Impacts on Coastal Ecosystems and Coastal Tourism: Habitat and Endemic Species

Tunisian scale

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Co-Evolve4BG

Analysis of Threats and Enabling Factors for Sustainable Tourism at Pilot Scale

Habitat and Endemic Species

Tunisian scale

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OVERVIEW

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REVIEW

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Abstract

In general, biodiversity in the Mediterranean Sea is concentrated in the 0-50m deep coastal strip. It is linked mainly to photic, climatic, and hydrodynamic factors. Parallelly, some ecosystems are characterized by high biodiversity/biological productivity and high presence of endemic, rare and threatened species. In Tunisia, they are particularly lacunar/island ecosystems; insulate banks, Posidonia meadows, coralligenous biocenosis and *Cystoseira* beds. Tunisia has made significant efforts both in terms of scientific research and management of marine resources, to preserve habitats and threatened populations. Among the human activities that threaten endemic species and their habitats in Tunisia, the tourism can be cited. It is relatively an old activity located mainly on the coast, notably on the East coast, Djerba (SE) and Tabarka (NW). It contributes significantly to the national economy, but fluctuating from year to year, mainly since the revolution (2011).

Beach tourism with hotels along coastal areas and the occupation of beaches have had negative effects on the marine/coastal biodiversity in Tunisia. This has affected certain specific ecosystems, sensitive and/or rich in biodiversity and endemic species. According to international organizations, around 35 % of marine species are threatened on the coast of Tunisia. Thus, in the tourist areas, phanerogam meadows (Posidonia and eelgrass) and algae are absent in shallow depths (swimming area). In the Gulf of Gabès, the Posidonia meadows have strongly declined due to several other factors, including siltation caused by discharges of phosphogypsum, trawling, organic pollution, Troll fishing and maritime constructions. Biological invasions also represent an additional disturbance factor which has been accentuated in recent decades with the increase in human activities. Some of them, as blue crabs *Callinectes sapidus* (Rathbun, 1896) and *Portunus segnis* (Forskål, 1775) newly introduced in Tunisian waters and the green algae *Caulerpa taxifolia* (M.Vahl) C.Agardh, 1817 introduced about thirty years ago, are invasive and considered as the second cause of biodiversity loss.

I. Overview of habitat and endemic species

In the Mediterranean, specific/functional biodiversity is unevenly distributed. In general, it is concentrated in the 0-50 m deep coastal strip where macro-algae and phanerogams live. This distribution is linked to several factors, photic, climatic, and hydrodynamic, and is strongly correlated with the presence of animals, through trophic chain (Boudouresque, 1997; Numa Troya, 2011; Anonymous, 2017).

Bellan-Santini *et al.* (1994) distinguished, according to the vertical gradient of light, two great systems; the phytic system in which all types of vegetation live and the a-phytic system in which only certain sciaphilic macroalgae remain.

The phytic system, the most important in terms of biodiversity, comprises 4 subdivisions or stages:

- The Supralittoral stage (beach): The upper limit of this zone corresponds to the zone moistened by waves and sea spray. In this stage live organisms which require a high degree of wetting, but which are never immersed.
- The Medio-littoral stage (tidal swing zone): It corresponds to the zone normally beaten by waves, subject to variations in sea level due to winds, atmospheric pressure and tides;
- The Infralittoral stage (permanently submerged zone): This is the submerged zone compatible with the life of marine phanerogams and photophilic algae.
- The Circalittoral stage (area with very low light): It is between the lower limit compatible with the life of phanerogams and photophilic algae and the lower limit compatible with the life of sciaphilic algae.

In the Mediterranean, the Bathyal stage reaches great depths, and the Abyssal stage (deeper) does not exist.

Although marine biodiversity is concentrated in the 0-50m deep coastal strip, some habitats and ecosystems are distinguished by high biodiversity and certain specificities, such as the high presence of endemic species, rare species and threatened species (Ghrabi-Gammar *et al.* 2009; UNEP/MAP-RAC/SPA, 2015). The Mediterranean Basin is recognized as a hotspot for biodiversity: its exceptional flora counts between 15,000 and 25,000 species, 60% of which are unique to the region. Almost a third of the Mediterranean fauna is endemic (CSE, 2008).

Tunisia is known for the great diversity of its marine environment (Boudouresque, 1997; Anonymous, 2014), with the presence of remarkable habitats and ecosystems rich in species. In general, the geomorphology of the Northern region, a mosaic of biotopes (*e.g.,* rocks, cliffs, loose sediments, islands, and marine banks), offers diverse habitats and micro-habitats those are remarkable for the presence of benthic species. As for the Southern coasts, they are characterized by sandy and sandy-muddy bottoms, favorable to the development of sea plant meadows, mainly Posidonia meadows. They have a

very extensive continental shelf, with a very gentle slope and are characterized by a large tide and relatively higher salinity. This gives them a particular biodiversity. The Eastern coasts are an alternation of rocky bottoms and soft bottoms and provided with a relatively extensive continental shelf with Posidonia meadows and lawns with Caulerpa and Cymodocea which are quite frequent and in good condition.

Although these marine ecosystems are characterized by a rich and diverse flora and fauna, certain marine habitats (*e.g.,* Posidonia meadows, coralligenous) and certain important taxonomic groups (*e.g.,* bryozoans, ascidians, crustaceans, cnidarians) remain little or poorly studied (Chebbi, 2010). Knowledge of marine "biodiversity hotspot" habitats along the Tunisian coasts remains partial due, on the one hand, to the lack of complete and up-to-date data and, on the other hand, to the spatial and temporal discontinuity in studies. This makes it difficult to monitor the spatio-temporal evolution of a particular habitat or ecosystem.

II. Data collection (Studies, Projects, Networks, and Initiatives)

II.1. Data from projects

In application of the Convention on Biodiversity (CBD), Tunisia has made significant efforts both in terms of scientific research and the management of marine resources. Several research projects have been carried out by its research institutions aimed at inventorying marine resources for the purposes of sustainable management and conservation. Other international projects have also been carried out in Tunisia, including:

- GIS Posidonia: Scientific Interest Group for the marine environment, Posidonia is an association created in 1982 at the initiative of the French Ministry of the Environment and the National Park of Port-Cros (law of 1901). It brings together academics and managers of the Mediterranean marine environment, Posidonia meadows. Several scientific works carried out by GIS Posidonia with the collaboration of other institutions have been carried out in Tunisia.
- Project "Protection of marine and coastal resources of the Gulf of Gabès - Protection des resources marines et côtières du Golfe de Gabès". Tunisian Government & International Bank for Reconstruction and Development (Grant N ° TF054942-TN), Lot A: Inventory and monitoring of lagoon, marine and introduced species. Lot B: Ballast water management applied to introduce species.
- SPA/RAC - UN Environment/PAM, 2017: National monitoring program for marine biodiversity in Tunisia - Programme national de surveillance de la biodiversité marine en Tunisie. By Ben Haj S., Ed. SPA/RAC, EcAp-MEDII Project.
- Project "National planning in the area of biological diversity in support of the implementation of the 2011-2020 strategic plan of the CBD in Tunisia - Planification nationale en matière de diversité biologique en appui à la mise en oeuvre du plan stratégique 2011-2020 de la CBD en Tunisie": financed by the Global Environment Facility (GEF) and the United Nations Development Program (UNDP).
- Several research projects at national level and/or in cooperation with foreign parties with the objective of inventorying marine flora and fauna for management and conservation purposes.

II.2. Origins of Data

Data relating to endemic marine species in Tunisia is scarce and fragmentary. The list provided in this report is drawn primarily from scientific articles, doctoral theses, and scientific reports.

III. Identification of habitat and endemic species threats and impacts on coastal ecosystems

III.1. Identification of Habitats

In addition to the euphotic coastal zone which concentrates most of the biodiversity, some remarkable ecosystems stand out for their high biodiversity/productivity (Ghrabi-Gammar *et al.* 2009; UNEP/MAP-RAC/SPA, 2015). Among these habitats:

III.1.1. Lacunar ecosystems

Coastal lagoons are generally the area of a strong primary production, induced by the continental inputs of nutritive nutrients and the strong luminosity in the water column. Tunisian lagoons host a specific fauna with several endemic, rare, threatened, and exotic species (Bradaï *et al.* 2004).

III.1.1.1. Boughrara Lagoon

The Boughrara lagoon is in the South-East of Tunisia. It extends over approximately 500km2, thus representing the largest surface area of all Tunisian lagoons. It is surrounded to the North by the Djerba Island and to the other side by the continent. The maximum depth in Boughrara Lagoon is around 16m, but most bottoms vary from 3 to 8m depth.

In 2000, 37 species of macrophytes were reported including 2 Phanerogams (*Cymodocea nodosa* (Ascherson, 1870) and *Posidonia oceanica* (Linnaeus) Delile, 1813), 11 Rhodophyceae (red algae), 12 Phaeophyceae (brown algae) and 12 Chlorophyceae (green algae). Benthic Cyanophyceae, including Lyngbia majuscula (Harvey ex Gomont, 1892), are present and develop in clusters covering large areas. The phanerogam Cymodocea nodosa (Ascherson, 1870) represents 70% of the phytomass and the green algae Caulerpa prolifera (Forsskål) J.V. Lamouroux, 1809 represents 20%. Green nitrophilic algae are only important in some areas near the South-East and South shores and around Jlij islet (10%). As for the benthic macrofauna, it is distributed between the mediolittoral stage, of tidal swing and the infralittoral stage. In the mediolittoral, the gastropod *Potamides conicus* (Blainville, 1829) dominates this zone, especially in the Southeastern region (Khedhri, 2016).

For the infralittoral stage, especially in the first three meters, the benthic community consists mainly of euryhaline and eurythermal species, like the lamellibranch *Cerastoderma glaucum* (Derbali, 2011).

For the Northwestern sector, the bivalve *Ruditapes decussatus* (Linnaeus, 1758) is very abundant, while the Guellela region is dominated by the species *Pinctada imbricata* (Röding, 1798). The Ajim-Jorf canal area is characterized by the bivalves *Donax venustus* (Poli, 1795), *Venus verrucosa* (Linnaeus, 1758), *Mimachlamys varia* (Linnaeus, 1758) and *Flexopecten glaber* (Linnaeus, 1758). On the other hand, the Northwestern region is marked by the presence of *Pinna nobilis* (Linnaeus, 1758) and *Pinctada imbricata* (Röding,

1798). The central zone of the lagoon, with a muddy bottom, is characterized by the species *Axinella polypoides* (Schmidt, 1862) and *Polycarpa pomaria* (Savigny, 1816) and the detrital coastal bottoms by *Cardites antiquatus* (Linnaeus, 1758) and *Mimachlamys varia* (Linnaeus, 1758). While the Southern part of the lagoon is characterized by *Modiolus barbatus* (Linnaeus, 1758) and *Pinna nobilis* (Linnaeus, 1758). Also note the abundance of sponges, characteristic of hot sciaphilic areas, molluscs with around 38% of the fauna and echinoderms represented mainly by sea cucumbers (Cherbonnier, 1956).

III.1.1.2.El Bibane Lagoon

It is in the South of Tunisia and is characterized by the presence of a *Neogoniolithon* (calcareous red algae) reef, over 30km long and unique in the Mediterranean. This hyper-salty lagoon (41 to 49) is remarkably lined by the phanerogams *Ruppia maritima*, *Cymodocea nodosa*, as well as the pheophycae *Cystoseira* spp. which occupy almost all the available substrate. While *Posidonia oceanica* is confined to the El-Marsa area, *Caulerpa* proliferates in the El-Oued and El-Marsa areas. The bottoms are characterized by the presence of dense populations of *Pinna nobilis* and *P. rudis* (Bivalves) as well as certain Sponges (*e.g.,Aplysina aerophoba*, *Ircinia chevreuxi*, *I. fasciculata*, *Cacospongia mollior*, *Tethya auarantium*, *T. citrina*). These areas are also well frequented by avifauna.

But the peculiarity of this ecosystem lies in the presence of a kind of sponge reef, built mainly by *Ircinia* sp. and *Fasciospongia cavernosa* which can be 0.4—0.8m wide and extend over 2m² in area. This is the first time that such formations have been described in the Mediterranean.

III.1.2. Island ecosystems

Tunisia has about 62 islands and islets (*e.g.,* Galite, Zembra, Zembretta, Kneiss, Kuriatesand Kerkennah). These ecosystems, both rich and fragile, are home to characteristic flora and fauna, many of which are rare, threatened, or endemic and therefore require special attention. Other species are introduced, and some are invasive:

III.1.2.1. Archipelago of Zembra-Zembretta

This site is characterized by the exceptional beauty of the seabed and the emerging landscape as well as by the presence of a good number of benthic populations (characteristic of the Mediterranean), several of which are threatened, rare or endemic. For example, the islet of Entorche, which belongs to the Zembra-Zembretta archipelago, constitutes the most beautiful underwater landscape in the whole Mediterranean. On the biocenotic level, the vegetal/animal populations are very rich and the inventories, not exhaustive, carried out on this site made it possible to identify more than 70 vegetal species, 130 mega-benthos species (*e.g.,* Sponges, Cnidarians, Bryozoans, Echinoderms and Ascidians) and nearly 60 species of Fish. However, the originality of this site lies in the presence of species requiring special attention such as the *Phaeophyceae Ralfsia verrucosa* (Medilittoral), *Cystoseira stricta* (near the surface), *C. spinosa* and *C. zosteroides* (in depth). The phanerogam *Posidonia oceanica*, *Gastropods Patellaferruginea* (endemic to the Mediterranean) and *Patella rustica* (up to 6 m above

sea level), *Anthozoan Astroides calycularis*(down to -27 m), gorgonian, Alcyonium stands (in depth) and*Echinoderm Paracentrotus lividus*. This site remains to this day natural, wild, and showing no signs of deterioration of its ecosystem.

III.1.2.2. Archipelago of La Galite

The archipelago of La Galite is in the North of Tunisia, 81km from Bizerte and 64km from Tabarka. It is made up of the 6 islets Galite, Galiton, Fauchelle, Gallo, Gallina and Pollastro. The archipelago of La Galite presents an exceptional biological and ecological wealth with several endemic, rare, threatened, and protected species. The shallow rocky bottoms covered with phanerogam/coralligenous beds are home to many species of purely ecological or fishing interests. These habitats represent a natural nursery for many species. A multitude of species of biological interest for the Mediterranean spread over many underwater landscapes including the organogenic formations of Vermets (*Dendropoma petraeum*, *Goniolithon byssoides*, *Astroides calycularis* and*Cladocora coespitosa*), *Cystoseira beds*, *Laminaria rodriguezii* beds, *Dictyopteris polipodioides* populations and maerl beds (Antonioli *et al.* 1999).

III.1.3. Insulate banks

A marine bank is a submarine plateau or mountain that rises from the seabed towards its surface. In Tunisia, most of the marine banks (*e.g.,* Sorelles, Speiss, Mezzarilles and Esquerquises) are in the North zone, beyond 100m depth. They are areas of high biological productivity and are home to diverse and specific deep-sea communities made up, among other things, of sponges and corals. Fish and other species of commercial interest aggregate in these areas and are highly vulnerable to trawling. The Tunisian marine banks undoubtedly have a great role to play in maintaining marine biodiversity, especially regarding safeguarding the many endemic species frequenting these sectors. Among these important offshore ecosystems:

Marine bank of Hallouf: Located to the East of Monastir, this bank is characterized by the immersion at 45m depth of a rocky bottom, 8 to 12m high and surrounded by loose bottoms made up mainly of coarse sand, gravel, large shell debris and maerl (calcareous algae).

Several species, mainly sciaphiles, and remarkable biocenotic associations have been reported at this site and most of them require protection, like marine turtles. The bottom of the Hallouf bank is covered with several vegetations among which the Fucophycae (*e.g.,Sargassum hornschuchii* and*S. valgarae*), the Rhodophycae (*e.g.,Ptilophora mediterranea*, *Phyllophora nervosa*, *Vidalia volubilis*) and the Chlorophycae (*e.g.,Caulerpa racemosa*, *Udotea petiola* and *Palmophyllum crassum*). This area is also the preferred habitat of several animal populations such as sponges, sea urchins *Centrostephanus longispinus* and *Sphaerichinus granularis*, the gorgonian *Eunicella singularis* and fishes such as *Epinephelus alexandrinus*, *E. guaza*, *Seriola dumerlii*, *Serranus scriba*, *S. carbilla*, *Boops boops*, *B. selpa*, *Spicara maena* and*Sciaena umbra*.

III.1.4. Posidonia meadows

The phanerogam *Posidonia oceanica* is an endemic species of the Mediterranean. It develops in the coastal fringe, from the shore to the lower limit of the infralittoral. The Posidonia meadow represents a major center of marine biodiversity of Mediterranean species. In Tunisia, Posidonia meadows are unevenly distributed along the coasts. The most important are those of the Gulf of Gabès (South) where the presence of the densest Posidonia meadow has been reported across the Mediterranean. The current state of this ecosystem in Tunisia is fragile, especially in the South of the country, for various reasons. On the one hand, trawling operations cause the uprooting and damage of these meadows, destabilize the nature of the substrate, and increase the turbidity of the water, which decreases the penetration of the light necessary for the development of the vegetations. On the other hand, the Caulerpa and Zosteira meadows, which facilitate the establishment of Posidonia by enriching the substrate with mucus (organic matter), have also clearly declined.

III.1.5. Coralligenous biocenosis

The coralligenous biocenosis is formed by a concretion of coralline and sciaphilic calcareous algae. It is generally colonized by many animal species with hard and coarse substrates (*e.g.,* Sponges, Ascidians, Bryozoa and Cnidarians). It constitutes the main hotspot of marine biodiversity in the Mediterranean since between 1400 and 1600 benthic species have been reported there. It is the most beautiful underwater landscape in the Mediterranean.

In Tunisia, the coralligenous biocenosis occupies large areas, located mainly in the North region. It can be found either on the littoral rock (*e.g.,* island cliffs of Zembra, Cap Bon, entrances to caves and tunnels in the Cani Islands and Tabarka), or in hard bio-concretion forming the plateau coralligenous (true coralligenous deposit surrounded by soft bottoms), or on offshore rock (generally benches). The coralligenous biocenosis can also be found on a loose substrate (maerl bottom) formed by a coarse detrital and concreted by corallinacae algae of the *Neogoniolithon* genus and where the sponges of the Clionidae family present predominant facies between 35 and 65m depth. But this coralligenous is subject to the devastating action of trawls given the accessibility of soft bottoms by these fishing gears.

The coralligenous ecosystem plays an important role in the conservation of marine biodiversity in the Mediterranean:

- Morphological role: It protects the shore from the actions of waves and swells and conditions the movement of water masses.
- Biological role: It ensures the bio-mineralization of carbonates, shelters the vagile organisms (*e.g.,* crustaceans, echinoderms, and fish) and sessile (*e.g.,* annelids, anthozoa and algae) and releases organic matter in particulate or dissolved forms which will in turn be used later by pelagic species.
- Sedimentary role: Biodestructive organisms work the sediment and suspend large quantities of sedimentary materials which disperse over large areas.

III.1.6.Cystoseira beds

The *Cystoseira* beds (*Cystoseira* spp.) in Tunisia are still badly now. Scientific studies to date have shown the presence of 16 species whose distribution is not limited to certain areas. These *Cystoseira* are generally in a good status and form beds that can be grouped into:

- *Cystoseira* beds in beaten mode: They are frequent in hard substrates (1m depth) subjected to strong agitation. The characteristic species are *Cystoseira stricta*, *C. mediterranea*, *C. spicata* and *C. amentcea*.
- *Cystoseira* beds in calm mode: They consist of species of *Cystoseira* living in the first meters of the infralittoral stage such as *C. sauvageauna*, *C. crinita* and *C. coespitesa*.
- Deep *Cystoseira* beds: The characteristic species are *Cystoseira spinosa* (infralittoral) and *C. zosteroides* (circalittoral). These beds are home to a wide variety of populations of cnidarians, sponges, bryozoans, and epiphytes such as Ectocarpacae, Elachistacae and Ceramiacae.

In polluted areas, *Cystoseira* are gradually giving way to more resistant species such as the Fucophycae *Padina pavonica* and *Stypocaulon scoparium*.

III.1.7 Lithophyllum lichenoides sidewalks, vermet sidewalks and Neogoniolithon reefs

Lithophyllum lichenoides entanglement is better known as sidewalk. It is a bio-concretion built by the calcareous rhodophyte *Lithophyllum lichenoides* (= *L. tortuosum*) which lives at the base of the mediolittoral stage, a little above mean sea level, especially in very beaten mode and when the lighting is reduced (*e.g.,* case of leaves and corridors; Laborel, 1987; Boudouresque, 1997). These bio-concretions are threatened in the Mediterranean, especially by surface pollution (hydrocarbons in particular).

Vermets' sidewalks generally develop in the same tier as *Lithophyllum lichenoides* entanglement (mediolittoral). These bio-concretions are built mainly by the gastropod *Dendropoma cristatum* (Biondi, 1859) (also called *D. petraeum*[Monterosato, 1884] and unfairly *Vermetus cristatus*), with the participation of other organisms, in particular a calcareous rhodophyte *Neogoniolithon brassica-florida* (Harvey) Setchell L.R. Mason, 1943 (*N. notarisii*) and a foraminifera *Miniacina miniacea* (Pallas, 1766). According to Boudouresque (1997), vermets' sidewalks more or less cover the erosion platform (a few centimeters thick) and delimit basins; on the edge (wide side) of this platform, the vermets (*Dendropoma*) build a bulge that can reach several tens of centimeters in thickness. These external bulges are often hollowed out with cavities that host rich sciaphile flora and fauna. The width of the vermets' sidewalks is between a few meters and a hundred meters. Vermets can also build on the subvertical rock wall of the bulges. Several kinds of micro-atolls built by vermets have been described (Laborel, 1987; Boudouresque, 1990;1997).

L. lichenoides sidewalks and vermets' sidewalks are characteristic of warm temperate waters of the Atlantic and the Mediterranean. In the Mediterranean, they can be observed on the Southern shore of Corsica, Italy, Algeria, and Tunisia (notably in Zembra and Cap Blanc). They are particularly developed in the Eastern Mediterranean (Boudouresque, 1997).

The *Neogoniolithon* reefs are built by the calcareous rhodophyte *N. brassica-florida* (Harvey) Setchell L.R. Mason, 1943 (*N. notarisii*). They are very widespread in the Mediterranean, and in Tunisia they develop mainly along the spit that closes El Bibane lagoon, about 30km in length. The environmental conditions, very calm mode, high temperature and salinity, favor the formation of these reefs, because they limit interspecific competition and grazing of *N. brassica-florida* by herbivores (Boudouresque, 1997). These little-known reefs have great heritage value and are not threatened by human activities.

III.2. Species threats and their impacts on coastal Ecosystems

During the Messinian crises (5 to 6 million years ago), the Mediterranean dried up with the disappearance of most of its communities. Following these crises, the communities of the Mediterranean had to be reconstituted from the Atlantic. Thus, Atlantic species, entering the Mediterranean, evolved to give rise to several species and varieties. The endemic species are therefore the descendants of certain immigrants. This is a recent endemism or neo-endemism manifested at the specific level. The rate of endemism is very high in the Mediterranean compared to other regions of the world (Capapé, 1986; Stehmann and Bürkel, 1986; Fredj and Maurin, 1987; Fischer *et al.* 1987; Bradaï, 2000).

Endemic marine species have not been the subject of specific inventories in Tunisia and the few reports made were mostly reported accidentally. As a result, the inventory carried out in this work required extensive research in scientific articles, doctoral theses and scientific reports. Thus, the list below is not exhaustive and the endemic species in Tunisia would be significantly more numerous.

III.2.1. Mognoliophyta

Posidonia oceanica (Linnaeus) Delile, 1813

Plantae (Kingdom); Viridiplantae (Subkingdom); Streptophyta (Infrakingdom); Tracheophyta (Phylum (Division)); Spermatophytina (Subphylum (Subdivision)); Magnoliopsida (Class); Lilianae (Superorder); Alismatales (Order); Posidoniaceae (Family); *Posidonia* (Genus); *Posidonia oceanica* (Species)

Posidonia is a phanerogam species, endemic to the Mediterranean. The meadows it forms play a key role in controlling sediment dynamics, storing carbon dioxide, recruiting species of economic interest (spawning grounds/nurseries) and exporting organic matter to deep ecosystems. In the infralittoral level, it settles on a hard or soft substrate between 0 and 40m deep (UNEP/IUCN/GIS Posidonie, 1990; Ramos-Esplá *et al.* 2011)

where it forms a climax, *i.e.*, the ultimate evolution of a biocenosis (Pérès and Picard, 1964). In the Gulf of Gabès, Le Danois (1925) reported that *P. oceanica* could be found at a depth of 30m. However, De Gaillande (1970) notes a significant decline in the lower limit, with a loss of the extension of Posidonia meadows due to silting. This loss of the extension that the meadows once covered (Le Danois, 1925; Molinier and Picard, 1953; Ramos-Esplá *et al.* 2011) has been confirmed by Zaouali (1993) and BenMustapha *et al.* (1999; 2004). A strong vitality of Posidonia was noted in the Kerkennah area, which can colonize degraded bottoms. A few live rhizomes were taken down to - 39.6m (SE Kerkennah). However, the maximum depth where a living rhizome was found was 44.5m. In the Gulf of Gabès, the lower limit of *P. oceanica* has receded well. Hattour and Ben Mustapha (2013) attributed this decline in part to siltation caused by pollution induced by phosphogypsum discharges and by trawling. In addition, these authors estimate that the total area occupied by *P. oceanica* in the Gulf of Gabès is around 1,151,900 ha, or 34% of the total area studied.

Organic pollution, siltation, trawl fishing, maritime constructions (marinas, ports and dikes), sediment deposition and/or the artificial fattening of beaches (Ben Mustapha *et al.* 1999, 2004; Ben Mustapha and Afli, 2007; Ramos-Esplá *et al.* 2011) are the main threats. In the Gulf of Gabès, the Posidonia meadow shows significant differences. While it is heavily impacted by trawl fishing, especially in the Southwestern sectors of Kerkennah, West and East of Djerba, the meadow appears to be in good condition, in the South-East of Kerkennah and around Kneiss, with some signs of recovery. The monitoring of network set up by Hattour and Ben Mustapha (2013) should make it possible to assess the dynamics of this meadow over the years, with a view to preservation. In addition, these authors offer relevant recommendations for the conservation of this biocenosis.

This species is endangered or threatened according to the Barcelona Convention (Appendix II) and Bern Convention (Appendix I). It forms a Habitat of priority interest according to the Habitat Directive 92/43 of the European Union (Annex I). It is necessary to underline the presence of important tiger formations and barrier reefs, in particular in Kerkennah (Blanpied *et al.* 1979; Burollet and Ellouz, 1986), object of a stricter protection (UNEP/IUCN/GIS Posidonie, 1990; Ramos-Esplá *et al.* 2011).

III.2.2. Chlorophyta

Caulerpa ollivieriDostál, 1929

Plantae (Kingdom); Viridiplantae (Subkingdom); Chlorophyta (Phylum (Division)); Chlorophytina (Subphylum (Subdivision)); Ulvophyceae (Class); Bryopsidales (Order); Caulerpaceae (Family); *Caulerpa* (Genus); *Caulerpa ollivieri* (Species)

It is a species of macroalgae endemic to the Mediterranean (France, Libya, Spain, and Turkey). It lives on sandy bottoms in shallow sheltered sites. Known sites are extremely rare and isolated, generally less than one hectare. In Tunisia, it has not been reported and its presence is probable (Ramos-Esplá *et al.* 2011).

III.2.3. Phaeophyta

Cystoseira amentacea var. stricta Montagne, 1846(including *var. stricta* and *var. spicata)*

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira amentacea* (Species); *Cystoseira amentacea var. stricta* (Variety)

This macroalga is endemic to the Mediterranean with three varieties: *amentacea* (Eastern Mediterranean), *spicata* (Adriatic) and *stricta* (Western Mediterranean; Ramos-Esplá *et al.* 2011). It lives in the infralittoral stage, on a hard substrate near the surface with strong hydro dynamism. Threats mainly include pollution (it has receded nearly in all major urban areas), grazing by some micro-herbivores, pollution from coastal development (water turbidity), anchoring/mooring of boats and harsh fishing methods for benthic habitats. The inventory and mapping of this alga gives it the status of a strictly protected species (Ramos-Esplá *et al.* 2011).

Cystoseira mediterranea Sauvageau, 1912

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass)

Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira mediterranea* (Species)

It is a species of macroalgae endemic to the Mediterranean (Ramos-Esplá *et al.* 2011). It is rarer and more localized than *C. amentacea* but replaces it in parts of the Western Mediterranean. It lives in the infralittoral stage, on a hard substrate near the surface with a strong dynamism. It is threatened like *C. amentacea* (Ramos-Esplá *et al.* 2011).

Cystoseira sedoides (Desfontaines) C.Agardh, 1820

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira sedoides* (Species)

This macroalga is endemic to the coasts of Algeria (from the outskirts of Algiers to El Kala), Tunisia and the extreme South of Italy (Pantelleria Island) (Ramos-Esplá *et al.* 2011). It is a long-lived species, living in a very narrow ecological niche, on hard substrates with moderate wave movements. Its status is comparable to that of *C. amentacea*, but given its narrow ecological niche, it is more threatened (limited distribution area and scarcity of sites) (Ramos-Esplá *et al.* 2011).

Cystoseira spinosaSauvageau, 1912(accepted name:*Cystoseira montagnei* J.Agardh, 1842)

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira spinosa* (Species)

It is a macroalga endemic to the Mediterranean. It lives on hard substrates in the infralittoral stage, in deep water (15–35m) and in sciaphilic biotopes (Ramos-Esplá *et al.* 2011). It formed large beds until the 1960s and now it is reduced to isolated individuals. Threats include pollution, uprooting by nets and trawlers and grazing by sea urchins (Ramos-Esplá *et al.* 2011).

Cystoseira zosteroides (Turner) C.Agardh, 1821.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira zosteroides* (Species)

This alga is endemic to the Mediterranean. It lives in deep water in the infralittoral stage, but mainly in the circalittoral stage (up to 100m) on hard substrates in sectors with unidirectional currents. It is rare in many sites and widely abundant in others. Threats include increased water turbidity, sedimentation, and sea urchin grazing (Ramos-Esplá *et al.* 2011).

Laminaria rodriguezii Bornet, 1888***.***

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Laminariales (Order); Laminariaceae (Family); *Laminaria* (Genus); *Laminaria rodriguezii* (Species)

It is a macroalga endemic to the Western Mediterranean. It lives in much localized sites at great depths (60–150m), where the water is cold and very clear, with strong seabed currents. Threats include eutrophication and/or increased turbidity (Hattour and Ben Mustapha, 2015).

Cystoseira schiffneri Hamel, 1939

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira schiffneri* (Species)

It colonizes sandy bottoms and small hard substrates between 1 and 5m deep (UNEP/IUCN/GIS Posidonie, 1990; Ramos-Esplá *et al.* 2011). It is abundantly found stranded

on the beaches of the Kerkennah, Sfax and Djerba islands (UNEP/IUCN/GIS Posidonie, 1990). The species has been found in the lawn at *Cymodocea*, between 0 and 3m deep. It is abundant in the infralittoral bottoms of the South-East of Kerkennah and El Bibène, between 0 and 5m deep. The remarkable abundance of this species should be noted in the El Bibène lagoon, where it forms small beds with *C. compressa*. This association can be included in threatened *Cystoseira* calm mode stands that need protective measures. It is an endemic species to Tunisia (UNEP/IUCN/GIS Posidonia, 1990 in Hattour and Ben Mustapha, 2015).

The species is threatened mainly by organic pollution, coastal works (*e.g.,* fattening of beaches, marinas, ports) and small "kiss" trawl fishing. It is considered endangered or threatened by the Barcelona Convention (Annex II). Its inclusion in Annex II (endangered or threatened species) is also proposed by the European Union: Annexes to Habitat Directive 92/43 (COM (2009) 585); Proposed by IUCN for its protection (UNEP/IUCN/GIS Posidonie, 1990; Ramos-Esplá *et al.* 2011).

Cystoseira corniculata (Turner) Zanardini, 1841.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira corniculata* (Species)

It lives on the rocks of the infralittoral, in light-loving places, in beaten and calm mode; up to 70m deep. It is also present in coastal lagoons. In the Gulf of Gabès, the species proliferates on loose substrate (sandy, sandy-muddy, and muddy) and is frequent on beaches. The species is endemic to the Mediterranean (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015), the Adriatic and the Eastern basin. This is a relict species of the tertiary. However, it is recorded in the North of the Atlantic Ocean in European waters. It is threatened by organic pollution, coastal works (*e.g.,* marinas, ports and fattening of beaches) and trampling of the sediment. It is proposed to be included as a species in danger or threatened (Barcelona Convention, Appendix II).

Cystoseira crinita Duby, 1830.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira crinita* (Species)

It lives on the rocks of the infralittoral, in light-loving places, in beaten and calm mode; between 0–3m deep (Gómez-Garreta *et al.* 2001). It is anendemic species to the Western and Eastern Mediterranean, Adriatic, and Black Seas, also present in the Canaries (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). *C. crinita* abounds on the beaches of La Chebba and Zarziss, especially during the hot season. It is affected by organic pollution, coastal works (*e.g.,* marinas, ports and fattening of beaches) and

trampling of the sediment. It is a species proposed as endangered or threatened by the Barcelona Convention (Appendix II).

Cystoseira dubia Valiante, 1883.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta(Phylum);Phaeista(Subphylum);Limnista(Infraphylum);Fucistia(Superclass); Phaeophyceae(Class);Fucophycidae(Subclass);Fucales(Order);Sargassaceae(Family); *Cystoseira* (Genus); *Cystoseira dubia* (Species)

It lives on the rocks of the lower infralittoral and circalittoral and deep detrital, between 25 and 170m depth. It is a species endemic to the Mediterranean, Southwestern Italy, Sicily, the Adriatic Sea, and the Eastern basin (Greece, Tunisia,and Syria) (Hattour and Ben Mustapha, 2015). It is threatened by organic pollution, excess sediment,and trawling. It is proposed as an endangered or threatened species (Barcelona Convention, Annex II).

Cystoseira sauvageauana Hamel, 1939.

Chromista (Kingdom), Harosa (Subkingdom), Heterokonta (Infrakingdom), Ochrophyta(Phylum),Phaeista(Subphylum),Limnista(Infraphylum),Fucistia(Superclass), Phaeophyceae(Class),Fucophycidae(Subclass),Fucales(Order),Sargassaceae(Family), *Cystoseira* (Genus), *Cystoseira sauvageauana* (Species)

It lives on the rocks of the infralittoral, in light-loving and not beaten places (UNEP/IUCN/GIS Posidonia, 1990). It is an endemic species to the Mediterranean, more frequent in the Western basin, but also in the Gulf of Cadiz (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). The species seems to be much localized in the Gulf of Gabès: Djerba and Kerkennah lagoons. It is threatened by organic pollution, coastal works (*e.g.,*marinas, ports and fattening of beaches) and excess sediment. It is considered vulnerable (UNEP/IUCN/GIS Posidonie, 1990; Boudouresque, 1997).

Cystoseira brachycarpa J.Agardh, 1896.

Chromista (Kingdom), Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta(Phylum);Phaeista(Subphylum);Limnista(Infraphylum);Fucistia(Superclass); Phaeophyceae(Class);Fucophycidae(Subclass);Fucales(Order);Sargassaceae(Family); *Cystoseira* (Genus); *Cystoseira brachycarpa* (Species)

This species exists in Tunisia (Boudouresque, 1997) (= *Cystoseira brachycarpa* var. *Balearica* (Sauvageau) Giaccone, 1992 = *Cystoseira caespitosa* Sauvageau, 1912). It is an endangered or threatened species (Annex II of the Barcelona Convention). It lives in the Western and central Mediterranean and in the Atlantic, near the Strait of Gibraltar (Ramos-Esplá *et al.* 2011).

Cystoseira elegans Sauvageau, 1912.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira elegans* (Species)

This endemic species exists in Tunisia (Boudouresque, 1997; Ramos-Esplá *et al.* 2011). *Cystoseiraelegans* grew on semi-exposed to exposed rocky shores, in littoral pools, 0-1m depth, frequently associated with *C. algeriensis* (Ben Maïz *et al.* 1987; Bàez *et al.* 2005). It has been successively recorded from Algeria, Sicily, south of Italy, Spain, and Balearic Islands. In South Mediterranean, it extends its range of distribution to Tunisia where it was found close to the Algerian border (Melloula Bay) and along the Northeastern coast near Sidi Daoud and Kelibia (Bouafif *et al.* 2014).

Cystoseira foeniculacea (Linnaeus) Greville, 1830.

Chromista (Kingdom); Harosa (Subkingdom); Heterokonta (Infrakingdom); Ochrophyta (Phylum); Phaeista (Subphylum); Limnista (Infraphylum); Fucistia (Superclass); Phaeophyceae (Class); Fucophycidae (Subclass); Fucales (Order); Sargassaceae (Family); *Cystoseira* (Genus); *Cystoseira foeniculacea* (Species)

Originally described from the Adriatic Sea, *C. Foeniculacea* has been successively reported from the Balearic Islands, Corsica, Cyprus, Greece, Italy, Sardinia, Sicily, Spain and Turkey. This endemic species exists in Tunisia (Boudouresque, 1997; Ramos-Esplá *et al.* 2011). It has been observed in upper subtidal at 0-5m depth of the Tunisian Northern coasts (observed only along the coasts of Cap Bon Peninsula) from March 2012 to February 2013 (Bouafif *et al.* 2014).

III.2.4. Rhodophyta

Lithophyllum byssoides(Lamarck) Foslie, 1900.

Plantae (Kingdom); Biliphyta (Subkingdom); Rhodophyta (Phylum (Division)); Eurhodophytina (Subphylum (Subdivision)); Florideophyceae (Class); Corallinophycidae (Subclass); Corallinales (Order); Lithophyllaceae (Family); Lithophylloideae (Subfamily); Dermatolitheae (Tribe); *Goniolithon* (Genus); *Goniolithon byssoides* (Species)

It is a macroalga endemic to the Western Mediterranean in much localized sites (Corsica, Sicily, Algeria, and Adriatic). It is a calcareous alga with a very narrow ecological niche, in an infracoastal fringe, just below the surface of the water. It is subjected to strong wave movements, on a hard and well-lit substrate. It is vulnerable to trampling (fishermen on foot, swimmers) and to pollution (film of hydrocarbons on the surface of the sea; Hattour and Ben Mustapha, 2015).

Mesophyllum lichenoides (J.Ellis) Me.Lemoine, 1928 (reported as *Lithophyllum lichenoides*Stoneweed)

Plantae (Kingdom); Biliphyta (Subkingdom); Rhodophyta (Phylum (Division)); Eurhodophytina (Subphylum (Subdivision)); Florideophyceae (Class); Corallinophycidae (Subclass); Hapalidiales (Order); Mesophyllaceae (Family); *Mesophyllum* (Genus); *Mesophyllum lichenoides* (Species)

It is a calcareous alga living in the mid-littoral stage, on hard substrates, in biotopes subjected to strong wave movements and slightly in the shade (especially crevices). In a few sites, it has formed small mounds up to 2m wide (sidewalks) over a period of one thousand years. These formations are unique to the Mediterranean. Threats include surface pollution (mainly hydrocarbons) and trampling. The destruction of the mounds is irreversible (Hattour and Ben Mustapha, 2015).

Ptilophora mediterranea (H.Huvé)Norris, 1987 *(=Beckerella mediterranea =Phyllophora aegeae)*

Plantae (Kingdom); Biliphyta (Subkingdom); Rhodophyta (Phylum (Division)); Eurhodophytina (Subphylum (Subdivision)); Florideophyceae (Class); Rhodymeniophycidae (Subclass); Gelidiales (Order); Gelidiaceae (Family); *Ptilophora* (Genus)

Ptilophora mediterranea (Species)

It is a macroalga endemic to a limited area of the Mediterranean (between Greece and Crete): It is mainly localized at depth (25m to more than 120m), on hard substrates, on bioconcretions with calcareous algae (Hattour and Ben Mustapha, 2015).

Schimmelmannia schousboei (J.Agardh) J.Agardh, 1851.

Plantae (Kingdom); Biliphyta (Subkingdom); Rhodophyta (Phylum (Division)); Eurhodophytina (Subphylum (Subdivision)); Florideophyceae (Class); Rhodymeniophycidae (Subclass); Acrosymphytales (Order); Acrosymphytaceae (Family); *Schimmelmannia* (Genus); *Schimmelmannia schousboei* (Species)

This Mediterranean endemic species is found in much localized sites (Southern Italy, Libya, and a site off the French Atlantic coast). It lives in shallow sciaphilic biotopes (1–2m deep) on hard substrates, usually near cold fresh water. Sites are very rare and could be destroyed by coastal development (Hattour and Ben Mustapha, 2015).

III.2.5. Sponges

Aplysina sp. plur.

Animalia (Kingdom); Porifera (Phylum); Demospongiae (Class); Verongimorpha (Subclass); Verongiida (Order); Aplysinidae (Family); *Aplysina* (Genus)

It is endemic to the Mediterranean, found mainly in the region of Marseille (France) and the North Adriatic.It lives in caves and in sciaphilic biotopes up to 70m deep (Hattour and Ben Mustapha, 2015).

Axinella cannabina (Esper, 1794).

Animalia (Kingdom); Porifera (Phylum); Demospongiae (Class); Heteroscleromorpha (Subclass); Axinellida (Order); Axinellidae (Family); *Axinella* (Genus); *Axinella cannabina* (Species).

This species is endemic to the Mediterranean (mainly in the Southern Mediterranean). It lives in muddy bottoms of the circalittoral stage (up to 50m). It grows slowly, as all *Axinella* species. It was seriously affected by the regular trawling of the bottom (Hattour and Ben Mustapha, 2015).

Petrobiona massiliana Vacelet and Lévi, 1958.

Animalia (Kingdom); Porifera (Phylum); Calcarea (Class); Calcaronea (Subclass); Baerida (Order); Petrobionidae (Family); *Petrobiona* (Genus); *Petrobiona massiliana* (Species).

It is endemic to the Mediterranean. Distribution sites are rare, in the Western basin and the Adriatic. It lives in dark areas; in caves up to 30m. Threats include scarcity of distribution sites and fishing (Hattour and Ben Mustapha, 2015).

Sarcotragus pipetta (Schmidt, 1868) (= Hircinia pipetta Schmidt, 1868).

Animalia (Kingdom); Porifera (Phylum); Demospongiae (Class); Keratosa (Subclass); Dictyoceratida (Order); Irciniidae (Family); *Hircinia* (Genus); *Hircinia (Euricinia)* (Subgenus); *Hircinia (Euricinia) pipetta* (Species).

This massive sponge is endemic to the Mediterranean and is present particularly in El Bibène (Tunisia) and in Italy. According to Vacelet (1959), this species cannot be separated from *Ircinia fasciculata* Pallas, since the main difference is thought to be the presence of osculiferous papillae in the species described byTopsent (1894; 1928). However, Pulitzer-Finali and Pranzato (1980)support the existence of two different species. It is a Mediterranean endemic species.It lives on rocky bottoms, up to 35m deep. As described by Rützler (1976), horny sponges (*Spongia*, *Hippospongia*, *Ircinia* and *Sarcotragus*) constitute “an ecological niche particularly suited to harboring interstitial fauna”. For *I. fasciculata*, the author counted 825 individuals of the macro-benthic endofauna per kg of sponge, and as such sponges must benefit from certain measures ensuring their sustainability as an inseparable part of the marine habitat.

Hippospongia communis (Lamarck, 1814).

Animalia (Kingdom); Porifera (Phylum); Demospongiae (Class); Keratosa (Subclass); Dictyoceratida (Order); Spongiidae (Family); *Hippospongia* (Genus); *Hippospongia communis* (Species).

It lives in the Posidonia meadow, the lawn in *Caulerpa prolifera*, detrital bottoms, but also on rock, coralligenous seabeds and sandy mud bottoms (Soufi-Kéchaou, 2004; Soufi-Kéchaou *et al.* 2005; Ramos-Esplá *et al.* 2011). During the 2009 and 2010 missions, it was collected between 29 and 47m deep, on various bottoms (dead matte of Posidonia, coastal detritus with *Synascidia* and/or Echinoderms). The maximum length was 330mm. It has been reported in the deeper Boughrara area with *Pinna nobilis* and *Spongia zimocca*. On the other hand, *H. communis* has not been observed in the Boughrara lagoon. It is a good indicator of the impact of the trawl. In addition, the species represents the habitat of a high number of organisms (Ascidians, Crustaceans, Polychaetes and Cnidarians). It is a Mediterranean endemic species (Hattour and Ben Mustapha, 2015). It is a common species in the Gulf of Gabès between 1 and 200m deep (Ramos-Esplá *et al.* 2011). The species is threatened by silting, trollingand uncontrolled harvesting.

Calyx nicaeensis (Risso, 1826) (S-O Kerkennah, 40-41m, photo Alfonso Ramos-Esplà).

Animalia (Kingdom); Porifera (Phylum); Demospongiae (Class); Heteroscleromorpha (Subclass); Haplosclerida (Order); Phloeodictyidae (Family); *Calyx* (Genus); *Calyx nicaeensis* (Species).

It lives in the Posidonia meadows, 1m deep, but it has been observed on a detrital coastal bottom of*Synascidia* and *Echinoderma*, between 40–41m deep (Ramos-Esplá *et al.* 2011).It is a Mediterranean endemic species (Ramos-Esplá *et al.* 2011). It has been reported in the Gulf of Gabès; however, it seems very rare. A single specimen was captured in July 2009 in the Southeastern sector of Kerkennah between 40–41m deep. It is threatened by siltation and trawl fishing (Hattour and Ben Mustapha, 2015).

III.2.6. Briozoans

Electra posidoniae Gautier, 1954.

Animalia (Kingdom); Bryozoa (Phylum); Gymnolaemata (Class); Cheilostomatida (Order); Membraniporina (Suborder); Membraniporoidea (Superfamily); Electridae (Family); *Electra* (Genus); *Electra posidoniae* (Species).

The species lives associated with the leaves of *Posidonia oceanica* and *Cymodocea nodosa* where it forms stolonial and encrusting colonies (De Gaillande, 1970). Normally, it grows well in dense seagrass beds, between 5 and 15m deep.The species is annual due to its epiphytism on the leaves of *Posidonia* and *Cymodocea* (Pérès et Picard, 1964). As is the case with *Asterina panceri*, *E. posidoniae* also grows in *Posidonia* meadows and to a lesser extent in *Cymodocea* lawns.Any threat to these meadows and their degradation will pose a risk to the populations of this species, particularly the silting up and development of epiphytes.It is a Mediterraneanendemic species (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). In the Gulf of Gabès, it is indicated byDe Gaillande (1970).It is abundant in areas/sectors (South of Kerkennah and East of Djerba and Kneiss) where the meadows are in good status with well-developed leaves.

Rectonychocella disjuncta Canu and Bassler, 1930.

Animalia (Kingdom); Bryozoa (Phylum); Gymnolaemata (Class); Cheilostomatida (Order); Flustrina (Suborder); Microporoidea (Superfamily); Onychocellidae (Family); *Rectonychocella* (Genus); *Rectonychocella disjuncta* (Species).

According to Canu and Bassler (1930) and Boudouresque (1997), this species is present in Tunisia. It has been also observed in different regions of the Mediterranean, notably in Tripoli (Lebanon) with low densities (Harmelin *et al.* 2016).

III.2.7. Ascidians

Clavelina nana Lahille, 1890.

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Clavelinidae (Family); *Clavelina* (Genus); *Clavelina nana* (Species).

It inhabits the *Posidonia oceanica* meadows, the dead mat of Posidonia and muddy sediment with Caulerpa, between 4 and 14m deep (Ben Mustapha *et al.* 1999, 2004; Chebbi, 2010; Hattour and Ben Mustapha, 2015). Currently, this species represents a complex of species (*Clavelina* and *Pycnoclavella*).The Atlanto-Mediterranean species has been reported in the Eastern Atlantic (from the Channel Canal to Senegal) and mainly in the Western Mediterranean basin and in the Adriatic.In the Gulf of Gabès, the species is recorded in Kerkennah by Ben Mustapha *et al.* (1999; 2004)and Ramos-Esplá *et al.* (2011).The main threats are siltation, organic pollution, and trawl fishing.

Halocynthia papillosa (Linnaeus, 1767)***.***

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Stolidobranchia (Order); Pyuridae (Family); *Halocynthia* (Genus); *Halocynthia papillosa* (Species).

A species that is very sensitive to siltation and organic pollution (bio-indicator), specific to the coralligenous, present in the coastal detrital, between 35 and 80m deep (Chebbi, 2010). It rarely occurs on the rhizomes of Posidonia dislodged and on the valves of *Pinctada radiata* in the mud, between 5 and 13m deep (Ben Mustapha *et al.* 1999).It is a Mediterranean endemic species, which stretches also to the Atlantic, from Portugal to the Canary Islands (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). Considered rare in the Gulf of Gabès, it is threatened by siltation, organic pollution, trolling and scavenging (Ben Mustapha *et al.* 1999; Ramos-Esplá *et al.* 2011).

Microcosmus sabatieri Roule, 1885***.***

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Stolidobranchia (Order); Pyuridae (Family); *Microcosmus* (Genus); *Microcosmus sabatieri* (Species).

The species colonizes infra and circalittoral rocky bottoms, Posidonia meadows, coastal detrital, silted detrital and offshore detrital, terrigenous muds;between 1 and 265m deep (Chebbi, 2010).Currently, the genus*Microcosmus* includes the species *M. nudistigma*, *M. polymorphus*, *M. sabatieri* and *M. vulgaris* (Ramos-Esplá *et al.* 2011).It is a Mediterranean endemic species which extends to Portugal (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). It is reported in the Gulf of Gabès, and it is threatened by chemical pollution, Troll fishing and collection by divers (Ramos-Esplá *et al.* 2011).

Microcosmus vulgaris Heller, 1877.

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Stolidobranchia (Order); Pyuridae (Family); *Microcosmus* (Genus); *Microcosmus vulgaris* (Species).

This species lives in circalittoral rocky bottoms, coastal detrital, silted detrital, offshore detrital and terrigenous muds;between 10 and 380m deep (Chebbi, 2010; Ramos-Esplá *et al.* 2011). It is a species endemic to the Mediterranean with a distribution deeper than *M. sabatieri* (Hattour and Ben Mustapha, 2015). It was reported in the Gulf of Gabès. Troll fishing represents its main threat (Ben Mustapha *et al.* 1999; Ramos-Esplá *et al.* 2011).

Pseudodistoma obscurum Pérès, 1959.

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Pseudodistomidae (Family); *Pseudodistoma* (Genus); *Pseudodistoma obscurum* (Species).

It lives on hard bottoms (littoral rock, coralligenous, rhizomes of Posidonia and coastal detrital), between 0 and 40m deep (Ramos-Esplà, 1991).It is endemic to the Mediterranean (Chebbi, 2010; Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). It has been reported in the Gulf of Gabès byBen Mustapha *et al.* (1999)and has been observed later (Ramos-Esplá *et al.* 2011). The main threats are Troll fishing, siltation,and habitat degradation (Posidonia meadowsand coralligenous).It is the conservation of the Posidonia meadows that allows the development of *P. obscurum* since this is its preferred habitat.

Eudistoma tridentatum (Heiden, 1893)

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Polycitoridae (Family); *Eudistoma* (Genus); *Eudistoma tridentatum* (Species).

Eudistoma tridentatum is a Mediterranean endemic species of limited distribution.It is present mainly in the Western basin of the Mediterranean.In Tunisia, it has been observed in the North, in Galite and Zembra islands (Chebbi, 2010). It has also been observed in Sfax and Kerkennah (Anonymous, 2001; Ramos-Esplá *et al.* 2011).

Eudistoma plumbeum (Della Valle, 1877).

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Polycitoridae (Family); *Eudistoma* (Genus); *Eudistoma plumbeum* (Species).

As *Eudistoma tridentatum*, *E. plumbeum* is also a Mediterranean endemic species of limited distribution (Chebbi, 2010).It is present mainly in the Western basin of the Mediterranean.In Tunisia, it has been observed in the North, in the Galite and Zembra Islands (Anonymous, 2001). It has also been observed in Sfax and Kerkennah (Ramos-Esplá *et al.* 2011).

Eudistoma mucosum (Drasche, 1883).

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Polycitoridae (Family); *Eudistoma* (Genus); *Eudistoma mucosum* (Species).

Eudistoma tridentatum is a Mediterranean endemic species of limited distribution (Chebbi, 2010).It is present mainly in the Western basin of the Mediterranean.In Tunisia, it has been observed in the North, in Galite and Zembra Islands of (Anonymous, 2001). It has also been observed in Sfax and Kerkennah (Ramos-Esplá *et al.* 2011).

Aplidium conicum (Olivi, 1792).

Animalia (Kingdom); Chordata (Phylum); Tunicata (Subphylum); Ascidiacea (Class); Aplousobranchia (Order); Polyclinidae (Family); *Aplidium* (Genus); *Aplidium conicum* (Species).

It is a Mediterranean endemic species observed at 3-100m depth under the name *Amaroucium picardi* (Anonymous, 2001). It lives in photophilic algae in calm mode, sciaphilic algae in calm mode, Posidonia meadow/rhizomes and *Caulerpa prolifera* bottoms, coastal detrital and coastal terrigenous bottoms. Its distribution in the Mediterranean is large, it has been observed in Balearic Islands, Ceuta (Morocco), Girona, Tabarka Islands, Bay of Alicante (Spain), France, Italy, Tunisia (Kerkennah) (Ramos-Esplá *et al.* 2011), Egypt and ex-Yugoslavia (Chebbi, 2010).

III.2.8. Cnidarians

Corallium rubrum (Linnaeus, 1758).

Animalia (Kingdom); Cnidaria (Phylum); Anthozoa (Class); Octocorallia (Subclass); Alcyonacea (Order); Scleraxonia (Suborder); Coralliidae (Family); *Corallium* (Genus); *Corallium rubrum* (Species).

It is a species endemic to the Mediterranean, found mainly in the Western part and in the Adriatic. The species is rare in the Eastern part (Aegean Sea). The colony is rigid and red in color and the branches extend in all directions. This species of red corals

lives on rocky substrates slightly exposed to light, at shallow depth and in caves up to 400m below sea level. The polyps of *C. rubrum* capture plankton preys with its tentacles and stinging cells (nematocysts) (Mojetta and Ghisotti, 1996). The species is mainly exploited in Algeria, France, Italy, Morocco and Tunisia by the jewelry industry.Its overexploitation locally caused the disappearance of the species at shallow depths. Destructive fishing techniques have also contributed to its scarcity.Today the species is collected mainly by scuba diving and the deep colonies remain out of the reach of divers.This red coral is also used in homeopathy.

Errina aspera (Linnaeus, 1767).

Animalia (Kingdom); Cnidaria (Phylum); Hydrozoa (Class); Hydroidolina (Subclass); Anthoathecata (Order); Filifera (Suborder); Stylasteridae (Family); *Errina* (Genus); *Errina aspera* (Species).

It is endemic to the Mediterranean but occurs only in two known sites: Strait of Gibraltar and surroundings (Atlantic coast) and Strait of Messina (Italy).It lives at 100m depths where sea currents are strong.It is rare, due to the limited distribution area (Hattour and Ben Mustapha, 2015).

Cladocora caespitosa (Linnaeus, 1767).

Animalia (Kingdom); Cnidaria (Phylum); Anthozoa (Class); Hexacorallia (Subclass); Scleractinia (Order); Scleractinia incertae sedis (Family); *Cladocora* (Genus); *Cladocora caespitosa* (Species).

It is a Mediterranean endemic species (Hattour and Ben Mustapha, 2015). However, in the prospected areas between 20 and 25m deep on the dead mat of Posidonia, both South-West of Kerkennah and West of Djerba, only the remains of dead colonies were observed as a testimonyof the presence of this important species.The species is recorded on *Posidonia oceanica* beds, *Cymodoceanodosa* and/or *Caulerpa prolifera* lawns, coastal detritus and silted detrital;between 11 and 80m deep (Ben Mustapha *et al.* 1999, 2004). De Gaillande (1970)and Ramos-Esplá *et al.* (2011)reported *Cladocora coespitosa* as an accompanying species with no specific ecological significance.The presence of another species of *Cladocora* (*C. debilis*) sampled by the dredge in the South-East of Kerkennah, between 17 and 18m deep, should be noted. As a Mediterranean species, reported from Southern Portugal and Agadir (Morocco), in the Gulf of Gabès, it seems to be common in bottoms spared from bottom trawling such as the South-East of Kerkennah at –14m;and in Kneiss, between 6–7m deep.It is threatened mainly by silting and Troll fishing.

Eunicella singularis (Esper, 1791).

Animalia (Kingdom); Cnidaria (Phylum); Anthozoa (Class); Octocorallia (Subclass); Alcyonacea (Order); Holaxonia (Suborder); Gorgoniidae (Family); *Eunicella* (Genus); *Eunicella singularis* (Species).

It colonizes coastal detritus, between 35 and 100m deep (Ben Mustapha *et al.* 2004).It is an endemic species of the Mediterranean, mainly in the Western basin and the Adriatic (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). It is much localized in the Gulf of Gabès and considered uncommon in the coastal detritus (35–100m deep), while for Ben Mustapha *et al.* (2004), it is common in Fora Mostafa, on thalli of maerl (40–55m).It is threatened mainly by silting and Troll fishing.

Leptogorgia sarmentosa (Esper, 1789).

Animalia (Kingdom); Cnidaria (Phylum); Anthozoa (Class); Octocorallia (Subclass); Alcyonacea (Order); Holaxonia (Suborder); Gorgoniidae (Family); *Leptogorgia* (Genus); *Leptogorgia sarmentosa* (Species).

It lives in the coastal detritus, between 35 and 100m deep.It is a Mediterraneanendemic species (Ramos-Esplá *et al.* 2011). Much localized in the Gulf of Gabès, it is considered uncommon in the coastal detritus (35–100m deep).Siltation and trawl fishing are the main threats (Hattour and Ben Mustapha, 2015).

III.2.9. Polychaeta annelids

Unanereis zghali Ben Amor, 1980.

Animalia (Kingdom); Annelida (Phylum); Polychaeta (Class); Errantia (Subclass); Phyllodocida (Order); Nereidiformia (Suborder); Nereididae (Family); Nereidinae (Subfamily);

Unanereis (Genus); *Unanereis zghali* (Species).

This Mediterranean endemic species exists in Tunisia (Boudouresque, 1997). It has been observed in the Zembra Islands off Cap Bon region (Ben Amor, 1980).

III.2.10. Arthropods

Pachylasma giganteum (Philippi, 1836).

Animalia (Kingdom); Arthropoda (Phylum); Crustacea (Subphylum); Multicrustacea (Superclass); Thecostraca (Class); Cirripedia (Subclass); Thoracica (Infraclass); Thoracicacalcarea (Superorder); Balanomorpha (Order); Chthamaloidea (Superfamily); Pachylasmatidae (Family); Pachylasmatinae (Subfamily); *Pachylasma* (Genus); *Pachylasma giganteum* (Species).

It is a Mediterranean endemic species, known only in Sicily (Straits of Messina, Italy). Nevertheless, Darwin (1854)has also reported it from the shores of Great Britain and the Northern United States, with a larger average size than in Sicily.It is a small crustacean that lives in hard substrates at relatively great depths.It is rare and threatened by its restricted geographical distribution (Di Geronimo and Fredj, 1987; Hattour and Ben Mustapha, 2015).

III.2.11. Echinoderms

Asterina pancerii (Gasco, 1876).

Animalia(Kingdom);Echinodermata(Phylum);Asterozoa(Subphylum);Asteroidea(Class); Valvatacea (Superorder); Valvatida (Order); Asterinidae (Family); *Asterina* (Genus); *Asterina pancerii* (Species).

It is a Mediterranean endemic species observed in Italy, Spain, France, Greece, and Libya, and has not been observed in Tunisia. It is a tiny starfish (10–20mm) that is red or green in color with white spots (Ramos-Esplá *et al.* 2011). It is a small starfish living in the deep Posidonia meadows. The species is hermaphroditic, but does not self-breed, and reproduction occurs in the spring. Once abundant, it now appears to be in decline due to trawling in the Posidonia meadows leading to its recession. Thus, the species continues to decline along with Posidonia meadows, and its protection is therefore linked to them (Bernard *et al.* 1996).

Ocnus syracusanus (Grube, 1840).

Animalia (Kingdom); Echinodermata (Phylum); Echinozoa (Subphylum); Holothuroidea (Class); Actinopoda (Subclass); Dendrochirotida (Order); Cucumariidae (Family); *Ocnus* (Genus); *Ocnus syracusanus* (Species).

This Mediterranean endemic species has been observed in the Gulf of Gabès (Mustapha *et al.* 1999; Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). It lives on Posidonia meadows and detrital bottoms, from the surface up to 100m. In the Gulf of Gabès, it has been found on the seabed of Posidonia, on coarse and silted sediment, muddy sand, mud and silted coastal detrital, between 5 and 30m deep (Ben Mustapha *et al.* 1999). Outside of Kerkennah, it was captured East of Djerba and El Bibane (Ben Mustapha *et al.* 1999).

III.2.12. Mollusks

Pinna nobilis Linnaeus, 1758.

Animalia (Kingdom); Mollusca (Phylum); Bivalvia (Class); Autobranchia (Subclass); Pteriomorphia (Infraclass); Ostreida (Order); Pinnoidea (Superfamily); Pinnidae (Family); *Pinna* (Genus); *Pinna nobilis* (Species).

It is a Mediterranean endemic species. Its length can reach one meter (Ramos-Esplá *et al.* 2011). It lives half-buried in the infralittoral and sometimes even in the circalittoral, on soft bottoms, among the Posidoniameadows. It is a planktophagous filter feeder. Its reproduction is little known, except that the eggs are released in open water. Its fishing is occasional. It is used fresh or as bait and it has become very scarce. This species is considered threatened.

Patella ferruginea Gmelin, 1791.

Animalia (Kingdom), Mollusca (Phylum), Gastropoda (Class); Patellogastropoda (Subclass); Patelloidea (Superfamily); Patellidae (Family); *Patella* (Genus); *Patella ferruginea* (Species).

This species is endemic to the Western Mediterranean, quite rare in the mediolittoral and infralittoral zones (Hattour and Ben Mustapha, 2015). *Patella ferruginea* is found on rock bands, solitary, periodically deviating from its location for trophic reasons. The breeding season (Frenkiel, 1975) is very short, two months at most, in late summer and autumn(Hattour and Ben Mustapha, 2015).

Patella nigra da Costa, 1771.

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Patellogastropoda (Subclass); Patelloidea (Superfamily); Patellidae (Family); *Patella* (Genus); *Patella nigra* (Species).

This species lives permanently at the Intertidal stage on the beaten and lit rocks where it constitutes dense populations. It is favoured by its organization which allows it to withstand both wave shocks and desiccation (Kallouche, 2018). In Tunisia, it was observed in la Galite and Zembra (Anonymous, 2001). It has also observed in North Morocco and Algeria (Kallouche, 2018).

Dendropoma cristatum (Biondi, 1859)[***Dendropoma petraeum*** (Monterosato, 1884)]

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Caenogastropoda (Subclass); Littorinimorpha (Order); Vermetoidea (Superfamily); Vermetidae (Family); *Dendropoma* (Genus); *Dendropoma cristatum* (Species).

It is a Mediterranean endemic species, particularly in the warm waters of the coasts of North Africa, the Eastern Mediterranean, Southern Spain, Sicily, Malta, and Corsica. Some isolated populations are limited in the Atlantic at the level of the Strait of Gibraltar (Hattour and Ben Mustapha, 2015). Species contributing to the formation of calcareous reef of biological origin, the sidewalks, and ledges with Vermets are the product of the close association between a calcareous Corallinacea algae, a certain number of epilithic and endolithic forms (*foraminifera* for example) and a Gastropod Vermetidae like *Dendropoma petraeum* often referred to in the literature as *Vermetus cristatus*. The species is not rare, its protection comes from the fact that to get it, divers must break the limestone drop offs on which it lives, thus destroying all the neighbouring species (Hattour and Ben Mustapha, 2015).

Steromphala nivosa (A. Adams, 1853) [***Gibbula nivosa*** A. Adams, 1853]

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Vetigastropoda (Subclass); Trochida (Order); Trochoidea (Superfamily); Trochidae (Family); Cantharidinae (Subfamily); *Gibbula* (Genus); *Gibbula nivosa* (Species).

It is a species endemic to the Malta area. Other species of *Gibbula* are present in the Mediterranean, but with different pigmentations from those of *G. nivosa*. It lives exclusively under the tidal zone in shallow water of Posidonia meadows or hidden under rocks. It is a nocturnal species (collections are made between midnight and early morning) (Hattour and Ben Mustapha, 2015).

Spondylus gaederopus Linnaeus, 1758.

Animalia (Kingdom); Mollusca (Phylum); Bivalvia (Class); Autobranchia (Subclass); Pteriomorphia (Infraclass); Pectinida (Order); Pectinoidea (Superfamily); Spondylidae (Family); *Spondylus* (Genus); *Spondylus gaederopus* (Species).

This species colonizes the mats of Posidonia, the coastal detrital, between 10 and 80m deep (Ben Mustapha *et al.* 1999), also on rock and small boulders. Species endemic to the Mediterranean, its distribution has reached Southern Portugal (Ramos-Esplá *et al.* 2011; Hattour and Ben Mustapha, 2015). During surveys carried out in the Gulf of Gabès, some much eroded upper valves were collected by the large trawl West of Djerba between 14 and 21m deep, on the dead mat of Posidonia and bottom of *Fulvia fragilis*. Moreover, Ben Mustapha *et al.* (1999) found it dead (empty shells) and very rare in a muddy sediment covering the dead mattes of Posidonia, with *Caulerpa prolifera* or on the rhizomes of a regressing seabed. Empty *Spondylus* shells in Western Djerba were also collected (Ben Mustapha *et al.* 1999).

Steromphala umbilicaris(Linnaeus, 1758).

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Vetigastropoda (Subclass); Trochida (Order); Trochoidea (Superfamily); Trochidae (Family); Cantharidinae (Subfamily); *Steromphala* (Genus); *Steromphala umbilicaris* (Species).

This Mediterranean endemic species exists in Tunisia. It has been observed in the Gulf of Gabès, 1m deep in seaweeds of Sidi Youssef, Kerkennah (Boudouresque, 1997). It is frequently confused with other Trochidae and it has been oftendecribed as *Gibbula umbilicaris* (Affenzeller *et al.* 2017).

Gibbula ardens (Salis Marschlins, 1793)***.***

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Vetigastropoda (Subclass); Trochida (Order); Trochoidea (Superfamily); Trochidae (Family); Cantharidinae (Subfamily); *Gibbula* (Genus); *Gibbula ardens* (Species).

This Mediterranean endemic species was observed in Tunisia (Boudouresque, 1997). Aloui-Béjaoui and Afli (2012)and Cheour *et al.* (2014)have observed it in the port area and around the Kerkennah islands (Tunisia). It is frequently confused with other Mollusc Trochidae and it has been oftendecribed as *Gibbula barbata* (Affenzeller *et al.* 2017).

Jujubinus unidentatus (Philippi, 1844).

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Vetigastropoda (Subclass); Trochida (Order); Trochoidea (Superfamily); Trochidae (Family); Cantharidinae (Subfamily); *Jujubinus* (Genus); *Jujubinus unidentatus* (Species).

This Mediterranean endemic species exists in Tunisia. It has been observed in the upper infralittoral at 1m deep, in Posidonia meadow of the Gulf of Gabès, mainly in Kerkennah and Djerba Islands (Boudouresque, 1997).

Columbella rustica (Linnaeus, 1758).

Animalia (Kingdom); Mollusca (Phylum); Gastropoda (Class); Caenogastropoda (Subclass); Neogastropoda (Order); Buccinoidea (Superfamily); Columbellidae (Family); *Columbella* (Genus); *Columbella rustica* (Species).

This Mediterranean endemic species was observed in Tunisia, along the Tunisian Eastern coasts and in the Gulf of Gabès, mainly around the Kerkennah Islands (Boudouresque, 1997; Ouannes-Ghorbel, 2009; Anonymous, 2016).

III.2.13. Pisces

Ben Rais Lassram (2009) studied the ichthyological diversity in the Mediterranean and focused on endemic fishes in the Mediterranean and in Tunisia. A synthesis of the results of this study and other studies published before and thereafter (Capapé, 1986; Stehmann and Bürkel, 1986; Fredj and Maurin, 1987; Fischer et al. 1987; Ramos-Esplá et al. 2011). According to Bradaï (2000) and Bradaï et al. (2012), 23 endemic fish species were identified in Tunisia, which represent 18% of the total ichthyological fauna.

Raja asterias Delaroche, 1809.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Elasmobranchii (Class); Neoselachii (Subclass); Batoidea (Infraclass); Rajiformes (Order); Rajidae (Family); Raja (Genus); Raja asterias (Species).

It is a Mediterranean endemic species, known in both basins of this sea and in the Adriatic. On the East Atlantic coasts, it is reported in Southern Portugal and Northern Morocco (Fischer et al. 1987). This species is predominantly Mediterranean, but extending Westwards from Gibraltar, off the Tunisian-Algerian border and in the Gulfs of Tunis, Hammamet and Gabès (Le Danois, 1925; Lubet and Azouz, 1969; Vinciguerra, 1884; Capapé, 1989).

Raja radula Delaroche, 1809.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Elasmobranchii (Class); Neoselachii (Subclass); Batoidea (Infraclass); Rajiformes (Order); Rajidae (Family); Raja (Genus); Raja radula (Species).

It is an endemic species, known in the two basins of the Mediterranean and in the Adriatic.In the Atlantic, it has been accurately reported in Northern Morocco. However, Capapé (1989) considers it as a Mediterranean endemic species. In Tunisia, it has been observed along the entire coasts (Le Danois, 1925; Lubet and Azouz, 1969).

Raja polystigma Regan, 1923.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Elasmobranchii (Class); Neoselachii (Subclass); Batoidea (Infraclass); Rajiformes (Order); Rajidae (Family); Raja (Genus); Raja polystigma (Species).

It is a Mediterranean endemic Species, known in its western and eastern basins and in the Adriatic. In the Eastern basin, its presence is practically limited to the Tunisian, Libyan and Greek coasts. In Tunisia, it is reported along the entire coasts (Bradaï, 2000).

Leucoraja melitensis (Clark, 1926)(synonym: Raja melitensis Clark, 1926)

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Elasmobranchii (Class); Neoselachii (Subclass); Batoidea (Infraclass); Rajiformes (Order); Rajidae (Family); Raja (Genus); Leucoraja melitensis (Species).

It is a Mediterranean endemic species, known both in the western basin and in the eastern basin. However, it is only recorded along the Algerian, Tunisian and Libyan coasts. This species is common along the Northern Tunisian and Maltese coasts and rare in Algeria, only one capture has been reported from Southern Italy (Bradaï, 2000).

Salaria basilisca (Valenciennes, 1836).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Blennioidei (Suborder); Blenniidae (Family); Salariinae (Subfamily); Salaria (Genus); Salaria basilisca (Species).

It is a Mediterranean endemic species, reported in the eastern and western basins of this sea and in the Adriatic. However, records of this species are apparently following isolated captures. In Tunisia, it is recorded in the center of the country under the synonym Blennius basiliscus. It has also been reported in the Center and the South in the region of the Gulf of Gabès (Bradaï, 2000).

Microlipophrys dalmatinus (Steindachner and Kolombatovic, 1883) (synonyme: Lipophrys dalmatinus (Steindachner and Kolombatovic, 1883)).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Blennioidei (Suborder); Blenniidae (Family); Salariinae (Subfamily); Lipophrys (Genus); Lipophrys dalmatinus (Species).

It is a Mediterranean endemic species, reported in the eastern and western basins of this sea and in the Adriatic. However, it is mentioned in the Mediterranean following isolated captures.It should be noted that it has been observed in the Eastern Mediterranean.In Tunisia, this species has been reported from Mahdia, La Goulette and Bizerte for the first time (Bradaï, 2000).

Aidablennius sphynx (Valenciennes, 1836**).**

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Blennioidei (Suborder), Blenniidae (Family); Salariinae (Subfamily); Aidablennius (Genus); Aidablennius sphynx (Species).

It is a Mediterranean endemic species, reported in the eastern and western basins of this sea, in the Adriatic and black Seas. It is considered endemic to the Mediterranean but is also present on the Atlantic coasts of Morocco and in Northern and central Tunisia. It is not a strict endemic (Bradaï, 2000).

Echiodon dentatus (Cuvier, 1829).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Ophidiiformes (Order); Carapidae (Family); Carapinae (Subfamily); Echiodon (Genus); Echiodon dentatus (Species).

It is a Mediterranean endemic species, reported in the eastern and western basins of this sea and in the Adriatic and black Seas (Fredj and Maurin, 1987). However, according to Trott and Olney (1986), its distribution would extend from Gibraltar to Greek and Libyan waters. Since then, it has been in the Eastern Levantine basin. On the Eastern Atlantic coasts, a mention in Moroccan waters has been reported. It has been recorded on the coasts of central and Northern Tunisia (Le Danois, 1925; Bradaï, 2000).

Aphanius fasciatus (Valenciennes, 1821).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Cyprinodontiformes (Order); Cyprinodontidae (Family); Cyprinodontinae (Subfamily); Aphanius (Genus); Aphanius fasciatus (Species).

It is a Mediterranean endemic species, living in the two basins of this sea and in the Adriatic. However, A. fasciatus is absent from the Western basin of Morocco, Western Algerian, Spanish and French coasts. Corsica and the Northern Adriatic represent the Northern distribution limits of the species. In Tunisia, this species has been reported in the North (Northern lagoon of Tunis or “Lac de Tunis”), in the Center (Khnis) and in the South (Sfax and Sidi Mansour), where Bradaï (2000) observed it in abundance in a few centimetres of water, and previously in the Skhira and in the oasis of Chénini, the only oasis whose irrigation canals are connected to the sea by the Wadi Gabès.

Trisopterus capelanus (Lacepède, 1800) (Trisopterus minutus capelanus (Lacepède, 1800))

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Gadiformes (Order); Gadidae (Family); Trisopterus (Genus); Trisopterus minutus (Species.); Trisopterus capelanus (Subspecies)

This species, with a cold affinity, is endemic to the Mediterranean, and is present in its Western and Eastern basins and in the Adriatic. On the South shore, T. capellanus is present in Algeria, in the North of Tunisia and on the coasts of Eastern Mediterranean countries. In Tunisia, it has been reported in the Gulf of Gabès and on the Northern coasts (Le Danois, 1925; Lubet and Azouz, 1969).

Gobius geniporus Valenciennes, 1837.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order)

Gobioidei (Suborder); Gobiidae (Family); Gobiinae (Subfamily); Gobius (Genus); Gobius geniporus (Species).

This species is endemic to the Mediterranean. It is recorded in the Eastern as well as in the Western basin and in the Adriatic. On the North shore, it is mentioned in the Aegean Sea, Adriatic Sea, Tyrrhenian Sea, around Sicily and in Corso-Liguro-Provençal Sea. Thereafter, it was reported in Eastern Levantine. In Tunisia, it has been mentioned in the Gulf of Gabès (Bradaï, 2000).

Zosterisessor ophiocephalus (Pallas, 1814).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Gobioidei (Suborder); Gobiidae (Family); Gobiinae (Subfamily); Zosterisessor (Genus); Zosterisessor ophiocephalus (Species).

It is a Mediterranean endemic species with warm affinity. Its mention in this sea was made following isolated captures. It was reported in Northern Tunisia (under the name Gobius ophiocephalus), in the Gulf of Gabès (under the name Gobius ophiocephalus) and also in the lake of Ichkeul (Bradaï, 2000).

Pomatoschistus tortonesei Miller, 1969.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Gobioidei (Suborder); Gobiidae (Family); Gobiinae (Subfamily); Pomatoschistus (Genus); Pomatoschistus tortonesei (Species).

Species endemic to the Mediterranean, it is known in its two basins. However, it is only mentioned following two isolated captures in Western Sicily (Marsala) and in the lagoon of Farwah (Western Libya). It was observed for the first time in Tunisia, in the lagoons of Ghar El Melh, Tunis and El Bibène (Bradaï, 2000).

Zebrus zebrus (Risso, 1827).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Gobioidei (Suborder); Gobiidae (Family); Gobiinae (Subfamily); Zebrus (Genus); Zebrus zebrus (Species).

Species endemic to the Mediterranean, it is known in its two basins and in the Adriatic. It has been reported only on the Northern shore of the Mediterranean following isolated captures. It is generally occasional there. However, it was observed later in Southwestern Spain and in Eastern Levantine. In Tunisia, it was fished in Salakta, Sfax and in the lagoons of Bizerte and El Bibène (Bradaï, 2000).

Symphodus rostratus (Bloch, 1791).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Labroidei (Suborder); Labridae (Family); Symphodus (Genus); Symphodus rostratus (Species)

Endemic species, it is known in the two basins of the Mediterranean, in the Adriatic and in the Black Sea.This species is recorded also in the Gulf of Gabès (Bradaï, 2000).

Symphodus ocellatus (Linnaeus, 1758) (Symphodus (Crenilabrus) ocellatus Forsskal, 1775)

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Labroidei (Suborder); Labridae (Family); Symphodus (Genus); Symphodus ocellatus (Species)

This warm-affinity species is endemic to the Mediterranean.It has been observed in the Eastern and Western basins, in the Adriatic and in the Black Sea.This species has been reported in the Gulf of Gabès and in the North of Tunisia (Lubet and Azouz, 1969).

Symphodus doderleini Jordan, 1890.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Labroidei (Suborder); Labridae (Family); Symphodus (Genus); Symphodus doderleini (Species).

This species, warm affinity, is endemic to the Mediterranean. It is known in the Western basin (except the Gulf of Lion), in the Eastern basin and in the Adriatic. In Tunisia, it is reported in the Gulf of Gabès (Bradaï, 2000).

Hyporthodus haifensis (Ben-Tuvia, 1953) (Epinephelus haifensis Ben Tuvia, 1953)

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Percoidei (Suborder); Serranidae (Family); Epinephelinae (Subfamily); Epinephelus (Genus); Hyporthodushaifensis (Species).

This is a Mediterranean endemic species, known on the coasts of Palestine, Lebanon, and Morocco. In June 1998, it was observed in Zarziss coming from Libya. Then in July of the same year, a specimen was observed in Sfax whose provenance is unknown. In July 2000, six specimens were caught by longliners from Zarziss (Bradaï, 2000).

Solea egyptiaca Chabanaud, 1927.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Pleuronectiformes (Order); Soleidae (Family); Solea (Genus); Solea aegyptiaca (Species).

This species is endemic to the Mediterranean. It is known in its Eastern basin and in the Adriatic. However, it is present in the Eastern Mediterranean, from the east coast of Tunisia to the east countries. It has been reported in the Languedoc lagoons (France). This species seems to have crossed the Suez Canal in 1899 and currently lives in the Red Sea. It has long been considered a subspecies of Solea vulgaris. Genetic studies have shown that these are two valid species. It is often confused with S. vulgaris which is similar in morphology and color to S. aegyptiaca. In Tunisia, it was mentioned in the South-East of Tunisia, in the Gulf of Tunis and in the Lake of Ichkeul and, consequently, in the marine area of Bizerte because it reproduces at sea and comes to feed in the lake (Bradaï, 2000).

Synapturichthys kleinii (Risso, 1827) (Solea kleini (Risso) Bonaparte, 1833).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Pleuronectiformes (Order); Soleidae (Family); Solea (Genus); Synapturichthys kleinii (Species).

This species is endemic to the Mediterranean. It is known in the Western and Eastern basins and in the Adriatic. It has been recorded also near the Atlantic. It is therefore an Atlantic-Mediterranean species with a warm affinity. Its distribution in the Mediterranean should be extended to the Eastern Levantine where it has been recorded. On the East Atlantic coast, it is known mainly along West Africa. It has been reported in Tunisia, in the Gulf of Gabès where it has been regularly observed (Bradaï, 2000).

Diplodus sargus (Linnaeus, 1758).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Percoidei (Suborder); Sparidae (Family); Diplodus (Genus); Diplodus sargus (Species).

It is a Mediterranean endemic species, known in the two basins of the Mediterranean and in the Adriatic. It has also been observed in the Black Sea. This species is found in Southern Tunisia (Le Danois, 1925), in the Center (Le Danois, 1925) and the North (Lubet and Azouz, 1969).

Tripterygion tripteronotum (Risso, 1810).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Perciformes (Order); Blennioidei (Suborder); Tripterygiidae (Family); Tripterygiinae (Subfamily); Tripterygion (Genus); Tripterygion tripteronotum (Species).

This piece is endemic to the Mediterranean, known in both basins, in the Adriatic and in the Black Sea. It has also been observed in the Eastern Levantine. This species was observed for the first time in Tunisia on the Eastern coasts (Bradaï, 2000).

Dasyatis tortonesei Capapé, 1975.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Elasmobranchii (Class); Neoselachii (Subclass); Batoidea (Infraclass); Myliobatiformes (Order); Dasyatidae (Family); Dasyatis (Genus); Dasyatis tortonesei (Species).

This Mediterranean endemic species exists in Tunisia (Anonymous, 2001). It lives along the Tunisian littoral in Posidonia meadows and seagrass beds, and in sandy/sandy-muddy bottoms up 100 m deep. It is frequently observed in wadis mouths and in the Gulf of Gabès (Capapé, 1978).

Zu cristatus (Bonelli, 1819).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Lampriformes (Order); Trachipteridae (Family); Zu (Genus); Zu cristatus (Species).

This species has been observed in Tunisia under the name Trachypterus cristatus (Anonymous, 2001). It is an Atlantic-Mediterranean endemic species with warm affinity. It is frequently observed in the North of Tunisia (Baradaï et al. 2004).

Trachipterus trachypterus (Gmelin, 1789).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Pisces (Superclass); Actinopterygii (Class); Lampriformes (Order); Trachipteridae (Family); Trachipterus (Genus); Trachipterus trachypterus (Species).

This species has been observed in Tunisia under the name Trachypterus taenia (Anonymous, 2001). It is an Atlantic-Mediterranean endemic species, frequently observed in the Gulf of Gabès (Baradaï et al. 2004).

Astatotilapia desfontainii(Lacepède, 1802): Endemic fish from rivers in North Africa (Algeria and Tunisia):https://www.aquaportail.com/fiche-poisson-3089-astatotilapia-desfontainii.html

Pseudophoxinus punicus (Pellegrin, 1920):

The genus Pseudophoxinus belongs to the Family of "Cyprinidae" which are Mediterranean endemic species, living in only Tunisian and Eastern Algerian freshwaters. Pseudophoxinus includes three species (P. punicus, P. callensis and P. chaignoni) hardly discernible from morphological criteria alone (Dkhil-Abbès and Kraïem, 2008).

III.2.14. Aves

Puffinus yelkouan (Acerbi, 1827).

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Tetrapoda (Superclass); Aves (Class); Procellariiformes (Order); Procellariidae (Family); *Puffinus* (Genus); *Puffinus yelkouan* (Species).

It is a Mediterranean endemic species with two clearly defined subspecies:*Puffinus y. mauritanicus* breeding in the Balearic Islands and*Puffinus y. Yelkouan* in the Tyrrhenian, Adriatic, and Aegean seas. It disappeared from Corsica. It is a strictly pelagic species that breeds on islands and rocky islets. Nocturnal, it nests in burrows, crevices or under rocks. Its existence in Tunisia is unlikely (Bradaï, 2000).

Sterna bengalensis Lesson, 1831.

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Tetrapoda (Superclass); Aves (Class); Charadriiformes (Order); Laridae (Family); *Sterna* (Genus); *Sterna bengalensis* (Species).

In the Mediterranean, small, localized population of endemic subspecies *Sterna b. emigrata* is isolated from the breeding range of other subspecies (Indian Ocean and Red Sea). It is restricted to small isolated offshore islands on sandy soil, in dry saltmarsh.

Nest scrapes are shallow and dense. Food is primarily composed of small fish: anchovy, sardine, and pilchards. The present breeding population is less than 4000 pairs on two offshore islands in Libya. Occasional breeding recorded elsewhere (France, Greece, Italy, and Spain). Inventory and map critical habitats confer strictly protected status on this species (destruction and disturbance of species/habitat, collect or trade without a permit; Bradaï, 2000).It has been observed in Libya, France, Greece, Italy, and Spain. Its existence in Tunisia is unlikely (Bradaï, 2000).

III.2.15. Delphinids

Tursiops truncatus (Montagui, 1821)***.***

Animalia (Kingdom); Chordata (Phylum); Vertebrata (Subphylum); Gnathostomata (Superclass); Tetrapoda (Superclass); Mammalia (Class); Theria(Subclass);Cetartiodactyla(Order);Cetancodonta(Suborder);Cetacea(Infraorder); Odontoceti (Superfamily); Delphinidae (Family); *Tursiops* (Genus); *Tursiops truncatus* (Species).

This common bottlenose dolphin *Tursiops truncatus* is a Mediterranean endemic species frequently observed in Tunisia (Benmessaoud *et al.* 2018). Its density has been estimated to be 19 individuals/100km^2. The average estimated value in Tunisian waters is 3977 dolphins, with a relatively large confidence interval, of 1982 to 7584 individuals. The species was however abundant in the Monastir-Chebba and the Gulf of Gabès. In the Cap Bon, the relative abundance was relatively low compared to the other zones (Ben Naceur *et al.* 2004).

IV. Relationship between habitat, endemic species, and coastal tourism

Tourism in Tunisia is relatively an old activity; it has developed since the country's independence (1956).It is mainly located on the coast (95% of tourist activities), notably on the East coast between Nabeul and Sfax (more than 50%)(Krakimel, 2003) but also the Djerba Islands(SE) and Tabarka (NW). The tourism sector in Tunisia contributes on average 6–8% of the GDP, 18–20% of foreign exchange earnings and employs around 400,000 people.The overall capacity of tourism in Tunisia is around 241,000 beds.However, the number of tourists has fluctuated markedly from year to year, mainly since the revolution (January 2011).For example, the number of entries of non-residents during the period from January 1 to July 10 was 3,637,718 in 2010; 4,148,142 in 2019 and 1,366,958 in 2020 (Anonymous, 2021).However, the evolution between 2010 and 2019 was not steady and experienced ups and downs, depending on several factors, including the political and security situation of the country.

Over several decades, tourism activity has had negative effects on coastal ecosystems. The construction of hotels along coastal areas and the occupation of beaches have certainly a negative impact on habitats and biodiversity in general, including endemic species subject of this work (Lootvoet *et al.* 2010).According to the MedWetCoast program, 35% of species (all taxa combined) are threatened on the coast of Tunisia. This has affected certain specific ecosystems, sensitive and/or rich in biodiversity and endemic species (Krakimel, 2003).

In general,in Tunisian tourist areas (Tabarka, Hammamet, Sousse, Monastir and Djerba), phanerogam meadows (Posidonia and eelgrass) and algae are absent in shallow depths (swimming area). They are often large and relatively in good condition at medium depths, like the seagrass beds on the East of the Djerbalsland and in the Gulf of Hammamet. The phanerogam endemic to the Mediterranean, *Posidonia oceanica*, constitutes the main fields of marine plants in the Mediterranean where they represent the first hotspot of biodiversity. But Posidonia is not endangered as a species; it is rather the meadows that it forms that are threatened. In the Gulf of Gabès (Southern Tunisia), Posidonia meadows were the densest compared to the whole Mediterranean. In general, the Posidonia meadows in Tunisia have declined due to several factors, including tourism. Siltation caused by discharges of phosphogypsum (Gulf of Gabès), trawling, organic pollution, troll fishing and maritime constructions have all contributed to the general decline of Posidonia meadows. It is practically the same for macroalgae that grow in the intertidal or even the medio littoral, like *Cystoseira*. On the other hand, other algae appear to be more spared since they live further offshore such as *Laminaria*.

The 237 Tunisian coastal wetlands (*e.g.,*lagoons, sabkhas, salt marshes, swamps, wadis and chotts) which communicate with the sea and/or between them contributein general to improving the biodiversity of the Tunisian coasts (Anonymous, 2001; 2002). It should be noted that among the humic zones, only the coastal lagoons have been the subject of several studies. They are seven in number and represent the most productive

wetlands. They are the seat of a high and characteristic biodiversity and are home to quite a few endemic species. Most Tunisian lagoons are subject to various sources of pollution (*e.g.,*town planning, urban and industrial discharges) and some lagoons are the subject of significant fishing activities. As for tourism, it has negative impacts especially on lagoons close to tourist areas or beaches, such as Ghar El-Melh and Boughrara lagoons.

In Tunisia there are 62 islands and islets. They host a remarkablehigh biodiversity. Some islands are more important in terms of biodiversity than others (Boudouresque *et al.* 1996).The Galite archipelago, located about 50km from the northern coast of Tunisia, is made up of a set of islands and islets. La Galite is the only inhabited island in the archipelago and no waste or sewage collection structure currently exists. The archipelago is frequented mainly by boaters. With a view to preserving the supposed habitat of the monk seal, the Galiton Island in the west has been classified since July 1980, by order of the Ministry of Agriculture, as a "Strict Nature Reserve". In 1995, a decree from the Ministry of Agriculture banned fishing in the 1.5 MN band around the islands. The archipelago is home to many rare, endemic, and threatened species.It can, therefore, be considered of major importance in terms of biodiversity:

- -The brown algae *Cystoseira stricta*, endemic, bio-indicator of pure waters.
- -The calcareous red algae *Phymatolithon calcareum* which indicates the presence of a maerl facies, very widely threatened on the Mediterranean.
- -The large Mediterranean mother-of-pearl (nacre), which is considered endangered in many areas around the Mediterranean.
- -The two gastropods, the Mediterranean Conch and *Astrea rugosa*.
- -The large black limpet is rare and much endangered "Atlantic" species and a bio-indicator of the coasts of the Western Mediterranean.
- -The red lobster is the object of targeted fishing which remains the main fishing activity of the archipelago.

The Galite archipelago is relatively protected from the impacts of tourism (although it is said that the disappearance of the monk seal is due to hunting tourists) due to the distance to the coast and the poor shelter (Krakimel, 2003).

The Zembra-Zembretta Islands are inNorth-East of the Gulf of Tunis, opposite Cap Bon, with cliffs extending below the sea to the -50m isobaths. The archipelago is of major importance for biodiversity, at the floristic level (four threatened species are reported, two of which are endemic). Zembra Island is included in UNESCO's MAB "Biosphere Reserves" list and the "Zembra and Zembretta Islands National Park" was established in 1997.

Among the 200 species of benthic fauna listed: the orange madrepore, the newt and fluted ton gastropods, the giant limpet (or ferruginous)*Patella ferruginea* which is an endemic species that is particularly threatened on the scale of the Mediterranean (Krakimel, 2003). For the impact of tourism, the Zembra archipelago is subject to strong pressure from underwater hunting, which certainly has a negative effect on biodiversity in general and endemic species.

The Kuriates Islands are located facing the town of Monastir. They are two small flat islands, low and 2km apart. Off the Northern and rocky part of the two islands, maerl formations, at very shallow depths, are very rare and very vulnerable on a Mediterranean scale. The Kuriates Islands are an important site for some seabirds. Most interestingly, these islands are one of the most important and endangered loggerhead sea turtles*Caretta caretta* nesting sites in the Mediterranean. Tourism has a significant effect on these islands, as they are very popular with tourists. As a result, the Kuriates Islands constitute a fragile and vulnerable ecosystem. Efforts have been made by Tunisia to promote environmentally friendly tourism (national strategy for sustainable coastal tourism). As for the coralligenous, it is the second hotspot of biodiversity in the Mediterranean. Being located further offshore, in depths greater than 20–30m, the coralligenous is spared from the nuisances caused by tourism, except spearfishing and trawling which affect these biogenic constructions.

Biological invasions have been accentuated in recent decades with the increase in human activities (*e.g.,* trade, navigation, port activities and travel). Biological invasions (introduction of alien species, some of which are invasive) are considered by many international organizations, including IUCN, as the second cause of biodiversity loss internationally, just after habitat destruction. Endemic species are, arguably, affected by the presence of invasive species (Ounifi-Ben Amor *et al.* 2016).

Thus, legal and regulatory structures were created; the creation of the Coastal Protection and Planning Agency (APAL, responsible for applying the State's policy on coastal protection, in general, and the public maritime domain, in particular) and the elaboration of development plans for tourist areas (Krakimel, 2003).

In this context, a network of Marine and Coastal Protected Areas, mainly located in island environments was created (the Galite archipelago, the KneissIslands, the KuriatesIslands, the Zembra and Zembretta Islands, the coast of Cap Negro at Cap Serrat). Protected areas are an effective way to conserve rare and endemic species (Abdulla *et al.* 2008). The objectives of the creation of this network in Tunisia are to (i) guarantee the protection of marine environments and rare, threatened, and endemic species; (ii) contribute to the sustainable development of coastal areas, through the controlled development of ecotourism; (iii) contribute to raising public awareness for the protection of biodiversity.

During the last decade, anarchic town planning has invaded the Tunisian coast; whereas during the last decades, the tourist urbanization of the coast has been rapid and has occupied a very large part of the beaches. According to Krakimel (2003), the direct main consequences of tourist urbanization in Tunisia are:

- The absence/poor treatment of wastewater resulting in pollution and eutrophication of lagoons and coastal waters.
- The construction of service infrastructures in land areas and nautical infrastructures at sea (*e.g.,* ports, dikes, jetties, groins and marinas) leading to the fragmentation of habitats and hydrodynamic modifications at sea (hence the fragmentation or the disappearance of certain habitats, flora and fauna species).
- The work carried out on the coast leads to an increase in the turbidity of coastal waters and a decrease in photosynthesis of seagrass beds and coralligenous communities.
- Water withdrawals from watersheds to supply fresh water to seaside resorts are also a source of significant impacts, especially in semi-arid regions.
- The construction of dams on rivers leading to the coast results in a sediment deficit that is detrimental to seagrass beds and to the entire food chain.
- Seaside activities are also another major source of ecosystem disturbance.
- The artificialization of beaches for swimmers may be the source of triggering phenomena of erosion, trampling of vegetation, destruction of sea turtle nests and disruption of the behavior of the latter due to noise and night lighting.
- Water sports (motorized pleasure boat, jet-ski, and diving) are sources of disturbance of the fauna (monk seal and turtles), direct mortality by boats (turtles and sharks) and degradation of certain marine biocenoses (caves by diving).

V. Conclusions

Although marine studies in general are numerous in Tunisia and cover several aspects of biodiversity, studies on endemic marine species are rare and fragmentary. To date, there is no complete inventory of endemic marine species in Tunisia, and even less on their status, geographic distribution, and nuisance factors. The data reported in this work were collected from scientific articles, doctoral theses, and scientific reports. They are fragmentary and scattered, and endemic species are generally mentioned incidentally in most scientific work. Therefore, the list of endemic species given in this report is not exhaustive.

Several factors affect biodiversity and endemic species, and most often act concurrently. These include climate change, urban and industrial discharges, excessive fishing, tourism, and biological invasions. Invasive species thrive at the expense of native species, especially endemic species (Ounifi-Ben Amor *et al.* 2016). They compete with them and even exclude some of them. Especially since certain endemic species form ecosystems rich in biodiversity and host many endemic species such as Posidonia and *Cystoseira* which are affected by the invasive tropical algae Caulerpa taxifolia (M.Vahl) C.Agardh, 1817 (Langar *et al.* 2002).

The impact of nuisance factors on biodiversity in general is obvious and has resulted in the disappearance of certain endemic species such as the monk seal and the rarefaction of others. Thus, it is very difficult to be able to separate the share of the impact of tourism in relation to all other factors affecting the marine environment, except perhaps in tourist areas where the effect is palpable.

This work represents the first specific study on endemic species under the impact of tourism and other environmental/anthropogenic factors. The temporal monitoring of these species will make it possible to complete the list of endemic species and to mark the evolution of their status, mainly in areas under the influence of tourist activities. This will help decision-makers and managers to adopt strategies and economic development plans that are more respectful of the environment and that will ensure the conservation of these endemic species.

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