Application of Abundance Biomass Curve in Ecological Health Assessment of Khure-Mussa (Northwest of the Persian Gulf)

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Abstract
Khuzestan coastal waters have high fisheries potential and ecological importance. Since different sources of stress exist in this area, the present study was conducted to evaluate ecological quality and to determine health status in Khuzestan coastal sediments based on benthic communities and their biological parameters. Seasonal sampling was done from 20 creeks of Khur-e-Mussa area in Khuzestan coastal waters by 0.125 m² Peterson grabsampler during winter 2008 to autumn 2009. Macro-invertebrates were separated, sorted and identified to the lowest possible taxon. In addition, biological parameters such as diversity, richness, biomass and abundance were calculated. The results were analyzed using univariate analysis method, ABC (Abundance–Biomass Curve). The most abundant groups were polychaets (58%), crustaceans (25%) and mollusk (9%), respectively. The ABC plots showed that majority of creeks could be classified as moderately disturbed and polluted. The ranges of H’ diversity index values in majority of stations indicated moderate ecological status.

Keywords: ABC (Abundance-Biomass Curve), Benthic communities, Khur-e-Mussa area, Khuzestan coastal waters

1. Introduction

Macrobenthic studies have achieved a fundamental role in estuarine and marine impact assessment and marine management. Because marine macrobenthic invertebrates usually exhibit well-defined responses to environmental change, especially those stressors which influence the sediment structure (McLusky and Elliott, 2004).

Many researches have been carried out attempting to detect different stressors as result of environmental deterioration by using benthic communities in the coastal areas of the world (Gray and Wu, 2002; Borja et al., 2000; Muxika et al., 2003; Simboura, 2003; Borja et al., 2004; Borja and Muxika, 2005).

In last two decades, the study of marine communities has benefited from the use of so-called graphical/distributional representations (Warwick and Clarke, 1991; Warwick, 1993), such as the Abundance–Biomass Comparison (ABC method) (Warwick 1986; Warwick et al. 1987). This method is conceptually intermediate between univariate and multivariate approaches, and in contrast with multivariate analyses it has the advantage that a value judgment can be compared with results

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regardless of any comparison with control location (Warwick and Clarke, 1991).

The ABC method is an internal comparison of abundance and biomass distributions based on the differential performance of those distributions in response to environmental conditions (Warwick 1993 and 1986). This method is based on the assumption that in undisturbed communities, the presence of large organisms results in the biomass curve lying entirely above the abundance curve for at least the first three species plotted; in grossly disturbed communities, dominated by large numbers of small individuals, the abundance curve lies entirely above the biomass curve for at least the first three species plotted in moderately disturbed communities. These curves are closely coincident and crossed for the first three species (one or more times). Originally proposed for macro-zoobenthic communities on subtidal soft substrata (Warwick 1986), it has subsequently been applied to other marine habitats, with varying degrees of success (Dauer et al. 1993; Penczakand Kruk 1999; Stenton-Dozey et al. 1999). The utility of the ABC model should be determined in different habitats and for various biological components, according to its ability to predict changes in biotic data series previously known (McManus and Pauly 1990; Lardicci and Rossi 1998). Jouffre and Inejih (2005) and Yamen and his colleagues (2005) assessed the impact of fisheries on demersal fish assemblages using dominance curves and Abundance Biomass Comparison (ABC) curves. Several studies on macrobenthic abundance and diversity in Khure-Mussa creeks have been carried out (Nabavi 1997, 2000) but a few studies were done on health evaluation in Khure-Mussa by using different biotic indices (Dehghan-Madiseh 2008; Dostshenas 2009).

The aim of this study was to evaluate ecological quality in twenty tidal creeks in Khure-e-Mussa area, in Khuzestan coastal waters. For this reason, ABC method was used to determine the spatial sediment contaminant which induced by probable pollution sources in this area such as, riverine inputs, shipping and fisheries activity, several out falls and discharging of many types of industries.

2. Materials and Methods

Twenty creeks in Khure-Mussa area in the Northwest of the Persian Gulf were studied (Fig. 1). Seasonal sampling was carried out from winter 2008 to autumn 2009. Three replicates of each site for macrobenthos studying, grain size analysis and total organic matter (TOM) were obtained by Peterson grab (0.125 m²).

![Fig. 1: The location of studied creeks in Khure-Mussa area (2008-09) 1-Ghanam 2-Patil 3-Bihad 4-Ghazale 5-Majidieh 6-Semaili 7-oil station 8-Odleh 9-Jafari 10-Zangi 11-Doragh 12-Shipping station 13-Ahmad 14-Petrochemistry station 15-Maavi 16-Khure-mussa (1) 17- Khure-Mussa(2) 18- Khure-Mussa(3) 19- Khure-Mussa(4) 20- Khure-Mussa(5)](image-url)

For macrobenthos study, samples were immediately sieved through a 0.5 mm mesh screen and benthic organisms were removed. Macrobenthos were separated to the lowest animal taxonomic groups (by using: Barnes 1987; Jones 1986; Hutchings 1984; Carpenter and Niemi1998; Sterrer1966) and all species were counted and weighted.

Abundance (number of individual per m²), Biomass (g/m²), diversity (Shannon-Wiener H') and Margalef richness indices were calculated. For each
station, dominance curves for abundance and biomass were obtained following the ABC method (Warwick 1986). In the method, species are ranked in order of importance based on percent dominance of abundance or biomass. The plots were produced using PRIMER statistical software. The area between the abundance curve and the biomass curve is called W-statistic (Yemane et al., 2005). Biomass dominance and an even abundance distribution gives a value of +1 for undisturbed, and the reverse case a value of -1 for grossly disturbed. The W-statistics (Clarke 1990) also were computed for each case by applying the equation:

\[ W = \frac{\sum_{i=1}^{n}(B_i - A_i)}{50(S - 1)} \]

Where \( B_i \) is the relative biomass of the \( i \)th species, \( A_i \) is the relative abundance of the \( i \)th species and \( S \) is the number of species. ANOVAs were calculated using SPSS 14 software.

3. Results

The organic matter and silt-clay percentage of sediments were 10.57 to 29.75% and 63.60 to 95.59%, respectively (Fig. 2).

The lowest percentage values were in KhureMussa 3 (10.57), Patil (10.80) and Somali (10.90) and the highest percentage values were in Doragh (29.75), Ghazaleh (24.30), Zangi (21.80), Majidie (21.59) and Shipping-st. (19.46). Two way ANOVA of silt-clay percentages showed no significant difference between seasons (P<0.05), but significant differences were observed between different creeks (P<0.05). In addition, two way ANOVA showed no significant difference between different creeks based on total organic matter (P<0.05), however, there were significant differences between seasons (P<0.05).

In total, 28 faunal groups of benthic animals were identified including Polychaetes (25 families), Crustacean (32 families), Mollusca (23 families), Nemerteana, Echinodermata, Echiura, Tunicata, Seapens and Bryozoa. Each group differed in its abundance and biomass (Table 1).

Table 1. The percentage of total biomass and abundance of macrobenthic fauna in Khure-Mussa creeks

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Abundance (%)</th>
<th>Taxa</th>
<th>Biomass (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polychaeta</td>
<td>58.06</td>
<td>Seapen</td>
<td>94.24</td>
</tr>
<tr>
<td>Crustacea</td>
<td>24.82</td>
<td>Mollusca</td>
<td>2.61</td>
</tr>
<tr>
<td>Mollusca</td>
<td>9.35</td>
<td>Polychaeta</td>
<td>2.08</td>
</tr>
<tr>
<td>Seapen</td>
<td>5.24</td>
<td>Crustacea</td>
<td>1.07</td>
</tr>
<tr>
<td>Others</td>
<td>2.53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means of macrobenthos abundance and biomass in different seasons and creeks are represented in Figures 3 and 4, respectively.

Two way ANOVAs showed significant differences between creeks and seasons based on mean abundance (p<0.05).

Fig. 3: Variation of macrobenthic means abundance and biomass in different seasons (2008-2009)
The creeks also showed significant differences based on biomass ($p<0.05$). Figures 5a and 6a, show the results of clustering of the stations using Bray-Curtis index for similarities based on macrobenthic abundance and biomass. MDS ordination confirmed the results of cluster (Figs. 5b and 6b). Majority of creeks showed above 85% similarity for abundance and above 80% for biomass. The range of diversity and Richness indices values were (1.95 to 3.58) and (14 to 33), respectively. The range of Shannon diversity index was 1.95 (in Shipping-st) to 3.58 (for Patil).
The Shannon index value was above 3 in Ghannam, Bihad, Odelleh, Jafary, Zangy, Ahmady, Petrochem-st, Kh-Mussa (3), and Kh-Mussa (5). Patil had the highest richness value (33) and the lowest value (14) was in Oil station, Khure-Mussa (3), and Kh-Mussa (4), and Kh-Mussa (5). Two-way ANOVAs based on Richness and Shannon index values, showed only significant differences for Richness values (P<0.05). ABC curves were obtained for all creeks. With few representative plots of the environmental conditions observed in different creeks presented in Figure 7. W index values were positive and near zero for all creeks.

4. Discussion

According to the grain size analysis and TOM content, it is clear that all creeks were characterized by soft muddy bottom. The difference between TOMs of different creeks was not significant. However, the high amount of organic matter in sediments (10.758-29.75) could be related to changing seasonal condition. In addition, physical factors such as prevailing water currents and instability of surface sediments can also lead to variation of TOM. Percentages of TOM sediments in all studied creeks were above EPA standard (EPA, 2002). Studied creeks showed significant differences between biological parameters (abundance and richness) values due to differences in benthic community structure. Significant differences between seasons showed that there were seasonal variations in macro-benthic communities in this area. This temporal variation could have occurred due to obvious seasonal changes in physico-chemical and biological parameters in this area (Sabzalizadeh and Nilsaz, 1996; Nilsaz et al., 2005).
Some biological characteristics like, longevity, reproduction strategy, depth of habitat, trophic level and also fishing pressure exert important influence in variation of frequency, succession and diversity of macrobenthic species (Little, 2000). The seasonal means of diversity index in the present study are less than its reported value in Khuzestan coastal waters (Nilsaz et al., 2005). It is probably due to dominance of opportunistic species such as *Capitella sp, Cossura sp*, and *Chaetozone sp*, which contributed to lower diversity index values. However, some evidence indicated that macrobenthic responses differed between metal contamination and organic enrichment. For example, metal contamination could detrimentally affect all taxa, whereas organic enrichment could only favor certain opportunistic taxa (Rygg, 1986; Wilson and Jeffrey, 1994).

Based on (H') diversity index values, all creeks are classified in poor and declining ecological status according to WFD (European Water Framework Directive) water quality assessment classification (cited in Borja et al., 2003).

W index values in all creeks were positive and near zero, which suggested the moderate ecological status in all studied creeks. The low value of W and crossings between most of the curves led to classifying these stations as moderately perturbed. According to the abundance-biomass curves, some variations could be observed.

The creeks (Jafari, Zangi) and Petrochem stations showed more signs of disturbance condition, the creeks Bihad, Ghazaleh, Doragh, Semaili, Majidieh, Odleh, Ahmadi, Maavi, Oil station and Kh-mussa(4) showed moderate disturbed condition, and the Kh-mussa(1), Kh-mussa(2), Kh-mussa(3), Kh-mussa(5), Shipping station, Patil and Ghannam showed less disturbed condition. The last groups mostly were located in Khure-Mussa channel or placed outside the embayment of Mahshahr creeks. Mahshahr creeks could be affected by many probable pollution...
sources. In general, according to ABC plots, the most creeks in Khure-Mussa area showed moderate pollution status.

The ABC curve is widely used for the detection of pollution effects on macrobenthos communities (Warwick, 1986; Warwick et al., 1987; Clarke, 1990). High similarity index values could emphasize the same ecological status based on macrobenthic animals in studied areas. In unpolluted systems, with a high evenness and several large-bodied species, the biomass curve will fall well above that for abundance, the reverse being true for heavily polluted situations dominated by high numbers of small species (Adams, 2002).

As a result of different types of exploitation, industrial and shipping activities in Khure-Mussa area, unbalanced and moderate ecological status for sediment quality are expected. Khure-Mussa creeks are characterized by sever water exchanges in their base; This and with predominantly silt-clay sediment, high rate of sedimentation might also be a major factor in benthic animals fluctuation. For better evaluation, chemical and biological monitoring is necessary.

Adjusted SAB (Species-Abundance-Biomass) relationships varied in their details with respect to different classes of sediment contamination, but all types of SAB stress appear to exhibit similar basic characteristics. Moreover, rapid decrease in the B/A ratio with increasing contamination supported the concept that relatively long-lived, large-bodied, equilibrium taxa decline markedly at high concentration of toxicants (Rakocinski et al., 2000).

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