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Research Article

Catch per Unit Area (CPUA) estimation and distribution pattern of grunts in the Oman Sea

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Abstract

It is reported on the results of a trawls survey to assess the amount of catch Per Unit of Area (CPUA) and also to determine the distribution pattern of grunts of demersal fishes as one the most critical and commercial fish species in the north of Oman Sea. The catch per unit area CPUA as the main index was estimated. A CPUA and distribution change of this group was undertaken from 2003 to 2013. There was an annual monitoring survey during the years 2003-2013 by swept- area of the trawling area in the Oman Sea using R/V 'Ferdows-1'covering into five strata (or sub-region) and four depth layers of 10-20, 20-30, 30-50, and 50-100 meters in the northern Oman Sea. The Results showed that central and eastern regions could be considered as main fishing grounds of this group of fishes with high abundance. However, the highest mean CPUA belongs to strata C & E (420.7 and 306.1 kg/nm2) and B (266.1 kg/nm^2) as the primary fishing grounds comparing to the other two covering strata A & D, respectively. The Results of depth layers density revealed the highest frequency was for the depths < 30 m (475.3 kg/nm2). As well as, CPUA had a descending trend by increasing the depth. The highest and lowest value belonged to the depths 20-30 and 50–100 m, respectively. Grunts (Haemulidae family) have economic importance in terms of the commercial catch in the Oman Sea. In the last decade, CPUA of grunts shows a decreasing trend, which represents the significant decrease in fisheries resources.

Keywords: Demersal fishes, Haemulidae, grunts CPUA, Oman Sea

Introduction

The Oman Sea, with an approximate length of 610 km, is located in the northwest Indian Ocean (Daryanabard *et al.* 2012). This sea has a lot of economic valuable fish resources and can be considered as one of the critical areas for commercial fishing. Still, unfortunately, its stock has been overfished within the last two decades (Valinassab *et al.* 2014). Fishing is one of the primary occupations in the Oman Sea coasts, and an annual catch of demersal fishes was reported over 130000 tons (Planning and Programming Dept. of IFO). That is funded a significant portion of the protein requirements from the sea from 2003 to 2011 (Daryanabard *et al.* 2012).

Sustainable management is the concept that uses optimal aquatic ecosystems, and so the destruction of the ecosystem will have a direct effect on fishing (Azhir *et al.* 2012). The years, excessive population, caused to lack of appropriate employment, protein requirements, and unethical exploitation of the sea and the estuaries So that by referring to the past and present reference and compare them, is visible the impact of fishing pressure (Fischer and Bianchi 1984).

Awareness of the fish resources status and their composition and distribution in different depths in the Oman Sea can play a role in the scientific

management of valuable stocks (Mohammad Khani 2005). Demersal fishes are one of the marine resources and exploitable those who have perception by industrial trawl fishing fleet in part of the Oman Sea (Abbaspour *et al.* 2010). Haemulids are including commercial fishes caught by gill nets. The stock is one of the most important coastal resources in the waters of the Persian Gulf, and Oman Sea, and the habitat has been reported up to a depth of 75m (Azhir *et al.* 2012). The fish family Haemulidae is divided into two subfamilies, Haemulinae and Plectorhynchinae (sweetlips), including approximately 17 genera and 145 species (Tavera *et al.* 2012).
They are concentrated around coral reefs in the morning, and also they are living in the sandy bed, Greek, and brackish estuary at night. To feed, they are moving from the rocks to sandy beds (Carpenter *et al.* 1996). Demersal fishes choose habitat based on the nature of the seabed so that it will have a significant impact on the distribution of the stock (Wootten 1991). Diets of these aquatic resources include small fish, crustaceans, and Polychaeta to highest frequency (Fischer and Bianchi, 1984). The ecological role of the resources in the marine ecosystem and food chain as well as reveals the importance of study and the economic value them from a fisheries perspective. Grunts in research projects evaluating have been observed in the reserves of 12 categories in the Oman Sea (Valinassab 2011) (Table1).

Table 1. Species of the family Haemulidae in bottom trawl catches in the Oman Sea

Species	English name	Ecological group	Economic value
Pomadasys kaakan	Javelin grunt	Demersal	commercial
Pomadasys maculates	Saddle grunt	Demersal	Non- commercial
Rhonciscus stridens	Striped piggy	Demersal	Non- commercial
Diagramma pictum	Painted sweetlips	Demersal	Non- commercial
Plectorhinchus pictus	Trout sweetlips	Demersal	Non- commercial
Pomadasys argyreus	Bluecheek silver grunt	Demersal	Non- commercial
Plectorhinchus gaterinus	Blackspotted rubberlips	Demersal	Non- commercial
Plectorhinchus flavomaculatus	Lemon sweetlips	Demersal	Non- commercial
Pomadasys opercularis	Smallspoted grunt	Demersal	Non- commercial
Pomadasys multimaculatum	Cock grunt	Demersal	Non- commercial
Pomadasys furcatus	Banded grunt	Demersal	Non- commercial
Plectorhinchus schotaf	Minstrel sweetlips	Demersal	Non- commercial

The research was to assess the stocks of the Persian Gulf and Oman Sea in the framework of regional project UNDP/FAO where 8 countries participated in the Persian Gulf and the Oman Sea basin was from 1976 to1979 (Sivasubramaniam 1981).The first study of the status of demersal fishes that grunts are included. In waters of the Oman Sea, more than six seasonal researches were performed in 1998 and 1999, and CPUA calculated and presented separately (Mohammad Khani 2005). With the completion of this project, it was decided that this study assess the monitoring and annual fluctuations of CPUA to be continued. As well as ongoing from 2000 to 2015 (Mohammadkhani 2001, Daryanabard *et al.* 2002, Daryanabard 2004, Valinassab 2011). This study was to estimate the grunts CPUA to separate areas and different depth layers and check its trend of the index from 2003 to 2013.

Materials and Methods

Study area and sampling stations

The study area was restricted to the Iranian waters of the Oman Sea, between longitudes 58° 50'E and 61°25'E (Figure 1) and isobaths from 10 to 100m. The total area was stratified into 5 strata (A to E). Each stratum was classified into four-depth substratum: 10-20, 20-30, 30-50 and 50-100 m. A total of 82 trawl stations were selected following a stratified random procedure, with the number of hauls in each substratum being proportional to the area of the (Table 2).

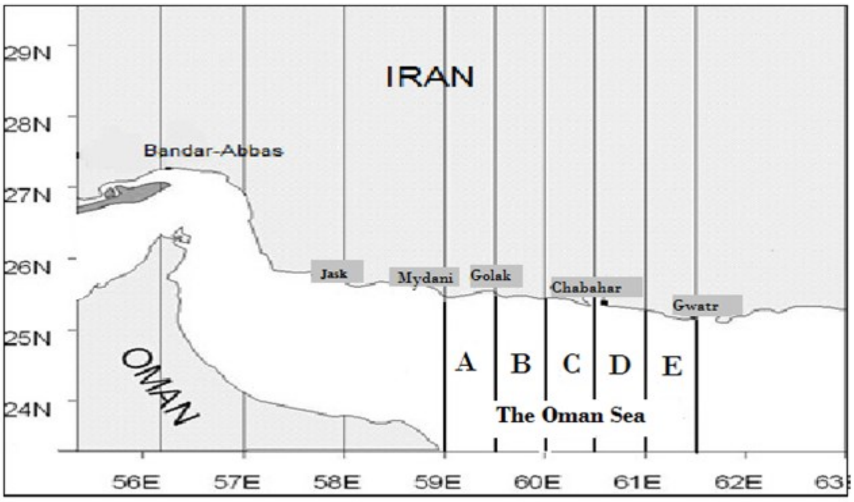

Figure 1. Map of the study area for assessment the Haemulids stock in the north of Oman Sea

Table 2. The number of trawl stations and areas of each stratum in the north of Oman Sea

Stratum	A	B	C	D	E
Area(n.m^2)	115.9	180.9	235	268.5	363.8
Station	15	17	20	20	20

Sampling

This research became operational from 2003 to 2013 by using R/V Ferdows-1. This vessel is a stern trawler (673 GRT, 45.4m length) and is equipped with a Global Positioning System (GPS), ITInet sounder system, two echo sounders and a bottom-trawl net (mesh size of cod-end 80mm and headline 72m). For each trawl, the following data were logged: date, time, duration, bottom depth, GPS position, towing distance, towing speed and distance from the coast. Each trawl lasted one-hour duration, following which the net was hauled and the catch sampled as follow:

(a) All large fish (such as sharks, rays, large catfish) were separated from the catch, counted and weighed;

(b) The remaining catch was distributed into equal-sized baskets and one in every five baskets was selected randomly;

(c) For each selected basket, all fish were identified to species (12 categories recognized, see Table 1), and animals in each group were counted and weighed;

(d) Total number and weight for each category were calculated by multiplying average (total) weight for the randomly selected baskets by the total number of baskets, then adding the number and weight of large fish. The information was recorded fish catch datasheet.

CPUA Estimation

CPUA were estimated based on Sparre and Venema (1992) and Valinassab *et al.* (2006). The towing distance at a given station in a given substratum (dj,k, in nautical miles, nm^2) was measured by GPS-plotter or using the formula:

$d_{j,k} = v_{j,k} t_{j,k}$

Where: $v_{j,k}$ speed of the vessel during towing (n.m. h71) at Station j in substratum k and t_{jk} =towing duration (hours) at station j in substratum k.

Swept area (aj,k, nm^2) at each station was then estimated As:

aj,k = dj,khX

Where dj,k=towing distance (nauthical mile) for station j in substratum k, h=headline height and X_1= wingspread coefficient= 0.7 (calculated using the ITI net-sounder; thus

wingspread is measured in relation to trawl mouth opening).
The catch per unit area (CPUAi,j,k, kg n.m.72) for category i at station j in substratum k is then given by
CPUAi,j,k = Ci,j;k/aj,k
Where Ci,j,k= catch (kg) of category i at station j in substratum k and aj,k= swept area (nm^2) for station j in substratum K.
Biomass (Bi,k) for each category in each substratum is then estimated as:
b= CPUAi,j,k/X2
Where X_2 =0.5 catch coefficient (using the value proposed by Sparre and Venema, 1992, Valinassab *et al.* 2006), for the multi-species demersal group in tropical and subtropical areas. And b (kg/nm^2) = the average biomass per unit area of the species in category i at station j in substratum k. Also, the Arc-GIS software (Version 10) was used for preparing the distribution pattern maps to accompany with Inverse Distance Method.

Results

A total of 12 species of Haemulids were found during this investigation (Table 1). Among the various species of the family (*Pomadasys kaakan*) frequency, they have more than other species in the study area and are considered as the most dominant species.
Distinct depth layers overlapping strata indicated that mean CPUA was relatively high (410 kg/nm2) in B stratum for a 10-20 m depth layer. As well the minimum CPUA was found in E stratum (205.9 kg/nm2) (Fig. 2). The overall distribution pattern of grunts showed that the maximum CPUA was observed for 20-30 m depth layer (423.7 kg/nm2) in D stratum; meanwhile, the minimum goes to E stratum (181.4 kg/nm2) (Fig. 3).

A	B	C	D	E
385.7	410.0	309.4	227.7	205.9

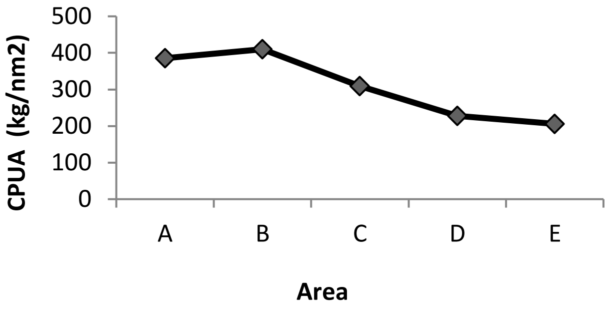

Figure 2. Mean CPUA depth layer 10 -20 (m) for Haemulids in the north of Oman Sea

In 30-50 depth layers, the highest and lowest mean CPUA were found in C stratum (730.1 kg/nm^2) and E stratum (118.9 kg/nm^2). (Fig.4).
Finally, maximum CPUA was estimated for depth layer 50-100m in D stratum (173.7 kg/nm^2) and on the other hand the minimum CPUA was found in B stratum (53.7 kg/nm^2) (Fig. 5).
The overall mean CPUA for Iranian waters of the Oman Sea was estimated at 261.3 (kg/nm2) from the year 2003 to 2013 (Tables 3 & 4). The presence of these resources in strata D (143. 4 kg /nm2) minimum CPUA was showed than any
other region. The distribution grunts in the Oman Sea, maximum CPUA were found in strata C (420. 7 kg/nm2) and E (306. 1 kg/nm2) from the year 2003 to 2013, respectively (Fig. 6).

A	B	C	D	E
391.9	294.8	334.4	423.7	181.4

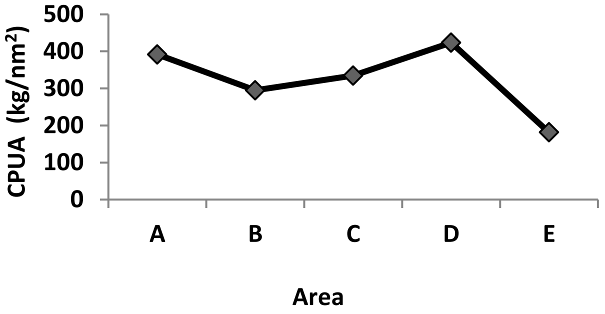

Figure 3. Mean CPUA depth layer 20 -30 (m) for Haemulids in the north of Oman Sea

A	B	C	D	E
291.0	217.9	730.1	202.7	118.9

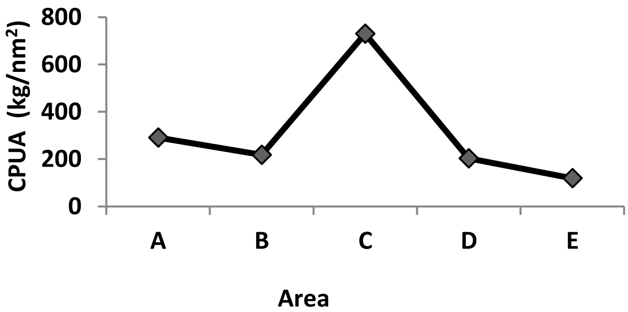

Figure 4. Mean CPUA depth layer 30 -50 (m) for Haemulids in the north of Oman Sea

A	B	C	D	E
167.2	53.7	105.0	173.7	149.4

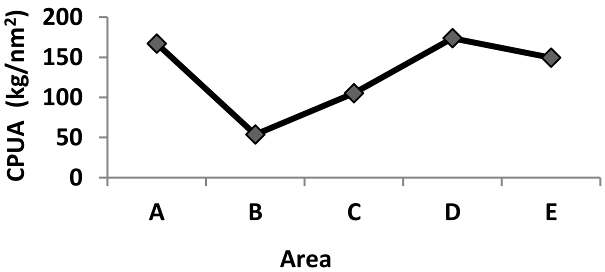

Figure 5. Mean CPUA depth layer 50 -100 (m) for Haemulids in the north of Oman Sea

Table 3. Mean CPUA for the Haemulids in different stratum

Year	A	B	C	D	E	Mean
2003	275.5	1420.2	648.1	133.1	2696.7	1252.3
2004	97.2	88.7	436.3	22.6	648.9	319.5
2005	572.8	473.9	746.1	43.5	543.9	461.3
2007	81.2	749.1	1564.7	269.0	922.9	790.8
2008	257.8	378.0	2473.4	419.1	212.5	746.8
2009	175.1	59.9	72.4	0.0	11.4	44.9
2010	162.3	0.0	1058.9	44.0	543.9	410.0
2011	271.7	119.8	668.4	53.7	183.2	250.3
2012	853.1	818.5	316.5	1798.0	319.7	790.6
2013	833.5	1213.8	428.8	85.4	38.7	390.0
Mean	179.0	266.1	420.7	143.4	306.1	

Table 4. Mean CPUA for the Haemulids in different depth layers

Year	10-20	20-30	30-50	50-100	Mean
2003	3203.8	1677.6	61.6	0.7	1252.3
2004	910.3	251.6	4.4	0.4	319.5
2005	1178.3	626.6	14.7	1.3	461.3
2007	762.1	1139.6	2340.7	81.5	790.8
2008	1662.9	252.9	339.3	373.5	746.8
2009	72.8	62.8	85.1	0.5	44.9
2010	812.6	1030.0	12.3	1.0	410.0
2011	272.9	507.0	499.3	35.9	250.3
2012	229.6	443.5	364.5	1533.8	790.6
2013	400.3	160.9	455.9	446.7	390.0
Mean	475.3	307.6	208.9	123.8	

The trend follows a special pattern so that it showed CPUA is increasing from the West to East of the Oman Sea in the areas. Also compared the results of CPUA have shown that stratum C and E than stratum D and A have the highest and lowest CPUA, respectively (Fig. 6).

Overall, results showed that mean CPUA was relatively high (475.3 kg/nm^2) in 10-20 m and (307.6 kg /nm^2) in 20-30m depth layer and markedly maximum than the deepest layers (50- 100 m, 123.8 kg/nm^2) (Fig. 7). CPUA in the different depth layers showed that in 10 to 30 m and 50 to 100 m, the highest and lowest depth layers, respectively. Hence, CPUA in 10-30 m depth layers is 4 times higher than in depth layer of 50-100m .This comparison was done for different depth layers and CPUA were observed in shallow waters of 10-20 m depth layer (Fig. 7). On the other hand, Chi-correlation function model showed a very strong correlation between CPUA trend and depth layers .So that the rate decreases with depth (Fig. 7).

A comparison of annual changes CPUA can be achieved to the details of the changes. In the last ten years, the highest CPUA has shown in year 2003(1252.3 kg/nm^2) and the lowest in year 2009 (44.9 kg/nm^2), respectively. Also, Monitoring of Haemulids in the Oman Sea from years 2003 to 2013, maximum CPUA with 1252.3 (kg/nm^2) and 746.8(kg/nm^2) was calculated in the years 2003 and 2008, respectively (Fig. 8).

The lowest CPUA after year 2009 is estimated in year 2011 (250.3 kg/nm^2). In Iranian waters of the Oman Sea, changes in the fish stock of mean CPUA from year 2003 to 2013 has shown downward trend (Fig. 8).

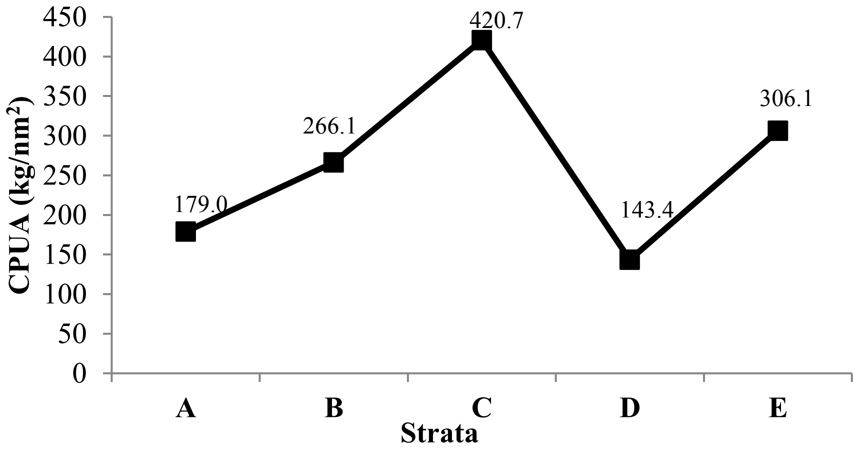

Figure 6. Mean CPUA in separate depth layers for Haemulids in the north of Oman Sea

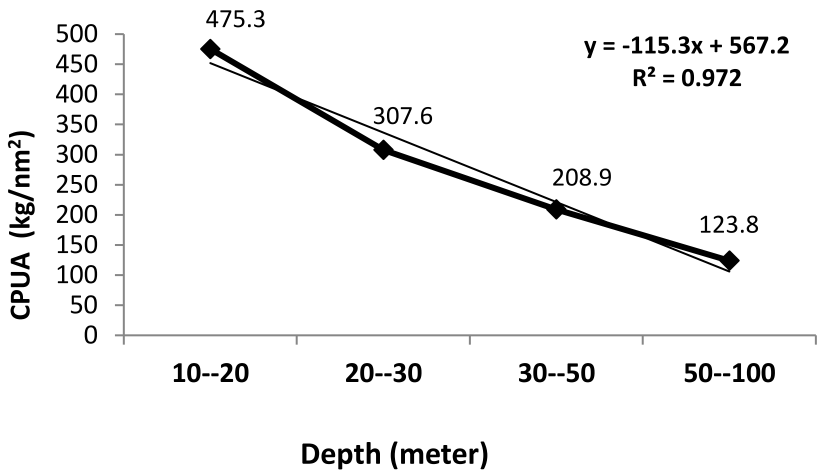

Figure 7. Mean CPUA in separate stratum for Haemulids in the north of Oman Sea

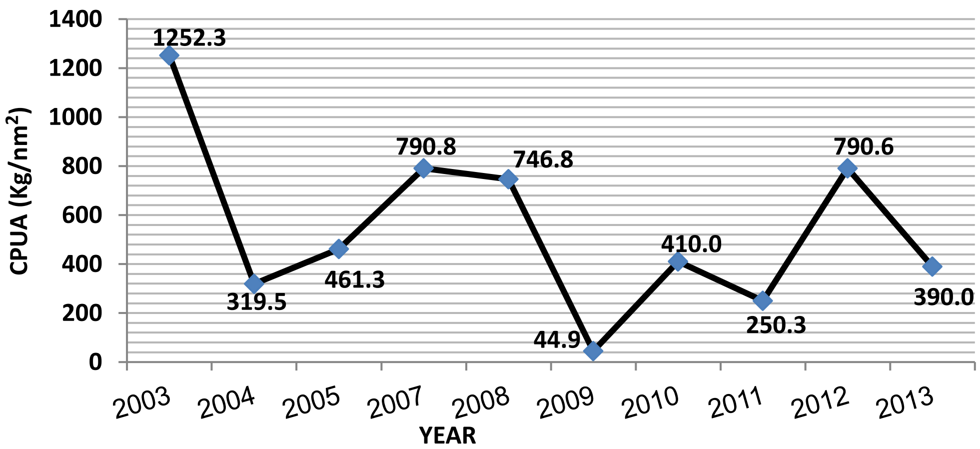

Figure 8. Annual mean CPUA trend of the Haemulids, in the north of Oman Sea

The spatial distribution has shown that the fish CPUA in all depth layer stratums C have highest density and abundance. As well as < 30 m depth layers in stratum E. On the other hand, stratum D in over 50 m depth layer revealed high density CPUA. However strata A and D have lowest frequency in all the depth layers, respectively. Maximum CPUA has observed in Central and Eastern regions and lowest in the Western regions in the Oman Sea (Fig. 9).

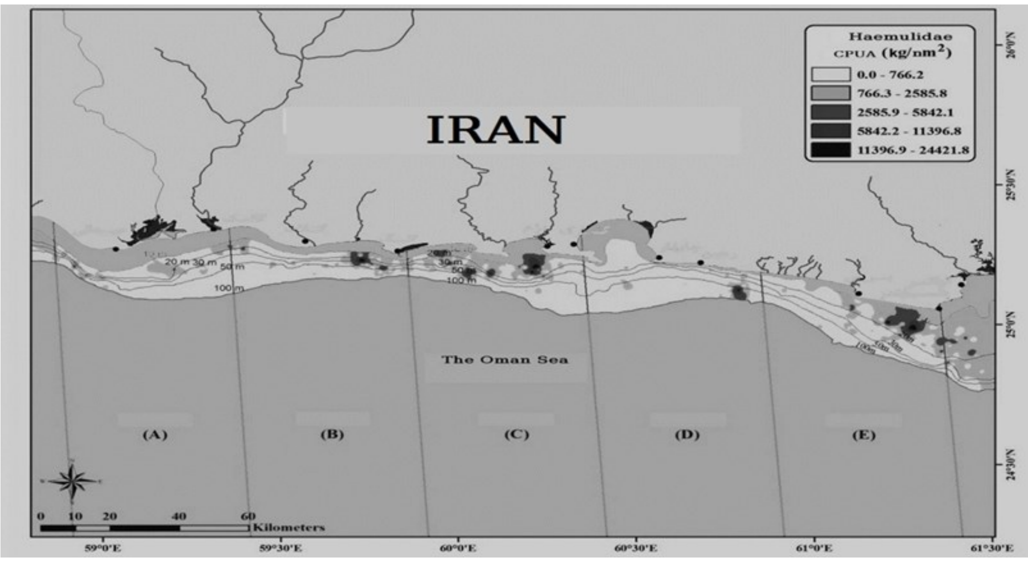

Figure 9. Density and spatial distribution of the Haemulids CPUA, in the north of Oman Sea

Discussion

Sustainability, in both ecological and socio-economic senses, is now recognized as the essential feature of the exploitation of living marine resources. A rational and long-term approach to management is necessary to achieve sustainable and successful exploitation (Valinassab *et al.* 2006).

Haemulids during years 2003-2013 revealed that the value of this index in the Oman Sea, excluding 2003, remained constant in most years and 2009 due to a decrease in performance trawl only increase the population of jellyfish, the amount of catch, as CPUA was reduced in year 2002. Comparison CPUA into 5 strata (A to E) were showed that the highest distribution and abundance in years 2003 and 2007, respectively. As well as, the rate in stratum C and E were good condition from Haemulids in year (2012) Valinassab *et al.* 2005). Stratum C is always good condition in terms of CPUA and showed the highest density in the central regions of the Oman Sea in all these years. And stratum E is the most eastern regions, too, because of the importance these resources is located in the second, especially in recent years (Valinassab 2012). Sea currents by creating upwelling or down welling to enrich and prosperity in the fishing region indirectly (Nia-Maymandi and Khorshidian 1993). As well as, these fish in the water with low salinity compatible (Fishbase 2019).The highest CPUA in the depth layers 10-30 m Due to favorable ecological conditions near the shore. Also Grunts chose simple biotopes so they prefer to focus depth layers less than 30 m (Helfman *et al.* 1982). So, there was a descending trend of CPUA of Haemulids with increase of depth. And other words, the depth layer 30(m) with an area of significant but are not part influence of the CPUA (Valinassab *et al.* 2010). The best place to catch these stocks was found stratum E among 5 strata. Generally, coastal features has caused that these areas are particular importance and dependence on fish resources in various ways effect on abundance and biodiversity (Nia-Maymandi and Khorshidian 1993).

On the other hand, due to the abundance of food and security is particular importance to ecological aspects. These areas are indeed the sea bio-banks (Mahin *et al.* 2014). Fishing increased in the past decade, as well as abundance and fish biomass decreased in all regions. As, frequency of 30% in 2003 to about 8% in 2011 declined (Daryanabard *et al.* 2012).

Various factors are important in the process. Iranian waters of the Oman Sea is a place for Trawler vessels that causes minimum catch per unit area, and this may be caused by excessive fishing pressure in these regions (Valinassab *et al.* 2010). Also, considering the CPUA reported by Valinassab *et al.* (2011) ,the rate fluctuations associated with that can be caused by weather conditions, availability stock and can be reduced to fish, trophic levels is leading and then a phase of decline or stagnation, catching up with the report presented by Pauly *et al.* (1998) agrees. Thus, despite existing restrictions on fishing effort (a ban of trawling for fish in the Oman Sea), it appears that there remains a need for additional management measures (Valinassab et al . 2004).

Concerning the implementation of the ban on fishing season from March to September , the croakers can be expected that during the peak spawning grunts also be stopped, Besides, extensive mesh size of the croakers in the area ban to be put into effect unlikely(Azhir *et al.* 2012). In the Persian Gulf and Oman Sea to reduce the population of many species has been observed in recent years. Therefore it is necessary that a part of the year as the fishing ban declared aquatic species or group, to provide an opportunity to revive stocks (Valinassab *et al.* 2003). Living components of a system varies with environmental conditions and stability ecosystem to needs strategic and dynamic nature so it revealed some variability.

Conclusions

The fishing pressure in some coastal areas especially strata D more than in other regions. Therefore, it is more focused on the fisheries management optimal management is an important step to conserve of the stock. It is necessary to always declared as the fishing ban in part of the year. In this way, fishing pressure will be reduced in these areas and it provides the stock reconstruction opportunity. As well as, it could be balanced amount of the aquatic resource and level of sustainable exploitation.

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