

## TUNISIAN MEGA BENTHOS FROM INFRA (*POSIDONIA* MEADOWS) AND CIRCALITTORAL (*CORALLIGENOUS*) SITES

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### ملخص

توزيع المجتمعات القاعية والشعاب المرجانية على طول السواحل التونسية : لقد تم القيام خلال العشرية الأخيرة بالعديد من الحملات البحرية عن طريق الغوص بهدف جمع الإسفنج قصد تصنيفه ودراسته وتوزيعه البيوجغرافي إضافة إلى دراسة وتوزيع معاشب *Posidonia oceanica* على طول السواحل التونسية. ولقد مكنت هذه الحملات من مسح 555 موقع لإقتناء العينات يصل العمق فيها إلى 60 م. كما اهتم هذا العمل بدراسة المجتمعات في بعض الأعماق بهدف إبراز حالتها العامة نذكر منها خاصة معاشب *Posidonia* والشعاب المرجانية. كما تم في الأثناء إعداد قائمة بأهم الكائنات التي تعيش في هذين المنظومتين القاعيتين. ومن أهم خصائص هذين المنظومتين أنهما في حالة جيدة على طول السواحل التونسية باستثناء بعض المناطق كخليج قابس، حيث أظهرت التحاليل المفصلة حدوث تغيرات في تركيبة المجتمعات القاعية. وبمثل وجود *Caulerpa racemosa* في العديد من المواقع المنتشرة على طول السواحل التونسية ووجود *Caulerpa toxifolia* في منطقة سوسة موضوع إنشغال في حين تشكل الدراسة الحالية لـ 600 عينة من الإسفنج إضافة هامة لقائمة 132 نوع التي تم إلى الآن ذكرها في تونس. هذا ولم تظهر الدراسة الأخيرة بخصوص الإسفنج ومعاشب *Posidonia* في منطقة صيد تقليدية في عرض سواحل جرجيس ( بنك ميسوي، الجنوب التونسي ) أية علاقة بين خصائص مجتمعات الإسفنج وكثافة غطاء معاشب *Posidonia*.  
كلمات مفاتيح : مجتمعات قاعية، شعاب مرجانية، معاشب *Posidonia oceanica*، إسفنج، تونس.

### RESUME

**Mega benthos de l'infralittoral (herbier de Posidonie) et du circalittoral (coralligène) tunisien :** Plusieurs campagnes marines ciblant la collecte de démosponges marines afin d'étudier leur taxonomie ainsi que leur biogéographie et visant à étudier la phénologie et la distribution de *Posidonia oceanica* le long les côtes tunisiennes ont été conduites ces 10 dernières années. Elles ont permis une prospection en plongée sous-marine des zones de l'infra et du circalittoral dans 555 stations marines.

Ce travail de terrain a été aussi dirigé vers la description des associations observées dans certains fonds, afin de mettre en évidence l'état général des communautés principales, particulièrement celles à *Posidonia* et les formations coralligènes. Par ailleurs, les espèces les plus remarquables de ces deux habitats benthiques ont été signalées.

En général, ces deux habitats sont bien préservés le long des côtes tunisiennes. À part quelques points noirs, principalement au golfe de Gabes, où l'analyse détaillée a montré de grands changements de la structure des communautés benthiques dans les étages infra et circalittoraux. La signalisation de la Caulerpale *Caulerpa racemosa* dans plusieurs sites partout sur les côtes tunisiennes et de *Caulerpa toxifolia* dans le secteur Sousse constitue un sujet d'inquiétude. Quant à l'étude en cours de 600 spécimens de la faune des spongiaires, elle enrichira la liste de 132 espèces jusqu'ici enregistrées en Tunisie.

Par ailleurs, la récente analyse détaillée de la structure de populations d'éponges d'une zone de pêche aux éponges traditionnelle au large de Zarzis (Sud de la Tunisie) et de celle de l'herbier de Posidonie recouvrant ces fonds, n'a pas montré une corrélation évidente entre cette structure et la densité de l'herbier.

**Mots clés :** Ascidies, communautés Benthiques, Bryozoaires, Coralligène, *Posidonia oceanica*, Eponges, Tunisie.

### ABSTRACT

Several marine campaigns aiming to collect marine demosponges for specific research projects on their taxonomy and biogeography and to study the phenology and distribution of *Posidonia oceanica* along the Tunisian coasts were conducted these last 10 years. They allowed a scuba diving prospecting of the infra and

circalittoral zones of 555 marine stations. This field work was an occasion to describe some bottom's associations, to highlight the general state of the main communities, specially the *Posidonia* and the coralligenous formations, and to draw up a list of their mega benthic species.

In general, both biota are well preserved along the Tunisian coasts. except for some black spots, mainly the one of the gulf of Gabes, where detailed analysis showed large changes in the structure of the benthic communities at the infra and circalittoral levels. Other subject of concern is the presence of the Caulerpale *Caulerpa racemosa* in several sites all over the Tunisian coasts and *Caulerpa taxifolia* in Sousse area. Regarding the ongoing study of 600 specimens of the sponge fauna, it will enrich the list of 132 species hitherto recorded from the Tunisian coasts.

Furthermore recent detailed analysis of the sponge population structure of a traditional sponge fishing ground off Zarzis coasts (South of Tunisia) and the *Posidonia oceanica* meadows covering the ground, showed no evident relationships between this structure and the meadow's density.

**Keywords:** Ascidians; Benthic communities; Bryozoans; Coralligenous; *Posidonia oceanica*; Sponges; Tunisia.

## INTRODUCTION

Mediterranean marine biodiversity is well represented in its two main littoral benthic assemblages; the sea grass meadows *Posidonia oceanica* and the coralligenous assemblage (Boudouresque. 1997; Ramos-Espla et Sanchez-Lizaso; 2002, Ballesteros, *under press*). Both are present off the Tunisian coasts and have a wide geographical distribution, as it can be seen in several specific scientific papers dealing with some macro benthic species and/or macro benthic assemblages (Topsent. 1894; Seurat. 1929; Canu. et Bassler. 1930; Topsent. 1934; Molinier et Picard. 1954; Peres. 1954; Cherbonier. 1956; Ben Mustapha. 1967; Ben Alaya. 1969, 1972; Rüetzel. 1973, 1976; Ben Maiz, 1984; Boudouresque et al. 1986; Ben Maiz. 1995; Zaouali. 1993; Afli et Ben Mustapha. 2001; Ben Mustapha et El Abed. 2001; Ben Mustapha et al. 2002 a et b); as well as from some general review of the benthic communities of the trawling areas located over the 50 m bathymetric limit (Anonyme. 1923; Le Danois. 1925; Lubet et Azouz. 1969; Azouz et Capapé. 1971; De Gaillande. 1970 a et b; Ktari-Chakroun et Azouz. 1971; Azouz. 1972, 1973; Ben Othman. 1973; etc.).

Generally, authors consider that the bottoms of the littoral marine area of the northern Tunisian coasts are mainly rocky; while those of the eastern (Hammamet gulf) and southern (Gabes gulf) ones are sandy to sandy-muddy (Le Danois. 1925; Azouz. 1966, Ben Mustapha. 1966; Poizat. 1970; Azouz. 1973; Ben Othman. 1973; Blanpied et al. 1979; Ben Mustapha et Hattour. 1992; Pergent et Kempf. 1993; Brahim et al. 1994; Ben Mustapha et al. 1999).

Consequently and in general, the review of this literature shows that the marine littoral rocky bottoms of the northern coasts offer the best substratum for the colonization of a very rich coralligenous assemblages (Azouz. 1973; Anonyme. 1997; Boudouresque et al. 1986; Ben Mustapha et El Abed. A.. 2001, (present work) etc.) while in "la petite Syrte" *i.e* the gulf of Gabes *sensus largo*, and

in several part of the Hammamet gulf, where the presence of a loose sediment is predominant, the *posidonia's* meadows show their maximum geographical range distribution (Ktari-Chakroun et Azouz. 1971; Ben Othman. 1971; El Abed et Hattour, 1997; Ben Mustapha et al. 1999 etc.). Nevertheless, it should be emphasized again that both biocenosis, are well represented in all the different region off the Tunisian coasts (Azouz. 1966; Pergent et Kempf. 1993, Afli et Ben Mustapha. 2001; Ben Mustapha et El Abed. 2001; Ben Mustapha et al. 2002 a et b; (present work)).

This paper list mega benthos representatives species recorded from remarkable sites a long the Tunisian coasts. It briefly summarizes the main unpublished results of several marine campaigns conducted these 10 years. This prospecting of several sites by scuba diving up to 62 m depth, was an occasion to draw a general overview about the distribution of such species of the mega benthos of the Circa and infra littoral area, and highlight the main features of some meadows of *Posidonia oceanica* (L) Delille.

## METHODS

As the purposes of the marine campaigns were not the same, we used different methodologies either for the collection of marine demosponges or to study the phenology of the sea grass meadows.

### 1. MARINE SPONGES COLLECTIONS AND BENTHIC ECOLOGY

The study of components of the species diversity of the Tunisian marine biodiversity, particularly representatives of few phylum, was done by random sampling ("*récoltes sauvages*"), except for the 2000 - 2001 study of the structure of the sponge population of Messioua banc, east of Zarzis where we used a metallic quadrat of 1m<sup>2</sup>, used five times successively along a fixed bottom line; in order to have all the data reported to an area of 5m<sup>2</sup>; then the fixed line was displaced twofold in each stations, in order to knew the qualitative ecological parameters

of this population for an area of 15m<sup>2</sup> (Stirn. 1981; Diaz et al. 1990; Schmahl. 1990). Furthermore, the list of the main macro benthic sessile species, identified *in situ*, was done for all the prospecting dives, focusing mainly on sponges. To date, a total of 600 demosponges were sampled and are conserved in ethanol 75° for further detailed taxonomic analysis, further to 132 species already recorded from Tunisian waters (Ben Mustapha et al, a et b, *under press*).

## 2. STUDY OF *Posidonia oceanica* (LINNAEUS) MEADOWS

Several marine campaigns, aiming to cartography and/or to analyze the phenology of the main sea grass communities off the Tunisian coasts, were conducted. A metallic quadrat of 1 m<sup>2</sup> divided in 22 small quadrats (one quadrat of 0,16 m<sup>2</sup> and 21 one of 0,04 m<sup>2</sup> each) was used for the estimation of the sea grass coverage, the shots density and the phenological parameters of these meadows (Drew. 1971; Stirn. 1981; Gili et Ras. 1984; Pessani et al. 1987). In general, sampling was repeated three times in each station. The expression of the density and the coverage of the meadows where done using the classification of Giraud (1977), Meinesz et Laurent (1978) and Augier (1986). In addition, in Messioua banc (east off Zarzis, Tunisia) a recent marine campaign was done in order to scan *Posidonia* meadows with a multi-beam sonar, SEABAT 9001 (Reson Co.), attached to the R/V Hannibal, the marine research vessel of INSTM. (Komatsu et al. 2001).

## RESULTS AND DISCUSSIONS

The results of this general review are presented in two main sections. The first section presents the results related to the northern Tunisian coasts (e.g. Islands of Tabarka, Cani, Zembra), while the second one develops data gathered from several places off the eastern (e.g. Banc of Korba, and Sousse, Monastir and Salakta areas) and the southern (e.g. Kerkenah platier, Zarzis bancs) littoral (Fig. 1). Each section is divided into parts dealing with one or the other of representatives of these two main benthic assemblages, or presenting results of both assemblages for specific areas of study. In general these data, highlighting the state of these assemblages either for their high biodiversity or for their ecological degradation, are not yet described in any published work. It should be pointed out that we did not include, the state of the benthic biota of the gulf of Hammamet and the gulf of Gabes as they were already fully described elsewhere (Darmoul. 1988, Anonyme. 1992, Ben Mustapha and Hattour.

1992; Hattour et al. 1998. Ben Mustapha et al. 1999, Afli et Ben Mustapha, 2002)

## 1. REMARKABLE SITES AND BENTHIC ASSEMBLAGES FROM THE NORTHERN COASTS

### A- *Posidonia* Meadows

*Posidonia oceanica* meadows are well represented in this part of Tunisia. Several authors recorded their presence (Ostenfeld. 1918; Le Danois. 1925; Chambost. 1928 ; Molinier et Picard. 1954; Lubet et Azouz. 1969; Ben Alaya. 1969 et 1972; Azouz. 1973; Boudouresque et al. 1986; Ben Mustapha *in* Anonyme. 1991; Ben Mustapha et El Abed , 2001; Ben Mustapha et Hattour. 1992). In general they are represented by patches rather than extended areas; such as those off the islands of la Galite, Fratelli, and Zembra. In front of Bizerte and around Cani, they are geographically more extended. For instance, the meadows surrounding Cani islands reach the coast of Sidi Ali El Meki, 10 NM southerly. As they extend till cap Zebib; further field work should be focusing on the geographical area covered by the meadows off these coasts. These meadows might be more important than the remaining ones actually spreading in the gulf of Gabes, historically known as the most important ones of the Mediterranean (Ben Mustapha et Hattour. 1992; Pergent et Kempf. 1993; Boudouresque. 1997; Anonyme. 1998; Batisse et Jeudy de Grissac. 1998; Ben Mustapha et al. 1999; and present work).

In Tabarka, la Galite Fratelli and Zembra the lowest limit of the meadows was found within the Mediterranean limits, at a range depth from 30 to 40 m (Boudouresque. 1997; Ben Mustapha et al. 1999); while in the case of the meadows of Sidi Daoud's area, the limit varies from 23 to 27 m depth.

Occasionally these limits might reach deeper areas such as the ones in the Strait of Cani – Sidi Ali Mekki, found at 41 m depth. The coverage and density of the meadows vary also from an area to another, from a density of 700 shoot/m<sup>2</sup> in Zembra (Boudouresque et al. 1986), to a density of 600 shoots/m<sup>2</sup> in Galite island (Anonyme. 1998) to a one of 350 to 550 shoots/m<sup>2</sup> in Sidi Daoud's areas and 450 to 500 shots/m<sup>2</sup> in the Strait of Cani island – Sidi Ali Mekki (Ben Mustapha et al. 2002 (present work)).

Another area of importance is the one covering the eastern coasts of the gulf of Tunis; mainly starting from the south of Sidi Daoud to Ras Fartas; where the meadows grow on detritic or rocky bottoms. If we compare the distribution of the *Posidonia oceanica* meadows in the gulf of Tunis, as described by Ben Alaya (1969, 1972) with the data available nowadays, we see no general degradation in term of

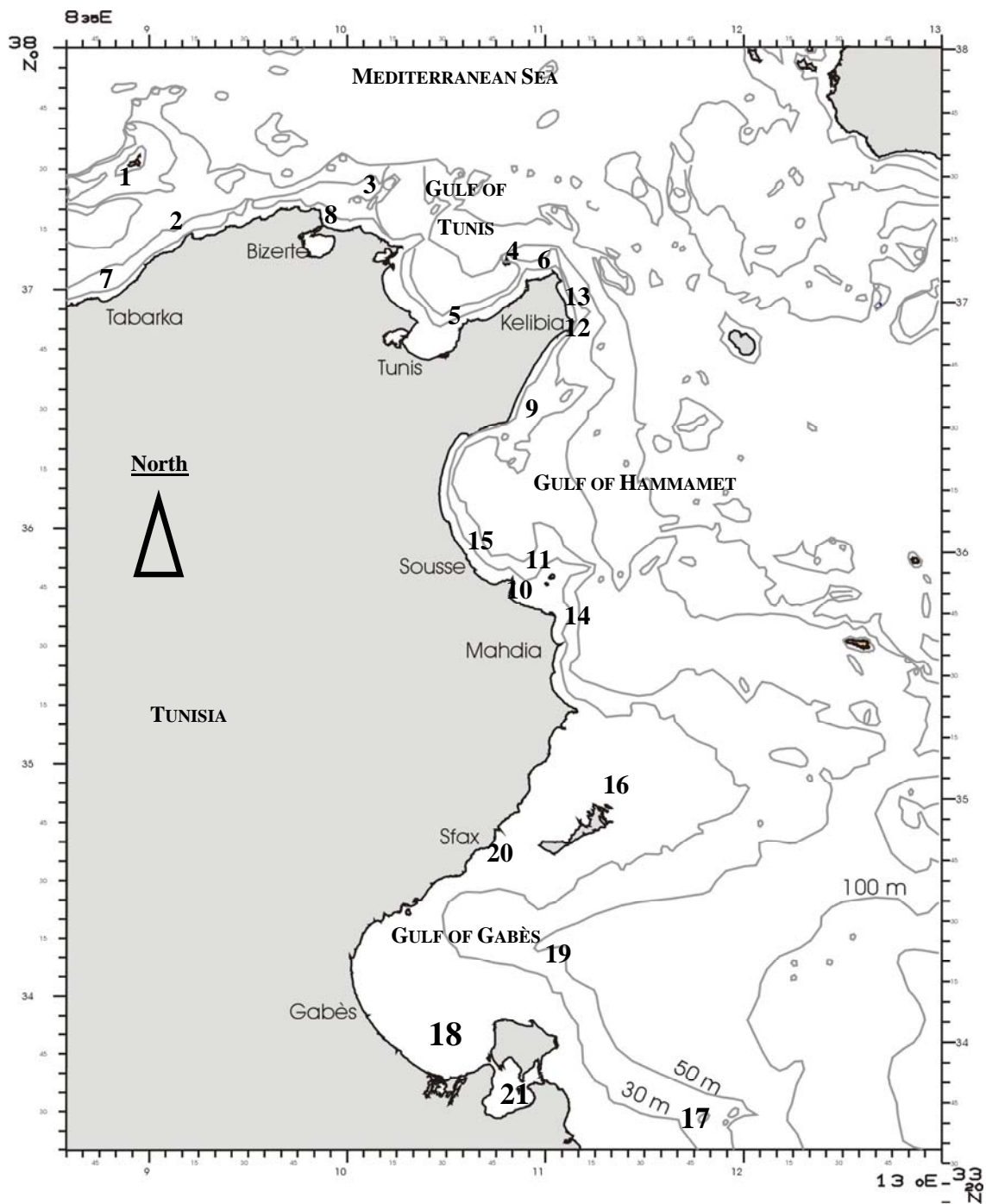


Fig. 1. Location of the main area covered by the present study. 1. Galite island; 2. Fratelli island; 3. Cani island; 4. Zembra – Zembretta area; 5. Cap Fartas; 6. Cap Bon area; 7. Tabarka; 8. Bizerte; 9. Maamoura et Korba bancs; 10. Monastir area; 11. Kuriat area; 12. Kelibia area; 13. Kerkouène area; 14. Salakta; 15. Sousse; 16. Kerkennah platier; 17. Zarzis bancs; 18. Djerba island; 19. Central area of the gulf of Gabès; 20. Sfax, 21. Bibane lagoon

area coverage. We found the meadows around Cap Farina (western part of the gulf) and the ones extending from Ras Fartas till Sidi Daoud (eastern part of the gulf). We also found the “*recif barrière*” in front of Sidi Rais; till 15 m depth. But elsewhere, few patches have been experiencing severe environmental conditions, such as the meadows extending from Salammbô to la Goulette, which already disappeared or, if they still exist, they are present as meadows limits type 2 to 3 i.e meadows in very bad healthy conditions. While the ones in front of Gammarth, seem to have their inner limits withdrawing (Ben Mustapha *in* Anonyme, 1991; Ben Mustapha et Hattour; 1992; Ben Mustapha et al. 2002 (present work); Zaouali. 2002 (pers. comm.)).

### B- Coralligenous assemblages from sciaphilic habitats

A great number of sites showed a high diversity of sessile macro benthic organisms representing healthy coralligenous assemblages. However few black spots were recorded, mainly within the gulf of Tunis. Hence, in general, few station's biota are changing from detritic to muddy's ones. Consequently in such areas, the sessile macro-benthos representatives of detritic and rocky bottoms of the circalittoral level such as the calcareous red alga *Lithotamnium corallioides*, *Lithotamnium calcareum*, the sponges *Suberites domuncula*, *Petrosia ficiformis*, *Agelas sp*, *Axinella cannabina*, *Spirastrella cunctatrix*, are replaced by representatives of muddy bottoms e.g the anthozoan *Alcyonium palmatum*, the Bryozoans *Pentapora fascialis*, the Echinoderma *Holothuria forskali*, *Ophioderma longicaudum* the Ascidian *Microcosmus sp* (Peres. 1985).

Nevertheless, a part from such located areas, despite the mortality of macro benthic invertebrates that occurred in the region in 1999 (Ben Mustapha et El Abed. 2001) coralligenous assemblages, were well represented in the circalittoral zone of Tabarka, Zembra, Galite, Fratelli and Cani, both from rocky and detritic bottoms. Indeed, the Cap Bon area, where the two Mediterranean basins joint, shows one of the greatest variability of macro benthic assemblages, with populations of sponges, such as *Clathria sp*, *Raspaciona sp*, *Phorbas sp*, *Timea sp*, reaching coverage up to 1 m<sup>2</sup>, in horizontal and sub-horizontal exposure. The species recognized *in-situ* were *Ircinia fasciculata*, *Ircinia oros*, *Ircinia sp*, *Cacospongia mollior*, *Cacospongia sp*, several species of *Sarcotragus*, *Dysidea sp*, *Petrosia ficiformis*, *Calyx nicaensis*, several species of *Haliclona* and *Chalinula*, *Poecilosclerida* representatives were abundant, with several species of *Phorbas*, *Clathria*, *Microciona*, *Artemisia*, *Raspaciona*. Also observed *Hemimycale columella*,

*Crambe crambe*, *Crambe sp*, *Timea sp*, *Cliona viridis*, *Cliona sp*, *Agelas oroides*, *Agelas sp*, *Axinella cannabina*, *Axinella polyoides* and *Oscarella lobularis*. Furthermore, this variability is also related to the changes that are actually occurring in some areas of this region, reflected by species recorded for the first time in this Mediterranean region, such as:

- A rare Gorgonian, *Ellisella sp*, recorded only in the Spanish island of Chafarinas off the Moroccan Mediterranean coasts (Calvin Calvo. 1995), and found at a depth of 47 m in front of Sidi Daoud, on a very rich coastal detritic assemblage with patches of biogenic buildups “*coralligène de plateau*”.

- The Caulerpale *Caulerpa racemosa*, listed in several stations both on detritic (e.g south-east of Zembretta island at – 45 m depth), sandy (e.g. north of Haouaria at 30 m depth) or rocky bottoms (e.g. Cani islands at – 12 m depth, Sidi Daoud at – 1.5 m depth), as well as on muddy substrate in the marina of Bizerte, at –2 to - 3 m depth (Djallouli. 2000; Ben Mustapha and El Abed. 2001). Lastly; *Caulerpa racemosa* was signaled in the Marine Protected Area of Zembra island from 16 to 34 m depth (Ben Mustapha et al. 2002 a).

B.1. The “Tunnel” area, located at – 25 m, north-west off Tabarka

Inside the tunnel, the population of the Bryozoans *Myriapora truncata* is very high. The sponges diversity is also high, with important populations of the two Poecilosclerida: *Crambe crambe* and *Hamigera hamigera*, and a massive presence of *Oscarella lobularis*, *Agelas oroides*, *Dysidea tupa*, *Sarcotragus muscarum*. Numerous specimens of the Gorgonians *Eunicella cavolini* and *Eunicella singularis*, the Bryozoans *Sertella septentrionalis*, the Hydorzoans: *Halocordyle disticha* and *Halecium halecium*., the Ascidians *Aplidium conicum* and *Pseudodistoma sp*, and the Echinoderms *Paracentrotus lividus* and *Holothuria polii* were also observed. Algae where mainly represented by the coralline ones such as *Pseudolithophilum expansum* and the chlorophyceae *Halimeda tuna* and *Flabellia petiola*. The sea grass *Posidonia oceanica* was present growing on several places mainly outside the tunnel.

B.2. A second “tunnel, located near a dense meadow of *Posidonia oceanica* (770 shots/m<sup>2</sup>), north-east off Cani Islands at –21 m depth

The sponge population was very high and was represented mainly by *Plakina sp*. Other species were listed with dense populations: *Spirastrella cunctatrix*, *Crambe crambe*, *Hemimycale columella*,

*Phorbas tenacior*, *Oscarella lobularis*, *Petrosia ficiformis*, *Chalinula sp*, *Spongia officinalis*, *Sarcotragus sp*, *Dysidea tupa* and *Dysidea fragilis*.

B.3. The caves; located at 30 m depth, west off the "Cathedrale Rock" in Zembra islands

The sponge population was well represented, mainly by representative from the orders *Agelasida*, *Poecilosclerida*, and *Haplosclerida*. The overhang concretions were mainly colonised by representatives from the Dendroceratida sponge order e. g. *Pleraplysilla spp* and *Dendrilla spp*. The living pharetronid sponge *Petrobiona massilensis* was also recorder for the first time in Tunisia, (Ben Mustapha. 1985 (unpublished.); Boudouresque et al. 1986; Ben Mustapha et al. 2002 a, present work).

B-4. The east-west fault of Zembra-Zembretta

It is a rocky bottom line located at 35 m depth and cumulating at 28 m, extending from Zembra to Zembretta. The macro benthic fauna is very riche, with gorgonians covering all substratum such as *Eunicella singularis* with a density of 17 to 24 colonies/m<sup>2</sup>, *Eunicella cavolonii*, with a more scarce presence of 3 colonies/m<sup>2</sup>, while representatives of *Leptogorgia sarmentosa* do not seem to be considered as competitive species for the space competition as they are represented by a number of colonies less then 1/m<sup>2</sup>. Bryozoarians are represented mainly by *Myriapora truncata*, *Pentapora fascialis* and *Sertella sp*; while representative species from the genus *Aplidium* and *Clavelina* are the most common ascidians. Finally, sponge population is well represented; mainly with high density of *Axinella cannabina*, *Axinella damicornis*, *Axinella polypoides*, *Agelas sp*, *Petrosia ficiformis*, *Spongia officinalis*, *Hippospongia communis*, *Sarcotragus muscarum*, *Sarcotragus sp*, *Ircinia sp*, *Cacospongia mollior*, as well a number of species from the Poecilosclerida order such as *Mycale sp*, *Hemimycale columella*, *Myxilla sp* and *Phorbas sp*, *Microciona sp*, *Clathria sp*, *Crambe sp*. *Eudendrium racemosum* and species from the Aglopheninae family are the most common Hydrozoans. Regarding the benthic flora, Cystoseiraceae are the most common representatives of a photophilic community of the horizontal substratum which includes a high density of *Dictyota dichotoma*; while *Flabellia petiola* and *Halimeda tuna* have a higher density on the vertical face of the rocky bottom.

## 2.EASTERN AND SOUTHERN COASTS

Starting from the Cap bon, till the Tunisian-Libyan border, this very large area presents some very interesting bionomic features due to the presence of

several eastern bancs off the Tunisian coasts, two large islands (Djerba and Kerkennah) and the "Kerkennah platier" (Buroillet and al. 1979). We'll focus mainly on observations that might highlight new characteristics of some sites.

### A. Korba and Maamoura bancs

Both located at a depth range of 26 to 33 m, east of Hammamet gulf, with patches of dense *Posidonia* meadows. Inter-mattes are of coarse detritic bottoms, covering a paving dale (Maamoura banc) with coralligenous assemblage (*Mesophyllum sp*, *Lithothamnion calcareum*, *Lithothamnion sp*, and *Eunicella singularis*). As recorded by Ben Mustapha and Hattour (1992), the dense meadows, growing on mattes are of type 3. The sponge and ascidian fauna is very rich, with species such as *Cliona vastifica*, *Cliona viridis*, *Ircinia oros*, *Ircinia fasciculata*, *Sarcotragus muscarum*, *Cacospongia mollior*, *Scopalyna lophyropoda*, *Axinella polypoides*, *Agelas sp*, *Hemimycale columella*, *Anchone fictitius*, *Hamigera hamigera*, *Crambe crambe*, *Petrosia ficiformis*, *Dysidea fragilis*, *Dysidea tupa* and *Aplysilla sulfurea* for the sponge phylum. Ascidians were represented by several species such as *Aplidium conicum*, *Aplidium tabarquensis*, *Pseudosdistoma crucigaster*, *Pseudodistoma sp*, *Didemnum maculosum*, *Diplosoma sp*, *Polycitor adriaticum* and *Polycitor. sp*.

### B- Hallouf Banc (30 NM east of Monastir)

In Hallouf banc, where the coralligenous is the dominant benthic habitat, actual data allow us to record the presence of a dense pheophyceae coverage, represented mainly by *Dictyota membranacea*, *Sargassum hornschurchii*, *Sargassum vulgareae* and *Zonaria tournefortii*. Rhodophyceae are represented by a bigger number of species such as : *Faucea repens*, *Galaxaura oblongata*, *Ptilophora mediterranea*, *Phyllophora nervosa*, *Vidalia volubilis*, *Chondrymnea lobata*, *Sebdenia dichotoma*, *Halarchnion ligatum*, *Halymenia sp*, *Peysonella rosa-marina*, *Peysonella rubra*, *Litophyllum expansum* and *Lithothamnium sp*; while the Chlorophyceae were the less represented group of algae with two main dominant species: *Flabellia petiola*, and *Caulerpa racemosa*; while we also recorded the sciaphil species *Palmophyllum crassum* in some stations of the bancs. The sponge fauna is well represented with individuals of *Hippospongia communis*, *Cacospongia mollior*, *Ircinia dendroides*, *Ircinia fasciculata*, *Petrosia ficiformis*, *Callyspongia sp*, *Cliona sp*, *Chondrosia reniformis*, *Crambe crambe*, *Hamigera hamigera*, *Phorbas sp*, *Acanthella acuta*, *Agelas oroides*, *Axinella damicornis*, *Axinella polypoides*, *Spongia officinalis*,

*Spongia nitens*, *Cacospongia mollior*, *Fasciospongia cavernosa*, *Ircinia fasciculata*, *Sarcotragus spinosula*, *Ircinia chevreuxi*, *Sarcotragus muscarum*, *Dysidea fragilis*. This small list of sponges will enrich the list of 35 sponges recorded from the coralligenous assemblages from the tunisian coasts (Ben Mustapha and al, 2002). Other representatives from the mega benthos are the sea urchin *Sphaerichinus granularis* with densities ranging from 4 to 6 individuals/m<sup>2</sup>, and a diameter of 7 cm (mean) and the, rather, rare *Centrostephanus longispinus*, the gorgonian *Eunicella singularis*, with a density of 2 individuals/5 m<sup>2</sup> and *Lophophorgia sp.* Annelides were also present with two species: *Spirographis spallanzanii* and *Cerianthus sp.*

The bibliographical data relative to this area are practically non existent, at least to our knowledge:

- Pruvot (1923), described the station *T 61* (55 m depth), which is situated in the zone of the banc, having "a bottom with "sable coquillier" corresponding to a bionomic *faciès* of brown algae and *floridés* ".

- In another document (Anonyme, 1923), which includes a synthesis of all the marine campaigns data collected by the "*Perche*", "*l'Orvet* ", the "*Pourquoi pas*" etc., the author without specifying explicitly these "*faciès*" made of brown algae, represents all the same two drawings of *Fucus* (*F .serratus* and *F .vesiculosus*.) in the part dedicated to this area of the gulf of Hammamet.

- Finally, in 1925, Le Danois did not focus particularly on the bionomic features of this area, nevertheless he spoke about "a *faciès* of brown alga " that he recorded from that region.

In summary, the presence of such an important quantity of these *pheophycae*, directed those authors to describe a new bionomic "*faciès*" of "brown algae" off the Tunisian coasts. Our campaign, although of short duration was able to confirm the importance of this assemblage in rather southern region of Tunisia.

### **C- Sponges, Ascidians and Bryozoans from the Posidonia meadows off the Sahel coasts and "Kerkennah platier"**

The meadows start from the "Sahel coasts" i.e Sousse-Monastir area, continue to the east towards Kuriat island, and to the south towards the "Kerkennah platier" (Amari., 1984), surround it easterly and south. These very extended meadows, of type 2 to 3 (Coverage between 50% and 100%, generally growing on mattes up to 1m high) can reach 27 to 30 m depth. Of course from place to place there is discontinuity, but we shall consider it as a very large area of sea grass development. The specie richness of the associated fauna differs from place to place. We'll focus briefly on the meadows

off "Kerkennah platier" i.e located at a range depth of 15 to 25 m and those situated in few other places such as Sousse port, Monastir, the channel between Kuriat island and Monastir at 26 m depth, and Cap Salakta.

#### **C.1. Sousse**

The *Posidonia* meadows in front of Sousse are more and more confronted to the presence of the invasive alga *Caulerpa taxifolia*, signaled in Tunisian waters by Langar et al (2000) for the first time. First investigations showed that the presence of mattes of 2 m high, is a past testimony of a dense and healthy meadow. Actually, and in general, the perimeter of the mattes is still occupied by *Posidonia*, while the bottoms of the central area are sandy or muddy-sandy, and are covered by death leaves of *Posidonia*. The limit of the seagrass meadows located at 15 – 17 m depth, is of type 3 (few *Posidonia* rhizomes still exist with rare shots, and a coverage of 5 to 30%, in a muddy bottom), which didn't allow the fixation of a pre-coralligenous lower strata on the rhizomes. We listed only two species of sponges; *Dysidea fragilis* and *Ircinia fasciculata*, and two Ascidians; *Aplidium conicum* and *Aplidium sp.*; as well as a very scarce presence of alga such as *Flabellia petiolo*, *Halimeda tuna* and *Lithophyllum sp.*; while *Codium bursa* was present on the muddy bottom with *Caulerpa prolifera*. This limit as well as all the space made free by the merchants ships anchors action (anchoring area) is invaded by *Caulerpa taxifolia*, with partial replacement of the *Caulerpa prolifera* meadow.

#### **C.2. Monastir**

The southern area of this region is covered by a *Posidonia oceanica* and *Caulerpa prolifera* meadows where the following species were recorded: Sponges represented by *Verongia aerophoba*, *Ircinia fasciculata*, *Cacospongia mollior*, *Fasciospongia cavernosa*, *Dysidea tupa*, *Hemimycale columella*, *Haliclona mediterranea*, *Timea sp*, *Crambe crambe*, *Cliona celata*, *Cliona viridis*, *Phorbas fictitius*, *Phorbas tenacior*, *Phorbas sp*, *Oscarella lobularis*; Ascidians, represented by *Aplidium conicum*, *Didemnum maculosum*, *Polycitor sp*, *Microcosmus sp*, *Ecteinascidia turbinata*, finally *Pentapora fascialis*, *Sertella septentrionalis* and *Aldeonella calveti* represent the Bryozoans phylum. In this area, the meadows can be of type 3, with mattes high up to 1.5 m, while in the northern area, these meadows reaching 25 m, represent a regressive limit of type 3. *Caulerpa racemosa* was recorded in several stations of Monastir, such as on rocky substratum in the fishing port of Monastir and on the muddy bottoms of the meadows of limit type 3 at 25 m depth.

### C.3. Kuriat – Monastir chenal

Despite the presence of type II meadows with 600 shots/m<sup>2</sup>, the macro benthic sessile fauna was surprisingly impoverished, in comparison with other places such as the bancs described before. We listed few species of sponges such as *Dictyonella sp*, *Scopalina lophyropoda*, *Tethya aurantium*, *Dysidea avara*, *Ircinia oros*, *Sarcotragus muscarum* and few ascidians such as *Aplidium conicum* and *Polycitor adriaticum* as well as the Bryozoans *Sertella septentrionalis*.

### C.4. Salakta

The bottoms located in the southern area of Salakta at a depth of 6 m are sandy, with several patches of *Posidonia* meadows and rocky slabs. The mattes of the *Posidonia* meadows (type III, with a 750 shot/m<sup>2</sup>) might be higher than 2 m. The sandy bottom is covered by *Cymodocea nodosa* or, from place to place, by *Zostera noltii*. *Caulerpa racemosa* and *Caulerpa prolifera* were both recorded. Sponges species were not abundant neither were ascidian's ones. *Tethya aurantium*, *Tethya citrina*, *Dysidea fragilis*, *Sarcotragus muscarum* and *Crambe crambe*, *Polycitor adriaticum* and *Haloyocintha papillosa* are the sponges and ascidians species that we listed in this area, plus very rare skeletons of Madreporarians belonging to *Leptopsamia pruvoti* and *Cladocera cespitosa*.

### C.5. "Kerkennah Platier"

Several stations around the "Kerkennah platier" were visited. Meadows cover a very important geographical area, all around the Kerekannah's shallow water "platier". In the north they reach 37 m depth in front of Chebba, while the eastern and southern limits are less deep, as they're located between 18 to 25 m. In these areas, the meadows are less dense than those growing in the northern region, but both present healthy meadows of type I to II, even though the density of shots by meter square can be lower than the one occurring in other similar types of meadows (Ben Mustapha et al. 1992; Ben Mustapha et al. 1999, Ben Mustapha et al. 2002 a and b; present work), due to the illegal trawling activity occurring all over the eastern coasts off Kerkennah island (Ramos. Espla A. et al, 2000).

These meadows are very rich in sponges, hydrozoans, bryozoans and ascidians species. The sponges *Cliona vastifica*, *Cliona viridis*, *Cliona sp*, *Aplysilla sulfurea*, *Chondrilla nucula*, *Hemimycale columella*, *Mycale massa*, *Phorbas paupertas*, *Phorbas tenacior*, *Haliclona mediterranea*, *Cacospongia mollior*, *Hippospongia communis*, *Ircinia fasciculata*, *Sarcotragus sp*, *Dysidea fragilis*; the Anthozoans *Caryophyllia sp*, *Cladocera cespitosa*, *Leptotasmia pruvoti*, *Balanophyllia sp*,

*Plumularia sp*, *Halochordyle disticha*; the Bryozoans *Filograna implexa*; *Sertella septentrionalis*, and the Ascidians *Polycitor sp*, *Botryllus schlosseri*, *Aplidium conicum*, *Clavelina nana*, *Ecteinascidia sp*, *Diazona sp*, are the most representative species of these phyla. The more common and recognized alga were *Sphaerococcus sp*, *Lithotamnium sp*, *Pseudolithophillum expansum*, *Halimeda tuna* and *Flabellia petiola*.

### D-The series of bancs off Zarzis coasts

They constitute the most important topographic features of this area. The first banc, Ras Dzira is located at 12 NM east of Zarzis at a depth ranging from 6 to 11 m, followed by Bancacou and Messioua bancs, respectively located at 20 to 30 NM east of Zarzis, at a depth ranging from 20 to 33 m, finally this series are ending with the most famous one, El Greco banc at 35 NM in the same direction at a depth ranging from 25 to 35 m. These bancs are all covered by sea grass meadows, mainly *Posidonia oceanica*, while in the sandy bottom of the inter-mattes channels, *Cymodocea nodosa* is well represented. Nevertheless, rocky and biogenic buildups bottoms are also a main feature of these bancs, specially in Messioua and Greco bancs.

#### D.1. *Posidonia* meadows

Present several types of development, from type IV (i.e the less "healthy" one) in rare places of Messioua bancs at a depth of 20 or 30 m, to type I (i.e. the healthiest one) in Messioua and Greco. These meadows can present a continuous covering as seen in Greco, Messioua and Ras Dzira, or can present large patches as seen in Bancacou, and some stations of Messioua and Greco. The *Posidonia*'s mattes can be short (30cm high) or nonexistent, mainly near the deepest limit of the meadows (as seen at 30 m depth in Messioua) or even at 20 m depth in Banacaou. Elsewhere, the matte's height varies between 0.7 to 1.5 m. The coverage also varies from less than 40 % (Messioua and Bancacou) to near 100 % (Messioua, Ras Dzira and Greco). The density of shots/m<sup>2</sup> is very high in general in Messioua, Greco and Ras Dzira, varying from 525 (meadows of type II) to 1125 shots/m<sup>2</sup> (meadows of Type V), that means the highest density of shoot/m<sup>2</sup> in the whole Mediterranean region and for such a range of depth (Ben Mustapha et al, *under press*). Nevertheless, in several places of Bancacou and the deepest stations of Messioua, this density is low, varying from 350 to 500 shots/m<sup>2</sup> (meadow of type III and type II). The presence of such meadow, which represent in several places meadows in limits of type 1 to 2 in the deep area of Messioua banc on detritic bottoms (33m depth); or in several places of Bancacou at a depth of 20 to 22 m, can not be only explained as a result of luminosity impoverishment related to the depth, but

mainly as a result of illegal trawling activities in the region, as several trawl nets traces were observed.

In Messioua bank (Ben Mustapha et al, *under press*), the number of adult leaves varied from 2 to 6 per shot. They measures in maximum 65 cm in length and 1 cm in width, while intermediaries (maximum length 55 cm and width 0.9 cm) and juveniles (maximum length 0.6 cm and width 0.6 cm) were ranging from 0 to 3 leafs/shot. This data are not in contradiction with the hypothesis of the general small size of the *Posidonia* leaves recorded from the eastern Mediterranean basin (Ben Mustapha et al, 1999). Nevertheless, the small size structure of the leaves seems to be compensated by the high density of the coverage of the meadows (ranging up to 100% in several station) translated by the density of shots per m<sup>2</sup> as well as the number of leaves per shots.

The Leaf Area Index, that indicates the total area of *Posidonia* leaves available per m<sup>2</sup> of substratum, ranges from 108 m<sup>2</sup> to 602 m<sup>2</sup>, with a mean value of 353 m<sup>2</sup> of *Posidonia* leaf/m<sup>2</sup> of substratum. Such values are the highest ever recorded from any seagrass meadow around the Mediterranean bassin (Ben Mustapha et al, *under press*)

#### D.2. Macro benthic assemblages

Rocky bottoms were also encountered in Messioua and Greco bancs, but their morphology differs. Messioua's rocky bottoms are mainly of paving type, even though they can reach few cm high (till 40 cm), whereas those of Greco are of both type: paving and rock blocs, that might reach 2 m high. Biogenic constructions are also very common, due principally to the action of *melobesia* calcareous red algae.

A part from several stations in Bancacou and few others in Messioua, the macro benthos sessile fauna (and flora) is very well represented, mainly regarding filter feeding invertebrates such as representatives from the Sponges and Ascidiens phyla. In the three bancs, Hydrozoans such as *Plumularia setacea*, *Halocordyle disticha*, Madreporarians such as *Balophyllia europea* and *Cladocera cespitosa*, were recorded. Sponges were abundant, specially from the Dictyoceratida order such as *Hippospongia communis*, *Spongia officinalis*, *Spongia nitens*, *Cacospongia mollior*, *Fasciospongia cavernosa*, *Ircinia fasciculata*, *Ircinia spinosula*, *Ircinia chevreuxi*, *Sarcotragus muscarum*, *Dysidea fragilis*. Other species were also very abundant, such as *Oscarella lobularis*, *Cliona viridis*, *Cliona celata* and representatives of the genus *Chalinula*, *Crambe crambe*, *Phorbis tenacior*, *Hemimycale columella*, *Hamigera hamigera*. While other sponges species were linked to the depth such as *Petrosia ficiformis*, present in deeper area (30 m depth), some were very rare e.g. *Verongia aerophoba* and *Chondrilla nucula*, and others were absents: *Tethya aurantium*, *Tethya*

*citrina* and *Geodia cydonium*; or were recorded only in one banc (Ras Dzira). The Ascidiens phylum was also very well represented with *Aplidium sp*, *Pseudodistoma sp*, *Didemium sp*, *Diplosoma sp*, *Polycitor*, *Clavelina*, *Ecteinascidia turbinata* and *Botrylloides sp*; while Bryozoans were represented by *Pentapora fascialis*, *Reptadeonella sp*, *Sertella septentrionalis*, *Schizoporella sp*, and *Margaretta sp*. The sponge population of Messioua, studied during the campaigns of 2000 and 2001, is represented by 27 most frequent species (Ben Mustapha et al, in preparation). The ranging density for Poecilosclerida species vary from 0.4 to 2.4 individuals/m<sup>2</sup>; while Dictyoceratida species have a ranging density from 0.13 to 3 individuals/m<sup>2</sup>, which is higher than the one of Salakta's sponges beds (Ruetzler, 1976).

We tried to harmonize the data collected from Messioua banc in august 2001, during the scanning of *Posidonia* meadows (Komatsu et al. 2001) with a multi-beam sonar able to send several decadal beams from the transducer to measure not only the bottom depths but also height distribution of seagrass beds, by data from field truth campaigns (October 2000; May and August 2001). The analysis of the first data related to the density as well as the richness of the sponge population do not seems to be correlated to the values of the number of *Posidonia oceanica* shoots per m<sup>2</sup> (fig. 2). Nevertheless, such correlation might exists only for the commercial sponges of the *Spongiidae* family (*Hippospongia communis*, *Spongia officinalis*, *Spongia nitens* and *Spongia virgultosa*), while all other representatives from the Dictyoceratida order do not show such correlation (e.g. *Sarcotragus muscarum*, *Ircinia fasciculata*).

Furthermore, these field campaigns were also an occasion to note the presence of disturbed biota as the one of banc El Biban (in front of El Bibane laguna), and the one off the city of Zarzis, where sponges from the Dictyoceratida order present evidence of diseases .

Finally, two signalizations of alga should be mentioned here, both recorded from the Messioua banc:

- The Caulerpale *Caulerpa racemosa*, at 24 m depth covering the detritic substratum produced by the burrowing sponges *Cliona celata* and *Cliona viridis*. The same biota was also recorded for *Caulerpa racemosa* in several stations off the cap bon area (see above), where the alga was always present near these burrowing sponges and at a depth of 45 m; off the south-eastern coasts of Kerkennah island (Ben Mustapha et El Abed. 2001) and in the gulf of Gabes (Hamza et al, 1995).

- The Grateloupiacea (Rhodophyceae) *Halymenia dichotoma*, at 21 m depth in the pre-coralligenous assemblage of the circalittoral enclave of *Posidonia*'s rhizomes. Referring to the review of Ben Maïz

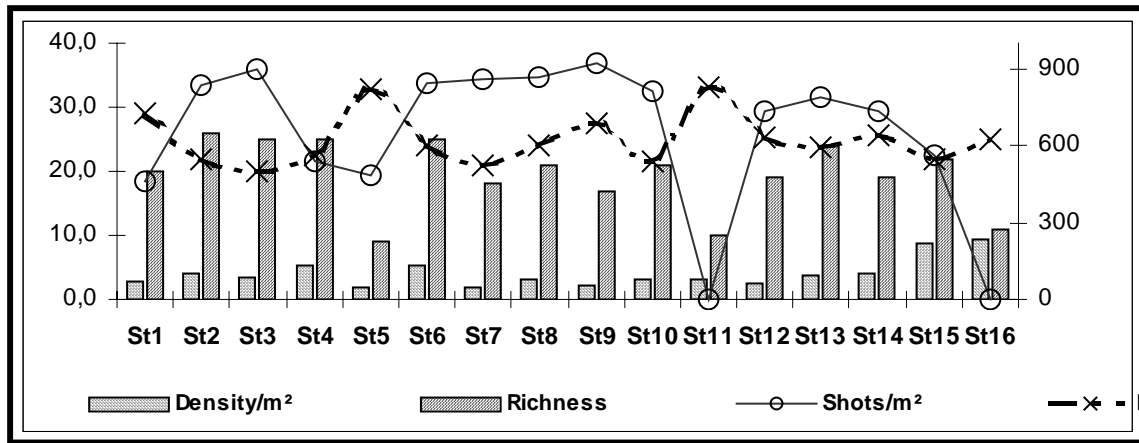


Figure 2. Sponge population density and richness from Messioua banc, in relation to the depth and to the density of *Posidonia*'s shoots/m<sup>2</sup>.

(1995) of the Tunisian marine macro algae, and to Boudouresque. (1997); this should be the first signalization of this species off Tunisian coasts, at it was only recorded in the Adriatic and western Mediterranean (Riedl, 1993).

#### E- Fora Mostapha and the surrounding area

This "cuvette" is well known as a trawling area for the shrimp fisheries located east/south-east off the gulf of Gabes. Despite the muddy bottoms and the intense shrimp trawling activity occurring in this area (Hattour. 1991; Caddy. 1993, 1995; Ben Mustapha. 1995, El Abed et Hattour. 1997 etc.), few patches of detritic biota, located between 40 till 55m depth, with coralligenous assemblage are still presents with numerous calcareous rhodophyceae such as *Lithothamnion calcareum* and *Lithothamnion coralloides*. The dominant species recorded were sponges, and the echinoderm *Cucumaria sp.* The most abundant sponges were presented by *Geodia cydonium* and *Fasciospongia cavernosa*. Less dominating species of sponges, were *Verongia aerophoba*, *Dictyonella sp.*, *Suberites domuncula*, *Cacospongia mollior*, *Sarcotragus muscarum*, *Spongia nitens* and *Hippospongia communis*. The gorgonian *Eunicella singularis* was also listed.

#### F- El Bibane Lagoon

Since 2000, several campaigns were done in this 230 km<sup>2</sup> lagoon in order to monitor the population density of the Ascidian *Ecteinascidia turbinata*. Furthermore, a pilot campaign was also done (summer 2001) to scan the benthic habitats with a multi-beam sonar, SEABAT 9001 (Reson Co.), attached to a small vessel from the El Bibane S.A., in parallel to the scanning campaign of the *Posidonia* meadows from Messioua banc (Komatsu et al. 2001). For the purposes of this scanning campaign,

15 stations were studied by scuba diving, in order to draw up the main characteristics of these habitats. The most important results deal with the important distribution of the Phanerogam *Ruppia maritima*, *Cymodoesa nodosa*, as well as the *Pheophyceae Cystoseira sp.*, which occupy nearly all the available substratum, while *Posidonia oceanica* is confined only to "El Marsa" area, and *Caulerpa prolifera* is located mainly in "El Oued" and "El Marsa" areas.

Mega Invertebrates are represented by a dense population of *Pinna nobilis* and *P. rudis*, ranging from 3 to 10 individuals/m<sup>2</sup> in several zones of the laguna, as well as by a sponge population, with a short list of species but often a high density of individuals: Such as *Aplysina aerophoba*, *Ircinia chevreuxi*, *Ircinia fasciculata*, *Tethya auarantium*, *Tethya citrina* while other species are common only in some areas of the laguna, such as *Dysidea sp.*, *Haliclona mediterranea*, *Haliclona sp.*, *Ircinia sp* from El Marsa. The population of the ascidian *Ecteinascidia turbinata* is also well represented in the lagoon, with density of colonies up to 18/m<sup>2</sup> (late in spring).

At a depth of 2 m in "El Marsa", *Posidonia* patches reach a diameter ranging from 0,6 to 2 m<sup>2</sup>, with a density of shoots varying from 187 to 375 shoots/m<sup>2</sup> and leaf length ranging from 28 till 62 cm. The coralline algae *Neogoniolithon notarsii* buildups extend on 30 km in very shallow waters in the eastern coasts of the laguna.

The study of "El oued" area is worthwhile, as it's the canal connecting the Laguna with the open sea. Its depth ranges from 3 to 17 m. Due to the strong water current, large cliffs cover partially the river's banks and the bottom's substrate is detritic with coarse sediments and pebbles. Sponges are mainly represented by *Cacospongia mollior* (5 individuals/m<sup>2</sup>), *Ircinia fasciculata* (10 to 15

individuals/m<sup>2</sup>); while *Tethya aurantium*, *avara* and *Cliona viridis* are also well represented.

The particularity of this site is the presence in several places of a kind of sponge reefs "buildups" (Main sponge builders are *Ircinia sp* and *Fasciospongia cavernosa*), which might extend till 2 m<sup>2</sup> in surface, and from 40 to 80 cm thick; such formations are recorded for the first time in the Mediterranean. Very frequent are also the anthozoarian *Sargartia troglodytes* (5 colonies/m<sup>2</sup>) and the Bryozoans *Pentapora foliacea* (2 colonies/m<sup>2</sup>) and *Schizoporella sp* (2 colonies/m<sup>2</sup>).

The algae are not common, a part *Flabellia petiolo* with a density of 350 plants/m<sup>2</sup>; *Caulerpa prolifera* is very rare in comparison to the other green algae *Anadyomena stellata*. Red algae are very rare in number of species *Liagora tetrasporifera* was recorded as well as numerous dead skeleton of the calcified red algae *Neogoniolithon notarsii*

## CONCLUSIONS

This brief review of some aspects of some representatives of the infra and circalittoral zone from sites of the Tunisian coasts, with an emphasis on their Sponges fauna, allows us to conclude that the state of the macro benthos communities of the Posidonia and coralligenous biota along the Tunisian coasts, is generally satisfactory. This is specially the case for the Tunisian islands and bancs. Furthermore, we updated the listing of some macro benthic sessile species in some areas (annexe 1), with special attention on several *Posidonia oceanica*'s meadows features.

However, few sites showed a slightly disturbed state of their benthic marine environment (Bancacou banc and Fora Mostapha), while other presented a more disturbed biota such as the meadows in front of Sousse and Monastir, the remaining ones of the gulf of Gabes (El Abed et Hattour. 1997; Hattour et al. 1998; Ben Mustapha et al. 1999) and the coastal detritic biota of the gulf of Tunis, experiencing major changes of their macro benthic assemblages which might rapidly lead to the installation of a biota of muddy bottom.

In 1999, the coralligenous biota of some sites, mainly in the Cap Bon and Tabarka areas, have been experiencing important degradation of some population assemblage due to a massive mortality of their Gorgonian representatives, which was supposed to be a result of the persistence of high temperature in the whole water column up to 60m depth (Ben Mustapha et El Abed. 2001), with the lack of both the seasonal thermocline located at 20 m depth and the important vertical gradient of temperature of 10°C (Samari et al, 2001). Nevertheless, prospecting made in 2000 and 2001 shows a good recovery of these biota.

other sites, like the one located in Sousse harbour, Haouaria and Sidi Ddaoud, where *Caulerpa taxifolia* was signaled, and the ones in the south east of Kerkennah, in the Cap Bon area; including the marine protected area of Zembra, and in Cani, or Messioua bancs, where *Caulerpa racemosa* is starting to cover area till 45m depth, shall prompt us for more carefulness given that in most cases, this "colonization" is mainly located within either *posidonia* meadows or coralligenous biota, or at their direct borders.

Lastly, the study of some Tunisian bancs showed very interesting results as for Messioua where the Posidonia meadow has the highest density in the Mediterranean, or for Hallouf banc, where we described very interesting coralligenous assemblages with unique phaeophyce coverage, and for El Bibane lagoon, where a largely spread coverage of *Pinna nobilis* and *Pinna rudis* was found and where we signaled the presence of a very special kind of sponge reefs "buildups", recorded for the first time in the Mediterranean.

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