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ECOLOGICAL CHARACTERISTICS OF THE LITTORIAL FAUNA AT TUBLI BAY, BAHRAIN

By

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الخصائص البيئية للحيوانات الساحلية في خليج توبلي (البحرين)

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تمت دراسة الحيوانات الساحلية لعدة بيئات مميزة في خليج توبلي الذي يقع علي الساحل الشرقي للبحرين ، لأول مرة على مدى عدة فصول .

بينت الدراسة وجود ٢٩ نوعاً من الحيوانات الساحلية تختلف في توزيعاتها ومواسم توافرها ، وتبعاً لذلك رصدت الدراسة التغيرات الموسمية في اعداد الحيوانات الساحلية مقارنة بالتغيرات الناتجة من نشاطات الإنسان مثل صرف مياه المجاري المعالجة والتصريف الساحلي لمياه المزارع المحاذية لخليج توبلي .

وقدتبين أنه يوجد إختلاف في توزيع الحيوانات الساحلية فحول مصرف مصنع معالجة مخلفات المجاري تؤلف السرطانات الساحلية ما يقارب ٥٠٪ مقارنة بالراسقدميات أو الحلزونات الساحلية التي كانت سائدة في بقية القطاعات الساحلية ، كما وجد أن حلزون *Pirnella conica* يمثل ما يقارب ٩٠٪ من مجموع الحيوانات الساحلية في هذه المناطق وقد أشارت الدراسة إلى زيادة الحيوانات الساحلية في أشهر الصيف وذلك نتيجة لتكاثرها .

خلصت الدراسة إلى أن توفر الوسط المناسب والقدره على تحمل إنخفاض الملوحة وزيادة الأملاح الغذائية بالاضافة إلى إزدياد العناصر الثقيلة والترسبات الطينية من أهم العوامل التي تتحكم في أنواع الحيوانات الساحلية وتوزيعاتها في خليج توبلي .

Keywords: Littoral fauna, Sewage outfall, Ecology, Tubli Bay, Bahrain

ABSTRACT

The intertidal fauna inhabiting a wide range of habitats at Tubli, an inshore bay on the eastern part of Bahrain has been surveyed, for the first time, over a period of several seasons. Quantitative and qualitative samplings have resulted in the collection of 29 species and made it possible to separate natural from unnatural variability in the littoral fauna caused by waste water outfall from sewage treatment plants and brackish water discharges from farms on the adjacent coastal area. Around the outfall, the littoral fauna was greatly reduced in the number of species and individuals. Shore crabs were the dominant group, forming more than 50% at the transect adjacent to the waste water outfall. Gastropods dominated the fauna at other transects; *Pirnella conica* was found to comprise more than 90% of the fauna.

Overall, summer months were found to support greater number of individuals, indicating that spawning and recruitment occur in warmer periods of the year. Availability of appropriate substrate and ability to tolerate reduced salinity, high nutrient input, greater trace metal concentration and siltation seem to control the type and distribution of littoral fauna at Tubli Bay.

INTRODUCTION

Bahrain supports a rich and varied marine environment such as seagrass beds, coral reefs, offshore islands, submarine springs, and different types of coastal environments which include lagoons and bays. Several terrestrial environments such as desert, freshwater springs, and temporary aquatic ponds are of common occurrence. Such varied environments, which are concentrated within a small geographical area, make them vulnerable to environmental deterioration as a result of human activities such as coastal development, which occur at an accelerated rate, especially at Tubli Bay.

Tubli is an inshore coastal bay covering an area of 12.56 km^2 on the eastern side of Bahrain. The bay plays an important role in the life cycle of several marine organisms of commercial importance [1]. Shrimp and some fishes visit the bay for spawning and to feed on the abundant organic matter. However, several practices make abay vulnerable to environmental deterioration. A waste water outfall from a sewage treatment works discharges tertiary treated domestic water at a rate of 125000m^3 /day at the northern end of the bay. Brackish water drainage from the Adhari spring and adjacent agricultural farms collectively add more nutrients, such as nitrates and phosphates which lead to algal eutrophication. Within the last few years coastal infilling has led to the reclamation of large stretches of coastal areas with the subsequent loss of intertidal habitats and their inhabitants.

In Bahrain, a few ecological investigations have been carried out to assess the impact of human activities on the marine environment. Saudi-Danish Consultant [2] carried out an environmental impact assessment study and predicted that building a causeway connecting Bahrain to Saudi Arabia will not have an adverse effect on the marine environment to the west of Bahrain. Prince [3] carried out an ecological study of the east coast of Bahrain, and concluded that the Asker marine area is one of the most productive intertidal flats and that benthic algae are the main primary producer. Voudson [4] employed the remote sensing technique to define, map and characterize critical marine habitats around Bahrain. The technique shows habitats which needed urgent protection against human interference. The Ministry of Public Works, Power and Water contracted the Watson Hawksley Company in 1984 to carry out an investigation of the water current pattern and the associated fauna at Tubli Bay, prior to building the sewage treatment plant [5]. They concluded that the bay suffers from environmental deterioration in some areas.

A common factor in all such studies is that they are based on interpretation of ecological data collected over one season. However, concern about the lack of long term seasonal data at Tubli Bay prompted us to carry out the present investigation which will allow us to characterize natural fluctuations in the composition of the littoral fauna adjacent to the sewage treatment plant.

MATERIAL AND METHODS

The littoral area at the western part of the bay was surveyed on several occasions in June 1990, February-March 1991 and October 1991. Five stations were sampled along 4 transects running from the high water mark down to the low water mark (Fig. 1). The 4 transects lie at different parts of the littoral area. Transect 1 is located in the northern end of the bay parallel to the sewage waste water outfall, whereas 2, 3 and 4 lie in the middle and southern part of the bay several kilometers away from the sewage outfall and characterized by the presence of sandy to hard substrates.

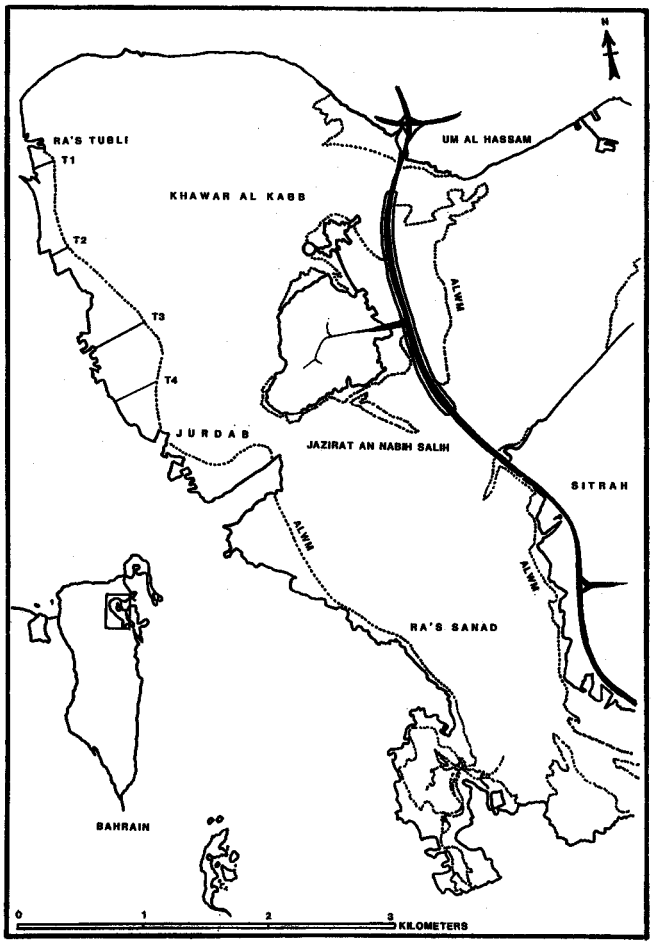

Fig. 1. Map showing location of 4 transects in Tubli Bay.

The sets of sample were collected, one quantitative and the other qualitative. Epifauna were carefully collected by hand from quadrats, each measuring 0.25 m^2. Infaunal organisms were quantitatively sampled by removing the sediment from inside a smaller quadrant (0.06 m^2) and sieved, subsequently, using a 1 mm sieve. Quantitative samples of crabs were obtained by digging the burrows carefully and collecting the crabs by hand from inside 1 m^2 quadrats. Efficiency of recovering crabs was improved as more experienced was gained. Three replicates were obtained from every location along each transect. Samples were kept in the freezer at -18° C before processing.

Sorting and identification of animals were carried out under a stereo-microscope which has a large working distance. At each time a small portion of previously sieved samples were examined carefully and the animals were gently picked out. Each animal was identified to generic and species level whenever possible and then counted. Diversity of the littoral fauna was calculated by the Margalef index [6] and Shanon-Wiener index [7]. In addition, a similarity coefficient, Bray-Curtis [8], was calculated to assess the degree of similarity of fauna between transects. Observations were made at each location on the substrata, algal bloom, siltation, fresh water input and halophytic plants.

RESULTS

Results of quantitative sampling from 4 transects, collected in the Tubli intertidal zone from June 1990 to October 1991 are given in Table 1. A total of 29 different species of macrobenthic fauna was found inhabiting the littoral area at Tubli Bay. Crabs were dominant group, forming more than 50% of Transect 1 (Fig. 2), adjacent to the waste water outfall. Gastropods dominated the fauna at Transects 2, 3 and 4 respectively, forming more than 50% of the total. Meanwhile the euryhaline snail *Pirnella conica* was found to comprise more than 90% of the gastropod-dominated areas. Seasonal abundance of key species at each sampling site is given in Fig. 3 a, b and c.

A clear pattern has emerged, which indicates during the summer and autumn periods larger numbers of individuals are present (Table 1). At all transects, animals showed a clear pattern of zonation in their distribution along the littoral area. At Transect 1, the substrate of the upper shore is mainly muddy-sand covered by halophytic plants

Table 1
Mean number of animals per m^2 at different transects during sampling periods

Animal Species	Transects									
	1			2			3			4
	Sampling Dates									
	June 90	Mar. 91	Oct. 91	June 90	Feb. 91	Oct. 91	July 90	Feb 91	Oct. 91	June 90
Sabella sp.	-	-	-	8	-	10	-	-	-	-
Nereis sp.	-	-	-	-	-	-	-	-	-	-
Polychaete sp. 1	-	32	-	-	-	-	-	28	-	-
Polychaete sp. 2	-	32	-	-	-	-	-	-	-	-
Polychaete sp. 3	-	16	-	-	-	-	-	-	-	-
Siphonaria lacinosa	-	-	-	317.3	-	-	250	20	48	-
Diodora sp.	-	-	-	-	-	-	-	4	-	-
Balanus sp.	-	-	-	-	149	-	-	16	-	-
Sphaeroma sp.	-	-	-	-	210	-	-	12	-	-
Pirnella conica	32	-	-	824	26	2180	10	2022	2571	2385
Cerithidea cingulata	1520	16	-	80	8	150	426	38	1081	44.4
Cirithium scabridum	-	-	-	8	798	141	20	28	-	133
Planaxis sulcatus	-	-	-	1520	-	-	-	10	-	-
Mirrella blanda	-	-	-	-	100	152	-	4	287	44.4
Cerithium sp. 1	-	-	-	-	104	-	-	-	-	44.4
Atys cylendrica	-	-	-	-	26	100	-	12	-	-
Turritellidea sp.	-	-	-	-	-	-	-	-	-	44.4
Monillea obscura	-	-	-	-	28	-	4	4	24	-
Dosinia ceylonica	-	16	-	-	466	348	-	1406	1150	1007
Tellina sp.	-	-	-	-	62	25	-	26	54.8	44.4
Isognomin sp.	-	-	-	-	8	-	-	-	-	-
Tylodiplax indica	832	168	-	-	-	-	-	54	-	44.4
Macrophthalmus depressus	96	-	-	-	-	-	-	-	-	-
Metaplax indica	32	32	13.33	-	-	-	-	-	-	-
Cleistostoma dotilliforme	32	424	-	-	-	-	-	-	-	-
Scopimera crabricauda	-	16	197.33	-	-	16	28	40	136	-
Metopograpsus messor	-	-	-	16	-	-	4	6	-	-
Diogenes avarus	-	-	-	478	1500	268	8	348	2756	1555
Eurycarcinus orientalis	16	16	-	-	-	-	-	-	-	-

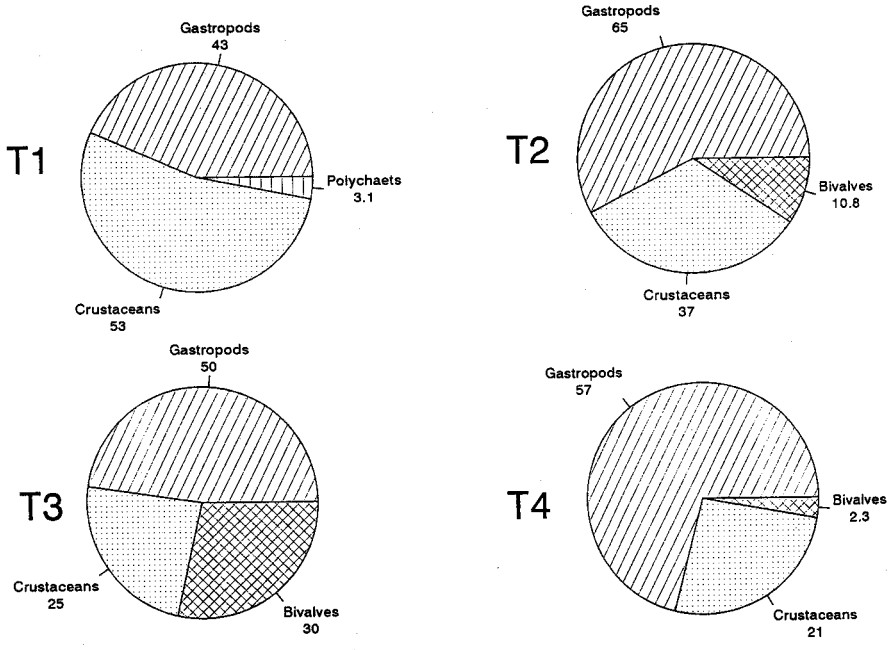

Fig. 2. Percentage composition of major animal groups at Tubli Bay.

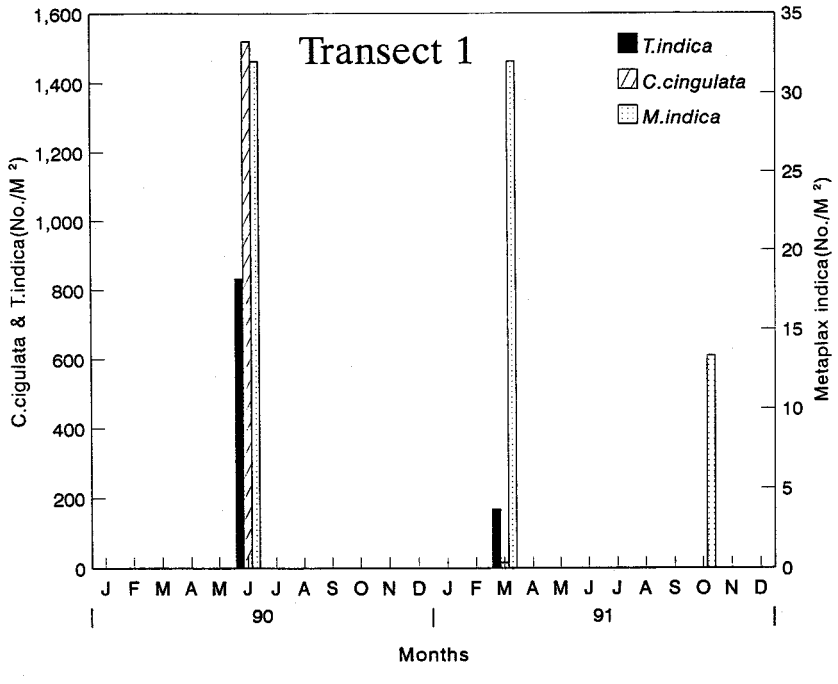

Fig. 3 a: Seasonal changes in number of key species at transect 1 in Tubli Bay

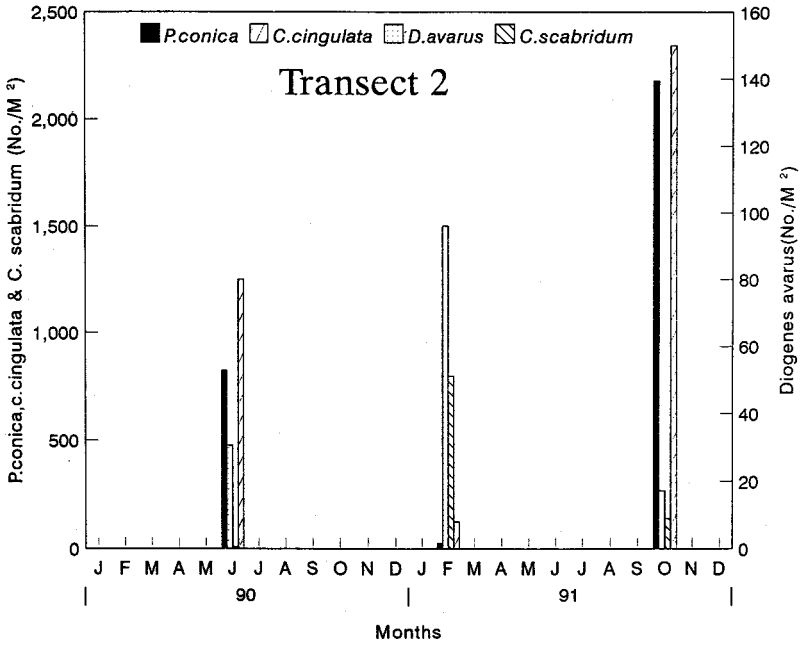

Fig. 3 b: Seasonal changes in number of key species at transect 2 in Tubli Bay.

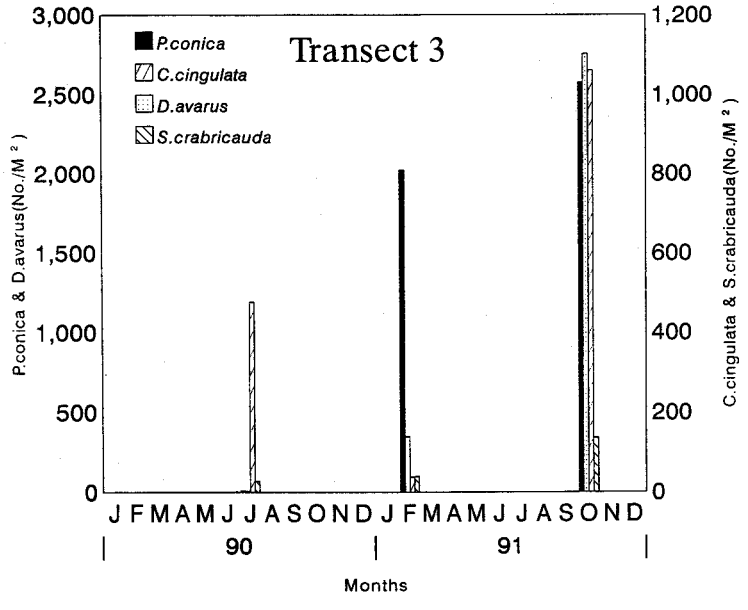

Fig. 3 c: Seasonal changes in number of key species at transect 3 in Tubli Bay.

(e.g.*Avicennia marina)* and algal mats forming a salt marsh vegetation. The fauna at the upper and lower shore was dominated by burrowing shore crabs of various sizes such as *Tylodiplax indica* and *Metaplax indica* which build burrows with characteristics towers. At the lower shore the substrate was very soft mud and the mud-snail *(Cerithidea cingulatus)* was the most conspicuous organism, especially around the tidal pools.

The fauna at remaining sampling sites showed a similar pattern of distribution. Rocky outcrops occurred at the high water mark leading to a sandy upper shore. A few halophytic plants were represented, mainly by the mangrove shrubs. The mixed sediments at the upper shore provide a substrate for inhabitants like the little crab *Scopimera crabicauda*, the *barnacle Balanus* sp. and the snail *Planaxis sulcatus.* The middle shore substrate is hard and is covered by a thin layer of sand suitable for macroinfauna, such as the bivalve Dosinia ceylonica and ploychaete worms. The hard bottom of the lower shore is suitable for animals characteristic of rocky shores such as Balanus sp., *Palanaxis sulcatus* and the limpet *(Diodora sp.)*

Two indices of diversity[6,7] were used in order to compare species richness of both epifauna and infauna at each sampling site (Table 2) and to test the possible effect of the waster water outfall from the sewage works on the littoral community. Both indices indicated that Transects 2, 3 and 4 supported a greater number of both species and individuals which, compared to Transect 1, supported a reduced number of species. The Bray-Curtis [8] similarity coefficient was also used to assess the variation of fauna between transects (Table 3). The coefficient showed that a high degree of similarity (70%) occurred between transects 2, 3 and 4, whereas the fauna at Transect 1 was found to be very different from that found at remaining transects.

Table 2
Number of individuals (N). number of species (S) and diviersity indices : Margalefs (d)., Shanon-Wiener function (H). at each transect in Tubli Bay during different sampling periods.

Transects	Parameters	June - July 90	Feb-March 91	October 91
1	S	8	11	2
	N	2640	800	210.66
	d	1.031	1.455	0.186
	H	1.597	2.446	0.381
2	S	8	13	11
	N	3251	3485	3808.9
	D	1.247	1.454	1.635
	H	2.031	1.970	2.588
3	S	8	18	9
	N	750	4079.31	8587.94
	D	1.928	1.928	1.172
	H	2.371	1.716	2.212
4	S	9	Not	Not
	N	8451.94		
	D	1.048	Sampled	Sampled
	H	1.97		

Table 3
Bray-Curtis Similarity Index of littoral fauna at different transects at Tubi Bay

	1	2	3	4
1	-	-	-	-
2	12.57	-	-	-
3	17.58	69.61	-	-
4	5.65	61.4	58.96	-

DISCUSSION

It is widely known that coastal habitats and their inhabitants are extremely vulnerable to human interference. This is certainly true in Tubli Bay which is found to suffer from environmental deterioration. The present study reveals that there is an overall spatial variation in the intertidal fauna at Tubli Bay. Fauna around the waste water outfall was dominated by crustaceans, especially burrowing crabs such as *Tylodiplax indica, Metaplax indica, Eurycarcinus orientalis* and *Scopimera carbicauda*, as well as the mud-snail *Cerithidea cingulatus*. On the other hand crabs were less dominant at the remaining sites and were replaced by gastropods, of which *Pirnella conica* was the most conspicuous. Such difference in percentage composition of intertidal fauna between transects could be attributed to the combined action of several factors. The substrate, which was predominantly muddy around the outfall, could be a result of precipitation of fine sediments from dredging activities which took place in the northern part of Tubli Bay. Since the sewage treatment plant was established in 1982, discharges have been in large quantities and mad up of brackish water with salinities as low as 2-5°/00 [9]. These discharges lead to increases in turbidity and trace metals and, more specifically, high concentrations of dissolved nutrients such a nitrates and phosphates in the water adjacent to the outfall. Moreover, the intermittent overflow of waste water, due to an overload of domestic waste, aggravates the condition further, rendering the habitat inhospitable for some intertidal fauna. Benthic fauna around the sewage outfall is usually dominated by small organisms such as oligochaete annelid worms that are tolerant of reduced oxygen tensions [10]. In the present study, polychaete annelid worms occurred around the outfall in comparatively larger numbers than in other areas. The considerable growth of halophytic plants, such as the black mangrove *Avincinna marina.*, may have been caused by inorganic elements associated with the organic load from the outfall. However, a large proportion of the area north of the outfall, which supported a salt marsh vegetation, has been reclaimed since our first survey, thereby destroying an important type of vegetation unseen elsewhere in Bahrain. Living in shallow coastal areas, the intertidal fauna are more responsive to atmospheric temperature than sublittoral communities. Greater number of individuals were found during the summer moths (June-October) than in winter months, indicating that new recruitment occurred during the warmer months. Field observation revealed the presence of mature and gravid female crabs *(M. indica* and *C. dotiliform)* in May and June. Furthermore, numerous gastropods *(Pirnella conica)* and bivalves *(Dosinia sp)* were found, indicating recruitment. Similar results were reported by Snewdon [11], who found the greatest number of individuals during the summer months.

The seasonal changes in species diversity do not show a clear pattern. However, the overall species diversity was comparatively low in comparison to other coastal habitats in Bahrain. Linden *et al* [12] studied diversity, abundance and biomass of the benthic fauna off a major oil refinery on the east coast of Bahrain and reported a greater species diversity in most of the stations he surveyed. Moreover, Watson Hawksley [5] described the fauna of Tubli Bay as reduced and concluded that it had undergone environmental stress, but did not give any causative factors. However, during the 1970's, the relative paucity of the littoral fauna at Tubli Bay was aggravated by the construction of the 2-mile Sitra causeway which partially blocked the bay and restricted free exchange of water to the area beneath the two bridge spans. Although such action led to a greater current velocity, it changed the pattern of current direction and reduced the area over which water is freely exchanged with the open sea. Recent coastal infilling activities which took place inside the bay also aggravated the conditions further by the total destruction of coastal habitats and by increasing silation of water, which has lead to modification of the natural bottom sediment. Tubli Bay is important to the local economy by providing nursery and feeding grounds for shrimp and fish species of commercial importance.

Abdulqader [1] was the first to provide substantial evidence for the importance of Tubli Bay for shrimp fisheries. Four penaeid species, Penaeus *simisulcatus, Metapenaeus stebbbingi, M. kutchensis* and *P. latisulcatus* were found inside the bay. *M. stebbingi* and *M. kutchensis* were found to spawn in Tubli Bay. Although the bay does not support the entire stock of *P.semisulcatus* of Bahrain, it is an important nursery ground for both *P. semisulcatus* and *M. stebbingi.*

The mudflats of the northern part of the bay were also found to provide a good source of food and shelter for some migratory birds, namely the reef heron *Egretta gularis* [13].

In conclusion, Tubli Bay is unique marine ecosystem that supports different coastal habitats such as salt marsh, mangrove swamp and rocky shores. Recently the bay has come under stress from urbanization and development, especially landfilling and liquid waste disposal. Therefore, unless urgent measures are taken environmental deterioration will continue and will subsequently lead to declining catches of economically important marine organisms.

REFERENCES

[1] **Abdulqader, E.,** 1993. The role of Tubli Bay in the life cycle of the penaeid shrimps of Bahrain pp: 24038. In Symp. on "Tubli Bay-Problems and Solutions". Bahrain Centre of Studies & Research and Bahrain Chemical Society, Bahrain.

[2] **Saudi-Danish Consultant,** 1976. Saudi Arabia Bahrain causeway study Final Report. Ministry of Finance and National Economy. Kingdom of Saudi Arabia. 241 pp.

[3] **Prince, A., D. Vousden, and R. Ormond,** 1984. An ecological study of sites on the coasts of Bahrain. Report of ICUN to UNEP Regional Sea Programme, Geneva. 70 pp.

[4] **Vousden, D.H.,** 1988. The Bahrain Marine Habitat Survey, Bahrain Environmental Protection Technical Secretariat, P.O. Box 26909, Bahrain.

[5] **Watson Hawksley,** 1984. Tubli Bay Marine Survey-Report of State of Bahrain, Ministry of Works, Power and Water.

[6] **Margalef, P.R.,** 1957. La tearia de la informaceion en ecologica Mem. Real. Acad. Ciencius Yartes de Barcelona.

[7] **Shanon, C.E. and Wiener** 1963. The Mathematical Theory of Communication. University of Illionis Press, Urbana, 125 pp.

[8] **Bray, J.R. and S.T. Curtis,** 1957. An Ordination of The Upland Forest Communities of Southern Wisconsin. Ecol. Monograph 27. pp: 325-349.

[9] **Raveendran E., S.T. Bauli H. Al-Sayed I. Khalaf** 1992. Physical and chemical characteristics of water and sediment in the vicinity of a major sewage treatment plant outfall. 1st Bahrain International Conference on Environment. E.P.C. & BSE. Bahrain.

[10] **Nybakken, J.,** 1993. Marine Biology: An Ecological Approach. 462 pp. 3rd Edition. Harper Collins College Publishers, New York.

[11] **Snewdon, R.J.,** 1992. The importance of baseline in oil pollution monitoring as exemplified by Gulf War oil spill. P.188-203. 1st Bahrain International Conference on Environment. E.P.C. & BSE. Bahrain.

[12] **Linden, O., U. Larson, and Z. Al-Alawi,**1988. Effects of chronic oil pollution in a shallow sub-tropical marine environment. Oil & Chemical Pollution, 5,: 65-79.

[13] **Saleh, M. and S. Mohamed,** 1990. The western reef heron (Egretta gularis Hemprich & Ehrenberg, 1833) in Bahrain. pp:306-317. Fauna of Saudi Arabia, II.