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Temporal and spatial variations of zooplankton distribution in the Eastern Harbor, Alexandria, Egypt.

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ABSTRACT

The Eastern Harbor is receiving several kinds of untreated pollution و which affect zooplankton distribution along the harbor. For this reason, the present work aims to study of the spatial and temporal distribution of the zooplankton community in the harbor and shed some light on their diversity and abundance. Four seasonal cruises (spring 2017, summer 2017, autumn 2017, and winter 2018) were carried out at nine stations along the Eastern Harbor to achieve the aim of this work. The result revealed that the zooplankton community in the Eastern Harbor comprised 87 species and other immature forms belonging to 19 groups with a total standing crop of 4984.31 ind./m^3. Copepoda was comprised of the main bulk of zooplankton, it represented by 39 species and constituted 81.97% of the total zooplankton count. Polychaeta (4.97%) was the second abundant group, followed by Mollusca (3.85) and Cirripedia (2.91). Foraminifera, Tintinnida and Rotifera were the most diverse groups after copepods, they represented by 12, 10, and 5 species, respectively. Nematoda, Cirripedia, Decapoda, and Echinodermata were represented in the present study only by immature stages. Seasonally, zooplankton was flourished during winter and declined during autumn. Spatially, the abundance was high at the water inlet to the harbor (Boghaz 1 station) and low at the water outlet from the harbor (Boghaz 1 station) and at El-Qalaa station outside the harbor. The ecological diversity indices were widely ranged among investigated stations within four seasons. The fluctuation of diversity indices values between stations confirms and indicates that there are disturbances in zooplankton distribution between stations during the study period.

INTRODUCTION

The Eastern Harbour of Alexandria is one of the embayment which has ecological, economic and touristy importance on the southeastern Mediterranean coast. It is mainly influenced by several kinds of human activities including fishing, yacht sport, land-based effluents, boat building industry, recreation and sailing boats anchoring inside the harbour **(Saad and Shreadah, 1984)**. In the Eastern Harbour, there are many small private shipyard slip ways used for building and maintenance of fishing boats, yachts and leasure small boats. So, this Harbour receives several kinds of untreated domestic sewage, atmospheric deposition, petroleum hydrocarbons pollution, industrial and municipal wastes, and others resulting from shipment activities inside it **(Emara *et al*., 2008)**.

In aquatic environments, zooplankton plays an important role in the transfer of energy from primary producers to the higher levels in the food chain. Furthermore, they are themselves favorite food items for many animals including economic fishes **(El-Naggar *et al*., 2019)**. In this respect, the quantitative and qualitative investigation of zooplankton organisms in any aquatic environment is essential regarding the knowledge about the productivity and diversity in that specific environment **(El-Damhougy *et al*., 2019)**. The study of zooplankton is essential for the evaluation of ecosystem conditions, even though their passive transportation does not permit the formation of clearly defined units, as is possible for benthic system **(Ibrahim *et al*., 2017; Zakaria *et al*., 2018a)**. Therefore, study of the distribution of these organisms is also useful for the general monitoring of certain aspects of the environment, such as hydrographic events, eutrophication, pollution, warming trends and long-term changes which are signs of environmental disturbance **(Zakaria and El-Naggar, 2019; Zakaria et al., 2019)**.

Several studies on zooplankton have been carried out in the Eastern Harbor. Such as **Dowidar (1965), Dowidar and El-Maghraby (1970), El-Zawawy (1980), Dowidar *et al*., (1983) and Khalil *et al*., (1983)**, The last quantitative estimation of zooplankton in the Eastern Harbor was done depending on data collected by **Aboul Ezz *et al*., (1990)**, **AboulEzz and Zaghloul (1990)** and **Zakaria (2006)**. Hence the importance of this work to study of the spatial and temporal distribution of zooplankton community in The Eastern Harbor and shed some light on diversity, and abundance of zooplankton communities in this Harbor.

MATERIALS AND METHODS

The Eastern Harbour of Alexandria is a relatively small, shallow and semicircular basin; lies between longitudes 29^{o} $53^{'}$ and 29^{o} $54.4^{'}$ E and latitudes 3^{o} $12^{'}$ and 31^{o} $13^{'}$ N. Its area is about 2.53 x 10^{6} m^{2}, with an average depth of 6.5 m and water volume of 16.44 x 10^{6} m^{3}. The Harbor is occupying the central part of Alexandria coast. The water exchange between the Harbor and the Mediterranean takes place through two main openings El-Boughaz and El-Silsila **(Saad and Shreadah, 1984)**. Nine stations were chosen to represent different regions in the Harbor (Figure, 1).

The Zooplankton samples were collected during four seasons (spring 2017, summer 2017, autumn 2017 and winter 2018). The samples were collected by vertical hauls (from certain depth to the surface) using the fine standard plankton net of 30 cm mouth diameter and 55 µm mesh size. Immediately, the collected samples were preserved in 5% neutral formalin solution. In the laboratory, the sample volume was concentrated to 100 ml and triplicate of 3 ml subsample were transferred into a countering cell (G.F.C. rafter cell) and each zooplankter was counted under binuclear microscope. Also, the whole sample was examined in Petri dech to identify all species. The zooplankton identification was done by using many keys such as**, kofoid and Campbell (1929); Rose (1933); Tregouboff and Rose (1957); Marshall (1969); Santhanam and Srinivasan (1994); Boltovskoy (1999); Conway *et al*., (2003) and EL-Naggar (2014)**.

Figure 1. A land satellite image showing the study stations at the Eastern Harbour.

The number of zooplankton individuals present in a cubic meter (m^3) of the sample was calculated according to the following formula **(Santhanam and Srinivasan, 1994)**:

$$N = n \frac{v}{V} 1000$$

***Where*:**

N : Total number of zooplankton individuals per cubic meter of water filtered.
n : Average number of zooplankton in subsamples.
v : Volume of plankton concentrates (ml).
V : Volume of total water filtered (L).

$$V = \text{л} \times r^2 \times d$$

Where:

r: Mouth diameter of using plankton net. **d:** Investigated depth of water column.

Four diversity indices were calculated to estimate the stability of community structure: species richness **(Margalef, 1968)**, Shannon–Wiener diversity index **(Shannon and Wiener, 1963)**, Evenness or equitability **(Pielou, 1975)**, and Simpson index **(Simpson, 1949)**.

RESULTS

1. Community Composition of Zooplankton

A Total of 19 zooplankton groups with an average annual abundance of 4984.31 ind./m^3 were recorded during the present study (Table, 1). According to the table (1), Copepoda (81.97% of the total zooplankton abundance) was the main abundant group, followed by Polychaeta (4.97%); Mollusca (3.85%); Cirripedia (2.91%); Appendicularia (1.88%); Rotifera (0.97%); Cladocera (0.79%); Tintinnida (0.67%); Ostracoda (0.58%); Cnidaria (0.57%); Foramenifera (0.36%); Radiolaria (0.13%); Decapoda (0.12%); Nematoda (0.11%); Chaetognatha (0.06%); Echinodermata (0.02%); Euphausiacea (0.01%); Amphipoda (0.01%) and Fish Larvae (0.01%). Eighty-six zooplankton species and other immature forms were recorded and belonging to 69 genera, 50 Families and 17 classes. Copepods (39 species, 45.25% of the total recorded species) were the most diversified group, followed by Foraminifer (12 species, 13.95%), tintinnides (10 species, 11.63%), Rotifers (5 species, 5.81%), Polychaeta (3 species, 3.49%), appendicularians (3 species, 3.49%), cladoceranse (3 species, 3.49%), ostracods (3 species, 3.49%), cnidarians (2 species, 2.33%), Radiolaria (2 species, 2.33%), molluscs (1 species, 1.16 %), Chaetognatha (1 species, 1.16 %), Euphausa (1 species, 1.16 %), amphipod (1 species, 1.16 %) and other groups were represented by only immature stages.

Table 1. The annual abundance, relative abundance and number of species for each zooplankton groups recorded in Eastern Harbor.

Groups	Average	Relative Abundance (%)	No. of species	No. of species (%)
Copepoda	4085.78	81.97	39	45.35
Foraminifera	18.11	0.36	12	13.95
Tintinnida	33.42	0.67	10	11.63
Rotifera	48.15	0.97	5	5.81
Polychaeta	247.60	4.97	3	3.49
Cladocera	39.52	0.79	3	3.49
Ostracoda	29.12	0.58	3	3.49
Appendicularia	93.69	1.88	3	3.49
Radiolaria	6.39	0.13	2	2.33
Cnidaria	28.50	0.57	2	2.33
Mollusca	192.02	3.85	1	1.16
Euphausiacea	0.73	0.01	1	1.16
Amphipoda	0.48	0.01	1	1.16
Chaetognatha	3.12	0.06	1	1.16
Nematoda	5.44	0.11	0	0.00
Cirripedia	144.95	2.91	0	0.00
Decapoda	6.02	0.12	0	0.00
Echinodermata	0.92	0.02	0	0.00
Fish Larvae	0.37	0.01	0	0
Total Zooplankton	**4984.31**	**100**	**86**	**100**

2. Abundance of zooplankton recorded in the Eastern Harbor.

2.1. Temporal variations

As shown in the obtained data, the zooplankton abundance was varying slightly from season to another. They were flourished in winter with an average of 5792.24 ind./m^3 (29.05% of the total zooplankton abundance), followed by summer (4936.13 ind./m^3, 24.76 %), spring (4715.55 ind./m^3, 23.65 %), and autumn was the lowest (4493.34 ind./m^2, 22.54 %) (Figure, 2).

On the same side, copepods were the main abundant group during all seasons [winter (4671.7 ind./m^3), summer (4183.57 ind./m^3), autumn (3769.89 ind/m^3) and spring (3717.97 ind/m^3)]. Polychaetes were high abundant during winter (581.87 ind/m^3) and low during summer (53.18 ind/m^3). The highest abundance of molluscs was during spring (579.95 ind/m^3) and the lowest during autumn (9.22 ind/m^3). Cirripedies were high abundant during winter and absent during spring. Appendicularians abundance was high during autumn and low during winter. Rotifer highest abundance was during summer and lowest abundance during spring. Cladocerans were flourished during spring, while tintinnids appeared only during summer and spring. Cnidarians abundance was high during autumn and very low during summer. Ostracods were highly abundant during winter, while foraminiferans were more abundant during autumn and free-living nematods appeared high abundance during summer. Radiolarians and Chaetognatha appeared only during autumn and summer, but echinodermates recorded during spring and winter. Decapod meroplankters represented by very low abundance during all seasons. The rarest groups; euphausiaces recorded during summer only, amphipods presented only during autumn and fish larvae appeared during winter.

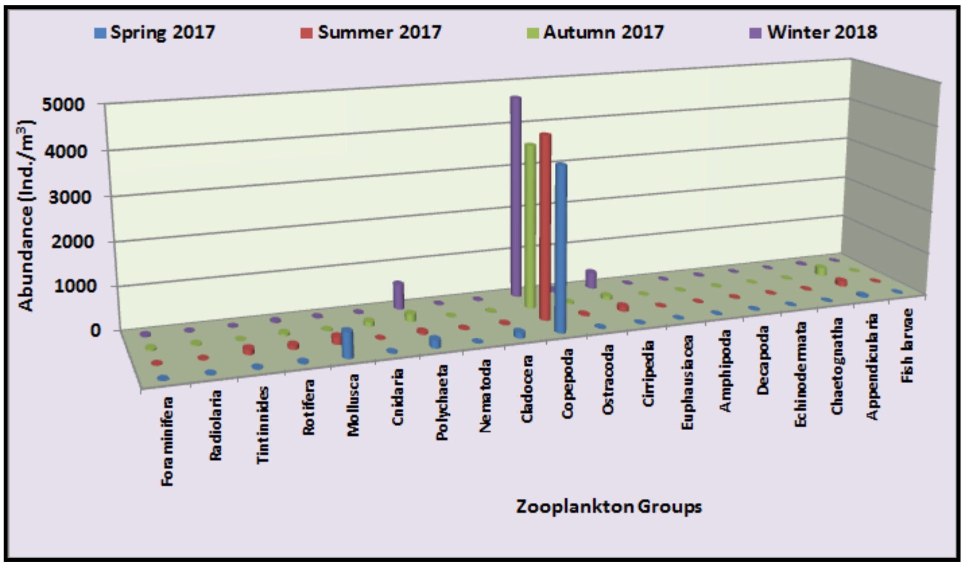

Figure 2. The abundance of the zooplankton recorded in the Eastern Harbor during different seasons.

2.2. Spatial variation

The data of spatial variation of zooplankton abundance showed that it was high at Boghaz 1 (10850.61 ind./m3), followed by El-Raml (6420.05 ind./m^3), and Middle (5330.71 ind./m^3) stations and low at El-Qalaa (1781.53 ind./m^3), followed by Boghaz 2 (2045.95 ind./m^3), and NIOF (3433.16 ind./m^3) (Figure, 3).

In this context, the highest copepods abundance was recorded at at Boghaz 1 (9658.62 ind./m^3) and the lowest at El-Qalaa (1517.11 ind./m^3). Also, Boghaz 1 had the highest abundance of each polychaets, cirriped larvae, appendicularians and cladocerans, while El-Qalaa had the lowest abundance from them. Successively, ostracods, cnidarians, decapods, Nematods and Chaetognatha were recorded their highest abundance at Boghaz 1, while their lowest abundance were recorded at Fishing, Middle, El-Selsela, El-Raml and El-Manshya stations, respectively. Whereas, the molluscs were recorded its highest abundance at Fishing station, the Rotifers were high abundant at El-Raml, tintinnids were more abundant at El-Qalaa, Foraminiferans were high abundant at El-Manshya, and Radiolarians abundance was high at Boghaz 2. On the other hand, echinodermata were recorded in three stations only and equally distributed between them. Euphausiacea were recorded in two stations (El-Selsela and El-Raml). The very rarest groups were amphipods and fish larvae were collected only from El-Raml and El-Manshya, respectively.

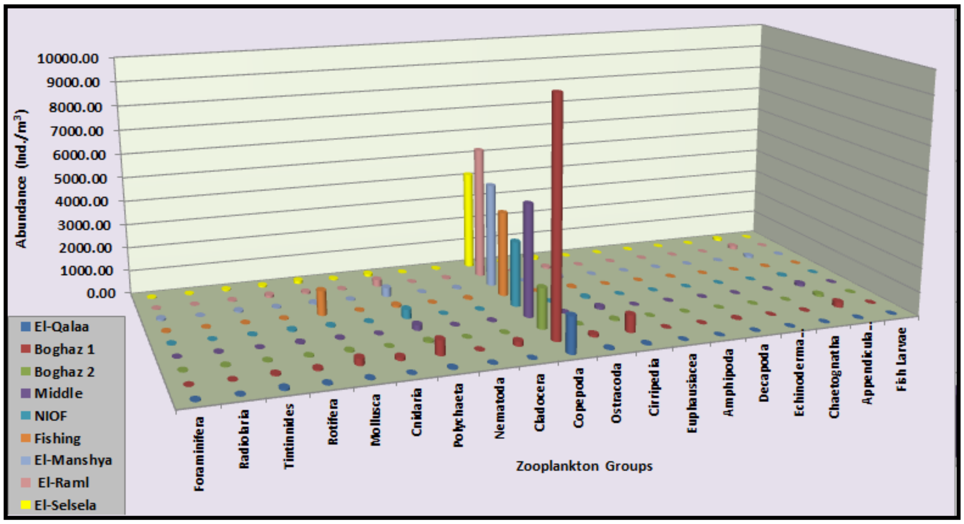

Figure 3. The average abundance of zooplankton throughout different stations at the Eastern Harbor.

3. Number of zooplankton species recorded in the Eastern Harbor.

3.1. Temporal variations

According to the present result, the numbers of zooplankton species were varied seasonally within narrow range. Where, the highest species number (49 species) was recorded in autumn, followed by summer (48 species), winter (46 species) and the lowest species number (43 species) was recorded in spring (Figure, 4).

The seasonal variations of species numbers of each group explained that there are 28 copepods species, 6 foraminiferans, 4 rotifers, 3 appendicularians, 2 cladosrans, and only one species of Radiolaria, Cnidaria, Polychaeta, Ostracoda, Amphipoda, Chaetognatha were recorded during autumn. While in summer, there are 21 copepods species, 7 tintinnids, 3 Rotifera, 3 Polychaeta, 3 Appendicularia, 2 Foraminifera, 2 Mollusca, 2 Cladosera, beside only one species for each Radiolaria, Cnidaria, Ostracoda, Euphausiacea and Chaetognatha were recorded. During winter, there are 27 copepods species, 9 Foraminiferans, 2 Rotifera, 2 Polychaeta, 2 Appendicularia in addition to one species for each Mollusca, Cnidaria, Cladocera and Ostracoda were recorded. Finally, spring's zooplankton were comprised from 23 copepods species, 6 tintinnids, 3 cnidarians, 2 Mollusca, 2 Polychaeta, 2 Ostracoda, 2 Appendicularia, besides one species for each of Foraminifera , Rotifera and Cladocera.

3.2. Spatial variations

It is clear from the Figure 5, the spatial variation of zooplankton species number showed that El-Manshya station harbored the highest number of zooplankton species (47 species, 54.65% of the total recorded species), out of them 20 copepods species, 9 foraminiferans and 4 tintinnids species. Boghaz 1 was the second diversify station harbored 45 species (52.33%) which comprised 26 copepods species, 3 tintinnids, 3polychaets, and so on. Also, NIOF station had the same (45 species, 52.33%) include 20 copepods species, 4 rotifers, 3 foraminiferans and others. Successively, El-Raml station had 42 species (48.84%) which represent 20 copepods species, 5 tintinnids, 3 polychaets, 3 cladosrans etc,. In this context, 39 species (45.35%) were collected from each of El-Selsela and Fishing stations; El-Selsela contain 18 copepods species, 4 tintinnids, 3 foraminiferans, and so on.; while, Fishing station include 20 copepods species, 5 foraminiferans , 3 tintinnids, and etc,. Thirty-four species (39.53%) were recorded in El-

Qalaa station, out of them 20 copepods species, 6 tintinnids, 3 rotifers and 2 foraminiferans. Middle station was contain 33 zooplankters (38.37%) include 19 copepods species, 3 rotifers, 3 cladocerans and 3 appendicularians. Finally, the lowest number of species (25 species, 29.07%) was recorded in Boghaz 2 station (16 copepods, 2 tintinnids, 2 appendicularians and only one species of foraminiferan, radiolarian, rotifer, cladoceran and ostracods).

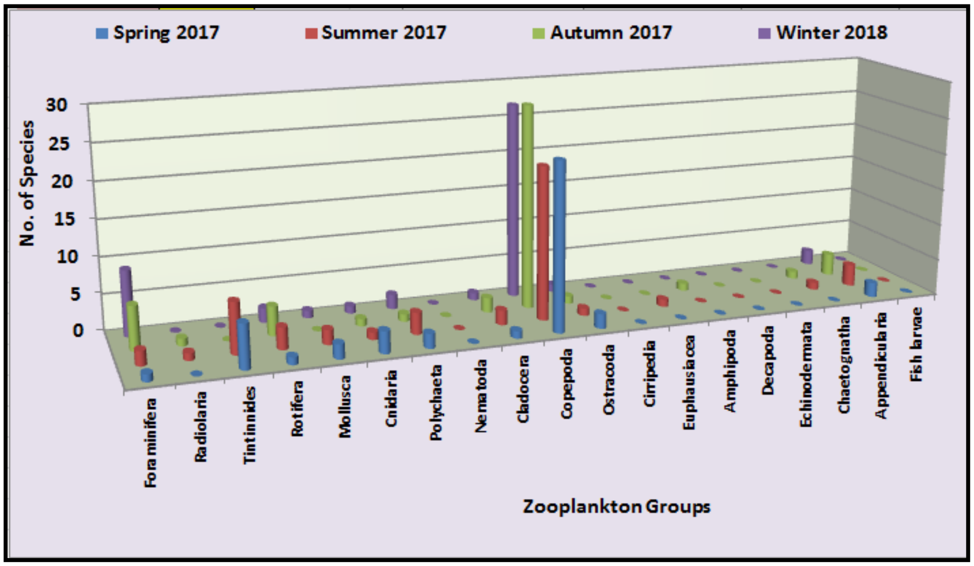

Figure 4. Seasonal variations of the species numbers of the zooplankton groups.

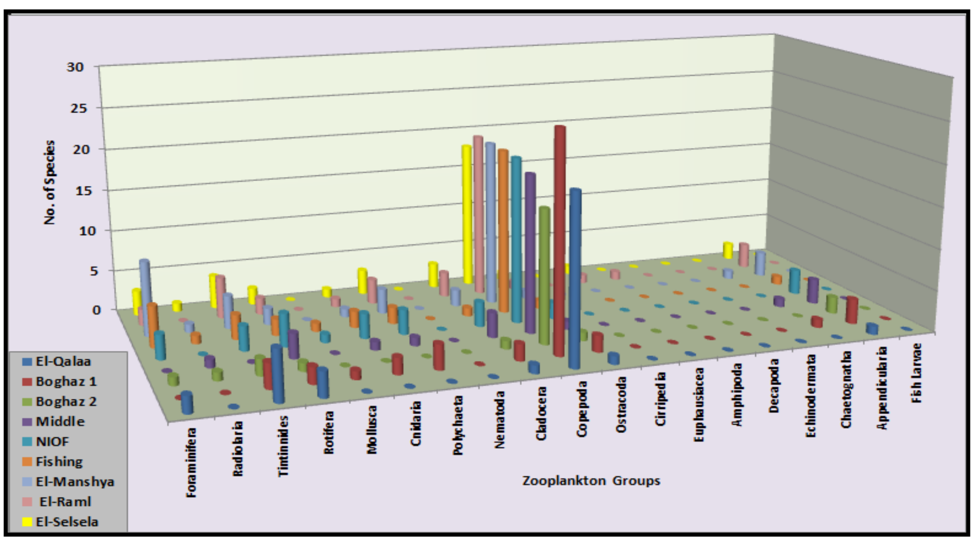

Figure 5. Spatial variations of the species numbers of the zooplankton groups.

4. Zooplankton frequency of occurrence

4.1. Temporal frequency:

The temporal frequency of zooplankton species revealed that 36 species were recorded in one season and represented 41.86 % of the total recorded species, 21 species (24.42 %) were identified in two seasons, 10 species (11.63%) were recorded in three seasons in addition to 19 species (22.09%) were recorded in four seasons (Figure, 6).

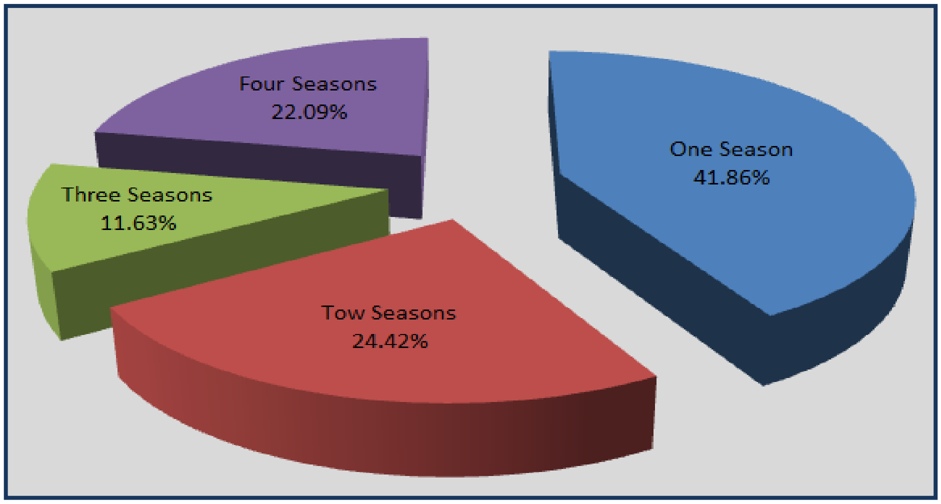

Figure 6. Temporal frequency of zooplankton through different seasons at the Eastern Harbor.

4.2. Spatial frequency:

The spatial frequency of zooplankton species in Figure (7) shows that 29 species were recorded in one stations and represented 33.72% of the total recorded species, there are eight species (9.30%) were recorded in two stations, seven species (8.14%) were seen in there stations, seven species (8.14%)were recorded in four seven species (8.14%) were recorded in five stations, five species (5.81%) were seen in six stations, five species (5.81%) were recorded in seven stations, six species (6.98%) were recorded in eight stations as well as twelve species (13.8%) were recorded in nine stations.

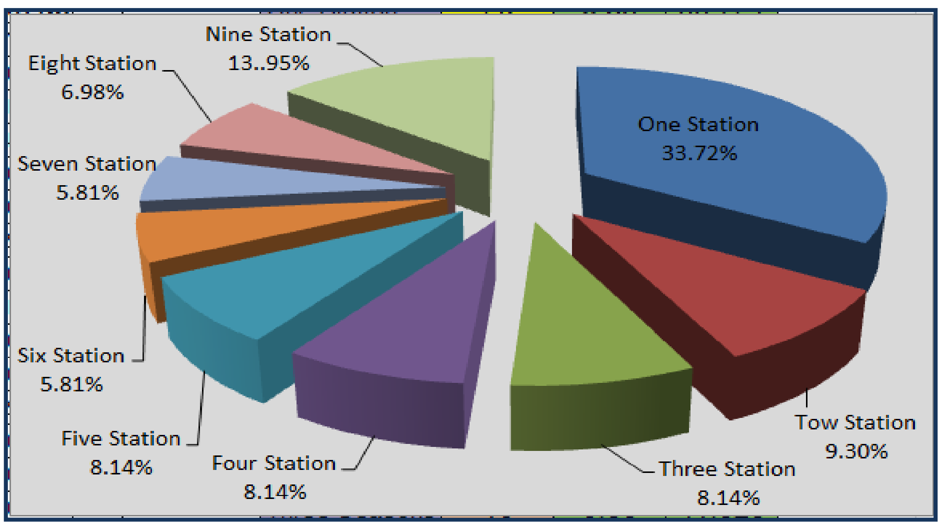

Figure 7. Spatial frequency of zooplankton through different seasons at the Eastern Harbor.

5. Diversity indices of zooplankton distribution in the Eastern Harbor

According to the data in the Table 2, the diversity indices were widely ranged among investigated stations within four seasons. Whereas, the species richness was recorded its highest value (3.796) at NIOF station during spring 2017, followed by 3.721 at El-Manshya station during winter 2018, but it was recorded its lowest value (1.003) at Boghaz 2 during summer 2017, followed by (1.133) at Middle station during autumn 2017. Concerning the Shannon index, the highest value (3.098) was occurred at El-Qalaa station during summer and (2.925) at Boghaz 1 station during autumn, while the lowest value (1,578) was occurred at Boghaz 2 during summer and (2.012) at El-Qalaa station during winter. On the other hand, the highest Evenness values were 0.989 and 0.959 in Middle and NIOF stations during autumn, respectively. While, the lowest Evenness values were 0.709 and 0.730 at Boghaz 1 and El-Raml during summer, respectively. The Simpson index was fluctuated from its highest values of 0.936 and 0.933 at El-Qalaa during summer and NIOF during autumn, respectively to its lowest value of 0.735 and 0.832 recorded at Boghaz 2 and Boghaz 1 during summer, respectively.

Table 2. The Diversity indices of zooplankton distribution at the Eastern Harbour.

Seasons	Station	Species richness	Shannon index	Eveness index	Simpson index
	El-Qalaa	0.9048	1.691	0.944	0.807
	Boghaz 1	2.729	2.911	0.883	0.929
	Boghaz 2	1.41	2.048	0.932	0.858
	Middle	1.424	2.176	0.945	0.877
Spring 2017	NIOF	3.796	2.735	0.782	0.903
	Fishing	2.585	2.389	0.742	0.848
	El-Manshya	2.639	2.342	0.7747	0.848
	El-Raml	2.966	2.564	0.797	0.883
	El-Selsela	3.065	2.531	0.768	0.871
	El-Qalaa	3.89	3.098	0.911	0.936
	Boghaz 1	3.034	2.337	0.709	0.832
	Boghaz 2	1.003	1.578	0.811	0.735
	Middle	2.894	2.631	0.789	0.893
Summer 2017	NIOF	3.538	2.496	0.741	0.855
	Fishing	3.557	2.623	0.764	0.887
	El-Manshya	2.753	2.49	0.784	0.872
	El-Raml	3.696	2.574	0.73	0.871
	El-Selsela	3.296	2.66	0.782	0.9
	El-Qalaa	2.713	2.5	0.787	0.877
	Boghaz 1	3.518	2.925	0.837	0.918
	Boghaz 2	2.124	2.633	0.894	0.914
	Middle	1.133	2.058	0.989	0.872
Autumn 2017	NIOF	2.632	2.773	0.959	0.933
	Fishing	1.875	2.231	0.824	0.862
	El-Manshya	3.136	2.723	0.817	0.904
	El-Raml	2.8	2.585	0.793	0.887
	El-Selsela	2.757	2.556	0.794	0.883
	El-Qalaa	1.37	2.012	0.916	0.849
	Boghaz 1	3.11	2.76	0.804	0.901
	Boghaz 2	2.025	2.698	0.952	0.925
	Middle	2.526	2.74	0.862	0.911
Winter 2018	NIOF	2.424	2.511	0.812	0.889
	Fishing	2.812	2.489	0.794	0.877
	El-Manshya	3.721	2.722	0.772	0.901
	El-Raml	2.697	2.786	0.865	0.923
	El-Selsela	2.256	2.68	0.927	0.918

DISCUSSION

Although zooplankton has been extremely well studied in marine ecosystems, its potential value as indicators of alterations in the marine environmental status still needs to be assessed. higher trophic levels in the marine plankton usually receive less attention in environmental monitoring **(Gismervik *et al*., 1996; Farrag *et al*., 2019)**, although changes in the abundance, distribution and succession of zooplankton organisms are indicator of changes in the environmental **conditions (Marques *et al*., 2008; Falcao *et al*., 2011)**. The zooplankton studies in the Easetrn Harbor have received little attentions in the past decade, where the last survey was done since 2004-2005 **(Zakaria, 2006)**.

The zooplankton standing stock in the Easetrn Harbor is greatly decreased when compared with that previously recorded. It decreased from 294.57×10³ ind/m^3 in 1976-1977 **(El-Zawawy, 1980)** to 273.45×10³ ind/m^3 in 1986-1987 **(Aboul Ezz *et al*., 1990)** to 42.728×10³ ind/m^3 in 2004-2005 **(Zakaria, 2006)** and reached to 4984.314 ind/m^3 in the present study.

The percentage of dominant zooplankton groups in the Eastern Harbor also changed along the time. Where, the protozoa percentage showed a great increase from 8.3% of the total zooplankton count during the years 1961- 1963 **(Dowidar and El-Maghraby, 1970)** to 40.5% in 1976-77 **(El-Zawawy, 1980)** to 42.1% in 1986-87 **(Aboul Ezz *et al*., 1990)** and reached to 49.7% of the total zooplankton count in 2004-05 **(Zakaria, 2006)** and then showed a sharply decrease to 1.16 % in 2017-18 during the present study. The changes in the abundance or biomass of protozoan species are considered as indicators for changes in the microplankton community, as a consequence of the changed trophic state **(Zakaria *et al*., 2018b)**. Rotifers species are considered as the most sensitive bio-indicator to water quality **(Musharraf *et al*., 1990; El-Naggar, 2015)**. The percentage of rotifers in the study area have been increased from 1% to 8.8% and 37.1% of the total zooplankton abundance during the previous successive investigations **(Dowidar and El-Maghraby, 1970; El-Zawawy, 1980; Aboul Ezz *et al*., 1990)** and greatly decreased to 10.23% in investigation of **Zakaria (2006)** then sharply declined to 0.97% of the total zooplankton abundance in the present study.

Copepoda is considered as the major dominant zooplankters in the marine water, they was represented about 74.14% of the total zooplankton counts at the Egyptian Mediterranean waters **(Zakaria *et al*., 2016)**. The percentage of Copepods frequency has been decreased from 65% during 1961-1963 to 36.8% in 1976-1977 to 15.9% during 1986-1987 and then increased in 2004-2005 to 27%. It increased again in the present study with a huge rang to achieving 81.97% to total zooplankton crop. The increase in the contribution of Copepoda and decrease of the Rotifera indicated that, the water quality of the harbor has been improved during the last two decades as a result of closing the sewage outfalls existing in the harbor **(Zakaria, 2006)**.

The community of zooplankton in the present study was comprised 87 species and other immature forms. Also, **Zakaria (2006)** was identified 85 zooplankton taxa in the harbor. Regarding species composition of the dominant zooplankton groups, there are great differences in the species composition between the previous studies and the present one. Where, 45 crustaceans (39 copepods, 3 cladocerans, 3 ostracods, one Euphausiace and one Amphipod) and 24 protozoan species (12 foraminifera, 2 radiolaria and 10 tintinnides) were recorded in the present study, while **Zakaria (2006)** found 17 crustaceans (13 copepods, 3 cladocerans and one species of ostracods) and 53 protozoan species during her survey. Rotifera was less diversified in species composition in the Eastern Harbor, only 5 species were recorded in the present study. They were less than previously recorded by **Zakaria (2006)** who found 7 rotifers species and completely different from the 6 species recorded by **Aboul Ezz *et al*. (1990)**.

The huge varieties in the number and abundance of zooplankton species between the present study and the previous ones were attributed to many reasons include; the difference of studied stations; period and mode of collection, mesh size of collecting zooplankton net and climatic changes. Different method of collection yielded different result as investigated by **Abd El-Rahman (2005) and El-Damhougy *et al*. (2017)**. Also, the successive decreasing of the standing stock of zooplankton can be due to that the harbor continuously receiving several kinds of untreated pollution and contaminbation which affect on the water componants balance. The Eastern Harbor is considered as one of the Alexandria's most affected ports by various human activities, which undoubtedly has a strong direct impact on the biodiversity as well as the distribution and diversity of zooplankton inside the harbor. the anthropogenic stressors are potential factors that are responsible for the degradation and instability of any ecosystem **(El-Naggar *et al*., 2017; Mona *et al*., 2019)**.

As for the seasonal variations in the zooplankton abundance, it has appeared that they were high during winter and summer, and low during spring and autumn. in contrast to **Zakaria (2006)** who recorded the highest abundance of zooplankton during spring and summer, while the lowest was recorded during winter. This sitution may be due to the increase of copepods numbers at the entrance of the harbor at Bogaz 1 station from the Mediterranean Sea, it may be becouse they transferred for protection inside the port.

Concerning the spatial distribution of zooplankton, it was found that the highest abundance of zooplankton was at Bougaz 1 station due to an increase of the abundance copepods enters from the sea into the harbor with the eastern current of the Mediterranean. the second abundant station was El-Raml followed by Middle station, which is also in the direction of the entry of the copepods from the sea to the harbor. While, Boughaz 2 station was the lesser abundant, which is considered as the exit opening of water from the harbor. **Zakaria (2006)** got the opposite of this result, where she found the highest abundance of zooplankton in El-Manshia, NIOF and El-Raml stations, while the lowest abundance was at the openings of entry and exit of water from the harbor at Boughaz 1 and Boughaz 2 stations in addition to the El-Qalaa station outside the harbor.

Changes in environmental stressors can influence the distribution of species and assemblages, the timing of important life-cycle events, abundance and groups structure **(Moller *et al*., 2015; Hasaballah and El-Naggar 2017; El-Naggar and Hasaballah, 2018)**. Zooplankton groups are highly sensitive to environmental variation. As a result, changes in their abundance, species diversity, or groups composition can provide important indications of environmental change or disturbance. They respond to a wide variety of disturbances including nutrient loading **(Dodson, 1992)**, acidification **(Marmorek and Kormann, 1993)**, contaminants **(Yan et al., 1996)**, fish densities **(El-Naggar *et al*., 2019)**, and sediment inputs **(Cuker, 1997)**.

In concerning of the diversity indices that use as a measure of ecological "health" or stability of the biotic groups. Also, the species indices values resulting from the present data confirm and indicate to the species disturbance between stations during study period. **(Bojanic et al., 2012)** found that the species richness (S) was positively related to overall zooplankton abundance on a temporal scale, but the strength of that relation was negatively related to increased trophic state. Zooplankton abundance and species dominance increased proportionally with increased trophic state. They concluded that species richness was positively related to overall abundance temporally and was also affected by environmental trophic state.

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