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Spatial distribution and abundance of the megabenthic fauna community in Gabes gulf (Tunisia, eastern Mediterranean Sea)

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Abstract

The aim of this paper is to bring to light the knowledge of marine diversity of invertebrates in Gabes gulf. The spatial distribution of the megabenthic fauna community in Gabes gulf (Tunisia, Eastern Mediterranean Sea), together with the bottom type and vegetation cover, were studied. The abundance of the megabenthic fauna was represented by eight groups: Echinodermata (38%), Crustacea (21%), Tunicata (19%), Mollusca (13%), Porifera (4%), Cnidaria (3%), Bryozoa, and Annelida (2%). It was spatially more concentrated in the coast area of the gulf than in the offshore waters. This area, especially, in Southern Kerkennah, North-east of Gabes and North-east of Djerba appeared to be in a good ecological condition hosting a variety of species like the pagurids Paguristes eremita and Pagurus cuanensis, the brachyura Medorippe lanata, Inachus dorsettensis, the Gastropoda Hexaplex trunculus, Bolinus brandaris, Aporrhais pespelecani, and Erosaria turdus, the Bivalvia Fulvia fragilis, the Echinoidea Psammechinus microtuberculatus, Holothuria polii, Ophiothrix fragilis and Antedon mediterranea, and the Ascidiae Aplidium cf. conicum, Didemnum spp, and Microcosmus exasperatus.

The species' compositions of the megabenthic fauna community showed clearly that the spatial analysis represented the differences between the community of these two regions (inshore waters and offshore waters). These differences were closely related to peculiar characters of the fauna and biotopes (depth, bottom type and vegetation cover community). The results of the present study should be considered as a necessary starting point for a further analysis of priceless benthic fauna contribution to the marine environment and its organisms.

Keywords: Benthic soft communities, megabenthos, invertebrata, Gabes gulf (Tunisia) Central Mediterranean.

Introduction

The Tunisian marine zones, like the rest of the Mediterranean, are subject to an increasing pressure in the anthropogenic activities (urbanization, industry, tourism, overfishing and maritime traffic). The consequences can be detected on the general state of ecosystems, mainly in inshore waters which are more sensitive and more exposed (Zaouali, 1993b; Ben Mustapha et al., 1999; Ayari & Afli, 2003). In the last three decades, Gabes gulf was the best example that illustrated the disturbances that were mainly caused by the phosphate industry (Darmoul, 1988; Darmoul et al., 1980), the bottom-trawling fishing (Hattour, 1991; M’Rabet, 1995), and a possible threat due to the climatic change (Zouari et al., 1996). However, to detect the possible changes, the use of some structural parameters such as simple numerical values (Shannon’s diversity index) may be insufficient and the intrinsic characters of the populations should also be taken into account to detect these changes in species abundance (Zenetos & Simboura, 2001). The inventory study, abundance and the space distribution of the megabenthic fauna community in Gabes gulf could be a useful tool to monitor its spatial variation (in the inshore and offshore waters). The studies carried out in Tunisia on megabenthic fauna are generally very few. The benthos of Gabes gulf is little studied, and research started with Le Daunois (1925) and followed mainly by Molinier & Picard (1954); Pérès & Picard (1956), De Gailland (1970), Ben Othman (1971a), Ktari-Chakroun & Azouz (1971), Fehri-Bedoui (1986), Zaouli (1993b) and Ben Mustapha et al. (1999). Our study represents a new contribution to the spatial distribution of this megabenthic fauna in the gulf.

Materials and Methods

Study area

This study was carried out in Gabes gulf, located
in the southern Ionian Sea (between 35°-33°N and 10-13.5°E) and extends from “Ras Kapoudia” to the Tunisian-Libyan border (Fig. 1) with two large islands (Kerkennah & Djerba) and coastal lagoons (Boughrara & El Bibane). Its climate is dry (average annual precipitation: 210 mm year⁻¹) and sunny with strong easterly winds resulting in severe aeolian erosion. The Gabes gulf opens eastwards to the offshore area and has a wide continental shelf. The tide is semidiurnal, with a maximum range of about 2 m (Bradai, 2000). The vast area of the gulf’s shallow water was affected by two differential effects of warming and cooling (Sammari et al., 2006). These observations were corroborated by Béranger et al. (2004) model, which showed that the superficial Algerian Current brought the upper layer eastwards and splits it into two branches at the Sicily Strait entrance, one flowing to the Tyrrhenian Sea, the other into the Sicily Strait. The latter is composed of two streams referred to as the Atlantic Ionian Stream (AIS) and the Atlantic Tunisian Current (ATC). Along the Tunisian coast, and during the cold period (winter-spring), the intermediate flow salinity (MAW, Modified Atlantic Water) is low (37.3 to 37.5 psu) closely resulting to that of the superficial layers. Conversely, during the warm season, the salinity strongly increased (>38 psu) and pronounced local circulation patterns were detected, most likely linked to a decline in the Eastern MAW-induced advection (Béranger et al., 2004).

Sampling

The megabenthic fauna species’ samples were collected between 20 and 260 m depth in spring 2009 in 36 stations (Fig. 1). The inshore area depth in 21 sampling stations was <60 m and offshore waters depth in the remaining 15 stations was >60 m.

Sample methods

The megabenthic fauna was collected (i.e. about 10 mm side) on board of the boat R/V “Hannibal” of the “Institut National des Sciences et Technologies de la
Mer (INSTM), using two experimental trawl types: i) type “shrimp” to the lower depths <60 m; and ii) vertical opening trawl “GOV” for depths >60 m. The horizontal opening was 23 and 15 m in the shrimp and GOV trawl, respectively, with a 20 mm mesh diameter both. The trawl was towed at a 2.9 knots medium speed for an hour. Before starting sorting, the bottom type (substrate, communities) and main characterizing vegetables and animal species were estimated and recorded. Thereafter, the megabenthic fauna samples were sorted and classified on board, only the most difficult species to identify were preserved in ethanol (70%) before being identified in laboratory. Specimens’ identification were carried out on the basis of external and internal morphology, following the criteria in literature (Koehler, 1921, 1927; Forest & Guinot, 1956; Cherbonnier, 1960; Tortonese, 1965; Zariquiey, 1968; Fishier et al., 1987; Ramos-Espla, 1991; Koutsoubas, 1992; Desroy et al., 2003).

The Gabes gulf is characterized by heterogeneous substrate (coastal detritic, muddy detritic, sand, muddy sand, sandy mud and mud). However, its grounds are principally constituted of mud and sand bottoms (Table 1). The vegetation and megabenthic fauna associated varied by substrate type and depth. Gabes gulf is largely covered with soft sediment, sandy, muddy and carbonate of biogenic origin with a terrigenous input (Burollet, 1979).

### Data analysis

Analysis of biocenotic parameters (specific richness, S, abundance, A, diversity, H’, and equitability, E, parameters) and statistical analysis (Dendrogram analysis) have been carried out. The specific richness (S) is the cumulated number of species in a station or in a site. The abundance (A) is the average per surface unit, related to one hectare. The Shannon-Wiener index (H’) (Shannon & Weaver, 1963) is calculated at each station by the following formula:

$$H' = - \sum_{i=1}^{s} \frac{n_i}{N} \log_2 \left( \frac{n_i}{N} \right)$$

Where $n_i$ is the individuals’ number of the species i, N is the total number of individuals and S is the number of species at the station. The equitability E (H’) (Pielou, 1966) is calculated at each station by the following formula:

$$E(H') = H' / \log_2 S$$

Dendrogram analysis was performed using PRIMER v5.0 for Windows XP (Clarke & Gorley, 2001), to identify the abundance of different megabenthic fauna group and the clustering samples with a similar species composition.

The megabenthic fauna mapping was performed using the geographic information system (GIS). GIS can

### Table 1. Bottom type and communities per station in Gabes gulf. The station localisation is shown in Figure 1.

| Stations (G) | Depth (m) | Substrate, communities |
|-------------|----------|------------------------|
| 6,14        | 29-51    | Mud with *Ophiothrix fragilis* and *Antedon mediterranea* |
| 5           | 28       | Dead meadow of *Posidonia* and muddy sand with Polyclinidae |
| 4,9         | 26-41    | Detritical-muddy bottom and dead meadow of *Posidonia*, with Holothuroidea and polyclinidae |
| 10          | 42       | Sand bottom with *Antedon mediterraneus* and Polyclinidae |
| 1           | 22       | Sandy mud, detritical and dead meadow of *Posidonia* with *Pinctada radiata* and Holothuroidea |
| 8,2,3       | 22-32    | Mud and dead meadow of *Posidonia* with *Fulvia fragilis* |
| 11,18       | 52-58    | Detritical coastal bottom with *Ascidiae* and Demospongiae |
| 21          | 55       | Mud with *Ophiothrix fragilis*, Demospongiae and *Ascidiae* |
| 15          | 59       | Mud with *Ophiothrix fragilis* and Demospongiae |
| 12,27,20    | 50-59    | Detritic-coastal bottoms with *Ascidiae* |
| 16,25       | 31-44    | Sandy mud and dead meadow of *Posidonia* with Holothuroidea and *Ascidiae* |
| 13,7        | 35-46    | Sandy mud with *Arthrocladia villosa* and *Ascidiae* |
| 17,34       | 70-83    | Sand with *Ascidiae* and Demospongiae |
| 35          | 86       | Sand with *Antedon mediterranea* |
| 31,36,33,24,26 | 98-256 | Sandy mud bottoms |
| 29          | 110      | Sandy mud with *Ascidiae* and *Cidaris cidaris* |
| 32,28       | 70-94    | Muddy sand with brown algae (*Taonia atomaria*) |
| 30,23       | 78-91    | Sandy mud bottoms |
| 22,19       | 60-64    | Sandy mud with red algae (*Rytiphloea tinctoria* and *Phyllophora nevosa*) |

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cross the map data with other data through specialized applications and processing tools (Bouaziz, 2002). We divide quantitative abundance (A) into three class intervals according to the individuals’ number (inds) per surface unit (1 hectare; ha):

- \( A > 100 \text{ inds/ha} \): High abundance;
- \( 100 < A \leq 50 \text{ inds/ha} \): average abundance;
- \( A < 50 \text{ inds/ha} \): low abundance.

**Results**

**Inventory and spatial distribution**

Megabenthic fauna assemblages in Gabes gulf were distributed in 208 species (Table 2). Eight groups were represented in order of abundance (%): Echinodermata (31 species, 38%), Crustacea (44 species, 21%), Tunicata (38 species, 19%), Mollusca (55 species, 13%), Porifera (31 species, 3%), Cnidaria (10 species, 3%), and finally, Annelida and Bryozoa (3 and 6 species, respectively, 21 species, 4%), Cnidaria (10 species, 3%), and finally, Annelida and Bryozoa (3 and 6 species, respectively, 2%) (Fig. 2).

**Echinodermata** was the most abundant group (Table 2). In the coastal area, four species could be seen as dominating: Ophiothrix fragilis (present in the 33% of stations), Antedon mediterranea (28%), Psammechinus miliaris (25%) and Holothuria polii (31%) with a maximum abundance of 494, 320, 114.50, 47.50 inds/ha, respectively. They were recorded, especially, in Southern Kerkennah and in Northern Djerba between 21 and 58 m depth (Table 2).

**Astropecten aurianciacus** and Coscinasterias tenusipina were sampled in Southern Kerkennah and in Eastern Djerba (29-58 m depth) although they respectively appear in 36% and 19% of stations, with a low abundance (~20 inds/ha). Echinaster sepositus was collected in the entire gulf (26-186 m depth); it had occurred in 25% of stations. Whereas in the offshore waters, Cidarids cidaris was the only dominating species with a maximum abundance of 121.50 inds/ha. It was collected in deep waters between 61 and 256 m and was present in 28% of stations.

**Crustacea** was sampled, especially, in the inshore waters. The most important species for this group were Trachysalambria palaeastiniensi, Squilla mantis and Paguristes eremite with a high abundance of 332, 175.25 and 121 inds/ha, respectively. They were present (22-58 m depth) in 36%, 25% and 36% of the stations, respectively. Inachus dorsettensis was developed in the inshore waters in 39% of stations, with an abundance of 11 inds/ha. Inachus thoracicus was sampled (in 14% of sations), only in the offshore waters between 70 and 110 m depth (Table 2).

**Tunicata** was dominated by four species Microcosmus exasperatus, Aplidium cf. conicum, Styela plicata and Didemnum spp which were sampled, especially, in the inshore waters with a high abundance of 313.5; 145, 47.75 and 25 inds/ha, respectively. Although they appeared in 19%, 44%, 11% and 36% of stations, respectively (Table 2). Aplidium cf. conicum and Didemnum spp were collected in the entire gulf (26-98 m depth).

Generally, Microcosmus exasperatus and Styela plicata were sampled together in the North-east of Gabes (21-32 m depth). Polycterus adriaticum showed an average abundance (28 inds/ha) in Southern Kerkennah and in the North-east of Djerba (45-58 m depth), it was present in 8% of stations. Ascidiella scabra was collected (in 36% of stations) in Southern Kerkennah and North-east of Djerba (40-55 m depth) and in the offshore waters (70-83 m depth), with a maximum abundance of 22 inds/ha. Ascidia mentula appearing only in the offshore waters, it was present in 14% of stations, with a low abundance of 7 inds/ha.

**Mollusca** was dominated by eight species (4 gastero-poda, 2 Bivalva and 2 Cephalopoda). Fulvia fragilis was abundant in the North-east of Gabes between 21 and 32 m depth, with a high abundance (>300 inds/ha), in 8% of the stations. Pinctada radiata was present only in two coastal locations (in North-east of Gabes in 22 m and South-east of Sfax between 21 and 30 m depth) with a maximum abundance of 22 inds/ha. Bolinus brandaris, Hexamphele trunculus, Aporhais pespelecani and Erosaria turdus had appeared in the inshore waters (especially, North-east of Gabes, Southern Kerkennah and North-east of Djerba) with a high abundance of 68; 29; 27 and 47 inds/ha, respectively. The two first species were present in 44% of stations, but Aporhais pespelecani and Erosaria turdus were sampled in 25% and 8% of stations, respectively. Sepia officinalis and Octopus vulgaris were collected in the entire gulf (22-256 m depth) in 67% and 53% of stations, with a low abundance of 3.5 and 1.5 inds/ha, respectively (Table 2).

**Porifera** was dominated by 3 species Suberites domuncula, Hippospongia communis and Aplysina aerophoba. They were collected in the North-east of Djerba and Zarzis and in the offshore waters. Suber-
Table 2. Taxonomic composition of megabenthic fauna community in Gabes gulf (spring 2009) with their ecological groups. (S) South; (N) North; (SW) South-west; (SE) South-east; (NE) North-east; (E) East; (W) West.

| Taxon                          | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m)                  |
|-------------------------------|--------------------------------------|---------------------------|----------------------------------------|
| **PORIFERA**                  |                                      |                           |                                        |
| Acanthella acuta Schmidt, 1862| 8                                    | 0.4                       | NE Djerba and Zarzis (50-58m) and offshore waters (65-186m) |
| Agelas cf. oroides Schmidt, 1864| 19                                   | 0.35                      | NE Djerba and Zarzis (45-59m)          |
| Aplysina aerophoba Schmidt, 1862| 33                                   | 2.5                       | NE Djerba and Zarzis (28-59m) and offshore waters (70-185m) |
| Calyx nicaeensis Risso, 1826  | 3                                    | 0.15                      | SE Kerkennah (31-45m)                  |
| Chondrosia reniformis Nardo, 1847| 6                                    | 0.90                      | NE Djerba (35-45m)                     |
| Cliona viridis (Schmidt, 1862)|                                      |                           |                                        |
| Dysidea fragilis Montagu, 1818| 11                                   | 2.20                      | NE Djerba and Zarzis (31-52m)          |
| Dysidea tupha Martens 1824    | 6                                    | 0.5                       | NE Djerba and Zarzis (50-58m)          |
| Haliclona mediterranea Griessinger, 1971| 8                                | 0.5                       | NE Djerba and Zarzis (50-58m)          |
| Hippopompilus communis (Lamarck, 1813)| 33                              | 10                        | NE Djerba and Zarzis (50-58m), S Kerkennah (52-58m) and offshore waters (65-100m) |
| Ircinia variabilis Schmidt, 1862| 3                                    | 0.2                       | NE Djerba and Zarzis (31-52m)          |
| Ircinia sp.                    | 11                                   | 0.65                      | NE Djerba and Zarzis (31-52m)          |
| Petrosia ficiformis Poiret, 1789| 19                                   | 0.30                      | NE Djerba and Zarzis (50-58m) and offshore waters (70-100m) |
| Raspaciona aculeate Johnston, 1842| 17                                  | 0.40                      | NE Djerba and Zarzis (31m), NE Gabes (23m) and offshore waters (78-95m) |
| Sertularella sp.               | 6                                    | 0.35                      | NE Djerba and Zarzis (31-52m)          |
| **HYDROZOA**                  |                                      |                           |                                        |
| Eudendrium sp.                | 17                                   | 2.85                      | NE Djerba (31m), NE Gabes (22m) and offshore waters (62-186m) |
| Nemertesia antennina Linnaeus, 1758| 14                               | 1.45                      | SE Kerkennah (50-58m), NE Djerba (50m) and offshore waters (110m) |
| *Sertularella* sp.            | 6                                    | 1                         | S Kerkennah (35-58m), NE Djerba (31-50m) |
| **ANTHOZOA**                  |                                      |                           |                                        |
| Aglaophenia spp.              | 16                                   | 1.55                      | S Kerkennah (50-58m), E Djerba (50-58m) and offshore waters (70m) |
| Cerianthus membranaceus Spallanzani, 1784| 6                                | 0.5                       | W Djerba (21-25m)                      |
| Calliactis parasitica Cauich, 1842| 19                                  | 21.5                      | S Kerkennah (40-55m) and E Djerba (42-46m) |
| Cladocora coespitosa Linnaeus, 1767| 11                                 | 0.5                       | SE Kerkenna (26-32m) and NE Djerba (30-35m) |
| Epizoanthus arenaceus Delle Chiaje, 1823| 20                               | 5.10                      | S Kerkennah (54m) and E Djerba (31-46m) |
| Hormathia sp.                 | 6                                    | 0.2                       | S Kerkennah (41-50m)                   |
| Pierocides griseum Pallas, 1766| 8                                    | 1                         | S Kerkennah (40-50m) and E Djerba (54m) |
| **POLYCHAETA**                |                                      |                           |                                        |
| Aphroditaeidae sp.            | 8                                    | 1.5                       | S Kerkennah (27-54m) and NE Djerba (31-45m) |
| Diopatra neapolitana (Delle Chiaje, 1841)| 6                                | 0.6                       | Offshore waters (61-65m)               |
| Laemonia hispida Savigny, 1816| 11                                   | 4                         | S Kerkennah (27-54m)                   |
| **CRUSTACEA**                 |                                      |                           |                                        |
| Aegaeon cataphractus (Olivi, 1792)| 14                                 | 6.05                      | S Kerkennah (26-30m) and NE Gabes (22-32m) |
| Balanus eburneus Gould, 1841  | 14                                   | 70                        | S Kerkennah (26-31m) and NE Gabés (22-32m) |
| Calappa granulata Linnaeus, 1767| 3                                    | 0.40                      | Offshore waters (256m)                 |
| Calcinus tubularis Linnaeus, 1767| 3                                    | 0.2                       | S Kerkennah (26-31m)                   |
| Chlorotocus crassicornis Costa, 1871| 3                                 | 1                         | Offshore waters (256m)                 |
| Diogenes pugilator Roux, 1828 | 6                                    | 0.6                       | S Kerkennah (26-31m)                   |
| Dardanus calidus Risso, 1827  | 3                                    | 5.60                      | Offshore waters (70m)                  |
| Dromia personata Linnaeus, 1759| 11                                   | 3.60                      | NE Djerba (45-52m) and offshore waters (70-91m) |

(continued)
| Taxon                          | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m)                                                                 |
|-------------------------------|---------------------------------------|---------------------------|----------------------------------------------------------------------------------------|
| Ethusa mascarone (Herbst, 1785) | 8                                     | 2                         | S Kerkennah (26-54m)                                                                   |
| Eucrate crenate de Haan, 1835 | 8                                     | 7.5                       | NE Gabes (21-32m)                                                                      |
| Goneplax rhomboides (Linnaeus, 1758) | 3                                     | 1                         | SE Kerkennah (41m)                                                                     |
| Ilia nucleus Linnaeus, 1758    | 8                                     | 1.5                       | NE Gabes (21-32m)                                                                      |
| Inachus dorsettensis (Pennant, 1777) | 39                                    | 11                        | NE Gabes (21-23m), S Kerkennah (26-50m) and NE Djerba (42-59m)                          |
| Inachus thoracicus (Roux, 1830) | 14                                    | 3.60                      | Offshore waters (70-110m)                                                              |
| Lambrus angulifrons (Latreille, 1825) | 8                                     | 4                         | S Kerkennah (26-30m)                                                                   |
| Latreillia elegans (Roux, 1830) | 8                                     | 0.40                      | Offshore waters (108-256m)                                                             |
| Liocarcinus corrogatus (Pennant, 1777) | 3                                     | 0.20                      | NE Gabes (21-32m)                                                                      |
| Liocarcinus depurator (Linnaeus, 1758) | 6                                     | 1                         | NE Gabes (21-23m)                                                                      |
| Liocarcinus cf. maculatus (Risso, 1827) | 3                                     | 0.20                      | NE Gabes (22m)                                                                         |
| Liocarcinus cf. maculatus     | 3                                     | 0.2                       | NE Gabes (1 and 23m) and E Djerba (39-45m)                                              |
| Macropipus tuberculatus (Roux, 1830) | 3                                     | 0.30                      | Offshore waters (256m)                                                                 |
| Macropodia longirostris (Fabricius, 1777) | 19                                    | 7.5                       | S Kerkennah (26-58m) and NE Djerba (31-43m)                                             |
| Macropodia rostrata (Linnaeus, 1758) | 8                                     | 1.5                       | S Kerkennah (30-50m)                                                                   |
| Maja crispata Risso, 1827      | 8                                     | 3.75                      | NE Gabes (21-32m)                                                                      |
| Medorippe lanata (Linnaeus, 1767) | 14                                    | 3                         | S Kerkennah (31-52m), NE Djerba (42-60m) and offshore waters (110m)                     |
| Melicertus kerathurus (Forskal, 1775) | 39                                    | 11                        | NE Gabes (22-32m), S Kerkennah (22-55m) and NE Djerba (31-58m)                          |
| Metapenaeus monoceros (Fabricius, 1798) | 8                                     | 1.5                       | NE Gabes (22-32m) and S Kerkennah (26-30m)                                              |
| Neprops norvegicus (Linnaeus, 1758) | 3                                     | 0.6                       | Offshore waters (256m)                                                                 |
| Paguristes eronita (Linnaeus, 1767) | 36                                    | 121                       | NE Gabes (22-32m), S Kerkennah (29-58m) and NE Djerba (31-60m)                          |
| Pagurus cuanensis (Bell, 1845)  | 25                                    | 9                         | S Kerkennah (40-50m) and NE Djerba (42-60m)                                             |
| Pagurus excavatus (Muller, 1788) | 3                                     | 1                         | Offshore waters (108m)                                                                 |
| Pagurus prideauxi (Leach, 1815) | 3                                     | 0.6                       | S Kerkennah (40m)                                                                       |
| Pagurus cf. alatus (Fabricius, 1775) | 3                                     | 2                         | NE Djerba (59m)                                                                        |
| Parapenaeus longirostrus (Lucas, 1847) | 14                                    | 14                        | Offshore waters (110-256m)                                                             |
| Parthenope angulifrons (Latreille, 1825) | 14                                    | 3                         | S Kerkennah (26-30m) and E Djerba (31-45m)                                             |
| Pilamnus hirtellus (Linnaeus, 1761) | 22                                    | 5                         | NE Gabes (21 and 23m), S Kerkennah (40-50m) and NE Djerba (45-52m)                      |
| Pisa tetradoron (Pennant, 1777)  | 3                                     | 1                         | Offshore waters (82m)                                                                  |
| Rimapenaeus similis (Smith, 1885) | 6                                     | 0.2                       | NE Gabes (22-24m)                                                                       |
| Sicyonia carinata (Brünnich, 1768) | 14                                    | 17.50                     | SE Sfax (21-23m) and S Kerkennah (26-30m)                                               |
| Solenocera membranacea (Risso, 1816) | 3                                     | 0.2                       | NE Gabes (22-32m)                                                                       |
| Squilla mantis (Linnaeus, 1758)  | 25                                    | 175.25                    | NE Gabes (22-32m) and S Kerkennah (29-50m)                                              |
| Synalpheus gambarellioides (Nardo, 1847) | 6                                     | 1.55                      | Offshore waters (70-82m)                                                                 |
| Trachyamalbria palaestinensis (Steinitz, 1932) | 36                                    | 332                       | NE Gabes (22-32m), S Kerkennah (22-29m) and NE Djerba (31-46m)                          |
| Palaemonetes antennarius (Milne-Edwards, 1837) | 3                                     | 0.5                       | Offshore waters (61m)                                                                   |
| **GASTROPODA**                 |                                       |                            |                                                                                        |
| Aplysia sp.                    | 3                                     | 0.3                       | SE Kerkennah (46m)                                                                      |
| Aporrhais pespelecani (Linnaeus, 1758) | 25                                    | 27                        | NE Gabes (21-32m), S Kerkennah (29-51m) and NE et E Djerba (32-58m)                     |
| Buccinulum corneum (Linnaeus, 1758) | 3                                     | 0.35                      | NE Djerba (55m)                                                                        |
| Bolinus brandaris (Linnaeus, 1758) | 44                                    | 68                        | NE Gabes (22-42m), S Kerkennah (26-55m) and NE Djerba (31-51m)                          |
| Bolma rugosa (Linnaeus, 1767)   | 3                                     | 0.2                       | S Kerkennah (36m)                                                                       |
| Bulla striata Bruguère, 1792    | 6                                     | 0.8                       | E Djerba (38-40m)                                                                       |
| Bursatella leachi De Blainville, 1817 | 3                                     | 0.2                       | E Djerba (31m)                                                                          |
| Calliostoma granulatum (Born, 1778) | 8                                     | 1.5                       | S Kerkennah (26-40m)                                                                   |
| Calliostoma zizyphinum (Linnaeus, 1758) | 6                                     | 1                         | S Kerkennah (26-40m)                                                                   |
| Cassidaria echinophora (Linnaeus, 1758) | 36                                    | 1.60                      | S Kerkennah (40-46m) and NE Djerba (28-55m)                                             |
| Corus ventricosus Gmelin, 1791  | 8                                     | 1                         | S Kerkennah (45-48m)                                                                   |
| Erosaria turdus (Lamarck, 1810)  | 8                                     | 47                        | NE Gabes (21-32m) and S Kerkennah (39m)                                                 |

(continued)
| Taxon                                    | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m)                        |
|-----------------------------------------|----------------------------------------|---------------------------|-----------------------------------------------|
| **Fusinus rostratus** (Olivi, 1792)     | 11                                     | 5                         | S Kerkennah (26-55m) and NE Djerba (45-51m)   |
| **Hexaplex trunculus** (Linnaeus, 1758) | 44                                     | 29                        | NE Gabes (22-42m), S Kerkennah (26-58m) and NE Djerba (31-51m) |
| **Luria lurida** (Linnaeus, 1758)       | 3                                      | 0.2                       | NE Djerba (59m)                               |
| **Natricula cruenta** (Gmelin, 1791)    | 8                                      | 0.5                       | S Kerkennah (26-31m)                          |
| **Natricula punctata** (Chernits & Karsten, 1789) | 14                                     | 1.5                       | S Kerkennah (26-39m)                          |
| **Philine aperta** (Linnaeus, 1767)     | 6                                      | 1.5                       | NE Gabes (21m) and S Kerkennah (26m)          |
| **Tonna galva** (Linnaeus, 1758)        | 6                                      | 0.5                       | S Kerkennah (26-55m)                          |
| **Xenophora crispa** (König, 1825)      | 6                                      | 1.20                      | Offshore waters (98-110m)                     |
| **Zonaria pyrum** (Gmelin, 1758)        | 8                                      | 1                         | NE Gabes (21-32m)                            |
| **BIVALVIA**                            |                                        |                            |                                               |
| **Acanthocardia echinata** (Linnaeus, 1758) | 3                                      | 1                         | NE Djerba (32m)                              |
| **Acanthocardia tuberculata** (Linnaeus, 1758) | 3                                      | 0.5                       | NE Djerba (32m)                              |
| **Anadara diluvii** (Lamark, 1805)      | 8                                      | 0.2                       | SW Kerkennah (26-45m)                         |
| **Arca noae** (Linnaeus, 1758)          | 8                                      | 1                         | NE Djerba (31-45m)                           |
| **Callista chione** (Linnaeus, 1758)    | 8                                      | 2                         | S Kerkennah (26-51m)                         |
| **Chlamys flexuosa** (Poli, 1795)       | 6                                      | 1                         | NE Gabes (22-32m)                            |
| **Chlamys glabra** (Linnaeus, 1758)     | 6                                      | 0.5                       | NE Gabes (22-32m)                            |
| **Ostrea tarentina** (Issel, 1882)      | 3                                      | 0.2                       | NE Gabes (22m)                               |
| **Pinctada radiata** (Leach, 1814)      | 6                                      | 4.80                      | S Kerkennah (26-41m)                         |
| **Venericardia antiquata** (Linnaeus, 1758) | 8                                      | 2                         | NE Gabes (22-32m) and S Kerkennah (26-54m)   |
| **Scaphopoda**                          |                                        |                            |                                               |
| **Bryozoa**                             |                                        |                            |                                               |
| **Bugula sp.**                          | 3                                      | 0.05                      | NE Gabes (21m)                               |
| **Eledone moschata** (Lamarck, 1798)    | 33                                     | 1.5                       | S Kerkennah (50-59m)                         |
| **Octopus vulgaris** (Lamarck, 1798)    | 53                                     | 1.5                       | The entire gulf between (22-256m)             |
| **Sepia officinalis** (Linnaeus, 1758)  | 67                                     | 3.5                       | The entire gulf between (22-256m)             |
| **Sepiatta oweniana** (Orbigny, 1839–1841) | 14                                     | 1                         | NE Gabes (22-32m) and offshore waters (65-256) |
| **Bryozoa**                             |                                        |                            |                                               |
| Taxon                                           | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m) |
|------------------------------------------------|---------------------------------------|---------------------------|------------------------|
| Chartella papyracea (Ellis & Solander, 1786)    | 3                                     | 0.05                      | SE Kerkennah (26m)     |
| Margareta cereoides (Ellis & Solander, 1786)   | 3                                     | 0.1                       | Offshore waters (62m)  |
| Pentapora fascialis (Pallas, 1766)              | 6                                     | 0.05                      | S E Kerkennah (26m) and NE Djerba (40m) |
| Reteporella grimaldi (Julien in Julien & Calvet, 1903) | 22                                    | 0.6                       | NE Djerba (42-59m) and offshore waters (62-98m) |
| Serpocellaria scruposa (Linnaeus, 1758)         | 11                                    | 0.2                       | NE Djerba (40-45m) and offshore waters (90-110m) |

**ECHINODERMAT**

| Taxon                                           | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m) |
|------------------------------------------------|---------------------------------------|---------------------------|------------------------|
| Antedon mediterranea (Lamarck, 1816)            | 28                                    | 320                       | NE Gabes and SE Sfax (21-42m), S Kerkennah (45-58m) and offshore waters (186-256m) |
| Astrepecoten jonstoni (Delle Chiaje, 1827)      | 11                                    | 1                         | S Kerkennah (31-50m)   |
| Astrepecoten irregularis (Pennant, 1777)        | 6                                     | 0.6                       | S Kerkennah (40-50m)   |
| Astrepecoten spinulosus (Philippi, 1837)        | 6                                     | 0.5                       | NE Djerba (31-58m)     |
| Astrepecoten aranciacus Linnaeus, 1758          | 36                                    | 14.72                     | S Kerkennah (29-58m) and NE Djerba (31-58m) |
| Anseropoda placenta (Pennant, 1777)             | 14                                    | 1.20                      | Offshore waters (70-110m) |
| Bristus unicolor (Leske, 1778)                  | 6                                     | 0.5                       | S Kerkennah (26-31m)   |
| Chaetaster longipes (Retzius, 1805)             | 3                                     | 0.3                       | Offshore waters (108m) |
| Centrostephanus longispinus (Philippi, 1845)    | 8                                     | 10.5                      | Offshore waters (70-110m) |
| Cidaris cidaris (Linnaeus, 1758)                | 28                                    | 121.56                    | Offshore waters (61-256m) |
| Cocinasterias tenispina (Lamarck, 1816)         | 19                                    | 8.33                      | S Kerkennah (26-54m) and E Djerba (42-57m) |
| Echinaster sepositus (Retzius, 1783)            | 25                                    | 1.77                      | S Kerkennah (26m), N Djerba (31m) and offshore waters (62-110m) |
| Echinocardium mediterraneum (Forbes, 1844)      | 6                                     | 0.5                       | S Kerkennah (26-31m)   |
| Echinus acutus (Lamarck, 1816)                  | 14                                    | 9                         | Offshore waters (78-186m) |
| Hacelia attenuata (Gray, 1840)                  | 6                                     | 1                         | Offshore waters (70 and 256m) |
| Holothuria forskali Delle Chiaje, 1823          | 8                                     | 3.5                       | NE Gabes (21-32m) and NE Djerba (31m) |
| Holothuria poli Delle Chiaje, 1823              | 31                                    | 47.45                     | NE Gabes (21-32m), S Kerkennah (26-41m) and NE Djerba (31-51m) |
| Holothuria tubulosa Gmelin, 1790                | 28                                    | 33.85                     | NE Gabes (21-32m), S Kerkennah (26-41m) and NE Djerba (31-51m) |
| Holothuria mammata Grube, 1840                  | 19                                    | 8                         | S Kerkennah (31-45m) and NE Djerba (31-51m) |
| Holothuria helleri von Marenzeller, 1877        | 6                                     | 0.3                       | Offshore waters (110m) and (256m) |
| Holothuria sanctiri Delle Chiaje, 1823          | 3                                     | 2                         | NE Djerba (32m)        |
| Octus syracusanus (Grube, 1840)                 | 6                                     | 2.5                       | NE Gabes (22m) and E Djerba (45m) |
| Ophioderma longicaudaum (Retzius, 1805)         | 11                                    | 2.5                       | S Kerkennah (31 and 44m) and NE Djerba (31-54m) |
| Ophiomyxa pentagona (Lamarck, 1816)             | 8                                     | 1                         | SE Djerba and Zarzis (37-43m) and offshore waters (62-65m) |
| Ophiophris fragilis (Abildgaard, 1789)          | 33                                    | 495                       | S Kerkennah (29-58m), NE Djerba (46m) and offshore waters (70m) |
| Ophiura texturata Lamarck, 1816                 | 17                                    | 8.5                       | S Kerkennah (26-50m) and NE Djerba (31-54m) |
| Paracentrotus lividus (Lamarck, 1816)           | 11                                    | 13.60                     | S Kerkennah (26-32m) and NE Djerba (31m) |
| Psammechinus microtuberculatus (Blainville, 1825) | 25                                    | 114.53                    | S Kerkennah (26-50m) and NE Djerba (42-51m) |
| Schizaster canalicus (Lamarck, 1816)            | 6                                     | 0.3                       | Offshore waters (61-65m) |
| Spatangus purpureus (O.F.Muller, 1776)          | 14                                    | 0.5                       | Offshore waters (61-94m) |
| Stylocidaris affinis (Philippi, 1845)           | 17                                    | 27                        | Offshore waters (78-110m) |

**ASCIDIACEA**

| Taxon                                           | Percentage of occurrence by study (%) | High abundances (inds/ha) | Location and depth (m) |
|------------------------------------------------|---------------------------------------|---------------------------|------------------------|
| Aplidium asperum Drasche, 1883                  | 14                                    | 4                         | S Kerkennah (27-58m) and NW Djerba (31-45m) |
| Aplidium cf. conicum (Olivi, 1792)              | 44                                    | 145                       | The entire gulf between (26-98m) |
| Aplidium elegans (Girard, 1872)                 | 17                                    | 25                        | S Kerkennah (54-58m), NE Djerba (41-45m) and offshore waters (62m) |
| Aplidium haouarianum (Pérès, 1956)              | 14                                    | 4                         | S Kerkennah (54-58m) and NE Djerba (41-45m) |
| Aplidium proliferum (Milne-Edwards, 1841)      | 11                                    | 3                         | S Kerkennah (26-41m) |
| Aplidium aff. palidum (Verrill, 1871)           | 6                                     | 2.80                      | S Kerkennah (36-38m) |
| Aplidium sp.                                    | 19                                    | 16                        | S Kerkennah (29-52m), NW Djerba (31-45m) and offshore waters (62-70m) |
| Ascidia mentula O.F. Müller, 1776               | 14                                    | 7                         | Offshore waters (90-256m) |

(continued)
**ites domuncula** shows the greatest abundance between 28 and 70 m depth. In the inshore waters, *Suberites domuncula* and *H. communis* were collected in deep below 58 m. In the offshore waters, *H. communis* appeared at a 65 to 100 m depth, while *S. domuncula* was sampled only up to 70 m.

**A. aerophoba** was sampled in the coastal area (especially, in the North-east of Djerba and Zarzis between 28 and 59 m depth) and in the offshore waters (70-185 m depth). These three species were present in 33% of stations, with an abundance of 26.5; 10 and 2.5 inds/ha, respectively (Table 2).

**f) Cnidaria** was dominated by two species *Calliactis parasitica* and *Epizoanthus arenaceus* which were present respectively, in 19% and 20% of the surveyed stations. These species showed a low abundance in the gulf, they were sampled especially, in Eastern Djerba (31-55 m depth). *C. parasitica* showed a 21.5 inds/ha abundance.

g) **Annelida** was represented only in the epibenthic megafauna by 3 species and was dominated by the single species *Laetmonice hystrix* which was present (in 11% of stations) especially, in Southern Kerkennah (27-54 m depth). This species showed a low abundance of 4 inds/ha (Table 2). The low density of this group can be explained in that most of this group’s species were small in size, while the used fishing gear only received species of size >10 mm.

h) **Bryozoa** was dominated by the single species *Reticuloporella grimaldii* which was present in 22% of stations, it represented the lowest abundance in the gulf (0.6 inds/ha). It was collected in the North-east of Djerba (42-59 m depth) and in the offshore waters (61-98 m depth).

According to these observations, the megabenthic fauna community of Gabes gulf was distributed in two depth groups:
a) The inshore group (20-60 m depth), mainly with *Posidonia* meadows and macroalgae beds, with maerl bed patches, and represented by *Suberites domuncula*, *Calliactis parasitica*, *Epiozanthus arenaceus*, *Psammechinus microtuberculatus*, *Holothuria polii*, *H. tubulosa*, *Astropecten auriancicus*, *Coscinasterias tenuispina*, *Ophiothrix fragilis*, *Aporrhais pespelecani*, *Bolinus brandaris*, *Hexamaphex trunctulus*, *Erosaria turdus*, *Pinctada radiata*, *Fulvia fragilis*, *Eledone moschata*, *Trachysalambria palaestinensis*, *Squilla mantis*, *Melicertus kerathurus*, *Metapeneaus monoceros*, *Sicynia carinata*, *Aegaeon cataphracta*, *Paguristes eremita*, *Pagurus cuanensis*, *Inachus dorsetensis*, *Macropodia longirostris*, *Pilumnus hirtellus*, *Didemnum spp.*, *Aplidium cf. conicum*, *Polycliniidae spp.*, *Ecateinascidiella turbinata*, *Polycitor adriaticum*, *Eudistoma spp.*, *Microcosmus exasperatus* and *Styela plicata*.

b) The offshore group was associated with a muddy detritic and terrigenous muddy bottoms with brown and red algae (>60 m depth) represented by *Cidaris cidaris*, *Stylocidaris affinis*, *Ascidia mentula*, *Echinus acutus* and *Echinaster sepositus*. Whereas *Antedon mediterranea*, *Hippoposponia communis*, *Aphsysina aerophoba*, *Medorippe lanata*, *Eucrate crenata*, *S. officinalis*, *Octopus vulgaris*, *Pinctada radiata*, *Eledone moschata*, *Fulvia fragilis*, *Erosaria turdus*, *Pinctada radiata*, and *Botryllus schlosseri* were present in the two depth groups.

Univariate analysis

In Gabes gulf, the megabenthic fauna abundance varied from 17 (in 98 m depth) to 880 inds/ha (in 22.5 m depth), and a specific richness from 6 (in 228 m depth) to 35 species (in 45 m depth) (Fig. 3a). The megabenthic fauna diversity decreased towards the offshore waters ($H^* = 1.05$ bits/individual, 14 species, in 70 m depth). From the inshore waters, where $H^*$ reached a maximum of 4.03 bits/individual (in 43.5 m depth), and equitability had varied from 0.32 (in 57 m depth) to 0.88 (in 70.5 m depth) (Fig. 3b).

The megabenthic fauna community mapping showed high concentrations located along the shallow coastal fringe (20-60 m depth), with maximum abundances between 301 and 900 inds/ha, while their distribution was extremely low in offshore waters (Fig. 4a). The spatial distribution map of Echinodermata illustrated a high abundance (between 151 and 800 inds/ha) in the gulf’s inshore waters (especially, in the South-west of Kerkenah and Northern Djerba), and to a lesser extent, in the North-east of Gabes and in the offshore waters (Fig. 4b). The Crustacea came in second position with a maximum abundance between 81 and 560 inds/ha. It was concentrated in the costal area of Sfax and Gabes, North-west of Djerba (20-30 m depth) and in Southern Kerkenah (Fig. 4c). Tunicata showed an elevated abundance especially, in the North-west of Djerba, Southern Kerkenah and the North-east of Gabes with a maximum between 61 and 400 inds/ha. It was abundant in the gulf from 20 to 80 m depth (Fig. 4d). On the other hand, the Mollusca group showed an average abundance in the gulf between 81 and 300 inds/ha. This group was abundant only in the coastal area especially, in the North-west of Djerba, the North-east of Gabes and the South-west of Sfax (Fig. 4e). Porifera showed a low abundance in the study area with a maximum between 9 and 33 inds/ha. It had been concentrated in the inshore waters of the gulf, especially, in the North-east of Djerba and Northern Zarzis (26-55 m depth) and in the offshore waters around 75 m depth and to a lesser extent in the gulf remainder (Fig. 4f). Cnidaria illustrated a low abundance in the entire gulf between 2.1 and 22 inds/ha. It was localised in the middle of the gulf, between the North-east of Djerba, Northern Zarzis, the South-east of Kerkenah and the offshore waters up to 100 m depth (Fig. 4g). Annelida proved a low abundance in the gulf between 4 and 9 inds/ha. It was particularly collected, in Southern Kerkenah and the North-east of Djerba between 25 and 50 m depth (Fig. 4h). Bryozoa was poorly distributed in the study area with a low abundance between 0.31 and 0.60 inds/ha. It was sampled in the North-east of Zarzis around 50 m depth and in the offshore waters up to 110 m depth (Fig. 4i).

Statistical analysis

Dendrogram analysis of the megabenthic fauna group indicated the presence of two major groups in the gulf; the first gathered (G1) the most abundant benthic phyla such as Echinodermata, Crustacea, Tunicata and Mollusca. The second gathered (G2) the least group represented such as Porifera, Cnidaria, Annelida and Bryozoa (Fig. 5).

Discussion

This study indicated that the community of the megabenthic fauna is well distributed in Gabes gulf with a remarkable abundance in the inshore area associated with a dead meadow of *Posidonia* and macroalgae beds (301<A<900 inds/ha), while the offshore waters zone presented a weak abundance (A<150 inds/ha). Perseng & Kempf (1993) suggest that seagrasses were found around Kerkenah and Djerba. The Northern Djerba was bordered by a seagrass mixed with *Cymodocea nodosa* and *Caulerpa prolifera* which contained more or less extensive *Posidonia* patches. Along towards Gabes and Skhira areas (in the gulf Western part) there is a low density of phytobenthos and an abundance of the dead meadow of *Posidonia* (Zaouali, 1993b; Ben Mustapha et al., 1999). This allows us to deduce that the density of the megabenthic fauna community is related to the condition of vegetation cover.
In Gabes gulf, we counted 8 groups and 208 species of the megabenthic fauna, colonizing this area (31 species of Echinodermata, 44 Crustacea, 38 Tunicata, 55 Mollusca, 21 Porifera, 10 Cnidaria, 3 Annelida and 6 Bryozoa) (Table 2). The most abundant fauna communities are Ophiosthrix fragilis, Trachysalambria palaestiniensis, Aplidium cf., and conicum, these species were abundant between 20 and 60 m depth) (Tables 1 and 2).

The spatial distribution of the megabenthic fauna community in Gabes gulf may be affected, if the factors related to the disturbance sources still persist (industrial rejections and benthic trawling), and the possible increase of the fine sediment (Ben Mustapha et al., 1999). The present state showed some spatial separation between the gulf’s different groups of megabenthic fauna.

The Echinodermata group coupled with environmental factors (such as bottom type and vegetation cover) played important roles in the benthos ecosystems, and the effects of sea urchins, sea stars and holothurians over the benthic community structure were significant. The Echinodermata was concentrated in the inshore and, to a lesser extent, in the offshore waters of Gabes gulf. It was dominated in the inshore waters by Ophiosthrix fragilis, Psammechinus microtuberculatus and Holothuria polii and with other echinoderm species on mud or sandy mud bottoms associated with a dead meadow of Posidonia (Tables 1 and 2). Whereas in the gulf’s offshore waters, Cidaris cidaris, Stylocidaris affinis and Echinus acutus were dominated on sand bottom together with other species of echinoderms as Centrostephanus longispinus, Hacelia attenuata, Anseropoda placenta, Chastaster longipes, Spatangus purpureus and Holothuria helleri. Antedon mediterranea and Echinaster sepositus were present in both areas (inshore and offshore waters) with other megabenthic fauna on sand or mud bottoms. Ophiosthrix fragilis was sampled on mud bottom at a depth <70 m. The elevated density of these gulf’s species was probably due to their lifestyle, which was characterized by very short periods, allowing a dynamic generation, thus, a more active population. A. mediterranea and O. fragilis was distributed throughout the gulf and abundant in Southern Kerkennah on mud bottom and in the offshore waters around 250 m depth on sandy mud bottom. These results were consistent with previous observations. Koehler (1924) regards A. mediterranea as a primarily littoral species, which lives among algae, rocks or attached to various animals; Ranson (1924) and Cherbonnier (1956) noted that on the Tunisian coast, the species was found by 25 m on seagrass Posidonia and Halimeda; and Tortonese (1965) assigns it in bathymetric limits ranging from (0-200 m depth). Holothuria polii accompanied by H. tubulosa were present in the entire inshore waters of the gulf (especially, in Northern Djerba) on sandy mud bottom together with the Posidonia’s remains. Bruun (1940) and Cherbonnier (1956) confirm that H. tubulosa associated with H. polii are very common on the coast of Tunisia on sand bottom (0-40 m depth), or to 50 m limit, particularly in Gabes gulf (espacilly, in Ras Kaboudia, Djerba and El Biban) and in Tunis gulf. In the coastal area, on detrital and mud bottoms, we harvested an abundance of P. microtuberculatus with some specimens of Paracentrotus lividus (Tables 1 and 2). Currently, we noted that P. lividus appeared to be rare in Gabes gulf (in >23 m depths). The cause could be the competition with the sea urchin P. microtuberculatus which was very common there (21-51 m depth). Many authors have reported the abundance of P. lividus in the gulf between 4 to 44 m depth on different habitats (Le Danois, 1925; De Gaillande, 1970; Ben Othman, 1971b; Ktari-Chakroun & Azouz 1971; Fehri-Bedoui, 1986; Zaouali, 1993b; Ben Mustapha et al., 1999). Sea urchins were considered to be the most important herbivores in the Mediterranean, because of the high abundance in the overgrazing phenomena (e.g. Kempf, 1962; Nedelec, 1982; Verlaque, 1987; Hereu, 2004). Bruun (1940) sampled P. microtuberculatus with other echinoderms on mud bottoms around 80 m. C. cidaris and S. affinis were found in the offshore waters (75-260 m depth). Cherbonnier (1956) has sampled C. cidaris cidaris and Stylocidaris affinis in the Tunisian waters (40-250 m depth). Schizaster canalisferus appeared in the offshore waters on sandy mud bottom of red algae (Rytiphloea tinctoria and Phyllophora nevosa) around 61 m depth. S. purpureus were sampled on muddy sand bottom of brown algae (Taonia atomaria) between 70 and 94 m depth (Tables 1 and 2).
Fig. 4 (a,b,c,d,e,f,g,h,i): Spatial distribution of the megabenthic fauna groups abundance.
Crustacea group was concentrated in the gulf’s inshore waters (20-60 m depth), especially, in the costal area of Sfax and Gabes and North-west of Djerba (<32 m depth) on sand or mud bottoms with a dead meadow of Posidonia (with a maximum abundance between 81 and 560 inds/ha). In the North-east of Gabes, this group was dominated by eight species (T. palaestinensis (the most abundant ones with 332 inds/ha), Eucrate crenata, Maja crispate, Squilla mantis, Paguristes eremita, Sicyonia carinata, Inachus dorsettensis and Melicertus kerathurus) on mud bottom with Fulvia fragilis. Several authors announced the possible competition from exotic species M. monoceros, T. palaestinensis and R. similis with M. kerathurus (Jarboui & Ghorbel, 1995; Missaoui & Zaouali, 1995; Ben Abdallah et al., 2003; Ben Abdallah Hadj Hamida et al., 2009). According to our study, we observed a high abundance in exotic species, especially, in T. palaestinensis but, the most abundant crustaceans intruders showed a highly localized distribution, especially, on mud or muddy sand bottoms localized in the Western gulf. While the endemic species M. kerathurus showed a well spread distribution and properly structured throughout the inshore waters of the gulf. Galil et al. (2002) noted that T. palaestinensis was a nocturnal species that lived on sand or muddy sand bottoms (6-300 m depth). It was collected in Tunisia on unstable mud without phytobenthos or muddy sand bottoms with seagrasses meadows (of Posidonia or Cymodocea), between 5 and 50 m depth (Zaouali, 1993b; Missaoui & Zaouali 1995; Missaoui et al., 2003). Bradai (2001) stresses that M. monoceros had become very abundant, especially, in the Western area of Gabes gulf (Mahrès and Skhira) at a depth ranging from 20 to 50 m, but their value is lower than that of native prawn M. kerathurus. E. crenata was captured only in the North-east of Gabes (22-32 m depth), on mud bottom with a dead meadow of Posidonia and Fulvia fragilis (Tables 1 and 2). Galil et al. (2002) signaled that this Brachyura is an exotic species that lives on sand and silt bottoms (10-100 m depth). In Gabes gulf, Zaouali, (1993a) and Missaoui et al. (2003) signaled it (5-20 m depth) on detrital shelly mud with a dead meadow of Posidonia and silted with Cymodocea and impacted bottoms with phosphogypsum. In the offshore waters, we noted the presence of Nephrops norvegicus, Chlorotocus crassicornis, Calappa granulata on sandy mud bottoms (Tables 1 and 2) with very low abundance (<1.5 inds/ha). Parapenaeus longirostrus and Latreillia elegans were reported on sandy mud or sand bottoms (108-256 m depth). Medorippe lanata (3 inds/ha) was collected on heterogeneous substrates ( sands, muds, muddy sands and detrital coastal bottoms) in two areas.

The benthic Tunicata were distributed in the major part of the gulf with a high abundance (between 61 and 400 inds/ha). It was concentrated in the costal area, especially, in the North-west of Djerba and in Southern Kerkennah on sand or mud bottoms and in the offshore (continued) Fig. 4 (a,b,c,d,e,f,g,h,i): Spatial distribution of the megabenthic fauna groups abundance.
waters up to 98 m depth. This group is used as indicators of industrial pollution in Gabes gulf. In the coastal area, we note the relatively large presence of many species of Tunicata which are dominated by Aplidium cf. conicum, Didemnum sp, and Microcosmus exasperatus with other Ascidiae such as Polycitor adriaticum and Eudistoma spp on different types of bottom (sands, muds, muddy sands and detrital coastal bottom). The Similar results were reported in Tunisia by Pérès (1954) and Pérès & Picard (1956). Styela plicata is usually accompanied by a high density of M. exasperatus on mud bottom with Fulvia fragilis (especially, in the North-east of Gabes). Their presence may be linked to the industrial pollution of this site. Ecteinascidia turbinata was sampled in Eastern Djerba on sandy mud bottom with Arthrocladia villosa and in Southern Kerkennah (29-55 m depth) on muddy sand or mud bottoms. These results are consistent with previous observations; Pérès (1954) and Calvin Calvo (1995) regard E. turbinata as frequent in the sunny biotopes of the western Mediterranian basin. This group is dominated, in the offshore waters, by Ascidia mentula linked to sand or muddy sand bottoms with brown algae (Taonia atomaria). Diazona violacea and Microcosmus vulgaris are another interesting and rare species in the gulf. These two Ascidiae were collected on sandy mud bottom with Ascidiae and Cidaris cidaris around 110 m depth (in the same station) (Tables 1 and 2).

On the other hand, the Mollusca were abundant only in the coastal area, especially, in the North-west of Djerba on detrital coastal bottom, North-east of Gabes and South-west of Sfax on mud bottoms. Fulvia fragilis (272 inds/ha) was abundant in the North-east of Gabes on mud bottom (21-32 m depth). Zenetos et al. (2003) signaled that F. fragilis is a species living in shallow waters on sand, mud or muddy sand bottoms with Zostera sp. Pinctada radiata is present in the North-east of Gabes and the South-east of Sfax (21-30 m depth) on sandy mud or detritic bottoms. In the gulf, the preferred depth of these two species (F. fragilis and P. radiata) is about 21 m. Moreover, the North-east of Gabes is characterized by mud bottoms with F. fragilis, and the South-east of Sfax is characterized by muddy sand bottom with P. radiata. Rosso (1978) shows the colonization of P. radiata across Gabes gulf, where it has an exceptional prosperity (Tlig-Zouari & Zouali, 1994, 1998; Ben Mustapha et al., 1999). Bolinus brandaris and Hexamphex trunculus have appeared in the entire coastal area (22-58 m depth) on different types of bottom. Aporrhais pespelecani was sampled especially, in the North-east of Gabes, Southen Kerkennah and Eastern Djerba (21-58 m depth) on mud or muddy sand bottoms. Erosaria turdus was very abundant in the North-east of Gabes, at around 22 m depth on mud bottom with F. fragilis. Its abundance in the gulf is confirmed in an experimental trawl (Ben Soussi et al., 2005) and is also harvested by Boyer & Simbille (2006). Luria lurida is interesting and rare species in the gulf, and probably localized in a specific site on detritic-coastal bottom around 59 m depth (Tables 1 and 2). It was reported in Gabes gulf by Seurat (1929) and Ktari-Chakroun & Azouz (1971). In the 1920’s, this porcelain was frequent in the gulf (Seurat, 1929). We believe that the main cause of the scarcity of L. lurida is the competition with introduced species Erosaria turdus which has the same ecological niche. Buccinulum corneum was
sampled in the North-east of Djerba in 55 m depth on mud bottom with Ophiothrix fragilis, Demospongiae and Asciidae H. trunculus and B. brandaris, which reveal a substrate type of coastal detrital. Glycymeris glycymeris and Dentalium sp. were indicative of mud bottom, Corbula gibba was an indicator of muddy and unstable bottoms, Venericardia antiquata proved the presence of a soft substrate of intermattes and Venus verrucosa demonstrated a soft silted bottom. We also noted the presence of Mollusc Parvicardium exiguum which indicated it was a very muddy and polluted substrate. We noted the presence of molluscs (gastropods and bivalves), which is a sign of relatively large muddy environments. In the offshore waters, we noted rare species of Mollusca as Xenophora crispa, Ostreidae sp. Wherase Sepietta oweniana was sampled in two areas.

The phylum of Porifera was concentrated in the Eastern part of gulf (especially, in the North-east of Djerba, Northern Zarzis and offshore waters). Aplysina aerophoba was collected in the inshore waters (29-50 m depth) on detrital coastal or mud bottoms with Ophiothrix fragilis and Demospongiae and in the offshore waters on sand bottom. Topsent (1934) has reported it to a depth of 38 m in Gabes gulf. Hippopsongia communis is well present in the gulf up to 100 m depth. The similar result was reported in Gabes gulf by Ben Mustapha et al. (2002, 2003a, 2003b, 2004). Suberites domuncula is a coastal species, which was collected up to 70 m depth on different types of bottoms; it generally, wears one Paguridae. These three species were common in the gulf, they did not seem threatened. Among other Demospongiae in the gulf, we noted Dysidea sp, Cliona viridis and Haliclonia mediterranea with a low density. Spongia officinalis was sampled (with a low abundance (0.4 inds/ha)) in the gulf up to 50 m depth on detrial coastal bottom. Fehri-Bedoui (1986); Ben Mustapha and El Abed (2001); Ben Mustapha et al. (2002, 2003a, 2003b, 2004) affirmed that it was frequent in Posidonia, Cymodocea, lawn Caulerpa prolifera, coastal detrial bottoms (1-100 m depth). This species appeared to be rare and threatened.

Cnidaria was localised in the middle part of gulf with low abundance. It was present especially, in the North-east of Djerba, Northern Zarzis on detrial coastal bottom with a dead meadow of Posidonia and in the offshore waters on sand bottoms. The mainly present species for this group are Calliaclntis parasitica, Epizoanthus arenaceus, Eudendrium sp. and Nemertesia antennina. Calliaclntis parasitica was the most common especially, in Eastern Djebra (40-50 m depth) on detrial coastal bottom. Cladocora coespitosa was present in two locations around 31 m depth in the South-east of Kerkennah, on detrical-muddy bottom and in the North-east of Djebra on detrial coastal bottom. Zaouali (1993b) and Ben Mustapha et al. (1999) have noticed the abundance of dead tests of this endemic species in the Western part of Gabes gulf (11-21 m depth).

Annelida showed a low abundance in the gulf, which was mainly present in Southern Kerkennah on muddy sand bottom with a dead meadow of Posidonia. For this group, the most common species in the inshore waters was Laetomnic hystrix. Diopatra neapolitana was sampled on sandy mud bottom with red algae (Rytophloea tinctoria and Phyllophora nevosa) in the offshore waters (60-64 m depth).

This study illustrated that phulum of Bryozoa represented the lowest abundance and presence, compared to other groups. It was distributed in the North-east of Zarzis on detrial coastal bottom, and in offshore waters on sand bottoms, in many of the gulf’s sites. The two abundant species for this group were Reteporella grimaldii and Scrupocellaria scruposa. The most common one is R. grimaldii. This species appeared in the inshore waters on bottom with Arthrocladia villosa and Asciidae and on sandy mud bottom with red algae. In the offshore waters, R. grimaldii also appeared on sandy mud bottom with red algae (Rytophloea tinctoria and Phyllophora nevosa) at around 61 m depth and in the bottom with brown algae (T. atomaria) between 70 and 94 m. Azouz (1971); Ktari-Chakroun & Azouz (1971); Ben Mustapha et al. (1999, 2002) indicated that this species was clean of coralline, and present in the Posidonia grass and Caulerpa on detrial coastal (1-80 m depth).

Generally, H’ and E (H’) present in the offshore waters, showed less fluctuation compared to the inshore waters, where the abundance and the specific richness appeared lower on average than those of inshore waters. These parameters’ analysis already showed the first decrease signs in the abundance of megabenthic fauna community, by deep, going from coast area to oceanic area. In the offshore waters, the abundance was high enough, but the specific richness is low, which only shows some depth species, such as the Parapenaeus longirostrus, Chlorotocus crassicornis, Latreilla elegans, Cidaris cidar, Stylocidaris affinis and Ascidia mentula.

The bottom in Gabes gulf was successively covered by sand, sandy mud and muddy sand from 10 to 50 m depth; it was characterized by succession of muddy sand, sandy mud and sand from 50 to 80 m depth, and the sediment became an increasingly muddy sand from 80 to 200 m depth (Ben Othman, 1973). But this study showed a progressive siltation of the inshore waters in the Western gulf, especially, in Southern Sfax, North-east of Gabes and Western Djebra (Fig. 1 and Table 1). The siltation phenomena and seagrass meadows degradation were probably the consequences of higher fishing impact on Gabes gulf and the phosphogypsum rejection (by chemical industries located in Northern Gabes). These results were confirmed by Darmoul et al., 1980; Béjaoui et al., 2004; Hattour, 1991; Zaouali, 1993b; M’Rabet, 1995; Ben Mustapha et al., 1999.
Conclusion

The present study indicated that the spatial distribution of the megabenthic fauna communities in Gubes gulf showed a concentration in the inshore waters, especially in Southern Kerkennah and the North-east of Djerba. The South-west of Kerkennah was characterized by a mud bottom with *Ophiolithrix fragilis* and *Antedon mediterranea*, the South-east of Kerkennah was characterized by a sandy bottom with *Aplidium cf. conicum* and other Polyclinidae, the North-east of Djerba was marked by a sandy mud bottom with *Holothuroidea* (*Holothuria tubulosa*), Northern Zarzis was distinguished with detrital coastal bottom with Demospongia, Eastern Djerba was characterized by sandy mud bottom with *Arthrocladia villosa* and North-east of Gubes was characterized by mud bottom with *Fulvia fragilis*. The offshore waters were percieved by sand bottoms, sandy mud bottoms with red algae (*Rytiphloea tinctoria* and *Phyllophora nevosa*) and muddy sand bottom with brown algae (*Taoonia atomaria*). This site has showed the lowest density of the megabenthic fauna community.

The distribution of megabenthic fauna community is closely related to bottom type, vegetation cover and depth. The inshore waters appear, today, more balanced on the ecologic level.

Echinodermata, Crustaceae, Tunicata and Mollusca represent key-taxons in the megabenthic fauna community, particularly in Gubes gulf and future studies are needed to elucidate the community structure spatially and temporally over an annual survey.

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References

Ayari, R. & Afli, A., 2003. Bionomie benthique du petit golfe de Tunis. Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salamboé, Tunisie, 30: 79-90.

Ben Abdallah, O., Jarboui, O., Missaoui, H. & Ben Hadj Hamida, N., 2003. Croissance relative, sex-ratio et exploitation de la crevette blanche *Metapeneaus monoceros* (Fabricius, 1798) du golfe de Gabès (Tunisie). Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salamboé, 30: 49-54.

Ben Hadj Hamida-Ben Abdallah, O., Ben Hadj Hamida, N., Jarboui, O. & Foglia, C., 2010. First occurrence of the yellow roughneck shrimp, *Rimapeneaus similis* (Smith, 1885) Crustacea: Decapoda: Penaeidae) in the Mediterranean Sea (Tunisian waters). *Biological Invasions*, 12 (5): 999-1001.

Ben Mustapha, K., Battour, A., Mhetli, M., El Abed, A. & Triattar, B., 1999. Bionomie des étages infra et circalittoral du golfe de Gabès. Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salamboé, Tunisie, 26: 5-48.

Ben Mustapha, K. & El Abed, A., 2001. State of benthic community off the Tunisian coasts. p. 905-914. In: 5th International Conference on the Mediterranean Coastal Environment, MEDCOAST 01, October 23 - 27, Hammamet, Tunisia.

Ben Mustapha K., Komatsu, T., Hattour, A., Sammari, CH., Zarrour, S., Souissi, A. & El Abed, A., 2002. Tunisian megabenthos from infra (Posidonina meadows) and circalittoral (coralligenous) sites. Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salamboé, Tunisie, 29: 23-36.

Ben Mustapha, K., Zarrour, S., Souissi, A. & El Abed, A., 2003a. Diversité des Demosponges tunisiennes. Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salamboé, Tunisie, 30: 55-78.

Ben Mustapha, K., Boury-Esnault, N., Kartas, F., El Abed, A., Zarrour, S. & Souissi, A., 2003b. Sponge diversity in Tunisian waters. *Biologia Marina Mediterranea*, 11: (2): 478-480.

Ben Mustapha, K., Afi, A., Hattour, A. & El Abed, A., 2004. Sessile megabenthic species from Tunisian littoral sites. *MedSudMed Technical Documents*, 2: 82-97.

Ben Othman, S., 1971a. Etude préliminaire sur l’ichthyologie du Sud tunisien. Rapport P.V. Commission Internationale d’Exploration Scientifique de la Mer Méditerranée, 20 (2): 443-444.

Ben Othman, S., 1971b. Observations hydrologiques, draguages et chalutages dans le Sud-Est tunisien. Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salamboé, 2 (2): 103-120.

Ben Souissi, J., Trigui-El Menif, N., Mahoub, M.S., Mejri, H., Quignard, J.P., Capapé, C. & Zaouali, J., 2005. On the recent occurrences of marine exotic species in the Tunisian waters. p. 529-540. In: Proceedings of the Seventh International Conference on the Mediterranean Coastal Environment, MEDCOAST 05, Turkey.

Béjaoui, B., Rais, S. & Koutitonsky, V., 2004. Modélisation de la dispersion du phosphogypse dans le golfe de Gabès. *Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salamboé*, Tunisie, 31: 113-119.

Béranger, K., Mortier, L., Gasparini, G.P., Cervasio, L., Astraldi, M. & Crepon, M., 2004. The dynamics of the Sicily Strait: a comprehensive study from observations and models. *Deep Sea Research Part II: Topical Studies in Oceanography*, 51 (4-5): 411-440.

Bouaziz, S., 2002. Elaboration d’un Système d’Information Géographique (S.I.G) pour l’étude et la cartographie géologique de la région d’Agareb. Mémoire de DEA. Faculté des Sciences de Sfax, Tunisie, 87 pp.

Boyer, F. & Simbille, C., 2006. About the settling of *Erosaria turbinata* (Lamarck, 1810) in Mediterranean. *Bollettino Malacologico*, 41 (5-8): 9-12.

Bradai, M.N., 2000. Diversité du peuplement ichtyque et contribution à la connaissance des sparidés. Thèse de Doctorat d’Etat en-sciences naturelle, Université de Sfax, Faculté des Sciences de Sfax, Tunisie, 600 pp.

Bradai, M.N., 2001. Diversité biologique des vertébrés (poissons, tortues et cétacés) du golfe de Gabès. Espèces exot-
Bruun, A.F., Fr., Burollet, P.F., C., Clairefond, P., Winnock, E., 1979. La Mer pélagique et menacée. p.73-90. In : Elaboration d'une étude de création d'aires marines protégées et de récifs artificiels. 1. Golfe de Gabès. Rapport finale MEAT-INST.

Brousseau, A., 1956. Les échinodermes de Tunisie. Bulletin de la Station Océanographique de Salammbô, 40: 1-20.

Burollet, P.F., Clairefond, P. & Winnock, E., 1979. La Mer pélagienne. Etude sédimentologique et écologique du plateau tunisien et du golfe de Gabès. Géologie Méditerranéenne, 6 (1): 28-34.

Calvin Calvo, J.C., 1995. El ecosistema marino mediterraneo. Guía de su flora y fauna. Sana, 798 pp.

Cerbonnier, G., 1956. Les échinodermes de Tunisie. Bulletin de la Station Océanographique de Salammbô, 33: 1-23.

Cerbonnier, G., 1960. Complément à la faune échinodermique des Pyrénées-orientales. Vie & Milieu, 11 (1): 118-123.

Clarke, K. & Gorley, R.N., 2001. PRIMER v5: user manual/tutorial. PRIMER-E, Plymouth.

Darmoul, B., 1988. Pollution dans le golfe de Gabès (Tunisie), Bilan de six années de surveillance (1976-1981). Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche de Salammbô, 15: 61-64.

Darmoul, B., Hadj Ali Salem, M. & Vitello, P., 1980. Effects des rejets industriels de la région de Gabès (Tunisie) sur le milieu marin receptrice. Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche de Salammbô, 7: 5-61.

De Gaillande, D., 1970. Peuplements benthiques de l’herbier de Posidonia oceanica (Delile) et de la pelouse à Caulerpa prolifera Lamouroux du large du golfe de Gabès. Thèses, 2 (1-2): 373-384.

Desroy, N., Waremberg, C., Dewarumez, J.M. & Dauvin, J.C., 2003. Macrobenthic resources of the shallow soft-bottom sediments in the Eastern English Channel & Southern North Sea. ICES Journal of Marine Science, 60: 120-131.

Fehri-Bedou, R., 1986. Le chatelage à bord du chalutier “Zied” dans le golfe de Gabès. Technologie et analyse des apports durant les campagnes du 20 au 23 et 28 au 30 juillet 1984. DEA Biologie Marine et Océanographie, Université de Tunis, 148 pp.

Fishier, W., Schneider, M. & Bauchot, M.L., 1987. Guide FAO d’identification des espèces pour les besoins de la pêche. Méditerranée et Mer noir. Zone de pêche 37. Vol I. Végétaux et invertébrés. Rome, FAO, 760 pp.

Forest, J. & Guinot, D., 1956. Sur une collection de Crustacés Décapodes et Stomatopodes des mers tunisiennes. Bulletin Station Océanographique de Salammbô, 53: 24-43.

Gaillil, B., Froglia, C. & Noel, P., 2002. CIESM Atlas of Exotic Species in the Mediterranean. Vol. 2: Crustacean decapods and stomatopods. CIESM Publishers, Monaco, 192 pp.

Hattour, A., 1991. Le chalutage dans les eaux tunisiennes, réalités et considérations législatives particulièrement dans les golfs de Tunis et de Gabès. Notes de l’Institut National des Sciences et Technologies d’Océanographie et de Pêche, Salammbô, 1: 1-25.

Hereu, B., 2004. The role of trophic interactions between fishes, sea urchins and algae in the Northwestern Mediterranean rocky infralittoral. MSc Thesis. Universitat de Barcelona, Spain, 194 pp.

Jarboui, O. & Ghorbel, M., 1995. Sur la présence de Trachyneaus curviostris (Stimpson, 1860) dans le golfe de Gabès (Tunisie). Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salammbô, 22: 1-9.

Kempf, M., 1962. Recherches d’écologie comparée sur Paracentrotus lividus (Lmk) et Arbacia lixula (L.). Recueil des Travaux de la Station Marine d’Endoume, 25 (39): 47-116.

Koehler, R., 1921. Faune de France I. Echinodermes. Paris, Le Chevalier, 210 pp.

Koehler, R., 1924. Les Échinodermes des Mers D’Europe. Tome 1. Paris, Librarie Octave Doin, 362 pp.

Koehler, R., 1927. Les Échinodermes des Mers D’Europe. Tome II. Paris, Librarie Octave Doin, 339 pp.

Koutsoubas, D., 1992. Contribution to the study of the gastropod molluscs of the continental shelf of the North Aegean Sea. MSc Thesis. Aristotle University of Thessaloniki, 585 pp.

Ktari-Chakroun, F. & Aouzou, A., 1971. Les fonds chalutables de la région Sud-Est de la Tunisie (golfe de Gabès). Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salammbô, 2 (1): 5-47.

Le Danois, E., 1925. Recherches sur les fonds chalutables des côtes de de Tunisie (croisière du chalutier “Tanche” en 1924). Annales. Station Océanographique de Salammbô. Tunisie, 1: 1-56.

Missoui, H. & Aouali, M., 1995. Apparition de nouveaux crus-tacés dans les pêches de crevetières du golfe de Gabès. Tunisie. Marine Life, 5 (2): 27-34.

Missoui, H., Mahjoub, M.S. & CHALGHAF, M., 2003. Sur la présence de la phanérogame marine Halophila stipulacea (Forskal) dans le golfe de Gabès (Tunisie). Bulletin de l’Institut National des Sciences et Technologies de la Mer de Salammbô, Tunisie, 30: 111-114.

Moliner, R. & Picard, J., 1954. Élémnts de bionomie marine sur les côtes de Tunisie. Bulletin de la Station Océanographique de Salammbô, 48: 3-47.

M’Rabet, R., 1995. Les engins de pêche et les ressources halieutiques. Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salammbô, 6: 29 pp.

Nedelec, H., 1982. Ethologie alimentaire de Paracentrotus lividus dans la baie de Galeria (Corse) et son impact sur les peuplements de phytophentoniques. MSc Thesis. Université de Pierre et Marie de Curie, Paris, 175 pp.

Pérès, J.M., 1956. Résultats scientifiques des campagnes de la Calypso. II. Ascidies. Annales de l’Institut Océanographique, Paris, 32: 265-304.

Pérès, J.M., 1954. Contribution à l’étude des Ascidies de Tunisie. Bulletin de la Station Océanographique de Salammbô, 49: 1-21.

Pérès, J.M. & Picard, J., 1956. Etude sur le seul siculo-tunisien. 1. Recherches sur les peuplements benthiques du seul siculo-tunisien. Annales de l’Institut Océanographique, Paris, 32: 233-264.

Pergent, G. & Kempf, M., 1993. L’environnement marin côtier en Tunisie. Rapport de synthèse. 2. Étude documentaire. 3. Annexes. Brest, FREMER publications, 395 pp.

Pielou, E.C., 1996. Shannon’s formula as a measure of specific diversity: its use and measure. American Naturalist, 100 (914): 463-465.

Ramos-Espla, A.A., 1991. Ascidias litorales del Mediterráneo ibérico. Faunística, Ecología y biogeografía. Universidad de Alicante, Secretariado de publicaciones, 405 pp.

Sammari, C., Koutitansk, V.G. & Moussa, M., 2006. Sea level variability and tidal resonance in the Gabes gulf, Tunisia. Continental Shelf Research, 26 (3): 338-350.
Ranson, G., 1924. Liste des Echinodermes recueillis au cours de la croisière de « la Tranche », sur les côtes de Tunisie. Mémoire Officiel Scientifique Technique de. Pêches maritimes, Série spéciale, 3 (2): 53-55.

Rosso, J.C., 1978. Faune malacologique de la plate forme tunisienne: Etude de quelques dragages et carottages effectué à l’intérieur ou au large du golfe de Gabès. Bulletin de l’Institut National Scientifique et Technique d’Océanographie et de Pêche de Salammbô, 5 (1-4): 17-41.

Seurat, L.G., 1929. Observations sur les limites, les faciès et les associations animales de l’étage intercotidal de la petite Syrte (golfe de Gabès). Bulletin de la Station Océanographique de Salammbô, 12: 1-55.

Shannon, F.P. & Weaver, W., 1963. The mathematical theory of communication. University Illinois Press, Urbana, 117 pp.

Tlig-Zouari, S. & Zaouali, J., 1994. Reproduction de Pinctada Radiata (Leach, 1814) (Mollusque, Bivalve) dans les Îles Kerkennah (Tunisie). Marine Life, 4 (1): 41-45.

Tlig-Zouari, S. & Zaouali, J., 1998. Etude de quelques caractères biométriques de Pinctada Radiata des Îles Kerkennah (Tunisie Méridionale). Annales de l’Institut Oceanographique, 74 (2): 217-224.

Topsent, E., 1934. Etude d’éponges littorales du golfe de Gabès. Bulletin des travaux publiés par la Station d’aquiculture et de pêche de Castiglione, 2: 3-5.

Tortonese, E., 1965. Fauna d’Italia. Echinodermata, Vol. VI. Bologna, Edizioni Calderini, 422 pp.

Verlaque, M., 1987. Contribution à l’étude du phytobenthos d’un écosystème photophile thermophile marin en Méditerranée Occidentale. Université d’aix Marseille II, Faculté des Sciences de Luminy, 387 pp.

Zaouali, J., 1993a. Présence d’Eucrate crenata dans le golfe de Gabès (Crustacean, Decapoda, Brachyura). Marine Life, 2 (1): 53-56.

Zaouali, J., 1993b. Les peuplements benthiques de la petite Syrte, olfe de Gabès- Tunisie. Résultats de la campagne de prospection du mois de juillet 1990. Etude préliminaire : biocenoses et thanatocenoses récentes. Marine Life, 3 (1-2): 47-60.

Zariquey, R., 1968. Crustáceos decápodos ibéricos. Investigacion Pesquera, 32: 1-510.

Zenetos, A. & Simboura, N., 2001. Soft bottom benthic indicators. p. 339. In: 36th CIESM Congress Proceedings, 24-28 October, Monte Carlo.

Zenetos, A., Gofas, S., Russo G. & Templado, J., 2003. CIESM Atlas of Exotic Species in the Mediterranean. Vol. 3: Molluscs. Monaco, CIESM Publishers, 376 pp.

Zouari, K., Bouzid, J., Bousnina, A., Chayeb, M., Karray, N. & Bradai, M.N., 1996. Implications des changements climatiques sur la zone côtière de Sfax (Tunisie). UNEP, MAP Tecnical Reports Series, No 99, 326 pp.