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Day-Night distribution, composition and abundance of zooplankton groups in coastal waters along Karachi coast of North Arabian Sea, Pakistan

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Abstract
This study was conduct at two stations of coastal waters of Karachi, St.1 (Manora) and St.2 (Mubarak Village). The main purpose of study was to observe the day night abundance and distribution of different zooplankton groups and find out the productivity of these waters regarding the fish catch. Day and night distribution, composition and abundance of the main zooplankton groups were analyzed during the year of 2008-9. The copepods, comprising 64.95% in day time and 54.97% in night time at St.1 of the whole zooplankton groups and 73.91% in day time and 64.41% in night time at St.2 of the whole zooplankton population were the most abundant followed by the Appendicularia 20.31% in night and 20.44% in day time at St.1, 18.18% in night time and 14.13% in day time at St.2, Cladocera 18.50% in night time and 13.30% in day time at St.1, 15.61% in night time and 10.80% in day time at St.2. Generally, the day and night composition at both stations (St.1 and St.2) showed little different pattern, most of the zooplankton groups were present at a slightly higher abundance at day time. The Copepods abundance was highest during the month of April in day time and during the months of October and November in night time, other zooplankton groups also shows their high abundance during the same months. This study reveals that coastal waters of Karachi are stable and rich in zooplankton communities. The percentage of zooplankton is high in day time as compare to night time. The coastal waters of Karachi at both stations are productive for fishing.

Keywords: Day-night abundance, Karachi coast, zooplankton groups

Introduction
The physico-chemical parameters such as the temperature, salinity, dissolved oxygen, turbidity and pH shows great influence on abundance and distribution of marine life. Planktons which play an important role in maintaining the marine food chain are also affected by such water parameters. In marine ecosystem, zooplankton are found in pelagic and littoral zone and their study is important in relation to physico-chemical parameters as it could provides the information to predict and increase the productivity of waters [2 -14]. The study of zooplankton composition, abundance and seasonal variation is helpful in fishery management [8]. Zooplankton distribution and abundance is non-homogenous. It depends on availability of nutrients and climatic conditions along with physico-chemical parameters [18-6]. The study on day-night composition, distribution and abundance of zooplankton along with physico-chemical parameters at Karachi coast is not carried out, some workers as Amjad *et al*. 1995 [1]; Haq, 1968 [4]; Haq *et al*. 1973 [5]; khan,1974 [9]; Kidwai *et al*,1997 [11]; Kidwai & Amjad, 2000 [12]; Kidwai & Amjad, 2001 [10]; Mehar, 1983 [13]; Tirmizi & Nayeem, 1992 [21], have worked on near-shore and coastal waters, but their work mostly dealt with seasonal abundance of zooplankton or only on copepods. Manora and Mubarak village coasts are two main fishing zones at Karachi coast, where from different species of fishes including the shellfishes are caught which helps to generate the economy for country.

The main purpose of this study is to observe the influence of water parameters on the composition and abundance of zooplankton community during the day and night time. The coastal water of Karachi coast is rich in fishing sources and many people are engaged in this business so it is necessary to provide the information weather and proper timing for fishing. This data will provide the information to the concerned authorities to manage the fish catch properly, during day and night.

Materials and Methods

Study Area

For this study two stations were formed and samples were collected for day and night along the coast of Karachi (Fig: 1). Station 1 (St.1; 24° 45′ 4.75″ N, 66° 59′ 9.29″ E), 10m depth, coastal waters of Manora, station 2 (St.2; 24° 52′ 6.18″ N, 66° 37′ 21.86″ E), 14m depth, coastal waters of Mubarak village (MV).

Fig 1: Map showing the study area of Karachi coast. The coastal waters of Manora (St.1, 10 m contour line) and Mubarak village (St.2, 10 m contour line).

The night and day zooplankton specimens were collected from St.1 (Manora) and St.2 (Mubarak village), during April 2008 to March 2009. The night zooplankton samples were taken at around midnight (2400 hrs) from St.1 and from St.2, it was taken around (0200 hrs). The day zooplankton samples were taken from St.2 around noon (1200 hrs) and from St.1, it was around (1400 hrs).

Zooplankton samples were collected using 153 micro- mesh sizes net. Zooplankton samplings were made on 10 m depth in coastal waters of Manora and on 14 m depth in coastal waters of Mubarak village. Three replicate samples (250 ml each) were obtained from St.1 and St.2 and total 54 samples (27 night sample and 27 day sample) were collected from these two stations and preserve in 4% formalin for analysis. Numerical zooplanktons were identified to major taxonomic groups by using Olympus CX-31 binocular microscope and abundance was estimated as (No.ind /m^{-3}) number per cubic meter [3]. The sampling in the months of June, July and August 2008 to 2009 was not taken because of rough season in sea and restriction on movement of boats from concerned authorities.

Air and water temperature was measured by mercury filled centigrade thermometer. Secchi disc was used to measure the turbidity of water. Salinity was measured with the help of refractometer and pH was measured using Hanna, HI-9023. Dissolved oxygen was estimated by Wrinkle titration method [20]. Correlation coefficient (r) was calculated for physico-chemical parameters with zooplankton and the mean number/10ml±standard deviation is also calculated for different groups of zooplanktons. The standard formula was used to calculate the zooplankton diversity [19].

Results

Physico-chemical Parameters: The study was made to observe the correlation of zooplankton groups with physico-chemical parameters. The annual average air temperature at St.1 during 2008-9 recorded was 23.66°c, at night time and 24.55°c, at day time (Table; 1). Zooplankton abundance showed positive correlation with air temperature, St.1(r = 0.64) at night time and (r =0.59) at day time. The annual average air temperature at St.2 recorded was 24.11°c, at night time and 25.66°c, at day time. Zooplankton abundance showed positive correlation with air temperature, St.2 (r =0.36) at night time and (r =0.79) at day time.

The annual average water temperature at St.1 during 2008-9 recorded was 23.66°c, at night time and 23.88°c, at day time (Table: 1). Zooplankton abundance showed positive correlation with water temperature, St.1(r =0.55) at night time and (r =0.59) at day time. The annual average water temperature at St.2 recorded was 24.55°c, at night time and 26°c, at day time. Zooplankton abundance showed positive correlation with water temperature, St.2 (r =0.49) at night time and (r =0.56) at day time.

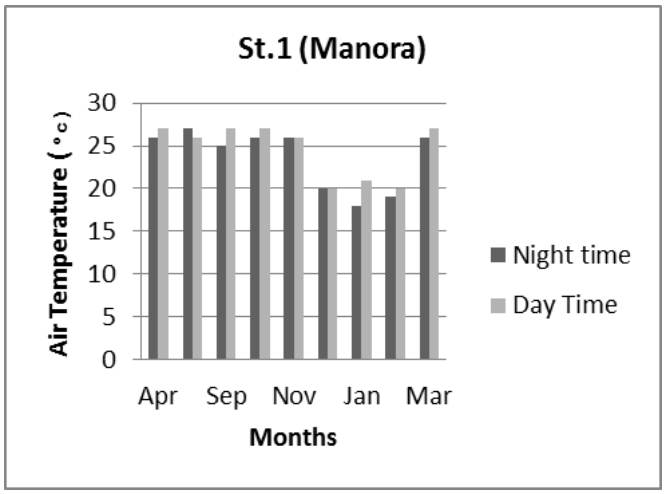
The annual average salinity at St.1 during 2008-9 recorded was 37.33‰, at night time and 37.33‰, at day time (Table: 1). Zooplankton abundance showed positive correlation with salinity, St.1(r =0.26) at night time and (r =0.21) at day time. The annual average salinity at St.2 recorded was 37.77‰, at night time and 38‰ at day time. Zooplankton abundance showed positive correlation with salinity, St.2(r =0.34) at night time and (r =0.60) at day time.

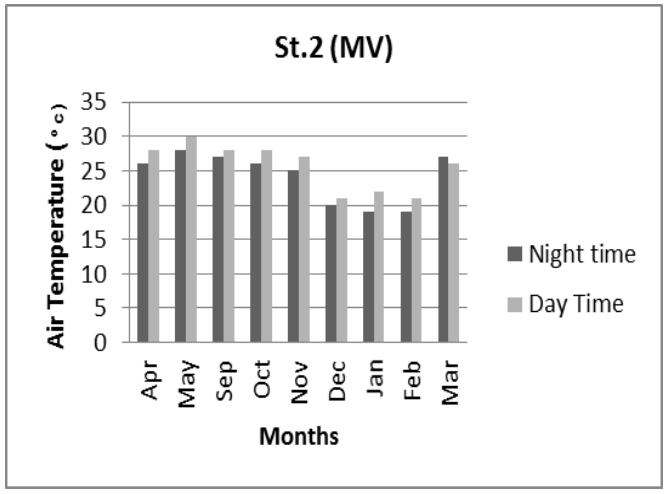
Table 1: Annual mean and standard deviation (mean±SD) of different physico-chemical parameters from St. 1 (Manora) and St. 2 (Mubarak Village) for night and day during April 2008 to March 2009.

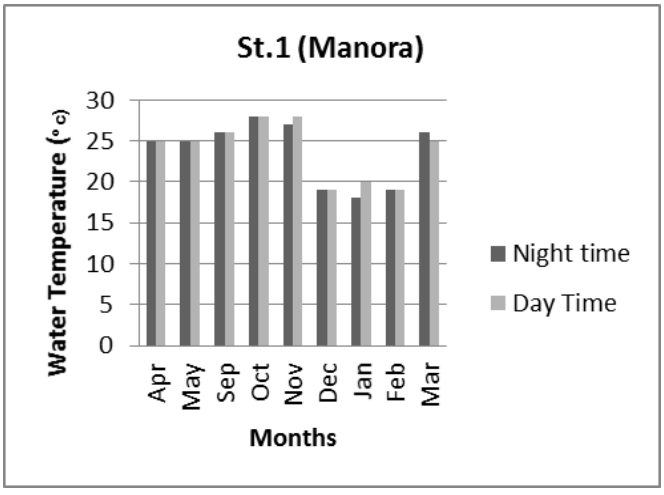
Stations	Air Temperature °c	Water Temperature °c	Salinity (‰)	pH	Transparency (m)	DO (mg/L^{-1})
St.1(Manora) Night (2400hrs)	23.66±3.36 (27-18)	23.66±3.65 (28-18)	37.33±0.65 (39-37)	7.27 ±0.24 (7.5-7)	9.77±0.41 ((10-9)	7.67±1.51 (10-4.5)
St.1(Manora) Day (1400hrs)	24.55±3.02 (31-19.1)	23.88±3.41 (28-19)	37.77± 0.91 (40-37)	7.22±0.23 (7.5-7)	9.55±0.49 (10-9)	7.72±1.69 (10-4.9)
St.2 (MV) Night (0200hrs)	24.11±3.47 (28-19)	24.55±3.14 (28-20)	37.77±0.47 (39-37)	7.33±0.21 (7.5-7)	11.33±1.15 (13-11)	8.03±1.74 (10-5.7)
St.2 (MV) Day (1200hrs)	25.66±3.23 (30-21)	26±3.43 (29-19)	38 ±0.94 (40-37)	7.27±0.24 (7.5-7)	11.44 ±1.57 (14-9)	8.38±1.46 (10-5.5)

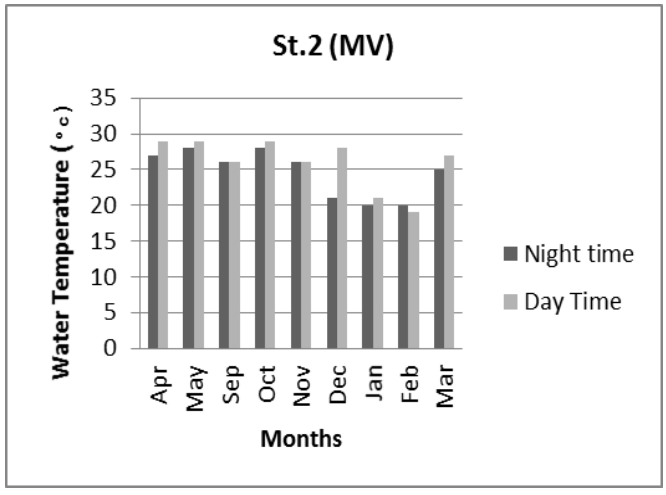
The annual average pH at St.1 during 2008-9 recorded was 7.27, at night time and 7.22, at day time. Zooplankton abundance showed positive correlation with pH, St.1(r =0.71) at night time and (r =0.82) at day time. The annual average pH at St.2 recorded was 7.33, at night time and 7.27 at day time. Zooplankton abundance showed positive correlation with pH, St.2 (r =0.42) at night time and (r =0.62) at day time. The annual average transparency at St.1 during 2008-9 recorded was 9.77(m), at night time and 9.55(m), at day time. Zooplankton abundance showed positive correlation with transparency, St.1(r =0.47) at night time and (r =0.15) at day time. The annual average transparency at St.2 recorded was 11.33(m), at night time and 11.44(m) at day time. Zooplankton abundance showed positive correlation with transparency, St.2 (r =0.14) at night time and (r =0.75) at day time.

The annual average dissolved oxygen at St.1 during 2008-9 recorded was 7.67(mg/L^{-1}), at night time and 7.72.55(mg/L^{-1}), at day time. Zooplankton abundance showed negative correlation with DO, St.1(r = -0.83) at night time and (r = -0.31) at day time. The annual average dissolved oxygen at St.2 recorded was 8.03(mg/L^{-1}), at night time and 8.38(mg/L^{-1}) at day time. Zooplankton abundance showed negative correlation with DO, St.2 (r = -0.09) at night time and (r = -0.47) at day time.









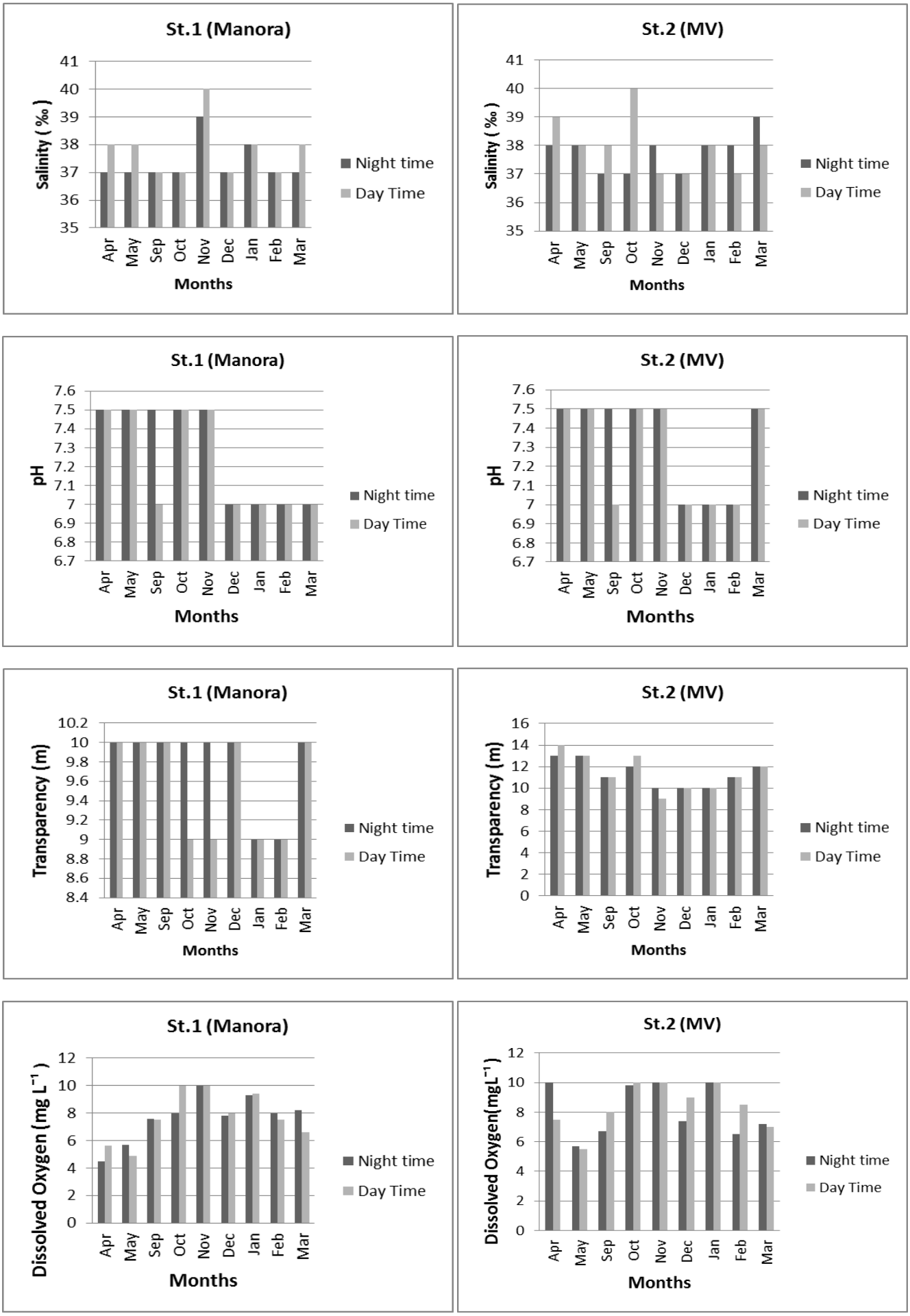


Fig 2: Seasonal variation in physico-chemical parameters from coastal waters of Karachi, St.1 (Manora) and St.2 (Mubarak Village) for night and day during April 2008 to March 2009.

Day and Night Composition and Abundance of Zooplankton Groups

Copepoda

The copepods were the most abundant zooplankton group at St.1 during 2008-9. The day and night abundance (mean number/10ml±standard deviation) of different groups of zooplankton at St.1 and St.2, during April 2008 to March 2009 at near shore waters of Manora and Mubarak village of Karachi coast is mentioned in table: 2. The percentage composition of Calanoid was 46.82%, Cyclopoid were 13.45% and Herpacticoid were 4.67%, altogether the copepods comprises 64.95% of total number of zooplankton groups at day time (Fig: 4). During night time at St.1, the percentage composition of Calanoids was 34.24%, Cyclopoid was 14.23%, and Herpacticoids were 6.48%, altogether the copepods comprises 54.97% of total number of zooplankton groups (Fig: 3). At St.2, during 2008-9, all three groups of copepods were most abundant. During day time at St.2, the percentage composition of Cyclopoid was 15.76%, Calanoid were 53.83% and Herpacticoids were 4.31%, all together, the copepods comprises 73.91% of total number of zooplankton groups (Fig: 6). During night time at St.2, the percentage composition of Cyclopoid was 13.67%, Calanoid were 45.14% and Herpacticoids were 5.60%, all together the copepods comprises 64.41% of total number of zooplankton groups (Fig: 5). The Cyclopoid abundance in day at St.1 was highest in November 25.72% and less abundance was recorded in October 6.48%. The Cyclopoid abundance in night at St.1 was highest in December 22.39% and less abundance was recorded in May 8.28%. At St.2, Cyclopoid abundance during day time was found highest in April 29.74% and less abundance was recorded in May 5.95%. The Cyclopoid abundance in night at St.2, was highest in January 23.11% and less abundance was recorded in May 5.12%. The Calanoids abundance in day at St.1 were highest in February 62.11% and less abundance was recorded in April 37.34%. The Calanoid abundance in night at St.1, was highest in November 40.44% and less abundance was recorded in February 25.09%. At St.2, Calanoid abundance during day was found highest in February 72.76% and less abundance was recorded in September 31.54%. The Calanoid abundance in night at St.2 was highest in February 61.09% and less abundance was recorded in April 23.98%.

The Herpacticoid abundance in day at St.1 was highest in April 6.48% and less abundance was recorded in October 2.72% (Fig: 4). During night, at St.1, the highest Herpacticoid abundance was in February 13.09% and less abundance was found in September 4.17% (Fig: 3). At St.2, Herpacticoid abundance during day was recorded highest in May 5.22% and less abundance was found in November 2.79% (Fig: 6). The Herpacticoid abundance in night at St.2, was highest in April 16.73% and less abundance was recorded in November 2.02% (Fig: 5).

Decapoda

During 2008-9, Lucifer was also counted. At St.1, in day time, the percentage composition of Lucifer was 0.36% (Fig: 4) and in night time, at St.1, it was 0.59% of total number of zooplankton groups (Fig: 3). At St.2, in day time, the percentage composition of Lucifer was 0.31% (Fig: 6) and in night time, at St. 2, it was 0.30% of total number of zooplankton groups (Fig: 5). The Lucifer abundance in day at St.1 was highest in October 0.59% and less abundance was recorded in December and March 0.19%, while in night time, at St.1, Lucifer abundance was highest in November 1.15% and less abundance was recorded in September 0.36%. At St.2, in day time the Lucifer abundance was highest in October 0.74% and less abundance was in December 0.27%, while in night, at St.2, Lucifer abundance was highest in October 0.79% and less abundance was in April 0.08%.

Appendicularia

The percentage composition of oikopleura (Appendicularia) at St.1, in day time was 20.44% (Fig: 4) and in night time, at St.1, it was 20.31% of total number of zooplankton groups (Fig: 3). At St.2, in day time the percentage composition of oikopleura was 14.13% (Fig: 6) and in night time, at St.2, it was 18.18% of total number of zooplankton groups (Fig: 5). The oikopleura abundance in day time at St.1 was highest in January 28.86% and less abundance was in February 14.60%, while in night at St.1, oikopleura abundance was highest in March 23.49% and less abundance was in December 15.26%. At St.2 in day time the oikopleura abundance was highest in January 24.77% and less abundance was in May 9.01%, while in night at St.2, the oikopleura abundance was highest in May 25.07% and less abundance was in February 8.48%.

Cladocera

Only two genera of Cladocera were found Evadna sp. and Penilia. During 2008-9, at St.1 in day time, the percentage composition of Evadna was 13.30% and Penilia was 0.05%, altogether the Cladocera comprises 13.36% of total number of zooplankton groups (Fig: 4). During night time at St.1, the percentage composition of Evadna was 18.50% and Penilia was 0.48%, altogether the Cladocera comprises 18.98% of total number of zooplankton groups (Fig: 4). At St.2, in day time the percentage composition of Evadna was 10.80% and Penilia was 0.21%, altogether the Cladocera comprises 11.02% of total number of zooplankton groups (Fig: 6). During night time, at St.2, the percentage composition of Evadna was 15.61% and Penilia was 0.19%, altogether the Cladocera comprises 15.80% of total number of zooplankton groups (Fig: 5). The Evadna abundance in day time at St.1 was highest in September 25.03% and less abundance was in January 1.28%, while the abundance of Penilia was highest in March 0.36% and less abundance was in May 0.09%. The Evadna abundance in night time at St.1 was highest in October 26.85% and less abundance was in January 11.48%, while the abundance of Penilia was highest in February 2.03% and less abundance was in April 0.22%. During night time, at St.2, the abundance of Evadna was highest in September 30.60% and less abundance was in January 3.36%, while the abundance of Penilia was highest in January 1.12% and less abundance was in May 0.13%. At St.2, in day time, the abundance of Evadna was highest in September 27.62% and less abundance was in November 3.32%, while the abundance of Penilia was highest in January 2.00% and less abundance was in May 0.14%.

Chaetognatha

The percentage composition of Chaetognatha (Sagitta sp.) at St.1 in day time was 0.86% (Fig: 4) and in night time, at St.1, it was 5.13% of total number of zooplankton groups (Fig: 3). At St.2 in day time, the percentage composition of Chaetognatha was 0.61% (Fig: 6) and in night time, at St.2, it was 1.28% of total zooplankton groups (Fig: 5). The Chaetognatha abundance in day time at St.1 was highest in March 2.10% and less abundance was in September 0.43%,

while in night time at St.1, the abundance of Chaetognatha was highest in March 7.43% and less abundance was in November 2.26%. At St.2, in day time, the Chaetognatha abundance was highest in November 1.03% and less abundance was in September 0.39%, while in night at St.2, the Chaetognatha abundance was highest in March 4.68% and less abundance was in September 0.27%.

Table 2: Day and night abundance (mean number/10ml±standard deviation) of different groups of zooplankton at St.1 and St.2, during April 2008 to March 2009 at near shore waters of Manora and Mubarak village of Karachi coast.

S. No.	Groups of zooplankton	St.1 (Manora)		St.2 (Mubarak village)	
		Night	Day	Night	Day
1	Cyclopoid	965.75(0.73±0.27)	1086.58(0.28±1.31)	1020.83(0.32±0.94)	950 (0.36±1.55)
2	Calanoid	2323.08(031±1.63)	3780.08(0.33±0.70)	3369.83(0.35±1.98)	3245.16 (0.29±0.75)
3	Herpacticoid	439.91(0.29±0.67)	377.66(0.29±1.00)	418.08(0.29±1.16)	259.83 (0.31±1.45)
4	Lucifer	40.25(0.33±0.96)	29.75(0.35±2.50)	22.75(0.29±6.39)	18.83 (0.32±1.35)
5	Oikopleura sp.	1377.83(0.33±1.30)	1650.41(0.33±1.02)	1357.75(0.28±1.37)	852.41 (0.33±0.98)
6	Evadna sp.	1254.83(0.31±1.51)	1074.5(0.38±11.48)	1165.58(0.31±3.90)	651.25 (0.38±3.12)
7	Penilia	33.08(0.34±1.10)	4.41 (0.52±0.34)	14.58(0.28±1.25)	13.08 (0.27±2.42)
8	Sagitta sp.	348(0.31±2.19)	70 (0.40±1..40)	95.66(0.34±3.43)	37.16 (0.37±0.80)

Percentage composition of different groups of zooplankton

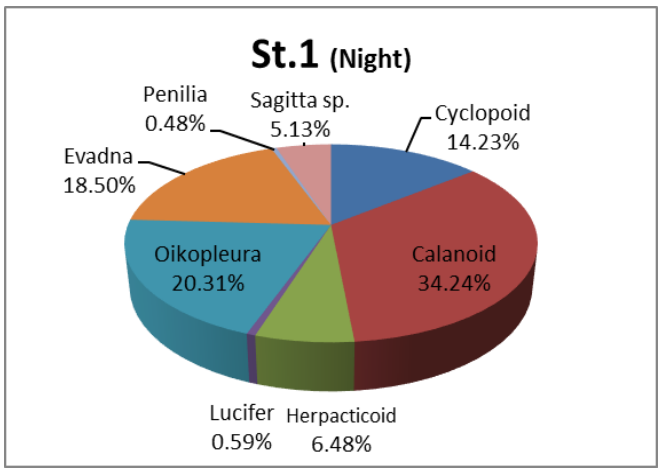


Fig 3: Percentage composition of different zooplankton groups in night time at St.1, during 2008-9 at coastal waters of Manora of Karachi coast.

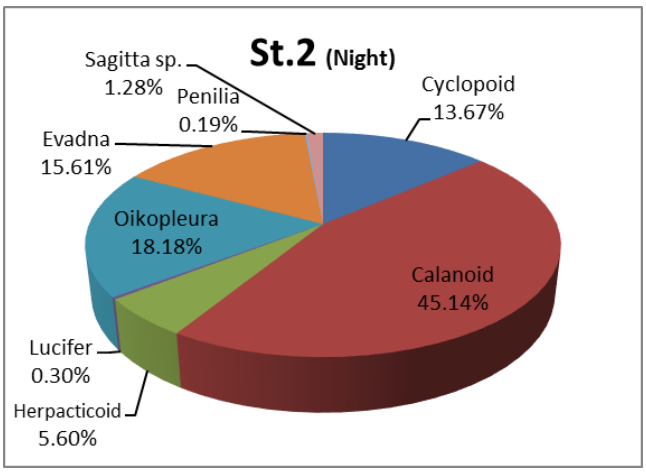


Fig 5: Percentage composition of different zooplankton groups in night time at St.2, during 2008-9 at coastal waters of Mubarak Village of Karachi coast.

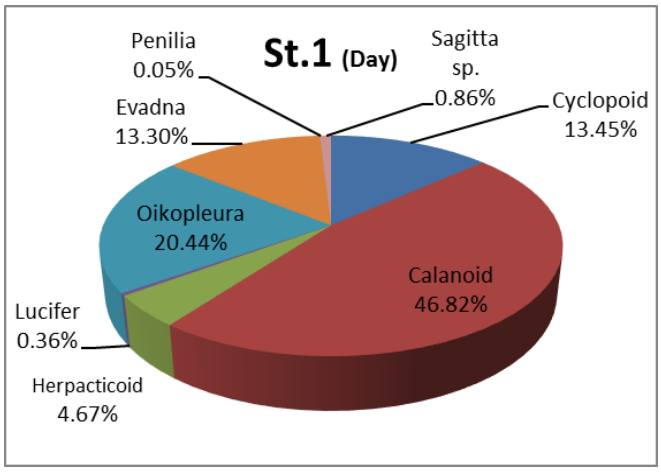


Fig 4: Percentage composition of different zooplankton groups in day time at St.1, during 2008-9 at coastal waters of Manora of Karachi coast.

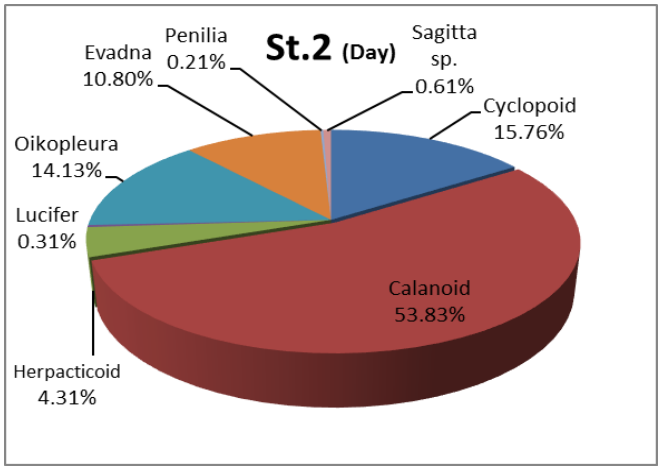


Fig 6: Percentage composition of different zooplankton groups in day time at St.2, during 2008-9 at coastal waters of Mubarak Village of Karachi coast.

Abundance of different groups of Zooplankton

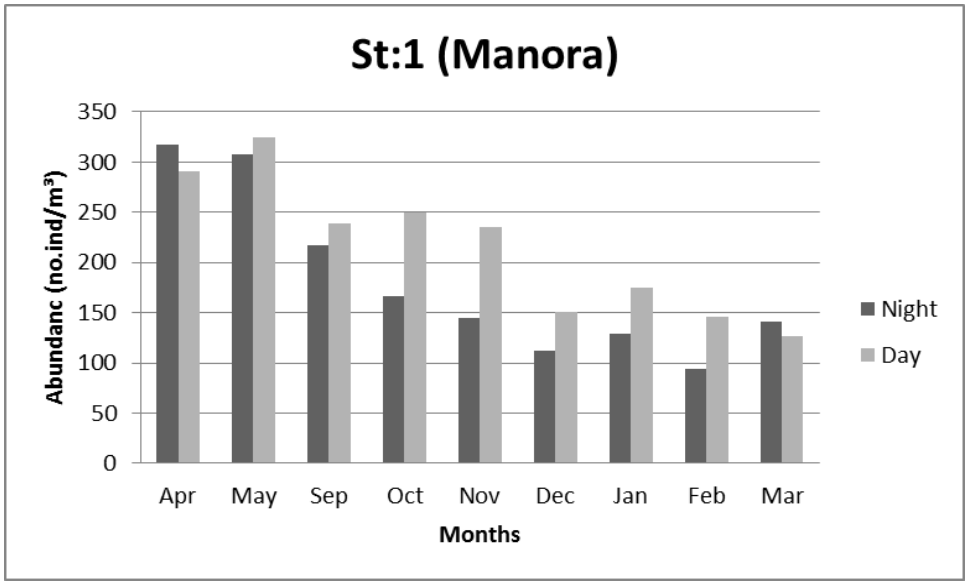


Fig 7: Abundance of Zooplankton in night and day time at St.1, during 2008-9, at coastal waters of Manora of Karachi coast.

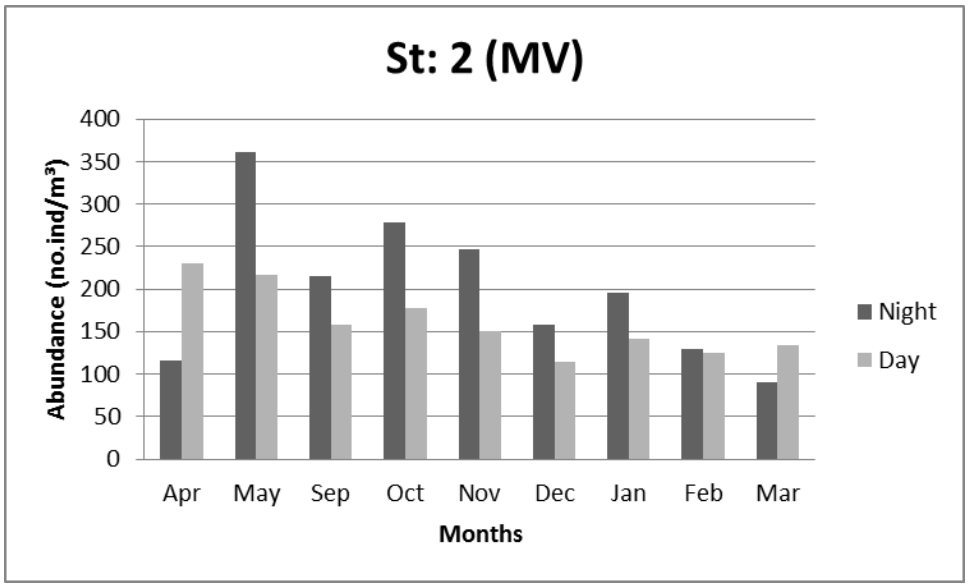


Fig 8: Abundance of Zooplankton in night and day time at St.2, during 2008-9, at coastal waters of Mubarak village (MV) of Karachi coast.

Zooplankton Diversity (H')

The zooplankton diversity shows very little difference during all the months of one year study from 2008 to 2009. High zooplankton diversity 1.781 (H') was observed in April, 2008 at St.1 in night time, 1.532 (H') was observed in day time, 1.626 (H') was observed at St.2, in night time, and 1.510 (H') was observed at St.2, in day time (Table: 3). Low zooplankton diversity 1.567 (H') was observed in October at St.1, in night time and 1.069 (H') was observed in February at in day time, 1.227 (H') was observed in February, at St.2, in night time and 0.888 (H') was observed in day time (Table: 3). The yearly, station wise calculation shows that, during April, 2008 to March 2009, the highest zooplankton diversity 1.781 (H') was recorded in April, at St.1, in night time (Table: 3) and lowest 0.888 (H') was recorded in February, at St.2, in day time (Table: 3).

Table 3: Monthly day and night zooplankton diversity (H') during 2008-9 at St.1 and St.2 at coastal waters of Manora and Mubarak village of Karachi coast.

Stations	Months											
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
St.1 Manora Night (2400 hrs)	1.781	1.609	-	-	-	1.622	1.567	1.575	1.673	1.664	1.77	1.716
St.1 Manora Day (1400hrs)	1.532	1.422	-	-	-	1.425	1.272	1.4	1.231	1.269	1.069	1.297
St.2 MV Night (0200 hrs)	1.626	1.367	-	-	-	1.506	1.286	1.375	1.45	1.337	1.227	1.593
St. 2 MV Day (1200 hrs)	1.263	1.227	-	-	-	1.51	1.321	1.311	1.035	1.305	0.888	1.139

Discussion

This study was conduct to examine the composition and seasonal abundance of zooplankton along with the physic-chemical parameters to better understand the dial variation of different zooplankton groups. The day and night study of different groups of zooplankton at both St.1 and St.2 revealed that the nocturnal increased occurred because of large-sized zooplankton [23], while during day time zooplanktivory by fish may be one of the major reason of decreased population of zooplankton [15]. Some large zooplankton experiences a greater susceptibility to visual predators [6] and they need to decreased and spend the day time near the bottom. Welch [22] suggested that prey and predation principles are the most important factors involved in diurnal migration of zooplankton. During the day time, the zooplankton descends to the bottom water to hide themselves from their predators and ascend upwards during night hours.

Zooplankton abundance in present study shows that at St.1, during night, zooplankton are at peak in the month of April (Fig: 7) and then trend is started to decreased, at the same station during day, zooplankton are at peak in the month of May and then trend is started to decreased. At St.2, during night, zooplankton peak found in the month of May (Fig: 8) and during day, it is in the month of April. During the whole year 2008-9, April and May are the two months where peak zooplankton abundance is found, it is may be because of high temperature and high rate of productivity. At St.1, during night zooplankton abundance is high in the month of April and low abundance is found in May during day time where at St.2, the condition is vice versa. It may be because of turbidity of Manora waters and zooplanktivory of fishes, but at night zooplankton comes on surface for grazing.

During this study, little variation found in physico-chemical parameters and in abundance and distribution of zooplankton during day and night. During all months of year, the calanoid and oikopleura remain as dominant zooplankton groups at both St.1 and St.2, it is perhaps because of stable environmental conditions. The copepods comprising about 64.95%, at St.1, during day and 54.97%, at St.1, during night and 73.91%, at St.2, during day and 64.41%, at St.2, during night, of the whole zooplankton's abundance. The copepods appeared to play an important role in the zooplankton population in coastal waters. They could represent an important trophic link between the larger predators [17]. During night and day, the zooplankton community rises and falls according to its tolerance of environmental conditions [7], but the environmental conditions of waters of Karachi coast, mostly remain calm and stable so there was no any significant difference in zooplankton community was found between night and day. It is also found that St.1 (Manora) also received the flow of freshwater drainage so the rate of productivity is very high which shows the influence on abundance of zooplankton. The percentage rate of zooplankton is found high in day time at St.1 (Fig: 4) as compare to night time (Fig: 3). At St.2 (Mubarak Village), where water body is more clean, calm and stable and but still there percentage of zooplankton is high in day time as compare to night (Fig: 5).

This study reveals that environmental conditions of coastal waters of Manora and Mubarak village of Karachi coast are very much stable and healthy with high abundance of major groups of zooplankton shows that these sites are highly productive in fish catch.

Conclusion

The conclusion of this study is that during day time the zooplankton abundance is high at coastal water, because most of the zooplankton, especially large size zooplankton hides themselves from

their predators and remain near to coastal waters but at night they appeared on surface for grazing, in this condition day time fishing is less productive as compare to evening time, so most of the fisher man at both stations (Manora and Mubarak village) went at night for catch. This study is informative for local fish authorities to follow and improve their fishing activities.

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