Determination of CPUA and distribution pattern of families Haemulidae, Nemipteridae and Ariidae in the Oman Sea

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Abstract

This trawl survey was carried out during 2013 for the stock assessment of families Haemulids, Nemipterids and Ariids in the Oman Sea. Sampling was carried out at five different stratum and depths. The highest value of CPUA of Haemulidae was estimated for *Pomadasys stridens* in "B" stratum (885.78 kg nm^{-2}), for *Pomadasys kaakan* at depths of 10-20 m (330.35 kg nm^{-2}), and for Nemipteridae it was estimated for *Nemipterus japonicus* in "D" stratum (1042.31 kg nm^{-2}) at 30-50 m depths (1734.97 kg nm^{-2}), and for Ariidae, it was estimated for *Netuma thalassina* in the stratum B (752.64 kg nm^{-2}) at 20-30 m depths (428.33 kg nm^{-2}). The highest biomass for Haemulidae was estimated in stratum B (320.53 ton) at 50-100 m depths (282.98 tons), and for Nemipteridae in "D" stratum (559.72 tons) and at depths of 30-50 m (604.04 tons), and for Ariidae it was estimated in "B" stratum (272.35 tons) and at 50-100 m depths (255.12 ton). Based on the results obtained, the highest species diversity for Haemulids was in "A" stratum at depths less than 50 m, while for Nemipterids it was similar in the total study area and different depth layers. Highest species diversity for Ariids were found in "A" and "D" strata at depth layers of 10-20 m and 30-50 m, respectively. In light of the fact that fishing efforts decreased during these years, our results illustrate that CPUA and biomass have ascending trends which indicate the relative stability of the stocks of these families.

Keywords: CPUA, Species diversity, Nemipteridae, Haemulidae, Ariidae, Oman Sea

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Introduction

Estimates of abundance and biomass are necessary for fisheries management purposes, and the demand for such information has increased dramatically in recent years. Indices of stock assessment and population dynamics such as Catch Per Unit Area (CPUA) and biomass rates required for quantifying and understanding of ecological processes are integral parts of knowledge for an effective fishery management (Myade *et al*., 2011).

Suitable assessment and management of a fishery requires an understanding of biology, life cycle and distribution of the species on which it is based and the aim of resources exploitation relative to the long-term sustainable levels (King, 2007).

The Oman Sea with an area of 94,000 km^2 and a depth reaching 3200 m (Valinassab *et al*., 2006), connects the Persian Gulf to the north-west Arabian Sea and then to the Indian Ocean. The water of the Oman Sea is unique inherently and contains unusual faunal assemblages (Carpenter *et al*., 1997). The topography of the bottom is mostly flat, featureless, dominated by soft sediments and with a few rocky areas in the Oman Sea (Valinassab *et al*., 2006).

Demersal fish are one of the most important groups for the fishing industry (Planning and Development Department, 2013) and demersal fish assessment is preconditional for optimal fishing (Masrikat, 2012). The first studies about Oman Sea demersal assessment was carried out in 1967-1979 by UNDP/FAO (Sivasubramaniam, 1981). Although other investigations have documented the fisheries and biomass of multi-species demersal fish in the Persian Gulf and Oman Sea (Daryanabard *et al*., 2003; Valinassab *et al*., 2003, 2004, 2008, 2011 and 2013a), these researches are not enough and supplemental information is needed. The fish target species of this investigation belongs to three main families of Perciformes, including: Haemulidae, Nemipteridae and Siluriformes including: Ariidae.

The Haemulidae family (Grunts), comprises 17 genera and about 145 species (with 17 identified species in the Oman Sea) distributed throughout the world, existing mainly in marine and estuarine environments (Iwatsuki *et al*., 2000; Lindeman and Toxey, 2002; Nelson, 2006; Valinassab, 2013b).

The Nemipteridae family belongs to the Perciformes order, has medium body sizes, and is common in bottom trawls (Gomelyuk, 2009). This family comprises 5 genera with about 64 species (with 19 identified species in the Oman Sea) (Russell, 2001; Nelson, 2006; Valinassab, 2013b).

The Ariidae family belongs to the order Siluriformes which is mainly marine (up to 100 m depth). They live in fresh or brackish water; worldwide, in tropical to warm temperate regions. This family has a total of 21 genera and 150 species (with 5 identified species in the Oman Sea) (Marceniuk and

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Ferraris, 2003; Teugels, 2003; Nelson, 2006; Valinassab, 2013a).

The main objectives of this study were:

(1) To estimate the biomass and CPUA of Nemipetridae, Haemulidae and Ariidae families in different strata and depth layers; and (2) To determine their catch composition and distribution.

Materials and methods

Study area and data collection

This study was carried out in coastal waters of the northern Oman Sea (58° 55´ E to 61° 25´ E), Iran (Fig. 1). The study area was divided into five strata (A, B, C, D, and E) and each stratum was classified into 4 layers according to their isobath depths (10-20, 20-30, 30-50 and 50-100 m). The survey was carried out in 2013 using R/V Ferdows-1 (673 GRT, 45.4 m overall length), equipped with GPS- Plotter, ITI net sounder and a bottom-trawl net (mesh size of cod end 80 mm and headline 72 m).

Sampling was conducted at 80 stations randomly, and at each station a one-hour haul was taken at the speed of 3 kn. The total area of each stratum or depth layer was calculated by using a plannimeter, which is given in Tables 1 and 2, respectively. The time and GPS position of the start and end of shooting and hauling were estimated for all towing. Total catch of fish on board were evacuated and fishes of Haemulidae, Nemipteridae and Ariidae families were separated, counted and weighed, and separation process was accomplished according to species.

Estimation of CPUA and biomass indices Sparre and Venema's (1992) method was used to calculate the indices of CPUA and Biomass in different strata and depth layers from swept area method (Sparre and Venema, 1992):

I. Calculating the amount of ($D_{j,k}$ in nautical miles, nm)
   $D_{j,k}= v_{j,k}\ t_{j,k}$
   $D_{j,k}$: towing distance (miles), $v_{j,k}$: average speed ($nm.h^{-1}$) at station j in substratum k, $t_{j,k}$: sampling time (hours) at station j in substratum k

II. Calculating the amount of ($a_{j,k}\ nm^2$)
   $a_{j,k}= d_{j,k}\ h\ x_1$
   $a_{j,k}$: Swept Area (mile), $d_{j,k}$: towing distance (mile), h: headline length (m)-that for the conversion to nm on 1852 Was divided, x_1: wing spread coefficient= 0.6

III. Calculating the value of ($CPUA_{i,j,k}\ nm^2$)
   $CPUA_{i,j,k}= Cw_{i,j,k}/a_{j,k}$
   $CPUA_{i,j,k}$: catch per unit area for family i at Station j in substratum k, $Cw_{i,j,k}$: catch (kg) of family i at Station j in substratum k, $a_{j,k}$: Swept Area ($miles^2$) for Station j in substratum k

IV. After calculating the mean of CPUA, biomass ($B_{i,k}$) for each family was calculated by the formula:
   $B_{i,k}= CPUA_{i,j,k} \times A/0.5$
   A: total area on the basis of nm^2, 0.5: catch coefficient.

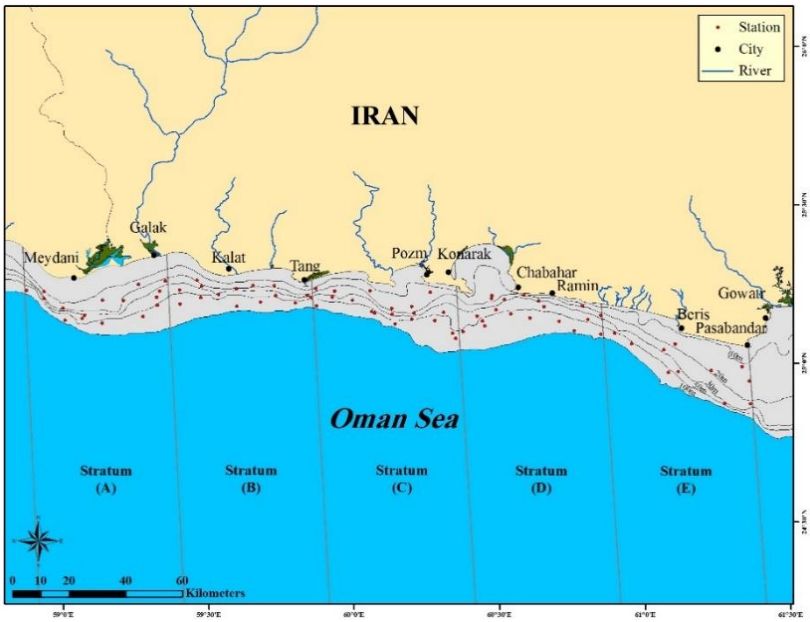

Figure 1: Map of sampling area along the Oman Sea, 2013.

Table 1: The number of trawl stations and area of each stratum in the Oman Sea, 2013.

Stratum	**A**	**B**	**C**	**D**	**E**	**Total**
Area (nm^2)	116.0	180.9	235.0	268.5	363.8	1164.2
Proportion of total area (%)	9.96	15.53	20.18	20.18	31.24	100
Station number	16	15	19	19	11	80

Table 2: The number of trawl stations and area of each depth layer in the Oman Sea, 2013.

Depth layer	**10-20m**	**20-30m**	**30-50m**	**50-100m**	**Total**
Area (nm^2)	358.3	178.2	174.08	453.6	1164.2
Proportion of total area (%)	30.77	15.30	14.95	38.96	100
Station number	20	14	18	28	80

Species diversity

To calculate species diversity, Shannon diversity index was used based on the following formula (Shannon, 1948; Nolan and Callahan, 2006):

$$H' = -\sum_{i=1}^{s} Pi \ln (Pi)$$

Where H' is the species diversity index, s is the number of species, and pi is the proportion of individuals of each species belonging to the i_{th} species of the total number of individuals.

Distribution pattern

After calculating CPUA for each station and possession of latitude and longitude using software Arc-GIS version 9.3, distribution map for Nemipteridae, Haemulidae and Ariidae families was plotted.

Statistical analyses

Statistically, based on Q-Q Plot and Shapiro-Wilk test, there was no normal distribution in CPUA values for families Nemipteridae, Haemulidae and Ariidae. Therefore, natural logarithm was used to normalize the CPUA data, based on Q-Q Plot, Shapiro-Wilk and Kolmogorov-Smirnov test, data of Nemipetridae and Ariidae were normal but data of Haemulidae were not normal. To determine the significant difference between strata and depth layers for Nemipetridae and Ariidae, the parametric test of one way ANOVA and Tukey was applied and for Haemulidae, the non-parametric test of Kruscal-Wallis and Mann-Whitney U test was used.

Results

Three families of fish Nemipteridae, Haemulidae and Ariidae were targets of this investigation among the total collected samples. In the present study, we identified 6 species belonging to Haemulidae family (*Pomadasys argyreus*, *P. stridens*, *P. maculatus*, *P. commersonnii*, *P. kaakan*, *Plectorhinchus flavomaculatus*), 7 species belonging to Nemipteridae family (*Scolopsis taeniata*, *S. vosmeri*, *Parascolopsis aspinosa*, *P. baranesi*, *Nemipterus japonicus*, *N. randalli*, *N. peronii*,) and 2 species belonging to Ariidae family (*Netuma thalassina*, *Plicofollis dussumieri*). The CPUA, biomass and species diversity for each species was estimated separately for different strata and different depth layers.

CPUA values

The mean CPUA values estimated for each target species of Haemulidae, Nemipteridae and Ariidae, and the obtained results have been tabulated in Tables 3 and 4. Mean CPUA for all Haemulids was estimated as 404.4 kg/nm^2, with the highest value for B stratum (1315.0 kg nm^{-2} -50% in all strata) at depths of 30-50 m (493.9 kg nm^{-2} - 32% in all depth) and the minimum value was estimated in E stratum (41.9 kg nm^{-2}-1.6% in all strata) at 20-30 m depth s(174.3 kg/nm^2 - 11% in all depth). Among six identified species of Haemulids in the bottom trawl catches, the highest mean CPUA value belonged to *P. stridens* and *P. kaakan* with total mean CPUA of 168.8 kg nm^{-2} (42%) and 189.89 kg nm^{-2} (47%), respectively. The CPUA index in different strata showed significant differences (Table 5) ($p<0.05$).

Mean CPUA for all Nemipterids was estimated as 855.7 kg nm^{-2}, with maximum CPUA value for D stratum (1992.7 kg nm^{-2}-51% in all strata) at depth layers of 30-50 m (3005.5 kg nm^{-2}-73% in all depths) and minimum value was estimated in E stratum (313.1 kg nm^{-2}- 8% in all strata) at depths of 20-30 m (90.1 kg nm^{-2}-2.2% in all depths).

Table 3: Mean CPUA (kg nm^{-2}) for each strata and different identified specie in the Oman Sea, 2013.

Stratum / Family/Species	A	SD	CV	B	SD	CV	C	SD	CV	D	SD	CV	E	SD	CV	Total
Haemulidae																
P. argyreus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.6	1.3	0.00	0.00	0.00	0.00	0.14
P. stridens	128.1	107.56	74.5	886	641.1	112.6	23.2	28.8	119	59.7	145.7	130.2	0.00	0.00	0.00	168.8
P. maculatus	80.8	45.16	91.9	37.7	66.9	148.9	100	276.6	165.8	14.7	28.3	195.4	7.7	8.2	200	39.9
P. commersonnii	1.4	8.40	200	0.00	0.00	0.00	6.7	27.55	200	8.1	22.7	137.3	6.3	6.7	200	5.34
P. kaakan	508.5	814.77	97.9	391.5	499	111	344.60	432	143.1	9.4	31.6	200	27.8	29.5	200	189.9
P. flavomaculatus	1.9	5.35	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	167.65	0.00	0.00	0.00	0.19
Total	**720.7**			**1315**			**464.5**			**92.5**			**41.9**			**404.4**
Nemipteridae																
S. taeniata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.2	0.5	200	0.00	0.00	0.00	0.04
S. vosmeri	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.8	2	200	0.00	0.00	0.00	0.18
P. aspinosa	0.00	0.00	0.00	0.00	0.00	0.00	12.4	14.5	200	57.9	54.9	184.9	28.4	82.2	177.15	24.72
N. japonicus	284.4	105.5	49.73	499.8	395.4	121.4	248.6	422.4	118.5	1042.3	2384.4	177.4	71.7	200.15	173.2	418.98
N. randalli	2.9	2.3	200	31	27.6	116.2	171.6	174.1	150.6	891.45	1611.2	159.9	281.2	873.8	191.3	333.21
N. peronii	25.8	40	90.7	63.3	114.8	137.3	17.5	18.3	94.7	0.00	0.00	0.00	200.2	469.3	136	78.49
P. baranesi	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.3	200	0.00	0.00	0.00	0.00	0.00	0.00	0.05
Total	**313.10**			**594.10**			**450.4**			**1992.7**			**581.48**			**855.7**
Aridae																
N. thalassina	580.85	919	106.2	752.6	443.3	64.6	386.3	478.9	81.9	22.5	18.4	60.7	4.7	16.7	200	259.48
P. dussumieri	243	643	192.1	0.00	0.00	0.00	0.00	0.00	0.00	13.85	33	188.95	0.00	0.00	0.00	27.40
Total	**823.8**			**752.6**			**386.3**			**36.4**			**4.7**			**286.9**

Table 4: Mean CPUA (kg nm^{-2}) for different depth layers among the species in the Oman Sea, 2013.

depth layer / Family/Species	10-20	SD	CV	20-30	SD	CV	30-50	SD	CV	50-100	SD	CV	Total
Haemulidae													
Haemulidae	0.00	0.00	0.00	0.21	0.56	223.61	0.75	1.23	223.61	0.00	0.00	0.00	0.14
P. argyreus	95.63	132.76	83.58	16.02	125.60	217.40	103.35	220.60	194.94	311.95	650.02	203.12	168.8
P. stridens	34.93	27.00	69.91	6.96	16.82	119.41	123.50	249.56	170.28	24.71	47.94	164.22	39.91
P. maculatus	6.41	5.99	223.61	0.88	7.51	223.61	21.59	27.75	137.98	0.00	0.00	0.00	5.34
P. commersonnii	330.35	616.91	116.89	150.16	699.57	169.53	244.70	518.35	190.38	73.49	108.07	133.41	189.88
P. kaakan	0.63	4.79	223.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Total	**468**			**174.3**			**493.9**			**410.2**			**404.4**
Nemipteridae													
S. taeniata	0.15	1.74	223.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
S. vosmeri	0.61	7.26	223.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
P. aspinosa	0.37	1.24	138.79	0.32	2.83	200	5.81	14.31	145.91	60.81	382.84	119.04	24.72
N. japonicus	47.62	254.12	93.00	65.27	213.11	75.18	1735	8079.3	149.58	346.29	1529.8	80.85	418.98
N. randalli	1.81	21.48	223.61	34.40	99.93	119.80	961.81	6028.7	214.52	471.18	2372.94	94.98	333.21
N. peronii	39.49	311.11	118.90	27.75	80.70	93.74	302.88	872.4	186.92	43.13	461.80	218.64	78.49
P. baranesi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.96	223.61	0.05
Total	**90.1**			**127.8**			**3005.5**			**921.6**			**855.7**
Aridae													
N. thalassina	108.96	226.17	123.79	428.33	918.65	107.95	339.69	421.10	103.56	281.23	421.04	140.58	259.48
P. dussumieri	86.63	574.19	210.17	0.67	1.73	137.43	2.55	14.44	223.61	0.65	1.86	223.61	27.40
Total	**195.6**			**429**			**342.3**			**281.9**			**286.9**

Table 5: Significant differences of CPUA index in different strata (*indicates significant differences). Oman Sea, 2013.

Stratum	A	B	C	D	E
A	-	-	-	*	-
B	-	-	-	*	-
C	-	-	-	*	-
D	*	*	*	-	-
E	-	-	-	-	-

Among the seven identified species of Nemipterids in the bottom trawl catches, the highest CPUA belonged to *N. japonicus* and *N. randalli* with total mean CPUA of 418.98 (49%) and 333.21 kg/nm^2 (38.9%), respectively. There were significant differences for CPUA index for different depth layers with the greatest difference being for depth layer 10-20 m with other depths

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($p<0.05$), but it does not reveal significant difference amongst different strata.

Mean CPUA for all Ariids was estimated as 286.9 kg/nm^2. Maximum CPUA value for this family was estimated in A stratum (823.8 kg/nm^2-41.1% in all strata) and at 10-20 m depths (429 kg nm^{-2}-34.4% in all depths) and minimum value for this family was estimated in E stratum (4.7 kg/nm^2–0.23%) and 10-20 m depth (195.6 kg nm^{-2}–15.7%). Between the two identified species of Ariids in the bottom trawl catches, the highest CPUA belonged to the *Nethuma thalassina* with total mean CPUA of 259.48 kg nm^{-2} (90.4%).

Biomass values

Biomass values calculated for Haemulids, Nemipterids and Ariids fishes, for 5 strata are given in Table 6 and for 4 depth layers are given in Table 7. The total biomass estimated for Haemulids, Nemipterids and Ariids fishes were 941.5, 1992.48 and 668.0 tons, respectively.

The highest biomass for Haemulids was estimated in B stratum (475.8 tons) and 50-100 m depth layers (372.1 tons). Among all identified species of Haemulidae family, the highest biomass in all strata and all depths belonged to *P. kaakan* (442.14 ton). The lowest biomass of this family was observed in E stratum (30.5 tons) and at 20-30 m depths (62.1 tons). Amongst the identified species, the lowest biomass was estimated for *P. argyreus* (0.34 tons).

The highest biomass for Nemipterids was estimated in D stratum (1070.1 tons) and at 30-50 m depths (1046.4 tons). Among all identified species of Nemipteridae, the highest biomass in all strata and all depth belonged to *Nemipterus japonicus* (975.6 tons). The lowest biomass of this family was estimated in A stratum (72.6 tons) and at 20-30 m depths (45.5 tons). Also the lowest biomass which was estimated in all strata and all depths belonged to the *S. taeniatus* (0.10 tons) and *N. peronii* (0.12 tons).

The highest biomass for Ariids was estimated in B stratum (272.4 tons) at 50-100 m depths (255.7 tons). Among two identified species of Ariidae family, the highest biomass in all strata and all depth belonged to *N. thalassina* (604.2 ton). The lowest biomass of this family was observed in E stratum (3.4 tons) and depth layers of 10-20 m (140.2 tons). Also the lowest biomass estimated in all strata and all depths, belonged to *P. dussumieri* (63.8 tons).

Species diversity

Shannon index (1948) was used to determine the species diversity in different strata and depth layers. This investigation for different strata revealed that the highest diversity was for Haemulids and Ariids families in A stratum and Nemipterids in E stratum (Table 8).

Table 6: Biomass (tons) of Haemulids, Nemipterids and Ariids in different strata. Oman Sea, 2013

Family-Species	A	B	C	D	E	Total
Haemulidae						
P. stridens	29.71	320.53	10.89	32.07	0	393.22
P. kaakan	117.94	141.66	157.24	5.02	20.25	442.14
Other Haemulids	19.55	13.61	50.17	12.61	10.25	106.1
Total	**167.2**	**475.8**	**218.3**	**49.7**	**30.5**	**941.5**
Nemipteridae						
N. japonicus	65.99	180.86	116.82	559.72	52.19	975.58
N. randalli	0.67	11.22	80.67	478.71	204.60	775.87
Other Nemipterids	5.97	22.91	14.19	31.65	166.3	241.5
Total	**72.63**	**214.99**	**211.68**	**1070.08**	**423.09**	**1992.5**
Ariidae						
N. thalassina	134.75	272.35	181.57	12.11	3.41	604.2
P. dussumieri	56.37	0.00	0.00	7.44	0.00	63.8
Total	**191.1**	**272.4**	**181.6**	**19.5**	**3.4**	**668**

Table 7: Biomass (tons) of Haemulids, Nemipterids and Ariids in different depth. Oman Sea 2013.

Family-Species	10-20m	20-30m	30-50m	50-100m	Total
Haemulidae					
P. stridens	68.53	5.71	35.99	282.99	393.22
P. kaakan	236.73	53.54	85.20	66.68	442.14
Other Haemulids	30.47	2.87	50.71	22.41	105.78
Total	**335.35**	**62.12**	**171.9**	**372.08**	**941.5**
Nemipteridae					
N. japonicus	34.12	23.27	604.04	314.13	975.58
N. randalli	1.30	12.26	334.86	427.43	775.86
Other Nemipterids	29.08	9.97	107.5	94.44	241.06
Total	**64.5**	**45.5**	**1046.4**	**836**	**1992.5**
Ariidae					
N. thalassina	78.08	152.71	118.26	255.12	604.23
P. dussumieri	62.08	0.24	0.8904	0.59	63.79
Total	**140.2**	**153.0**	**119.2**	**255.7**	**668**

Table 8: Species diversity of Haemulids, Nemipterids and Ariids in different strata. Oman Sea 2013.

Family-Species	A	B	C	D	E	Total
Haemulidae						
P. maculatus	0.13	0.07	0.11	0.14	0.04	0.13
Other Haemulids	0.27	0.06	0.24	0.11	0.13	0.17
Total	**0.40**	**0.13**	**0.35**	**0.25**	**0.17**	**0.30**
Nemipteridae						
N. japonicus	0.06	0.08	0.16	0.16	0.07	0.16
N. randalli	0.02	0.11	0.12	0.11	0.13	0.13
Other Nemipterids	0.12	0.09	0.05	0.03	0.21	0.11
Total	**0.20**	**0.28**	**0.33**	**0.30**	**0.41**	**0.40**
Ariidae						
N. thalassina	0.16	0.00	0.00	0.15	0.00	0.10
P. dussumieri	0.14	0.00	0.00	0.10	0.00	0.15
Total	**0.30**	**0.00**	**0.00**	**0.25**	**0.00**	**0.25**

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Furthermore, for different depths, the maximum diversity of Haemulids was estimated at 20-30 m depths, that of Nemipterids was approximately equal in all depths (10-100 m) and that of Ariids was in 10-20 m depths (Table 9). The highest diversity in all strata and all depths belonged to *P. maculatus*, *N. japonicus* and *P. dussumieri*.

Distribution pattern

Distribution pattern was plotted for Haemulidae, Nemipteridae and Ariidae with software Arc-GIS (Figs. 2-4). Based on the obtained results, Haemulids are mostly distributed in A and B strata; and Nemipetrids and Ariids fishes are mostly distributed in D and A strata, respectively.

Table 9: Species diversity of Haemulids, Nemipterids and Ariids in different depth. Oman Sea 2013.

Family-Species	10-20m	20-30m	30-50m	50-100m	Total
Haemulidae					
P. maculatus	0.12	0.12	0.16	0.07	0.13
Other Haemulids	0.21	0.29	0.19	0.05	0.17
Total	**0.33**	**0.41**	**0.37**	**0.12**	**0.30**
Nemipteridae					
N. japonicus	0.12	0.12	0.16	0.12	0.16
N. randalli	0.04	0.14	0.14	0.10	0.13
Other Nemipterids	0.19	0.13	0.09	0.14	0.11
Total	**0.35**	**0.39**	**0.39**	**0.36**	**0.40**
Ariidae					
N. thalassina	0.16	0.00	0.11	0.00	0.10
P. dussumieri	0.14	0.01	0.16	0.02	0.15
Total	**0.30**	**0.02**	**0.27**	**0.02**	**025**

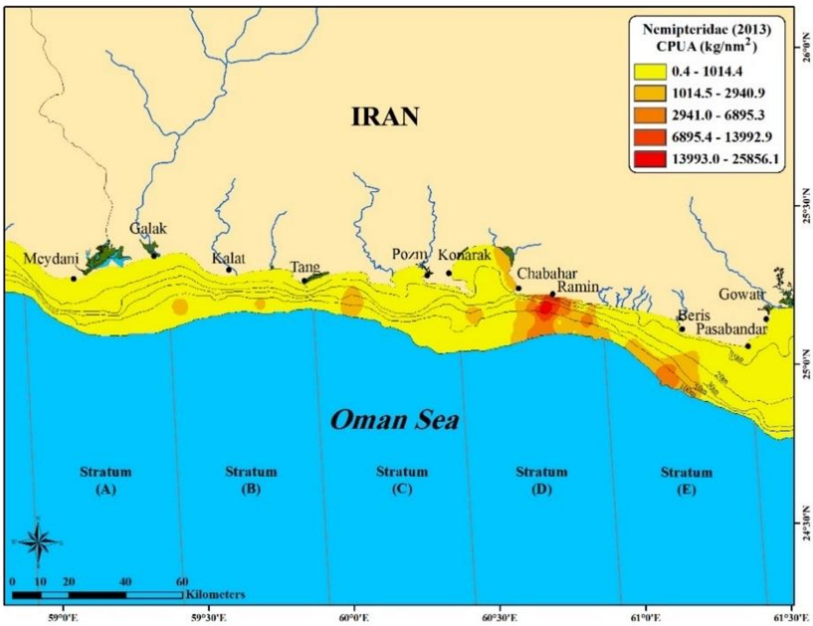

Figure 2: Distribution pattern of Nemipetridae, Oman Sea, 2013.

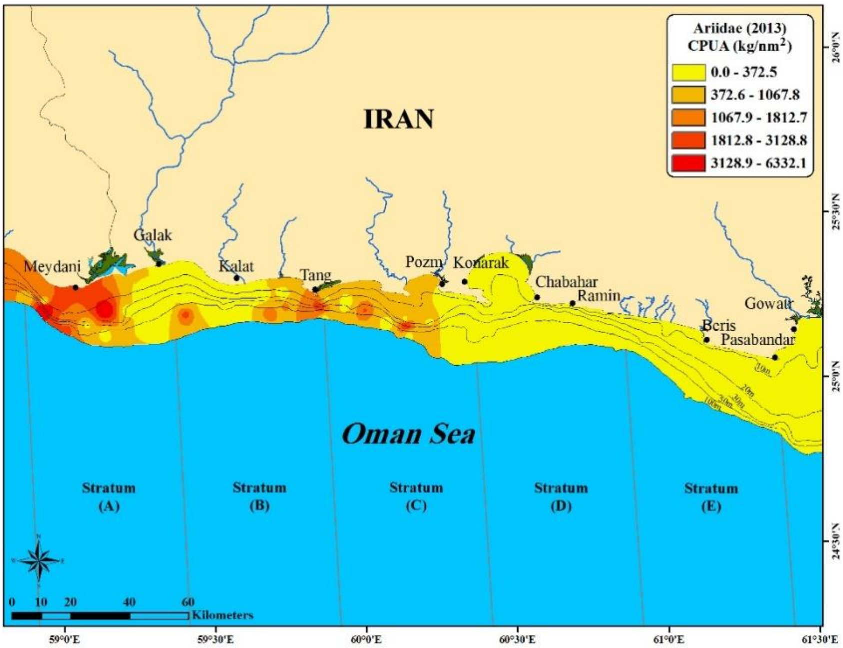

Figure 3: Distribution pattern of Ariidae, Oman Sea, 2013.

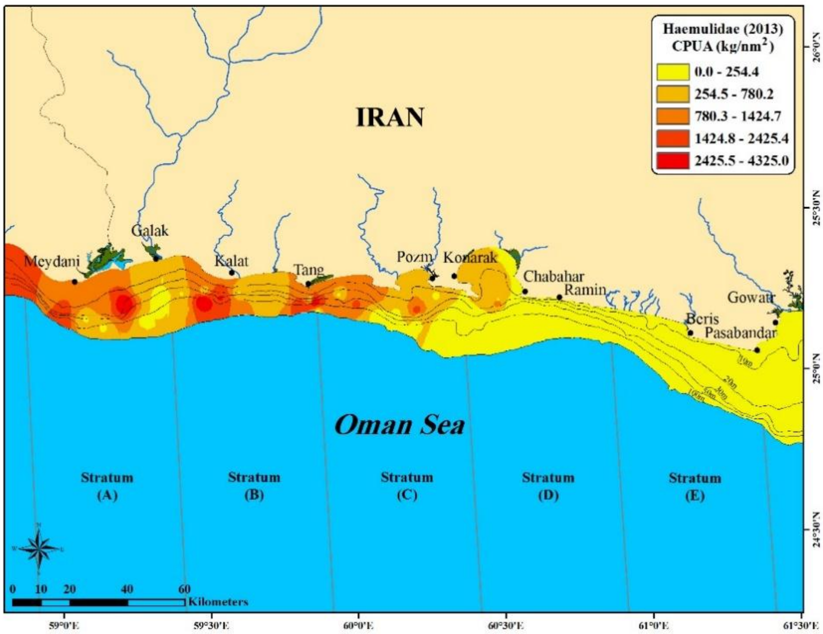

Figure 4 Distribution pattern of Haemulidae, Oman Sea, 2013.

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 for management is necessary to achieve sustainable and successful exploitation (Jennings et al., 2001). It is essential to monitor the status of the resource including the collection of biological data. CPUA and biomass estimates are commonly used as stock indices for management of demersal resource species (Sparre and Venema, 1992). CPUA and biomass values of the families Nemipetridae, Ariidae and Haemulidae were estimated.

Haemulidae

The highest mean value of CPUA for Haemulidae is related to B stratum with an amount of 1315 kg/nm^2 at 10-20 m and 30-50m depth layers with amounts of 468 kg nm^{-2} and 493.9, respectively. Also the lowest mean value CPUA for Haemulidae was detected in stratum E (41.9 kg nm^{-2}) at 10-20m depths (174.3 kg nm^{-2}). Based on previous studies during years of 2005, 2007, 2008, 2010 and 2011, the highest mean value of CPUA for Haemulidae was estimated in C stratum (Valinassab *et al*., 2011 and 2013a). It was determined that this family is distributed mainly at depths lower than 50 m (Dayanabard *et al*., 2003; Valinassab *et al*., 2011 and 2013b). The highest biomass for Haemulidae was detected in stratum B (475.8 ton) and 50-100 depth layers (372.1 ton). Reviews of previous studies show that the highest biomass for Haemulidae was mostly in stratum C and E and 10-20m depth layers (Dayanabard *et al*., 2003; Valinassab *et al*., 2006, 2011 and 2013b).

Among the species of Haemulidae family, *P. kaakan* had a high economic value. In another study, the highest CPUA and biomass values for *P. kaakan* was obtained in the eastern part of the Oman Sea, mainly in stratum E and depths of 10-20 m. The highest value of this index in 2003 in E stratum and depths of 10-20 m were 2426.5 and 1483.05 kg nm^{-2}, respectively. The highest biomass for this species in 2003 and 2009 was estimated in E stratum with a value of 1772.8 tons at depths of 10-20 m and with a value of 1382.9 tons, respectively. In previous years, the highest density and biomass of *P. kaakan* was observed at depths less than 20 m in the Oman Sea. In recent years, especially after 2007, the highest density and biomass were mainly at depths greater than 30 m (Dayanabard *et al*., 2003; Valinassab *et al*., 2003, 2004, 2006, 2008, 2011 and 2013a).

Nemipteridae

Based on the exploratory surveys and experimental fishing, Nemipterids are abundant beyond 50 m but show higher concentration at 100-200 m depths (Murty *et al*., 2001). In this study, the highest mean CPUA value for Nemipetridae was related to the stratum D at 1992.7 kg nm^{-2} and in the 30-50m depth layer, CPUA for this family was 3005.5 kg nm^{-2}. Also the lowest mean value of CPUA for Nemipetridae was detected in stratum A (313.1 kg nm^{-2}) and at 10-20m depth layers (90.1 kg nm^{-2}). Based on previous studies the highest mean CPUA for Nemipetridae was estimated in stratum A during the years 2005, 2008, and 2009 (Valinassab *et al*., 2011and 2013b) and in stratum D in the years 2007 and 2011 (Valinassab *et al*., 2011 and 2013b). It has been determined that this family is distributed mainly at depths more than 30 meters (Dayanabard *et al*, 2003;

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Valinassab *et al*., 2011 and 2013b). The highest biomass for Nemipetridae was detected in stratum D (1070.1 ton) and at 30-50 m depths (1046.4 ton). Reviews of previous studies showed that the highest biomass for Nemipetridae was mostly in stratum C, D and E (Valinassab *et al*., 2011 and 2013a) and 50-100m depth layer (Dayanabard *et al*., 2003; Valinassab *et al*., 2011 and 2013a).

Among the species of Nemipteridae, *N. japonicus* is one of the most important and most economical species in the Oman Sea. The highest CPUA and biomass values for *P. kaakan* in previous studies was obtained in the west Oman Sea, mainly in stratum B and at depths more than 30 m, especially at depths 30-50 m. The highest value of this index was obtained in 2005 in stratum A (3938/7 kg nm^{-2}) and at depths 30-50 m (936.9 kg/nm^{2}), while in the present study, the highest value was obtained in the East Oman Sea (stratum D). The highest biomass for this species was estimated in 2005 in stratum A with a value of 913.7 tons and with value of 1785.25 tons at depths 50-100 m (Dayanabard *et al*., 2003; Valinassab *et al*., 2003, 2004, 2006, 2008, 2011 and 2013a).

Ariidae

The highest mean value of CPUA for Ariidae was related to the stratum A at 823.8 kg nm^{-2} and to the 10-20m depth layers at 429 kg nm^{-2}. Also, the lowest mean value of CPUA for Ariidae was detected in stratum E (4.7 kg nm^{-2}) and at 10-20m depth layers (195.6 kg nm^{-2}). Based on previous studies the highest mean value CPUA for Ariidae was estimated in stratum C during the years 2003, 2004, 2007, 2008 and 2011 (Dayanabard *et al*., 2003; Valinassab *et al*., 2011 and 2013a). It has been determined that this family are distributed mainly at depths 10-20 meters (Valinassab *et al*., 2011, 2013a).The highest biomass for Ariidae was detected in stratum B (272.4 ton) and at 50-100 m depths (255.7 ton). The reviews of previous studies show that the highest biomass for Ariidae were mostly in stratum C (Dayanabard *et al*, 2003; Valinassab *et al*., 2011 and 2013a) and at 10-20m depths (Dayanabard *et al*., 2003; Valinassab *et al*., 2011, 2013a).

In this study, 2 species *N. thalassina* and *P. dussumieri* of the Ariidae family were detected. The highest CPUA value for *N. thalassina* in previous studies, was mostly obtained in the West and Central Oman Sea at depths more than 30 m. The maximum value of this index for this species was obtained in stratum C with a value of 566.9 kg nm^{-2} (2007) and at depths 10-20 m with value of 260.82 kg nm^{-2} (2004). The highest biomass for these species was obtained in the East and Central Oman Sea (maximum value in stratum E with amount of 336.7 ton in 2005 and 2010) at depths more than 10-20 m (maximum value at depths 50-100 m with the amount of 567 ton in 2008).

The highest CPUA and biomass values for *Plicofollis dussumieri* in

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previous studies were mostly obtained in stratum C and at depths 10-20 m. Also the maximum value of this index for these species was obtained in 2003 in stratum C with value of 2430.9 kg nm^{-2} and at depths 10-20 m with value of 1273.1 kg nm^{-2}. The highest biomass for these species was obtained with amounts of 1142.5 and 541.18 ton in stratum C and depths 10-20, respectively (Dayanabard *et al*, 2003; Valinassab *et al*., 2003, 2004, 2006, 2008, 2011 and 2013a).

These figures demonstrate an upward trend, which can be expressed by the following possible reasons:

1) Reduction in fishing effort, compared to previous years;
2) The effect of recent climate changes which happened in the region;
3) The role of fishermen in the regions and changes in the decrease and increase in the amount of fishing occurring;

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