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Assessment of the ecological quality of soft-bottom benthic communities in the Syrian coast, Eastern Mediterranean

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Abstract - The present study was aimed to evaluate several benthic biological indices to assess the ecological quality status of marine environments in Syria. Samples were obtained from four different areas of Syrian coast (Al-Bassit, Banias, Tartous and Al-Hamidia) on a monthly scale from March 2007 to December 2007. Results showed that the percentage of benthic species are increased significantly in the stations with healthy ecological status. The cluster analysis and the MDS have shown that the studied stations are subjected to environmental disturbance. Some species have been found to be more sensitive (high values of Hurlbert Index) than others such as the *Rhinoclavis kochi*, which belonged to the Gastropodes taxa and *Notomastus latericeus* belonged to the polychaetes taxa. The ecological quality of the Syrian coast was assessed using three biotic indices (H′, AMBI and BQI). The Shannon–Wiener index H′ was ranged from 2.88 to 5.39. Thus, the ecological status varied between moderate and high. The values of AZTI Marine Biotic Index (AMBI) and Benthic Quality Index (BQI) classified the ecological state between high and good (slight disturbance).

Keywords: Biotic indices, Ecological quality, AMBI, BQI and Syrian coast.

Introduction

The benthos (flora and fauna) is an important component in marine ecosystems. On one hand, it is a main element in the nutrient cycle, detrital decomposition and as a food source for higher trophic levels. On the other hand, the macrobenthic species are considered as sensitive indicators of changes in the marine environment caused by natural or anthropogenic disturbances. The effects of these disturbances comprise changes in diversity, biomass, abundance of stress tolerant or sensitive benthic species, and the structure of the benthic community (Warwick and Clarke, 1994; Kaiser *et al*., 2000; Grall and Chauvaud, 2002).

Recently, the benthic system was widely used in marine monitoring and assessment of ecological quality (Simboura and Zenetos, 2002; Quintino *et al*., 2006; Rosenberg *et al*., 2004; Reiss and Kroncke, 2005; Albayrak *et al*., 2006, 2010). The analysis of changes in benthic communities, using univariate measurements such as species abundance or richness (Quintino *et al*., 2006) or multivariate statistical approaches which distinguish patterns in species composition have become an important tool in the assessment and monitoring of the biological effects of marine pollution (Clarke and Warwick, 2001). Species sensitivity/tolerance values are frequently used in various indices for assessing marine environmental quality. A low sensitivity value means that the species has been found largely in species-poor environments. A high sensitivity value on the other hand means that the species occurs in a high diversity community and has a high competitive ability. It was seldomly found in species poor and disturbed environments (Fleischer *et al*., 2007).

Biotic indices are increasingly being used in quality status assessments and management (Borja *et al.*, 2003a; Muniz *et al.*, 2005). These include the Shannon–Wiener index (H′) (Borja and Muxika, 2007), AZTIs Marine Biotic Index AMBI (Borja *et al.*, 2000) and the Benthic Quality Index BQI (Rosenberg *et al.*, 2004). BQI was designed to assess environmental quality according to the Water Framework Directive (WFD). Tolerance scores, abundance, and species diversity factors are used in its determination. The main objective of this index is to attribute tolerance scores to the benthic fauna in order to determine their sensitivity to disturbance (Fleischer *et al.*, 2007). Borja *et al.* (2000) have proposed the adoption of AMBI, using macrobenthic organisms as bio-indicators. This index is based essentially upon the distribution of five ecological groups, of soft-bottom macrofauna (Grall and Glémarec, 1997). These are in relation to their sensitivity to an increasing stress gradient. Syrian marine coastal ecosystems as a sector of the eastern Mediterranean are affected by several anthropogenic activities such as overfishing along the coast, industrial effluents especially in Banias city, domestic sewage disposal, tourism, harbors... etc. Few previous studies estimate the biodiversity of zoobenthos of Syria (Kucheruk *et al.*, 1998; Saker *et al.*, 2002; Ammar, 2004, 2010; Ibrahim *et al.*, 2010; Ammar *et al.*, 2011; Ammar and Arabia, 2014). It is an important thing to indicate that, until now there is no study about the species specific sensitivity/tolerance measures.

The objectives of this study were: (i) to provide species sensitivity lists based on the datasets available, (ii) to compare different univariate and multimetric indices used for quality assessment purposes with regard to their variability, and (iii) to assess the environmental quality status in the sub-littoral zone by the fluctuations in variability of the benthic fauna composition.

Materials and Methods

Study area and Sampling Method:

Samples were collected from the sub-littoral zone at depth ranged between 10-50 m, at 4 sites along the Syrian coast (Table 1): Al-Bassit (at the north of syrian coast), Banias, Tartous and Al-Hamidia (at the south) (Fig. 1).

The structure of the bottom differs by station, muddy sand in Al-Bassit (A), where depth ranged between 40-50 m, coarse sand in Banias (B) where depth ranged between 20-25 m, muddy sand in Tartous (C), where depth ranged between 10-17 m and mixed (gravel with sand and mud) in Al-Hamidia (D), where depth ranged between 17-25 m. In addition, Al-Bassit is a main fishing and tourism area at the north of Syria, Banias coast is subject to different human activities such as fishing, oil and thermal pollution and sewage inputs. Tartous is a fishing basin and trade harbor. The longitudinal distance over which samples were obtained was ≈180 km.

Table 1. Dates of sampling during March to December 2007 and some features of the sites at the Syrian coast.

Sites	Date of sampling						Soft bottom structure	Depth	coordinate
	1	2	3	4	5	6			
Al-Bassit (A)	13/3	20/6	7/7	18/9	10/10	29/11	Muddy sand	40-50	N:′35° 35,35,51 E:′35° 44,44,59 to N: 35° 35,35,59 E: 35° 44,44,09
Banias (B)	12/3	23/5	21/7	4/9	28/10	28/11	Coarse sand	20-25	
Tartous (C)	3/4	1/6	19/7	15/8	12/10	30/11	Muddy sand	10-17	
Al-Hamidia (D)	7/4	10/6	12/7	23/9	11/10	31/12	Mixed (gravel with sand & mud)	17-25	

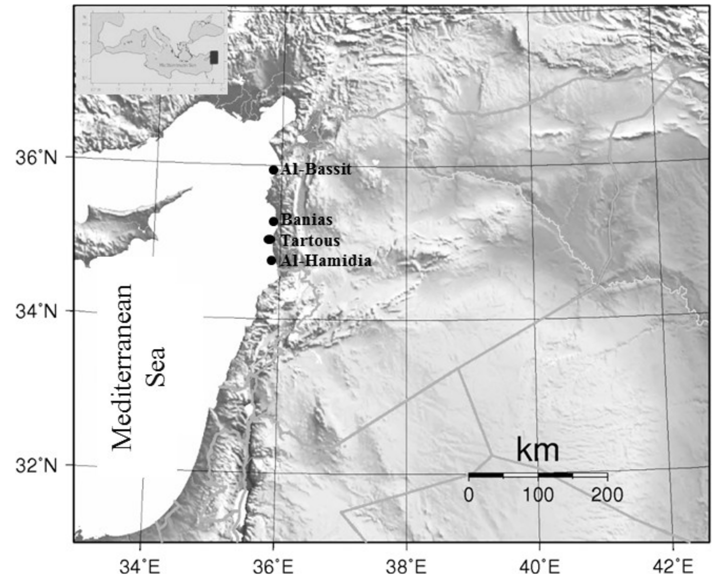

Figure 1. Map of the study area indicating the station locations.

All samples were taken by Van-Veen grab 1/40 m^2, five replicates samples were collected at each cruise, during March and December 2007 (Table 1). In all, 120 samples were obtained. All samples were immediately sieved through a 0.5 mm mesh screen, samples preserved in 5 % formalin. After the sorting process, macrobenthos were separated to the lowest animal taxonomic groups and all species were counted and weighted for each sample (Arabia, 2011).

Statistical Analyses:

For all the analyses, mean of abundance for every five replicates samples were considered and species abundance data were square root transformed. We used the Primer 7 statistical software to assess spatial variation of benthic communities between sites and temporal variation within sites. Furthermore, different techniques were performed: (i) Analysis of similarity (ANOSIM) was performed to detect differences in the benthic community structure between the different Ecological Status categories of the seawater; (ii) a cluster analysis was used to find natural groupings of samples and to find how the groups themselves form clusters at lower levels of similarity; and (iii) Non-metric Multidimensional Scaling (MDS) with the Bray-Curtis similarity index, to analyze variations in community composition in relation to the tropic status of the seawater.

Shannon–Wiener Index:

The Shannon–Wiener Index is a measure of species diversity of a particular site most commonly used in benthic ecology (Labrune *et al.*, 2005). This index incorporates species richness as well as equitability (Kroencke and Reiss 2010). In this study, the Shannon diversity was calculated using the logarithm for a base 2. It is dependent on sample size and was calculated according to the formula:

$$H' = -\sum P_i \times \log_2 P_i$$

Where Pi is the proportion of the i^{th} species in the sample. The minimum value for H' is 0 and is obtained when one species is present. Simboura and Zenetos (2002) indicated classification scheme for soft-bottom benthic communities based on H' values in response to five quality status classes of WFD.

Hurlbert Index:

We calculated the expected number of species (ES) according to Hurlbert's (1971) formula, which is used in the computer software Primer 7 (Warwick and Clark, 1994):

$$ES50 = \sum_{i=1}^{s}\left[1 - \frac{(N - N_i)! \times (N - 50)!}{(N - N_i - 50)! \times N!}\right]$$

Where N is the total number of individuals in a given sample and "N_i" is the number of the "*ith*" species in the same sample, for all samples with more than 50 individuals. This ES50 value is defined as the species specific sensitivity/tolerance measure.

The validation of the index is based on the individuals of each species being randomly distributed, which is not always the case. Low ES50 values are supposed to be calculated from samples where the mostly tolerant species are abundant and, therefore, from disturbed habitats. High values of ES50 come from samples with sensitive species and indicate a healthy environment (Fleischer *et al.*, 2007).

BQI:

The Benthic Quality Index (BQI) is a biotic index which was designed to assess environmental quality. Since, the original version of BQI is known to be sampling effort dependent (e.g. increase in sampling effort results in higher probability of obtained ingrare species), the adjusted calculation was applied (Fleischer *et al.*, 2007; Fleischer and Zettler, 2009). The index was expressed as:

$$BQI = \left(\sum_{i=1}^{n}\left(\frac{A_i}{totA} \times ES50_{0.05i}\right)\right) \times {}^{10}\log(S+1)$$

Where *totA* is the abundance of individuals of species *i* at the considered station; is the sum (at the considered station) of the abundances of individuals of all species for which it is possible to calculate the Hurlbert Index (ES50); *S* is the species richness at the considered station. The BQI normally varied between 0 (bad ecological quality) and 20 (high ecological quality) with a total of five stages of classification. Higher BQI vales are associated with lower pollution levels. The approach proposed by Rosenberg *et al.* (2004), follows the assumption that the most tolerant species are likely to be associated with the lowest biodiversity, lower ES50 values and therefore attaining lower sensitivity estimates.

AMBI:

The AZTI Marine Biotic Index (AMBI) of benthic species was assigned to five ecological groups ranging from sensitive species (group I) to species highly tolerant to stress (group V). A Biotic Coefficient can be calculated based upon the percentage of each ecological group within each sample (Reiss and Kroncke, 2005; Fleischer *et al.*, 2007):

$$AMBI = \frac{1}{100}\left[(0 \times EGI\%) + (1.5 \times EGII\%) + (3 \times EGIII\%) + (4.5 \times EGIV\%) + (6 \times EGV\%)\right]$$

Here, EG gives the percentage of the total numerical abundance in the sample for each of the five ecological groups considered. In general, AMBI identifies five ecological groups corresponding to most sensitive species (ecological group 1) to most opportunistic/tolerant species (ecological group 5). The AMBI normally varied between 0 (unpolluted) and 6 (heavily polluted) being 7 when the sediment is azoic (Borja *et al.*, 2000, 2003b) with a total of five stages of classification. For calculations of the AMBI index, we used the AMBI program which available on the web page: http://www.azti.es, where a list that includes >2700 benthic species and their assignment to the ecological groups presented.

Results and Discussion

Short-term description:

A total of 241 zoobenthic species were encountered of which 13 genera belonging to 13 Macrotaxa of this, 98 species(41 %) belonged to the Gastropoda, followed by Bivalvia with 58 species (28 %), while 47 species (18 %) belonged to the Polychaeta and 17 (3 %) belonged to the Crustacea. Other benthic groups such as Echinodermata, Bryozoa, Scaphopoda, Clitellata, Nematoda, Sipunculida and Anthozoa represented 3 % (Fig. 2). On the other hand, the top five most abundant benthic organisms in the Syrian water, considering all sampling sites, belonged to Molluska. *Cerithium scabridum* were by far the most abundant benthic organisms (20.98 %), followed by *Bittium tarentinum* (14.33 %), the *Bittiumt arenarium* (7.6 %), *Alvania cimex* (4.86 %) and *Axinulus croulinensis* (2.8 %). The dominance of two species of gastropoda *Cerithium scabridum* as non-indigenous species and *Bittium tarentinum* as native one, refer to competition on the habitat in the two sites A and D, while in C and D *Cerithium scabridum* was absolutely dominant, which may be due to specific and suitable or tolerant ability to environmental conditions such as increase in temperature and salinity.

In general, Al-Bassit (A) site was characterized by relatively high abundance of benthic organisms (Fig. 3) with 202 species and mean abundance 12468 ind./m^2, followed by Al-Hamidia (D) site with 144 species and 5173 ind./m^2, and in Banias (B) and Tartous (C) with 121 species 2408 ind./m^2, and 78 species 1760 ind./m^2, respectively. Number of species and abundance at each site reveals that the muddy and gravelly bottoms in Al-Bassit and Al-hamidiasites are richer in zoobenthos species than the coarse sandy bottoms in the other two sites. The changes in the benthic communities reflected the natural seasonal variation in the physico-chemical characters and anthropogenic temporal variability occurs in the four sites. Severe disturbances caused by oil pollution and increase in surface water temperature (+5 °C) occurred near the terminal of the electro thermal Station in Banias (B). The ANOSIM analyses indicated that the values of global R varied between ($R = 0.594$, $p<0.01$) for sites (A, B) and ($R=1$, $p<0.01$) for sites (C, D). The mid-range value of R (0.873) for the global test of sites A, B, C and D establishes that there are statistical significant differences in the benthic macrofaunal community composition between these sites. Similarity of mid-range values of Rare slightly lower (0.757, 0.856, 0.887 and 0.994) for the B v D, A v D, B v C and A v C comparisons, contrasted with much lower value of R (0.594) for A v B; imply that the two sites C and D differs from the other sites.

The Cluster dendrogram (Fig. 4) showed that site D has a different community composition across its replicates than the groups (B, A) or (B, C); note that, it is less clear whether there is any statistical evidence of a distinction between the (A and B)

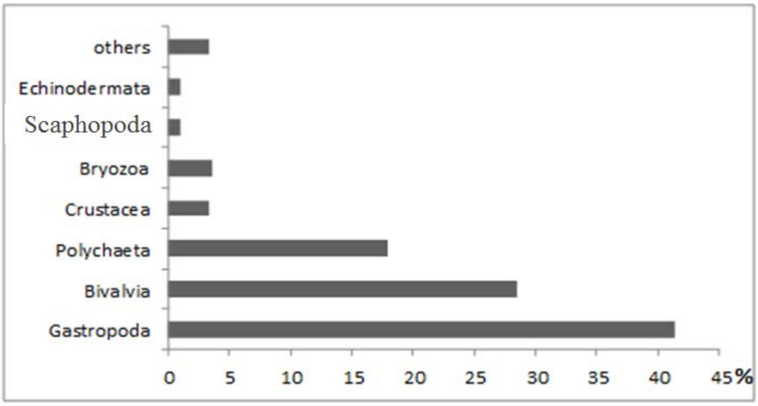

Figure 2. Percentage of zoobenthos taxa in the survey areas of the Syrian coast.

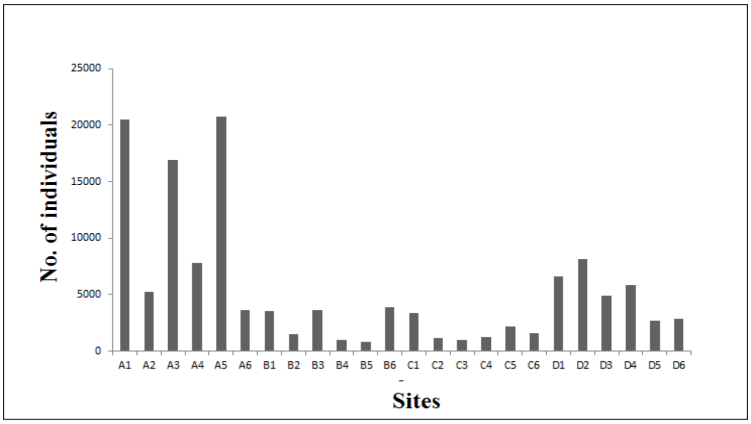

Figure 3. Number of individuals (ind.lm^{-2}) of zoobenthos in the survey areas of the Syrian coast.

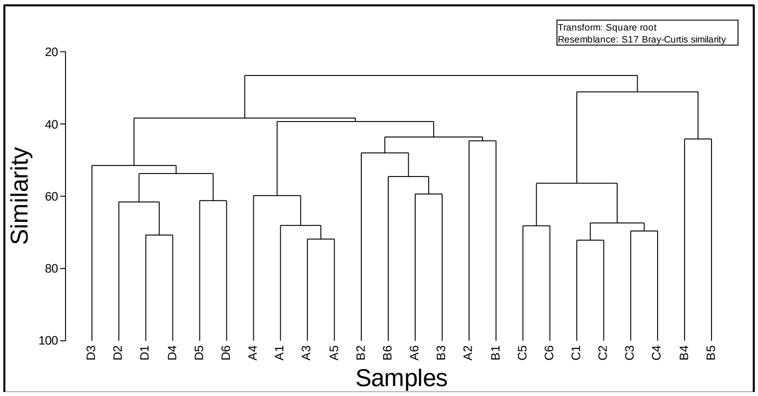

Figure 4. Cluster dendrogram of the zoobenthos showing reference sites; computed for the six replicates from each of the four sites (Al-Bassit A, Banias B, Tartous C and Al-Hamidia D).

and C sites.

The MDS plot at 40 % similarity (Fig. 5) was based on macrobenthic species-abundance data in each station. It can be seen that all six replicates from sites C and D, where the bottom of both sites is similar, are quite different in community composition from both sites A and B.

Shannon–Wiener Index:

The Shannon–Wiener index ranged from 2.88 to 5.39 (Fig. 6). Thus, the corresponding ecological status according to Simboura and Zenetos (2002) varied between moderate and high. At station Al-Bassit (A) the Shannon Index varied between 3.67 and 4.70, which corresponds to an ecological status from moderate in March to high in July. Atstation Banias (B), the Shannon Index ranged from 2.88 in March to 4.39 in July. Thus, the ecological status varied between moderate and high. At Tartous (C) and Al-Hamidia (D) sites, the variability were less pronounced, the ecological status was good-high in the both sites.

Hurlbert Index:

ES 50 values for 155 species were calculated and some of these listed in Table (2). The span between the lowest rank species and the highest ranked was from 0 to 19.476. Lowest values were calculated for *Gammarus* sp., *Donacilla cornea* and *Mitrella vatovai*. Highest values were recorded for *Rhino claviskochi* (19.476), *Turboella dolium* (17.258) and *Notomastus latericeus* (17.127). Examples of ES50 values of some common species in the area: *Cerithium scabridum* (13.119), *Bittium tarentinum* (10.139), *B. arenarium* (12.883), *Alvania cimex* (13.520) and the *Axinulus croulinensis* (9.662). Thus, for these species the values are rather similar and above the mean value 4.945. It is important to indicate that this is the first study of the species-specific sensitivity/tolerance measure. Though, this ES50 list represents a beginning stage for further development for Syrian waters. In addition, testing the index with other datasets in this study area may revealed the importance of pursuing the development of species sensitivity lists for Syrian waters.

BQI:

Mean BQI have been calculated for 24 sample occasions along the Syrian coast. The calculated BQI values varied between 15.74 and 21.04 (Fig.7). In general, the BQI were similar with minor temporal changes at the same station, where the BQI values indicate a good and high environmental status in the all sites. The highest values of BQI (21.04, 20.9) were obtained for site (A) during October and March. This may be due to the reproduction of many benthic groups especially crustacean and polychaetes. The lowest value was obtained for Banias (B), where this site was subject to intensive pressure. On the other hand, the highest obtained BQI values were coincided with the most abundant benthic organisms (*C. scabridum* and *B. tarentinum*), which reflect the fact that benthic macrofauna is an excellent ecosystem component which mirrors the ecological status of the marine environment, and therefore it has become a standard component of marine environmental monitoring (Bilyard, 1987).

The change in community structure induced by changes in the environmental status was related to the increase in the number of benthic species in Al-Bassit (A), while this site was characterized by the most relatively high abundant benthic organisms in the study area, where, the recruitment of zoobenthos occurs in spring and summer.

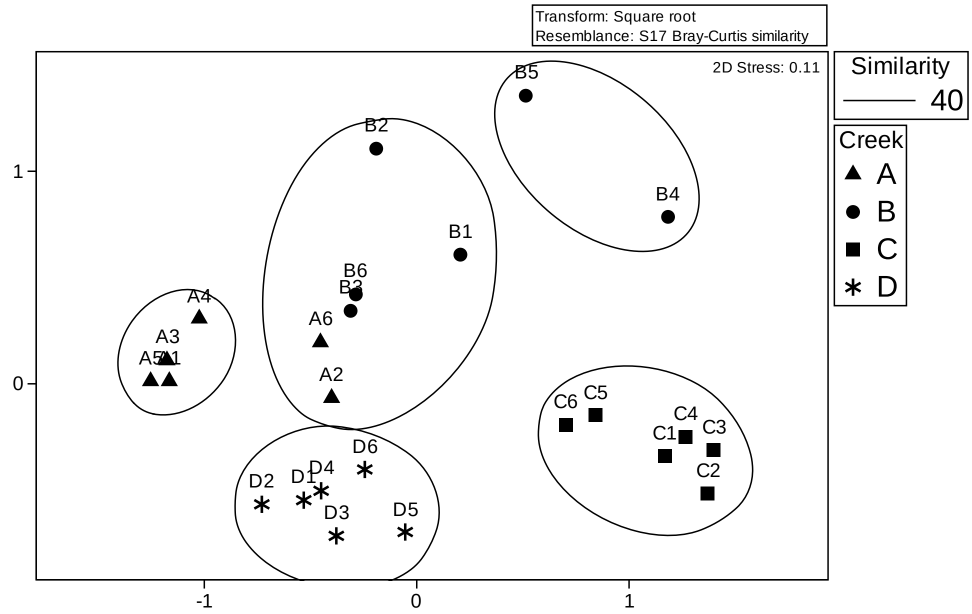

Figure 5. Non-metric multi-dimensional scaling (MDS) analysis ordination in two dimensions; computed for the six replicates of the zoobenthos from each of the four sites (Al-Bassit A, Banias B, Tartous C and Al-Hamidia D), based on Bray-Curtis similarity metric of benthic fauna.

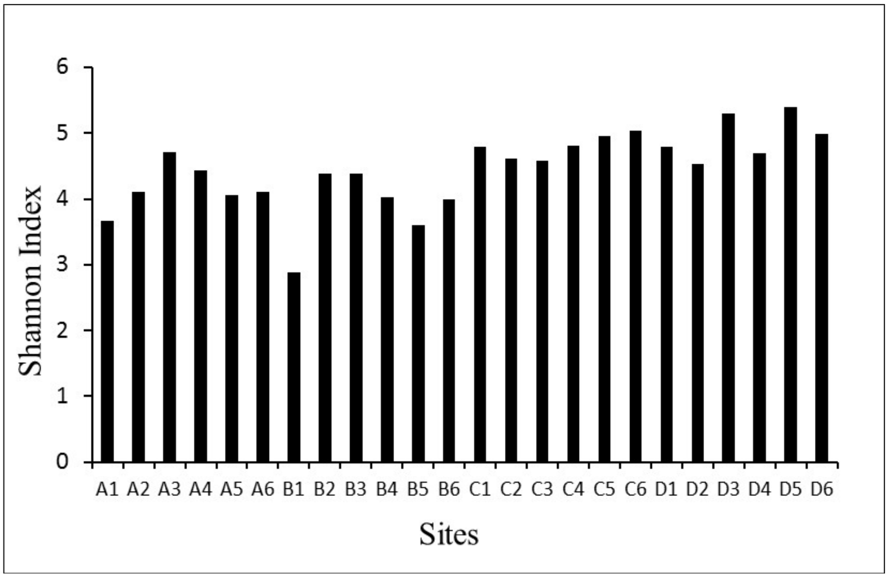

Figure 6. The Shannon Index of the zoobenthos for the six replicates from each of the four sites (Al-Bassit A, Banias B, Tartous C and Al-Hamidia D).

Table 2.Hurlbert Index (ES50) values for some species of zoobenthos in the Syrian coast.

Taxa	Specie	ES50	Taxa	Specie	ES50
Gastropoda	*Mitrella vatovai*	0	*plolychaeta*	*Aricidea fragilis*	10
Bivalvia	*Donacilla cornea*	0	*plolychaeta*	*Owenia fusiformis*	10
Crustacea	*Gammarus sp*	0	*Gastropoda*	*Bittium tarentinum*	10.14
Bivalvia	*Loripes lucinalis*	7	*Bivalvia*	*Astarte sulcata*	10.62
Bivalvia	*Nuculana pella*	7	*Gastropoda*	*Biforina perversa*	12
Bivalvia	*Scrobicularia plana*	7	*Bivalvia*	*Ctena decussate*	12
Bivalvia	*Venericardia corbis*	7	*Gastropoda*	*Bittium arenarium*	12.88
plolychaeta	*Heteromastus filiformis*	7	*Bivalvia*	*Tellina tenuis*	13
Gastropoda	*Bulla striata*	7.94	*Gastropoda*	*Cerithium scabridum*	13.12
Gastropoda	*Cantharus dorbignyi*	8	*Bivalvia*	*Tellina rostillum*	13.36
Gastropoda	*Ringicula conformis*	8	*Gastropoda*	*Alvania dorbignyi*	13.44
Bivalvia	*Nucula nucleus*	8	*Gastropoda*	*Alvania cimex*	13.52
plolychaeta	*Hesione pantherina*	8	*Gastropoda*	*Conus mediterraneus*	14
Gastropoda	*Cythara taeniata*	9	*Gastropoda*	*Mitra cornicula*	14
plolychaeta	*Pholoe glabra*	9	*Gastropoda*	*Buccinum humphreysianum*	16
Bivalvia	*Axinulus croulinensis*	9.66	*plolychaeta*	*Notomastus latericeus*	17.13
Gastropoda	*Rissoa ventricosa*	10	*Gastropoda*	*Turboella dolium*	17.26
Bivalvia	*Parvicardium exigum*	10	*Gastropoda*	*Rhinoclavis kochi*	19.48

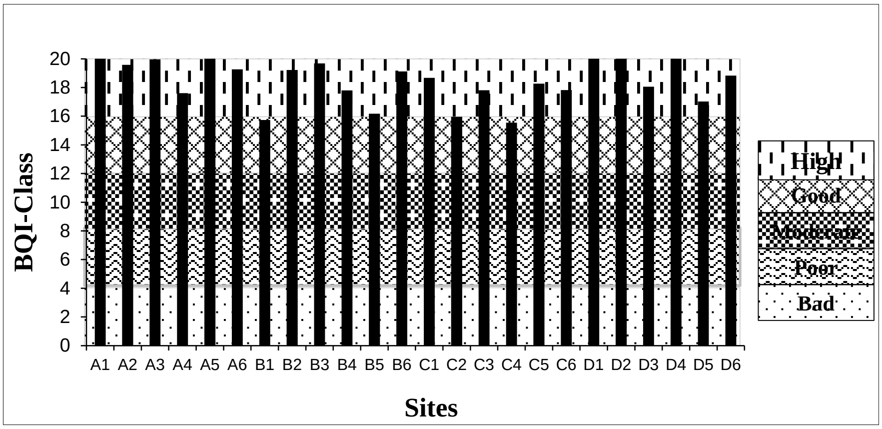

Figure 7. Mean BQI of the zoobenthos for the four stations of the Syrian coast during the study period.

AMBI:

The result of the AMBI index shows a high and good ecological status at all sites. However, the status was rather constant over the whole study period. Thus, the corresponding ecological status remained stable as well, with 100 % constancy (proportion of samples having the same ecological status) at station B, 84 % at station A and C, 67 % at station D. Nevertheless, the proportion of the ecological groups at each station changed slightly during the study period (Fig. 8).

On the other hand, the values of AMBI indicate as light disturbance of the benthic communities in most sampling stations and the ecological state ranges between high to good (*i.e.* slight disturbance) from one sampling site to another and from one month to another. Whereas, the proportion of the ecological groups at each station changed slightly between months (Fig. 9).

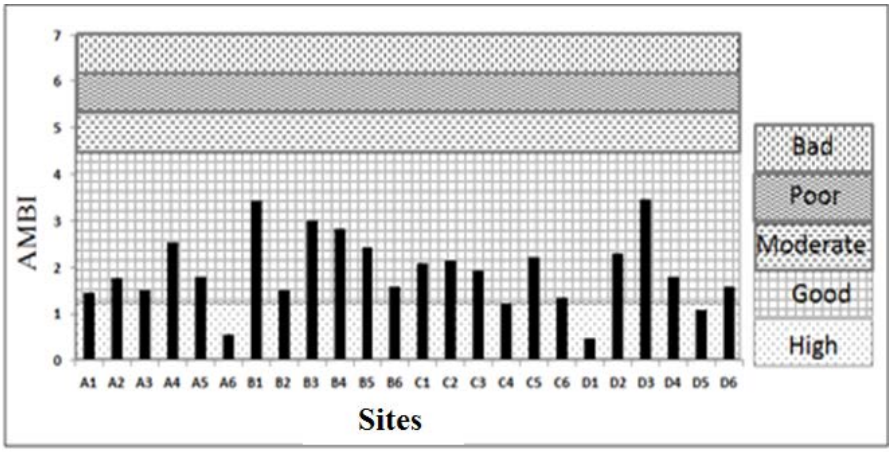

Figure 8. Mean AMBI of the zoobenthos for the three stations of the Syrian coast during the study period.

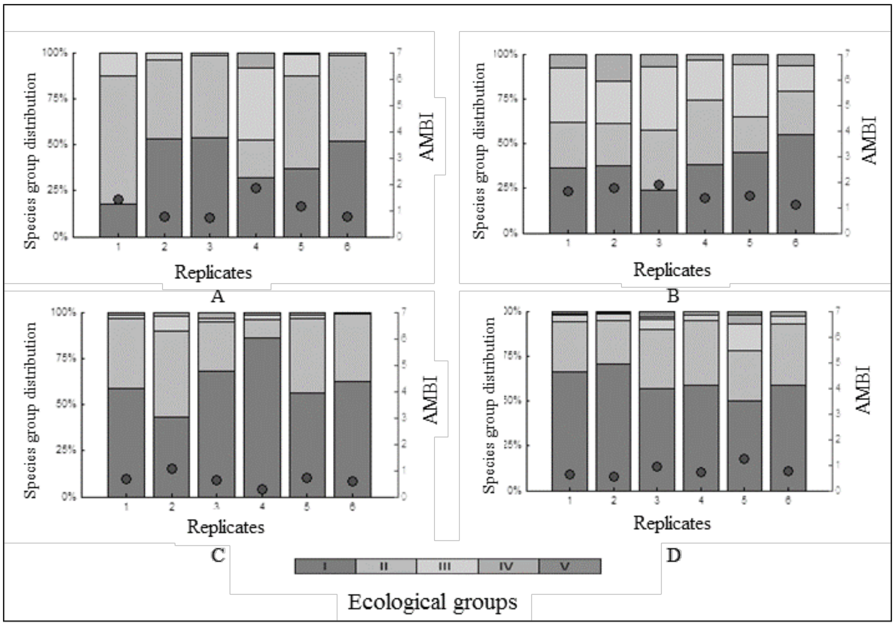

Figure 9. Relative abundance of ecological groups of the zoobenthos at the Syrian coast according to the AMBI: (I) disturbance-sensitive, (II) disturbance-in different, (III) disturbance-tolerant, (IV) second-order opportunistic and (V) first order opportunistic.

In Al-Bassit (A), the percentage of group I species (disturbance-sensitive) was more than 50 % during the study period. These species usually found at unpolluted environments (Muxika *et al.*, 2005), abundance of group II species (disturbance-indifferent) and group III species (disturbance tolerant) was highest at Banias (B) and Tartous (C).

However, the increase of disturbance tolerant species and decrease of sensitive one in these two sites refer to the level of stress. While in Al-Hamediah (D) site, the dominance of disturbance-sensitive species indicates unpolluted conditions.

The two multimetrics indices (AMBI, BQI) were chosen since they are based on two different approaches of ecological grouping. The composition of ecological groups, in the case of AMBI, changed temporally for each community, these changes were mainly due to the changes in abundance of the dominant species. Thus, the three indices Shannon-Wiener, BQI and AMBI are effective at the study sites.

Conclusion

In conclusion, the present study showed that (i) the temporal and spatial variability in abundance, diversity and community structure of the zoobenthos was mainly caused by different environmental conditions; (ii) the multimetric indices perform satisfactorily to assess the ecological quality status which seem to be less influenced by the seasonal variability of the macrofauna; (iii)The Shannon-Wiener index ranged the ecological status to moderatea high; (iv) the BQI and AMBI produced values indicating a good and high environmental status in the all sites.

Thus, at any future plan for redevelopment of the marine ecological system in Syria, it is an essential thing for the decision makers to depend on the benthic indices to assess the ecological quality status. In addition, it is also important to continue the development and improvement measurements of ecosystem components and ensure that these measurements are representative of the state of ecosystem in the Syrian coast.

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References

Albayrak, S., Balkis, N., Balkis, H., Zenetos, A., Kurun, A., Karhan, S.U., Caglar, S and Balci M. 2010. Golden Horn Estuary: Description of the ecosystem and an attempt to assess its ecological quality status using various classification metrics. Mediterranean Marine Science, 11(2): 295-313.

Albayrak, S., Balkis, H., Zenetos, A., Kurun, A. and Kuban C. 2006. Ecological quality status of coastal benthic ecosystems in the Sea of Marmara. Marine Pollution Bulletin, 52: 790-797.

Ammar, I. 2004. Benthic fauna of the Syrian coast/assessment of the state of migrant and invader species. 37th CIESM Congress, Barcelona, Conference abstracts 6-11 June.

Ammar, I. 2010. Distribution of Zoobenthos in the Vermetid Platforms of the Syrian Coast, Tishreen University Journal. Bio. Sciences Series, 32(5): 79-96.

Ammar, I and Arabia, I. 2014. Use of Benthic Indices to Assess Marine Environmental Quality on the north of Lattakia, Aleppo university research journal, 95: 13-32.

Ammar, I., Hasan M and Arabia, I. 2011. Biodiversity of Polychaeta along the Syrian Coast Journal for Research and Scientefec studies. Tishreen University Journal Bio. Sciences Series, 33(3): 161-180.

Arabia, I. 2011. A study of changing of Marine Benthic communities along the

Syrian Coast Using Classical and Newly Developed Benthic Indices. Thesis submitted to the university of Tishreen for the degree in Marine Biology, 185 pp.

Bilyard, G.R. 1987. The value of benthic infauna in marine pollution monitoring studies. Marine Pollution Bulletin, 18: 581-585.

Borja, A., Franco, J. and Muxika, I. 2003b. Classification tools for marine ecological quality assessment: the use fullness of macrobenthic communities in an area affected by a submarine outfall. ICES Journal of Marine Science, 02: 1-10.

Borja, A., Franco, J. and Perez, V. 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. Marine Pollution Bulletin, 40: 1100-1114.

Borja, A. and Muxika, I. 2007. Benthic indicators for aquaculture (analyses across ECASA sites). ECASA European Aquaculture Stakeholder Conference18-19 September Heraklion (Crete).

Borja, A., Muxika, I. and Franco, J. 2003a. The application of a Marine Biotic Index to different impact sources affecting soft-bottom benthic communities along European coasts. Marine Pollution Bulletin, 46: 835-845.

Clarke, K.R. and Warwick, R.M. 2001.Change in marine communities: an approach to statistical analysis and interpretation. 2nd Ed., PRIMER-E, Plymouth, UK.

Fleischer, D., Gremare, A., Labrune, C., Rumohr, H., Berghe, E.V., Zettler, M.L. 2007. Performance comparison of two biotic indices measuring the ecological status of water bodies in the Southern Baltic and Gulf of Lions. Marine Pollution Bulletin, 54: 1598-1606.

Fleischer, D. and Zettler, M.L. 2009. An adjustment of benthic ecological quality assessment to effects of salinity. Marine Pollution Bulletin, 58: 351-357.

Grall, J. and Chauvaud, L. 2002. Marine eutriphication and benthos: the need for new approaches and concepts. Global Change Biology, 8: 813-830.

Grall, J. and Glémarec, M. 1997. Using biotic indices to estimate microbenthi ccommunity perturbations in the Bay of Brest. Estuarine Coastal and Shelf Science, 44: 43-53.

Hurlbert, S.H. 1971. The non-concept of species diversity: A critique and alternative parameters. Ecology, 52: 577-586.

Ibrahim, I., Ammar, I. and Swied. S. 2010. Biodiversity of Cnidaria, Echinodermata and the Associated Fishes at Burj Islam and Al-Basitt Coasts (Lattakia-Syria), Tishreen University Journal. Bio. Sciences Series, 32: 209-224.

Kaiser, M.J., Ramsay, C.A., Richardson, C.A., Spence, F.E. and Brand, A.R. 2000. Chronic fishing disturbance has changed shelf sea benthic community structure. Journal of Animal Ecology, 69: 494-503.

Kroencke, I. and Reiss, H. 2010. Influence of macrofauna long-term natural variability on benthic indices used in ecological quality assessment. Marine Pollution Bulletin, 60: 58-68.

Kucheruk, N.O.V., Kuznetsov, A.P., Rybmikov, A.V. and Saker, F. 1998. The Eastern Mediterranean as a Laboratory Basin for the Assessment of Contrasting Ecosystems, Chapter 12, Composition of bottom and quantitative distribution of macrozoobenthos in Syrian coastal water, 51: 159-168.

Labrune, C., Amouroux, J.M., Sarda, R., Dutrieux, E., Thorin, S., Rosenberg, R. and Grémare, A. 2005. Characterization of the ecological quality of the coastal Gulf of Lions (NW Mediterranean). A comparative approach based on three biotic indices. Marine Pollution Bulletin, 52: 34-47.

Muniz, P., Venturini, N., Pires-Vanin. A., Tommasi, L. and Borja, A. 2005. Testing the applicability of a Marine Biotic Index (AMBI) to assessing the ecological quality of soft-bottom benthic communities, in the South America Atlantic region Marine Pollution Bulletin, 50: 624-637.
Muxika, I., Borja, A. and Bonne, A.W. 2005. The suitability of the marine biotic index (AMBI) to new impact sources along European coasts. Spain. Ecological Indicators, 5: 19-31.
Quintino, V., Elliott, M. and Rodrigues, A.M. 2006. The derivation, performance and role of univariate and multivariate indicators of benthic change: Case studies at differing spatial scales. Journal of Experimental Marine Biology and Ecology, 330: 368-382.
Reiss, H and Kröncke, I. 2005. Seasonal variability of benthic indices: An approach to test the applicability of different indices for ecosystem quality assessment. Marine Pollution Bulletin, 50: 1490-1499.
Rosenberg, R., Blomqvist, M., Nilsson, H.C., Cederwall, H. and Dimming, A. 2004. Marine quality assessment by use of benthic species-abundance distribution: a proposed new protocol within the European Union Water Framework Directive. Marine Pollution Bulletin, 49: 728-739.
Saker, F., Mohammad, I. and Ammar, I. 2002. Analysis of zoobenthos structure in the sub-littoral zone of Banias, using Multivariate & Univariate Techniques. Tishreen University Journal for Research and Scientific studies, 24: 133-158.
Simboura, N. and Zenetos, A. 2002. Benthic indicators to use in ecological quality classification of Mediterranean soft bottom marine ecosystems, including a new biotic index. Mediterranean Marine Science, 3: 77-111.
Warwick, R.M. and Clarke, K.R. 1994. Relearning the ABC: taxonomic changes and abundance/ biomass relationships in disturbed benthic communities. Marine Biology, 118: 739-744.

تقييم الجودة البيئة في تجمعات القاع الرخو في الشاطئ السوري، حوض شرق المتوسط

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المستخلص - تهدف هذه الدراسة لتقييم عدة مؤشرات حيوية قاعية ولتحديد واقع الجودة البيئية في البيئة البحرية السورية. جُمعت العينات من مناطق مختلفة من الشاطئ السوري (البسيط، بانياس، طرطوس والحميدية) بمُعدل مرة واحدة شهرياً من آذار ولغاية كانون الأول 2007. تُظهر النتائج أن النسبة المئوية للأنواع القاعية تزداد بشكل واضح في المحطة ذات الحالة البيئة السليمة، كما تُظهر نتائج التحليل التجميعي والمقياس المتعدد الأبعاد أن المحطات المدروسة خاضعة لاضطراب بيئي كما وأظهرت بعض الأنواع حساسية أعلى من غيرها (قيم مرتفعة لمؤشر Hurlbert Index) مثل: *Rhinoclavis kochi* من الرخويات بطنية القدم، والنوع *Notomastus latericeus* من عديدة الأهلاب.

تمَ تقييم الجودة البيئية للشاطئ السوري باستخدام ثلاثة مؤشرات: مؤشر شانون-وينر (H′)، المؤشر الحيوي البحري (AMBI) ومؤشر الجودة البيئة (BQI). وقد تراوحت القيم (H′) ما بين 2.88 و 5.39 مما يدل على أنّ الحالة البيئة تتباين ما بين المعتدلة والعالية. كما وقد صنفت قيم كل من المؤشرين (AMBI) و (BQI) الحالة البيئية مابين العالية والجيدة (قليلة الاضطراب).

الكلمات المفتاحية: المؤشرات القاعية، الجودة البيئية، (AMBI) ، (BQI) ، الشاطئ السوري.