Ecological classification of southern intertidal zones of Qeshm Island, based on CMECS model

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Abstract

The "Coastal and Marine Ecological Classification Standard (CMECS)", a new approach to ecological classification, was applied to 122 km of the southern intertidal zone of Qeshm Island located the Hormouz Strait - the Persian Gulf. Two components of this model, Surface Geology (SGC) and Biotic Cover (BCC) were used. Considering the extent and geomorphological alternations of the covered area, 12 sampling sites within 5 sub-regions were designated using by GPS. In total, 60 habitats (biotopes) with 47 codes were determined; this variety of biotopes is directly related to the diverse surface geology (substrate) of the covered area. Most of the biotopes and codes were recorded in the mid-eastern coastal zone, due to heterogeneity in substrate structure associated with numerous ecological niches in rocky shores. Crustacean species such as *Eriphia smithi*, *Thalamita prymna*, Molluscan species such as *Clypeomorous bifisciatus*, *Cerithium caeruleum* and echinoderm species such as *Echinometra mathaei* and *Ophiactis* sp. were characteristic of rocky shores, while Crustacea groups including *Ocypode rotundata* and *Dotilla* sp., and *Umbonium vestiarium* (Mollusca) were characteristic of sandy shores. Although the highest number of codes was recorded in Zeitun Park site (Eastern coast), it did not possess the expected specific species (such as *Diadema setosum*, *Linckia multiflora* and *Ophiocoma scolopendrina*), that were encountered in sites with similar surface geology. This could have been caused by tourist traffic at the Zeitun Park site.

Keywords: Surface Geology, Biotic Cover, Biotope, CMECS model, Coastal Zone, Qeshm Island

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Introduction

The Coastal Zone is a term used to define a transition area between terrestrial and aquatic ecosystems, which is more sensitive and vulnerable than other terrestrial ecosystems. Banica et al. (2003). Increasing pressure on these areas can decrease the quality of marine habitats, and can even lead to the loss of sensitive habitats. Lund and Wilbur (2007). Effective management of specific habitats and species requires a relatively clear understanding of their present distribution, the underpinning biology and ecology, and also their sensitivity to natural and anthropogenic changes. Elliott et al. (1998). Consistent mapping of habitats in environmental management and conservation requires standardized classifications and terminologies for habitats. In this regard, “Biotope” has been suggested as the most informative operational unit for research and management. Costello (2009). In the strict sense, biotopes are part of habitats in that they are defined by the species present, but the term is now more widely used to include both this habitat and the biocoenosis. Olenin and Ducrotoy(2006) that identified by dominant or diagnostic species, with emphasis on species that have a high constancy and physically linked to the habitat. Madden et al. (2009). Habitat classifications are therefore, most accurate and ecologically relevant at the biotope level because of the direct relationship between the biota and their environment. Andrefouet et al. (2003); Capolsini et al. (2003). The Coastal and Marine Ecological Classification Standard System (CMECS) is one of the newest models that have been applied for the classification of biotopes, it has included reviews and summaries of many habitat classification studies Madden et al. (2009). CMECS is a hierarchical framework that applies a uniform set of rules and terminologies across multiple habitat scales using a combination of oceanographic, physiographic and biological criteria. Keefer et al. (2007).The use of geological characteristics is proving to be effective tool for describing marine benthic habitats. Greene et al. (2000); Valentine et al. (2003). In fact, a benthic habitat is more than a substrate, and is formed from several components that, in addition to substrate, include species as well as the species’ tolerances and preferences. Diaz et al. (2004).

CMECS (Version III, 2009) Madden et al. (2009) has five distinct components including Surface Geology Component (SGC), Sub-benthic Component (SBC), Biotic Cover Component (BCC), Geo-Form Component (GFC) and Water Column Component (WCC), of which we have only applied SGC and BCC. The CMECS model is further divided into six Systems (nearshore, neritic, oceanic, estuarine, freshwater influenced and lacustrine) and two Subsystems defined by tidal regime. Madden et al. (2009). Of these we considered, intertidal zone since it has been more disturbed and damaged by anthropogenic activities than any other marine habitat. Pinn and Rodgers (2005). In the Biotic Cover Component (BCC), each subsystem is further divided into classes and then subclasses and finally biotic groups. Biotic groups are often observational and descriptive defined by obvious structure-forming organisms. Classes

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and subclasses for the SGC are determined by the dominant (in terms of percent cover) geologic or biogenic cover of the substrate. Madden et al. (2009). Finally, specific habitats have shown by Geographic Information System (GIS) maps for each dominant species. In GIS, a coding system facilitates data organization and queries. Kutcher et al. (2005). Maps showing habitat characteristics, such as seafloor topography and surficial sediments, are expected to improve the efficiency of managing the ocean environment (Tierney, 2004).Current version of CMECS (FGDC CMECS, 2012) is now available as this paper goes to publication.

Southern Qeshm Island encompass a wide range of coastal ecosystems such as backbarrier, floodway, creek, mangrove forests, cliff, rocky shore and sandy beach, which provide excellent habitats for various types of species. The present study aimed to assess classification of intertidal habitats of the southern coastal stretch of Qeshm Island as a tool for the environmental management of its highly important biogeographic and economic circumstances, considered as sensitive and vulnerable to anthropogenic activities.

Materials and methods

Qeshm Island (26-27˚N and 55-56˚E) with an area of 1491 km^2 (122 km long, 18 km wide on average) is the largest island in the Persian Gulf. It is situated in the Strait of Hormoz along Hormozgan province. GOMDAF (2004), FGDC CMECS (2012).

The study was carried out in four seasons during 2009-2010 and covered 122 km intertidal stretch of the southern Qeshm Island. Considering the extent and geomorphology of the covered area, 12 stations within 5 sub-regions were designated using by Garmin 60 CX GPS device.

Table 1: Names and locations of sampling sites /stations

Site / Station No.	Name	Latitude	Longitude	Coastline length (km)
1	Zeitun Park	N26˚ 56΄ 13.8"	E56˚ 16΄ 37.2"	6.1
2	Cistern	26˚ 55΄ 32.7"	56˚ 13΄ 49.0"	6.1
3	Creek mouth	N26˚ 54΄ 38.9"	E56˚ 10΄ 17.4"	10
4	Nakhl-e-Gol	N26˚ 50΄ 11.2"	E56˚ 07΄ 41.7"	9.4
5	Holyshrine	N26˚ 46΄ 38.7"	E56˚ 04΄ 15.0"	4.4
6	Backbarrier (Suza)	N26˚ 45΄ 30.1"	E56˚ 01΄ 56.7"	2.6
7	Backbarrier (Mesen)	N26˚ 44΄ 48.1"	E56˚ 00΄ 44.0"	3.5
8	South of Military Restricted Zone	N26˚ 41΄ 59.6"	E55˚ 57΄ 37.6 "	0.5
9	Hara Forest	N26˚ 42΄ 29.4"	E55˚ 55΄ 00.9"	6.9
10	Backbarrier (Salakh)	N26˚ 40΄ 57.5"	E55˚ 40΄ 45.3"	29.9
11	Salt Floodway	N26˚ 36΄ 44.9"	E55˚ 31΄ 34.8"	17.1
12	Dustaku	N26˚ 34΄ 46.1"	E55˚ 20΄ 21.3"	21.2

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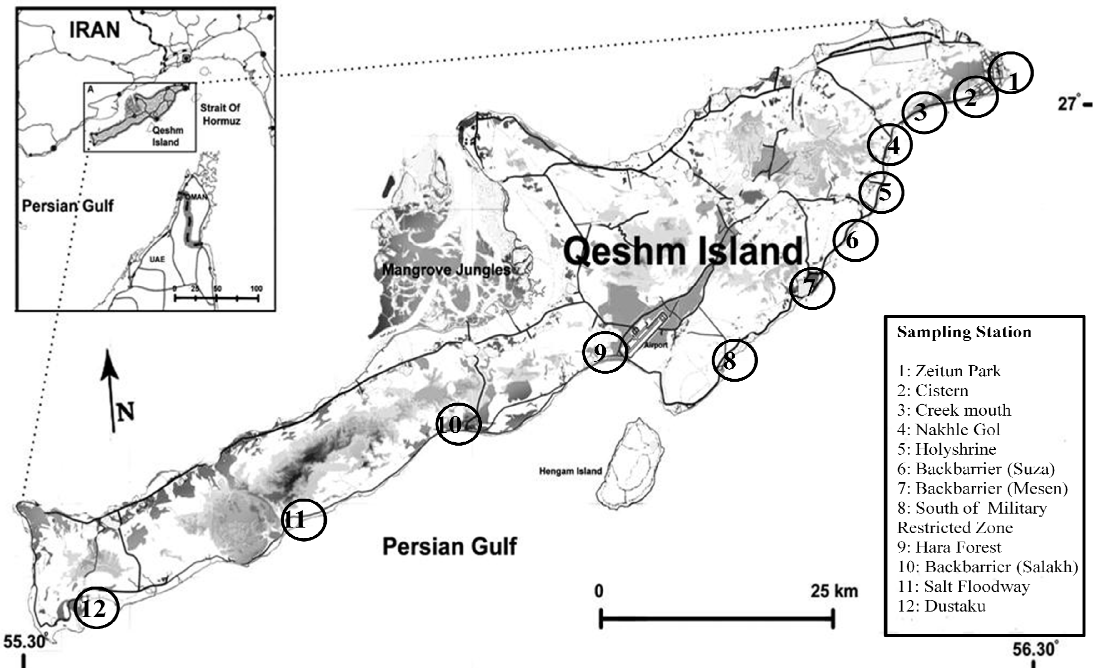

Figure 1: Map of Qeshm Island, showing the designated sites / stations in the southern coast

In order to record dominant species of fauna and flora, communities were observed and randomly sampled using 0.5×0.5 m quadrate (0.25 m^2) with three replicates at each station. Photos of the samples were also taken before collecting and preserving them in 4% formalin solution for further identification, which was carried to the lowest possible level using valid identification keys. Jones (1986); Bosch et al. (1995); Hosseinzadeh et al. (2001); Quddusi and Feroz (2006); Gharanjik and Rouhani (2010).

Sediments were sieved with a mechanical shaker for particle size analysis and determination of grain size. Eleftheriou and McIntyre (2005), the value of Total Organic Matter (TOM) was estimated by loss of weight on ignition. Motamed (1995) ; Luzak and Janquin (1997). For this purpose, 400-500 g of sediment was collected from the upper 15 cm of the surface for particle size analysis and 10-12 g of sediment was collected from the upper 5 cm of the surface for measuring organic matter. Eleftheriou, and McIntyre (2006), Madden et al. (2009). Sediment was also sieved in the seawater to observe infauna. Slope of the coast was also measured with laser distance measurer (LD 500 STABILA). According to CMECS, the sediment size and biological characteristics were used to categorize habitats within related class, subclass and lower levels.

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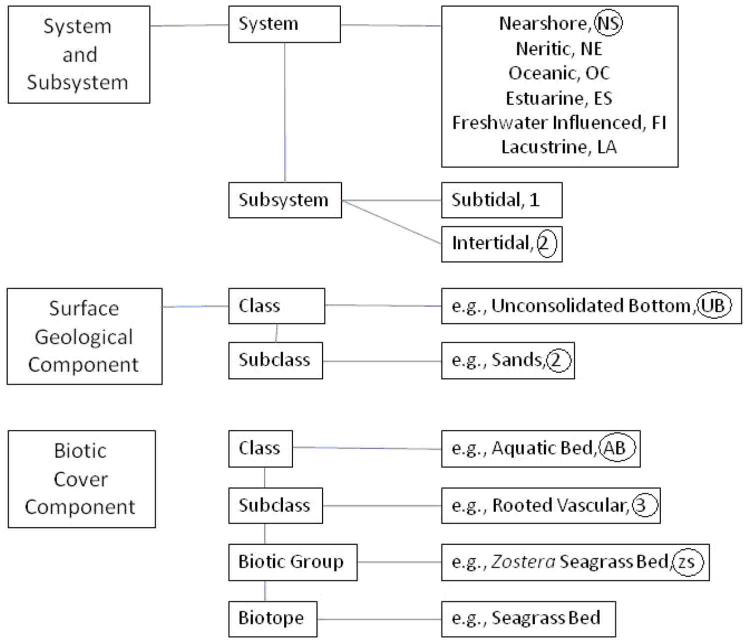

Figure 2:Example for classification of System, Subsystem, SGC and BCC

In addition, all of other data and information from earlier works in the same area were also assembled for present research and study which needed. Specific habitats and biotopes were identified based on the presence and abundance of dominant species. GPS coordinates for sites / stations were transferred to computer and converted into UTM using Mapsource software. Considering the two components of SGC and BCC, GIS maps (ArcGIS 9.3) were used to show biotope distributions (See Fig. 4).

Results

Taking the Surface Geology Component (SGC) and Biotic Cover Component (BCC) into consideration, the results of this study can be presented as follow:

Based on the composition, particle size and monitoring of the substrates, the 122 km intertidal stretch of the southern Qeshm Island was divided into 3 major substrate types of sandy (66.9% or 81 km), rocky-sand (24% or 29 km) and rocky (9.1% or 11 km) (Table 2, Fig. 3). Most of the hard substrate and most of the soft substrate were, respectively, located in the mid-eastern and mid-western part of the island.

Table 2: Surface geological characteristics of the sampling sites / stations

Site (Station)	Sediment composition (mean %)	TOM (mean %)	Slope (mean)	Coastal substrate structure
1	Sandy (75)	3<	4.0°	Rocky-Sandy
2	-	3<	5.0°	Rocky
3	Sandy (75)	3<	5.6°	Sandy
4	Sandy (>75)	>3	3.6°	Sandy
5	-	>3	6.6°	Rocky
6	Sandy (>75)	3<	6.0°	Rocky-Sandy
7	Sandy (>75)	>3	5.6°	Rocky-Sandy
8	-	>3	4.03°	Rocky
9	Sandy (>75)	>3	5.6°	Sandy
10	Sandy (>75)	>3	7.2°	Sandy
11	Sandy (>75)	>3	4.6°	Rocky-Sandy
12	Sandy (>75)	>3	5.0°	Sandy

One of the major features of Qeshm Island sandy shores is presence of homogeneous sandy platforms. Waves and fine sediments have important roles in formation of these platforms. In rocky and rocky-sand shores tide pools were observed. Which covered by algal mats in some seasons (Fig. 3).

Figure 3:Sandy beach with sandy platform (left), rocky-sand (center) and rocky shore with tide pools (right).

Biotic communities were categorized based on CMECS, and also by considering habitat diversity based on Surface Geology Characteristics (Table 3). All biotic groups were most abundant in rocky or rocky-sandy shores. Mollusca (18 taxa), corals (3 taxa) and fishes (1 taxon) represented the highest and the lowest diversity, respectively.

Table 3: Biotic groups (number and percent) in three substrate types (sandy, rocky androcky sandy)

Surface Geology / Biotic Groups	Sandy	Rocky	Rocky-Sand	Total (Number & Percent)
Mollusca	13 35.1%	18 48.6%	6 16.3%	37 100%
Crustacea	4 25%	6 37.5%	6 37.5%	16 100%
Echinodermata	- -	4 44.5%	5 55.5%	9 100%
Corals	- -	3 100%	- -	3 100%
Fishes	- -	1 100%	- -	1 100%

In order to follow CMECS model, the codes of dominant communities were determined, the domination criteria was based on the presence during the four seasons (Tables 4 & 5).

Table 4:Observed floral (algae and mangrove) groups in southern intertidal zone of Qeshm Island

Floral Groups	Genus	Species	Winter	Spring	Summer	Autumn
Scytosiphonaceae	Lyengaria	*L. stellata*	✓			
	Colpomenia	*C. sinuosa*	✓			
Dictyotaceae	Padina	*P. australis*				✓
		P. sp.	✓			✓
	Dictyota	*D. bartaresiana*				✓
		D. cervicornis	✓			
Sargassaceae	Sargassum	*S. angustifolium*				✓
Galaxauraceae	Actinotrichia	*A. fragilis*				✓
Avicenniaceae	Avicennia	*A. marina*	✓	✓	✓	✓

Based on Table 4, most of flora taxa were observed either in winter or autumn, but *Padina* sp. was observed both in winter and autumn and *Avicennia marina* was observed in all of the seasons. Table 5 shows that most of the fauna were abundant in the colder seasons (autumn / winter)

Table 5:Observed faunal groups in southern intertidal zone of Qeshm Island

	Faunal Group	Family	Genus	Species	Winter	Spring	Summer	Autumn
Crustasea	**Hermit Crabs**	Coenobitidae	Coenobita	*C.* sp.		✓		
		Diogenidae	Clibanariius	*C. signatus*	✓	✓	✓	✓
	Sand Crabs	Ocypodidae	Ocypode	*O. rotundata*	✓	✓	✓	✓
			Uca	*U. lactea*		✓	✓	
		Dotillidae	Dotilla	*D.* sp.	✓	✓	✓	✓
	Rock Crabs	Portunidae	Thalamita	*T. prymna*	✓	✓	✓	✓
				T. crenata				✓
				T. sp.				✓
			Portunus	*P. segnis*	✓			✓
		Eriphidae	Eriphia	*E. smithi*	✓	✓	✓	✓
		Grapsidae	Grapsus	*G.* sp.	✓	✓	✓	
				G. albolineatus	✓	✓	✓	✓
				G.granulosus			✓	✓
		Xanthidae	Leptodius	*L. exaratus*				✓
		Ocypodidae	Macrophthalmus	*M.* sp.				✓
	Barnacles	Balanidae	Balanus	*B.* sp.	✓	✓	✓	✓
Mollusks	**Gastropods**	Patellidae	Patella	*P.* sp.	✓		✓	✓

Table 5 Continue :

Faunal Group	Family	Genus	Species	Winter	Spring	Summer	Autumn
		Umbonium	*U. vestiarium*	✓	✓	✓	✓
	Trochidae	Trochus	*T.* sp.	✓			✓
		Osilinus	*O. kotschyi*				✓
	Turbinidae	Turbo	*T.* sp.		✓	✓	✓
		Lunella	*L. coronata*	✓	✓	✓	✓
			N. longii	✓	✓		✓
	Neritidae	Nerita	*N. albicilla*	✓	✓	✓	✓
			N. adenensis				✓
	Planaxidae	Planaxis	*P. sulcatus*	✓	✓	✓	✓
	Potamididae	Cerithidea	*C. cingulata*	✓	✓	✓	✓
	Strombidae	Strombus	*S.* sp.	✓			✓
	Cypraeidae	Cypraea	*C.* sp.	✓	✓	✓	✓
			T. savignyi	✓	✓	✓	✓
	Thaididae	Thais	*T. tissoti*				✓
			T. lacera				✓
		Bufonaria	*B. echinata*	✓			✓
		Cronia	*C. konkanensis*	✓	✓	✓	✓
	Bursidae						

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Table 5 Continue :

FaunalGroup	Family	Genus	Species	Winter	Spring	Summer	Autumn
	Solenidae	Solen	*S. roseomaculatus*	✓			
	Cerithiidae	Clypeomorus	*C. bifisciatus*	✓	✓	✓	✓
		Cerithium	*C. caeruleum*	✓	✓	✓	✓
	Muricidae	Morula	*M. granulata*	✓	✓	✓	✓
			M. anaxares	✓		✓	✓
	Nassariidae	Nassarius	*N.* sp.	✓		✓	✓
	Olividae	Oliva	*O.* sp.	✓	✓	✓	✓
	Conidae	Conus	*C.* sp.	✓	✓	✓	✓
	Turritellidae	Turritella	*T.* sp.	✓	✓		
	Siphonariidae	Siphonaria	*S.* sp.		✓		✓
	Bullidae	Bulla	*B. ampulla*	✓	✓		
	Onchididae	Onchidium	*O. peroni*				✓
	Chitonidae	Chiton	*C. lamyi*	✓	✓		✓
	Columbellidae	Anachis	*A. fauroti*				✓
Bivalves	Mytilidae	Mytilus	*M. edulis*	✓	✓		✓
	Arcidae	Barbatia	*B. decussata*				✓
	Veneridae	Amiantis	*A. umbonella*				✓
		Callista	*C. umbonella*	✓			
	Osteridae	Saccostrea	*S. cucullata*	✓	✓	✓	

Table 5 Continue :

	FaunalGroup	Family	Genus	Species	Winter	Spring	Summer	Autumn
Echinodermata	Sea Cucumbers	Holothuriidae	Holothuria	*H. arenicola*	✓	✓		
				H. leucospilota	✓	✓	✓	✓
				H. parva	✓	✓	✓	✓
	Sea Urchins	Diadematidae	Diadema	*D. setosum*				✓
		Echinometridae	Echinometra	*E. mathaei*	✓	✓	✓	✓
	Brittle stars	Ophiactidae	Ophiactis	*O.* sp.	✓	✓	✓	✓
		Ophiocomidae	Ophiocoma	*O. scolopendrina*	✓	✓	✓	✓
	Sea Stars	Ophidiasteridae	Linckia	*L. multiflora*			✓	✓
		Asterinidae	Aquilonastra	*A.* sp.	✓			✓
Cnidaria		Poritidae	Porites	*P. Comperssa*				✓
		Faviidae	Favia	*F. pallida*				✓
		Mussidae	Acanthastrea	*A.* sp.	✓			
Fishes		Gobiidae	Gobius	*G.* sp.			✓	✓

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Biotic groups in all the designated sites / stations were studied. The collected data were initially grouped into “biotic” and “abiotic”, and were combined into a single category represented in Table 6. Based on CMECS model, the Nearshore System and the Intertidal Subsystem are represented with [NS] and [2], respectively. Abiotic portion (SGC) [s] in this research is based on hardness or softness of the substrate and represented by “Rock Shore [RS]” and “Unconsolidated Shore [US]” classes, which are further divided into “Bedrock [1]”, “Boulder [2]” and “Sands [2]” subclasses. Biotic portion [b] is represented by “Faunal Bed [FB]”, “Aquatic Bed [AB]”, and “Forested Wetlands [FO]” classes, which are further divided into “Sessile Epifauna [1]”, “Mobile Epifauna [2]”, “Infauna [3]”, “Macroalgae [1]” and “Mangrove [2]” subclasses. Finally, 47 codes were determined and reflected on a map showing the distribution of biotopes (Fig. 4). Based on Table 6, the highest number of codes belongs to *Gobius* sp. with standard code NS.2_s: RS.2_b: FB.2.f. /*Gobi* sp. and sand crabs (*Ocypode rotundata*) with code NS.2_s:US.2_b: FB.2.mc. /*Ocy rot/Dot* sp.

Table 6: Surface Geology Component and Biotic Cover Component components classification and coding based on CMECS model in southern intertidal zone of Qeshm Island.

No	CMECS code❊	Site / Station No.											
		1	2	3	4	5	6	7	8	9	10	11	12
1	NS.1_s: RS.2_b: AB.1.aa. /*Pad* sp.							√					
2	NS.2_s: RS.1_b: AB.1.aa. /*Act fra*								√				
3	NS.2_s: RS.1_b: AB.1.aa. /*Col sin*					√							
4	NS.2_s: RS.1_b: AB.1.aa. /*Dic cov/Pad boe/Lye ste*		√										
5	NS.2_s: RS.1_b: FB1.sm. /*Chit lam/Aca had*		√										
6	NS.2_s: RS.1_b: FB.2.mc. /*Eri smi/Cli sig/Thal pr*		√			√			√				
7	NS.2_s: RS.1_b: FB.2.me. /*Hol par /Ophi sco/ Echi math.*		√						√				
8	NS.2_s: RS.1_b: FB.2.me. / *Ophi* sp. /*Ophi sco/Echi math*					√							
9	NS.2_s: RS.1_b: FB.2.mm. /*Cer cae/Lun cor/ Thai sav*					√							
10	NS.2_s: RS.1_b: FB.2.mm. /*Lun cor/Cer Cae/Cly bif*					√							
11	NS.2_s: RS.1_b: FB.2.mm. /*Pla sul/Cer cae/Thai sav*								√				
12	NS.2_s: RS.1_b: FB.3.sb. /Lep										√	√	
13	NS.2_s: RS.2_b: AB.1.aa. /*Dic fri/pad boe/ Aca spi*	√											
14	NS.2_s: RS.2_b: FB.1.mb. /*Myt edu/ Sac cuc*	√											
15	NS.2_s: RS.2_b: FB1.sc. /*Bal* sp.			√									
16	NS.2_s: RS.2_b: FB1.sm. /*chit lam*	√											
17	NS.2_s: RS.2_b: FB.1.sm. /*Pat* sp.				√								
18	NS.2_s: RS.2_b: FB.1.sm. /*Sac cuc/Bar dec*												√
19	NS.2_s: RS.2_b: FB.1.sm. /*Siph* sp.						√						
20	NS.2_s: RS.2_b: FB.2.f. /*Gobi* sp.	√				√			√				

Continue Table 6:

No	CMECS code*	Site / Station No.											
		1	2	3	4	5	6	7	8	9	10	11	12
21	NS.2_s: RS.2_b: FB.2.mc. /*Eri smi/Cli sig/Gra alb*				√								
22	NS.2_s: RS.2_b: FB.2..mc. /*Eri smi/Cli sig/ Thal pry*	√											
23	NS.2_s: RS.2_b: FB.2.mc. /*Gra alb*												
24	NS.2_s: RS.2_b: FB.2.mc. /*Gra alb/Cli sig*			√									
25	NS.2_s: RS.2_b: FB.2.mc. /*Gra* sp./*Cli sig*												
26	NS.2_s: RS.2_b: FB.2.mc. /*Pur pel/Scy ser*												√
27	NS.2_s: RS2_b: FB.2.me. /*Ophi sco/Hol are/Dia set*				√								
28	NS.2_s: RS2_FB.2.me. /*Ophi* sp./*Echi math*	√											
29	NS.2_s: RS.2_b: FB.2.mm. /*Pla sul/Lun cor*	√			√								
30	NS.2_s: RS.2_b: FB.2.mm. /*Thai sav*												
31	NS.2_s: RS.2_b: FB.2.mm. /*Thai sav/Cer cae/Mor gra*												
32	NS.2_s: RS.2_b: FB.2.mm. /*Umb ves*			√									
33	NS.2_s: RS.2_b: FB.3.sb. /Lep/Pse/Pro	√								√			
34	NS.2_s: US.2_b: AB.1.aa. /*Dic bar/Sar ang/Pad aus*												√
35	NS.2_s: US.2_b: AB.1.aa. /*Dic cov/Ent* sp./*Pad boe*										√		
36	NS.2_s: US.2_b: AB.1.aa. /*Lye ste*				√								
37	NS.2_s: US.2_b: AB.1.aa. /*Pad* sp./*Dic cer*			√									
38	NS.2_s: US.2_b: AB.1.aa. /*Sar ili/Pad boe/ Hyp* sp.									√			
39	NS.2_s:US.2_b: FB.2.mc. /*Ocy rot/Dot* sp.	√		√							√		
40	NS.2_s: US.2_b: FB.2.mc. /*Ocy rot/Dot* sp./*Uca lac*									√			
41	NS.2_s: US.2_b: FB.2.mc. /*Ocy rot/Sco cra*				√								
42	NS.2_s: US.2_b: FB.2.me. /*Ast hem/Ast ind*				√								
43	NS.2_s: US.2_b: FB.2.mm. /*Cer cin*												√
44	NS.2_s: US.2_b: FB.2.mm. /*Umb ves/Cer cin*									√			
45	NS.2_s: US.2_b: FB.2.mm. /*Umb ves/Cer cin/Mit bla*				√								
46	NS.2_s: US.2_b: FB.3.sm. /*Ami umb*												√
47	NS.2_s: US.2_b: FO.2.fm. /*Avi ma*									√			

* [aa] :Attached algae, [mc] :Mobile Crustaceans, [mm] :Mobile Mollusca, [mb] :Mollusca Bed, [f] :Fishes, [sm] :Sessile Mollusca, [me] :Mobile Echinodermata, [fm] :Forested Mangrove, [sc] :Sessile Crustacean, [sb] :Small Surface Burrowing Fauna,

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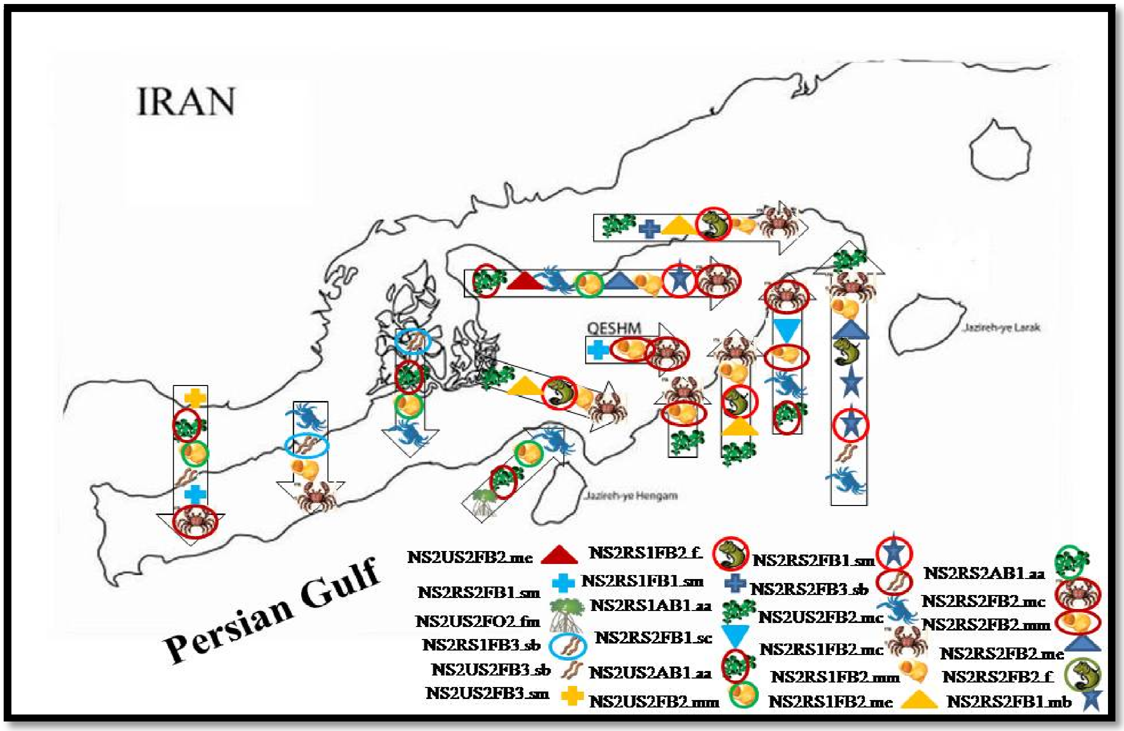

Figure 4: Biotope distributions in the southern intertidal zone of Qeshm Island, using by GIS

Discussion

Nowadays, coastal classifications based solely on geomorphology characteristic raise complications and problems (Haslett, 2000). All the world's coasts are divisible into a simple bifold division, viz, hard or stable and soft or unstable (Cotton, 1954; Fairbridge, 2004). Qeshm Island is no exception to this classification, having vast stable (rocky) and unstable (sandy) shores. Describing the composition of the surface substrate is a fundamental part of any marine classification scheme. The Surface Geology Component (SGC) of CMECS is a first-order characterization of the geology that provides context and setting for many marine processes, and provides soft or hard structure for benthic fauna. Madden et al. (2009). CMECS model applications require basic biotic and abiotic data. Abiotic data, such as SGC, is designed to interoperate with the BCC to provide an integrated assessment of the physical/geological and biological aspects of benthic cover (Madden et al., 2009). Generally, uniform shores were located in the mid-western and heterogeneous ones in the mid-eastern, which could be related to wave and wind force. Sandy beaches constitute almost 81 km (67%) of the total 122 km coastline covered in this study. Hara (mangrove) forests, located in the mid-western area, have not grown as well as result of higher ratio of sand in the sediment (Table 2). Rocky shores also exhibit a wide variety of morphologies because several factors have influenced their development. For example,

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the mid-eastern rocky coasts exhibit such morphologies as arch, stack, and cliff that are formed by erosion. Several processes are involved in bedrock erosion, but the most visible and important one is wave action, particularly during the colder seasons. Wave action has created numerous tide pools that provide shelters for diverse organisms (Stations 1, 2, 5 & 8). In addition, bioerosion can occur when marine invertebrates such as snails, limpets, sea urchins, and chitons abrade the rock surface in search of food or shelter or both. Physical characteristics of the substrate such as grain size and Total Organic Matter (TOM) are proving to be effective in describing marine habitats (Table 2). Sediment grain size is also an important factor in regulating the distributions of infauna and epifauna because many creatures are dependent on a certain grade of substrate. Tait and Dipper (1998). To create a coding system, Surface Geology Component (SGC) classes and subclasses were determined (in terms of percent cover) by the dominant geologic or biogenic cover of the substrate. Subclasses are defined by the substrate composition and particle size that will be used in coding, accordingly.

During the second decade of the twentieth century, pioneer studies of marine benthos were initiated. Tait and Dipper (1998). The intertidal zone encompass the smallest area of the world's oceans, yet it accommodates tremendous diversity of life, as great as or even greater than that found in the more extensive subtidal habitats. Olenin and Ducrotoy (2006). From pelagic environment point of view, the sea bed provides a far wider variety of habitats and, correspondingly, more diverse fauna. Based on the results of this research, 66 fauna taxa and 8 flora taxa were identified**,** of which molluscs (Bivalves and Gastropods, 37 taxa) and crustacean (16 taxa) had the highest distribution, while echinoderms (9 taxa) had an average distribution**.** In the previous studies in southern Qeshm Island, 65 mollusc species in 33 families Amini Yekta (2008), 19 crustacean species in 10 families Asgari (2008), and 15 echinoderm species in 4 classes Izadi et al.(2011) have been reported. Based on findings of this research, *Bufonaria echinata* (Gastropod), *Thalamita prymna*, *Grapsus granulosus* and *Macrophthalmus* sp. (Crustaceans), and also *Aquilonaster* sp. (Echinoderm) obsereved and reported; these species have not been reported earlier from southern Qeshm Island. The highest diversity in studied area was observed in the mid-eastern region where substrates were heterogeneous. Diversity decreased westward as substrates became more sandy. Although differences between communities can often be correlated with differences in sediments size, other factors such as light and turbidity can also influence them. Tait and Dipper (1998). Compared with the western sandy shore, the mid-eastern shores are rocky-sandy and, therefore, less disturbed by wave action, however providing more suitable habitats for organisms (Tables 3 & 4). There is usually a wide diversity of species inhabiting a rocky bottom due to its surface irregularities that provide a great variety of microhabitats. Crustacean species such as *Eriphia smithi*, *Thalamita prymna*, molluscan species such as

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Clypeomorous bifisciatus, *Cerithium caeruleum* and echinoderms such as *Echinometra mathaei* and *Ophiactis* sp. can be regarded as the rocky shores' characteristic species.

Community and population of tidal fauna in sandy shores mainly dwell below the surface, but sometimes there are species which emerge to crawl or swim. Although sandy beach constitutes the highest coverage in the southern Qeshm Island, diversity here was far less than on rocky coasts of the mid-eastern of Qeshm Island (Table 3). Macro-faunal diversity is dependent on particle size, gradient and wave action. Tait and Dipper (1998). Due to available of intensive wave action in the southern part of Qeshm Island, sediment particles are <62 micron (silt and clay). Thus wave action should be regarded as a major factor in distribution of the sand dwelling populations in southern Qeshm Island, since it can directly or indirectly influence many important characteristics of the substrate, such as stability, particle size, gradient and organic content. On the other hand, waves can carry creatures upward or downward in the shore to levels that could be unsuitable for their survival. The results show that mentioned factors are lower diversity in the sandy shore habitats, ultimately (Tables 3, 4 & 5). Salinity is also very important for distribution of organisms. The presence of the salt dome adjacent to station 11 and high salinity resulted in sandy beach species (such as *Ocypode rotundata*, *Dotilla sp.* (Crustacea) and *Umbonium vestiarium* (Mollusca).

Based on CMECS definition for biotope, 60 biotopes / habitats were identified and mapped out (See Table 6, Fig. 4), of which more than 65% were located in the mid-eastern area of the Qeshm Island, and the rest in the mid-western area. This uneven distribution is directly related to the substrates, being heterogeneous in the mid-eastern and homogeneous in the mid-western shores. The highest and lowest number of biotopes were recorded in stations Zeitun Park (9 codes) and back barrier (3 codes), respectively (Tables 1 & 6). Although Zeitun Park had the highest number of biotopes, it did not possess certain expected species (such as *Diadema setosum, Linckia multiflora, Ophiocoma scolopendrina*) that were encountered in stations with similar surface geology. It could be attributed to tourist traffic. Application of CMECS in Chabahar coast (along the Oman Sea) resulted in recording 27 habitats with 13 codes (Shahraki et al., 2010). Fewer codes in Chabahar than in the present study could be attributed to the application of older version of CMECS, and exclusion of SGC. Further, present study and research introduce new biotopes for echinoderms and infauna (Table 6), which not found in Oman Sea coastal habitats. Shahraki et al. (2010). In general, application of the CMECS model in tropical regions, where species diversity is high, is challenging because the biotope code may not refer to species. Seasonal distribution of organisms, and other details such as feeding, reproduction, and behavior of the organisms could also be considered in establishing a more advanced classification. This requires a good knowledge on the biology of the covered

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organisms, many of which still remain unknown, relatively.

It seems that intertidal area (with their high biodiversity and vulnerability to human activities), require special management to reduce the impacts on macroinvertebrates. Therefore, a classification scheme can be useful to coastal managers because: (1) it will provide a mechanism for identifying and mapping habitats, especially high value ones, in the ocean with standardized descriptions; (2) it will facilitate communication among scientists and managers, and; (3) it will help habitat mapping efforts by combining spatial information with a standardized coding system in GIS.

In this study, 60 habitats (biotopes) with 47 codes were determined; this large number of biotopes is directly related to diverse surface geology (substrate) of the covered area. The majority of biotopes were recorded in the mid-eastern coastal stretch associated with numerous ecological niches in rocky shores. Crustacean species such as *Eriphia smithi*, *Thalamita prymna*, molluscan species such as *Clypeomorous bifisciatus*, *Cerithium caeruleum* and Echinoderm species such as *Echinometra mathaei* and *Ophiactis* sp. can be regarded as the “rocky shores specific” species while *Ocypode rotundata*, *Dotilla* sp. (Crustacea) and *Umbonium vestiarium* (Mollusca) can be regarded as the “sandy shores specific” species. Although the greatest number of standard codes were recorded in Zeitun Park (adjacent to Qeshm city), this area did not contain certain expected species (such as *Diadema setosum, Linckia multiflora, Ophiocoma scolopendrina*) that were encountered in sites with similar surface geology. This could be attributed to tourist traffic in the Zeitun Park area.

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