Observations on the benthic macrofauna of the soft sediment on western side of the Arabian Gulf (ROPME sea area) with respect to 1991 Gulf War oil spill

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More than 80 species of the benthic fauna were recorded in the soft sediment on the western side of the Arabian Gulf (from Kuwait to Qatar) during the R.V Mt. Mitchell cruise (23rd April-3rd May 1992). Molluscs formed the main component in species composition, followed by crustacea, polychaeta and echinodermata. Stations with coarse sediment substrates between coral reef grounds showed an increase in number of species than those with fine-mud and silt substrates. With regards to the impact of 1991 Gulf War oil spill on the benthic communities, the species diversity and the rank-abundance relationships reflected no harmful effect on the soft sediment communities.

The bottom fauna form an important source of food for variety of fishes and other marine organisms in the Arabian Gulf as elsewhere. Sandy and muddy ecosystems extend down to about 40 m depth and are considered an important habitat for both motile and burrowing fauna. While sandy ecosystems are high energy habitats near coral reefs, the muddy habitats are low energy habitats in quite deep water.

Few studies\(^1\) on the distribution of benthic biota and their communities in the Arabian Gulf are on record. Among the important biological studies which yielded useful information on the subtidal sandy and muddy benthos were that carried out by the Danish Scientific Investigations in Iran\(^5\). Subsequent reports\(^6\) further provided details of faunal and community composition of the benthic biota. The present investigation embodies a general observation on soft sediment communities in the western part of the Arabian Gulf (from Kuwait to Qatar) after 1991 Gulf War oil spill. It has been carried out through a visibility study monitored and funded by the Regional Organization for the Protection of Marine Environment (ROPME) to assess the impact of oil spill on the marine ecosystem. The present study is restricted to presence/absence records for benthic fauna collected by R.V. Mt. Mitchell during its cruise (leg IV) from Kuwait to Qatar.

**Materials and Methods**

During the R.V. Mt. Mitchell cruise (leg IV, 23 April to 3 May 1992), in the western part of Arabian Gulf (ROPME sea area) from Kuwait to Qatar, soft sediments were collected by Smith McIntyre grab (0.1 m\(^2\)) from 8 stations (Fig. 1). From each station 3-4 grab samples were taken and from each sample large macrofauna were picked up and preserved in 5% formaline. The grab sediments were then screened through 2 mm mesh sieve and the retained organisms were sorted out and preserved. As the samples were preserved for a long time (about 18 months) they were kept in dark cold cabinets and few drops of formaline were added from time to time. With the beginning of January 1994, the samples were washed out, sorted and identified. During the cruise, the hydrographic parameters (temperature, salinity, pH, \(O_2\) saturation and chlorophyll-\(a\)) were recorded using an automatic CTD operated from the vessel deck. The grain size distribution of sediment was analyzed\(^8\). Similarities, diversity and the taxa-abundance relationships were calculated using suitable statistical tests\(^9\).

**Results**

Variations of temperature, salinity, \(pH\), \(O_2\) and chlorophyll-\(a\) between the investigated stations are presented in Table 1. Temperature values ranged between 18.9°C (in st. 2) and 22.4°C (in st. 8) whereas salinity readings ranged between 39.3 \(\times\) 10\(^{-3}\) (in st. 1) and 41.6 \(\times\) 10\(^{-3}\). \(pH\) levels fluctuated slightly around 8.3 with no significant variations between stations (ANOVA, \(P > 0.1\)). Also, the saturation of dissolved oxygen displayed a narrow variation between stations (115-122%) with no statistical difference (ANOVA \(P > 0.05\)) between them. Concentration of chlorophyll-\(a\) showed significantly higher values (\(P < 0.05\)) at sts 2, 3 and 6.
Table 1—Mean values (± S.D.) of temperature, salinity, pH, oxygen saturation and chlorophyll-a in the investigated stations

<table>
<thead>
<tr>
<th>St. no.</th>
<th>Temp. (°C)</th>
<th>Sal. (× 10^{-3})</th>
<th>pH</th>
<th>O₂ saturation (%)</th>
<th>Chlorophyll-a (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19.5 ± 1.1</td>
<td>39.3 ± 0.4</td>
<td>8.35 ± 0.05</td>
<td>122 ± 2.0</td>
<td>0.34 ± 0.21</td>
</tr>
<tr>
<td>2</td>
<td>18.9 ± 0.5</td>
<td>39.8 ± 0.3</td>
<td>8.36 ± 0.07</td>
<td>120 ± 3.0</td>
<td>1.92 ± 0.35</td>
</tr>
<tr>
<td>3</td>
<td>20.5 ± 0.9</td>
<td>39.8 ± 0.5</td>
<td>8.38 ± 0.1</td>
<td>118 ± 2.0</td>
<td>1.85 ± 0.56</td>
</tr>
<tr>
<td>4</td>
<td>22.3 ± 0.3</td>
<td>40.1 ± 0.5</td>
<td>8.34 ± 0.08</td>
<td>119 ± 4.0</td>
<td>0.57 ± 0.16</td>
</tr>
<tr>
<td>5</td>
<td>21.6 ± 0.5</td>
<td>39.5 ± 0.6</td>
<td>8.37 ± 0.12</td>
<td>115 ± 3.0</td>
<td>0.94 ± 0.42</td>
</tr>
<tr>
<td>6</td>
<td>20.7 ± 0.4</td>
<td>40.1 ± 0.7</td>
<td>8.41 ± 0.05</td>
<td>115 ± 3.0</td>
<td>1.84 ± 0.91</td>
</tr>
<tr>
<td>7</td>
<td>21.3 ± 0.4</td>
<td>40.7 ± 0.8</td>
<td>8.35 ± 0.12</td>
<td>122 ± 3.0</td>
<td>0.44 ± 0.16</td>
</tr>
<tr>
<td>8</td>
<td>22.4 ± 0.8</td>
<td>41.6 ± 0.7</td>
<td>8.29 ± 0.11</td>
<td>116 ± 4.0</td>
<td>0.81 ± 0.28</td>
</tr>
</tbody>
</table>

The nature of the sediment varied between muddy, silt coarse sand and small pebbles. Some were completely muddy in texture and others with mixture of mud and sand. Regarding infraunal composition, > 80 species were recorded and about 50% of them belonged to gastropod and bivalve molluscs (Fig. 2). Crustacea, polychaeta and echinodermata together accounted for 40% of the species composition. Very few dispersed colonies of sponges were also collected especially from stations located near the coral reef communities. Details of the sediment texture and infraunal composition are as follows:

Station 1—The sediment was fine muddy in texture and composed of clay, fine silt with some relict sand. It was green in colour without any oily smell. Median grain size is of 6.61φ (phi). Of the 24 recorded species (belonged to 6 taxa) (Fig. 2), gastropod and bivalve molluscs accounted for 45.8% of the species number. Crustacea (5 species), polychaeta annelida (3 species) and echinodermata (3 species) were occasionally recorded in low frequency as compared to molluscs. The mud-living gastropods like *Fusinus townsendi*, *Murex scolopax* and *Nephtys* sp. (polychaeta) were found burrowing deep down to 15 cm of the sediment.

Station 2—The substrate was silty and muddy, greenish (in colour), had some oil smell and seemed to be rich in organic matter. Grain size ranged between 4.85 and 6.5φ. The least number of species (18) was
recorded in this station (Fig. 2). Fauna was dominated by gastropod and bivalve molluscs (44.5%) as well as crustaceans (22.4%). Among gastropods, Cerithidea cingulata and Pirinella conica occurred in high numbers (between 20 and 30 individual from each grab sample). Also, Tellina sp., a soft sediment bivalve, was found in adequate number (15 individual). Other taxa were rarely represented by few species.

Station 3—The substrate at this station was a mixture of sand, silt and clay, having oily smell and also seemed to be rich in organic matter. The grain size ranged from 2.5 to 4.1φ with median size equal to 3φ. The fauna (25 species) was mainly dominated by mollusca (12), followed by polychaeta (5), crustacea (4) and echinodermata (3). Gastropoda accounted for 70% of the recorded molluscs and exhibited the dominance of deposit-feeding species. The sea urchin (Echinometra sp.) were collected in great number during bottom trawling in this station which may suggest that the bottom deposits are quite favourable for the sustenance of benthic life.

Station 4—Sediments at this station were mainly sandy (1.03φ grain size) mixed with traces of blue mud. Old traces of tar ball covered by 2-3 cm fine sand were also found. Algal debris, coral and shell fragments, covered by blue greenish mud was observed on the bottom surface. About 22 species belonging to 7 groups were identified with dominance of mollusca and crustacea (Fig. 2). Among the recorded species, Pinna bicolor spat (bivalve molluscs), and Idotea sp. (isopod crustaceans) were collected in moderate numbers (between 5 and 8 individuals for each species).

Stations 5 and 6—These stations are quite close to each other and situated at the north-east of Abu-Ali Island, therefore they exhibited similar bottom texture. The sediment is composed of fine and coarse sand (with grain size ranging between 0.98 and 2.38φ)in addition to fragments of broken corals, rubbles and shells. Small tarballs mixed with algal debris and covered with thin layer of sand were recorded at the two stations. As these stations located near coral grounds around Abu-Ali Island, the
faunal composition seemed to have representatives of animal groups which usually live in association with coral reef communities. Three species of sponges and spat of *Pinctada* spp and *Brachidontes* sp. were found on rubbles, shell and coral fragments. Also, some of tube-dwelling polychaetes and reef-living crustaceans and echinoderms were recorded among the infraunal communities. Molluscs, crustaceans and polychaete annelida dominated the recorded fauna at st. 5 whereas molluscs, polychaetes and echinoderms dominated at st. 6.

**Stations 7 and 8**—These stations are located between coral-reef grounds and the sediment is mostly composed of coarse sand and contain many coral and shell fragments as well as algal debris. Also broken starfish arms and crab appendages were found frequently between deposits. Grain size fluctuated between 0.98 and 1.48 μm with 1.02 μm median value. These stations as compared to other locations are rich in bottom fauna and this may be attributed to its location between enriched coral communities. The number of species in each category (Fig. 2) were approximately 1.5 ± 2 times those of other stations. Also the species variations and their number per each taxon revealed the great richness of these habitats. Molluscs dominated the collected fauna followed by crustacea, polychaeta and echinodermata (Fig. 2). The regression relationships (Fig. 3) when fitted between taxa (arranged in rank order) and percentage abundance was found to be exponential and follow broken-stick model. It was significant (*P* < 0.05) with no major differences between slope values at stts. 3-8. Station 2, however showed a significant decline (*P* < 0.01) in slope value indicating the rapid deterioration in the faunal abundance. The figure illustrates the presence of slight divergence between the expected and observed abundance at all stations. The divergence was quite obvious at st. 3.

Simpson faunal similarities for different taxa abundance (Fig. 4) reflected the high similarity between stations with a narrow range variations (82-89% similarities) between each other. Stations 5-8 showed the highest similarity level between each other whereas st. 1 interconnected with other stations (2, 3, 4) at the lowest similarity level.

The presence-absence Jaccard dendrogram for all species (Fig. 5A) or for the most abundant taxon (Fig. 5B) revealed the impoverishment in similarities between the recorded species. Similarity levels between stts. 5, 7, and 8 are slightly higher than other stations which are interconnected in a descending order. Amongst the molluscs (Fig. 5B), three distinct groups can be distinguished indicating that stations with relatively similar sediment (or similar habitats) are closely connected to each other.

Species diversity indices were calculated and found to show a small variation between the investigated stations (0.736-0.823). Lower values were recorded at st. 1 (*d* = 0.736), st. 2 (*d* = 0.752) and...
and high richness in faunal composition than small grain size areas. Similar results have been reported in the Gulf of Aqaba\textsuperscript{17} and in the northern part of the Arabian Gulf\textsuperscript{2}. Also, in a comparative study between benthic communities in soft substrate ecosystems in the Arabian Gulf regions and adjacent areas\textsuperscript{8,18,19}, the benthic abundance and diversity were reported to be low in mud and with distance from open ocean\textsuperscript{2}.

Stations with great number of species are mostly found between coral reef grounds or in sediments of the big coral fragments and dead shells which would increase the possibility of settlement of sessile animals as pearl oysters (Pinctada spp), mussels and tube-dwelling polychaetes. Basson \textit{et al.}\textsuperscript{3} and Price \textit{et al.}\textsuperscript{20} recorded many species of associated fauna and thalassinid shrimp in soft substrates around coral reef grounds or in its lagoons. In Red Sea,\textsuperscript{17} rich communities in sandy areas around coral reefs were dominated by molluscs and sea urchin \textit{Echinometra mathaei}. Such richness was inferred to the interactions and migrations of fauna between coral reef habitats.

With regards to species-dominance, most stations were dominated by gastropod and bivalve molluscs (about 44\% of the recorded species), followed by crustaceans (17\%), polychaetes (12\%) and echinodermics (11\%). These results indicate that soft sediments in the western side of Arabian Gulf are enriched with bottom feeding gastropods, suspension feeding bivalves and polychaetes as well as crawling crustaceans. Basson \textit{et al.}\textsuperscript{1} reported the dominance of polychaetes, gastropods and bivalves (in descending order) in muddy-sandy substrates. It was also reported\textsuperscript{9} that bivalve and gastropod molluscs accounted for 60.2\% of the species abundance in the sand silt substrate along the Saudi Arabian coasts whereas polychaetes accounted for 25.8\%. Although echinodermics are well represented by 9 species, their appearance frequency were extremely low (less than one individual/sample) except the sea urchin (\textit{Echinometra sp.}) in st. 3 where it was collected in large numbers by bottom trawling. Such aggregation of sea urchins suggests that the nature of soft bottom in this station is quite favourable for its feeding habits\textsuperscript{1} or it may be due to their spawning activities which was reported to take place during late spring\textsuperscript{21}.

As the present investigation was concerned mainly with the impact of the 1991 Gulf War oil spill on the soft-sediment faunal communities and its abundance, the recorded species richness and diversity showed no significant relationship with the presence (or absence) of the tar balls in the investigated stations. However, there is a positive relationship with sediment grain-size. Also, the
taxa-abundance relationships which can be used to
distinguish between stressed and non-stressed
environments\textsuperscript{11-22} showed no obvious divergence
between the expected and observed abundance.

Although the present observations do not reflect
any environmental stresses due to the 1991 Gulf War
oil spill, more quantitative studies are however
recommended to follow up its long term effect on such
soft sediment communities.

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