Journal of the Persian Gulf
(Marine Science)/Vol. 5/No. 15/March 2014/7/25-32

The Distribution and Abundance of Macrobenthic Invertebrates in the Hormozgan Province, the Persian Gulf

Pourjomeh, Fatemeh; Hakim Elahi, Maryam*; Rezai, Hamid; Amini, Nafiseh

Dept. of Biology, Iranian National Institute for Oceanography and Atmospheric Sciences, Tehran, IR Iran

Received: July 2013 *Accepted: November 2013*

Abstract

During the Persian Gulf and Oman Sea Oceanographic study (PG-GOOS) in autumn 2012, sampling of macrobenthos was undertaken in 31 stations in Hormozgan Province waters. Three samples were taken from each site using Van Veen grab. Effects of environmental variables on assemblages and distributions of macrobenthos were analyzed. A total of 5677 individuals of macrobenthos were counted being represented by 8 taxa (i.e. gastropods, bivalves, polychaetes, crustaceans, scaphopods, echinoderms, sipunculids). The highest average number of macrobenthos belonged to gastropds 52.67 ind. (±18.94). Macrobenthos were distributed mostly around Bu Mussa and Lavan Islands with lower abundances around Kish and Qeshm Islands. Canonical Correspondence and Pearson's Correlation Coefficient analysis found sediment temperature, total organic matter and depth as the main factors contributing to the macrobenthos assemblages ($P<0.05$).

Keywords: *Macroinvertebrate, Macrofauna, Environmental factors, Hormozgan Province, Persian Gulf.*

1. Introduction

Macrobenthos are defined as invertebrates living in or on the sediments or attached to hard substrates. Study of benthic communities is important because they are bio-indicators of specific environment and habitat conditions. They have important roles in food chain and recycling of organic matters, detoxifying pollutants, dispersion and burial and secondary production (Reish, 1960, 1967; Heilskov and Holmer, 2001; Blanchet et al., 2008; Kang et al., 2007; Dauvin, 2007; Bellan, 2008; Borja et al., 2008).

The Persian Gulf is a shallow semi-enclosed body of water with rapid changes in the environment (Sheppard et al., 2009). These changes occur due to temperature and salinity alterations, constructions, habitat loss, creation of beds of shifting or suspended sediments and so on (Sheppard et al., 2009). Thus, macrobenthic communities in the Persian Gulf are the largest and most important marine ecosystems (Naser, 2010). Macrobenthos in the Persian Gulf are characterized by high levels of biodiversity but low species richness due to harsh environmental conditions and any environmental alteration will affect these communities (Basson et al., 1977; Price, 2002; Al-

* *Email: hakimelahi.m@inio.ac.ir*

Yamani et al., 2009; Sheppard et al., 2010). Since macrobenthic communities provide important food sources for the fishes (Snelgrove, 1999; Thrush and Dayton, 2002), their losing will affect local fisheries that provide food security for the around Persian Gulf countries negatively.

Many studies have researched the biodiversity, distribution and habitat of macrobenthic communities in the Persian Gulf (Basson et al., 1977; McCain 1984; Coles and McCain, 1990; Zainal et al., 2007; Al-Yamani et al., 2009; Naser, 2010). Biodiversity and distribution of marine macrobenthos are influenced by sediment type, temperature, salinity, primary productivity, depth and physical disturbance (Basson et al., 1977; Coles and McCain, 1990). Hence, the study on the relationship between these factors and macrobenthos assemblages is of utmost importance. The purpose of this study was to determine the effect of environmental parameters on benthos community abundance and distribution in the Hormozgan Province, the Persian Gulf, Iran.

2. Materials and Methods

During the Persian Gulf and Gulf of Oman Oceanographic study (PG-GOOS) in autumn, 2012, sampling of macrobenthos was undertaken in 31 stations in waters of Hormozgan Province at different depths (Figure 1, Table 1). Three replicate samples were collected from each site by a Van Veen grab (0.025m2). Samples were sieved through 1 mm mesh and the remaining was fixed with formaldehyde and transferred to the Iranian National Institute for Oceanography and Atmospheric Science (INIOAS) laboratory. Organisms were counted and sorted to major taxonomic groups.

Parameters such as sediment temperature and depth were recorded in the field. Analysis of total organic matter (TOM) was carried out by burning sediment in furnace at 450°C for 5 h. (Neria and Hopner, 1994). Sediment grain size analysis was carried out with a laser-based particle size analyzer (LA-950, Horiba).

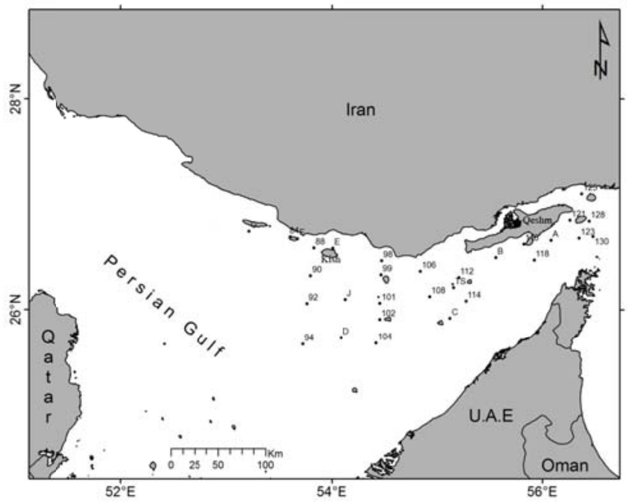

Fig. 1: Sampling stations in Hormozgan Province waters

Table 1. Station Coordinates and Depths in the study area.

Stn.	Coordinates N	Coordinates E	Depth (m)
67	27° 35' 54.6"	052° 07' 08.7"	72.0
71	27° 21' 07.5"	052° 30' 27.1"	65.0
73	27° 09' 25.6"	052° 19' 29.0"	81.0
75	26° 56' 49.2"	052° 07' 49.1"	56.0
82	26° 35' 48.4"	052° 54' 04.4"	81.0
84	26° 41' 23.7"	053° 28' 08.8"	59.0
88	26° 35' 07.1"	053° 50' 03.3"	50.0
90	26° 18' 27.9"	053° 48' 06.4"	86.0
92	26° 02' 28.7"	053° 47' 01.5"	75.0
94	25° 46' 39.4"	053° 43' 32.5"	60.0
98	26° 27' 26.9"	054° 28' 22.8"	25.0
99	26° 19' 23.9"	054° 29' 17.4"	72.0
101	26° 03' 27.8"	054° 27' 32.1"	50.0
102	25° 54' 10.2"	054° 27' 25.9"	38.0
104	25° 40' 48.6"	054° 25' 23.5"	34.6
106	26° 21' 40.0"	054° 50' 30.5"	15.4
108	26° 07' 10.0"	054° 55' 47.0"	10.5
112	26° 18' 06.1"	055° 12' 26.5"	50.0
114	26° 04' 41.1"	055° 16' 35.5"	76.2
116	26° 37' 11.7"	055° 49' 31.4"	13.0
118	26° 28' 03.0"	055° 55' 24.6"	60.0
121	26° 50' 35.1"	056° 15' 13.0"	45.0
123	26° 40' 34.9"	056° 20' 53.5"	37.0
125	27° 05' 44.8"	056° 22' 14.2"	31.0
126	27° 00' 31.1"	056° 23' 20.2"	30.0
A	26° 39' 21.5"	056° 04' 56.4"	59.0
B	26° 29' 28.9"	055° 33' 41.9"	60.7
C	25° 55' 19.1"	055° 06' 57.0"	71.0
D	25° 43' 15.6"	054° 00' 30.8"	63.0
F	26° 40' 09.2"	053° 40' 30.5"	17.0
G	26° 44' 34.8"	053° 12' 58.3"	84.0
H	26° 38' 15.6"	052° 27' 25.9"	70.0
J	26° 05' 39.5"	054° 07' 48.6"	85.0
TS	26° 13' 14.6"	055° 09' 17.4"	75.0
RAS	27° 38' 38.5"	051° 26' 09.7"	26.0

The mean density of each group in each station was calculated from the estimates of total density in each station. Plots of average abundance of major faunal groups were depicted in EXCEL2007. GIS map to show distribution pattern of macrobenthos communities in the study area was prepared in ArcGIS 10.1 software. A clustering analysis based on the occurrence of major group of taxa at each station was done. Based on Bray–Curtis dissimilarity matrices of square-root, average density of each group was used to compare the assemblages of macroinvertebrates in study stations. Cluster analysis was done in PRIMER5 software (Clarke and Warwick, 2001). Pearson's correlation coefficient (SPSS version 9) software was employed to find environmental parameters, which best explained the benthic communities.

A manual forward selection process in Conoco was used to select the subset of environmental variables (i.e. Total Organic Matter (TOM), depth, sediment temperature, sediment textures) that best explained the spatial patterns in macroinvertebrate abundance. The data were squared root transformed to reduce skewness and outliers and approximate normality. Canonical Correspondence Analysis (CCA) analyses were performed using CANOCO 4.5 (Ter Braak and Smilauer, 2002).

3. Results

A total of 5677 individuals of macroinvertebrates were counted in total of 31 stations.This represented 7 major faunal groups of gastropods, bivalves, polychaets, crustacea, scaphopods, sipunculids and echinoderms. The average density per stations was 52.67 ind. (± 18.94) for gastropods followed by 8.32 ind. (± 3.77) for bivalves, 7.92 ind. (± 2.05) for polychaets, 1.28 ind. (± 0.52) for crustacea, 0.46 ind. (± 0.17) for scaphopods, 0.32 ind. (± 0.10) for echinoderms and 0.59 ind. (± 0.37) for sipunculids (Figs 2 and 3), resprctively.

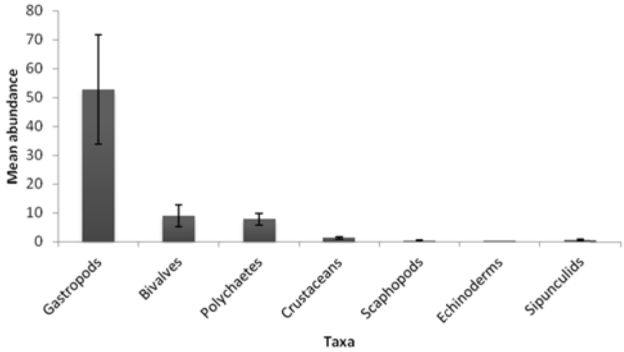

Fig. 2: Mean abundance of major faunal groups.

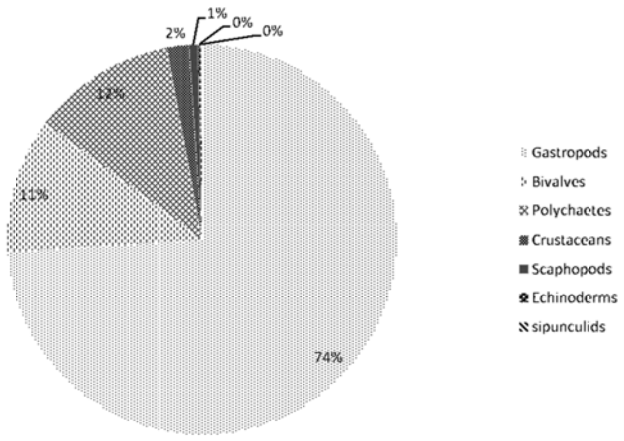

Fig. 3: Percent abundance of major faunal groups.

GIS map showed high abundance of macrobenthos around Bu Mussa and Lavan Islands followed by Farur Island and southern port of Kish Island. The poorest zones in terms of abundance were near Kish and Qeshm Islands (Fig. 4).

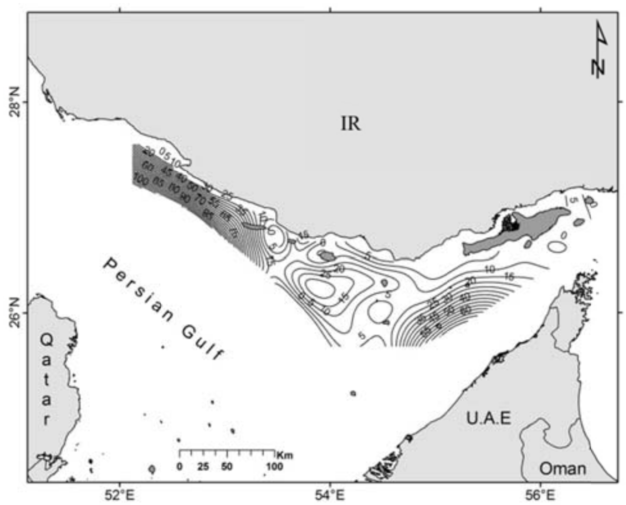

Fig. 4: Benthos abundance in the study area

Cluster analysis of the sampling stations based on the occurrence of major groups of taxa at each station, demonstrated three major clusters of sites (Figure 5).

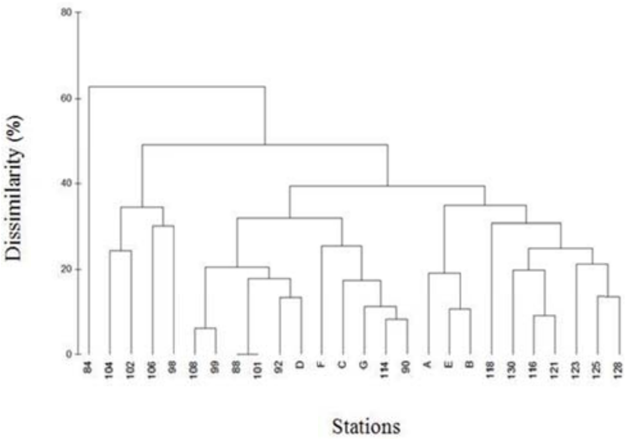

Fig. 5: Dendrogram of macroinvertebrate assemblage structure.

Due to Spearman's Correlation analysis, environmental variables such as sediment temperature, depth and TOM were correlated with benthic macroinvertebrate assemblages (Table 2).

Table 2. Spearman's correlation between macrobenthos abundance and environmental parameters

	Depth	TOM	sediment temperature	very fine sand	fine sand	very fine coarse
Correlation coefficient (r)	0.47*	-0.57**	-0.47*	-0.23 ns	0.19 ns	0.32 ns

(*= *P*< 0.05, **= *P*< 0.01, ns= non significant)

The result of CCA analyses based on manual forward testing found that different variables were responsible for variation in spatial patterns of macroinvertebrate assemblages. Overall, depth significantly correlated with the abundance of macroinvertebrates ($F= 3.2$, $P<0.05$). Furthermore, result of CCA analyses (Fig. 6) shows increase in abundance and distribution of scaphopods with sediment temperature, very fine sand and TOM, polychaetes with TOM and fine sand, gastropods with depth and very fine sand, bivalves with very coarse sand sipunculids and crustacea and echinoderms with sediment temperature.

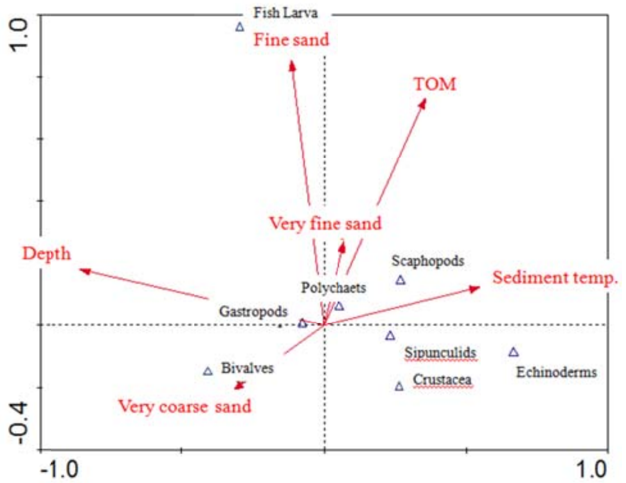

Fig. 6: CCA ordination diagram showing associations between environmental variables and spatial patterns in macroinvertebrate assemblages

4. Discussion

The present study demonstrated that abundance of molluscs (gastropods and bivalves) was higher than other groups followed by polychaetes and crustaceans. This result mirrored the findings of other studies in which molluscs, polychaetes and crustaceans were the most abundant groups in the Persian Gulf waters (Coles and McCain, 1990; Al-Yamani et al., 2009). In contrast, Bu-Olayan and Thomas (2005) found annelids as the most abundant groups in the Kuwait Bay, in the northeastern-western Persian Gulf. The differences between the results of this study with those of Bu-Olayan and Thomas (2005) might be because of differences in the study area or sampling times. Annelids can tolerate environmental stress in Bay more than other organisms. Moreover, Bu-Olayan and Thomas (2005) reported more annelids during summer time. Furthermore, Bu-Olayan and Thomas (2005) reported high trace metal levels and other pollutants which resulted in mortality of the shelled organisms during summer.

Environmental factors such as sediment type, temperature, salinity, primary productivity, depth, etc. are known to influence the structure of macrobenthos assemblages in the Persian Gulf (Basson et al., 1977). The result of Spearman's correlation analysis demonstrated that sediment temperature, depth and TOM were highly correlated with benthic macroinvertebrate assemblages. Likewise, Al-Yamani et al. (2012) stated that factors like depth, temperature and salinity, and type of sediment texture as the main factors that determined the benthic community structure.

Further investigation through CCA analysis indicated depth as the main factor which affected the macrobenthos assemblages. Earlier studies have shown depth as an important factor on shaping macrobenthos assemblages especially molluscs (Raby et al., 1994; Gaspar et al., 2002; Greenstreet et al., 2006; Mutlu and Ergev, 2008; Mutlu et al., 2010; Mutlu and Ergev, 2012). Also, comparing the macrobenthos distribution map with depth, it was concluded that high abundance of macrobenthos almost existed in shallow waters confirming the conclusion of correlation analysis. Moreover, the results of CCA analysis showed different taxa of macrobenthos were influenced by different factors. For example, Gaspar et al. (2002) and Al-Yamani et al. (2012) found significant relation between molluscan population with depth, grain size and total organic matter.

Polychaetes play an important role in the functioning of benthic communities (Hutchings, 1998). Gambi and Giangrande (1986) found significant linkage between polychaetes community and sediment particle size similar to findings of this study. Polychaetes are also important in environmental monitoring studies because of their sensitivity to the pollution (Giangrande et al., 2005). This study also showed the relationship between polychaetes and sediment total organic matters (TOM) content. Another example could be observed in crustaceans and echinoderms communities, which showed negative correlation with depth, and this finding mirrored the findings of other studies (Chou et al., 1999; Kroh and Nebelsick, 2010; Mutlu and Ergev, 2013). With increasing rate of the environmental variations in the Persian Gulf, such as temperature and salinity, constructions, habitat and lack of accurate information on benthic communities, it is necessary to support conservation and proper management of these unique ecosystems. Therefore, there is an urgent need for more study in benthic-pelagic coupling, secondary production of macroinfauna and meiofauna, trophic studies and interactions among groups.

References

Al-Yamani, F., Boltachova, N., Revkov, N., Makarov, M., Grintsov, V., Kolesnikove, E. and Murina, V., 2009. Winter species composition diversity and abundance of macrozoobenthos in Kuwait's waters, Persian Gulf. ZooKeys, 31: 17-38.

Al-Yamani, F.Y., Skryabin, V., Boltachova, N., Revkov, N., Makarov, M., Grinstov, V. and Kolesnikova, E., 2012. Illustrated Atlas on the Zoobenthos of Kuwait. Kuwait Institute for Scientific Research. 401 P.

Basson, P., Burchard, J., Hardy, J. and Price, A., 1977. Biotopes of the western Persian Gulf.Marine life; Environments of Saudi Arabia. Dhahran, Saudi Arabia: Aramco Department of Loss Prevention; Environmental Affairs Publishers, 284 P.

Bellan, G., 2008. Pollution indices. Encyclopedia of Ecology, 2861–2868.

Blanchet, H., Lavesque, N., Ruellet, T., Dauvin, J.C., Sauriau, P.G., Desroy, N., Desclaux, C., Leconte, M., Bachelet, G., Janson, A.-L., Bessineton, C., Duhamel, S., Jourde, J., Mayot, S., Simon, S. and de Montaudouin, X., 2008. Use of biotic indices in semi-enclosed coastal ecosystems and transitional waters habitats implications for the implementation of the European Water Framework Directive. Ecological Indicators, 8 (4): 360–372.

Borja, A., Dauer, D.M., Díaz, R., Llansó, R.J., Muxika, I., Rodríguez, J.G. and Schaffner, L., 2008. Assessing estuarine benthic quality conditions in Chesapeake Bay: A comparison of three indices. Ecological Indicators, 8:395-403.

Bu-Olayan., A.H and Thomas, B. V., 2005. Validating species diversity of benthic organisms to trace metal pollution in Kuwait Bay, off the Persian Gulf.

Applied Ecology and Environmental Research, 3(2): 93–100.

Chou, W., Lai, S.H and Fang, LS., 1999. Benthic crustacean communities in waters of southwestern Taiwan and their relationships to environmental characteristics. Acta Zoologica Taiwanica, 10: 25-33.

Clarke, k and warwick, R., 2001. A further biodiversity index applicable to species lists: variation in taxonomic distinctness. Marine Ecology-Progress Series, 216: 265-278p.

Coles, S and McCain, J., 1990. Environmental factors affecting benthic communities of the western Persian Gulf. Marine Environmental Research, 29: 289-315pp.

Dauvin, J.C and Ruellet, T., 2007.Polychaete / amphipod ratio revisited. Marine Pollution Bulletin, 55: 215–224.

Gambi, M and Giangrande, A., 1986. Distribution of soft-bottom polychaetes in two coastal areas of the Tyrrhenean Sea (Italy): structural analysis. Estuarine, Coastal and Shelf Science, 23: 847-862.

Garrison, T., 2005. Oceanography: An Invitation to Marine Science (5 edition). United States: Thomson the Brooks/Cole. 522 P.

Gaspar, M.B., Leita, O, F., Santos, M.N., Sobral, M., Chı´charo, L., Chı´charo, A. and Monteiro, C., 2002. Influence of mesh size and tooth spacing on the proportion of damaged organisms inthe catches of the Portuguese clam dredge fishery. ICES Journal of Marine Science, 59: 1228– 1236.

Gaspar, M.B., Leita˜o, F., Santos, M.N., Sobral, M., Chı´charo, L., Chı´charo, A.A. and Monteiro, C.C., 2002. Influence of mesh size and tooth spacing on the proportion of damaged organisms in the catches of the Portuguese clam dredge fishery. ICES Journal of Marine Science, 59: 1228– 1236.

Giangrande, A., Licciano, M. and Musco, L., 2005. Polychaetes as environmental indicators revisited. Marine Pollution Bulletin, 50(11): 1153-1162.

Gonçalves, E.M and lana, P., 1991. Padrões de distribuição de Bivalvia e Gastropoda plataforma continental da costa sudeste do Brasil (24ºS - 27ºN); Nerítica, 6: 73-92p.

Greenstreet, SPR., Armstrong, E., Mosegaard, H. and Jensen, H., 2006. Variation in the abundance of sand eels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63:1530–1550.

Heilskov, A.C and Holmer, M., 2001. Effects of benthic fauna on organic matter mineralization in fish-farm sediments: importance of size and abundance. ICES Journal of Marine Science, 58: 427-434.

Hutchings, P., 1998. Biodiversity and functioning of polychaetes in benthic sediments. Biodiversity and Conservation, 7: 1133–1145.

Kang, C.K., Choy, E.J., Paik, S.K., Park, H.J., Lee, K.S. and An, S., 2007. Contributions of primaryorganic matter sources to macroinvertebrate production in an intertidal salt marsh (*Scirpu striqueter*) ecosystem. Marine Ecology-Progress Series, 334: 131–143.

Kroh, A and Nebelsick, J.H., 2010. Echinoderms and Oligo–Miocene carbonate systems: potential applications in sedimentology and environmental reconstruction. International Association of Sedimentologists Series, 42:201–228.

McCain, J., 1984. Marine ecology of Saudi Arabia: the nearshore soft-bottom benthic communities of the northern area, Persian Gulf, Saudi Arabia. Fauna of Saudi Arabia, 6: 79-101pp.

Morton, J.E., 1967. Molluscs. 4th edition.Hutchinson University Library. London: 244 P.

Mutlu, E. and Ergev, M.B., 2008. Spatio-temporal distribution of soft-bottom epibenthic fauna on the Cilician shelf (Turkey), Mediterranean Sea Revista de Biologia Tropical, 56: 1919-1946.

Mutlu, E., Çinar, M.E. and Ergev, M.B., 2010.Distribution of soft-bottom polychaetes of the Levantine coast of Turkey, eastern Mediterranean Sea. Journal of Marine Systems, 79(1–2): 23–35.

Naser, H., 2010. Using Macrobenthos as a Tool in

Ecological Impact Assessment: Applications in Environmental Impact Assessment (EIA). Lambert Academic Publishing, Saarbrucken. 264 P.

Neria, C and Hopner, T., 1994. The role of *Heteromastus filiformis* (Capitellidae, polychaeta) in organic carbon cycling.Ophelia. 39(1):55-73.

Price, A., 2002. Simultaneous 'hotspots'; 'cold spots' of marine biodiversity; implications for global conservation. Marine Ecology-Progress Series, 241: 23-27.

Raby, D., Lagadeuc, Y., Dodson, J. and Mingelbier, M.,1994. Relationship between feeding and vertical distribution of bivalve larvae in stratified and mixed waters. Marine Ecology Progress Series, 103:275–284.

Reish, D.J., 1960. The use of marine invertebrates as indicators of water quality. In: Pearson, E. A. (ed.) Proceedings of the first international conference on waste disposal in the marine environment. Pergamo Press, New York, 92-103pp.

Reish, D.J., 1967. Relationship of polychaetes to varying dissolved oxygen concentrations. In: Marota, J. P., Josa, R. (ed.) Proceedings of the third international conference on water pollution research. Water Pollution Control Federation, Washington, D.C., 199-216pp.

Russell-Hunter, W.D., 1983. Overview: Planetary Distribution of and Ecological Constraints upon the Mollusca. In: The Mollusca. K. M. Wilbur (ed.) 6: 1-27. Academic Press. New York.

Sheppard, C., Al-Husiani, M., Al-Jamali, F., Al-Yamani, F., Baldwin, R., Bishop, J., Benzoni, F., utrieux, E., Dulvy, N., Durvasula, S., Jones, D., Loughland, R., Medio, D., Nithyanandan, M., Pilling, G., Polikarpov, I., Price, A., Purkis, S., Riegl, B., Saburova, M., Namin, K., Taylor, O., Wilson, S. and Zainal, K., 2010. Persian Gulf: a young sea in decline. Marine Pollution Bulletin 60: 13-38.

Sheppard, C.R.C., Davy, S.K. and Pilling, G.M., 2009. The Biology of Coral Reefs. Oxford University Press, Oxford, UK. 352P.

Snelgrove, P., 1999. Getting to the bottom of marine biodiversity: Sedimentary habitats.BioScience, 49: 129-138

Ter Braak, C.J.F and Smilauer, P., 2002. CANOCO Reference manual and CanoDraw for Windows user's guide: Software for Canonical Community Ordination. Version4.5. Ithaca: Microcomputer Power.

Thrush, S and Dayton, P., 2002. Disturbance to marine benthic habitats by trawling anddredging: Implications for marine biodiversity. Annual Review of Ecological andSystematics, 33: 449-473

Zainal, K., Al-Sayed, H., Ghanem, E., Butti, E and Nasser, H., 2007. Baseline ecological survey of Huwar Islands, The Kingdom of Bahrain. Aquatic Ecosystem Health & Management, 10: 290-300