M. 2017). Introduced marine macroflora of Lebanon and its distribution on the Levantine coast. Mediterranean Marine Science.
9. Costello, M.J. & Emblow, C. 2005. A classification of inshore marine biotopes. In: The Intertidal Ecosystems: The Value of Ireland's Shores. J.G. Wilson (ed.), Royal Irish Academy, Dublin, p. 25-37.
10. Davis, C.E. & Moss, D. 2004. EUNIS Habitat Classiication Marine Habitat Types: Revised Classiication and Criteria. European Topic Centre on Nature Protection and Biodivesity EEA Project: C02492, 84pp.
11. Golani, D., Öztürk, B., Başusta, N. 2006. Fishes of the eastern Mediterranean. Turkish Marine Research Foundation, Istanbul, Turkey. 259 pp.
12. Gruvel, A. 1931. Les Etats de Syrie. Richesses marines et pluviales. Soc. Edit. Géogr. Marit. et Colon., Paris, 453 p.
13. http://staff.aub.edu.lb/~is08/research.htm
14. http://www.balamand.edu.lb
15. www.fishbase.org
16. Lakkis, S. & Novel-Lakkis, V. 2000. Distribution of the Phytobenthos along the coast of Lebanon (Levantine coast, East Mditerranean). Medit.Mar.Sci.,1/2;143-164.
17. Lakkis, S. 2013. Flore et faune marines du Liban (Méditerranée Orientale). Biologie, biodiversité, biogéographie. Aracne Publ., Rome, 510 pp.
18. Lebanon's Marine Protected Area Strategy. 2012. Supporting the management of important marine habitats and species in Lebanon. Beirut, Lebanon, Gland, Switzerland y Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 p.
19. Louisy, P. 2002. Guide d'identification des poissons marins. Europe et Méditerranée. Ulmer Ed., 430 p.
20. MoE/AECID/TRAGSA. 2009. Guidelines for the management of the Palm Islands Nature Reserve. 173 p.
21. MoE/UNEP/GEF. 2015. Fifth National Report of Lebanon to the Convention on biological Diversity, 147 p.
22. MoE/UNEP/GEF. 2016. National Biodiversity Strategy and Action Plan. Project – NBSAP, 113 p.
23. Mouneimné, N. 2002. Poissons marins du Liban et de la Méditerranée orientale. Printed by IPEX: 271p.
24. Pérès, J.M. & Picard, J.M. 1964. Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec. Trav. St. Mar. Endoume, 31, 47, 137 p.
25. Perez, T., Vacelet, J., Bitar, G., Zibrowius, H., 2004. Two new Lithistids (Porifera: Demospongiae) from a shallow eastern Mediterranean cave (Lebanon). J. Mar. Ass. U.K., 84, 15-24.

26. RAC/SPA–UNEP/MAP. 2014. Ecological characterization of sites of interest for conservation in Lebanon: Enfeh Peninsula, Ras Chekaa cliffs, Raoucheh, Saida, Tyre and Nakoura. In: Ramos-Esplá, A.A., Bitar, G., Khalaf, G., El Shaer, H., Forcada, A., Limam, A., Ocaña, O., Sghaier, Y.R. & Valle, C. (eds) RAC/SPA - MedMPAnet Project, Tunis: 146 p. + annexes.

27. Riedl R. 1971. Water movement. In: O. Kinne (ed). Marine Ecology, pp 1123-1156. John Wiley, New York.

28. Steller, D.L., Riosmena-Rodriguez R., Foster M.S. & Roberts, C.A. 2003. Rhodolith bed diversity in the Gulf of California: the importance of rhodolith structure and consequences of disturbance. Aquatic Conservation: marine and Freshwater

Ecosystems, 13: S5-S20.

29. Templado, J., Richter, A. & Calvo, M., 2016. Reef building Mediterranean vermetid gastropods: disentangling the Dendropoma petraeum species complex. Mediterranean Marine Science. 17: 13-31.

30. UNEP/IUCN/GIS-Posidonia. 1990. UNEP/IUCN/GIS Posidonie. 1990. Livre rouge 'Gérard Vuignier' des végétaux, peuplements et paysages marins menacés de Méditerranée. MAP Technical Report Series, No. 43. UNEP, Athens, 250 pp.

31. UNEP-MAP-RAC/SPA. 2006. Classification of Benthic Marine Habitat Types for the Mediterranean Region. Ed. Regional Activity Centre for Special Protected Areas, Tunis. 14 pp.

32. UNEP-MAP-RAC/SPA. 2015. 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. Denise BELLAN-SANTINI, Gérard BELLAN Ghazi BITAR, Jean Georges HARMELIN, Gérard PERGENT. Ed. RAC/SPA, Tunis. 161 p? + Annex (Orig. pub. 2002).

33. Vacelet, J., Bitar, G., Carteron, S., Zibrowius, H., and Perez, T. 2007. Five new sponge species (Porifera: Demospongiae) of subtropical or tropical affinities from the coast of Lebanon (Eastern Mediterranean). J. Mar. Biol. Ass. U.K., 87: 1539 – 1552.

Bottlenose dolphin (*Tursiops truncatus*) © Tunisian Dolphin Project

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# III. NATIONAL MONITORING PROGRAMME FOR MARINE MAMMALS

## 1. GENERAL CONTEXT

### 1.1. Cetaceans

Marine mammals and cetaceans in particular, in their quality of apex/alpha predators, represent an important element of marine biodiversity, which is, however, seriously threatened in most of the world's marine ecosystems. In particular, cetaceans living in the Mediterranean and Black Seas must face the manifold pressures which are exerted on the marine environment by a variety of human activities in these semi-enclosed seas (Notarbartollo di Sciara and Birkin, 2010). Most of these threats result from interactions with human activities and practices. Thus, cetaceans are subject to the impacts of pollution, navigation, fishing activities and tourism. While climate change represents an additional threat to their environmental balance.

Cetaceans are very mobile species, and many are highly migratory. With few exceptions, these mammals are not confined to waters within the jurisdiction of any single nation. In parallel, critical habitats of most cetacean populations living in this area also extend beyond national waters, as well as in areas beyond national jurisdictions.

It is now well-known that the threats, which weigh on the cetacean populations on a world level, and in particular in the Mediterranean Sea, are obvious and present an emergency character. The cetacean populations are thus under high-risk of endangerment due to alarmingly declining numbers.

According to occasional observations during scientific missions at sea, the Lebanese territorial waters are conclusive as for the presence of the dolphins and their potentially critical habitats. However, cetacean stranding - even sporadic - on the Lebanese coast, as well as the occasional catches of the dolphins by fishermen nets (sometimes intentional) constitute imminent threats for these animals. The insufficient knowledge of the cetacean ecology associated with a lack of capacity to ensure protection for these species populations constitutes yet another obstacle against the efforts of conservation.

#### 1.1.1. Legislation context

Lebanon is a contracting partner to the Barcelona Convention (since 1994), which gives priority to the conservation of the marine environment, to the constituent elements of its biological diversity, in particular the cetacean, and to the permanent monitoring of this biodiversity. As such, Lebanon is held, by international legislation, to preserve and protect the marine mammals and to maintain them in a favourable state of conservation.

Prior to 2004, the only national legislation related to the conservation of cetacean was a Ministerial decision (Nº 1/125 of September 23rd, 1999): «Prohibition of fishing and marketing of by-products related to cetaceans and turtles.»

In 2004, the Lebanese parliament ratified The Agreement of ACCOBAMS on February 11th, 2004 by Law 571, which was subsequently followed by three important decisions:

- Ministerial decision Nº 69/2004 of July 2nd, 2004: «Establishment of a permanent inter-ministerial committee to implement the ACCOBAMS agreement.»
- Decision Nº 524 of the General Secretary of Ministers Council of May 10th2005: «Designation of the National Centre for Marine Sciences - CNRS as the focal point of the ACCOBAMS agreement"
- Ministerial decision No1154, 2013, "General conditions to protect marine mammals (whales, dolphins and monk seal)".

#### ACCOBAMS agreement

Stimulated by concern for the conservation status of cetaceans in their region, the nation's bordering the Mediterranean and Black Sea resolved to implement an agreement to ensure the survival of cetaceans in the area, called "Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area" (ACCOBAMS).

ACCOBAMS, an agreement between 23 parties, was signed in 1996 and entered into force in 2001. Parties to ACCOBAMS agree to implement a detailed "Conservation Plan" to achieve and maintain favourable conservation status for cetaceans.

The ACCOBAMS Conservation Plan specifies the actions that parties shall take in the areas of adoption and enforcement of national legislation; assessment and management of human cetacean interactions; habitat protection; research and monitoring; capacity building; collection and dissemination of information; training and education; and responses to emergency situations.

During the 6th meeting of parties in 2016 a resolution (6.13) was adopted related to the Comprehensive Cetacean population estimates and distribution in the ACCOBAMS area (monitoring of Cetacean distribution, abundance and ACCOBAMS Survey Initiative). The implementation of the survey is programmed for the summer of 2018.

### 1.1.2. Scientific implementation context

In February 2000, the National Centre for Marine Sciences (NCMS) participated in the first ACCOBAMS workshop entitled "Recognition and conservation of cetaceans in the Mediterranean" in France. Following this meeting, the NCMS took charge of: (1) cetacean monitoring in Lebanon, (2) collection of available data on the stranding of these marine mammals through the creation of contact points on main Lebanese fishing ports.

Because of the sad events that Lebanon went through between 2004, when the agreement was signed, and 2007, and despite some activities undertaken by NCMS for the conservation of cetaceans; the launch of real activities commenced in late 2008. A national Action Plan was elaborated (Gonzalvo, 2009) in which four activities were considered: education and awareness, human resources, research and sustainable management.

### 1.1.3. Research activities and results

Many missions at sea, onboard the CANA-CNRS vessel, were executed between 2009 and 2013. The prospected zone covers the waters of the Lebanese coast from the Lebanese Syrian border in the North to the southern borders of Lebanon, with a length of 220 km.

The results highlight the regular presence of bottlenose dolphins in a central area of the Lebanese coast, adding a piece to the puzzle of the Mediterranean knowledge of this species' distribution.

91 individuals were detected in 32 sightings. The size of the groups ranged between a minimum of one individual and a maximum of 7 young and adult individuals.

The individual's relative abundance and sighting rate are higher in Beirut area (0.11 ind·km$^{-1}$) compared to values obtained for the entire Lebanese coast (0.032 sighting·km$^{-1}$) (khalaf, et al., 2013).

### 1.1.4. Cetaceans sightings

Data collected on cetaceans observed, either at sea or stranded on the beaches, allow us to recognize six species of dolphins, observed at least once, in the Lebanese marine environment (Gonzalvo, 2009; khalaf, 2016) (table below):

Bottlenose dolphin remains by far the most abundant species in Lebanese Marine Waters and has been the subject of a detailed study concerning its range and abundance.

On the other hand, this species occurs in higher numbers beyond the continental shelf, a fact which indicates that the bottlenose dolphins observed in the Lebanese waters belong to the offshore ecotype (Khalaf et al., 2013).

| Scientific Name | English Name | French Name |
|---|---|---|
| *Grampus griseus* | Risso's dolphin | Dauphin de Risso |
| *Steno bredanensis* | Rough-toothed dolphin | Dauphin sténo |
| *Stenella coeruleoalba* | Striped dolphin | Dauphin bleu et blanc |
| *Physester macrocephalus* | Sperm whale | Cachalot |
| *Ziphius cavirostris* | Cuvier's beaked whale | Baleine à bec de Cuvier |
| *Tursiops truncatus* | Bottlenose dolphin | Grand dauphin |

## 1.2. Mediterranean Monk -Seal

There is one species of seal in Lebanon: *Monachus monachus* or the Mediterranean monk seal. It is a sedentary species that lives in caves along the quiet coasts. It was considered missing in the western Mediterranean and in Greece in the 1980s (Tohmé et Tohmé, 1985). In Lebanon, it was reported by Gruvel in 1931 as existing in the pigeon cave at Raoucheh; in addition, fishermen had also reported it in Amchit. Because of its predatory behavior against fish, it is easily caught in the nets of fishermen who harass and kill it. Urbanization and socio-economic development of the Lebanese coast had a detrimental effect on the presence of this species.

The last couple was observed at Raoucheh in 1970 (Tohmé et Tohmé, 1985). However, since 2003, the monk seal has reappeared along the Lebanese coast. The NGO «Big Blue» reported that it is often observed in Raoucheh either individually or in groups of three, one of which is a juvenile. One individual was also observed in Batroun in 2015. A Sea Lion appeared along the Lebanese coast between Tyre and Naqoura for a period of about 20 days in 2014, then it disappeared completely. Ramadan Jaradi observed and photographed a seal in the area of Palm Islands Reserve in February 2016 recognized by the Seal Conservation Society as being a hooded seal.

## 2. OBJECTIVES AND SUB-PROGRAMMES FOR MONITORING

Cetaceans and monk seal are subject to a variety of threats, which adversely affect their presence in Lebanese marine waters, especially as the exploitation of petroleum will start in the very near future which would aggravate the situation of these animals (Borrell et al., 2000; Bearzi et al., 2004; Bearzi and Fortuna, 2006; Bearzi et al, 2008; Reeves and Notarbartolo di Sciara, 2006). The most important of these threats are: bycatch, decreased food supplies, pollution from wastewater and solid wastes, ship collisions and acoustic disturbances.

The protection and conservation of these animals are a necessity and must be subjected to a permanent monitoring programme in order to sustain their good ecological status.

In order to maintain the ecological status of these animals and to protect and preserve them, a permanent monitoring divided in sub-programmes must be established.

### 2.1. Cetaceans sighting campaigns from ships

#### 2.1.1. Logistic conditions

Campaigns carried out by the CNRS-L National Centre for Marine Sciences team on board the scientific vessel CANA-CNRS revealed that the common bottlenose dolphin *Tursiops truncatus* is the species most present in Lebanese marine waters. It is distributed along the coasts with the highest abundance facing Beirut (Khalaf et al., 2010, 2013).

Continuous monitoring should be developed to

(i) protect this species;

(ii) record other species that may be frequent in Lebanese marine waters. This activity also concerns the individuals of other species of Cetacean reported or observed occasionally in the Lebanese marine waters.

- ◊ Observation should begin in summer 2018 in accordance with «ACCOBAMS Survey Initiative»
- ◊ Ten consecutive days aboard the CANA-CNRS vessel to cover the 220 km of coastline for a width of 12 nautical miles (possibility of aerial surveillance by the support of the «ACCOBAMS Survey Initiative»)
- ◊ Line transect sampling is typically used to estimate abundance and assess density (Gannier, 2005)
- ◊ Ship speed: 8 knots
- ◊ Less than 3 Beaufort Sea scale
- ◊ Position of the vessel is regularly and automatically recorded through a computer connected to a GPS
- ◊ At each sighting, data concerning time, number of individuals and behaviour of the species must be recorded with other complementary environmental information.

#### 2.1.2. Biodiversity (EO1): Common indicators (CIs) related to cetaceans

The description, mapping of the distributional range (CI3), recognition of cetacean species and their population abundance (CI4) and demographic characteristics (CI5), more particularly the dolphins in Lebanese territorial waters should constitute the first elements of the ACCOBAMS Survey Initiative. This would require:

- Monitoring of the distribution of these species in Lebanese marine waters
- Recording and identification of species encountered
- Population size assessment: density, abundance, number of individuals per group
- Population description: demographic characteristics, structure of size or age class, sex ratio, fertility rate, survival / mortality rate
- Photo identification (made possible thanks to the CNRS acquisition of a 7m long CADMOS-CNRS catamaran)
- Visual surveys from aircraft or land observation platforms and Passive acoustic monitoring carried out during ship surveys with towed hydrophones can be supported by ACCOBAMS Survey Initiative.

### 2.2. Monitoring of cetaceans stranding

Shore stranding is one of the main sources of access to tissue and organ sampling to assess the ecological status of top predators and the functioning of the food web. From 2002 to 2016, twenty-two individuals of stranded cetaceans were recorded by the CNSM-CNRS along the Lebanese coast. They include: one individual of *Grampus griseus* (risso's dolphin), two individuals of *Steno bredanensis* (rough-toothed dolphin) and 19 individuals of *Tursiops truncatus* (bottlenose dolphin) (Khalaf, 2002; 2016).

The analysis of stranded individuals also allows us to study the effects of anthropogenic pressures on them such as bycatch, waste ingestion, collisions, and

contamination by toxic compounds. Hence, there is a need to create a network of stranding:

- Accredit contact points at major ports
- Contacts with the navy, merchants and fisheries for the transmission of data on stranding
- Intervention of municipalities, public defence and NGOs
- Allometric measurements
- Autopsy, if possible, with notifications of anatomical and physical remarks
- Taking tissue samples (local analysis or dispatch to specialized centres)
- Creation of a tissue bank
- Installing a database

### 2.3. Monitoring of common indicators (CI 3, CI4, CI5) related to monk seal

Despite its low numbers and rare observations, the monk- seal makes regular appearances (Raoucheh) or sudden appearances (Batroun, Amchit) and is a target for depredations. A dead pregnant female was drafted at sea next to Raoucheh in April 2015. This female was carrying an almost mature baby pup. Coastal urban development, the detriment of natural habitats, as well as, the intervention of fishermen, remain the main factors of depredation of this species. Its protection depends on several measures that fall to all the actors of the marine environment. Its continuous monitoring implies:

- Regular observations at the sites of its presence on board of the CANA-CNRS vessel or the catamaran CADMOS-CNRS or with fishermen vessels
- Group size
- Status of individuals
- Definition of the area of its presence
- Notifications of anatomical and physical remarks
- Photos identification
- Placement of instantaneous trigger cameras in the caves where they are found
- Have contact points in main regions of its appearance for transmission of data.

## 3. RECOMMENDATIONS

In order to develop the marine mammals monitoring programme and to establish a sustainable strategy for their conservation, important measures should be considered by involving all stakeholders and especially those concerned in the marine environment:

### 3.1. Education and awareness

- Production of materials for public awareness and education purposes. Make available a variety of materials to be used during seminars, training courses and awareness-raising events
- Dissemination of the documentary series “Cetaceans of the Mediterranean Sea” on DVD (as well as online)
- Facilitate the reporting of cetacean stranding. Develop an information network and make available a phone number (24 h/day) to report stranding events. Design and distribute flyers and stickers to let people know what to do in case they find a stranded cetacean
- Design and conduct awareness actions targeting the fisheries sector. Oral presentations and informal talks targeting fishermen cooperatives. Round tables to promote exchange of information between fishermen representatives and marine conservation biologists.

### 3.2. Capacity building

- Create capacity for the implementation of an effective cetacean stranding network Provide training and materials to create expertise on the management of cetacean stranding
- Create capacity in laboratory techniques. Organization of training courses on laboratory techniques for cetacean studies
- Create capacity in cetacean field research methods. Organization of training courses on field research techniques for cetacean studies for committed Lebanese researchers
- Opportunities for long-term training for Lebanese researchers and students.

- Create opportunities for the long-term professional training in Universities and laboratories possessing relevant expertise in cetacean research
- Create a Cetacean Library on cetacean biology and conservation.

### 3.3. Management

Grant protection to cetaceans in Lebanese waters. Promote marine mammal protection in the Lebanese legislation and ensure that new regulations contemplate the different issues related.

Make fisheries sustainable. Manage the fishing effort based on evidence provided by scientific studies. Implement GFCM Recommendations. Elaborate a review on fishing technics.

Ensure that environmental impact assessments give special consideration to cetaceans and their habitat. Require investigation of potential damage to cetaceans in environmental assessment studies.

Support the creation, development and growth of marine conservation-oriented NGOs.

## References


Bearzi, G., Holcer, D., Notarbartolo di Sciara, G. 2004. The role of historical dolphin takes and habitat degradation in shaping the present status of northern Adriatic cetaceans. Aquatic Conservation: Marine and Freshwater Ecosystems 14:363-379.

Bearzi, G. & Fortuna, C.M. 2006. Common bottlenose dolphin *Tursiops truncatus* (Mediterranean subpopulation). In: The Status and Distribution of Cetaceans in the Black Sea and Mediterranean Sea (Ed. by R.R. Reeves & G. Notarbartolo di Sciara, compilers and editors), pp. 64–73. IUCN Centre for Mediterranean Cooperation, Málaga, Spain.

Bearzi, G., Fortuna, C. & Reevers, R. 2008. Ecology and conservation of common bottlenose dolphins *Tursiops truncatus* in the Mediterranean Sea, Mammal Society, 2008.

Borrell, A., Aguilar, A., Forcada, J., Fernandez, M., Aznar, F.J. & Raga, J.A. 2000. Varamiento de cetáceos en las costas españolas del Mediterráneo durante el período 1989–1992. Miscellània Zoològica, 23, 53–69.

Gannier, A. 2005. Summer distribution and relative abundance of delphinids in the Mediterranean Sea. Revue d'Écologie (Terre et Vie), 60, 223–238.

Gonzalvo, J. 2009. Action Plan for the conservation of Cetacean in Lebanon. ACCOBAMS, Lebanon. 44 pp.

Gruvel, A. 1931. Les états de la Syrie. Richesses marines et fluviales. Exploitation actuelle. Avenir, 450 pp. Société d'Editions Géographiques, Maritimes et Coloniales, 184, Boul. Saint- Germain VI, Paris.

Khalaf, G. 2002. Action prioritaire 4 : Surveillance permanente de la diversité biologique marine et côtière. Plan pour la conservation de la diversité biologique en Méditerranée (SAP-BIO), Liban.

Khalaf, G. 2016. Suivi de la présence des cétacés au Liban. 6ème réunion des parties à l'ACCOBAMS, novembre 2016, Monaco. Présentation orale.

Khalaf, G., Fakhri, M., Ohanian, C. et Mina, R. 2010. Activités relatives aux cétacés dans le milieu marin libanais. INOC-International Conference on Biodiversity of the Aquatic Environment. Lattakieh, Syrie.

Khalaf, G., Fakhri, M., Ohanian, C., Abi Ghanem, C. et David, L. 2013. Distribution and relative abundance of the *Tursiops truncatus* in Lebanese marine waters (Eastern Mediterranean). Journal of Life Sciences, ISSN 1934-7391, USA. Vol. 7, No. 11, pp. 1196-1203.

Notarbartolo di Sciara, G., Birkin, A., Jr. 2010. Conserving whales, dolphins and porpoises in the Mediterranean and black Seas: an ACCOBAMS status report, 2010. ACCOBAMS, Monaco. 212 p.

Reeves, R. & Notarbartolo di Sciara, G. 2006. The Status and Distribution of Cetaceans in the Black Sea and Mediterranean Sea. IUCN Centre for Mediterranean Cooperation, Málaga, Spain. 137 pp.

Tohmé, G., et Tohmé, H. 1985. Les mammifères sauvages du Liban. Publication de l'Université Libanaise, Section des Sciences Naturelles, 16. 190 pp.

European shag (*Phalacrocorax aristotelis*) © SPA/RAC, Artescienza

# IV. National Monitoring Programme for Coastal and Marine Birds

## 1. INTRODUCTION

Based mainly on the Decision IG.22/7 on the Integrated Monitoring and Assessment Programme, Guidelines for Management and Monitoring Threatened Population of Marine and Coastal Bird Species and their Important Areas in the Mediterranean (UNEP/MAP - RAC/SPA, 2012) and the design given by the "Draft Integrated Monitoring and Assessment Guidance" (WG.420/4), as well as monitoring plans or programmes developed by EU Member States under the MSFD, this monitoring programme is a detailed accounting of how we propose going about accomplishing the task of designing and executing the monitoring of coastal and sea birds at national level in Lebanon.

This programme aims at:

- understanding what is happening to the coastal and sea birds (distribution, density or abundance, ecological status and role in the ecosystem) in order to adapt our interventions accordingly,
- detecting and acting on threats in appropriate time,
- providing ammunition for advocacy and information for designing interventions, and 4) assessing the effectiveness of conservation efforts.

The data provided by the monitoring programme at national level give information on national marine ornithology trends. This feeds directly into reporting for the CBD, SPA/RAC and other international and, where appropriate, national organizations.

The following document on integrated monitoring is limited to the sea birds of Lebanon only.

## 2. REGULATORY ASPECTS/ LEGISLATION

Nationally: The Law of Hunting 580/2004 doesn't include any sea bird among the game birds that are allowed for hunting. Thus, all sea birds, including foreshore birds are protected by the Lebanese Law on Hunting.

Regionally: Being a contracting party to the Barcelona convention, Lebanon is committed to the protection of the birds in Annex II of the Protocol concerning Specially Protected Areas (SPAs) and biological diversity in the Mediterranean.

Internationally: Lebanon is committed to the conservation of threatened water bird species as being Contracting Party to AEWA Agreement.

## 3. EXISTING MONITORING ACTIVITIES AND AVAILABLE HUMAN AND TECHNICAL RESOURCES

Ornithology and Birdwatching aren't well practiced in Lebanon. Since 1972, Lebanon hosts one professional ornithologist only. In his capacity as manager of Palm Islands Nature Reserve, he studied the birds of this protected area and issued a monitoring manual for its key bird species. He contributed also to the study of Tyr Coast Nature Reserve avifauna in a project implemented by the Lebanese University on behalf of the Ministry of Environment and funded by UNDP during 2004-2005. At the same period, he studied the birds of Naqoura and Damour under the marine conservation areas project of SPA/RAC. Few foreign birdwatchers worked in Lebanon and satisfied their hobbies of birding during weekends between 2000-2011. Only 4 or 5 of them paid modest attention to sea birds.

Lebanese birdwatchers emerged after 2012 as a reaction from responsible hunters against bird shooters. Presently there are seven individuals with always no interest to pelagic birds as the boat rental for their observation is costly.

In brief, the only existing seabirds monitoring scheme is on Palm Islands Nature Reserve. It was covered by SPA/RAC: Monitoring marine and coastal birds in Palm Islands Nature Reserve (SPAMI 2012) and its surroundings by the ornithologist professor Ghassan Ramadan Jaradi who also surveyed in 2017 the distribution of migrating and breeding Marine birds in North Lebanon. The other birdwatchers constitute a potential human and technical resource for sea bird monitoring activities.

## 4. PRESENTATION OF THE NATIONAL MONITORING PROGRAMME OF SEA BIRDS IN LEBANON

### 4.1. Introduction

Given the relevance of the Lebanese Sea as a migration corridor between the Eurasia and Africa, coastal

monitoring programmes could be of relevance to assess seabirds in the East Mediterranean region.

#### 4.1.1. Challenges of the sea birds monitoring programme

The aims of this programme are to monitor and assess the common indicators in relation to the Ecological objective 1 (EO1: biodiversity):

- Common Indicator 3 (CI3): the distributional range of marine bird species (EO1),
- Common Indicator 4 (CI4): the population abundance (EO1) and
- Common Indicator 5 (CI5): the population demographic characteristics (EO1).

In addition, marine birds as top predators are an essential avian group to understand the structure and functioning of ecosystems (EO8 CI16) and the trophic web (EO4 «Marine food web», which the related CIs are still under development). Moreover, the autopsy of the found dead birds allows to document the effects of the contaminants on the species (EO9 «Contaminants», CI17 to CI22) and the impacts of macro-waste on the birds (EO10 "Marine litter", CI 22 and CI 23). Finally, the programme will make it possible to periodically update the assessment of the group «seabirds» studied, as well as the impacts of various pressures including contaminants, waste, bycatches, renewable marine energies, extraction of granulates, etc.

#### 4.1.2. Evaluation of the achievement of the Good Environmental Status (GES) and associated Ecological Objectives

This programme makes it possible to monitor and assess the following ecological objective and their common indicators

Common Indicators of EO1 (Biodiversity):

**At the level of species**

Common Indicator 3: Species distributional range

- Areas of distribution
- Distribution map/scheme in the said area, where applicable

Common Indicator 4: Populations abundance

- Abundance or number of individuals in a population and/or biomass of populations (summed weights), depending on the case

Common Indicators 5: Population demographic characteristics

- Demographic characteristics of populations if any [p. ex. Structure by size or age, sex distribution, fertility rate, survival / mortality rate]
- Population genetic structure, if any

**At the level of ecosystems**

Ecosystems structure

- Composition and relative proportions of ecosystem components [habitats and species]

EO4 (Marine food web)

EO 8 (Contaminants)

Common indicator 16: Length of coastline subject to physical disturbance due to the influence of man-made structures.

Candidate Indicator 25[1]: Land use change

EO 10 (Marine litter):

- Impacts of Wastes on Marine Life

Candidate indicator 24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected marine mammals, marine birds and marine turtles[1].

#### 4.1.3. Evaluation of the characteristics of the ecosystem as well as the pressures and impacts needed to analyse the ecological status

This programme provides information primarily on the following Initial Evaluation (IE):

1- "Characteristics and Ecological Status" - Biological Status: Marine birds.

2- "Pressure/Impacts" Component - Physical Pressures:

- Ecological Impacts of Marine Waste
- Ecological impact of contaminants
- Disturbance to Wildlife

3- «Pressures/Impacts» - Chemical pressures:

- Impacts of chemical substance on the ecosystem

4- "Pressure/Impacts - Biological Pressures:

- Bycatch

#### 4.1.4. Evaluation of the achievement of environmental objectives and especially related operational objectives

This programme allows the evaluation of the achievement of the following environmental objectives:

[1] Candidate Indicators are indicators which still have many outstanding issues regarding monitoring and assessment, hence are recommended to be monitored in the initial phase on a pilot and voluntary basis. These indicators will be further developed towards common indicators in light of the ongoing implementation experience of IMAP.

◊ guarantee the potential of the marine environment hospitality for birds: food, resting, reproduction, movement. In particular:

- Protect functional areas for avifauna (feeding, resting, moving, breeding areas, especially offshore areas)
- Reduce the pressure (ex. Visits to Palm Islands Nature Reserve during the birds breeding season with pet animals (dogs/cats)) exerted by certain terrestrial species on islands and islets serving as breeding sites
- Limit disturbance, especially noise and light, in nesting sites. (ex. No permits to visit islands or organize events for public during breeding season of birds).
- Control the pressure exerted on the environment and other avian species by populations of Yellow-legged Gull (ex. Control of pressure on Audouin Gull and on babies of Loggerhead marine turtles).

### 4.2. Organisation

The national monitoring programme of seabirds consists of 5 sub-programmes. They are organized according to a geographical distribution (coast versus offshore). Sub-programmes relating to the status of the environment are also noted (sub-programmes 1 to 3) and sub-programmes related to the pressures:

Sub-programme 1 - Birds of the foreshore

Sub-programme 2 - Breeding sea birds

Sub-programme 3 - Birds at sea

Sub-programme 4 – Beaching of birds

Sub-programme 5 - Interactions between birds and human activities at sea.

### 4.3. General comments on the programme

The programme is based on relatively expensive but low periodic campaigns (mainly a general flight over the waters under Lebanon's jurisdiction), and on annually recurrent actions that could be carried out by associations, volunteers, managers of Marine Protected Areas and/or research teams. Unfortunately, the current observation or the monitoring of marine birds in Lebanon is very rare, whereas the coastal birds are occasionally targeted. This is probably due to the high cost of the marine trips, associated with lack of interest in marine birds by the new wave of young birders.

## 5. SUB-PROGRAMME 1: BIRDS OF THE FORESHORE

### 5.1. Objectives and presentation

Seabirds have received relatively little attention in the Lebanese Sea area, particularly regarding the study of their distribution patterns at shore and sea. The most extensive coverage of the region regarding marine top predators has been probably conducted by Ramadan Jaradi (2001), who has conducted several surveys since 1995, using point counts and transects methodology. However, seabirds have been only marginal to a research work focused on cetaceans and sea turtles, and little information is available for the target groups of this study.

On the other hand, a handful of seabird sporadic surveys have been conducted in the last recent years, providing some relevant information for the region.

Waders and some other species (geese, ducks) depend on the good state of the marine environment, particularly of the foreshore, hereinafter referred to as birds of the foreshore. The objective of this sub-programme is to better identify the distribution and evolution of the numbers of these species. On some key sites, a characterization (mapping, trophic quality) of the main feeding areas of these birds and their spatial evolution is necessary to assess their accessibility in relation to human activities. The study of populations should also make it possible to estimate the areas at stake (interactions with human activities, e.g. Sheikh Zennad Salinas and wetland) and to understand the functional ecology of the populations studied and their responses to changes due to anthropogenic activities. The monitoring also provides information on the demographic functioning of populations and their dependence on trophic resources (EO4 «Marine food webs»).

### 5.2. Parameters followed and link to other programmes

The parameters to be followed are as follows:

- Presence and distribution of foreshore species.

These parameters inform about the spatial and temporal distribution of populations.

- Abundance of foreshore species

These parameters provide information on the number of coastal non-breeding waders and their temporal and spatial evolution.

- Functional areas: feeding and resting area

- Food of waders: composition, analysis of stomach contents, faeces, regurgitated matters.
- Characteristic parameters of the trophic resource in the environment (abundance and specific composition of benthic fauna)

Sampling of sediment could be carried out under this sub-programme, in particular for the study of trophic resources of waders.

### 5.3. Means / tools used / protocol elements

Monitoring of foreshore species is carried out on foot from the foreshore (Waders) or by small coastal vessels and results in monthly counts, sampling and telemetric monitoring if any.

#### Elements of protocol

- The monitoring process will be done according to the methodology of point counts and linear transects. Some supplements may be made by also performing counts at low tide. The choice (stratified sampling stations) and number of sites (plots) will be determined in the first monitoring cycle prior to operational implementation.
- Feeding areas of the foreshore species: obtained visual observation of the behaviours. This makes it possible to assess accessibility in relation to human activities and/or the determination of the research effort. The determination of the main feeding areas then makes it possible to locate sampling stations to characterize the sediments and associated benthic macrofauna (protocol tested on 10 coastal communities in the Atlantic Channel since 2007 under the Intertidal Benthic Habitats section of the "Observatoire Patrimoine Natural Littoral RNF-AAMP");
- Diets of foreshore (including waders) bird species: analysis of stomach contents, faeces, regurgitated material (or stable isotopes) allows to define the composition and the quality of the diet; Trophic resources for the foreshore species, available biomass, distribution of prey tracers searched by species

### 5.4. Spatial coverage and sampling strategy

#### Spatial coverage

The areas covered by these monitoring activities should correspond to the zones of agglomeration of birds at high tide (repositories) and feeding areas at low tide, mainly located in the intertidal zone.

These monitoring activities concern littoral complexes identified as functional complexes for the resting of waders. Currently, about no one functional site is monitored.

The monitoring sites adopted during the national validation workshop of this programme are:

- The area from Ras Chekaa to Palm Islands,
- The area from: Beirut Harbor to Ramlet El Baida,
- The area of: Tyre, Tyre Coast Natural Reserve and El Bayada

#### Sampling Frequency

Sampling of shorebirds should preferably be monthly for the majority of sites and should be carried out at high tide (on the repository), and at low tide, as this is necessary for the study of the functionality of the sites, the state of the benthic resource, interactions with human activities, etc. The protocol will therefore evolve in this direction.

### 5.5. Implementation of the monitoring

#### Existing mechanisms for monitoring

Currently there is no specific national mechanism in function.

The monitoring will preferably be carried out according to the methodology of Point Counts and linear transects. Other monitoring activities conducted by volunteers within the framework of Wetland International as well as other monitoring activities conducted through tracking with Satellite (PTT), GPS, and GLS will be able to supplement the data acquired at the national level.

### 5.6. Conclusions on the implementation of this sub-programme

In conclusion, the monitoring process of birds of the foreshore should be developed soon in order to make the monitoring operational and carried out along the coasts of Lebanon. This monitoring can therefore be evaluated as early as 2019 for the needs of the programme. However, sampling is currently limited to two Marine Protected Areas, notably the Palm Islands Nature Reserve and the Tyr Coast Nature Reserve and therefore does not concern the entire Lebanese coast. For these reasons, this monitoring will be extended to other sites such as certain Special Protection Areas of Mediterranean Importance (SPAMIs). They should also be completed in terms of parameters and species to be monitored.

# 6. SUB-PROGRAMME 2: BREEDING SEA BIRDS

## 6.1. Objectives and presentation

The monitoring of breeding seabirds provides information on the demographic functioning of populations, their reproductive performance and their dependence on trophic resources (EO1»biodiversity», EO4 «Marine food web»). All these species of seabirds are meant to be protected at national level.

In addition, monitoring of pollution of the marine environment by the macro-waste (EO10 "Marine litter") can be done by listing the amount of macro waste used by certain species of seabirds to build their nest (indicator developed and used elsewhere in France). This indicator has great potential for assessing the good environmental status. This monitoring also tracks the contamination of certain pollutants in eggs (EO9 «Contaminants»).

## 6.2. Parameters tracked and link to other programmes

The parameters to be followed are:

- Presence and distribution of breeding species

  These parameters inform on the presence of the species by sites and specify the geographical distribution of the colonies by species and the temporal evolution of the latter.
- Nesting abundance

  This parameter indicates the number of breeding pairs by species and their demographic trend.
- Young production: average number of young fledglings per breeding pair
- Success of the reproduction: percentage of couples who successfully raised young birds These two parameters point to the reproduction performance and possible inter-annual or geographical variations.
- Movement of breeding birds

  This parameter makes it possible to evaluate feeding zones, their accessibility in relation to human activities, to determine the food research effort of individuals and thus to inform the functional areas.
  - Characteristic parameters of the trophic diet (composition, analysis of stomach contents, faeces, regurgitated matter or stable isotopes)
- Pathogens (parasites, viruses, bacteria)
- Quantity of waste in nests
- Quantity of pollutants in eggs

Data from this sub-programme may also be used for other monitoring programmes such as marine litter and contaminant programmes.

## 6.3. Means / tools used / protocol elements

Monitoring is usually carried out on land (for landing in breeding colonies) or on foot on the coast, or on board of small coastal vessels or by air means (on some colonies, aerial photo tracking is tested). Monitoring techniques are based on colony counts (with biopsies, feather sampling), and on macro waste monitoring for certain species, and on telemetry (when available) monitoring to answer specific questions.

### Elements of protocol

- Presence, distribution and numbers of breeding species: standardized census methodology.
- Demographic parameters: monitoring of breeding species to determine juvenile production and reproductive success and monitoring by capture-marking-recapture of individuals tagged in colonies.
- Trophic diet: species-specific studies: direct observations for Terns; Cormorants by analysis of regurgitation balls; Gannets and procellariiformes (Petrels and Shearwaters) by analysis of regurgitated matter; Isotopic signatures in feathers.
- Pathogens: by smear on eggs, by taking feathers, blood.
- Functional area for breeding birds: colonies/ feeding sites in the sea: telemetric monitoring of individuals (Argos beacons, GPS, GLS, etc.) and by monitoring in ships.

## 6.4. Spatial coverage and sampling strategy

### Decennial censuses (numbers, distribution, etc.)

The census should be maintained every 10 years on all colonies if existing. For logistical reasons, it is not feasible to carry out a complete census more regularly than on a decennial basis for seabird species with a wide geographical distribution.

### Yearly fine-tuned monitoring of target colonies (population case).

In addition to these national survey periods, intermediate data are collected by various structures at more regular time intervals, whether annual or not, and coordinated or not at regional scales. It is necessary to rely on all such regular monitoring activities if available. This is the case of studies and regular monitoring of birds on Palm Islands Nature Reserve and its surrounding waters.

In parallel with these counts, more specific and more detailed studies on target species and colonies need

to be put in place in order to estimate different state parameters.

A census of target colonies is recommended every year in nature reserves, national parks, marine natural parks and for the main colonies of other protected sites.

Data on demographic parameters, diet and pathogens on target colonies will be collected annually. Data will be analysed on these colonies to assess population trends, reproductive success, survival, diet, pathogens.

Finally, depending on the means available, telemetric surveys on some individuals of the main colonies of certain species should be funded and carried out. For target species such as gannet or the puffin in the Mediterranean, all the colonies will be followed.

### 6.5. Implementation of monitoring programme

#### Existing mechanisms for monitoring:

Currently there is no specific national mechanism in function.

The monitoring will preferably be carried out according to the methodology of Point Counts and linear transects. Other monitoring activities conducted by volunteers within the framework of Wetland International will be able to supplement the data acquired at the national level.

### 6.6. Conclusions on the implementation of this sub-programme

In conclusion, monitoring of breeding seabirds (Yellow-legged Gull excepted) is not yet operational in Lebanon. Specific monitoring on target species and colonies will be set up in order to estimate other parameters (breeding success, diet, pathogens ...). With respect to the use of telemetry on the colonies, annual monitoring of the census of target colonies in marine protected areas should be established whenever colonies are detected.

## 7. SUB-PROGRAMME 3: BIRDS IN SEA

### 7.1. Objectives and presentation

This sub-programme aims to map the distribution and density of seabirds (but also marine mammals and sea turtles). It contributes to the assessment of the ecological status of seabirds (EO1»biodiversity»), analysis of the functioning and the status of the trophic web (EO4 «trophic web»). It also helps to estimate the pressure of human activities (maritime traffic and fishing, waste – EO10 “Marine Litter”») on populations.

The monitoring of birds at sea can be carried out according to three types of devices:

#### Type A devices - Dedicated aerial observation campaigns (type SAMM: Suivi Aérien de la Megafaune Marine (Aerial Monitoring of Marine Megafauna))

The implementation of large surveys over all the waters under Lebanese jurisdiction will make it possible to collect observations on a large spatial scale and in a short space of time. It is a mean of monitoring that allows numerous optimizations between the EOs: EO1 «biodiversity», EO3 «commercial species», EO4 «Marine food web» and EO10 «Marine litter». It can be carried out at a fairly long time (6 to 12 years), giving an instantaneous picture of the distribution of species or groups of species for which specific identification is difficult with this type of method (ex. puffins), and human activities visible from an aircraft (fishing activities, boating, tourism, etc.).

#### Type B devices - Observation campaigns from non-dedicated vessels

This type of device provides an indication of the distribution and richness of species or groups of species. Repeated every year, it provides trends in spatio-temporal dynamics at shorter time scales and finer spatial resolutions than the previous one. Moreover, the system set up on the fishing campaigns makes it possible to obtain simultaneously information on the target species and their environment (as well as on their prey in some cases), data necessary for the characterization of habitats and food webs (Ecosystem approach).

#### Type C devices - Observations from the coast at a fixed point

Air counting does not always result in accurate identification of species and vessel counts rarely cover the ultra-coastal zone. The coastal zone has densities of individuals sometimes very high. This device provides elements of spatio-temporal dynamics at a high periodicity. These observations are carried out under different programmes: IWC (Wetland International).

In the framework of this programme, the A and B devices, considered as priorities, will be the subject of evolutions and an operational optimization with the monitoring of mammals and sea turtles (common devices). Type C devices, which are of lower priority (because they still require harmonization of practices and scientific details), will not be modified.

### 7.2. Tracked parameters and link to other programmes

The parameters to be followed are:

a. The presence and the distribution at sea of the individuals. These parameters specify the spatio-temporal distribution of the rates of encounter of the species

b. Abundance at sea refers to the size of a population or a relative or absolute fraction extrapolated from observations

The data produced by the devices described in this sub-programme may also be used for the purposes of other thematic monitoring programmes: «Marine litter» (sub-programme macro floating waste), «Marine mammals and turtles» (at sea) and «Fish and cephalopods «(pelagic fish).

### 7.3. Means / tools used / protocol elements

This sub-programme is based on aerial surveys and observation campaigns from non-dedicated vessels (mainly fishing campaigns, state ships at sea, regular lines), observations from the coast at a fixed point.

#### Type A devices - Dedicated aerial observation campaigns (SAMM type)

Observers placed in high-wing twin-engine aircraft fitted with bubble portholes collect observations of the species encountered (mammals, turtles, birds). The protocol to follow is the one implemented in the framework of the SAMM campaigns (Air Monitoring of the Marine megafauna) of the program PACOMM ((Programme d'Acquisition de Connaissances sur les Oiseaux et les Mammifères Marins). Protocol elements are available at the following address: http:// cartographie.aires-marines.fr/?q=node/45 (section 1)

#### Type B devices - Observation campaigns from non-dedicated vessels

Observers on non-dedicated vessels the fishing campaigns collect information on the bird species. The standard protocol on which to rely is to adapt to the Mediterranean campaigns according to the monitoring already carried out by local actors. Protocol elements are available at the following address: http: // cartographie. aires-marines.fr/?q=node/45 (section 2).

#### Type C devices - Observations from coast at fixed point

Observers, placed on strategic points of the Lebanese coastline, observe the seabirds with the binoculars or the long view.

The IWC (International Waterbird Census) monitoring is conducted by voluntary associations, one day a year. This monitoring concerns all water birds present in winter in Lebanon (anatidae, limicole, laridae, sternidae, podicipedidae… The data from the IWC monitoring are therefore complementary to the censuses of seabirds at the coast for wintering, and cooperation for a valuation of the available data are to be envisaged.

### 7.4. Spatial coverage and sampling strategy

#### Dedicated aerial observation campaigns (SAMM type)

The spatial coverage is adapted to the distribution of the species studied including marine mammals; The resolution is thus finer in coastal zone than offshore. The air campaigns will be carried out on all the Lebanese waters, when possible and appropriate, of the four marine sub-regions, with sampling in winter and one in summer. Indeed, distributions of seabirds are very different according to these two seasons. Only the completion of a flight plan with sufficiently fine mesh size, with extensive spatial coverage, repeated in both the winter and summer seasons, can yield statistically robust results for modelling habitats.

#### Observations from the coast at a fixed point

For coastal monitoring, the number and position of strategic points are those covering the most representative areas of the coastline.

### 7.5. Implementation of monitoring

#### Existing mechanisms for monitoring

Currently, there is no specific national mechanism in function.

The monitoring will preferably be carried out according to the methodology of Point Counts and linear transects. Other monitoring activities conducted by volunteers within the framework of Wetland International as well as other monitoring activities conducted through tracking with Satellite (PTT), GPS, and GLS will be able to supplement the data acquired at the national level.

### 7.6. Conclusions on the implementation of this sub-programme

Monitoring under this sub-programme may begin in 2018 with the implementation of aerial and observation campaigns from the fishing vessels. Coastal monitoring for seabirds is very important because they allow for more accurate identification than follow-up from aerial or oceanographic vessels; However, it is necessary to go further in analysing the data of the monitoring in order to adapt the resolution of these monitoring and to be able to propose a more operational sampling strategy.

## 8. SUB-PROGRAMME 4: BEACHING OF BIRDS

### 8.1. Objectives and presentation

Beaching on the coast represent the main source of access (with by-catch) to tissue and organ sampling to assess the ecological status of top predators (EO1 «biodiversity» of the Good Ecological State), the impact of anthropic pressures on them (EO10 «Marine litter», EO9 «contaminants») as well as the functioning of the trophic web (EO4 « Marine food webs»).

Beaching also provides information on the presence, distribution and relative abundance of species.

## 9. SUB-PROGRAMME 5: INTERACTIONS BETWEEN BIRDS AND HUMAN ACTIVITIES AT SEA

### 9.1. Objectives and presentation

This sub-programme aims to observe and monitor the in-situ interactions between human activities at sea and seabirds in order to provide information on the state of populations in relation to pressures (EO1 «biodiversity», CI3, CI4 and CI5 related to marine sea birds) and will help to update the bycatch assessment.

It should be noted that human activities that probably have the most interactions with seabirds are terrestrial activities that can be a source of pressure on breeding colonies. These interactions, addressed through the induced pressures (disturbance, human trafficking, contaminants, marine litter, etc.) are dealt with in other programs and sub-programmes, in particular sub-programmes No. 2 «Breeding sea birds» and No. 4 «Beaching of birds «.)

For offshore activities and the uses that are subject to authorization and require an environmental impact assessment and monitoring, it would be appropriate to use these elements to assess the IMAP's EOs and their CIs. However, but to date, there do not appear to be any activities of this type likely to have an impact specifically on birds.

For the fishing activity, there is currently no specific monitoring for this sub-programme. Elsewhere, there are currently punctual studies that are carried out on this subject, including a project under development entitled «LIFE OMEGA», carried out by the LPO in France, aimed at evaluating the interactions between seabirds and human activities as well as wind and aggregate extraction.

## 10. THREATS TO SEABIRDS

(Parts applicable in Lebanon are inspired from a study entitled Status of seabirds in the Alboran Sea: UNEP/MAP/RAC-SPA).

### 10.1. OVERVIEW

Seabirds are among the most threatened bird groups in the world (Croxall et al. 2012), and their conservation requires urgent and well-coordinated action (Lewison et al. 2012). This vulnerability is partly due to the fact that seabirds commute between two totally different environments, the sea and the land (breeding colonies), each with its inherent threats (Boersma et al. 2002). Furthermore, they are highly mobile organisms that can travel across most of the planet during their life cycle, and therefore, face different threats in different regions. To complete the picture, seabirds' life history is characterized by high adult survival (usually around 90 % annual survival in many species) and low reproductive success. Hence, their populations are very sensitive to any factors increasing adult mortality, as the population cannot compensate this "extra" loss of individuals by increasing its productivity (Croxall & Rothery 1991, Weimerskirch 2002).

Overall there is some consensus on major threats affecting seabirds (Boersma et al., 2002, Croxall et al. 2012). Inland, the most relevant are the pressure posed by invasive species (particularly predation by introduced mammals), habitat loss or degradation (due to coastal development), human disturbance, poaching and environmental change. At sea, the interaction with fisheries (especially bycatch), pollution, the proliferation of infrastructures and environmental change complete the list.

The relative importance of these threats may vary between regions and species, according to their geographical and ecological characteristics, and with the weight of the various human activities that take place in them. In the case of Lebanese sea and seashore, it is important to keep in mind that the local seabird community is diverse but partly composed by species that count with relatively small populations (due to the low productivity of the Mediterranean region).

### 10.2. THREATS INLAND

#### Coastal development

The increasing humanization of the coastline, including urban development, infrastructures, light pollution and disturbance, poses a threat to seabirds, particularly on their breeding grounds. This is particularly relevant for

gulls, terns and waders breeding in foreshore areas, as these habitats have been severely affected by human activities.
Monitoring will assist fine tuning this table.

Table 1. Overview of potential threats to the most relevant seabird species in the Mediterranean Sea

| | | Threat inland | | | | Threat at sea | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| English name | Scientific name | Predation by introduced Mammals | Coastal development | Human disturbance | Poaching | Fisheries bycatch | Prey depletion | Pollution | Infrastructures | Environmental change |
| Scopoli's shearwater | *Calonectris diomedea* | | | | | | | | | |
| Yelkouan shearwater | *Puffinus yelkouan* | | | | | | | | | |
| European storm-petrel | *Hydrobates pelagicus* | | | | | | | | | |
| Mediterranean gull | *Larus melanocephalus* | | | | | | | | | |
| Slender-billed gull | *Larus genei* | | | | | | | | | |
| Audouin's gull | *Larus audouinii* | | | | | | | | | |
| Sandwich tern | *Thalasseus sandvicensis* | | | | | | | | | |
| Lesser-crested tern | *Thalasseus bengalensis* | | | | | | | | | |
| Common tern | *Sterna hirundo* | | | | | | | | | |
| Little tern | *Sternula albifrons* | | | | | | | | | |

(from a conservation perspective: those listed in the SPA/BD - Barcelona Convention- and/or included in Annex I of EU Birds Directive).
Red: high impact; orange: moderate impact; green: low impact.

## 10.3. THREATS AT SEA

### Fisheries bycatch

Seabird bycatch in fishing gear is one of the most serious threats to many seabird species. However, the available evidence is very limited. On the other hand, reports from beached bird surveys suggest that demersal longlines, nets and pole lines could have some impacts on seabirds elsewhere (García-Barcelona et al. 2010c). Further research is necessary to properly assess the incidence of bycatch in Lebanese sea, as high levels have been described in neighbouring areas of the Mediterranean Sea.

### Fishing overexploitation

It is not known if the Lebanese sea holds a fishery for small-pelagic fish species, mainly sardine and anchovy, which has undergone severe fluctuations in the Mediterranean and is likely overexploited (Copemed II. 2011).

Since these are the main natural prey for most seabird species, keeping severe exploitation without proper assessment and management could cause impact on the seabird populations, both breeders and non-breeders (e.g. Louzao et al. 2006a, Cury et al. 2011).

### Pollution

Both background and acute-events pollution pose a serious threat to seabirds worldwide, and the Lebanese sea is no exception. Of particular relevance is the risk of acute events of pollution such as oil spills, since the Lebanese sea already suffered from political tension that heavily polluted its waters and shores with oil spill in 2006. This political instability persists till today with a risk of another oil spill at any time.

### Marine infrastructures

Development of infrastructures at sea could pose a risk to seabirds. Within the context of the Lebanon's sea, planned windfarms pose a particular threat given the relevance of the region for migrating seabirds

(i.e. intense flow of seabirds prone to colliding with these infrastructures). So far, the area includes a few proposals of wind-farm development where the risk to seabirds would be high.

## 11. BASELINE DATA FOR MONITORING OF SEA BIRD SPECIES

Information regarding seabirds in the Lebanese Sea is patchy and requires of further research, particularly in the offshore. The following information is chiefly extracted from the studies of Ramadan Jaradi et al 2008.

### 11.1. Trigger and Priority (threatened bird species) for monitoring

*Puffinus yelkouan* Mediterranean Shearwater: Common on passage, usually in small numbers from early August–early September (200 reported off Tripoli in late September) and March–April. Few winter records of singles or flocks (up to 50) often mixing with Common Black-headed Gull *Larus ridibundus* while resting on surface water during November-February (GR-J). Observed offshore Beirut, Palm Islands, Tripoli and Naqoura. First recorded in 1877 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

*Calonectris diomedea* Cory's Shearwater: Common on passage March–mid May and early August–late September and recorded irregularly in large flocks offshore and near Palm Islands in January–February. Seen in Batroun, Beirut, Naqoura, Palm Islands, Tripoli and Tyre Coast. First recorded by Van Dyck in 1873-1878 (Carruthers 1910, Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

European Storm-petrel *Hydrobates pelagicus* (vagrant): Three records: singles off Ras Beirut on 18 September 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1999), 10 April 1997 (Busuttil Flumm 1998a) and one at Naqoura, near southern border, on 21 December 2003 (GR-J). Ref. Ramadan Jaradi et al. 2008. Ref. Ramadan Jaradi et al. 2008.

European Shag *Phalacrocorax aristotelis*: Not yet recorded in Lebanon.

Pygmy Cormorant *Phalacrocorax pygmeus*: Occasional passage in November and March, and scarce winterer, December-February, principally off Naqoura in the south and Palm Islands in the north. A single adult bird lingered at Aammiq from 24 June to 14 July 2005 (seen on 17 dates) (Colin Conroy pers comm). In the past, reported from inland at the Litani River (Tristram 1864) and at Aammiq Swamp in November 1954 (Nevins 1960). Ref. Ramadan Jaradi et al. 2008.

White Pelican *Pelecanus onocrotalus:* Common regular passage migrant at both seasons with flocks of up to 1000 birds near coasts, at Aammiq and Qaraoun, and over mountains up to 1800 m asl. Occurs mid-February–early June and early September–late November, principally on Palm Islands. First recorded by Tristram (1882). Ref. Ramadan Jaradi et al. 2008.

Dalmatian Pelican *Pelecanus crispus:* Scarce: small flocks principally in March–April and November, in the Beqaa Valley, off Tyre, Tripoli and on Palm Islands (Ramadan-Jaradi & Ramadan-Jaradi 2001), and in Damour (Ramadan Jaradi et al. 2015). Largest flock encountered c45 on 3 April 1975 (Macfarlane 1978). Observed in Aammiq, Chtaura, Palm Islands, Qaraoun, Tripoli and Tyre. First recorded by Tristram (1882). Ref. Ramadan Jaradi et al. 2008, 2015.

Greater Flamingo *Phoenicopterus roseus:* Status prior to 1999 unclear (Ramadan-Jaradi 1999). Recent records suggest that the species is a rare passage migrant and probably an equally scarce winter visitor, rather than a vagrant (Ramadan-Jaradi et al 2004): recorded 14 times during December, January, March, April, May, June, August, September and October; at Aammiq, Batroun, Beirut, Byblos, Cheikh Zennad, Khaldeh, Nahr Ibrahim and Palm Islands. First recorded in 1881 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

Osprey *Pandion haliaetus:* Uncommon passage migrant throughout the country from late March–late April and early September–early November. Sighted at Aammiq, Beirut, Cheikh Zennad, Dalhoun, Faqra, Hermel, Palm Islands, Qaa, Qbeiyat, Qleiaat and Tanayel. First recorded by Tristram (1865-68). Ref. Ramadan Jaradi et al. 2008.

Eleonora's Falcon *Falco eleonorae:* Formerly bred (Tristram 1865-68). Extremely rare passage migrant (Ramadan-Jaradi & Ramadan-Jaradi 1999) late March-late May and early September-late October. Sighted at Aammiq, Ainab, Azour, Barouk, Beirut, Bjiro, Dalhoun, Damour, Deir el Qamar, Deir Mimas, Doueir, Fraidies, Hasrout, Kfarhim, Laqlouq, Nabatyeh, Niha, Qbeiyat, Ras el Chekaa, Tanayel, Tel el Akhdar and Wadi el Zeina. First recorded by Tristram (1865-68). Ref. Ramadan Jaradi et al. 2008.

Slender-billed Curlew *Numenius tenuirostris:* Not yet recorded in Lebanon.

Audouin's Gull *Larus audouinii:* Bred on Palm island in 1895 (Stenhouse 1904); 18 there but apparently not breeding on 3 April 1973 (Tohmé & Neuschwander 1974); seven more records at the same place: ten on 23 August 1997 (Ramadan-Jaradi & Ramadan-Jaradi 1999), one on 1, 4 and 25 April 1998 and one on 6 July 2000 (Ramadan-Jaradi & Ramadan-Jaradi 2001); three on 4 April 2002 and four on 11 August 2004 (GR-J). Elsewhere: three off Beirut on 3 October 1958 (Flach 1959), five at Cheikh Zennad on 25 August 1996 (Bara 1998), six there on 5 April 2002 and 14 on 1 September 2003 (Ramadan-Jaradi 2003). These records above suggest that the Audouin's Gull is a rare passage migrant rather than vagrant. Ref. Ramadan Jaradi et al. 2008.

Lesser Crested Tern *Thalasseus bengalensis:* Bred on Palm island in 1895 (Stenhouse 1904). No subsequent records (Ramadan-Jaradi & Ramadan-Jaradi 1999).

Sandwich Tern *Thalasseus sandvicensis:* Extremely rare passage migrant and winter visitor in early August-mid-April to coasts (Ramadan-Jaradi & Ramadan-Jaradi 1999) and Palm Islands (Ramadan - Jaradi & Ramadan-Jaradi 2001). Sighted at Beirut, Byblos, Cheikh Zennad, Damour and Palm Islands. First recorded in 1878 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

Little Tern *Sternula albifrons:* Bred on Palm Islands at the end of the 19th century (Stenhouse 1904) but no subsequent records until 11 at Cheikh Zennad on 14 June 1996, three there on 8 September 1996 and eight on 16 May 1997 (TB), one at Sanani island on 4 April 1998 (Ramadan-Jaradi & Ramadan-Jaradi 1999) and two at Qaraoun Lake on 27 September 2003 (GR-J). All these records suggest that the Little Tern is a very rare passage migrant rather than vagrant. First recorded in 1877 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

To fill the gaps in our knowledge of the species listed in the Action Plan, detailed surveys coordinated by national ornithological centres working together in a Mediterranean network, will have to be carried out.

### 11.2. Species of coastal wetlands for monitoring

White Pelican *Pelecanus onocrotalus*: Common regular passage migrant at both seasons with flocks of up to 1000 birds near coasts, at Aammiq and Qaraoun, and over mountains up to 1800m asl. Occurs mid-February–early June and early September–late November, principally on Palm Islands. First recorded by Tristram (1882). Ref. Ramadan Jaradi et al. 2008.

Dalmatian Pelican *Pelecanus crispus:* Scarce: small flocks principally in March–April and November, in the Beqaa Valley, off Tyre, Tripoli and on Palm Islands (Ramadan-Jaradi & Ramadan-Jaradi 2001), and in Damour (Ramadan Jaradi et al. 2015). Largest flock encountered c45 on 3 April 1975 (Macfarlane 1978). Observed in Aammiq, Chtaura, Palm Islands, Qaraoun, Tripoli and Tyre. First recorded by Tristram (1882). Ref. Ramadan Jaradi et al. 2008, 2015.

Greater Flamingo *Phoenicopterus roseus:* Status prior to 1999 unclear (Ramadan-Jaradi 1999). Recent records suggest that the species is a rare passage migrant and probably an equally scarce winter visitor, rather than a vagrant (Ramadan-Jaradi et al 2004):recorded 14 times during December, January, March, April, May, June, August, September and October; at Aammiq, Batroun, Beirut, Byblos, Cheikh Zennad, Khaldeh, Nahr Ibrahim and Palm Islands. First recorded in 1881 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

Lesser Crested Tern *Thalasseus bengalensis:* Bred on Palm island in 1895 (Stenhouse 1904). No subsequent records (Ramadan-Jaradi & Ramadan-Jaradi 1999).

Sandwich Tern *Thalasseus sandvicensis:* Extremely rare passage migrant and winter visitor in early August-mid-April to coasts (Ramadan-Jaradi & Ramadan-Jaradi 1999) and Palm Islands (Ramadan - Jaradi & Ramadan-Jaradi 2001). Sighted at Beirut, Byblos, Cheikh Zennad, Damour and Palm Islands. First recorded in 1878 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

Little Tern *Sternula albifrons:* Bred on Palm Islands at the end of the 19th century (Stenhouse 1904) but no subsequent records until 11 at Cheikh Zennad on 14 June 1996, three there on 8 September 1996 and eight on 16 May 1997 (TB), one at Sanani island on 4 April 1998 (Ramadan-Jaradi & Ramadan-Jaradi 1999) and two at Qaraoun Lake on 27 September 2003 (GR-J). All these records suggest that the Little Tern is a very rare passage migrant rather than vagrant. First recorded in 1877 by Van Dyck (Kumerloeve 1962). Ref. Ramadan Jaradi et al. 2008.

### 11.3. Species of special concern for monitoring

Yellow-legged Gull *Larus michahellis*: Resident breeder (eggs mid-April, except for 2007 when first chicks hatched on 12 April) in fair numbers on Palm Islands (see Ramadan-Jaradi & Ramadan-Jaradi 1997, 1999, 2001). Fairly common passage migrant in March–mid-May and mid-August–early November; a relatively common winter visitor in mid-November–late February, and not uncommon non-breeding summer visitor in May–July. Occasional at inland wetlands. First recorded by Tristram (1864) and first breeding record was on Palm Islands in 1956 (Hollom 1959). Recently breeding was reconfirmed (for over 36 years) at Palm Islands in 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1997, 1999, 2001). Ref. Ramadan Jaradi et al. 2008.

### 11.4. Species of foreshore that may be subject for monitoring

*Haematopus ostralegus* Eurasian Oystercatcher: With only four records between 1955 and 1998, the Oystercatcher was considered vagrant in Lebanon (Ramadan-Jaradi & Ramadan-Jaradi 1999). Recent observations on Palm Islands Nature Reserve (Ramadan-Jaradi 2003) cover in 2002 one on 23 April and, two on 28 September and in 2003, one on 7 April and five on 11 May. Elsewhere, a putrefied corpse was found at Qaraoun Lake on 24 May 2004 (GR-J). Outside the range of the passage dates, one at Beirut on 9 July 2006 (Colin Conroy pers comm). These records suggest that the Oystercatcher is a regular but scarce passage migrant, the September record being the first for autumn (Ra-

madan-Jaradi et al 2005). Reported from Beirut, Cheikh Zennad, Khaldeh and Palm Islands. First recorded in 1955 (Nevins 1960).

*Himantopus himantopus* Black-winged Stilt: Common passage migrant in early March– mid-May and mid-June–late October on islands (most on Palm Islands), coasts (principally at Cheikh Zennad) and inland waters (most at Aammiq). First recorded in 1877 by Van Dyck (Kumerloeve 1962).

*Recurvirostra avosetta* Pied Avocet: Scarce passage migrant in ealy-March–mid-May and early August–late October on coasts and islands. The occurrence of 2 at Cheikh Zennad on 18 January 2002 and one there on 20 December 2006 (GR-J) indicate that the species is also a rare winter visitor. Sighted at Beirut, Beirut River, Cheikh Zennad, Palm Islands, Qaraoun, Rachaya and Tanayel. First recorded by Schrader (1892).

*Vanellus spinosus* Spur-winged Lapwing: Breeding confirmed, and nest photographed at Tyre Coast Nature Reserve in June 2006 (GR-J). Scarce passage migrant in mid-February–mid-June (most mid-April–mid-May) and early August–late October. Most on Palm Islands, on coast, or at Aammiq and Qaraoun. Sighted at Aammiq, Beirut, Cheikh Zennad, Dbayyeh, Khaldeh, Nahr el Kalb, Palm Islands, Qaraoun, Saida and Tyre. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962) and first confirmed breeding record was at Tyre in 2006 (GR-J).

*Pluvialis apricaria* Eurasian Golden Plover: Scarce passage migrant in March–April and uncommon in October–mid-November, mostly on coasts and in the Beqaa; extremely rare elsewhere. Few overwinter (late November–late March) in south Beqaa, Aammiq and Cheikh Zennad. First recorded by Tohmé & Neuschwander (1974).

*Pluvialis fulva* Pacific Golden Plover: One record: one at Cheikh Zennad on 12 October 1996 is briefly described (Bara 1998).

*Pluvialis squatarola* Grey Plover: Scarce passage migrant and winter visitor to coasts and islands in mid-August–late May. Recorded in Beirut, Cheikh Zennad, Khaldeh, Palm Islands and Tyre Coat. First recorded by Tristram (1864).

*Charadrius hiaticula* Common Ringed Plover: Relatively common passage migrant in late March–early June and mid-August–late October on coasts, islands, fishponds and inland waters. Few overwinter in November–March on coasts and islands. Very small numbers of non-breeders oversummer from June–July at Tyre Coast, Cheikh Zennad and Palm Islands. Recorded at Aammiq, Beirut, Cheikh Zennad, Chwaifat, Joub Jannine, Khaldeh, Litani River, Palm Islands, Naqoura, Qaraoun and Tyre. First recorded in 1875 by Van Dyck (Kumerloeve 1962).

*Charadrius dubius* Little Ringed Plover: Relatively common in spring, from late March– mid May, and scarce autumn migrant, from early August–early October, on coasts and at inland waters (Beqaa). Also, a rare non-breeding summer visitor in June–late July, mainly on Palm Islands. Reported from Aammiq, Beqaa Valley, Cheikh Zennad, Ghadir River, Joub Jannine, Litani River, Palm Islands and Saida. First recorded in 1975 by Van Dyck (Kumerloeve 1962).

*Charadrius alexandrinus* Kentish Plover: Rare to scarce passage migrant from early February–late May and early August–late December on coasts, estuaries and inland waters. Few non-breeders occasionally in June–July, mainly on coasts, Aammiq and Qaraoun Lake. Sighted at Aammiq, Cheikh Zennad, Damour, Jiyeh, Khaldeh, Qaraoun, Palm Islands and Tyre. First recorded in 1904 (Carruthers 1910).

*Charadrius leschenaultii* Greater Sand Plover: Rare passage migrant from March–late April and occasional late July–September on coasts, fishponds and on Palm Islands. Reported from Aammiq, Beirut, Byblos, Cheikh Zennad, Damour, Jiyeh, Khaldeh, Palm Islands, Tyre Coast and Naqoura. First recorded in 1877 by Van Dyck (Kumerloeve 1962).

*Charadrius asiaticus* Caspian Plover : Four records: one at Beirut on 21 March 1904 (Carruthers 1910), one at the mouth of the Damour River on 26 April 1975 (Macfarlane 1978), one at Cheikh Zennad, on 11 April 2002 (Ramadan-Jaradi et al 2004), and one there on 22 September 2002 (Ramadan-Jaradi & Waterbury unpub).

*Charadrius morinellus* Eurasian Dotterel: Scarce in late September–November and only one spring record, of three at Tyre on 17 March 1995 (Ramadan-Jaradi & Ramadan-Jaradi 1999). Most records from coasts and the Beqaa Valley. Very small numbers occasionally winter in January–February at Qaraoun lake and the Litani River. Sighted at Baalbek, Beirut, Beqaa Valley, Cheikh Zennad (Plate 2), Damour, Litani River, Qaa, Qaraoun and Tyre. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Scolopax rusticola* Eurasian Woodcock: Not uncommon and regular passage migrant and winter visitor in moderate numbers across most of the country, mainly in mid-October–mid-April, chiefly in the Beqaa area. Reported from Aammiq, Ain Zhalta, Beirut, Beirut River Valley, Beqaa Valley, Bzebdine, Byblos, Cheikh Zennad, Damour Valley, Ehden, Jabal Barouk, Jabal Rihane, Jezzine and Tyre Coast. First recorded by Carruthers in 1904 (Kumerloeve 1962).

*Lymnocryptes minimus* Jack Snipe: Rare passage migrant and scarce winter visitor from mid-October–late April, with most at Palm Islands, Qaraoun, Aammiq,

Cheikh Zennad and the Litani River. Perhaps more common than records suggest. First recorded by Van Dyck in 1873 - 1878 (Kumerloeve 1960a, 1962).

*Gallinago media (NT)* Great Snipe: Rare passage migrant mainly recorded in the Beqaa Valley (with most at Aammiq) and on Palm Islands, in mid-March–mid-May. Only four in autumn: one at Aammiq on 6 October 1956 (Kumerloeve 1962), one trapped at Aammiq on 14 September 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1999), one there on 11 October 2005 (A Rocha Lebanon 2006), and [one reported at Lake Qaraoun on 6 October 2006 – (see Balmer & Betton (2007a)]. Sighted at Aammiq, Beirut, Beqaa Valley, Faraya, Palm Islands, Qaraoun, and Tyre Coast. First recorded in 1881 by Van Dyck (Tristram in Kumerloeve 1962).

*Gallinago gallinago* Common Snipe: Uncommon but regular passage migrant and winter visitor from mid-August–mid May. Occurs over most of the country but favours the Aammiq area, Bishmezzine and Tyre Coast, principally in winter. Sighted at Aammiq, Beirut, Beqaa Valley, Bishmezzine, Cheikh Zennad, Damour, Jounieh, Khaldeh, Palm Islands, Ryaq and Tyre Coast. First recorded in 1904 (Carruthers 1910).

*Limosa limosa (NT)* Black-tailed Godwit: Scarce passage migrant during March-April and August-November. Four records at Aammiq: two on 17 March 1975 (Macfarlane 1978), one on 20 March 1997 (Busuttil et al 1997), [one on 15 September 2000 (Kirwan 2001)], and two on 11 October 2001 (Ramadan-Jaradi 2003). Six records at Cheikh Zennad in April, August–September and November with a maximum of five on 5 April 1997 (Bara 1998). One at Cheikh Zennad on 14 April 2000 (Ramadan-Jaradi 2003), one at Tel el Akhdar on 27 April 2005 (François Tron pers comm), and one there on 16 April 2006 (Colin Conroy pers comm). First recorded at Aammiq in 1975 (Macfarlane 1978).

*Limosa lapponica* Bar-tailed Godwit: Only four records: one at Cheikh Zennad on 12 May 1996 (Bara 1998), one at Aammiq on 5 May 2000 (Ramadan-Jaradi 2003), one there on 15 September 2000 (Beale & Sprenger 2001), and one at Tyre Coast on 14 October 2004 (Ramadan-Jaradi et al 2005).

*Numenius phaeopus* Whimbrel: Rare passage migrant in April and early August–mid-October on coasts and islands. Recorded at Beirut, Batroun, Cheikh Zennad, Nahr el Kalb, Naqoura, Ouzaii, Palm Islands, Sarafand and Tyre. First recorded in 1956 (Hollom 1959).

*Numenius arquata* Eurasian Curlew: Five records: one at Cheikh Zennad on 21 April 1996 and two there on 30 April 1996 (Bara 1998); three at Damour on 4 September 1996 (Ramadan-Jaradi & Ramadan-Jaradi (1999), one at Cheikh Zennad on 21 August 2005 (Colin Conroy pers comm) and [one at Naqoura on 10 October 2006 (see Balmer & Betton 2007a)].

*Tringa erythropus* Spotted Redshank: With 14 records, the Spotted Redshank is a scarce passage migrant rather than true vagrant. It occurred at Aammiq, Cheikh Zennad, Khaldeh and Nahr Beirut in March-April and August-September, with only one winter record at Cheikh Zennad on 19 January 2000 (Ramadan-Jaradi et al 2005). First recorded in 1975 (Macfarlane 1978).

*Tringa totanus* Common Redshank: Uncommon but regular passage migrant in March– April and commoner from early August–late December. Few overwinter at Cheikh Zennad and Palm Islands during January-February. Regular on Palm Islands and coasts, much less so at inland waters (Ramadan-Jaradi & Ramadan-Jaradi 1999). Sighted at Aammiq, Batroun, Beirut, Beqaa Valley, Bishmezzine, Byblos, Cheikh Zennad, Palm Islands, Qaraoun and Tyre. First recorded in 1904 (Carruthers 1910).

*Tringa stagnatilis* Marsh Sandpiper: Uncommon passage migrant in early March–late April and early August–late October at coasts, estuaries and Palm Islands; and scarce at inland waters, including Aammiq. One winter record: at Al Ain near Tyre on 12 December 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1999). Eleven records at Cheikh Zennad in April and August– November, with a maximum of 31 on 17 April 2006 (Colin Conroy pers comm). First recorded by Tohmé & Neuschwander (1974).

*Tringa nebularia* Common Greenshank: Relatively common passage migrant in March–April and late July–late October over much of the country. Very few in winter, from January–mid-February, in the Beqaa, principally at Qaraoun and the Litani River; and on the coast, principally at Cheikh Zennad and on Palm Islands. Sighted at Aammiq, Anjar, Beirut, Beqaa Valley, Cheikh Zennad, Damour, Litani River, Nahr Beirut, Naqoura, Palm Islands, Qaraoun, Tanayel and Tyre Coast. First recorded in 1877 by Van Dyck (Kumerloeve 1962).

*Tringa ochropus* Green Sandpiper: Fairly common passage migrant in late February– late June (most mid-March–mid-April) and late July–late October. Scarce winter visitor in November–February. Most at Cheikh Zennad, Palm Islands and at inland waters, including Aammiq; very few coastal records. Reported from Aammiq, Ain Zhalta, Beirut, Cheikh Zennad, Jabal Mazar, Joub Jannine, Laqlouq, Litani River, Palm Islands, Qaraoun and Tyre Coast. First recorded in 1877 by Van Dyck (Kumerloeve 1962).

*Tringa glareola* Wood Sandpiper: Fairly common passage migrant from mid-February–late May and late July–early November, on islands, coasts and inland wetlands. Sighted at Aammiq, Cheikh Zennad, Damour, Joub Jannine, Khaldeh, Litani, Palm Islands and Qaraoun. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Xenus cinerea* Terek Sandpiper: Five records from Cheikh Zennad area only: one on 18 August 1996 (Bara 1998), one on 22 September 2002 (Ramadan-Jaradi et al 2005), one on 6 September 2003 (Marc Almecija pers comm), and three on 7 and a single on 21 August 2005 (Colin Conroy pers comm). These records suggest that the Terek Sandpiper is a rare passage migrant rather than vagrant.

*Actitis hypoleucos* Common Sandpiper: Common passage migrant and scarce winter visitor. Recorded year-round at inland waters, coasts and on islands. Reported from Aammiq, Amyoun, Anjar, Batroun, Beirut, Cheikh Zennad, Damour, Enfeh, Jieh, Joub Jannine, Jounieh, Khaldeh, Litani, Palm Islands, Qaraoun, and Tabarja. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Arenaria interpres* Ruddy Turnstone: Scarce but regular passage migrant, mid-February-May and August-October, along the coast and at inland waters. Most at Cheikh Zennad, Palm Islands, Tyre Coast and Qaraoun Lake. Only one record from Aammiq on 2 May 2001 (GR-J). First recorded by Tohmé & Neuschwander (1974).

*Calidris canutus* Red Knot: Only one record: one at Khaldeh pool on 2 April 1955 (Navins in Kumerloeve 1962).

*Calidris alba* Sanderling: Five records: one at Beirut in late spring 1876 (Van Dyck in Kumerloeve 1962), four at Cheikh Zennad on 15 September 1996 and eight there on 29 September 1996 (Bara 1998), three at Cheikh Zennad on 22 September 2002, and six at Tyre Coast Nature Reserve on 6 October 2004 (Ramadan-Jaradi et al 2005).

*Calidris minuta* Little Stint: Common passage migrant in flocks of up to several 100s in early March–late May and early August–late October on coasts, islands, and wetlands throughout the country. Sighted at Aammiq, Beirut, Bwar, Cheikh Zennad, Ghadir River mouth, Joub Jannine, Khaldeh, Litani River, Naqoura, Palm Islands, Qaraoun and Tyre Coast. First recorded in 1882 by Van Dyck (Kumerloeve 1962).

*Calidris temminckii Temminck's Stint:* Scarce but regular passage migrant in late April– late May and mid-August–late October, mainly in Beqaa and to a lesser extent on coast, fishponds and estuaries. Reported from Aammiq, Beqaa Valley, Cheikh Zennad, Damour, Ghadir River mouth, Joub Jannine, Litani River, Naqoura, Palm Islands and Qaraoun Lake. First recorded by West (1954).

*Calidris ferruginea* Curlew Sandpiper: Scarce but regular passage migrant in late April– May and August–October on coasts and wetlands throughout Lebanon. Very small numbers oversummer in June–July on Palm Islands. Perhaps more common than observations suggest (Ramadan-Jaradi & Ramadan-Jaradi 1999). Sighted at Aammiq, Beirut, Cheikh Zennad, Qaraoun Lake and Palm Islands. First recorded by Ramadan-Jaradi & Ramadan-Jaradi (1999).

*Calidris alpina* Dunlin: Common passage migrant in August–mid-November and to a lesser extent April–May on coasts, islands and inland wetlands. Regularly recorded in December– February on Palm Islands and occasionally or locally in smaller numbers elsewhere. Reported from Aammiq, Beirut, Cheikh Zennad, Chwaifat, Enfeh, Khaldeh, Naqoura, Palm Islands, Qaraoun, Tanayel and Tyre Coast. First recorded in 1875 by Van Dyck (Kumerloeve 1962).

*Limicola falcinellus* Broad-billed Sandpiper: Scarce passage migrant. Recorded on 14 different dates between mid-April-late May and early August-early October 1996-2007, usually in small numbers varying between one and four, most at Cheikh Zennad, with a maximum of 18 there on 1 September 1996 (Bara 1998) and to a lesser extent at Qaraoun, Palm Islands and Yammouneh (G Ramadan-Jaradi in prep). First recorded in 1964 (Benson 1970).

*Philomachus pugnax* Ruff: Common to abundant passage migrant in mid-February– late May (chiefly March-April) and early August–mid-November (chiefly September), principally in the Beqaa Valley, coast and estuaries. Scarce winter visitor, in late November–mid February, mainly to Cheikh Zennad and Palm Islands. Very small numbers oversummer at Cheikh Zennad in June – July (Bara in Ramadan - Jaradi & Ramadan - Jaradi 1999). Reported from Aammiq, Beirut, Beqaa Valley, Cheikh Zennad, Damour, Naqoura, Palm Islands, Qaraoun and Tyre Coast. First recorded in 1878 by Van Dyck (Kumerloeve 1962).

*Phalaropus lobatus* Red-necked Phalarope: Six records, none in breeding plumage: one juvenile on the coast near Zahrani on 3 August 1996 (Ramadan-Jaradi & Ramadan-Jaradi, 1999), one presumed adult at Palm Islands Nature Reserve on 17 August 2000 (Ramadan-Jaradi 2003), single juvenile at Cheikh Zennad on 22 July 2001 seen and photographed by Nidal Issa (pers comm), two juveniles there on 22 September 2002 (Ramadan-Jaradi & Waterbury unpub), one adult near Aana, south of Aammiq on 2 October 2003 (GR-J), and one at Cheikh Zennad on 21 September 2003 (Marc Almecija pers comm). These records suggest that the Red-necked Phalarope is probably a rare passage migrant rather than vagrant (G Ramadan-Jaradi in prep).

*Glareola pratincola* Collared Pratincole: Uncommon passage migrant in April–May and mid-August–early November, mostly on coasts and islands. Reported from Aammiq, Beirut, Cheikh Zennad, Chwaifat and Palm Islands. First recorded in 1875 by Van Dyck (Kumerloeve 1962).

*Glareola nordmanni (NT)* Black-winged Pratincole: Uncommon to rare passage migrant in April–May and mid-September–early October on islands, coasts, low montane areas (Dalhoun) and at Aammiq (Ramadan-Jaradi 1999). All subsequent records fall within the above periods. Sighted at Aammiq, Cheikh Zennad, Dalhoun, Palm Islands and Saida. First recorded in 1969 (Benson 1970).

### 11.5. Species of Gulls and Terns that may be subject for monitoring

*Larus hemprichii* Sooty Gull: One record: one near Tyre on 22 October 1958 (Flach 1959).

*Larus canus* Common Gull: Scarce passage migrant in March and early November– mid-December, and widespread and common winter visitor in December–late February, with small numbers over summering in June–July off Tripoli. Sighted at Beirut, Palm Islands, Tripoli, Tyre and Naqoura. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Larus audouinii* (NT) Audouin's Gull: Bred on Palm island in 1895 (Stenhouse 1904); 18 there but apparently not breeding on 3 April 1973 (Tohmé & Neuschwander 1974); seven more records at the same place: ten on 23 August 1997 (Ramadan-Jaradi & Ramadan-Jaradi 1999), one on 1, 4 and 25 April 1998 and one on 6 July 2000 (Ramadan-Jaradi & Ramadan-Jaradi 2001); three on 4 April 2002 and four on 11 August 2004 (GR-J). Elsewhere: three off Beirut on 3 October 1958 (Flach 1959), five at Cheikh Zennad on 25 August 1996 (Bara 1998), six there on 5 April 2002 and 14 on 1 September 2003 (Ramadan-Jaradi 2003). These records above suggest that the Audouin's Gull is a rare passage migrant rather than vagrant.

*Larus marinus* Great Black-backed Gull: Extremely rare passage migrant and winter visitor. The first part of Benson's (1970) statement that "a few are seen offshore here in most seasons, chiefly immature birds in autumn and winter" appears unlikely given the pattern of records elsewhere in this part of the Middle East. Singles off Antelias on 7 April and 12 December 1995, off Beirut on 15 March 1996, on Palm Islands on 5 May 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1999) and 14 at Cheikh Zennad on 22 September 2002 (Ramadan-Jaradi & Waterbury unpub). First recorded by Schrader (1892).

*Larus michahellis* Yellow-legged Gull: Resident breeder (eggs mid-April, except for 2007 when first chicks hatched on 12 April) in fair numbers on Palm Islands (see Ramadan-Jaradi & Ramadan-Jaradi 1997, 1999, 2001). Fairly common passage migrant in March–mid-May and mid-August–early November; a relatively common winter visitor in mid-November–late February, and not uncommon non-breeding summer visitor in May–July. Occasional at inland wetlands. First recorded by Tristram (1864) and first breeding record was on Palm Islands in 1956 (Hollom 1959). Recently breeding was reconfirmed (for over 36 years) at Palm Islands in 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1997, 1999, 2001).

*Larus armenicus* Armenian Gull: Four records: four at Tyre on 11 October 1996 (Ramadan-Jaradi & Ramadan-Jaradi 1999), eight at Cheikh Zennad on 22 March 1997 with one there on 5 April 1997 (Bara 1998) and [significant numbers were reported from Qaraoun Lake on 25 January 2001 - see Balmer & Betton (2001)].

*Larus cachinnans* Caspian Gull: One recorded at el Mina/Tripoli on 9 November 2004 (Nidal Issa pers comm), [a few adults and immature at Cheikh Zennad on 30 January 1998 were thought to be this taxon (TB)], and one adult observed and photographed at Palm Islands on 25 January 2008, following an intensive search since 13 January. The latter showed whiter spots on the black wing tip than the Yellow-legged Gull L. michahellis, paler grey upperparts, more flattened front, pinkish legs and black eyes (GR-J). Prior to the elevation of the Caspian Gull to the rank of species, most birders were not applying the ID criteria for the two forms. Nevertheless, few past photographs showed Caspian Gull characters clearly enough. Future observations will doubtless confirm the status of this species.

*Larus fuscus* Lesser Black-backed Gull: Abundant passage migrant (only ssp fuscus) in early March–late May and mid-August–early November, and common winter visitor in mid-November–mid-March along coasts and offshore. (Ramadan-Jaradi & Ramadan-Jaradi 1999). Vagrant at Aammiq wetland (Beale & Sprenger 2001). Very small numbers regularly over summer in coastal areas, particularly at Palm Islands. Reported from Aammiq, Beirut, Bwar, Byblos, Cheikh Zennad, Damour, Jiyeh, Jounieh, Nahr el Kalb mouth, Nahr Ibrahim mouth and Palm Islands. First recorded in 1824 (Hemprich & Ehrenberg (1833).

*Larus heuglini* Heuglin's Gull: Two records: two at Tripoli on 2 April 2001 (Marc Almecija pers comm) and one at the mouth of Beirut River on 6 January 2004 (Thierry Bara). Being insufficiently documented so far by the observers, this hard-to-identify species will necessarily be another candidate for the LBRC].

*Larus ichthyaetus* Great Black-headed Gull: Recently several records during October-April indicate that the Great Black-headed Gull is a scarce to uncommon passage migrant and winter visitor. Previously, it was considered vagrant with only five records (Ramadan-Jaradi & Ramadan-Jaradi 1999). Reported from Aammiq, Bellan Islet, Cheikh Zennad, Palm Islands, Qaraoun Lake, Ras Beirut, Ras el Chekaa, Saida, Tel el Akhdar, Tripoli and Tyre. First recorded in 1975 (Macfarlane 1978).

*Larus ridibundus* Common Black-headed Gull: Abundant passage migrant and winter visitor from August–late

April with peaks in November–December when flocks of several 100s are present. Recorded on islands, coasts, fishponds, estuaries and irregularly at inland waters where usually less than ten at one site. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Larus genei* Slender-billed Gull: Irregular spring passage migrant and winter visitor. Benson (1970) and Ramadan-Jaradi& Ramadan-Jaradi (1999) list few records. Recently: five offshore Tyre Coast on 11 April 2005 (GR-J) and four flew north past Tripoli on 3 Mar 2006 (Richard Prior pers comm). First recorded by Tristram (1864).

*Larus melanocephalus* Mediterranean Gull: Scarce and irregular passage migrant and winter visitor. Not uncommon offshore in autumn and winter (Benson 1970); recorded on seven dates in January (Nevins 1960, Macfarlane 1978), seven in February and five in March (Macfarlane (1978); two in December (Macfarlane 1978, [Balmer & Betton 2006]) and one record of two on 10 April 1997 (Busuttil et al 1998a). All observations are from Beirut. First recorded by Schrader (1892). The lack of records since 1997 is noteworthy, given its continuing presence in Cyprus waters. Has the reduction in sediment deposition in the Nile delta caused a long-term shortage of food for seabirds in the south-eastern Mediterranean?

*Larus minutus* Little Gull: Uncommon passage migrant September-November and March-mid-May with peaks up to 65 in April (GR-J), principally at Cheikh Zennad; and common winter visitor December-February, with peaks up to 100 in January (GR-J), on islands, coasts, estuaries and to a lesser extent at inland waters (Qaraoun and Yammouneh). Sighted at Aammiq, Beirut, Cheikh Zennad, Damour, Khaldeh, Palm Islands, Qaraoun, Qleiaat, Saida and Yammouneh. First recorded by Van Dyck in 1873-1878 (Kumerloeve 1960a, 1962).

*Rissa tridactyla* Black-legged Kittiwake: Recorded only from Ras Beirut: records in January (three), November (five) and December (eight) in 1974-1975 (Macfarlane 1978), and at Palm Islands Reserve on 15 February 1998 (Ramadan-Jaradi & Ramadan-Jaradi 1999).

*Gelochelidon nilotica* Gull-billed Tern: Tristram's late 19th century report that the species was found on sandspits and lagoons near Tyre and Beirut cannot be confirmed (see Kumerloeve 1962). With only two records at Qaraoun and Cheikh Zennad in 1996-97 (Bara 1998), the Gull-billed Tern was considered a vagrant (Ramadan-Jaradi &Ramadan-Jaradi (1999). Recently, four additional records suggest that the species is a rare passage migrant rather than vagrant: three among tern flocks at Mina/ Tripoli, on 14 January 2000, 11 at Cheikh Zennad on 31 March, with 13 there on 2 April 2001 (Marc Almecija pers comm); and two at Lake Qaraoun on 4 August 2005 (Colin Conroy pers comm).

*Thalasseus bengalensis* Lesser Crested Tern: Bred on Palm island in 1895 (Stenhouse 1904).

No subsequent records (Ramadan-Jaradi & Ramadan-Jaradi 1999).

*Thalasseus sandvicensis* Sandwich Tern: Extremely rare passage migrant and winter visitor in early August-mid-April to coasts (Ramadan-Jaradi & Ramadan-Jaradi 1999) and Palm Islands (Ramadan - Jaradi & Ramadan-Jaradi 2001). Sighted at Beirut, Byblos, Cheikh Zennad, Damour and Palm Islands. First recorded in 1878 by Van Dyck (Kumerloeve 1962).

*Sterna hirundo* Common Tern: Formerly bred on Palm Islands (Stenhouse 1904) but considered a vagrant by Cramp (1985). Presently, common passage migrant in early April–late May and early August–early October, on coasts and islands; only one early record – 21 February 1998 (see Ramadan-Jaradi & Ramadan-Jaradi 1999). Observed at Abdeh, Beirut, Cheikh Zennad, Jounieh, Khaldeh, Palm Islands, Tripoli and Naqoura. First recorded by Schrader (1892).

*Sternula albifrons* Little Tern: Bred on Palm Islands at the end of the 19th century (Stenhouse 1904) but no subsequent records until 11 at Cheikh Zennad on 14 June 1996, three there on 8 September 1996 and eight on 16 May 1997 (TB), one at Sanani island on 4 April 1998 (Ramadan-Jaradi & Ramadan-Jaradi 1999) and two at Qaraoun Lake on 27 September 2003 (GR-J). All these records suggest that the Little Tern is a very rare passage migrant rather than vagrant. First recorded in 1877 by Van Dyck (Kumerloeve 1962).

*Chlidonias hybrida* Whiskered Tern: Bred in 1995 and 1996 in a flood plain at Assi River (Ramadan-Jaradi & Ramadan-Jaradi 1997, 1999). Scarce on passage in April–mid-May and early August–late September at inland waters, on coasts and islands. Sighted at Aammiq, Assi River, Beirut, Bishmezzine, Palm Islands, Tanayel and Tyre Coast. First recorded by Tohmé & Neuschwander (1974) and the first breeding confirmed at the Assi River in 1995 (Ramadan-Jaradi & Ramadan-Jaradi 1997).

*Chlidonias leucopterus* White-winged Tern: Not uncommon passage migrant in mid-March–mid-May and early August–late October at inland and coastal waters (Ramadan-Jaradi & Ramadan-Jaradi 1999). Reported from Aammiq, Cheikh Zennad, Khaldeh, Nahr el Kalb, Naqoura,Palm Islands, Qaraoun, Kassimyeh, Tanayel and Yammouneh. First recorded in 1904 by Carruthers (Kumerloeve 1962).

*Chlidonias niger* Black Tern: Between 1974 and 1998, there were eight records (Ramadan-Jaradi & Rama-

dan-Jaradi 1999). Recently, five records: one at Ras Beirut on 2 September 2001, three at Khaldeh on 11 August and one there on 2 October 2003, one at Bishmezzine on 3 April and singles at Naqoura on 9 September 2005 (GR-J). More recently, one at Aammiq on 25 April 2007 (Colin Conroy pers comm). Together, these records suggest a rare passage migrant, early August-mid October and April, rather than a vagrant species. Reported from Aammiq, Beirut, Bishmezzine, Cheikh Zennad, Khaldeh, Naqoura and Qaraoun. First recorded in 1974 (Macfarlane 1978).

*Stercorarius pomarinus* Pomarine Skua: Twenty records: twelve records at Ras Beirut in February, August–September and December 1974-1976 (Macfarlane 1978), one or two off Beirut on 10 April (Kirwan 1997), six there during 8–11 April 1997 (Busuttil & Flumm 1998a), one single at El Mina/Tripoli on 14 January 2000 (Marc Almecija pers comm), one off Palm Islands on 20 February 2001 and one off Beirut on 17 April 2001 (Ramadan-Jaradi & Ramadan-Jaradi 2002); and one single over Palm Islands on 11 May 2001 (Ramadan-Jaradi & Sandwith unpub). All these records show that the species is a scarce passage migrant and rare winter visitor rather than a vagrant (see Ramadan-Jaradi & Ramadan-Jaradi 1999). First recorded in 1974 (Macfarlane 1978).

*Stercorarius parasiticus* Arctic Skua: Recorded off Ras Beirut and Tripoli on 11 May, 21–28 August and 6 September 1974, 1975 (Macfarlane 1978), four at Ras Beirut on 10 April 1997 (Busuttil & Flumm 1998a), four birds off Ras Beirut during 8–11 April 1997 were either this species or Pomarine Skua (Ramadan-Jaradi & Ramadan-Jaradi 1999), one on Palm Islands on 21 February 1998 (Bara 1998), one was harassing gulls off Ras Beirut on 5 and 28 December 2005, and one was at Tripoli on 3 March 2006 (Richard Prior pers comm) and 11 above el Mina/Tripoli harbour on 30 January 2008 (GR-J), one off Ras Beirut on 27 December 2005 (Colin Conroy pers comm). With these records, the species is a rare passage migrant and rare winter visitor rather than vagrant (see Ramadan-Jaradi & Ramadan-Jaradi 1999). First recorded in 1974 (Macfarlane 1978).

## References


Boersma, P.D., J.A. Clark y N. Hillgarth. 2002. Seabird conservation. En:Schreiber, E.A. y J.

Burger (Eds.): Biology of marine birds, pp. 559-579. CRC Press, New York.

CopeMed II. 2011. Report of the Working Group on Small Pelagic Fisheries Management in the Alboran Sea under the Ecosystem Approach to Fisheries.

Croxall, J., Rothery, P., 1991. Population regulation of seabirds: implications of their demography for conservation. In: Perrins, C.M., Lebreton, J.D., Hirons, G.M. (Eds.), Bird Population Studies, Relevance to Conservation and Management. Oxford University Press, Oxford, UK

Croxall, J.P., S.H.M. Butchart, B. Lascelles, A.J. Stattersfield, B. Sullivan, A. Symes y P. Taylor. 2012. Seabird conservation status, threats and priority actions: a global assessment. Bird Conservation International, 22: 1-34.

Cury et al. 2011. De Juana, E., J. Varela y H.H. Witt. 1984. The conservation of seabirds at the Chafarinas Islands. En: Croxall, J.P., Evans, P.G., & Schreiber, R.W. (eds). Status and conservation of the world's seabirds. pp. 363-370.

García-Barcelona, S., D. Macías, J.M. Ortiz de Urbina, A. Estrada, R. Leal & J.C. Báez. 2010a.

García-Barcelona, S., J.M. Ortiz de Urbina, J.M. de la Serna, E. Alot y D. Macías. 2010b. Seabird bycatch in Spanish Mediterranean large pelagic longline fisherie, 2000-2008. Aquatic Living Resources, 57: 65-78.

García-Barcelona, S., J. Fregenal, M.D. Santaella y L. Aleixos Alapont. 2010c. Resultados de las ICAOS en Málaga 2007-2010. VII Congreso del Grupo Ibérico de Aves Marinas, Santurtzi, Bizkaia, 30 y 31 de Octubre y 1 de Noviembre de 2010.

Lewison, R., D. Oro, B. Godley, L. Underhill, S. Bearhop, R.P. Wilson, D. Ainley, J.M. Arcos, P.D. Boersma, P.G. Borboroglu, T. Boulinier, M. Frederiksen, M. Genovart, J. González-Solís, J. A. Green, D. Grémillet, K. C. Hamer, G.M. Hilton, K. D. Hyrenbach, A. Martínez-Abraín, W. A. Montevecchi, R. A. Phillips, P. G. Ryan, P. Sagar, W. J. Sydeman, P. Yorio, S. Wanless,Y. Watanuki, y H. Weimerskirch. 2012. Research priorities for seabirds: Improving seabird conservation and management in the 21st century. Endangered Species Research 17: 93-121.

Louzao, M., J.M. Igual, M. McMinn, J.S. Aguilar, R. Triay y D. Oro. 2006a. Small pelagic fish, trawling discards and breeding performance of the critically endangered Balearic shearwater: improving conservation diagnosis. Marine Ecology Progress Series, 318: 247-254.

Louzao, M., K. Delord, D. García, A. Boué y H. Weimerskirch. 2012. Protecting Persistent Dynamic Oceanographic Features: Transboundary conservation efforts Are Needed for the Critically Endangered Balearic Shearwater. PLoS One 7 (5): e35728.

Ramadan Jradi ,G. Ramadan Jaradi ,M. (2001).- The Avifauna of Palm Islands Reserve Lebanon 1893 to 2000. Lebanese Science Journal. Vol. 2, No.1, 2001:17- 35.

Ramadan Jaradi, G., Bitar, G., Halwani, J., Sabbagh, H. (2001). Impact of management activities on birds, fishes, plants and water quality on Palm Islands Reserve., UNESCO CAIRO OFFICE, pp: 1- 69.

Ramadan Jaradi, G., M. Haber, R. Sadek and I. Saoud 2007. Biodiversity Assessment and Monitoring in the Palm Island Nature Reserve. AUB, MOE. IUCN.

Ramadan Jaradi, G. & Bara, T. and Ramadan Jaradi, M. (2008) Revised checklist of the birds of Lebanon 1999-2007. Sandgrouse 30 (1): 22-69.

Ramadan Jaradi, G., Bara, T. (2008) First confirmed breeding record of Spur-winged Lapwing Vanellus spinosus for Lebanon. Sandgrouse 30 (2).

Ramadan Jaradi Ghassan (2010). Rehabilitation of Economic Functions of War-damaged Palm Islands Nature Reserve (PINR) Lebanon. Obtained on 20/12/2010 the Prize of KSA for the best environmental management in Arab countries that was organized by the Arab League States.

Ramadan-Jaradi, Ghassan. 2017. Status and distribution of migrating and breeding Marine birds in North Lebanon. Lebanese Science Journal. Vol. 18, No. 2: 156-165.

Weimerskirch, H. 2002. Seabird demography and its relationship with the marine environment. En Schreiber, E.A. y J. Burger (Eds.): Biology of Marine Birds, pp. 115-135.

UNEP/MAP - RAC/SPA, 2012. Guidelines for Management and Monitoring Threatened Population of Marine and Coastal Bird Species and their Important Areas in the Mediterranean. By Joe Sultana. Ed. RAC/SPA, Tunis. 24pp.

UNEP-MAP-RAC/SPA. 2014. Status of Seabirds in the Alboran Sea. By J.M.Arcos. Draft internal report for the purposes of the Mediterranean Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, Malaga, Spain, 7-11 April 2014.

UNEP-MAP-RAC/SPA, 2017. Monitoring marine and coastal birds in Palm Islands Nature Reserve (SPAMI/2012) and its surroundings; by: [Ghassan RAMADAN/JARADI/PINRC, MOU no48 SPA/RAC_2016, SPA/RAC, Tunis, 27 pp.

*Caretta caretta* © SPA/RAC

# V. National Monitoring Programme for marine turtles

## 1. INTRODUCTION AND HISTORICAL BACKGROUND OF WORK DONE IN LEBANON

The two most studied marine turtle species of the Mediterranean are the loggerhead turtle *Caretta caretta* and the green turtle *Chelonia mydas*. The females of these two species frequent the sandy beaches of the eastern coast of the Mediterranean in order to lay their eggs. Their presence in the Lebanon was reported by Hraoui-Bloquet, S. 1981. These two species have been classified as being threatened and in danger of extinction. They are listed in Annex II of the SPA/BD Protocol (pertaining to specially protected areas and biological diversity in the Mediterranean) as well as on the IUCN red list. *Caretta caretta* is quite frequent in the Mediterranean whereas the *Chelonia mydas* is rare. The leatherback sea turtle Dermochelys coriacea which is occasionally found in deep waters of the Mediterranean, is sometimes captured in fishermen's nets in Lebanon. It is also threatened and in danger of extinction. It is on IUCN's red list. A fourth sea turtle species was found in the Mediterranean in Southern Lebanon in 2014, in the Tyre region (Sidon), and that is the Lepidochelys olivacea. It too is on the IUCN red list. The presence of this Atlantic species was first reported in the Eastern Mediterranean (Revuelta, O., et al., 2016). The hawksbill turtle *Eretmochelys imbricata* is exceptionally seen in the Mediterranean. A sixth sea turtle species whose presence is also exceptional was reported in the Mediterranean and that is the Kamp turtle Lepidochelys kampii. These last two species have so far not been spotted in Lebanon's territorial waters.

The first study in Lebanon on these marine reptiles (sea turtles) was carried out in 1998. This 3-year study project was financed by the Lebanese CNRS from 1998 to 2001. The results from this study led to some publications and reports (Hraoui-Bloquet, et al., 1998; Hraoui-Bloquet and Sadek, 2001; Demirayak, et al., 2002; Hraoui-Bloquet, and Sadek, 2003; Tohmé et al., 1999 a,b,c and Tohmé, et al., 2004). The study focused on the coastal observations in order to determine the state of the Lebanese coast and the beaches frequented by the females of C. Caretta and C. Mydas who came there to lay their eggs.

The observations were made all along the Lebanese coast, from Nakoura, the coastal area in the far south of Lebanon until the river in the north of Lebanon (Nahr Al Kébir Al Jénouby) on the Syrian border. Figure 1 represents the map of Lebanon and indicates the sandy beaches which were studied. The unused sandy beaches which remain along the coast are very rare. The most important and best-preserved ones are in southern Lebanon.

Table 1: Sea turtles observed in Lebanese territorial waters and their frequency.

| Species | *Caretta caretta* | *Chelonia mydas* | *Dermochelys coriacea* | *Lepidochelys Olivacea* |
|---|---|---|---|---|
| Place where spotted or captured | All along the Lebanese coast | South and North | South and North | South (Near Tyre) |
| Frequency | +++ | + + | + | Only 1 specimen was caught |

Signs: +++ (frequent); ++ (average frequency); + (rare)

Beaches to the north of Tripoli are highly polluted and the sand is encrusted with solid waste which has been rejected by the sea thus forming several layers which have become covered with sand in the course of the years (plastic bags, metal cans, glass bottles, pieces of wood, shoes, clothes and other solid waste objects) so that these beaches are not usable and unfit for the nesting of sea turtles. The sandy beaches most frequented by the females who come to lay their eggs between May and August are those of the region in the South where the females of the two species (*Caretta caretta* and *Chelonia mydas*) come to lay their eggs. *C. Mydas* frequents only the sandy coast of Al Mansoury-Al Kleily (to the south of the town of Tyre).

The females of *C. caretta* lay their eggs on the same beach and on all the other sandy beaches which are not used for touristic and urban purposes and which are not seriously polluted. The sandy coast of the « Palms islands » in the North of Lebanon (Natural Reserve) located offshore from Tripoli is frequented only by the females of *C. Caretta*. Unfortunately, part of this coast is unstable and often damaged by the waves (Ramadan Jaradi, et al., 2006). During the egg laying period of the *Caretta caretta* turtles, often the nests present in this part of the isle are damaged and their contents swept away by the waves.

Law no.121/92 designated the Islands in the North of Lebanon (Palms islands) as a « Natural Reserve », signed on 9 March 1992 by the Ministry of Agriculture. The sandy beach to the north of the town of Tyre has been declared a « Natural Reserve » protected by Law no.708/98, signed the 5 November 1998 by the Ministry of Agricul-

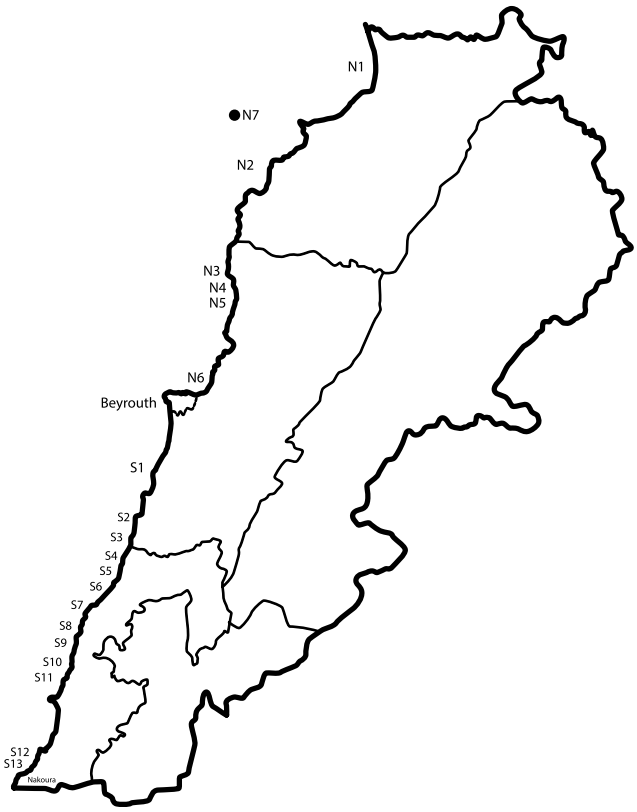


Figure 1: Map of Lebanon. The beaches are indicated by the letters S (South) or N (North) followed by a figure. N1 (Cheik Zennad); N2 (Anfé); N3 (Amchit); N4 (Jbeil); N5 (Al Aaqaiby); N6 (Bourj Hammoud); N7 (Palm islands ); S1 (Damour); S2 (Jeiyé); S3 (Rmailé); S4 (Saida); S5 (Ras El Aïn); S6 (Al Aaboudié); S7 (Adloun); S8 (Al Mahmoudieh); S9 (Al Yahoudieh); S10 (Al Bourglieh or Qasmieh); S11 (al Abassieh); S12 (Al Mansoury); S13 (Al Kleily) in the Tyre region.

ture (MoA). This latter Reserve is used for touristic purposes so much that no sea turtle nests have been seen during our observations from 1998 until 2001.

### Data on marine turtles in Lebanon is still not available:

Turtles at sea have never really been studied in Lebanon. We do have some discontinuous data on their presence in some regions and during specific periods of the year in the Mediterranean Sea of Lebanon. *Caretta caretta* has always been observed in the sea near the port of Beirut (data communicated through observations made when the vessel CANA went out to sea and which carried out studies on marine fauna). We also received other data from the team which studied the birds when out at sea using the boat of the "Palms islands" reserve. They recorded the presence of some individuals of *Chelonia mydas* especially in the winter near the "Palms islands". Finally, we received other observations from divers who were specialists of marine ecosystems (such as Dr Ghazi Bitar) who reported having seen the *Chelonia mydas* marine turtle in the Tyre region. We also have data from the bathers and fishermen who were active along the Lebanese coast.

## 2. CONSERVATION STATUS: CONVENTIONS AND PROTECTION LAWS TO PROTECT THE SEAS AND THE OCEANS

As for marine reptiles or marine turtles, there is international interest for their protection in the seas and the oceans as well as for the females who come to lay their eggs on the sandy beaches as well as for the newly hatched turtles and the protection of the nests. As a signatory of the Barcelona Convention and other relevant conventions and agreements (such as the CBD), Lebanon has the obligation and responsibility for participating in a proactive collection of knowledge for the protection and monitoring of the management and protection of this particular group.

### The following conventions and laws protect marine turtles:

(13) The Convention on Biological Diversity (CBD), signed by the GoL in 1992 and ratified on 11/8/1994 by law no. 360.

(14) The Washington Convention (CITES) (Convention on International Trade in Endangered Species) of Wild Flora and Fauna, 1973 which protects threatened species. This convention imposes the protection of marine turtles, mentioned in annex (I). It has not been adopted.

(15) The Mediterranean Action Plan law, (UNEP) 1975. It was signed and ratified by the Lebanese government.

(16) The Decision of the Ministry of Agriculture (MoA) of Lebanon corresponds to no. 125/1 of 23/9/1999 which forbids the fishing for marine turtles, monk seals and whales as well as the sale, utilisation or trading with any of the products derived from the species mentioned.

(17) The UN Convention on the Law of the Sea was signed and ratified in 1995 by the MoA.

(18) Lebanon signed the 1976 Barcelona Convention and its protocols which in Articles 8 and 12 of the Protocol provides for the protection of the Mediterranean sea against pollution from land-based sources and activities and Article 4 of the Protocol pertaining to cooperation for the prevention of pollution by vessels and, in case of a critical situation in combatting pollution in the Mediterranean sea, Articles 3, 15 and 20 of the Protocol concerning the specially protected areas (for Lebanon the 2 coastal protected areas are: the sandy beach of the town of Tyre - Law no. 708/98 declaring the Tyre coast as a Natural Reserve, signed on 5 November 1998 by the MoA and Law no.121/92 declaring the islands of the North (Palms islands ) off the coast of Tripoli as a Natural Reserve signed on 9 March 1992 by the MoA.

(19) The 1979 Bonn Convention. Convention of Migratory Species (CMS); the protection of migratory species at sea (protection of 6 sea turtles of the Mediterranean *C. mydas, C. caretta, Dermochelys coreacia, Eretmochelys imbricata, Lepidochelys kempii* and *Lepidochelys olivacea*). It has not been signed by the Lebanese government.

## 3. MARINE TURTLES OF LEBANON

In Lebanon, as elsewhere in the Mediterranean, the sea turtle populations are threatened by the loss of nesting habitats due to the extraction of sand, associated coastal erosion, urban sprawl and poorly planned touristic development. In the marine environment the interactions with fisheries causes mortality in the population of marine reptiles. Sea turtles captured accidentally in the fishing gears are abandoned on the beaches if they are dead or else sold on the fishing display counter.

The 220 km long Lebanese coast at present has very rare sandy beaches (20 percent). The females of *Caretta caretta* and *Chelonia mydas* frequent some of these beaches to lay their eggs. The best studied egg laying sites of the females of these 2 species and which we have chosen for our observations, are the beaches to the south and to the north of the town of Tyre and the sandy coast of the "Palm islands" to the north. But all the sandy beaches were inspected during the summer of 2001 to study their potentiality and the presence of turtle nests on these beaches.

### 3.1. *Caretta caretta*

This sea turtle is a carnivorous species. It feeds on crustaceans, fish, jellyfish etc...

#### 3.1.1. Former Distribution

We do not have old data (prior to 1997) on the egg laying sites of the loggerhead turtle *Caretta caretta* on Lebanon's coast or its movements at sea.

#### 3.1.2. Present population distribution area along the Lebanese coast

As pointed out above, only 20 percent of the Lebanese coast has sandy beaches. The rest of the coast is mostly rocky with sometimes pebble beaches (Demirayak, et al., 2002).

The nests of *Caretta caretta* females have been observed or reported on sandy beaches of the Lebanese coast from the south right up to the north. Some females sometimes lay their eggs in nests dug out on very small beaches or on what is left of some of the beaches which are being used.

The beaches on which the nests were observed as those of Al Kleily, Al Mansoury, Al Abassieh, Al Bourglieh (Qasmieh), Al Adoussieh, Adloun, Al Aaboudié, Palm islands. Fishermen and people frequenting the beaches have confirmed the nestings on the following coasts: Al Yahoudieh , Al Mahmoudieh, Ras El Ain, Saida, Rmailé, Jeiyé, Damour, Bourj Hammoud, Al Aaqaiby , Jbeil, Amchit, Anfé, Cheik Zennad (Figure 1).

The Tyre Natural Reserve in the south and the Al Herry coast could be very good beaches for egg laying by female sea turtles if they were not being exploited for touristic purposes.

The Ousaii sandy coast to the south of Beirut which had been frequented by sea turtles has disappeared due to the expansion of the Beirut international airport and the opening of highways.

It should be pointed out that the beaches to the north of Tripoli up to the sandy coast of Cheikh Zennad seem to be frequented by the female sea turtles, these sites

are close to the Syrian border and are unsuitable for the reproduction of the *Caretta caretta* females because they are polluted by solid waste stuck in the sand. These coastlines, furthermore, are just not wide enough and unsuitable for egg laying by the female sea turtles.

### 3.1.3. Study areas of Caretta caretta on the Lebanese coast and changes in the number of nests (abundance)

Regular monitoring of the egg laying sites of *Caretta caretta* make it possible to obtain the exact number of nests per reproduction season and the variation of this number in the course of several successive years. Unfortunately this monitoring is done only for some rare egg laying sites of this species in the Lebanon such as the Natural Reserve of the Palm islands ; the Natural Reserve of the beach to the north of the town of Tyre as well as the sandy beaches of Al Abassieh, Al Adoussieh, Al Mansoury and Al Kleily.

- The Palm islands Reserve: the sandy coast of the island is situated to the East. The central part of this beach is very narrow and unstable with continuous changes taking place due to erosion (Hrauoi-Bloquet, et al., 1998; Ramadan Jaradi, et al., 2007). The nests of *Caretta caretta* which are in this part of the area are often destroyed by waves and their contents swept away into the sea. Monitoring of the egg laying of the *Caretta caretta* females since 1997 until 2000 was not done regularly and every day by the team members of this reserve and according to them, the number of *Caretta caretta* nests increased from 3 nests in 1997 to 36 in 2000. This data was published by Kasparek in 2004. During our monitoring in 1998 and in 1999, the number of *Caretta caretta* nests varied from 8 to15. The length of this beach is only 200 meters.
- The Tyre Coast Nature Reserve: the monitoring was done by the "TCNR" group for two successive years for the 2004 and 2005 reproduction season. According to their observations, the number of nests increased from 0 to 9.
- According to our observations in 2000 and in 2001, we have not observed any marine turtle nests on the beach of this Natural Reserve. Furthermore, the sandy coast of this Natural Reserve is a beach stretching over 4,5 km and its width varies between 50 to 100 m. The sandy dunes of this coast have disappeared due to successive development works of the beach for touristic purposes.
- The sandy beaches of Al Abassieh and Al Adoussieh: They are to the north of the town of Tyre. In 2000 we observed two nests and in 2001 four nests of *Caretta caretta*. Even though the beach is quite extensive measuring 2,5 km long and quite wide (40 to 60 m), and it is not exploited for touristic purposes, there are very few *Caretta caretta* females who frequent this beach during the reproduction season (Demirayak, et al., 2002; Hraoui-Bloquet and Ryiad Sadek, 2003). But we have seen dead *Caretta caretta* turtles decomposing on the beach. The monitoring carried out by the TCNR group between 2002 and 2005 shows that the number of nests has increased, from 4 in 2002 to 10 nests in 2005. This data has been published by Newuburry et al., 2002 and Cross & Bell, 2006.
- The sandy coasts of Al Mansoury and of Al Kleily: They are the last sandy beaches of the Lebanese coast before the border with Israel which are frequented by the C. Caretta and C. mydas female turtles during the reproduction season. They are confined by agricultural land areas (orange groves, lemon trees, avocado trees, banana trees….). In 2001 we observed 15 nests of *Caretta caretta* on this beach (Demirayak, et al., 2002). The results of the observations and studies carried out by the MEDASET group between 2002 and 2006 have shown that the number of nests for the coasts of Al Mansoury and Al Kleily (beaches of 2 Km long and 23 to 60 m wide) increased from 33 to 67. The results of this study have been published by St John et al., 2004).

### 3.1.4. Distribution at sea of *Caretta caretta*

The distribution at sea of the young, juveniles, sub-adults and adults has not been studied. We have very rare data on the presence of this species at sea which has been reported by fishermen. This species is seen at sea from the south to the north of Lebanon. It is sometimes captured in the nets of the Lebanese fishermen. It is necessary to know the areas of its presence at sea and to determine the areas of reproduction, hibernation, feeding etc.

N.B.: In the Tyre region a *Caretta caretta* turtle is monitored via a telemetric device since 2012 by the TCNR group with SPA/RAC. This turtle stayed close to the Tyre coast during the seven months of the monitoring period by using a relatively small area of less than 50 km² (figure 2). Most of the sites were in shallow waters of less than 10 m depth.

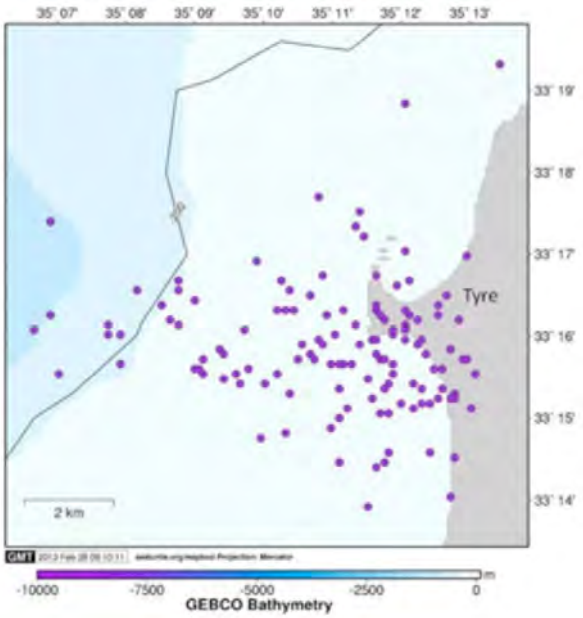


Figure 2: Satellite sites of the 'Nabigha" loggerhead turtle. The feeding area of the Tyre coast. The sites on land are due to inaccurate calculations during the upper satellite passage and these should be withdrawn from any future analysis.

### 3.1.5. Population abundance

We have no population abundance data on *Caretta caretta* at sea for the Lebanon region.

We noted that the number of females frequenting the sandy beaches for egg laying has increased considerably. The number of nests increased from 40 to 122 between 1997 and 2006 (Aureggi, M. and Khalil, M., 2010). We have no data after the year 2006. This data stems only from the four sites which were studied and referred to above. For Lebanon it is necessary and important to monitor the sandy beaches every day during the reproduction season and for several successive years (6 to 7 years). This would give us the number of nests and females who come to lay their eggs along the whole Lebanese coast.

NB: If the number of nests is 122 then this does not mean that 122 females came to lay their eggs. A female can lay her eggs 3 or 4 times per reproduction season. Adult females do not lay eggs every year. But what is encouraging for Lebanon is that the number is increasing and not diminishing.

### 3.1.6. Population demographic characteristics

As for the age class structure, sex ratio, fecundity levels, survival/mortality rates, so far, we have no data whatsoever for the sea or for the individuals found stranded or dead on the beaches or for the females who come to lay their eggs.

### 3.1.7. Threats

Threats exist out in the sea and on the beaches. We can point out the threats in Lebanon for sea turtles, namely the erosion of beaches, sand extraction, development of beaches and their exploitation for tourism, household waste, livestock on some beaches (Aureggi, M. et al. 2005), stray dogs, jackals, crabs (the latter three eat the eggs and the newly-hatched ), men in some coastal regions dig up the eggs for consumption, the beach lights and neighbouring buildings disorient the females and the newly-hatched.

At sea the threats are dynamite fishing, which is prohibited but still practised, accidental bycatch in

fishing gears (longline fishing or use of gillnets) ingested solid waste, chemical contaminants, collisions with boats and the destruction of ecosystems.

### 3.2. *Chelonia mydas*

Adult individuals of the green turtle (*Chelonia mydas*) are herbivorous. They feed on macrophytes.

#### 3.2.1. Former Distribution:

We have no old data (prior to 2000-2001) on the egg laying sites of the green turtle *Chelonia mydas* along Lebanon's coast or its distribution out at sea.

#### 3.2.2. Recent distribution and abundance of females frequenting the beaches during the reproduction period:

So far, the green turtle has been observed only on the sandy coasts of Al Mansoury and Al Kleily. It was spotted for the first time in 2000 on a well-preserved sandy beach not exploited for tourism. Monitoring during the reproduction season in 2001 was done in collaboration with SPA/RAC and the results were published by Demirayak, et al., 2002. From 2001 until the present time the monitoring of this coast is done in coordination with MEDASET. Observations between 2002 and 2006 have shown that the number of nests per reproduction season has increased from 0 to 16 (Cross and Bell, 2006). As we can see for this threatened species and in danger of extinction, the number of females using the Lebanese coasts to lay their eggs are very rare, as they prefer wide beaches with sand dunes.

#### 3.2.3. Distribution at sea of *Chelonia mydas*

No old data available.

The distribution at sea of the young, the juveniles, sub-adults and adults has not been studied. We have very scarce data on the presence of this species at sea which has been reported by fishermen, divers etc (already indicated above). This species can be seen at sea from the south to the north. It is sometimes caught in the fishermen's nets. It is necessary to know the sites of its presence at sea and to determine the sites of reproduction, hibernation, feeding and to study its movements, its migration etc.

N.B.: in the Tyre region a *Chelonia mydas* turtle is monitored via a telemetric device since 2012 by the TCNR group with SPA/RAC. During the two months of transmission, the spatial distribution of this male turtle (called "Elias") was limited to the Tyre area before going to the waters of the South Lebanon (Figure 3).

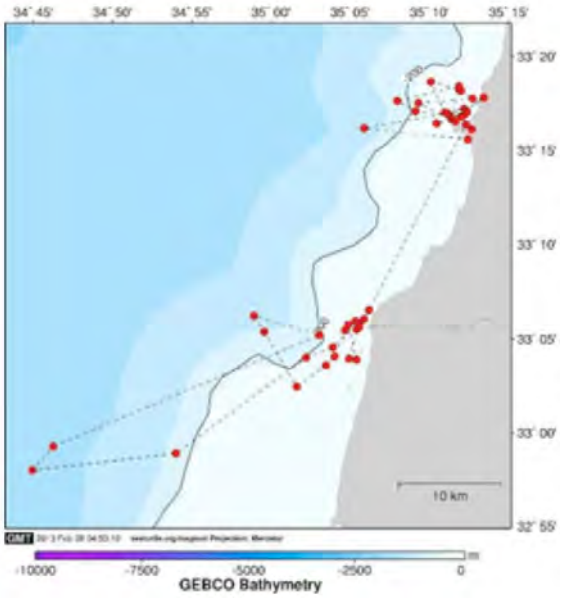


Figure 3: Reconstituted travel route of the green turtle "Elias", showing that most of the sites (red circles ) are on the continental shelf close to the coast. Additional filtering may be necessary to delete the wrong sites of the itinerary.

#### 3.2.4. Population abundance

No data available for the sea.
Observations lasting 5 years were made on the Al Mansoury and Al Kleily beaches and the number of nests varied between 0 and 9 from 2002 to 2006 (Cross and Bell, 2006). So, the number of *Chelonia mydas* females who come to lay their eggs on the Lebanese coast is very scarce.

#### 3.2.5. Population demographic characteristics

As for the age class structure, sex ratio, fecundity rates, survival/mortality rates, so far, we have no data whatsoever for the sea or for individuals found stranded or dead on the beaches or for the females who come to lay their eggs.

#### 3.2.6. Threats

The threats are the same as for *Caretta caretta*, described above with the exception of solid waste (as the species is herbivorous).

### 3.3. *Dermochelys coriacea*

This carnivorous species is endangered and threatened with extinction. It is on the IUCN red list. It is observed in the Eastern and Western Mediterranean. It does not reproduce on the Lebanese coast. In Lebanon it gets caught in the fishermen's nets especially in North Lebanon. One individual was tagged by the protection committee of the "Palm islands" and released into the sea.

#### 3.3.1. Former Distribution in the sea

We have no data for Lebanon.

#### 3.3.2. Recent Distribution and abundance at sea

The *Dermochelys coriacea* turtle seems to be present in the Mediterranean from the north to the south of Lebanon. It sometimes gets caught in the fishermen's nets along the Lebanese coast. We do not have any scientific data on its movements and its abundance in the sea near Lebanon.

## 4. PRESENTATION OF THE MONITORING PROGRAMME OF MARINE TURTLES IN LEBANON

### 4.1. Challenges of the monitoring programme of Marine Turtles in Lebanon

The marine turtles of Lebanon are most threatened and it is thus necessary and urgent, in order to protect them, to set up a monitoring programme so as to be able to restore their ecological state and study the population status, the areas they frequent in order to feed, hibernate, reproduce and track their movements in the sea.

This programme aims to determine the distribution of sea turtles in the in the Lebanese waters and to determine the size or the density of their population in the sea as well and this is difficult especially as these are migratory species. Only the density and the size of the adult female populations of the sea turtles (*Caretta caretta* and *Chelonia mydas*) can be studied when they come for nesting on the sandy coasts of Lebanon. But this evaluation will only be approximate as the females do not come every year to lay their eggs and a single female can lay her eggs 2, 3, 4 times per reproduction season. Their status or ecological state, food web etc also needs to be studied.

In fact, the autopsy of sea turtles stranded on the beaches makes it possible to take tissue samples to determine the potential causes of their death and to study the effect of contaminants. The incidence of solid waste (like plastic bags) found in the digestive tract of the *Caretta caretta* turtles is an important point to be monitored as this is a threat which causes their death either through suffocation or occlusion of the digestive tract. Other solid objects could also be found in the stomachs of sea turtles which were found stranded.

Finally the programme would make it possible to have a periodical update of the state of the "Chelonians" group as well as the impacts of the various pressures which affect them such as the contaminants, marine litter, accidental bycatch in fishing gears including dynamite fishing (which happened very often during the civil war in Lebanon) and the loss of habitat due to the extraction of sea sand.

#### 4.1.1. Evaluating achieving the Good Environmental Status and associated Ecological Objectives (study duration of 6 successive years renewable)

This programme gives information on the Good Environmental Status (GES), the Ecological Objectives (EO) and the following common indicators:

◊ Common indicators related to EO1 (Biodiversity)

- Species concerned

1.1. Distribution of sea turtles

1.1.1. Distribution area of marine turtles in the sea and on the sandy beaches of the Lebanese coast.

1.1.2. Distribution pattern of these two species in Lebanon

1.2. Size of populations

1.2.1. Determining the abundance of these 2 species and adult females on the egg-laying beaches during the reproduction season

1.3. State of the populations

1.3.1. Studying the population demographic characteristics [ e.g. structure per size or age, distribution per sex, rates of fecundity, survival/mortality rates).

1.3.2. Determining the genetic structure of the populations

- As for the ecosystems

> Structure of the ecosystems

- Composition and relative proportions of the ecosystem's components [habitats and species]

> Common indicators related to the EO4 « food web »[2]

Amongst the marine turtles observed in the Mediterranean, the adult *Chelonia mydas* is herbivorous and the other species are carnivorous. *Caretta caretta* feeds on fish, crustaceans, jellyfish etc....it is useful to determine the diet of the sea turtles by studying their stomach contents and their faeces.

> Common indicators related to EO8 « waste »

- Incidences of waste material on marine life and on the *Caretta caretta* sea turtle who swallows solid waste such as plastic bags and other products found in its stomach and which cause its death through suffocation or through occlusion of the digestive tract.
- Determining the quantity and composition of waste material ingested by studying the stomach contents of dead individuals.

#### 4.1.2. Evaluating the characteristics of the ecosystem, pressures and impacts which are necessary for the analysis of the ecological state

Analyzing and evaluating the impact or effect caused by these pressures: physical pressures (solid waste materials), chemical (contaminants) and biological ones (pathogens) and accidental bycatch on the ecological and biological state of marine turtles.

##### Solid waste materials: physical pressures and their impacts

- Solid waste in the sea is a trap for sea turtles who confuse them with marine species which are part of their diet. Unfortunately, these products are deadly for marine chelonians.

  Evaluating the number of deaths per year due to the ingestion of solid waste by studying the stomach contents of dead turtles stranded on the beaches.
- Work and intervene with the Lebanese government so that solid waste is not discharged on specific parts of the coast or dumped into the sea. Some beaches in Lebanon are open air rubbish dumps with all kinds of solid waste (household and medical waste and other types of waste).

##### Chemical pressures and their impacts

- Impacts of chemical substances on the ecosystem (Ecological and biological modifications)
- Impacts of chemical substances on sea turtles through the food chain. Tissue samples of dead and stranded individuals on the beaches will be studied and analyzed in specialized and well-equipped laboratories (make arrangements to set them up and this will require quite a substantial budget).

##### Biological pressures and their impacts

- Pathogens for the species to be determined on tissue samples taken from dead or stranded individuals on the coast and studied by specialists (veterinarians).
- Accidental bycatch (turtles caught in fishermen's nets)
- Some captures are not accidental but intentional as the bathers take the turtles out of the water when these marine reptiles swim close to the coast and illtreat them unto death.

[2] The Ecological objective EO4 related to the marine food webs and its associated common indicators are still under development in the framework of the Barcelona convention Ecosystem approach.

#### 4.1.3 Evaluating the achievement of environmental objectives and especially the associated operational objectives

This programme makes it possible to assess the degree of achievement of the following environmental objectives for Lebanon:

- Strive to maintain or restore the populations of marine reptiles in a good state of conservation:
- Diminish the collision risk of vessels with sea turtles
- Limit other anthropogenic disturbances: developments carried out along the littoral, coastal trawling, dynamite fishing, scuba diving, extraction of sand etc…
- Organize research activities to study the size and population dynamics of the sea turtles.
- Protect the females who come to lay their eggs as well as their nests during the reproduction period.
- Control the lighting of the coasts during the reproduction season.

### 4.2. Organisation of the monitoring programme

The monitoring programme has 3 sub-programmes as follows:

- Marine turtles at sea
- Stranding of sea turtles
- Interactions between marine turtles and human activities

For Lebanon the monitoring programme must comprise relatively costly campaigns such as areal monitoring or by using boats.

The monitoring programme must be based on actions carried out by associations, voluntary networks, research teams supported by funding from the State or Associations, voluntary networks which often use opportunities as they arise and managers of marine protected areas (E.g. Tyre Coastal Nature Reserve and the Nature Reserve of Palm islands).

## 5. SUB-PROGRAMME 1 – MARINE TURTLES AT SEA

This sub-programme aims to map the distribution and the density of marine turtles in the sea. It makes it possible to evaluate their ecological status, to analyze the functioning and the state of the food web. It also contributes towards estimating the pressure of human activities on the populations. Monitoring at sea of marine turtles can be done through two means: through aerial observation and observation using the boat.

- Aerial observations

Flying over all the waters under Lebanese jurisdiction makes it possible to collect observations on a considerable spatial scale and in a very short time. Observations made over a period of 6 to 12 years give an instant image of the distribution of sea turtles in the Lebanese waters and human activities which can be seen from the aeroplane (fishing activities, pleasure boating, tourism etc.)

As for aerial observations, Lebanon does not have an aeroplane equipped for such a mission. So, we rely on assistance from the Regional Associations who do have such equipment and with whom we can coordinate our work

- Observations from vessels

The CANA boat used by the (NCMS) marine research centre and attached to the Lebanese CNRS could be used for the monitoring of marine turtles in the sea by making 2 sea trips per year (1 in the winter and 1 in the summer) lasting 5 consecutive days for each trip and over a period of 6 years.

Fishing boats too can be used as an observation platform on turtles by getting observers on board during fishing activities. The second alternative should be to acquire information from the fishermen.

#### Other means could be used for monitoring at sea

- Telemetric monitoring

The GPS telemetric monitoring in Lebanon would make it possible to study the distribution area of marine turtles (*Caretta caretta* and *Chelonia mydas*), their movements and their migration trajectories. The objective is to identify and characterize the different habitats used by these marine reptiles to help with decision-making in terms of the management and conservation of the areas and species in the Mediterranean. This project will be carried out in partnership with the local and national Institutions concerned.

- Monitoring through tagging

This method makes it possible to monitor the movements of marine turtles in the sea.

### 5.1. Means / tools used / protocol elements

This sub-programme is based on aerial monitoring and observation campaigns using vessels. The data processing entails using spatial modelling and various environmental, especially oceanographic variables.

### 5.2. Spatial coverage and sampling strategy

- Dedicated aerial observation campaigns

Spatial coverage is suitable for the distribution of the species being studied (sea turtles) and the resolution is more fine-tuned in the coastal area rather than at sea. Aerial campaigns will be carried out over all over Lebanon's marine waters with one sampling being done in the winter and one in the summer. The distribution of sea turtles is very different depending on these two seasons. Only a flight plan with a sufficiently fine grid with an extensive spatial coverage, repeated during the winter and during the summer season, can yield quite robust statistics in order to do a modelling of the habitats.

A campaign every 6 years could be scheduled (winter + summer).

- Observation campaigns using dedicated vessels

Spatial coverage will use the campaigns carried out by the "CANA" boat of the Lebanese CNRS which is used for the observations of marine mammals of Lebanon and will be extended by developing embarkations on other fishing boats.

The temporal resolution with the CANA boat will be 2 times per year (1 trip in the winter and 1 trip in the summer) for 6 successive years. Observations made with the fishermen will be on an annual basis.

### 5.3. Conclusions on the implementation of this sub-programme

The monitoring scheduled in this sub-programme can start in 2019, during the second phase of the ecosystem approach process, with the setting up of aerial and observation campaigns using fishing campaigns and vessels.

## 6. SUB PROGRAMME 2: STRANDING OF SEA TURTLES

### 6.1. Objectives and presentation

Stranding of sea turtles on the coasts and accidental bycatch are the main source of access to tissue and organ samples so as to assess the ecological state. An analysis of the stranded individuals also makes it possible (provided the decomposition is not too bad) to study the effects of anthropogenic pressures on them such as accidental bycatch, ingestion of waste materials, collisions and contaminants. The stranding also provides information on the presence, distribution and relative abundance of the species.

### 6.2. Parameters to be followed and link with the other programmes

- Presence and distribution by monitoring the number of stranding.
- Feeding and diet (stomach contents, isotopic signatures, metal markers, fatty acids)
- Apparent cause(s) of mortality of sea turtles (natural causes, accidental bycatch, collision, ingested waste, level of contamination…)
  - Population structure (ecological and genetic markers)

### 6.3. Means / tools used / protocol elements

Set up and update an inter-ministerial circular (starting from 2018) so that reports of stranded or captured marine turtles can be communicated so as to take samples of the marine turtles. Their identification, samples and autopsy could be carried out by having recourse to a network of trained and qualified volunteers in coordination with a State institution such as the MoE and the MoA or the CNRS or Associations for the Protection of Nature.

A « marine turtles » care centre was set up in 2015 in the Tyre Coast Nature Reserve. A second care centre for marine turtles should be opened in the North of Lebanon (in Tripoli).

The following steps to be undertaken in the care centre and in a research laboratory:

- Counting the number of stranding
- Examinations, dissections, autopsies of carcasses. Standard sampling of tissues to identify the causes of mortality and biological parameters.
- Health and demographic status by estimating the weight (overweight) and bio-demographic parameters such as age and reproductive status.
- Population structure: ecological and genetic markers
- Feeding and diet: digestive contents, isotopic signatures (to be done systematically) metal markers, fatty acids
- Level of contamination: metals and persistent organic pollutants (POPs) in connection with the EO related to « contaminants » of the Good Ecological Status
- Quantity and type of ingested waste by analyzing the stomach contents/faeces of the marine turtles

### 6.4. Spatial coverage and sampling strategy

Sampling is done continuously along the whole coast. There is no sampling strategy as data collection depends on reported sightings and also on the abundance and mortality at sea.

Analyses of stranded animals should include all the biological parameters (diet, bio-geochemical markers, age, reproductive status, contaminants, etc.) and not only the causes of mortality.

### 6.5. Implementation of monitoring

#### Existing means making monitoring

In Lebanon there is already a care centre which needs to be improved. For analyses a laboratory will be necessary with specific equipment and specialized researchers to ensure the necessary follow-up for these analyses. Therefore, it is necessary to plan the installation and equipment of a research laboratory in 2018.

#### National Stranding Network (NSN)

There is no such identical network in Lebanon, hence the necessity of setting up a national stranding network.

#### Facilities to be set up

Setting up of a national stranding network to recover the stranded turtles on the beaches and to study the causes of their death in a research laboratory as well as their diet (by analyzing their stomach contents and their faeces), the effects of contaminants etc….

### 6.6. Conclusions on the implementation of this sub-programme

The sub-programme consists of setting up a « National Stranding Network » and « Marine Turtles Networks » starting in 2018 to count the stranded animals and to collect biological tissues. A number of parameters for measuring should be added (e.g. isotopic signatures, diet) and autopsies should be carried out much more systematically as well as the diagnosis of the causes of mortality (waste, hydrocarbons, contaminants, etc.).

## 7. SUB-PROGRAMME 3: INTERACTIONS BETWEEN MARINE TURTLES AND HUMAN ACTIVITIES AT SEA

### 7.1. Objectives and presentation

This sub-programme aims to observe and monitor the interactions in situ between human activities at sea and marine turtles so as to gain information on the state of the populations in view of the pressures affecting them. As for fishing activities, the monitoring of interactions will be done by using the following existing mechanisms:

- Observation of accidental bycatch on fishing boats
- Indirect and independent observation during the monitoring of stranding (causes of mortality) within the framework of stranding and accidental bycatch by networks and « marine turtles » care centres.

The monitoring of sea turtles will be accompanied by early warning network development activities and a survey of the « small trades » and if possible, a group should be formed like the example in France which would be named the GTML (Lebanon Marine Turtles Group).

This sub-programme also makes it possible to use other parameters for the sea turtles such as their presence and distribution, population structure, demographic parameters, health status and conditions of individuals and diet. But great caution is necessary with these parameters as the individuals which are caught accidentally could be representative of only some segments of the population (e.g. the youngest).

### 7.2. Monitoring parameters and links with other programmes

Parameters to be applied to marine turtles are as follows:

- Data on the capture or the area (to identify the hotspots of interaction with fishing activities)

  Fishing gear

  Turtle species (+ if possible, the sex, length and width of the shell)

  State of the turtle: dead/alive

Data collected within the framework of the mechanisms described in this sub-programme are to be analyzed together with all the data of the « marine turtles » programme but do not contribute to other sub-programmes. The data of the "stranding of marine mammals and marine turtles" sub-programme will also contribute to provide information on the parameters referring to the « food interaction » and « demographic impact of fishing on marine turtle populations ».

### 7.3. Means / tools used / protocol elements

Sampling is done on board of vessels of opportunity (fishing vessels) by observers on board. As for marine turtles, additional data is also collected through surveys via a semi-directive interview.

### 7.4. Spatial coverage and sampling strategy

- Marine turtles' networks and care centres
  Set up, like France, networks which would work along the whole coast and develop, in partnership with the National Maritime Fisheries Directorate, an early warning network and technical files for fisheries professionals likely to increase the number of declarations.
- Logbooks to be made available to Lebanese fishermen

### 7.5. Implementation of monitoring

#### 7.5.1. Existing mechanism making it possible to implement the monitoring

In Lebanon there is already a care centre which needs to be improved. For analyses a laboratory will be necessary with specific equipment and specialized researchers.

#### National Stranding Network

This does not exist in Lebanon as yet. A network identical to that in France should be set up.

#### Networks and care centres for marine turtles

A care centre for marine turtles was opened in 2015 in the Tyre region. Data collection from fishermen who do not take observers on board is strengthened within the framework of collaboration with marine turtle networks and this collaboration is to take place in Lebanon through semi-directive interviews.

#### Declaration of unwanted bycatch from the fishing logbooks (DPMA)

The use of data on unwanted bycatch from the fishing logbooks will also provide interesting information on accidental bycatch.

## 8. NEED FOR THE CONSERVATION AND MONITORING OF MARINE TURTLES IN LEBANON

Teams are to be trained for the monitoring of marine turtles and ensure that they are trained adequately. It is recommended to work in coordination with Regional Bodies such as SPA/RAC and with NGOs such as MEDASSET.

In order to complete the observations of the beaches with marine observations, it is necessary to do the monitoring at sea with a boat and aeroplane as well as with telemetric monitoring of the two species of marine turtles *Chelonia mydas* and *Caretta caretta* in order to determine their distribution at sea as well as their abundance. For aerial monitoring we will need to coordinate our observations with Regional Associations which have an aeroplane for monitoring the sea. A budget will be necessary to cover the expenses.

There is a need for a care centre for marine turtles in the north of Lebanon (Tripoli) in order to look after injured, stranded or dead animals on the beaches in order to care for them if they are still alive.

A well-equipped research laboratory is necessary in order to study the tissue samples taken from individuals to find out the causes of their death and also to undertake genetic studies. A quantitative and qualitative study of the stomach contents should also be carried out.

## 9. RECOMMENDATIONS

The number of Marine Reserves should be increased by adding them to the two that already exist (Palms islands and Tyre Coast Nature Reserve), the coasts to the north of the town of Tyre ( those of Al Abassieh and of Al Bourghlieh or Qasmieh) for their potentialities of getting female marine turtles to come for nesting and also those in the far south of the Lebanese coast (Al Mansoury and Al Kleily). The latter two are frequented by the two species of marine turtles *Chelonia mydas* and *Caretta caretta*. A monitoring programme for these two beaches has been set up in coordination with MEDASET since 2002.

Long term and sustainable monitoring programmes should be set up for data collection and to set up a conservation strategy.

A monitoring programme will cover all the sandy beaches along the Lebanese coast which are known for the female marine turtles who come there to lay their eggs and those beaches which have the necessary potential for these female turtles. We can in particular refer to the beaches of Al Kleily, Al Mansoury, the Tyre Coast Nature Reserve, Al Abassieh, Al Bourghlieh (or Al Qasmieh), Al Yahoudieh, Al Mahmoudieh, Al Adoussieh,

the sandy beach of Damour, the sandy beach to the north of Saida, the sandy beach of Jbeil, the Reserve of the Palm islands, the sandy beach of Cheikh Zennad (close to the Syrian border).

The already existing laws for the protection of the coast and the sea are to be respected so as to stop the exploitation of what remains of the sandy and rocky natural coasts of Lebanon.

A National Action Plan (NAP) for marine turtles in Lebanon is to be set up in association with the Mediterranean Action Plan (UNEP; SPA/RAC), for the protection of marine turtles in Lebanon.

Collaboration to be established with NGOs (International Institutions) for an exchange of information and knowledge on the conservation of marine turtles.

A management plan is to be set up for the two Marine Natural Reserves of Lebanon (those of Tyre and the "Palm islands"). This plan should yield better divisions of the areas of these reserves. The nesting zones should be identified and protected. Advice should be given to the committees of these reserves to that they can design and develop their own education and awareness-creation programmes.

A detailed scientific study programme for the monitoring of marine turtles in Lebanon along the whole coast with priority objectives should be prepared and submitted to the Lebanese CNRS and to the MoE and continued for a long time.

Undo the damage on some of the beaches and reconstitute the sand dunes necessary for the nesting of marine turtles. All the solid waste dumps near the sea should be closed and rehabilitated ecologically. The waste dump sites chosen recently (La Costa Prava and Bourj Hammoud) beaches with a suitable potential for egg-laying by marine turtles are a marine ecological disaster.

## References


Aurreggi, M., Risk, C., Venizelos, L. 2005. Survey on sea turtle nesting activity South Lebanon. 2004. Joint report of (alphabetical order) MEDASET and MEDASETCOAST. 35 PP.

Aureggi, M. and Khalil, M. 2010. Sea turtles in the Mediterranean, distribution, threats and conservation priorities Casale P and Margaritoulis, D. (Eds) (2010) Gland Switlzerland: IUCN, p. 148-155

Cross, H. and Bell, S. 2006. Sea turtle monitoring and public awareness in South Lebanon

2005. Testudo 6(3), 13-27.

Demirayak, F., Venizelos, L., Sadek, R., Hraoui-Bloquet, S. and Khalil, M. 2002. Marine Turtles Conservation in the Mediterranean – Lebanon: a first survey for Chelonia mydas and Caretta caretta nesting in Lebanon. Proceedings of the 22nd Annual symposium on Sea Turtle Biology and Conservation.

Hraoui-Bloquet, S. 1981. Les Reptiles du Liban., Ecologia Mediterranea, No. 7 (2), 93-101.

Hraoui-Bloquet S., Sadek, R. and R. Yammine-Saad, 1998. Reptiles from Palm Islets, off Tripoli (North Lebanon). Miaud C. et Guyétant R. (Eds) Le Bourget du lac, France, S.E.H. p. 207-213.

Hraoui-Bloquet, S. and Sadek, R. 2001. Reproduction des Tortues Marines sur les côtes sblonneuses du Liban. Congress 2001, 11th OGM- SHE (Slovenia)

Hraoui-Bloquet, S., Sadek, R., Sindaco, R. and Venchi, A. 2002. The herpetofauna of Lebanon; new data on distribution. Zoology in the Middle East, 27 p. 35-46

Hraoui-Bloquet, S. and Sadek, R. 2003. Marines turtles of Lebanon, preliminary records. Zoology in the Middle East, 32, p.23-26

Kasparek, M. And R. Kinzelbach, 1991. Distribution and bionomics of the Nile Soft shelled Turtle, Tryonyx triunguis, in the Eastern Mediterranean- Zeitschrift fur angewandte Zoologie, 78:137-159, Berlin.

Kasparek, M. 2004. The mediterrannean coast of Lebanon habitat for endangered fauna and flora. Joint effort by the MSC Project funded by the EU, the MEDWETCOAST Project funded by the French GEF, and MEDASSET. 35 pp.

Newbury, N., Khalil, M., Venizelos, L. 2002. Population status and conservation of marine turtles at Al Mansouri Lebanon. Zoology in the Middle East 27, 47-60

Ramadan Jaradi, G., Haber, M., Sadek, R. and Saoud, L. 2007. Biodiversity Assessment and Monitoring in the Palm Island Nature Reserve. AUB, MOE. IUCN.

Revuelta, O., Carreras, C., Domenech, F., Gozalbes, P. and Tomas, J. 2015. First report of an olive ridley (Lepidochelis olivacea) inside the Mediterranean Sea. Home> Vol. 16. No 2, Revuelta.

St John, F., Al Khalil, M., Venizelos, L. 2004. Marin turtles nesting in South Lebanon, 2003, Project by MEDASETT. 18 pp.

Thomé, G. Tohmé, H., Ramadan-Jaradi, G., Hraoui-Bloquet S. et Gèze, R. 1999 a. Biodiversité de la Réserve de Tyre

Thomé, G. Tohmé, H., Ramadan-Jaradi, G., Hraoui-Bloquet, S. et Gèze, R.1999 b. Biodiversité de la réserve des Iles des Palmiers

Tohmé, G., Tohmé, H., Hraoui-Bloquet, S., Karakira, M., Slim, K. and R. Gèze, 1999 c. Report on Five protected areas in Lebanon. National Council for Scientific Research. (Project UNDP nº Leb.95-G31-AIG-99).

Tohmé, G., Tohmé, H., Ramadan-Jaradi, G., Hraoui-Bloquet, S. and Gèze, R. 2004. Biodiversity Assessment and Monitoring in the Protected Areas /Lebanon LEB/95/G31, The Lebanese University.

*Caulerpa taxifolia var. distichophylla* with *Bunodeopsis strumosa* ©SPARAC, Oscar Ocaña

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# VI. National Monitoring Programme for non-indigenous species

## 1. INTRODUCTION

Lacking any regulations concerning non-indigenous species (NIS), particularly marine species, the National Biodiversity Strategy and Action Plan (NBSAP) is as follows: "By 2030, Lebanon's biodiversity is sustainably valorised and managed for the protection and conservation of its ecosystems and of its habitats, and the provision of ecosystem goods and services." (MoE/UNEP/GEF, 2016).

This vision presents a major challenge for biodiversity; the steps are presented as falling into thirteen priorities. One of these is "invasive exotic species" and the others are "threatened species", "genetic diversity", "protected areas", "sustainable management and use of the ecosystems and natural resources", "restoring ecosystems", "access and sharing of advantages", communication, education and public awareness, integrating biodiversity within national and sub-national plans and policies, climate change, research and transfer of knowledge, institutional and legal framework, and mobilisation of resources. The action plan to attain this vision includes 18 national objectives with their 91 respective national actions. Progress towards the objectives of the national actions (political, institutional, technical, legislative, economic or other) involves the pursuit of existing programmes and practices and includes new initiatives based on changing circumstances and the evolution of science (MoE/UNEP/GEF, 2016). According to the national objective on invasive alien species (IAS), by 2030 efficacious measures will be in place to check the introduction of IAS into the environment.

## 2. STAKES IN THE NATIONAL NON-INDIGENOUS SPECIES (NIS) MONITORING PROGRAMME (ECOLOGICAL OBJECTIVE 2-OE2)

The objectives of the national programme for monitoring non-indigenous species are to supply information enabling the ecological status of habitats to be assessed and to make sure that these species, introduced by human activities, are, as far as is possible, at levels that do not harm the ecosystem, and then that the introduction of non-indigenous species is minimised to the greatest degree possible to attain Good Environmental Status (GES).

The stakes in monitoring NIS involve setting a watch on the arrival of new species and following the spread of those that have already been introduced.

Non-indigenous species may bring about unpredictable and irreversible changes in marine ecosystems, such as competition or predation with indigenous species and/or the restructuring of habitats. Various economic or human health impacts may also happen, via, for example, the modification of habitats, fouling, or harmful algal blooms and stinging jellyfish such as *Rhopilema nomadica*.

## 3. COMMON INDICATOR 6 OF ECOLOGICAL OBJECTIVE OE2-IC6: "TRENDS IN THE ABUNDANCE, TEMPORAL OCCURRENCE AND SPATIAL DISTRIBUTION OF NON-INDIGENOUS SPECIES, PARTICULARLY INVASIVE NON-INDIGENOUS SPECIES, PARTICULARLY IN AT-RISK ZONES, IN RELATION TO THE MAIN VECTORS AND ITINERARIES OF THE SPREAD OF SUCH SPECIES."

This part is especially based on the personal observations of G. Bitar over more than 35 years and on unpublished data and on his published scientific work either written alone or in collaboration with international researchers since 1981: Abboud-Abi Saab et al., 2003; Bitar, 1996, 1999, 2008, 2010 a and b, 2011, 2013, 2014; Bitar & Bitar-Kouli, 1995 a and b; Bitar et al., 2000; Bitar & Kouli-Bitar, 1995 a and b; Bitar et al., 2007; Bitar et al., 2017; Bitar & Zibrowius, H., 1997; Crocetta et al., 2013 a and b; Crocetta et al., 2014; Harmelin et al., 2007, 2009; Harmelin-Vivien et al., 2005; Kapiris et al., 2014; Katsanevakis et al., 2011; Logan et al., 2002; Morri et al., 2009; UNEP/MAP-RAC/SPA, 2014; Zenetos et al., 2015; Zibrowius & Bitar, 1981 and 2003. This is also so for the following works: Abdul Malak et al., 2011; Basson et al., 1976; Bellan-Santini et al., 1994; Golani et al., 2006; Gruvel, 1931; Lakkis, 2013; Lakkis & Novel-Lakkis, 2000; Lebanon's Marine Protected Area Strategy, 2012; Louisy, 2002; MoE/UNEP/GEF, 2016; Mouneimné, 2002; UNEP/IUCN/GIS-Posidonia, 1990; UNEP-MAP-RAC/SPA, 2006; UNEP-MAP-RAC/SPA, 2015.

Grounded on the recommendations made by IMAP, the national programme for monitoring NISs must be based on a 'risk' approach that involves focusing on the IESs. Methodologies and measures for checking and quality assurance are described in the integrated monitoring and assessment directions (http://www.rac-spa.org/sites/default/files/ecap/ig22_inf7.pdf). A guiding descriptive file has been crafted for each common indicator, describing the protocols and monitoring techniques to adopt as part of the implementation of the EcAp process (https://wedocs.unep.org/bitstream/handle/20.500.11822/21262/17wg444_6_eng.pdf?sequence=1&isAllowed=y).

Examining the various documents from France's monitoring programme that fall within the Strategy Framework Directive for the Marine Environment (MSFD), available on internet sites, shows which are deemed to be particularly pertinent and useful, especially those of the Western Mediterranean marine sub-region.

Monitoring the common indicator 6 in relation to the NIS describes the trend in abundance, occurrence, temporal change and spatial distribution, in particular of invasive non-indigenous species, mainly in at-risk zones or hotspots of introduction (ports and their surroundings, quays, marinas, fish farming facilities, sites of hot effluent outflow from electric power stations, open sea facilities). The same holds good for special interest areas like marine protected areas, according to a case by case approach, if need be, according to their proximity to the hotspots of introduction of exotic species.

To give an idea about the ecological characterisation of non-indigenous species, we must look at the following constituents: vectors of introduction, features of the existing non-indigenous species, and their status, origins and impacts on the indigenous species and habitats.

### 3.1. Vectors of introduction

The vectors of introduction of non-indigenous species can be put into three categories: deliberate (intentional) introductions, escaped species (fugitive or accidental), and stowaways. The main vectors are the Suez Canal, species accompanying fish farming species, fouling (oil tankers, commercial ships, pleasure craft, regional transport, drilling platforms, buoys, pillars…), ballast water, escaping species (from fish farms), escaping species (from aquariums) and bait for fishing. The Suez Canal is by far the main vector of the introduction of non-indigenous species into Lebanon, followed by shipping.

### 3.2. Non-indigenous species in Lebanon

Non-indigenous species of macrophytes, invertebrates, especially benthic, and fishes sighted and/or caught along the Lebanese coast are considered. According to Table 1, the total number of species recorded was 1,588, 237 of which were non-indigenous species. These were divided into 207 macrophytes, of which 29 were NISs, 1,072 invertebrates, of which 156 were NISs, and 309 fishes, of which 52 were NISs (unpublished data, Bitar).

#### 3.2.1. Non-indigenous macrophytes

The 29 species of macrophytes were divided into 3 Chromobionta, 13 Rhodobionta, 12 Chlorobionta and 1 Streptobionta (Bitar et al., submitted).

Table 2 includes all the characteristics that give an overall view of each species: status, date, locality, reference of first sighting in Lebanon, origin, vector of introduction and how successfully established.

Among these 29 species, two only are occasional whereas the others are well-established; of these, *Stypopodium schimperi, Galaxaura rugosa, Laurencia cf. chondrioides, Codium parvulum* and *Ulva lactuca* are the five potentially invasive species, already occupying vast stretches of the Lebanese coast. The Palm Islands Nature Reserve has not been spared the impact of non-indigenous macrophytes, in particular *Stypopodium schimperi, Padina boergesenii, Galaxaura rugosa* and *Codium parvulum*. The most important vector is the Suez Canal, and most of the species are of Indo-Pacific origin. It should be noted that only 5 out of these 29 species are on the IUCN International Union for the Conservation of Nature's blacklist of invasive species: *Stypopodium schimperi, Asparagopsis taxiformis, Lophocladia lallemandii, Womersleyella setacea* and *Halophila stipulacea* (Otero et al., 2013).

From our regular explorations of the last 30-plus years, we have noticed that the rate at which a new species of macrophyte appears increases in such a way that the period when a new species appears after the preceding species is becoming increasingly short, and it seems that the latest (the most recent) will take over from the others. Currently, the most invasive of the non-indigenous species are *G. rugosa, C. parvulum* and *L. cf. chondrioides*.

As to distribution areas, most of these macrophytes exist throughout the Lebanese coast. However, some are currently confined to the southern part of the country

Table 1. Statistics on indigenous and non-indigenous species of macrophytes, benthic invertebrates and fishes in Lebanon

| Taxa | Total number of species | Number of NIS |
|---|---|---|
| Macrophytes | 207 | 29 |
| Invertebrates | 1,072 | 156 |
| Fishes | 309 | 52 |
| Total | 1,588 | 237 |

only, like for example *L. cf. chondrioides*, which is found between Nakoura in the south and Saadiyat in the north. Others are of limited distribution, like *C. mexicana*, which is only found in the Beirut area (Bitar et al., 2017).

Table 2. List of exotic marine macrophytes of the Lebanese coast, with alien status, date, locality and source of the first record in Lebanon, origin, putative pathways of introduction and establishment success.

| TAXA (NIS) | STATUS | DATE | LOCALITY | SOURCE | ORIGIN | PATHWAYS | SUCCESS |
|---|---|---|---|---|---|---|---|
| **CHROMOBIONTA** | | | | | | | |
| ***Padina boergesenii*** Allender & Kraft | Al | 1992 | Tripoli | Bitar, 1999 | IP | C/SC | E |
| ***Spatoglossum variabile*** Figari & De Notaris | Al | 2009 | Tabarja | Present study | IP | C/SC | E |
| ***Stypopodium schimperi*** (Kützing) Verlaque & Boudouresque | Al | 1991 | Barbara | Bitar, 1999 | IP | C/SC | Inv |
| **RHODOBIONTA** | | | | | | | |
| ***Acanthophora nayadiformis*** (Delile) Papenfuss | Cr | 1991 | Tabarja | Bitar, 2010b | IP | C/CAE C/SC T-S/Sh | E |
| ***Asparagopsis taxiformis*** (Delile) Trevisan de Saint-Léon (Tetrasporophyte) | Cr | 1973 | Selaata, Barbara, Zouk Mkayel Khalde | Basson et al., 1976 | A/IP? | C/CAE C/SC T-S/Sh | E |
| ***Asparagopsis taxiformis*** (Delile) Trevisan de Saint-Léon (Gametophyte) | Cr | 1993 | Barbara, Batroun | Bitar et al., 2000 | A/IP ? | C/CAE C/SC T-S/Sh | E |
| ***Chondria coerulescens*** (J. Agardh) Falkenberg* | Qu | 1973 | North Lebanon | Basson et al., 1976 | A | T-C/A | E |
| ***Galaxaura rugosa*** (J. Ellis & Solander) J.V. Lamouroux | Al | 1995 | Kfar Abida | Bitar et al., 2000 | IP | C/SC | Inv |
| ***Ganonema farinosum*** (J.V. Lamouroux) K.C. Fan & Y.C. Wang | Cr | 1993 | El Heri | Bitar et al., 2000, as *Liagora farinosa* | IP | C/SC T-S/Sh | E |
| ***Hypnea cornuta*** (Kützing) J. Agardh | Al | 1973 | North Lebanon | Basson et al., 1976, as *H. hamulosa* | IP | C/SC T-S/Sh | E |
| ***Hypnea spinella*** (C. Agardh) Kützing | Al | 1998 | Beirut, | Present study | A/IP | C/SC T-S/Sh | E |
| ***Hypnea valentiae*** (Turner) Montagne* | Qu | 2014 | Batroun | Belous & Kanaan, 2015 | IP | C/SC T-S/Sh | C |
| ***Laurencia cf. chondrioides*** Børgesen* | Qu | 2009 | El Baiada, Tyr, Nakoura | Present study | A | T-S/Sh | Inv |
| ***Lophocladia lallemandii*** (Montagne) F. Schmitz | Al | 1973 | North Lebanon | Basson et al., 1976 | IP | C/SC T-S/Sh | E |
| ***Polysiphonia atlantica*** Kapraun & J.N. Norris* | Qu | 2014 | Batroun | Bellous & Kanaan, 2015 | A/P | T-S/Sh | C |
| ***Sarconema filiforme*** (Sonder) Kylin | Al | 2001 | Beirut | Bitar, 2010b | IP | C/SC | E |
| ***Womersleyella setacea*** (Hollenberg) R.E.Norris | Al | 2016 | Batroun | Present study | IP | R/Aq T-S/Sh | E? |
| **CHLOROBIONTA** | | | | | | | |
| ***Bryopsis pennata*** J.V. Lamouroux* | Qu | 1973 | Khalde | Basson et al., 1976 | IP | C/SC T-S/Sh | E |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Caulerpa chemnitzia*** (Esper) J.V. Lamouroux | Al | 1931 | Beirut | Hamel, 1931, as *C. racemosa* | IP | C/SC | E |
| ***C. mexicana*** Sonder ex Kützing | Al | 1941 | Beirut | Rayss, 1941, as *C. crassifolia* | IP | C/SC | E |
| ***C. racemosa var. lamourouxii f. requienii*** (Montagne) Weber van Bosse | Al | 1991 | Beirut | Present study | IP | C/SC | E |
| ***C. scalpelliformis*** (R.Brown ex Turner) C. Agardh | Al | 1930 | Beirut | Hamel, 1930 | IP | C/SC | E |
| ***Caulerpa taxifolia var. distichophylla*** (Sonder) Verlaque, Huisman & Procaccini | Al | 2016 | El Madfoun Byblos, | Present study | IP | R/Aq T-S/Sh | E |
| ***Cladophora herpestica*** (Montagne) Kützing | Al | 1973 | Barbara, Zouk Mkayel, Khalde, Doha | Basson et al., 1976, as *Cladophoropsis modonensis* | IP | C/SC | E |
| ***Cladophora patentiramea*** (Montagne) Kützing* | Qu | 2005 | Selaata, Tyr | Bitar et al., 2007 | IP | C/SC | E |
| ***Codium arabicum*** Kützing | Al | 2007 | Hannouch | Present study | IP | C/SC | E |
| ***C. parvulum*** (Bory ex Audouin) P.C.Silva | Al | 2008 | Nakoura | Bitar, 2010 b | IP | C/SC | Inv |
| ***C. taylorii*** P.C. Silva | Al | 2002 | Ouzai, Beirut | Abboud-Abi Saab et al.,2003 | IP/A | T-C/A T-S/Sh | E |
| ***Ulva lactuca*** Linnaeus | Cr | 1991 | Beirut | Bitar, 1999, as *U. fasciata* | IP | C/CAE T-S/Sh | Inv |
| **STREPTOBIONTA** | | | | | | | |
| ***Halophila stipulacea*** (Forsskål) Ascherson | Al | 1966 | Saida | Lipkin, 1975 | IP | C/SC | E |

Alien status: Al = Alien (non-indigenous); Cr = Cryptogenic; Qu = Questionable. Origin: A = Atlantic; IP= Red Sea / Indo-Pacific. Pathways: Categories / Subcategories according to the CBI (2014) classification: C/CAE = Corridor / Canal of Ancient Egyptians; C/SC = Corridor / Suez Canal; R/Aq = Release in nature / Aquarium species; T-C/A, Transport-Contaminant / Aquaculture; T-S/Sh = Transport-Stowaway / Ship hull fouling or ballast water. Establishment success in Lebanon: E = established; Inv = invasive; C = casual; E? = establishment to precise by further investigation. * = Identification requiring confirmation (Bitar et al., submitted)

### 3.2.2. Non-indigenous invertebrates

Here we consider specifically the benthic invertebrates and the two plankton species the jellyfish *Rhopilema nomadica* (of Indo-Pacific origin) and the ctenophore species *Mnemiopsis leidyi* (of West Atlantic origin), frequently met in our underwater diving, the first because of its impact on human health and tourism, the second because of its occasional bloom in the water column, particularly near the surface.

In Table 3 the benthic invertebrates include 1,072 species, 156 of which are NISs, divided into 9 zoological groups: foraminifers (2 species), cnidarians (11), bryozoans (28), polychaetes (18), molluscs (49), crustaceans (34), pycnogonida (1), echinoderms (5) and ascidians (8).

Table 3. List of non-indigenous invertebrate species with their status

| TAXA (NIS) | Status and introduction vectors/origin of NIS | NIS to be monitored (+) |
|---|---|---|
| **FORAMINIFERES** | | |
| *Amphistegina lobifera* | E, IP | - |
| *Heterostegina depressa* | E, IP | - |
| **CNIDAIRES** | | |
| *Eudendrium carneum* | E, SC, V | + |
| *Eudendrium merulum* | E, SC, V | + |
| *Macrorhynchia philippina* | E, SC | + |
| *Diphasia digitalis* | E, SC, V | - |
| *Dynamena quadridentata* | E, SC, V | - |
| *Sertularia marginata* | E, V | - |
| *Sertularia tongensis* | E, V | - |
| *Clytia linearis* | E, V | - |
| *Oculina patagonica* | E, V | + |
| *Rhopilema nomadica* | E, SC | + |
| *Mnemiopsis leidy* | E, V | + |
| **BRYOZOAIRES** | | |
| *Amathia verticillata* | E, V | + |
| *Akatopora leucocypha* | E, V | - |
| *Bugula neritina* | E, V | + |
| *Licornia jolloisii* | E, SC, V | - |
| *Thalamoporella harmelini* | E, SC, V | - |
| *Thalamoporella rozieri* | E, SC, V | - |
| *Celleporaria cf. brunnea* | E, V | - |
| *Celleporaria labelligera* | E, SC, V | - |
| *Celleporaria cf. sherryae* | E, V | - |
| *Celleporaria vermiformis* | E, V | - |
| *Drepanophora birbira* | E, V | - |
| *Parasmittina egyptiaca* | E, SC, V | - |
| *Parasmittina protecta* | E, SC, V | - |
| *Parasmittina serruloides* | E, SC, V | - |
| *Parasmittina spondylicola* | E, SC, V | - |
| *Smittina nitidissima* | E, V | - |
| *Watersipora subtorquata* | E, V | - |
| *Microporella browni* | E, V | - |
| *Microporella coronata* | E, V | - |
| *Microporella genisii* | E, V | - |
| *Microporella harmeri* | E, V | - |
| *Mucropetraliella thenardii* | E, V | - |
| *Celleporina bitari* | E, V | - |
| *Predanophora longiuscula* | E, SC, V | - |

| | | |
|---|---|---|
| *Scorpiodinipora costulata* | E, V | - |
| *Rhynchozoon larreyi* | E, SC | - |
| *Schizoretepora hassi* | E, SC, V | + |
| **POLYCHETES** | | |
| *Linopherus incarunculata* | ?, SC | - |
| *Eusyllis kupfferi* | E, V | - |
| *Ceratonereis mirabilis* | E, SC | - |
| *Pseudonereis anomala* | E, SC | - |
| *Lysidice natalensis incert.* | ? | - |
| *Cirriformia semicincta* | ? | - |
| *Branchiomma cingulatum* | E, V | - |
| *Branchiomma luctuosum* | E, V | - |
| *Branchiomma cf. bairdi* | E, SC,V | - |
| *Spirobranchus kraussii* | E, SC, V | + |
| *Serpula hartmanae* | E, V | - |
| *Hydroides cf. brachyacanthus* | E, SC, V | + |
| *Hydroides dirampha* | E, V | - |
| *Hydroides elegans* | Inv, V | + |
| *Hydroides heterocera* | E, SC, V | - |
| *Hydroides minax* | E, SC, V | - |
| *Hydroides operculatus* | E, SC, V | - |
| *Spirobranchus tetraceros* | E, SC, V | + |
| *Spirorbis (Spirorbis) marioni* | E, V | + |
| **MOLLUSQUES** | | |
| *Cellana rota* | R, SC | + |
| *Pseudominolia nedyma* | ?, SC | - |
| *Trochus erithreus* | E, SC | + |
| *Cerithium scabridum* | E, SC | + |
| *Rhinoclavis kochi* | E, SC | + |
| *Finella pupoides* | ?, SC | - |
| *Cerithiopsis pulvis* | ?, SC | - |
| *Conomurex persicus* | Inv, SC | + |
| *Purpuradista gracilis notata* | E, SC | + |
| *Ergalatax junionae* | E, SC, V | + |
| *Indothais sacellum* | E, SC, V | + |
| *Murex forskoehlii* | E, SC | + |
| *Zafra savignyi* | ?, SC | - |
| *Fusinus verrucosus* | E, SC | + |
| *Pyrgulina fischeri* | ?,SC | - |
| *Pyrgulina maiae* | ?, SC | - |
| *Cingulina isseli* | ?, SC | - |
| *Syrnola fasciata* | ?, SC | - |
| *Amathina tricarinata* | R, SC | - |

| | | |
|---|---|---|
| *Ventomnestia girardi* | ?, SC | - |
| *Acteocina mucronata* | ?, SC | - |
| *Pyrunculus fourierii* | ?, SC | - |
| *Elysia grandifolia* | E, V | + |
| *Bursatella leachii* | E, SC | + |
| *Syphonota geographica* | E, SC | - |
| *Pleurobranchus forskalii* | E, SC | - |
| *Goniobranchus annulatus* | E, SC | + |
| *Hypselodoris infucata* | E, SC | + |
| *Plocamopherus ocellatus* | E, SC | - |
| *Flabellina rubrolineata* | E, SC | + |
| *Anadara natalensis* | E, SC | + |
| *Brachidontes pharaonis* | Inv, SC, V | + |
| *Lioberus ligneus* | E, SC | + |
| *Pinctada imbricata radiata* | E, SC | + |
| *Malleus regula* | Inv, SC | + |
| *Spondylus spinosus* | Inv, SC | + |
| *Spondylus sp.* | E, SC | + |
| *Dendostrea folium* | E, SC | + |
| *Chama asperella* | R, SC | - |
| *Chama pacifica* | Inv, SC | + |
| *Afrocardium richardi* | E, SC | + |
| *Fulvia fragilis* | E, SC, V | + |
| *Mactra lilacea* | E, SC | - |
| *Mactra olorina* | E, SC | + |
| *Gafrarium savignyi* | E, SC | + |
| *Petricola fabagella* | E, SC | - |
| *Sphenia rueppelli* | E, SC, V | + |
| *Laternula anatina* | ?, SC | - |
| *Sepioteuthis lessoniana complex* | E, SC | + |
| **CRUSTACES** | | |
| *Amphibalanus eburneus* | E, V | - |
| *Amphibalanus improvisus* | E, V | - |
| *Balanus trigonus* | E, V | + |
| *Apanthura sandalensis* | E, V | - |
| *Apanthura stanjeki* | E, V | - |
| *Cirolana manore* | ?, V | - |
| *Metacirolana rotunda* | E, V | - |
| *Paracerceis sculpta* | ?, V | - |
| *Paradella dianae* | E, V | - |
| *Pseudocerceis seleneides* | ?, V | - |
| *Sphaeroma walkeri* | E, V | - |
| *Cymothoa indica* | E, V | - |

| | | |
|---|---|---|
| *Erugosquilla massavensis* | ? SC | - |
| *Ixa monodi* | E, SC | + |
| *Leucosia signata* | E, SC | - |
| *Myra subgranulata* | E, SC | + |
| *Matuta victor* | E, SC | - |
| *Micippa thalia* | E, SC | - |
| *Halimede tyche* | R, SC | + |
| *Portunus (Portunus) segnis* | E, SC | + |
| *Callinectes sapidus* | E, V | + |
| *Charybdis (Charybdis) hellerii* | E, SC | + |
| *Charybdis(Goniohellenus) longicollis* | E, SC | + |
| *Thalamita indistincta* | R, SC | - |
| *Thalamita poisonii* | ?, SC | - |
| *Actaea savignii* | ?, SC | - |
| *Atergatis roseus* | E, SC | + |
| *Plagusia tuberculata* | ?, SC, V | + |
| *Percnon gibbesi* | E, V | + |
| *Penaeus pulchricaudatus* | E SC | - |
| *Metapenaeus monoceros* | E, SC | - |
| *Metapenaeus stebbingi* | E, SC | - |
| *Penaeus semisulcatus* | E, SC | - |
| *Saron marmoratus* | R, SC | + |
| **PYCNOGONIDES** | | |
| *Anoplodactylus digitatus* | R, SC, V | - |
| *ECHINODERMES* | | |
| *Diadema setosum* | R, SC, V | + |
| *Aquilonastra burtoni* | E, SC | - |
| *Ophiactis macrolepidota* | E, SC | - |
| *Ophiactis savignyi* | E, SC | - |
| *Synaptula reciprocans* | E, SC | + |
| **ASCIDIES** | | |
| *Phallusia nigra* | E, V | + |
| *Rhodosoma turcicum* | E, V | - |
| *Herdmania momus* | E, V | + |
| *Microcosmus exasperatus* | E, SC, V | + |
| *Botryllus sp.* | R, SC | - |
| *Polycarpa sp.* | R, SC | - |
| *Styela plicata* | E, V | + |
| *Symplegma brakenhielmi* | E, SC | + |

E=established species; Inv=invasive species (abundant, forming facies); R=rare; SC=Suez Canal; V=shipping ; IP=Indo-Pacific; +=species to be monitored; -=species that is small in size or not really recognisable on the spot by a scientist or even specialist diver; ?=unknown status (old mention, and/or found in a single locality particularly by another researcher)

Column 2 in the table shows the status of each species and the corresponding vector of its introduction (or its origin). As for the status of these species, most are established (E); those marked with the sign (?) were mentioned only once in the past literature, and their current status is not known. Invasive species (Inv) are: *Hydroides elegans, Conomurex persicus, Brachidontes pharaonis, Malleus regula, Spondylus spinosus*, and *Chama pacifica*. These species form big facies in many localities throughout the Lebanese coast.

As for the vector of introduction, there is a dominance of Indo-Pacific species introduced by shipping (V). The three Atlantic-origin species are: *Mnemiopsis leidy, Callinectes sapidus*, and *Percnon gibbesi*. The two species *Bugula neritina* and *Smittina nitidissima* are of temperate-hot-tropical origin.

The species marked with the sign (+) in the third column include established and invasive species that need to be monitored. They are big and can be recognised by a specialist diver.

### 3.2.3. Non-indigenous fishes

The number of non-indigenous fishes is 52 species. Table 4 shows the following characteristics:

As for status, most of the species are well established (E) on the Lebanese coast. Some 'rare' species (R) are established in several places but in very small numbers. Rare species that are not established are those found in small numbers (between 2 and 4 individuals) once only in two or three places. This is the case for:

- *Abudefduf vaigiensis*, photographed in two localities on rocky beds between 2 and 5 m down. Four individuals together in Khaizaran (July 2012) and one only in Tyre (September 2012) (Bitar, 2013)
- *Pseudanthias squamipinnis*; one or two individuals were found quite often south of Beirut port by A.Assal in May-June 2000 (Bitar, 2003)
- *Enchelycore anatina*; a single individual found and photographed (May 2008) in the entrance to the Chak El Hatab cave north of Selaata, then in Ramkine (May 2011) and Batroun (June 2011) (Bitar, 2013)
- *Scarus ghobban*; a single individual in three places: Amchit (2009), Beirut (2004), and Sarafand (2005) (Bariche and Saad, 2005)
- *Pomacanthus maculosus*: two adult individuals were sighted south of Beirut (Bariche, 2010)
- *Ostracion cubicus*; one specimen found in Ramkine Island (January, 2011) (Bariche, 2011)
- *Champsodon vorax*; two individuals in 2010 caught in Beirut (Bariche, 2010 and 2011)
- *Epinephelus fasciatus*; a single individual caught north of Tripoli (Bariche & Heemstra, 2012)
- *Heniochus intermedius*; a specimen caught in the Palm Islands Marine Reserve (Bariche, 2012)
- *Platycephalus indicus*; a specimen caught north of Beirut (Bariche, 2012)
- *Tylerius spinosissimus*; a specimen caught in Okaibeh north of Beirut (Mytilineou et al., 2016).

But the far most abundant invasive species (Inv) were the two herbivorous Siganidae *Siganus luridus* and *S. rivulatus*, which compete with the two indigenous herbivorous species *Sarpa salpa* and *Sparisoma cretense*, whose populations seem to be increasingly dwindling.

Table 4. List of Lebanese non-indigenous fishes with their status

| Taxa | Status et introduction vector of NIS | NIS to be monitored |
|---|---|---|
| *Abudefduf vaigiensis* | R, SC | + |
| *Alepes djedaba* | E, SC | + |
| *Apogonichthyoides nigripinnis* | E, SC | + |
| *Atherinomorus forskalii* | E, SC | + |
| *Callionymus filamentosus* | E, SC | + |
| *Champsodon vorax* | R, SC | + |
| *Cheilodipterus novemstriatus* | E, SC | + |
| *Cynoglossus sinusarabici* | R, SC | + |
| *Dussumieria elopsoides* | E, SC | + |
| *Enchelycore anatina* | R, A | + |
| *Epinephelus fasciatus* | R, SC | + |
| *Equulites klunzingeri* | E, SC | + |
| *Etrumeus teres* | E, SC | + |
| *Fistularia commersoniii* | E, SC | + |
| *Hemiramphus far* | E, SC | + |
| *Heniochus intermedius* | R, SC | + |
| *Herklotsichthys punctatus* | E, SC | + |
| *Himantura uarnak* | E, SC | + |
| *Hippocampus fuscus* | R, SC | + |
| *Hyporhamphus affinis* | E, SC | + |
| *Lagocephalus sceleratus* | E, SC | + |
| *Lagocephalus spadiceus* | E, SC | + |
| *Lagocephalus suezensis* | E, SC | + |
| *Liza carinata* | E, SC | + |
| *Lutjanus argentimaculatus* | R, SC | + |
| *Nemipterus randalli* | E, SC | + |
| *Ostracion cubicus* | R, SC | + |
| *Oxyurichthys papuensis* | R, SC | + |
| *Parexocoetus mento* | E, SC | + |
| *Pelates quadrilineatus* | R, SC | + |
| *Pempheris vanicolensis* | E, SC | + |
| *Platycephalus indicus* | R, SC | + |
| *Plotosus lineatus* | E, SC | + |
| *Pomacanthus maculosus* | R, SC | + |
| *Pomadasys stridens* | E, SC | + |
| *Pseudanthias squamipinnis* | R, SC | + |
| *Pteragogus trispilus* | E, SC | + |
| *Pterois miles* | E, SC | + |

| | | |
|---|---|---|
| *Sargocentron rubrum* | E, SC | + |
| *Saurida undosquamis* | E, SC | + |
| *Scarus ghobban* | R, SC | + |
| *Scomberomorus commerson* | E, SC | + |
| *Siganus luridus* | Inv, SC | + |
| *Siganus rivulatus* | Inv, SC | + |
| *Sillago sihama* | E, SC | + |
| *Sphyraena chrysotaenia* | E, SC | + |
| *Stephanolepis diaspor* | E, SC | + |
| *Torquigener flavimaculosus* | E, SC | + |
| *Tylerius spinosissimus* | R, SC | + |
| *Tylosurus choram* | R, SC | + |
| *Upeneus moluccensis* | E, SC | + |
| *Upeneus pori* | E, SC | + |

E=established species; Inv=invasive species; R=rare; SC=Suez Canal; A=Atlantic via Gibraltar; += species to be monitored

As for the vectors of introduction, all the species were Indo-Pacific introduced via the Suez Canal (SC), apart from the fish Enchelycore anatina, which is of eastern-Atlantic origin (A).

These 52 species of fishes are all to be monitored (+), especially since most of them frequent depths that can be accessed by underwater diving.

Observation on the 3 NIS lists: these lists should be permanently evolving according to the improvement in knowledge and the results of regular sea follow-ups.

### 3.2.4. Non-indigenous species in at-risk zones

#### 3.2.4.1. Case of ports

The ports that correspond to the main areas where non-indigenous species enter are deemed to be at-risk zones. The monitoring of these introduced species is vital. From 2000 on, we were able to explore 4 main ports from north to south: Tripoli, Beirut, Saida and the small port of Nakoura.

- Tripoli port

  In September 2002, G. Bitar and H. Zibrowius found the macrophyte *Caulerpa chemnitzia*, the hydra *Macrorhynchia philippina*, the bryozoa *Bugula neritina*, the serpula *Spirobranchus kraussii*, the mollusc *Trochus erythaeus* and the ascidians *Phallusia nigra, Herdmania momus, Styela plicata* and *Symplegma brakenhielmi* (Bitar, unpublished data).

- Beirut port

  In June 2000, several dives were undertaken by G. Bitar and H. Zibrowius in several localities within Beirut port. The main finding of the diving was that a number of Lessepsian species were being particularly encouraged in this environment, on hard seabeds (black silt at the bottom of the blocks and quays below a superficial layer). *Chama pacifica* was found as a dense population not far from the old lighthouse, seemingly drawing, as a filterer, maximum benefit from the urban sewage. The gastropod Thais sacellum was discovered there for the first time in the Mediterranean and later found in abundance in other sites in the port that were visited. The nudibranch *Hypselodoris infucata*, small (about 1 cm) but easily noticed because of being multicoloured, was very abundant near the old lighthouse in June 2000, but the abundance was probably seasonal, for the species was scarcely noticed in September 2002. The black holothurian *Synaptula reciprocans* in September 2002 was extremely abundant on the blocks near the end of the jetty. The superficial concretions caused by the serpulidae polychaete *Spirobranchus kraussii* covered the blocks for a good distance along the main jetty and the vertical walls of the quay elsewhere. Probably fast-growing, these encrustations could become bothersome on the port structures colonised. Currently, *S. kraussii* is found in several localities throughout the Lebanese coast (Abboud-Abi Saab, 2003).

- Saida port

  In September 2013, as part of the MedMPANet project in Lebanon, G. Bitar, Y. Sghaier and H. El Chaer sighted the macrophytes *Laurencia cf. chondrioides* and *Codium parvulum*, the hydra *Macrorhynchia phillipina*, the ascidiacea *Phallusia nigra*, the mol-

luscs *Brachidontes pharaonis, Spondylus spinosus, Chama pacifica, Malleus regula, Gafrarium savignyi, Conomurex persicus, Ergalatax junionae, Hypselodoris infucata* and the fishes *Siganus rivulatus* and *Sargocentron rubrum* (RAC/SPA-UNEP/MAP, 2014).

- Nakoura port

  In September 2002, in Nakoura port, near the quay represented by a 4-5 m high cliff, G. Bitar and H. Zibrowius found the scleractinian *Oculina patagonica* (both on the cliff and on the seabed), the three molluscs *Spondylus spinosus, Gafrarium savignyi* and *Trochus erithreus*, and the fishes *Sargocentron rubrum* and *Siganus rivulatus* (Bitar, unpublished data).

  It should be said that all the species mentioned in the 4 ports were well established, apart from *Caulerpa chemnitzia*, which has not been found in Tripoli port since it was first sighted in 2002.

#### 3.2.4.2. Case of fouling

In the populations of fouling, the phenomenon of the growth of the exotic species is spectacular, especially for example on the pillars of Beirut port in Ouzai. These pillars are totally covered by exotic invertebrates from the surface down to 20 m depth: *Bugula neritina, Brachidontes pharaonis, Pinctada radiata, Chama pacifica, Malvufundus regulus, Spondylus spinosus, Charybdis hellerii, Phallusia nigra, Styella plicata, Herdmania momus* and *Symplegma brakenhielmi* (Bitar et al., 2007). The polychaetes *Branchiomma cf. bairdi* are very abundant.

## 4. IMPACTS OF NON-INDIGENOUS SPECIES

Alien invasive species (AIS) are seen as one of the main causes of biodiversity loss, and of impacts on habitats or ecosystems and thus on the economy and human health. The pressure of the presence of AIS also brings about a loss of a habitat's structure, processes and functions. Thus, the final effect is often the restructuring of habitats, biotic homogenisation and biodiversity reduction.

The pressures and impacts of EISs at the level of species and habitats are numerous.

### 4.1. Competition for space

This pressure gives rise to a reduction and contraction of the indigenous species' niche, and even their replacement. This is so for the potentially invasive non-indigenous macrophytes: *Stypopodium schimperi, Galaxaura rugosa, Laurencia cf. chondrioides, Codium parvulum* and *Ulva lactuca*.

As for evolution and occurrence in time, we give the example of the invasive species *Stypopodium schimperi* (Bitar et al., 2000). We first found it in Barbara in 1991. In 1993, in the same locality, we started to study its seasonal variations and expansion. The vegetation period extends from late February to September. Young fronds (3 to5 cm high) were observed in the last week of February. The adult thalli appear in April-May. In June, the fronds are over 22 cm high. In this period, the alga invades the seabed at the expense of other species. During the months of June and July, big masses of drifting alga can be seen on the bed and along the coast. In late August, the populations regress and the alga become scarcer. In November it disappears almost completely. Since 2000, this species has become very abundant throughout the Lebanese coast from the surface down to 45 m depth, at the expense of the indigenous benthic associations (Bitar et al., 2000; Bitar, 2010 b; RAC/SPA-UNEP/MAP, 2014). The associations affected by Stypopodium and also by other invasive macrophytes are (inter alia): *Stypocaulon scoparium, Colpomenia sinuosa, Dictyota spp.* and *Dictyopteris polypodioides* (Bitar et al., 2000).

### 4.2. Competition for food

This is the case for the two exotic siganids *Siganus luridus* and *S. rivulatus* and the two indigenous species *Sarpa salpa* and *Sparisoma cretense*, which are all herbivorous species competing for the same food source.

Because of this, competition for space and food has a negative impact on the structures and functioning of the ecosystems. IAS can often change the habitat's structures and functioning; for example, invasion by herbivorous species like *Siganus rivulatus* in Lebanon can modify the structure of the rocky bed and denude the marine environment of all macrophytic cover.

### 4.3. Predation

The absence of indigenous predators encourages the establishing of IAS. This is so for the *Siganus* species that has no local predators. Another example is Stypopodium, which possesses a powerful ichthyotoxin, stypoldione, which can partly explain its success in comprehensively covering large stretches of the seabed (Bitar et al., 2000). The repercussions of predation, expressed in the reduction of prey (or vegetation), reflect the fact that the native species may not have evolved defences against the IASs.

### 4.4. Direct impact of NISs on human health and activities

In Lebanon, the typical example of an invasive species capable of directly affecting human health and activities is the stinging jellyfish *Rhopilema nomadica*. This species, which causes pain and harm, prevents the local people and tourists from going to the beach, especially in the summer. Other species that affect human health are the following fish species: *Lagocephalus sceleratus, Lagocephalus spadiceus, Lagocephalus suezensis, Torquigener flavimaculosus, Pterois miles* and *Plotosus lineatus*.

### 4.5. Vulnerability

An ecosystem's vulnerability to invasive species also seems to be linked to its environmental status: polluted or physically degraded environments are more vulnerable to invasion than very clean sites. But in Lebanon this is not always the case. The exotic species' resistance capacity is explained by their ability to settle at different depths and in both clean and polluted zones, including ports (e.g. *Chama pacifica, Spondylus spinosus, Spirobranchus kraussii, Synaptula reciprocans, Sargocentron rubrum*); other species can be found simultaneously in and outside caves (e.g. *Spirobranchus kraussii* and *Phallusia nigra*) (Bitar, 2008).

### 4.6. Role of climate change

According to Bitar's report (2008) 'National overview on vulnerability and impacts of climate change on marine and coastal biodiversity in Lebanon', the arrival of exotic species and their adaptation to the ecological conditions of their new environment are due in great part to its being tropicalized and to their having a greater resistance capacity than the indigenous species. Indeed, the impacts of exotic species are encouraged by the effects of climate change as regards the deterioration of ecosystems, mortalities and the disappearance of sensitive species in the eastern Mediterranean, in particular Lebanon. It should be remembered that the impact of global change is older in the eastern Mediterranean than in the north-western Mediterranean (the early 1990s). In 1964, Pérès and Picard highlighted the high frequency of warm-affinity species in the Levantine basin, but did not mention the influence of exotic species from the Red Sea (species of Indo-Pacific origin). Probably the role of these species in structuring the Mediterranean biocenoses was not yet significant. In this sense, the Lebanese coast is an interesting biotope for studying the changes linked to the 'tropicalization' of the Mediterranean and to the exotic species (introduced or migrating via the Suez Canal), especially since knowledge about the benthic and ichthyological communities has progressively increased (Bitar et al., 2007).

According to Bitar (2008), the Levantine basin, where the thermal register is much higher, is more affected by climate change and thus gives a picture of what the beds and habitats of the western basin could in time become. In the hottest parts of the Mediterranean, like the Levantine coast, the deterioration in the ecosystems, mortalities and the disappearance of species sensitive to warming have long been under way (e.g. the gorgonians, the black mussel *Mytilus galloprovincialis*, and the posidonian *Posidonia oceanica*). In 1938, the *Mytilus galloprovincialis* mussels that used to exist "in abundance and of fine size", according to Gruvel (1931) were "absolutely [lacking] on the Lebanese littoral" (Pallary, 1983). The mussel was replaced by the exotic species Brachidontes pharaonis both in Lebanon and in Syria. The *Posidonia oceanica* meadow has not been seen in Lebanon since at least 1977. The meadow has been replaced by that of *Halophila stipulacea*. The gorgonians that were sighted by Gruvel in 1931 have no longer been cited in the literature. In this regard, a gorgonian *Swiftia pallida* was recently found, in October 2016, within the Deep-Sea Lebanon project, 600 m down on silted-up rock.

As for the herbivorous fishes, the two Lessepsian species *Siganus rivulatus* and *S. luridus*, which have commercial value, are replacing the local species *Sarpa salpa*, which is becoming increasingly scarce. The same holds good for the crab *Charybdis helleri*, which is becoming increasingly abundant at the expense of *Eriphia verrucosa, Pilumnus hirtellus* and *Pachygrapsus marmoratus* (Bitar, 2008).

One of the consequences of the introduction of exotic species and climate change is the spatial displacement of species, enabling them to hold steady in environmental conditions that are favourable to their growth and reproduction. As an example, the two fishes *Thalassoma pavo* and *Balistes carolinensis*, abundant in the eastern Mediterranean, have become common in the north-western Mediterranean; the same holds good for *Diplodus cervinus cervinus*, which was unknown in that region until 1980 (Pérez, 2008).

### 4.7. Critical status of some indigenous species

It should be noted that we are currently experiencing a dwindling in the abundance, or even an extreme scarcity or a critical status, of several indigenous species (Bitar, personal observation).

- The 2 urchins in the superficial stages that were explored using aqualung, *Paracentrotus lividus* and *Arbacia lixula*, are very rare, or even 'absent', in many parts of the Lebanese coast, if not all. This seems to be due to several reasons: the overexploiting of these herbivorous urchins, the replacing of indigenous macrophytes (the source of the urchins' food) by non-indigenous macrophytes, some of which

secrete harmful substances, and lastly global warming. This holds good also for the asterids *Marthasterias glacialis, Coscinasterias tenuispina* and *Echinaster sepositus*.

- The ophiurans *Ophioderma longicauda*, which were present until 2003, are now absent. They used to be found under little blocks.
- The facies with the acorn-shell *Perforatus perforatus* are everywhere in poor condition, for during our dives we found empty tests still fixed to the substrata; the same for the exotic acorn-shell *Balanus trigonus*. We wonder whether this is not because of the calcareous sponges (*Cliona parenzani*) that carpet the rock. These carpet-forming sponges form facies of 2-3 square metres everywhere, especially in shallow water. It is not rare to find rocky beds covered by this species, with no macrophyte cover

## 5. IMPLEMENTING THE OPERATIONAL PLAN AND MONITORING

The monitoring programme of the non-indigenous species goes hand in hand with the study of benthic habitats.

### 5.1. Means, tools and methods used

Monitoring the IASs in the supra- and medio-littoral stages, including vermetid platforms, is done on foot, while monitoring in the shallows is done without the use of aqualung. But monitoring the infra- and circa-littoral stages is done using aqualung. 'Drop cameras' and quadrate photos (not yet available) are always useful.

Moving around out at sea is done with the help of the national oceanographic boat, the Cana, while coastal trips are made either in little rented traditional fishing boats or in a small Navy boat. The Lebanese CNRS has just got a 7 m-long catamaran (CADMOS-CNRS) which will be well-equipped for all field studies done near the coast.

The traditional way of monitoring NIS is by the visual method, with sampling for species that are not directly recognisable by underwater diving. Underwater photography is certainly necessary for the monitoring programme, as for that of monitoring benthic habitats.

### 5.2. Monitoring systems

Unlike other countries, Lebanon does not possess systems for monitoring (specifically or not) NIS. It is therefore recommended to create various systems for macrophytes, fishes, and other zoological groups, and for certain potentially invasive species.

### 5.3. Operational implications requested and suggested for the correct follow-up of the programme

#### 5.3.1. Human resources

- The first priority as regards requirements is the enhancing of Lebanese specialists' capacities in oceanology generally, and especially taxonomy, to be able to distinguish indigenous from non-indigenous species. Training in undersea diving will be necessary
- Qualified divers to accompany the scientists and specialists in field work
- At least two sailors to carry on the work on board the little boat CADMOS-CNRS and to help the divers.

#### 5.3.2. Equipment and devices requested

As in the benthic habitat monitoring programme, (EO1), it is recommended to have complete diving equipment for 4 people in order to work in total safety, at least two underwater cameras, a drop camera and quadrate photos. The rest of the equipment and means of research exist in the Batroun National Centre for Marine Science.

#### 5.3.3. Sites to be monitored

Three sites or areas of monitoring are proposed (see figure 1):

- 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

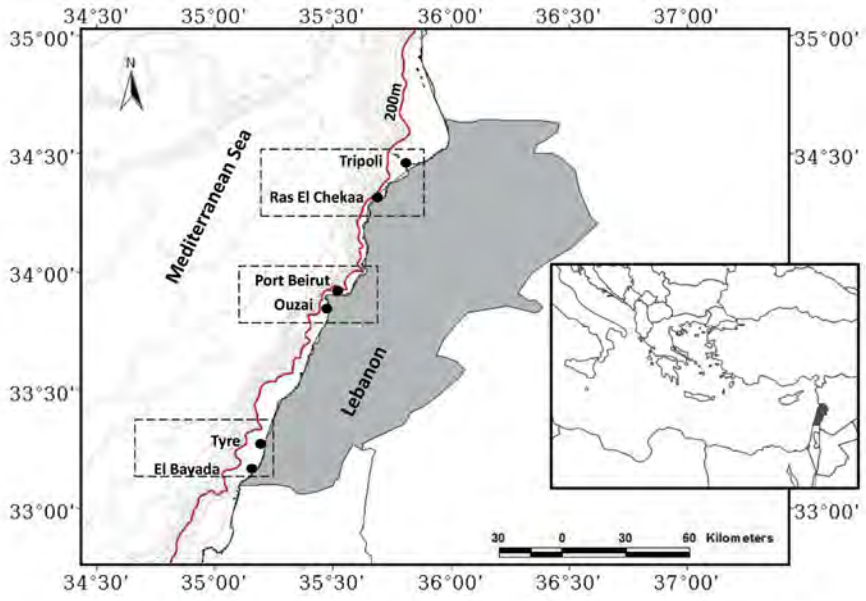


Figure 1. Monitoring sites

### 5.3.4. Strategy for exploring and sampling

Given that this ecological objective (EO2) is directly related to that for marine habitats (EO1-Benthic Habitats), both monitoring programmes can be carried on together once a year. As well, it is important, even necessary, to organise one or two short assignments a year (one in March-April and another in September-October) to correctly follow-up the introduction of exotic species, given:

- the geographic situation of Lebanon, near the Suez Canal, seen as a vector of introduction of Indo-Pacific exotic species, and
- the kinetics of introduction and the rate of arrival of exotic species in the Lebanese coast, which is accelerating compared to the western Mediterranean, particularly for NIS.

### 5.3.5. Storing, sharing and accessing scientific data

The MoE, through the Lebanese Environment and Development Observatory (LEDO) used to centralise all the basic data on marine and other environmental information. But since 2002, the LEDO has not been running. Currently, each university centralises its own data, as do the CNRSL and the NCMS. For the marine environment, the Centre for Marine Sciences has long taken on the monitoring with a network of about thirty stations along the Lebanese coast, covering physical, chemical and bacteriological issues. So, we suggest that the CNRS and its National Centre for Marine Sciences, working alongside the MoE, become responsible for the management and storing of all marine environment data at national level. It is for them to take the necessary steps for the scientific community to have access to this data.

### 5.3.6. Link with other monitoring programmes

Data from this programme can of course be used for the requirements of the Benthic Marine Habitats monitoring programme.

### 5.3.7. Those responsible for implementation

The MoE, all the concerned ministries, the CNRSL, the NCMS, the universities, research institutes, national committees, donors, and private sectors plus the important assistance and associated expertise of the United Nations bodies, the UNEP-MAP-RAC/SPA, the IUCN, and the specialist researchers, especially in taxonomy, from regional and international universities and marine research centres. Also, recourse to 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 impact on local habitats.

### 5.3.8. Conclusion and recommendations for implementing the programme of monitoring NIS in Lebanon

It is very important to take into consideration the different points dealt with in this report. The recommendations for implementing this national programme are:

- The most important obligation and priority is training national specialists to have taxonomic skills in most of the groups of NIS.
- In the absence of binding regulations on the introduction of new species into the territory, the ecological status in 2020 or in 2030, suggested by the MoE concerning non-indigenous species, will automatically be less good than now, and the GES objectives of the EcAp will not be attained. Indeed, without these regulations, it is almost impossible to restrict the introduction of new species. Once they are introduced, it is illusory to want to restrict their impacts. Thus, the need to strengthen the legislation on the introduction of species. In this regard, we must take into consideration:
  - the harmful effects of ballast water
  - the socio-economic impact of biological invasions on the marine environment
  - remedies and means of fighting this
- Regulations must include the two most binding preventions; two lists must be made:
  - A blacklist of species whose entry into the territory must be forbidden
  - A white list of species for which it has to be shown that they present no danger or invasive nature
- Creation of a permanent observatory of introductions of species into the marine environment
- Skill in risk analysis and applied modelling for the introduction of invasive species is required
- Creation of a national internet site to spread information about introduced/invasive species in the marine environment. This web interface would be fed by scientific experts and would have the assignments of:
  - information: species sheets, distribution cards, brochures and posters with photos of NIS, particularly invasive species
  - monitoring: enabling the signalling of new species, notification of changes in the distribution of those already introduced, and
  - awareness: for the wider public (precautions concerning pleasure boating, purchase of bait, aquariology…), awareness as to the need for evolving regulations
- Developing the skills and enhancing the capacities of users of ports, the coastal region and the sea, in the field of protecting nature and its resources
- Directing research to give priority to:
  - developing protocols for monitoring and impacts of NISs (e.g. the Rapid Assessment Survey type) and long-term studies on biological invasions, in order to follow up ecological change over periods of five or more years. The various diving clubs or associations must be encouraged to play a part in this monitoring programme
  - the impact of global climate change on indigenous and non-indigenous species
- Setting up long-term national and international research programmes within a framework of strengthening cross-border cooperation
- Setting up national, regional and international inter-organ coordination on the issue of non-indigenous species, in particular invasive species
- Sites proposed for the monitoring of non-indigenous species should satisfy the choice criteria recommended by the IMAP. The monitoring, or the space and time element of the covering, could be changed according to unexpected needs
- The results emerging from this programme could also be used for the purposes of the Marine Benthic Habitats monitoring programme.

## References


1. Abboud-Abi Saab, M., Bitar, G., Harmelin, J.G., Harmelin-Vivien, M., Romano, J.C., Zibrowius, H. 2003. Environnement côtier et biodiversité marine sur les côtes libanaises ; inventaire et mise en place d'un ensemble matériel et humain d'observation et d'analyse de leur évolution, degré d'altération des communautés benthiques littorales. RAPPORT FINAL. Programme de coopération Franco-Libanaise CEDRE (1999-2002): 75 p.
2. Abdul Malak, D. et al. 2011. Overview of the Conservation Status of the Marine Fishes of the Mediterranean Sea. Gland, Switzerland and Malaga, Spain: IUCN. vii + 61pp.
3. Bariche, M. & Saad, M. 2005. Settlement of the Lessepsian blue-barred parrotfish Scarus ghobban (Scaridae) in the Mediterranean. JMBA2 - Biodiversity records, published online.
4. Bariche, M. 2010. First record of the angelfish Pomacanthus maculosus (Teleostei: Pomacanthidae) in the Mediterranean. Aqua, International Journal of Ichthyology, 16, 31-33.
5. Bariche, M. 2010. Champsodon vorax (Teleostei: Champsodontidae), a new alien fish in the Mediterranean. Aqua, International Journal of Ichthyology, 16, 197-200.
6. Bariche, M. 2011. First record of the cube boxfish Ostracion cubicus (Ostraciidae) and additional records of Champsodon vorax (Champsodontidae) from the Mediterranean. Aqua, International Journal of Ichthyology, 17, 181-184.
7. Bariche, M. & Heemstra, P. 2012. First record of the blacktip grouper Epinephelus fasciatus (Teleostei: Serranidae) in the Mediterranean Sea. Marine Biodiversity Records, 5, e1.
8. Bariche, M. 2012. Recent evidence on the presence of Heniochus intermedius (Teleostei: Chaetodontidae) and Platycephalus indicus (Teleostei: Platycephalidae) in the Mediterranean Sea. BioInvasions Records. Volume 1
9. Basson, P.W., Hardy, J.T. & Lakkis, V. 1976. Ecology of marine macroalgae in relation to pollution along the coast of Lebanon. Acta Adriatica, 18: 307-325.
10. Bellan-Santini, D. Lacaze, J.C. & Poizat, C. 1994. Les biocénoses marines et littorales de Méditerranée: Synthèse, menaces et perspectives. Muséum National d'Histoire Naturelle, Collection Patrimoines Naturels, Vo. 19, 246 pp.
11. Bitar, G. 1996. Le macrozoobenthos. in: Etude de la biodiversité biologique du Liban. Pub.5: Faune et flore marines et côtières. Projet GF/ 6105-92-72. Minist. Agr. Liban, PNUE: 41-48, Tab. 22: 113-126.
12. Bitar, G. 1999. Sur les Caulerpa de la côte libanaise (Méditerranée orientale). Actes de l'atelier sur les espèces Caulerpa invasives en Méditerranée. Heraklion, Crète Grèce, 18-20 mars 1998. PNUE, PAM, MED POL. MAP Technical Reports Series N,. 125: 275-277.
13. Bitar, G. 2008. National overview on vulnerability and impacts of climate change on marine and coastal biodiversity in Lebanon. Contrat RAC/SPA, N° 16: 35 pages.
14. Bitar, G. 2010 a. Impact des changements climatiques et des espèces exotiques sur la biodiversité et les habitats marins au Liban. Rapp. Comm. Int. Mer Médit., 39, p. 452.
15. Bitar, G. 2010 b. La flore marine benthique introduite de la côte libanaise. Etat actuel de trois espèces envahissanates. INOC-Tischreen University, International Conference on Biodiversity of the Aquatic Environment: 107-114.
16. Bitar, G. 2011. Les peuplements benthiques et ichthyologiques du littoral libanais. Impacts des espèces exotiques et du réchauffement climatique sur la biodiversité et les habitats marins. Rapport final des recherches sur la biodiversité marine benthique effectués dans le cadre de l'« Etablissement d'un projet de surveillance et d'environnement durable de la côte libanaise: Projet CANA-CNRS » (Contrat Réf.: 111/ 2010). 45 p., Annexe, 22 p.
17. Bitar, G. 2013. Sur la présence des poissons exotiques nouveaux de la côte libanaise (Méditerranée orientale). Rapp. Comm. Int. Mer Médit., 40, p. 592.
18. Bitar, G. 2014. Les Mollusques exotiques de la côte libanaise. Bull. Soc. zool. Fr., 139 (1-4): 37- 45.
19. Bitar, G. Bitar -Kouli S., 1995a. Aperçu de bionomie benthique et répartition des différents faciès de la roche littorale à Hannouch (Liban-Méditerranée orientale). Rapp. Comm. int. Mer Médit., 34, p.19.
20. Bitar, G., Bitar – Kouli, S. 1995b. Impact de la pollution sur la répartition des peuplements de substrat dur à Beyrouth (Liban-Méditerranée orientale). Rapp. Comm. int. Mer Médit., 34, p.19.

21. Bitar, G., Harmelin, J.G., Verlaque, M., Zibrowius, H. 2000. Sur la flore marine benthique supposée lessepsienne de la côte libanaise. Cas particulier de Stypopodium schimperi. RAC/SPA, (eds), Proceedings of the First Mediterranean Symposium on Marine Vegetation, Ajaccio, 3 et 4 Oct. 2000. Mednature 1, RAC/SPA, PNUE: 97-100.

22. Bitar, G., Kouli- Bitar, S. 1996. Inventaire des mollusques marins connus jusqu'à présent au Liban. Données biogéographiques et écologiques de quelques espèces nouvelles pour la côte libanaise. Xe.Congrès Soc. Francaise Malacologie, Agadir (Maroc).

23. Bitar, G., Kouli- Bitar, S. 1998. Inventaire des mollusques marins benthiques du Liban et remarques biogéographiques sur quelques espèces nouvellement signalées. Mésogée, Marseille. 56: 37-44.

24. Bitar G., Kouli- Bitar, S. 2001. Nouvelles données sur la faune et la flore benthiques de la côte libanaise. Migration lessepsienne. Thalassia Salentina, Italie. 25:71-74.

25. Bitar, G., Ramos-Esplá A.A., Ocaña O., Sghaier Y.R., Forcada A., Valle C., El Shaer H., Verlaque, M., 2017. Introduced marine macroflora of Lebanon and its distribution on the Levantine coast. Mediterranean Marine Science.

26. Bitar, G, Ocaña, O & Ramos-Esplá, A. 2007. Contribution of the Red sea alien species to structuring some benthic biocenosis in the Lebanon coast (Eastern Mediterranean). Rapp. Comm. Int. Mer Médit., 38, p. 437.

27. Bitar, G., Zibrowius, H., 1997. Scleractinian corals from Lebanon, Eastern Mediterranean, including a non-lessepsian invading species (Cnidaria: Scleractinia). Sci. Mar., 61 (2): 227-231.

28. Crocetta, F., Bitar, G., Zibrowius, H., Capua, D., Dell'Angelo, B. & Oliverio, M. 2014. Biogeographical homogeneity in the eastern Mediterranean Sea – III. New records and a state of the art of Polyplacophora, Scaphopoda and Cephalopoda from Lebanon (Mollusca). Spixiana 37 (2): 183-206.

29. Crocetta, F., Bitar, G., Zibrowius, H., and Oliverio, M. 2013 a. Biogeographical homogeneity in the eastern Mediterranean Sea. II. Temporal variation in Lebanese bivalve biota. Aquat Biol 19: 75–84.

30. Crocetta, F., Zibrowius, H., Bitar, G., Templado, J. and Oliverio, M. 2013 b. Biogeographical homogeneity in the eastern Mediterranean Sea - I: the opisthobranchs (Mollusca: Gastropoda) from Lebanon. Medit. Mar. Sci., 14/2, 2013, 403-408.

31. Golani, D., Öztürk, B., Başusta, N. 2006. Fishes of the eastern Mediterranean. Turkish Marine Research Foundation, Istanbul, Turkey. 259 pp.

32. Gruvel, A. 1931. Les Etats de Syrie. Richesses marines et pluviales. Soc. Edit. Géogr. Marit. et Colon., Paris, 453 p.

33. Harmelin, J. G., Bitar G., Zibrowius H. 2007. «Schizoretepora hassi n.sp. (Bryozoa, Phidoloporidae) from Lebanon (Eastern Mediterranean) and reappraisal of Schizotheca serratimargo (Hincks, 1886)». Cahiers de Biologie Marine. 48: 179 - 186.

34. Harmelin, J. G., Bitar, G., Zibrowius, H. 2009. Smittinidae (Bryozoa, Cheilostomata) from coastal habitats of Lebanon (Mediterranean Sea) including new and non-indigenous species. Zoosystema 31 (1): 163-187.

35. Harmelin-Vivien, M.L., Bitar, G., Harmelin, J.G., Monestiez, P. 2005. The littoral fish community of the Lebanese rocky coast (eastern Mediterranean Sea) with emphasis on Red Sea immigrants. Biological Invasions, 7: 625-637.

36. https://wedocs.unep.org/bitstream/handle/20.500.11822/21262/17wg444_6_eng.pdf?sequence=1&isAllowed=y

37. http://www.rac-spa.org/sites/default/files/ecap/ig22_inf7.pdf

38. Kapiris, K., Apostolidis, C., Baldacconi, R., Başusta, N., Bilecenoglu M., Bitar, G., Bobori, D.C., Boyaci, Y.Ö, Dimitriadis, C., Djurović, M., Dulčić, J., Duruan, F., Gerovasileiou, V., Gökoğlu, M., Koutsoubas, D., Lefkaditou, E., Lipej, L., Marković, O., Mavrič, B., Y. Özvarol, Y., Pesic, V., Petriki, O., A. Siapatis, A., Sini, M., Tibullo, D. and Tiralongo, F. 2014 (Collective Article A). New Mediterranean Marine biodiversity records (April, 2014). Medit. Mar. Sci., 15/1, 198-212.

39. Katsanevakis, S., Poursanidis, D., Yokes, M. B., Mactic, V., Beqiraj, S., Kashta, A L., Sghaier, Y. R., Zakhama-Sraieb, R., Benamer, I., Bitar, G., Bouzaza, Z., Magni, P., Bianchi, C. N., Tsiakkiros, L. and Zenetos, A. 2011. Twelve years after the first report of the crab Percnon gibbesi (H. Milne Edwards, 1853) in the Mediterranean: current distribution and invasion rates. Journal of Biological Research-Thessaloniki 16: 224 – 236.

40. Lakkis, S. 2013. Flore et faune marines du Liban (Méditerranée Orientale). Biologie, biodiversité, biogéographie. Aracne Publ., Rome, 510 pp.

41. Lakkis, S. & Novel-Lakkis, V. 2000. Distribution of the Phytobenthos along the coast of Lebanon (Levantine coast, East Mditerranean). Medit.Mar.Sci.,1/2;143-164.

42. Lebanon's Marine Protected Area Strategy. 2012. Supporting the management of important marine habitats and species in Lebanon. Beirut, Lebanon, Gland, Switzerland y Malaga, Spain: the Lebanese Ministry of Environment / IUCN. 64 p.

43. Logan, A., Bianchi, C.N., Morri, C., Zibrozius, H., Bitar, G. 2002. New records of recent brachiopods from the eastern Mediterranean Sea. Annali del Museo civico di Storia naturale «G. Doria», Genova, 94: 407- 418.

44. Louisy, P. 2002. Guide d'identification des poissons marins. Europe et Méditerranée.Ulmer Ed., 430 p.

45. MoE/UNEP/GEF. 2016. National Biodiversity Strategy and Action Plan. Project – NBSAP, 113 p.

46. Morri, C., Puce, S., Bianchi, C.N., Bitar, G., Zibrowius, H., Bavestrello, G. 2009. Hydroids (Cnidaria: Hydrozoa) from the Levan Sea (mainly Lebanon), with emphasis on alien species. J. Mar. Biol. Association, UK, 89 (1): 49-62.

47. Mouneimné, N., 2002. Poissons marins du Liban et de la Méditerranée orientale. Printed by IPEX: 271p.

48. Mytilineou, C., Akel, EH., Babali, N., Balistreri, P., Bariche, M., Boyaci, YÖ., Cilenti, L., Constantinou, C., Crocetta, F., Çelik, M., Dereli, H., Dounas, C., Durucan, F., Garrido, A., Gerovasileiou, V., Kapiris, K., Kebapcioglu, T., Kleitou, P., Krystalas, A., Lipej, L., Maina, I., Marakis, P., Mavrič, B., Moussa, R., Peña-Rivas, L., Poursanidis, D.,Renda, W., Rizkalla, SI., Rosso, A., Scirocco, T., Sciuto, F., Servello, G., Tiralongo, F., Yapici, S., and Zenetos, A. 2016. New Mediterranean Biodiversity Records (November, 2016) Mediterranean Marine Science, 17, 794-821.

49. Otero, M., Cebrian, E., Francour, P., Galil, B., Savini, D. 2013. Monitoring Marine Invasive Species in Mediterranean Marine Protected Areas (MPAs): A strategy and practical guide for managers. Malaga, Spain: IUCN. 136 pages.

50. Pallary, P. 1938. Les Mollusques marins de la Syrie. J. Conchyol., Paris. 82 (1): 5-58.

51. Pérès, J.M., Picard, J. 1964. Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec. Trav. St. Mar. Endoume, 31(47): 1-133.

52. Pérez, T. 2008. Impact des changements climatiques sur la biodiversité marine et côtière en Méditerrranée. UNEP-MAP-CAR/ASP (N°27/2007/RAC/SPA), Tunis: 58 p.

53. RAC/SPA - UNEP/MAP. 2014. Ecological characterization of sites of interest for conservation in Lebanon: Enfeh Peninsula, Ras Chekaa cliffs, Raoucheh, Saida, Tyre and Nakoura. By Ramos-Esplá A.A., Bitar G., Khalaf G., El Shaer H., Forcada A., Limam A., Ocaña O., Sghaier Y.R. & Valle C. Ed. RAC/SPA - MedMPAnet Project, Tunis: 146 p + annexes.

54. UNEP/IUCN/GIS-Posidonia. 1990. Livre rouge 'Gérard Vuignier' des végétaux, peuplements et paysages marins menacés de Méditerranée. MAP Technical Report Series, No. 43. UNEP, Athens, 250 pp.

55. UNEP-MAP-RAC/SPA. 2006. Classification of Benthic Marine Habitat Types for the Mediterranean Region. Ed. Regional Activity Centre for Special Protected Areas, Tunis. 14 pp.

56. UNEP-MAP-RAC/SPA. 2015. 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. Denise BELLAN-SANTINI, Gérard BELLAN, Ghazi BITAR, Jean Georges HARMELIN, Gerard PERGENT. Ed. RAC/SPA, Tunis, 161 p. + Annex (Orig. pub. 2002).

57. Zenetos, A., Akel E.H. KH., Apostolidis, C., Bilecenoglu, M., Bitar, G., Buchet, V., Chalari, N., Corsini-foka, M., Crocetta, F., Dogrammatzi, A. , Drakulić, M., Fanelli, G., Giglio, G., Imsiridou, A., Kapiris, K., Karachle, P.K., Kavadas, S., Kondylatos, G., Lefkaditou, E., Lipej, L., Mavrič, B., Minos, G., Moussa, R., Prato, E., Pancucci-Papadopoulou, M.A., Renda, W., Ríos, N., Rizkalla, S.I., Russo, F., Servonnat, M., Siapatis, A., Sperone, E., Theodorou, J.A., Tiralongo, F. and Tzovenis, I. 2015 (Collective Article A). New Mediterranean Biodiversity Records (April 2015). Medit. Mar. Sci., 16/1, 266-284.

58. Zibrowius. H., Bitar. G. 1981. Serpulidae (Annelida Polychaeta) indopacifique établis dans la région de Beyrouth, Liban. Rap. Comm. int. Mer Médit.: 27(2): 159-160.

59. Zibrowius. H., Bitar. G., 2003. Invertébrés Marins Exotiques sur la Côte du Liban. Lebanese Science Journal. Vol. 4, No. 1: 67- 74.

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