**BIODIVERSITAS**
Volume 18, Number 1, January 2017
Pages: 153-159

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d180122

# Application of Coastal and Marine Ecological Classification Standard to organize island ecosystem: the Abu Musa Island, Persian Gulf case study

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Manuscript received: 30 October 2016. Revision accepted: 1 December 2016.

**Abstract.** *Zare R, Sinaei M, Shakouri A, Kourandeh MB, Gerami MH. 2017. Application of Coastal and Marine Ecological Classification Standard to organize island ecosystem: the Abu Musa Island, Persian Gulf case study. Biodiversitas 18: 153-159.* A first step in marine conservation plans is to identify and classify habitat types. These classifications should be scientificallyrigorous with high application. The Coastal and Marine Ecological Classification Standard (CMECS) is a nested, hierarchical framework that applies a uniform set of rules that have a high capacity in marine habitats classifications. In this study, this capacity was tested for the Abu Musa Island ecosystem, Persian Gulf. The Surface Geology Component and the Biotic CoverComponent were analyzed and encoded with the given instructions. In total, 21 codes were determined for benthic communities and 19 codes for geoform component, which showed high diversity of habitats and variety of biotopes in this island.Finally, results indicated that the CMECS approach was successful in Abu Musa habitat classification. In addition, results were very useful for sustainable development especially for ecotourism plans.

**Keywords**: Abu Musa Island, CMECS, ecotourism, habitat classification

## INTRODUCTION

Isolation and high availability of empty niches have caused diversification on islands with unique ecosystem (Steinbauer et al. 2012).However, the valuable island's biota are under severe threatdue to habitat loss and climate change (Kreft et al. 2008). Ecological classification is a fundamental role to increase the knowledge about spatial patterns and maintainingecosystem services (Carollo et al. 2013). Indeed, changes in marine biodiversity are thecause of change of several ecosystem services (Worm et al. 2006). Therefore, effective management of these ecosystems requires relatively clear understanding of their presentecology, and also their sensitivity to naturaland anthropogenic changes (Ansari et al. 2014). The Coastal and Marine EcologicalClassification Standard System (CMECS) is a catalog of terms that classifies ecological units using a simple,standard format and common terminology (Madden et al. 2008). CMECS was developedwith the input of over 40 coastal and 20 marine habitats and recently endorsed by the USFederal Geographic Data Committee (FGDC) as the first national standard for classifying coastal and marineecosystems and is a wide-spread implementation (Carollo et al. 2013; Madden et al. 2008). This method provides a framework to linkcoastal and marine habitats to ecosystem servicesand contributes diverse disciplines such as economics, biology,ecology, oceanography, geology, and fisheries; in order to establish a national classification with national and regionalcapabilities and boundaries of different habitats such as estuaries, rivers or coastlines.

Many researchers applied CMECS for Island ecosystems to assess and identify the ecological health and habitats. Ansari et al. (2014) achieved ecological classification based on CMECS model for the Qeshm Island in the Persian Gulf and stated that tourist traffic affected this classification. In addition, the Hengan Island coastal biotopes were identified by Mehrdost et al. (2014) and 24 standard codes successfully reported for this island. Furthermore, Carollo et al. (2014) applied identified and classified the US Gulf of Mexico habitat types based on CMECS and endorsed this method for this region.

The Abu Musa is an undeveloped island in the Persian Gulf which has 12.8 km$^2$ areas and diverse ecosystem compared to other island in this area (Afkhami et al. 2012). Therefore, it is fundamental to monitor environment prior any industrial or tourism activities in this region. In this study, we analyzed,natural parameters to map Abu Musa ecosystem. The map can present niche overlap or anthropogenic feedbacks, thereupon; management plans can apply based on ecological standards to produce sustainable development in fisheries, oil industries or even ecotourism.Overall, the main purpose of this study is to provide basic information for further studies in this region.

## MATERIALS AND METHODS

The survey was conducted in the Abu Musa Island coastline, Persian Gulf (25° 52′N 55 ° 02′E, Figure 1). This island belongs to Iran and inhabited by Iranian and Emirati. Due to lack of suitable farming land and freshwater, fisheries activates is the main profession in this island. The weather in Abu Musa is warm and humid with two distinct seasons. This study was carried out during 2014-2015 in two seasons (cold and warm season). Due to the depth of sea, oil tankers and big ships have to pass between Abu Musa and Greater and Lesser Tunbs; this makes these islands some of the most strategic points in the Persian Gulf (Ewan and Owen. 1993).

### Macrobenthic communities sampling

Van Veen Grab with 0.04 $m^2$ cross section used to sample from sediments and soft-sediments macrofouna. Sediments samples were sieved through 1000, 500, 250, 125 and 63 micron, respectively and the remains were heated to 70 C° in the oven and weighted after (Eleftheriou 2013). The U-50 Series multi-parameter water quality meters (Horbia, Japan) used to measure and log data.

Soft-bottom macroinvertebrates samples were sieved through 0.5 mm mesh and the remaining was fixed and preserved by 97% ethanol and transferred to laboratory for further analysis. Organism were stained by Rose Bengal and sorted to major taxonomic groups. Macroinvertebrates were identified by illustrated key such as: Fauchald (1997), Sterrer (1986), Bosch and Dance (1995) and Debruyne (2003). In addition, 50×50 quadrate employed to sample from hard-substrate macroinvertebrates communities.

### Coastline survey

Field survey and observation method employed to investigate coastline morphology, geology and anthropogenic features. Therefore, Supra tidal area investigated based on geodesy navigationand bio-indicators species. Finally, ecosystem levels and habitat boundarieswere distinguished based on field survey and GPS recorded data.

### Applying the CMECS classification

Collected data based on field survey, benthic and plankton sampling used to evaluate several levels of the CMECS classification system (Madden et al. 2008). The highestclassification level has four components: The Water Column Component (WC), Geoform Component (GC), Substrate Component (SC) and The Biotic Component (BC).WCdescribes the water column in terms of vertical layering, watertemperature and salinity conditions.SC with GCdescribe the geological composition and environment of the upper layer of the hard substrate and 15 cm of soft substrate. The main focus of this component is on the structural (non-living) aspects of biogenic substrates. Classes of these tow component are divided into Faunal Reef Substrate, Coral Reef Substrate, Rock Substrate and Unconsolidated Substrate. BCdescribesthe composition of floating andsuspended biotathe biological composition of coastal and marine benthos (Madden et al. 2008).However, in this study, WC excluded from final analysis due to lack of access and conditions. Encoding system employed to classifyeach level and component information according to the characteristics of each Biotope. Finally, classified data were plotted with Arc GIS 9.3.

## RESULTS AND DISCUSSION

### Biotic component (BC)

Geodesy navigation around revealed that *Prosopis* sp., *Ziziphus* sp., *Vachellia* sp., *Chamaerops* sp., *Albizia* sp., *Tamarix* sp. and *Pinus* sp.were plant biota in the island. *Prosopis* sp., *Ziziphus* sp., *Vachellia*sp.were more abundant than others and *Pinus* sp. was man made. Vegetation map of the island is represented in Figure 2.

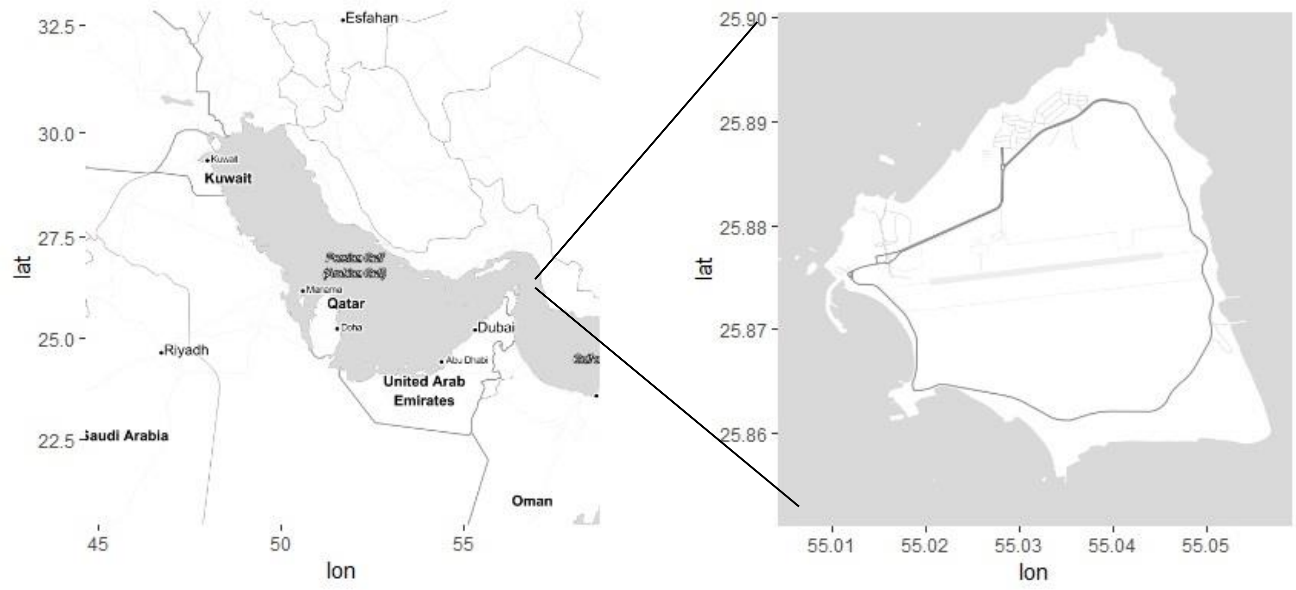


**Figure 1.** Map of Abu Musa Island location in the Persian Gulf

Results of macrobenthic identification showed that 79 genus from 61 families and 21 orders live in the Abu Musa Island coastline and marine environment. Check list of these invertebrates is represented in Table 1. Three main parts of the island identified and encoding system for benthic environment was applied for these three regions (Table1). The benthic biota encoding system is represented in Table 2. According to Table 2, fifty five habitats were distinguished in the coastal ecosystem. Sediments grain size was studied in three main parts of the island. Based on CMECS all the sediments type were categorized and geology map was plotted for each part (Table3, Figure 3).

**Discussion**

The most important challenge in habitat classification is to define habitats by their physical attributes versusdefining them by biological requirements, communitystructure or ecological functionality (Diaz et al. 2004; Kurtzet al. 2006).The CMECS encoding system attempts to solve this tension. Based on the CMECS method, all the coastal habitats of the Abu Musa belonged to intertidal and subtidal zone. Geoform coding revealed that more that 50% of the island substrate is Rock Substrate. Results of encoding system showed that the entire coastline in the Abu Musa Island has geological origin.Five natural geofrom of the Abu Musa Island was mud platform, sandy platform, canals, firth and tidal ponds. Maximum geological origin also reported by other researchers in other islands of the Persian Gulf (Ansari et al. 2014;Mehrdostet al. 2014; Aghajanpour et al. 2015).

Biological coding system recognized 55 habitats in the island benthic ecosystem. These habitats contained 10 codes in the CMECS which shows high biological and habitat diversity in this island. High biological diversity in the islands of the Persian Gulf was also reported by Fatemiand Shokri (2001) and Mostafavi et al. (2007) for Kish Island, Shojae et al. (2010) for Larak Island and Naderloo et al. (2013) for Qeshm Island.

Intertidal platforms with muddy-sandy substrate were the most abundant geoform in region 1. This region had 2 codes from Unconsolidated Substrate solely, which indicates the homogeneity of this region. Muddy platforms are the most appropriate habitats for benthic communities (Volkenborn and Reise 2007). Therefore, this region had highest diversity in comparison with region 2 and 3.Sandy platforms were the most abundant substrate in region 2. Due to rocky substrate, diversity in this region was low.

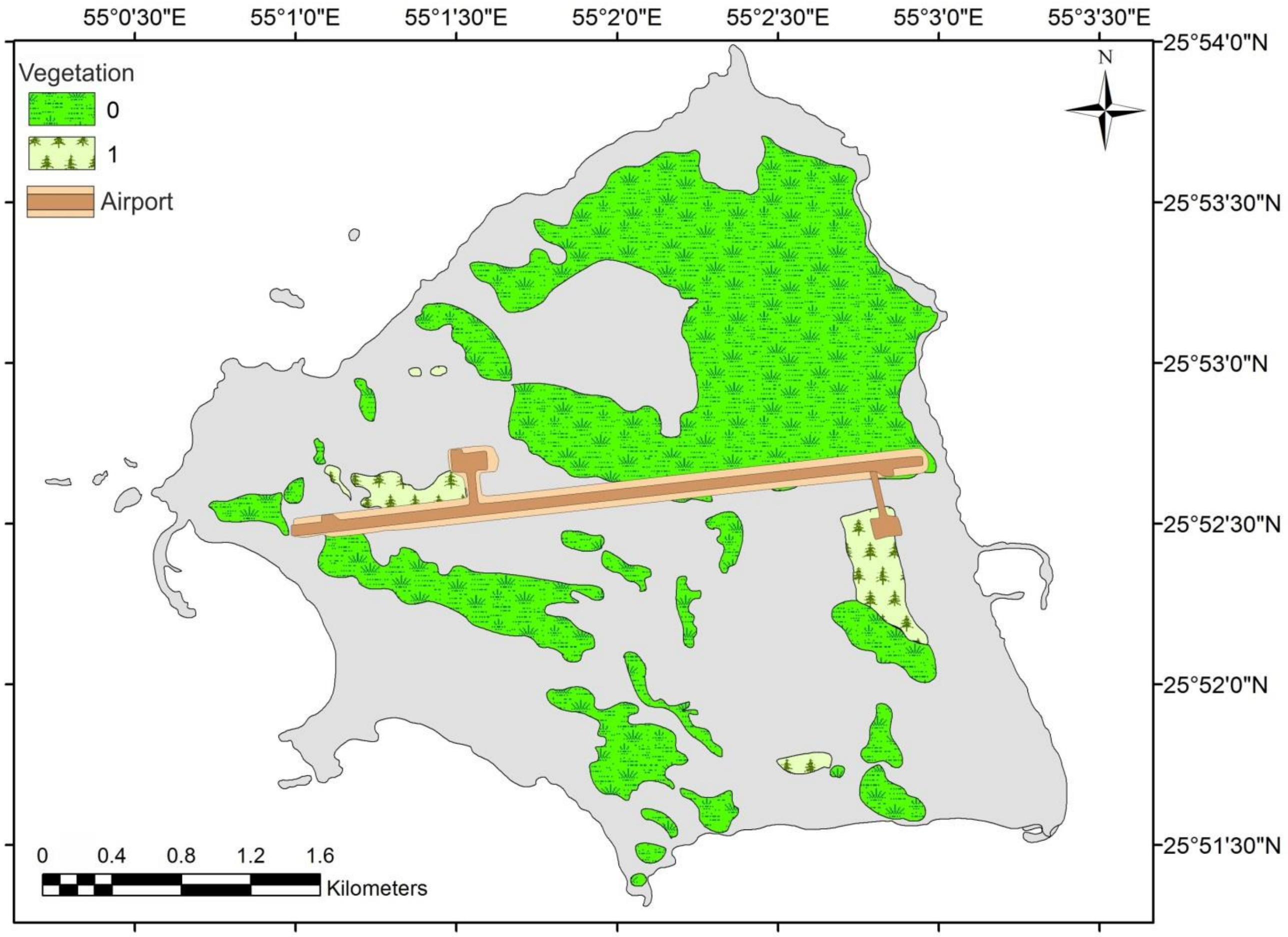


**Figure 2.** Vegetation map of the Abu Musa Island in 2014-2015. “0” shows natural and “1” shows man made vegetation respectively.

In general, application of the CMECS model in island ecosystems was successful in this study. Indeed, the new version of the CMECS coding system has increased the efficiency of this method in comparison to older versions (Cowardin et al. 1979; Greene et al. 1999; Madden et al. 2008). This method is a useful way to provide a mechanism for identifying andmapping habitats and will facilitate communication amongscientists and managers.Douvere and Ehler (2001) stated that marinespatial management plans are include defining the boundaries of the ecosystem, spaces with special ecological, biological and special economic value, and defining the spaces where are high

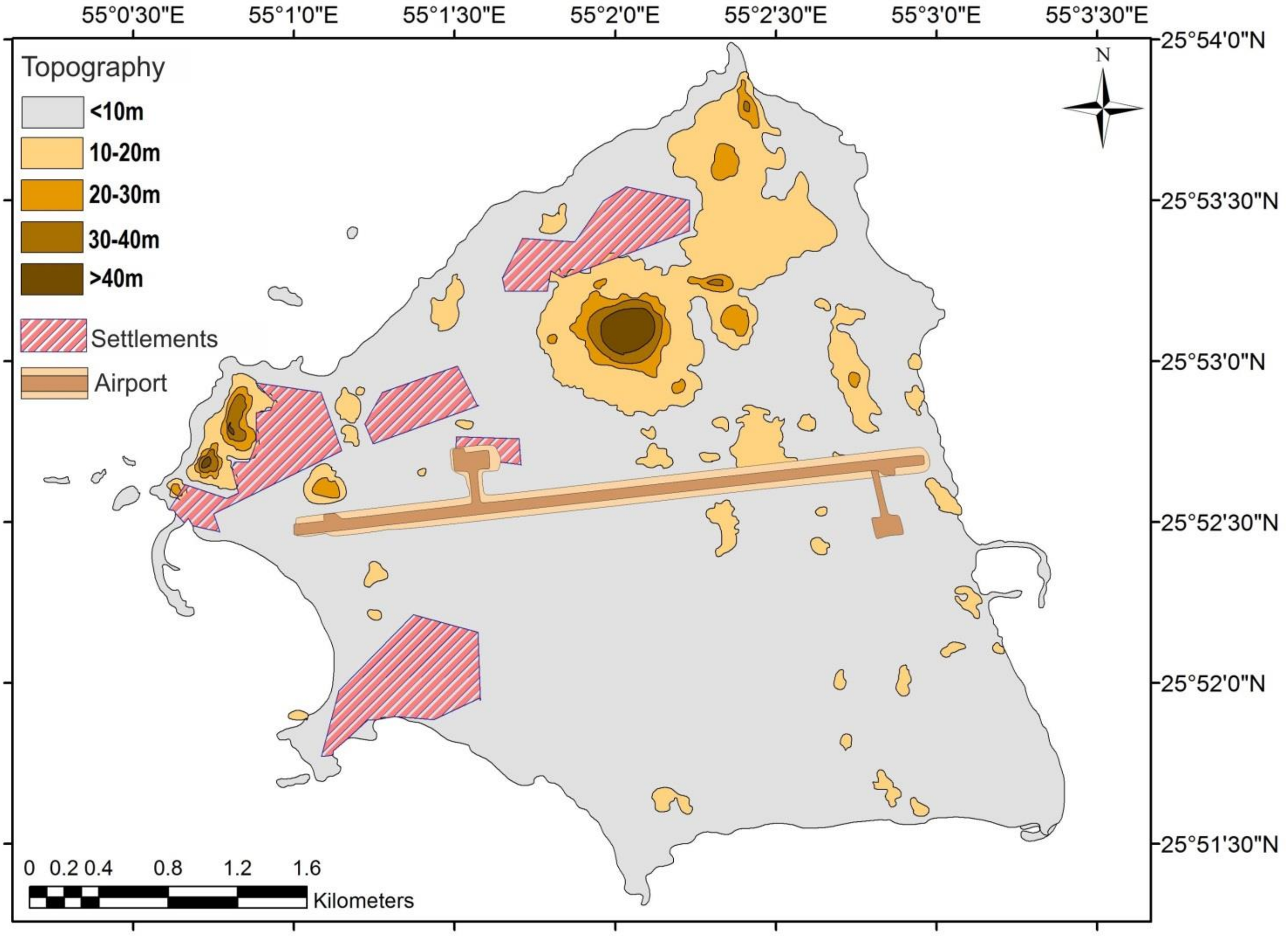


**Figure 3.** Topography map of the Abu Musa Island (2014-2015)

**Table 1.** Identified coastline marine macrobenthic during this study in the Abu Musa Island 2014-2015

| Phylum | Class | Order | Family | Genus |
|---|---|---|---|---|
| Mollusca | Polyplacophora | Neoloricata | Chitonidae | *Chiton* sp. |
| | Gastropoda | Anaspidea | Aplysiidae | *Aplysia* sp. |
| | | Onchidiacea | Onchidiidae | *Onchidella* sp. |
| | | Monotocardia | Buccinidae | *Engina* sp. |
| | | Neogastropoda | Diastomatidae | *Diastoma* sp. |
| | | | Tornidae | *Tornus* sp. |
| | | | Columbellidae | *Mitrella* sp. |
| | | | Conidae | *Conus* sp. |
| | | | Muricidae | *Hexaplex* sp. |
| | | | | *Morula* sp. |
| | | | Thaididae | *Cronia* sp. |
| | | | | *Thais* sp. |
| | | | Nassariidae | *Nassarius* sp. |
| | | | | *Bullia* sp. |

| | | | | |
|---|---|---|---|---|
| | | Archaeogastropoda | Fissurellidae | *Diodora* sp. |
| | | | Neritidae | *Nerita* sp. |
| | | | | *Nerita* sp.2 |
| | | | Turbinidae | *Turbo* sp. |
| | | | | *Turbo* sp.2 |
| | | | Trochidae | *Trochus* sp. |
| | | | | *Umbonium* sp. |
| | | | Patellidae | *Patella* sp. |
| | | | | *Patella* sp.2 |
| | | Mesogastropoda | Planaxidae | *Planaxis* sp. |
| | | | Architectoniicidae | *Heliacus* sp. |
| | | | Naticidae | *Natica* sp. |
| | | | Cymatiidae | *Gyrineum* sp. |
| | | | Cypraeidae | *Cypraea* sp. |
| | | | | *Cypraea* sp.2 |
| | | | Ceritiidae | *Cerithium* sp. |
| | | | | *Rhinoclavis* sp. |
| | | | | *Rhinoclavis* sp.2 |
| | | | | *Bittium* sp. |
| | Bivalvia | Myoida | Gastrochaenidae | *Gastrochaena* sp. |
| | | Arcoida | Arcidae | *Acar* sp. |
| | | | | *Barbatia* sp. |
| | | Pterioida | Ostreidae | *Saccostrea* sp. |
| | | | Spondylidae | *Spondylus* sp. |
| | | Mytiloida | Isognomonidae | *Isognomon* sp. |
| | | | Mytilidae | *Septifer* sp. |
| | | | | *Lithophaga* sp. |
| | | Veneroida | Veneridae | *Circenita* sp. |
| | | | Trapeziidae | *Trapezium* sp. |
| | | | Psammobiidae | *Asaphis* sp. |
| | | | Petricolidae | *Rupellaria* sp. |
| | | | Ungulinidae | *Diplodonta* sp. |
| Annelida | Polychaeta | | Eunicidae | *Lysidice* sp. |
| | | | Nereidae | *Nereis* sp. |
| | | | Polynoidae | *Halosydna* sp. |
| | | | Cirratulidae | *Cirriformia* sp. |
| | | | Polydoridae | *Polydora* sp. |
| | | | Arabellidae | *Arabella* sp. |
| | | | Syllidae | *Haplosyllis* sp. |
| | | | | *Odontosyllis* sp. |
| | | | Terebellidae | *Nicolea* sp. |
| | | | | *Amphitrite* sp. |
| Arthropoda | Crustacea | Cumacea | Bodotriidae | *Cyclaspis* sp. |
| | | Cirripedia | Balanidae | *Balanus* sp. |
| | | Copepoda | Clausiidae | *Clausidium* sp. |
| | | Stomatopoda | Gonodactylidae | *Gonodactylus* sp. |
| | | Amphipoda | Gammaridae | *Elasmopus* sp. |
| | | Isopoda | Sphaeromatidae | *Exosphaeroma* sp. |
| | | | Anthuridae | *Cyathura* sp. |
| | | | Oniscidae | *Ligia* sp. |
| | | Decapoda | Paguridae | *Pagurus* sp. |
| | | | Galatheidae | *Petrolisthes* sp. |
| | | | Alpheidae | *Alpheus* sp. |
| | | | Portunidae | *Charybdis* sp. |
| | | | Pilumnidae | *Pilumnopeus* sp. |
| | | | Hymenosomatidae | *Trigonoplax* sp. |
| | | | Leucosiidae | *Nursia* sp. |
| | | | Grapsidae | *Grapsus* sp. |
| | | | | *Sesarma* sp. |
| | | | Xanthidae | *Atergatus* sp. |
| | | | | *Etisus* sp. |
| | | | Eriphiidae | *Menippe* sp. |
| | | | | *Eriphia* sp. |
| | Insecta | Coleoptera | Staphylinidae | *Cafius* sp. |
| | Pycnogonida | Pantopoda | Ammotheidae | *Ammothella* sp. |

sensitive to anthropogenic activities. Although, CMECS can help in ecotourism approach, some errors and limitations found in this study which should be considered in further studies: (i) Biological limitations, such as restrictions in habitats due to mineral salt, climatic constraints (rainfall, high temperature and humidity) and lack of vegetation and wildlife in the island. (ii) Environmental limitations, such as geological and topographical problems, locating in an earthquake-prone area, limitations in flat grounds, salt domes, lack of freshwater and low rate of population growth in the island. In the end, it is well known that CMECS has the capacity to define all these topics. Therefore, it would be a useful approach to manage the Abu Musa Island and the other similar island around the world.


## ACKNOWLEDGEMENTS

This research was financially supported and carried out under the Iran National Science Foundation: INSF. Authors are thankful for the practical and mental support of colleagues and friends during the course of the research.


**Table 2.** CMECS coding system for benthic communities in the Abu Musa Island 2014-2015

| Reg. | System | Subsystem | Class | Subclass | Biotic Group | Biotope | CMECS Code |
|---|---|---|---|---|---|---|---|
| 1 | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreIntertidal_ b: FB.3.sb |
| | Marine [MS]* | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Uca* sp. | MS.NearshoreIntertidal_ b: FB.3.tm.*Uca* sp. |
| | Marine [MS] | Nearshore Subtidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Periophtalmus waltoni* | MS.NearshoreIntertidal_ b: FB.3.tm.*Perio wal* |
| | Marine [MS] | Nearshore Subtidal | Faunal Bed [FB] | Infauna [3] | - | Molluscs communities | MS.NearshoreIntertidal_ b: FB.3 |
| | Marine [MS] | Nearshore Subtidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreSubtidal _ b: FB.3.sb |
| | Marine [MS] | Nearshore Subtidal | Faunal Bed [FB] | Infauna [3] | | Molluscs communities | MS.NearshoreSubtidal _ b: FB.3 |
| 2 | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreIntertidal_ b: FB.3.sb |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Uca* sp. | MS.NearshoreIntertidal_ b: FB.3.tm.*Uca* sp. |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Periophtalmus waltoni* | MS.NearshoreIntertidal_ b: FB.3.tm.*Perio wal* |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | - | Bivalvia communities | MS.NearshoreIntertidal_ b: FB.3 |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Mobile Epifauna | Mobile Crustacean [mc ] | Paguridae community | MS.NearshoreIntertidal_ b: FB.2.mc |
| | Marine [MS] | NearshoreSu btidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreSubtidal _ b: FB.3.sb |
| | Marine [MS] | Nearshore Subtidal | Faunal Bed [FB] | Infauna [3] | - | Bivalvia communities | MS.NearshoreSubtidal _ b: FB.3 |
| 3 | Marine [MS] | Nearshore Intertidal | Aquatic Bed [AB] | Macroalgae [1] | Attached Ephemeral Macroalgae [ae] | Mixed ephemeral macroalgae | MS.NearshoreIntertidal_ b: AB.1.ae |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreIntertidal_ b: FB.3.sb |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Uca* sp. | MS.NearshoreIntertidal_ b: FB.3.tm.*Uca* sp. |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | Tunneling Megafauna [tm] | *Periophtalmus waltoni* | MS.NearshoreIntertidal_ b: FB.3.tm.*Perio wal* |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Infauna [3] | - | Bivalvia communities | MS.NearshoreIntertidal_ b: FB.3 |
| | Marine [MS] | Nearshore Intertidal | Faunal Bed [FB] | Sessile Epifauna [1] | Sessile Gastropda [sg] | *Planaxissulcatus* | MS.Nearshore Intertidal_ b: FB.1.sg.*Plan sul* |
| | Marine [MS] | NearshoreSu btidal | Faunal Bed [FB] | Infauna [3] | Small Surface Burrowing Fauna [sb] | Polychaeta communities | MS.NearshoreSubtidal _ b: FB.3.sb |
| | Marine [MS] | NearshoreSu btidal | Faunal Bed [FB] | Mobile Epifauna [2] | Mobile Crustacean [mc ] | Paguridae community | MS.NearshoreSubtidal _ b: FB.2.mc |

Note: *letters and numbers in [] indicating CMECS encoding system.

**Table 3.** CMECS coding system for geoform substrate in the Abu Musa Island 2014-2015

| Reg. | System | Subsystem | Physiographic setting | Coastal geoform | Anthropogenic geoform | CMECS code |
|---|---|---|---|---|---|---|
| 1 | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Fish Pond [FP] | g:Continental/Island shelf.FL.FP |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Sea Wall [SL] | g:Continental/Island shelf.FL.SL |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Jetty [JE] | g:Continental/Island shelf.FT.JE |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Pier [PE] | g:Continental/Island shelf.FT.PE |
| | Marine [MS] | Nearshore Supratidal | Continental/Island shelf | Flat [FT] | Pier [PE] | g:Continental/Island shelf.FT.PE |
| 2 | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | - | g:Continental/Island shelf.FL |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Fish Pond [FP] | g:Continental/Island shelf.FL.FP |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Sea Wall [SL] | g:Continental/Island shelf.FT.SL |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Sea Wall [SL] | g:Continental/Island shelf.FT.SL |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Harbor [HB] | g:Continental/Island shelf.FT.HB |
| | Marine [MS] | Nearshore Supratidal | Continental/Island shelf | Flat [FT] | - | g:Continental/Island shelf.BE |
| 3 | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Fish Pond [FP] | g:Continental/Island shelf.FL.FP |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Tidal Pool [TP] | - | g:Continental/Island shelf.TP |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Jetty [JE] | g:Continental/Island shelf.FT.JE |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Flat [FT] | Pier [PE] | g:Continental/Island shelf.FT.PE |
| | Marine [MS] | Nearshore Supratidal | Continental/Island shelf | Beach [BE] | - | g:Continental/Island shelf.BE |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Channal [CH] | - | g:Continental/Island shelf.CH |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Bay [BY] | - | g:Continental/Island shelf.BY |
| | Marine [MS] | Nearshore Intertidal | Continental/Island shelf | Channal [CH] | - | g:Continental/Island shelf.CH |

Note: *letters and numbers in [] indicating CMECS encoding system

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