International Journal of Zoology Studies
ISSN: 2455-7269; Impact Factor: RJIF 5.14
www.zoologyjournals.com
Volume 2; Issue 1; January 2017; Page No. 83-88

Studies on day-night distribution, composition and abundance of copepod groups in Manora waters along Karachi coast of North Arabian sea, Pakistan

[1] Muhammad Jawed Abbasi, [2] Zarina Abbasi, [3] Farah Naz Khokhar, [4] Pirzada Jamal Ahmed Siddiqui

[1, 3, 4] Center of Excellence in Marine Biology, University of Karachi, Karachi, Pakistan
[2] University of Sindh, Jamshoro, Hyderabad, Pakistan

Abstract
The present study was conducted to determine the distribution, composition and abundance of copepods during night and day time from Manora waters during April 2008 to March 2009 and recorded three groups, Cyclopoid, Calanoid and Herpacticoid. Copepods are major parts of all zooplankton groups. During the study period air temperature ranged from 19ºc -27ºc, water temperature ranged from 18ºc to 28ºc, Ph ranged from 7-7.5 and DO ranged from 4.5mg/ L^{-1} to 9.3mg/L^{-1} during night time and in day time it was recorded as air temperature ranged from 20ºc -27ºc, water temperature ranged from 19ºc to 28ºc, Ph ranged from 7-7.5 and DO ranged from 4.9mg/ L^{-1} to 9.4mg/L^{-1}. During this study the cyclopoid comprising 25.09%, calanoid comprising 64.05% and herpacticoid comprising 10.84% in night time and 21.32%, 69.70% and 8.97% in day time, respectively. Copepods indicated monthly richness (S) and evenness (E), ranging between 1.098 and 0.642-0.830 respectively, in day time and 1.098 and 0.706-0.946 respectively, in night time. Density of copepods was positively correlated with air temperature, water temperature, salinity, Ph, Transparency and DO. The diversity indices such as Shannon's diversity index (1.039- 0.776) in night time and (0.912-0.706) in day time were calculated. The calanoid among the copepod groups shows high abundance in night and day collection during the whole year 2008-9. This study reveal that copepod groups in manora waters are most abundant during day time and their abundance enhance the fishing activities during day time.

Keywords: copepods, manora, day-night abundance, Karachi coast

Introduction
Copepods are major members of zooplankton in biomass and abundance in marine pelagic ecosystem (de Puelles *et al*, 2003; Leandro *et al*, 2007) [7, 18]. Among all metazooplankton, copepods are the most abundant taxa (55% to 95%) in most sea areas (Beers *et al*, 1980; Webber *et al*, 1995) [4, 25]. Copepods are involved in regulation of nutrients and phytoplankton population on which they feed. They consume large quantities of bacteria (Wroblewski, 1980) [26], phytoplankton (Calbet *et al*, 2000) [6] and organic detritus (Steinberg *et al*, 1998) [23] and at the same time, they are preyed by higher trophic level such as fishes (Beaugrand *et al*, 2003) [3]. Their fore, copepods play pivotal role in the transferring of energy from primary producers and microbial food web to the traditional food chain (diatom-copepods-fish) (Sherr *et al*, 2009) [22]. The abundance and distribution of copepods are known to be influenced by hydrographic condition and they have been suggested as good biological indicator species for water masses (Lan *et al*, 2004; Boucher *et al*, 1978; Hsieh *et al*, 2004) [17, 5, 13], so in this study hydrographic parameters are also discussed.
Few studies have been carried out on the distribution and composition of different groups of copepods of North Arabian Sea of Karachi coast, most of work deals with their taxonomic level from off shore waters of Pakistan (Haq *et al*, 1973) [11]. Many workers have studied the composition and structure of zooplankton in coastal waters of Karachi which includes those of Ahmed (1951) [1] and Ali and Arshad (1966) [2] and then Haq (1968) [10]. Glolobov and Grobov (1970) [8], Haq (1973) [11], Khan (1976), Khan and Kamran (1975) and abbasi *et al* (2016). Khan (1974) [16] also worked on seasonal abundance of zooplankton but studies on day and night distribution and abundance and composition of copepods in coastal waters of Karachi of North Arabian Sea, is rare. This study is based to investigate the day and night abundance, composition and diversity of different groups of copepods and correlation with different water parameters. This study would benefit the fishing activities in the area.

Material and Methods
Study site
The collection of samples was made from Manora waters along the Karachi coast. Manora is a small Peninsula (2.5 km²) located just south of the port of Karachi, Sindh, Pakistan (Fig. 1). The sample site is located in coastal waters of Manora at 24° 38' 43.06" N and 66° 46' 10.26" E.

Fig 1: Location map

The night and day copepod specimens were collected during April 2008 to March 2009. The night copepod samples were taken at around midnight (2400 hrs) and day samples were taken at around noon (1200 hrs).

Copepod samples were collected using a using 153 micro- mesh size net. Samplings were made by vertical hauls from a depth of 10 m. Three, replicate samples (250 ml each) were obtained and total 36 samples for copepod abundance were taken at night and total 36 samples were taken at day time, during 2008 to 2009. The sampling in the month of June, July and August were not taken because of rough season in sea and restriction on movement of boats from concerned authorities.

The night and day copepod abundance samples were carried out at monthly intervals. The samples were preserved in 4% formalin. The Olympus CX-31 binocular microscope was used to identify the major taxonomic copepod groups and presented in (no.ind./m^3) number per cubic meter (Goswami, 2004) [9]. The biodiversity of copepod were calculated following the standard formula diversity (Shannon and wiener, 1949) [21]. The night temperature, salinity, dissolved oxygen and pH were measured during mid-night (2400 hrs) and day reading were taken around (1200 hrs). Air and water temperature were measured by mercury filled centigrade thermometer. The white Secchi disc, with a 30 cm diameter was used to measure the water transparency. Salinity was measured by hand refractometer and pH was measured by Elico pH meter (Model Lc-120). Dissolved oxygen concentration was measured by Wrinkler's method (Stickland and Parsons, 1972) [24]. Correlation coefficient (r) was calculated for water parameters with zooplankton diversity and the mean number/10ml±standard deviation is calculated for different groups of copepods.

Result

Physico-chemical Parameters: The annual average air temperature at night time, during 2008-9, recorded was 23.88°c, and 24.55°c, at day time. Copepods abundance showed positive correlation with air temperature (r = 0.76) at night time and (r =0.76) at day time.

Table 1: Annual mean and standard deviation (mean±SD) of different physico-chemical parameters from St.1 (Manora) for night and day during April 2008 to March 2009.

Stations	Air Temp. °c	Water Temp.°c	Salinity (‰)	pH	Transparency (m)	DO (mg/L^{-1})
St.1(Manora) Night (2400hrs)	23.88±3.28 (19-27)	23.66±3.65 (18-28)	37.33±0.65 (37-39)	7.27 ±0.23 (7-7.5)	9.44±0.49 ((9-10)	5.67±1.92 (4.5-9.3)
St.1(Manora) Day (1400hrs)	24.55±3.02 (20-27)	23.88±3.41 (19-28)	37.77± 0.91 (37-40)	7.22±0.23 (7-7.5)	9.55±0.49 (9-10)	6.83±1.42 (4.9-9.4)

The annual average water temperature at night time was recorded 23.66°c, and 23.88°c, at day time. Copepods abundance showed positive correlation with water temperature (r = 0.71) at night time and (r =0.72) at day time. The annual average salinity at Manora coast was recorded 37‰, at night time and 37.55‰, at day time. Copepods abundance showed positive correlation with salinity, (r =0.16) at night time and (r =0.15) at day time.

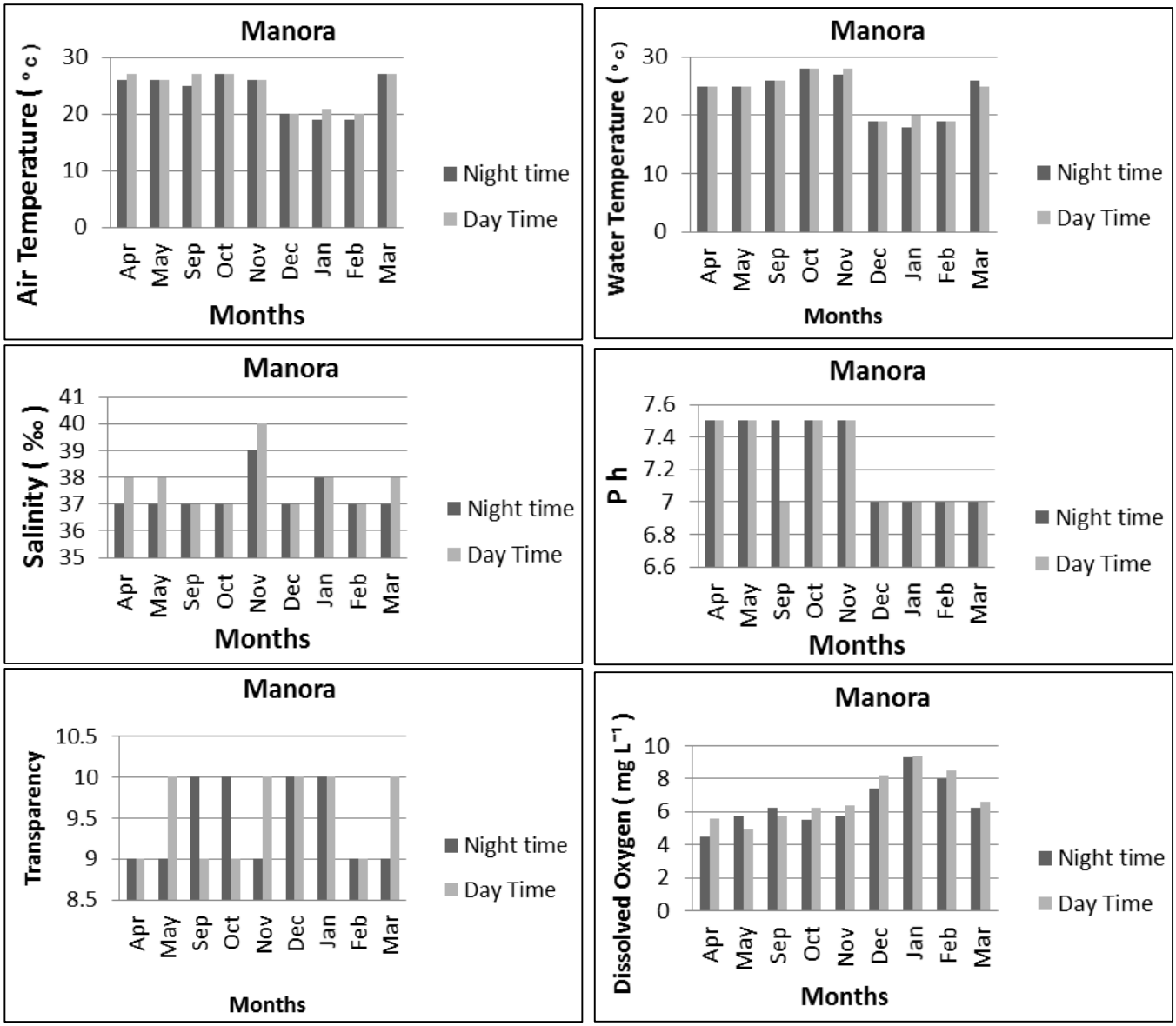

Fig 2: Seasonal variation in water parameters, air and water temperature(c°), salinity (‰), Ph, transparency (m) and dissolve oxygen (mgL^{-1}), observed during night and day time in the coastal waters of Manora, Karachi coast.

The annual average pH at Manora coast was recorded 7.27 at night time and 7.22 at day time. Copepods abundance showed positive correlation with Ph, (r =0.87) at night time and (r =0.78) at day time. The annual average transparency at Manora coast was recorded 9.33 m, at night time and 9.33 m, at day time. Copepods abundance showed positive correlation with transparency (r =0.18) at night time and (r =0.28) at day time. The annual average DO at Manora coast was recorded 6.05 mg/L^{-1}, at night time and 6.83 mg/L^{-1}, at day time. Copepods abundance showed positive correlation with DO (r =0.02) at night time and (r =0.04) at day time (Fig.2).

Seasonal composition and abundance of copepods: The copepods were the most abundant zooplankton group at manora shores. During night time the percentage composition of Cyclopoids were 25.09%, Calanoid were 64.05% and Herpacticoids were 10.84% (Table.2) and during day time the percentage composition of Cyclopoid were 21.32%, Calanoid were 69.70%, and Herpacticoids were 8.97 % (Table:3). The Cyclopoid abundance in night time at manora was highest in April (17.65%) and less abundance was recorded in January (6.47%). The cyclopoid abundance in day time was highest in April (16.66%) and less abundance was recorded in January (7.49%). The Calanoids abundance in night were highest in April (16.99%) and less abundance was recorded in February (3.26%). The calanoid abundance in day time was highest in May (16.26%) and less abundance was recorded in February (6.11%). The herpacticoid abundance in night time was highest in April (15.85%) and less abundance was recorded in February (8.01%). During day time, the highest herpacticoid abundance was in April (16.47%) and less abundance was found in February (7.54%. Total cyclopoid abundance were higher in night where as calanoid and harpacticoid shows higher abundance in day time. This is attributed to the upwelling and high productivity at coastal water (Table. 2&3).

Table 2: Percentage composition of different groups of copepods in night during April 2008 to March 2009 at coastal waters of Manora of Karachi coast.

Station	S. No.	Groups of Copepods	Apr.	May	Jun	Jul	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total	%
Manora Night (2400 hrs)	1.	Cyclopoid	2485 17.65%	1975 14.03%				1644 11.68%	1552 11.02%	1475 10.47%	1256 8.92%	912 6.47%	923 6.55%	1853 13.16%	14075	25.09
	2.	Calanoid	6105 21.89%	5623 20.17%				5421 11.31%	5301 9.48%	4176 10.44%	3210 7.00%	2318 8.31%	1173 4.20%	2597 7.15%	35924	64.05
	3.	Herpacticoid	065 15.85%	834 13.70%				753 12.37%	625 10.27%	697 11.45%	542 8.90%	531 8.72%	488 8.01%	650 10.68%	6085	10.84
Total			9555	8432				7818	7478	6348	5008	3761	2584	5100	56084	

Table 3: Percentage composition of different groups of copepods in day during April 2008 to March 2009 at near shore waters of Manora of Karachi coast.

Station	S. No.	Groups of Copepods	Apr.	May	Jun	Jul	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total	%
Manora Day (1400 hrs)	1.	Cyclopoid	2265 16.66%	1832 13.47%				1645 12.10%	1612 11.85%	1479 10.87%	1112 8.17%	1019 7.49%	1134 8.34%	1497 11.01%	13595	21.32
	2.	Calanoid	6432 14.47%	7231 16.26%				5987 13.47%	6760 15.20%	5034 11.32%	3759 8.45%	3149 7.08%	2719 6.11%	3374 7.59%	44445	69.70
	3.	Herpacticoid	943 16.47%	854 14.92%				621 10.85%	632 11.04%	595 10.39%	513 8.96%	453 7.91%	432 7.54%	680 11.88%	5723	8.97
Total			9640	9917				8253	9004	7108	5384	4621	4285	5551	63763	

Percentage composition of different groups of Copepods

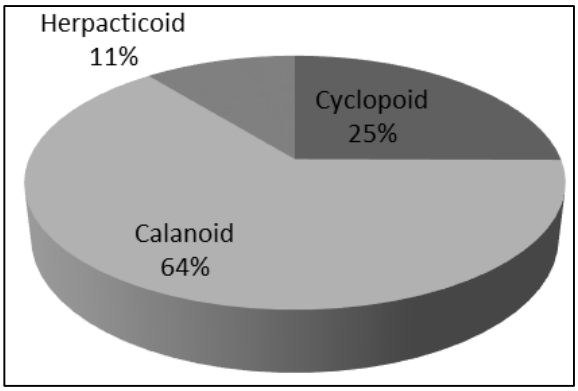

Fig 3: Percentage composition of copepod groups in night time, during 2008-9 at coastal waters of Manora of Karachi coast.

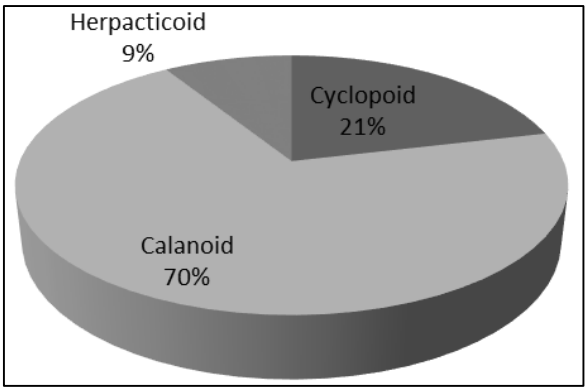

Fig 4: Percentage composition of copepod groups in day time, during 2008-9 at coastal waters of Manora of Karachi coast.

Seasonal abundance of different groups of Copepod

Table 4: Copepod groups (mean number/10ml±standard deviation) recorded during night and day time at Manora along Karachi coast in April 2008 to March 2009.

S. No.	Groups of Copepods	Manora	
		Night	Day
1.	Cyclopoid	1563.88±476.79	1510.55±371.83
2.	Calanoid	3991.55±1640.49	4938.33±1628.89
3.	Harpacticoid	676.11±146.23	635.88±161.88

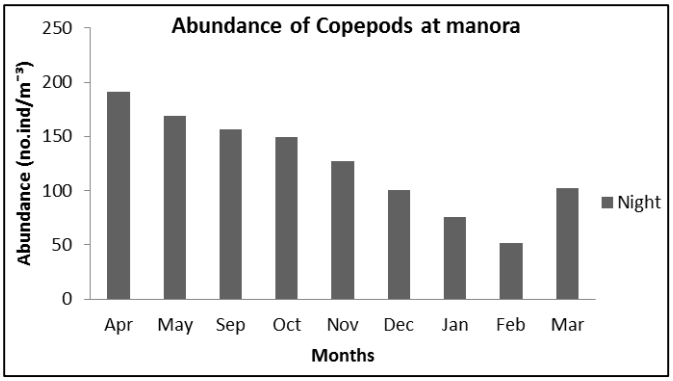

Fig 5: Seasonal abundance of copepod groups in night time at coastal waters of Manora of Karachi coast during 2008-9.

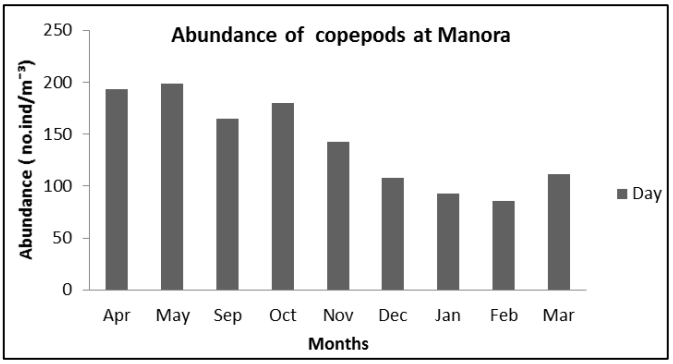

Fig 6: Seasonal abundance of copepod groups in day time at coastal waters of Manora of Karachi coast during 2008-9.

Copepods Diversity (H')

The high copepod diversity in night, 0.972 (H') was observed in March and low diversity in night, 0.776 (H') was observed in October, while high copepod diversity in day time, 0.912 (H') was observed in March, and low copepod diversity in night, 0.706 (H') was observed in October. (Table: 4).

Table 5: Diversity index (H') of copepod groups in night and day times at near shore waters of Manora Karachi coast during 2008-9.

Stations		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Manora Night (2400 hrs)	Diversity Index H'	0.866	0.836	--	--	--	0.805	0.776	0.854	0.871	0.917	1.039	0.972
Manora Day (1400 hrs)	Diversity Index H'	0.835	0.751	--	--	--	0.748	0.706	0.776	0.798	0.821	0.869	0.912

Species richness (S) and Evenness (E) of copepods

In this study, species richness(S) of copepod groups shows similarity because all three groups of copepods are present in all samples during year, while species evenness (E) decreased in day time and increased in night time. The maximum species richness (S) at Manora in night time were recorded 1.098 and evenness (E) were recorded 0.946 in the month of February while the minimum was same 1.098 and 0.706 respectively, the maximum species richness (S) at Manora in day time were recorded same 1.098 and evenness (E) were recorded 0.830 in the month of March, 2008-9, while the minimum was 1.098 and 0.642 respectively (Fig. 6).

Table 6: Species richness (S) and evenness (E) of copepod groups in night and day times during 2008-9 at coastal waters of Manora Karachi coast.

Stations	Parameters	Months											
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Manora Night (2400 hrs)	Richness(S)	1.098	1.098	--	--	--	1.098	1.098	1.098	1.098	1.098	1.098	1.098
	Evenness(E)	0.788	0.761				0.733	0.706	0.777	0.793	0.835	0.946	0.885
Manora Day (1400 hrs)	Richness(S)	1.098	1.098	--	--	--	1.098	1.098	1.098	1.098	1.098	1.098	1.098
	Evenness(E)	0.760	0.683				0.681	0.642	0.706	0.726	0.747	0.791	0.830

Discussion

This study was conduct to examine the composition and seasonal abundance of copepods along with the physic-chemical parameters to better understand the dial variation of different copepod groups. The result of present study indicated that the value of pH was same during the whole year (Fig.2), because there was little rainfall and dilution of proper water could not take place. The value of dissolved oxygen was high in winter, when temperature was low, while dissolve oxygen was low in summer (Fig.2) when temperature was high, low dissolved oxygen retaining capacity of water was attributed to increase in organism demand on high temperature (Hussain *et al*, 2013). The day and night study of different groups of copepod revealed that the nocturnal increased occurred because of large-sized copepods (Yahel *et al*, 2005a) [27], while during daytime zooplanktivory by fish may be one of the major reason of decreased population of copepods (Muscatine & Porter, 1977) [19]. Copepods experiences a greater susceptibility to visual predators (Hays *et al* 2001) [12] and they need to decreased and spend the day time near the bottom.

Copepods abundance in present study shows that in night, copepods are at peak in the month of April and then trend is started to decreased (Fig.5), in day time, copepods are at peak in the month of May and then trend is started to decreased (Fig.6). During the whole year 2008-9, April and May are the two months where peak copepod abundance is found, it is may be because of high temperature and high rate of productivity.

During all months of year, the calanoid remain as dominant copepod group in night as well as day time; it is perhaps because of stable environment conditions. The copepods could represent an important trophic link between the larger predators (Porter *et al*, 1979) [20]. During night and day, the population rises and falls

according to its tolerance of environmental conditions (Hutchinson, 1967) [15], but the environmental conditions of waters of Karachi coast, mostly remain calm and stable so there was no any significant difference in copepods population. It is also found that Manora also received the flow of freshwater drainage so the rate of productivity is very high which shows the influence on abundance of copepods. The percentage rate of calanoid is found high in day time (Fig: 3) as compare to night time (Fig: 4). This study reveals that environmental conditions of coastal waters of Manora are very much stable and high abundance of copepod groups shows that these sites are productive in fishing.

References

1. Ahmed M. Plankton of Karachi Coast and Their Bearing on Fishes, Agric. Pakistan, 1951; 2:22-31.
2. Ali M, Arshad M. Preliminary Observations on the Composition of Zooplanktons Along Karachi Coast, *Agric. Pakistan*, 1966; 17(2):227-237.
3. Beaugrand G, Brander KM, Lindley JA, Soussi S, Reid PC. Plankton effect on cod recruitment in the North Sea. *Nature*, 2003; 426:661-664.
4. Beers JR, Reid MS, Stewant GL. Microplankton population structure in southern California nearshore waters, Mar. Biol., 1980; 60:209-226.
5. Boucher M, Ibanez F, Prieur L. Daily and seasonal variations in the spatial distribution of zooplankton population in relation to the physical structure in the Ligurian Sea front, J. Mar. Res. 1978; 45:133-173.
6. Calbet, A, Landry MR, Scheinberg RD. Copepod grazing in a subtropical bay: species- specific responses to a midsummer increase in nanoplankton standing stock, Mar. Ecol. Prog. Ser. 2000; 193:75-84.
7. de Puelles ML, Gras FD, Hernandez-Leon S. Annual cycle of zooplankton biomass, abundance and species composition in the neritic area of the Balearic Sea, western Mediterranean, Mar. Ecol, 2003; 24:123-139.
8. Glolobov JA, Grobov AG. Summary Account on the Scientific Research Works of the Expedition in the Waters Adjacent to the Islamic Republic of Pakistan (January to December 1969), Azor-Black Sea Research Institute of Marine Fishery and Oceanography, Ministry of Fisheries of the USSR, 1970, 166.
9. Goswami SC. Zooplankton Methodology, Collection & Identification– a field Indian Ocean. Nat. Lon. 2004; 196:1224-1225.
10. Haq SM. Observations on the variations in planktonic copepod *Undinula vulgaris* (Dana 1849) from the north Arabian Sea. University studies, 1968; 5(3):86-92.
11. Haq SM, Ali-Khan J, Chugtai S. The distribution and abundance of zooplankton along the coast of Pakistan during the post monsoon and pre monsoon periods. *In* Ecological studies, analysis and synthesis Ed. by B. Zeitzschel. Springer Verlag, Berlin. 1973; 3:257-272.
12. Hays GC, Harris RP, Head RN. Diel changes in the near surface biomass of zooplankton and the carbon content of vertical migrants. Deep-Sea Res. 2001; 2(48):1063-1098.
13. Hsieh CH, Chiu TS, Shih CT. Copepod diversity and composition as indicators of intrusion of the Kuroshio Branch Current in to the northern Taiwan Strait in spring 2000, Zool. Stud. 2004; 43:393-403.
14. Hussain A, Sulehria AQ, Ejaz M, Maqbool A. Monthly variations in physico-chemical parameters of a flood plain reservoir on River Ravi near Balloki Headworks (Pakistan). Biologia (Pakistan). 2013; 59(2):371-377.
15. Hutchinson GF. A Treatise on Limnology, II. Introduction to Lake Biology and Limnoplankton. New York: John Wiley & Sons. 1967, 1115.
16. Khan MA. Seashore Distribution of bio-mass and Number of Zooplankton in Manora Channel During 1975-77, Biologia, 1974; 25:182-203.
17. Lan YC, Shih CT, Lee MA, Shieh HZ. Special distribution of copepods in relation to water mass in the Taiwan Strait, Zool. Stud. 2004; 43:332-343.
18. Leandro SM, Morgado F, Pereira F, Queiroga H. Temporal changes of abundance, biomass and production of copepod community in a shallow temperate estuary. Estuarine Coastal and Shelf Science, 2007; 74:215-222.
19. Muscatine L, Porter JW. Reef corals, mutualistic symbiosis adapted to nutrient-poor environment. Bioscience. 1977; 27:454-460.
20. Porter KG, Pace ML, Battey JF. Ciliate protozoas as links in freshwater planktonic food chains. Nature 1979; 277:563-565.
21. Shannon CE, Wear W. The mathematical theory of communication, Univ. of Illinois press, Urbana, 1949, 117.
22. Sherr E, Sherr B. Understanding roles of microbes in marine pelagic food webs: a brief history. In Kirchman, D L (ed), Microbial Ecology of the Ocean, 2nd ed. John Wiley & sons,Inc., New York. 2009, 27-44.
23. Steinberg DK, Pilskain CH, Silver MW. Contribution of zooplankton associated with detritus to sediment trap swimmer carbon in Monterey Bay, California, U.S.A, Mar. Ecol. Prog. Ser., 1998; 164:157-166.
24. Strickland JDH, Parsons TR. A practical handbook for seawater analysis. Fisheries research board of Canada. 1972, 167-311.
25. Webber MK, Roff JC. Annual structure of the copepod community and its associated pelagic environment off Discovery Bay Jamaica, Mar. Biol., 1995; 123:467-479.
26. Wroblewski JS. A simulation of the distribution of *Acartia clause* during the Oregon upwelling, August 1973. J Plank Res. 1980; 2:43-68.
27. Yahel R, Yahel G, Amatzia G. Near-bottom deletion of zooplankton over coral reefs, I, diurnal dynamics and size distribution, Coral Reefs 2005a; 24:75-85.