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INTRODUCTION

The present report deals with one section in the programme of plankton investigations carried out in the Eastern Mediterranean by the former Sea Fisheries Research Station, Haifa.

The epizooplankton includes both permanent epipelagic forms as well as deeper water organisms which inhabit the surface waters of the sea at certain times of the year. In view of the man-made changes induced in this part of the Mediterranean, first by the opening of the Suez Canal just over a century ago, and lately by the gradual operation of the Aswan High Dam in the Upper Nile, an analysis of this plankton community, subjected as it is to the direct influence of these factors, may elucidate some basic problems of migration and distribution of species.

For this purpose, this study included both a survey of the inshore waters of the Mediterranean coast of Israel to a depth of 75 fm as well as a grid of stations extending over the Levant Basin of the Eastern Mediterranean to the

* Study carried out within the framework of the joint project, »Biota of the eastern Mediterranean and the Red Sea«, supported by the Smithsonian Institution, Washington, D. C., and the Hebrew University of Jerusalem.

Dodecanese Archipelago and the Greek coastline. In this way, the above factors affecting the distribution of species in the Eastern Mediterranean, as well as the possible influence of the Atlantic current, could be taken into consideration when attempting to describe the characteristic features of this region.

The area has been the subject in recent years of an intensive study on the physical, chemical and biological characteristics of the Eastern Mediterranean. Some reports of the cruises connected with this study (designated C-01--C-28) have already been published (Oren, 1966, 1967; Kimor and Berdugo, 1967; Berdugo and Kimor, 1968; Oren and Burman, 1969; Kimor and Wood, 1975).

METHODS AND MATERIALS

The grid of stations sampled within the framework of this section of the plankton investigations covers the neritic waters of the continental shelf of Israel between the 10 and the 75 fm contours (Figure 1). Three fairly equidistant profiles, perpendicular to the coastline, were chosen, covering the northern, central and southern parts of the Mediterranean coast of Israel. Along these profiles samples were taken at monthly intervals, technical, weather and ship facilities permitting, at set stations of 10, 25 and 75 fm. In all, eight such cruises were carried out during 1968; the first one in March, covering only the northerly profile of Tira, the others covering in all cases the central profile of Netanya and the southern ones of Rubin and Ashkelon, which were visited alternatively and which form one unit for the purpose of the present paper.

The offshore plankton in the Levant Basin was collected in the course of three cruises carried out during 1968 in the Eastern Mediterranean under the leadership of Mr. O. H. Oren (Table 1). Figure 2 shows the location of stations for cruises C-07, C-08, C-10, and C-11. A fourth cruise, actually the first one carried out in that particular year, was not analyzed on a quantitative basis for technical reasons.

The zooplankton samples were collected by a standard plankton net of the Villefranche type as designed and described by UNESCO (1968). It has an internal mouth diameter of 57 cm, a total length of 261 cm, and mesh aperture width of the net material of 200 μ.

The horizontal hauls were carried out for ten minute periods at a cruising speed of 2 to 3 knots at each station site in the direction of the next one.

The quantities of seawater corresponding to the flowmeter readings were based on calibrations previously carried out on these instruments in the Hydraulics Department of the Technion — Israel Institute of Technology, Haifa.

The plankton samples collected in this manner were transferred into field jars by successive rinsings and fixed and preserved on board ship in a 4 percent buffered formalin.

Displacement volume estimations, expressed in cc, were carried out on each sample in the laboratory after removal of the larger forms of gelatinous

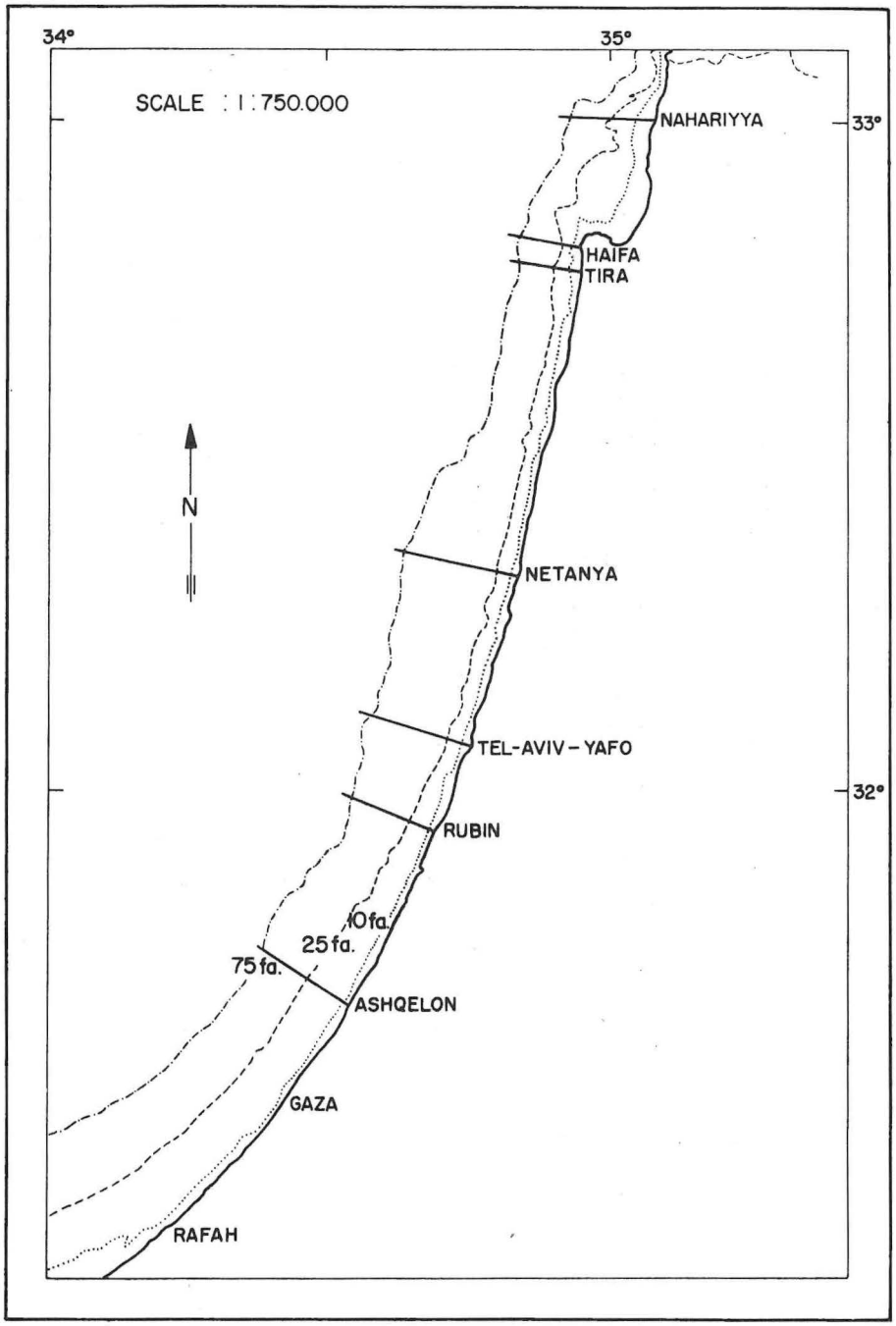


Fig. 1 — Location of inshore plankton profiles.

Table 1. Station data for offshore cruises C-08, C-10 and C-11 in the Eastern Mediterranean (Plankton cruise C-08 corresponds to Hydrographic cruise C-09. The hydrographic data were supplied by the courtesy of Mr. O. H. Oren.).

Cruise	Station number	Latitude	Longitude	Displacement volume (cc/1000 m³)	Temp. °C	Sal. ‰
C-08	1	32°55' N	34°34' E	62	23.82	38.93
	5	35°35' N	35°26' E	198	23.82	38.61
	7	36°05' N	34°05' E	64	24.48	37.20
	12	35°30' N	31°55' E	65	24.44	38.91
	13	36°10' N	31°00' E	51	22.00	38.77
	14	35°20' N	30°00' E	62	21.98	38.82
	15	34°50' N	28°55' E	104	22.12	39.07
	16	35°55' N	28°37' E	140	22.40	38.85
	18	36°30' N	28°13' E	41	22.74	38.94
	19	36°31' N	27°27' E	64	22.00	38.93
	21	37°12' N	24°51' E	76	21.28	39.15
	23	37°38' N	23°37' E	67	20.75	38.22
	30	35°14' N	26°33' E	42	22.62	39.21
	31	34°20' N	27°20' E	36	23.48	39.08
	36	33°25' N	30°20' E	20	24.52	39.05
	44	32°25' N	32°15' E	30	25.24	39.04
	47			146		
C-10	1	32°35' N	31°55' E	30	25.90	39.22
	8	34°37' N	32°20' E	25	25.86	39.32
	20	32°30' N	34°00' E	17	27.75	39.16
	22	32°30' N	33°21' E	22	27.26	39.22
	24	32°30' N	32°41' E	19	26.34	39.26
C-11	1	33°25' N	33°14' E	22	22.45	39.32
	3	32°01' N	33°25' E	33	22.70	39.36
	17	33°25' N	25°15' E	22	19.08	38.91
	21	34°47' N	25°10' E	18	18.20	39.15
	28	33°17' N	22°47' E	38	19.36	38.62
	39	35°11' N	22°15' E	22	17.96	38.50
	41	35°35' N	21°50' E	21	17.94	38.86
	43	35°57' N	22°15' E	31	18.28	38.68
	50	34°35' N	29°40' E	38	17.50	39.13
	52	34°20' N	32°25' E	14	18.76	39.07
	54	34°10' N	34°29' E	31	20.14	39.20
	55	33°30' N	34°45' E	32	20.47	39.21

organisms and other soft-bodied components of the zooplankton, such as coelenterates and pelagic tunicates. The samples were then split into smaller subsamples by means of a Wiborg splitter. Usually one to two-tenths of the original sample was used for numerical counts and identifications, although in the case of rarer organisms the counts were carried out on the whole sample. The numbers recorded for each taxon in the subsample were then related to the whole sample and computed as numbers per 1000 m^3 on the basis of the quantity of seawater which was actually filtered through the nets. The major macroplankton components were then sorted and transferred into separate vials for later taxonomic analyses and other studies.

Although 23 taxa in all were taken into consideration for the purpose of the numerical counts (results expressed as numbers per 1000 m^3), the dis-

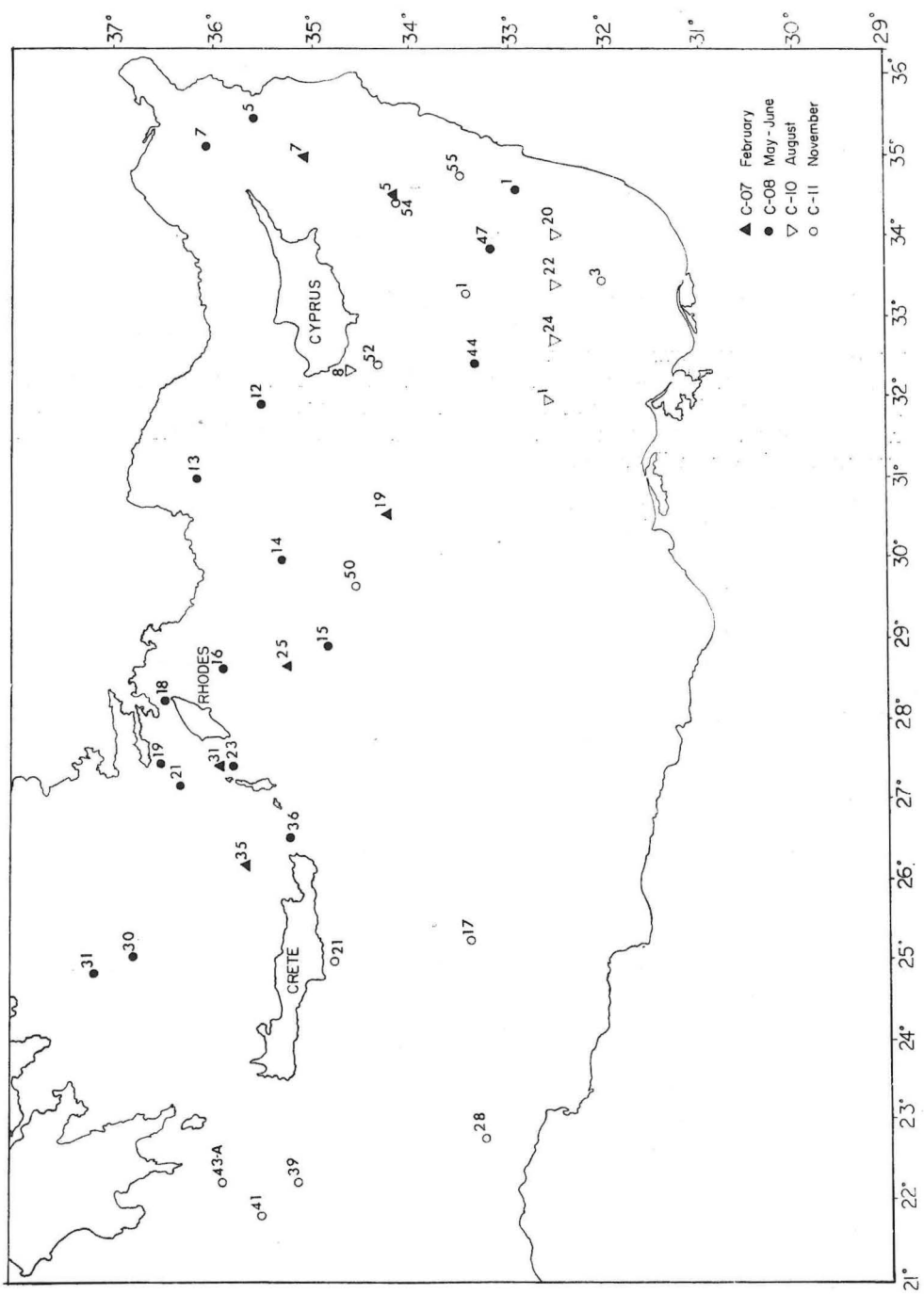


Fig. 2 — Location of stations for offshore cruises C-07, C-08, C-10 and C-11 in 1968.

cussion regarding composition of species and other specific aspects is limited only to those groups on which sufficient information was at the authors' disposal, either from their own work or from other sources.

RESULTS

The Inshore Plankton

Displacement Volumes. — The total displacement volumes of all samples collected in the neritic waters of Israel during 1968 are shown in Figure 3a, b, c, d, e. The histograms show the displacement volumes and the numerical abundance values of the zooplankters of each cruise. For comparison purposes, histograms of displacement volumes for 1967 and other stations sampled within the framework of other projects undertaken by the Sea Fisheries Research Station are shown in Figure 4.

An inspection of the displacement volumes for each month shows that while the seasonal changes are at times quite pronounced, those recorded between one profile and another during the same cruise are small and often negligible. From past data, however, it appears that this is not always the case (Komarovsky, 1959; Kimor, 1965). During an annual peak in the *Sardinella aurita* fishery along the Mediterranean coast of Israel in May-June 1958, the total standing crop of plankton was found to vary considerably not only from one contour line to another within the same profile, but also from one profile to another. The composition rather than the absolute size of the zooplankton standing crop was found to be related to the success or failure of the *Sardinella* fishery.

In April 1967, the displacement volumes were fairly high, coinciding with or following the spring phytoplankton blooms, with values reaching 113 cc/1000 m^3 at Tira at the 25 fm contour, and 106 cc/1000 m^3 at Netanya at the 75 fm contour. In July, a distinct decrease in the plankton standing crop was observed, with displacement volumes not exceeding 37 cc/1000 m^3 off Tira and Netanya. This is in accordance with previous data (Kimor, 1965) that the plankton standing crop during a five-year period (1959—1963) was consistently at its lowest during this time of the year.

October and November showed somewhat higher displacement volumes than in July, with values mainly between 20 and 54 cc/1000 m^3, with local fluctuations between one profile and another.

In December, there was a steep rise in the displacement volumes, particularly at Netanya, with values of 125 and 226 cc/1000 m^3 at 10 and 25 fm contours respectively. At the Tira and Ashkelon profiles, this rise was more moderate, with displacement volumes not exceeding 67 cc/1000 m^3.

As will be shown below, this rise, which seems quite unusual for this time of year, could be directly correlated with a parallel increase in the numerical abundance of the major zooplankton groups.

Numerical Abundance. — In general, there is a direct relationship between the displacement volumes and the total number of individuals of the

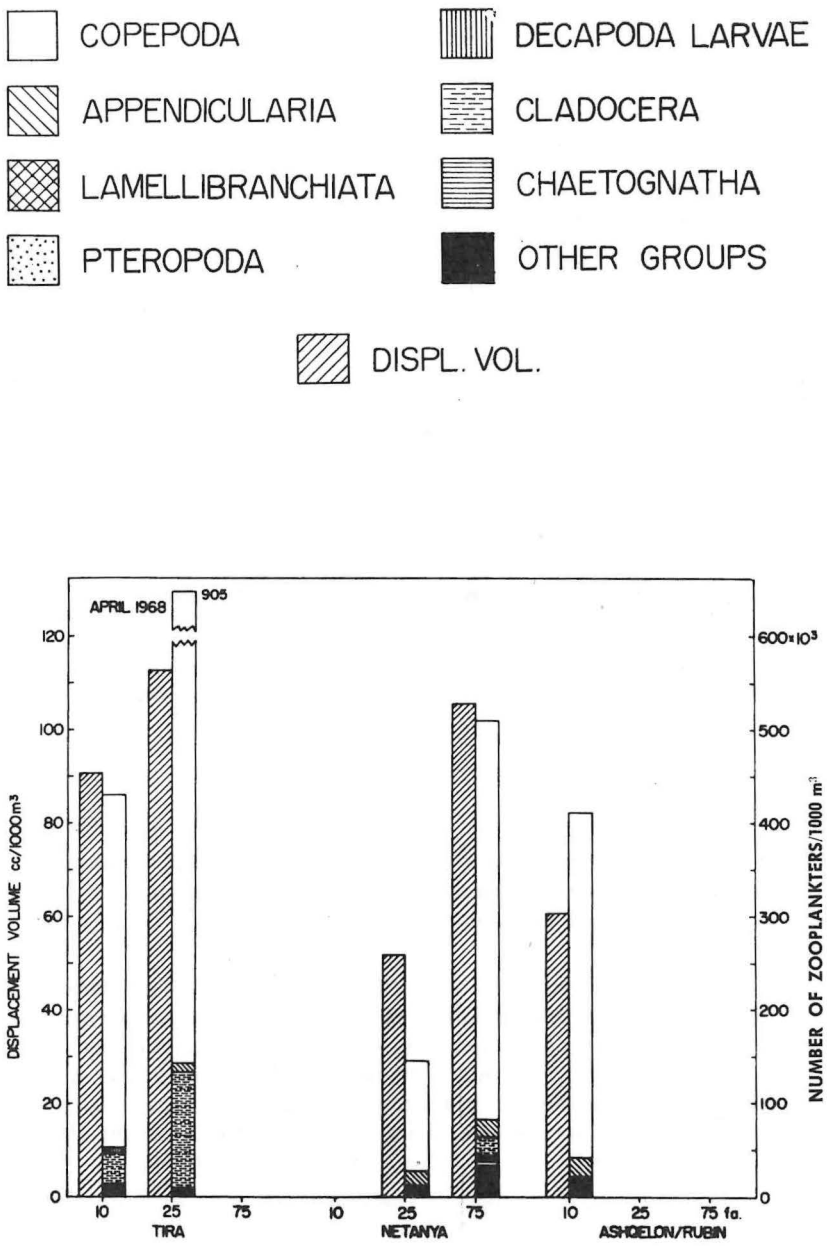


Fig. 3a — Displacement volume (cc/1000 m³) and numerical abundance (no/1000 m³) of inshore zooplankton from the Tira, Netanya and Ashkelon/Rubin profiles for April 1968.

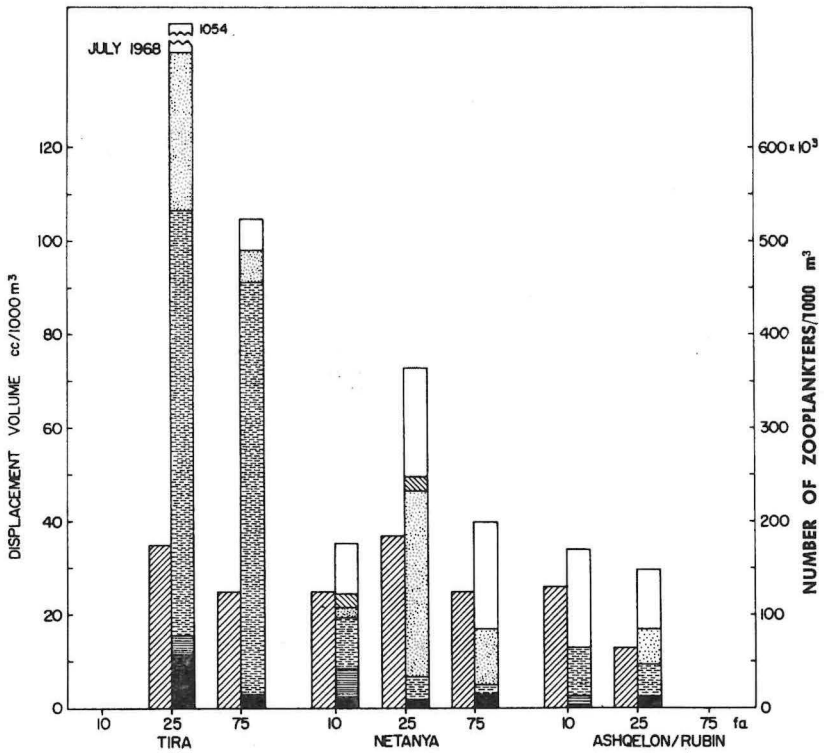


Fig. 3b — Displacement volume (cc/1000 m³) and numerical abundance (no/1000 m³) of inshore zooplankton from the Tira, Netanya and Ashkelon/Rubin profiles for July 1968.

major zooplankton groups. This may be explained on the basis of the major role of the Copepoda as biomass formers in view of their dominance in the general composition of the plankton. This was particularly true of the seasonal peaks in April-May and December 1968 which consisted largely of copepod crustaceans.

In exceptional cases, such as July 1968, there were considerably higher numbers of organisms corresponding to given displacement volumes as a result of a preponderance of smaller types of zooplankton, such as cladocerans and thecate pteropods. During this particular month, there was a noticeable decrease both in the number of individuals of Copepoda as well as in their relative proportion to other groups. This accounted for a larger share of the latter in the general composition of the plankton communities.

Similar cases of abrupt changes in the composition of a plankton community either through active predation by carnivorous zooplankters or through sheer competition within the same ecosystem, are known from both the Eastern Mediterranean and elsewhere (K o m a r o v s k y, 1959; F r a s e r, 1962).

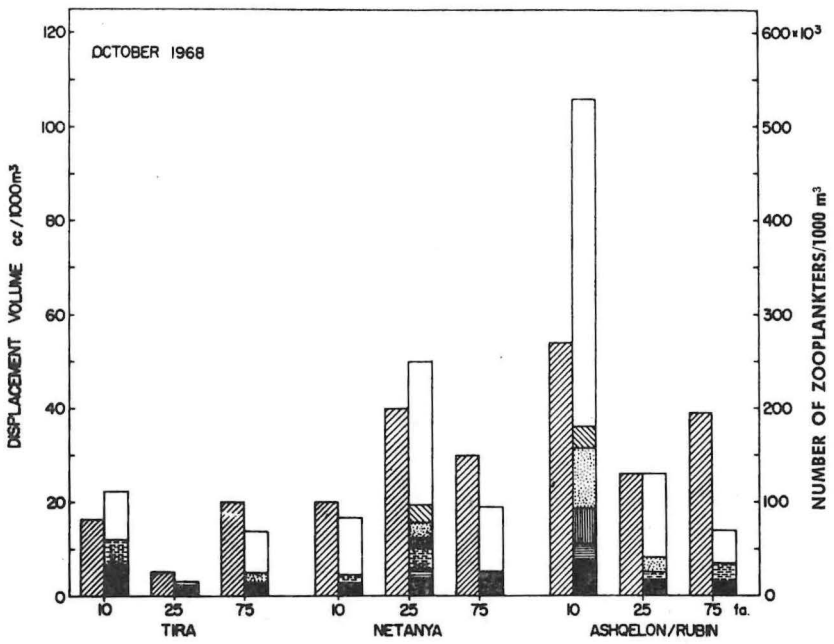


Fig. 3c — Displacement volume (cc/1000 m³) and numerical abundance (no/1000 m³) of inshore zooplankton from the Tira, Netanya and Ashkelon/Rubin profiles for October.

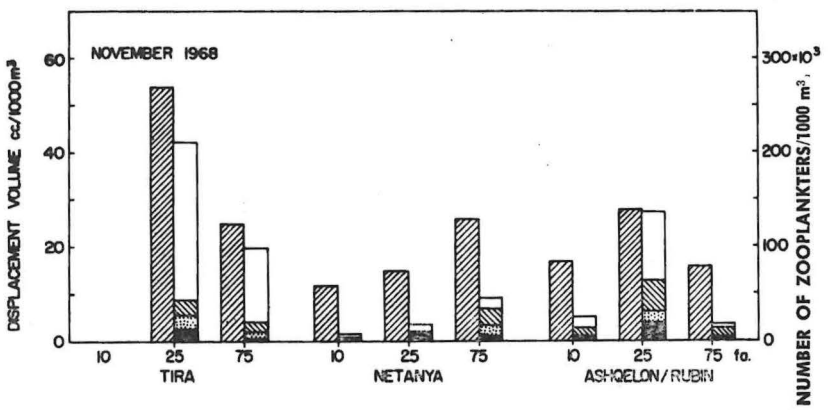


Fig. 3d — Displacement volume (cc/1000 m³) and numerical abundance (no/1000 m³) of inshore zooplankton from the Tira, Netanya and Ashkelon/Rubin profiles for November.

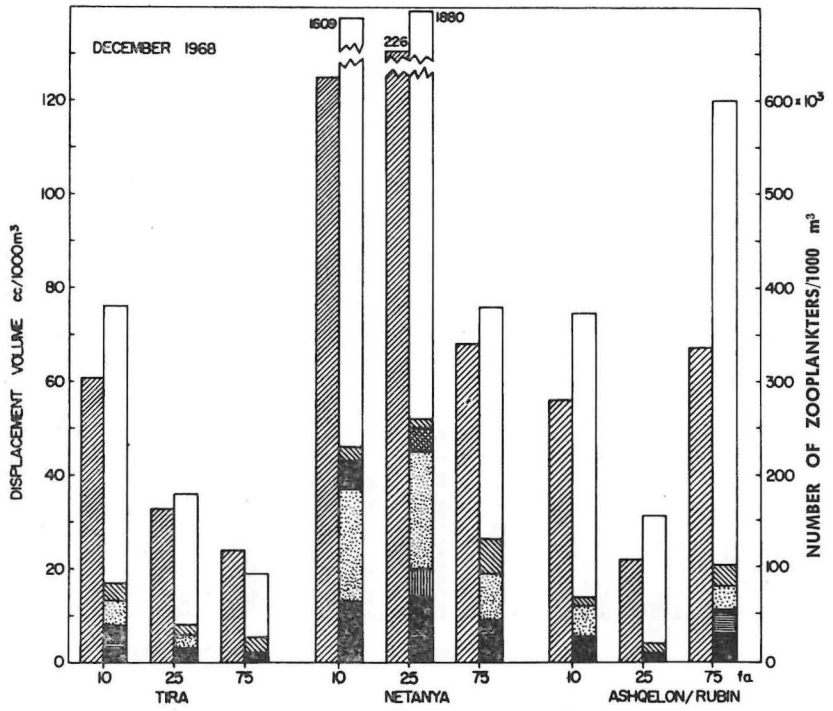


Fig. 3e — Displacement volume (cc/1000 m³) and numerical abundance (no/1000 m³) of inshore zooplankton from the Tira, Netanya and Ashkelon/Rubin profiles for December 1968.

Components of the Zooplankton. — 1. Copepoda. This was by far the most important group in the composition of the zooplankton, both as the largest contributor to the displacement volumes due to their numerical abundance as well as species diversity. Of the three suborders of Copepoda, the Calanoida were by far the most important as biomass formers and species representation, though at times the Cyclopoida, especially the Corycaeidae, became quite numerous, such as in December 1968.

In general, it may be said that the peaks in the distribution of Copepoda coincided with the two seasonal peaks of the total zooplankton, namely in April-May and December. During these peaks, the group reached values of 762,000/1000 m³ at 25 fm contour and 940,000/1000 m³ at the 10 fm contour respectively. In July and October, the numbers of copepods were noticeably lower than during the main peaks.

From the point of view of the distribution and numerical abundance of species, the differences between one season and another were considerable. The spring peak in April off Tira consisted of three species: *Paracalanus parvus, Centropages kröyeri and Isias clavipes,* with *Acartia clausi* as a minor constituent. During the same month, the composition of species along the southern profile off Rubin was only partly similar. In addition to *Paracalanus*

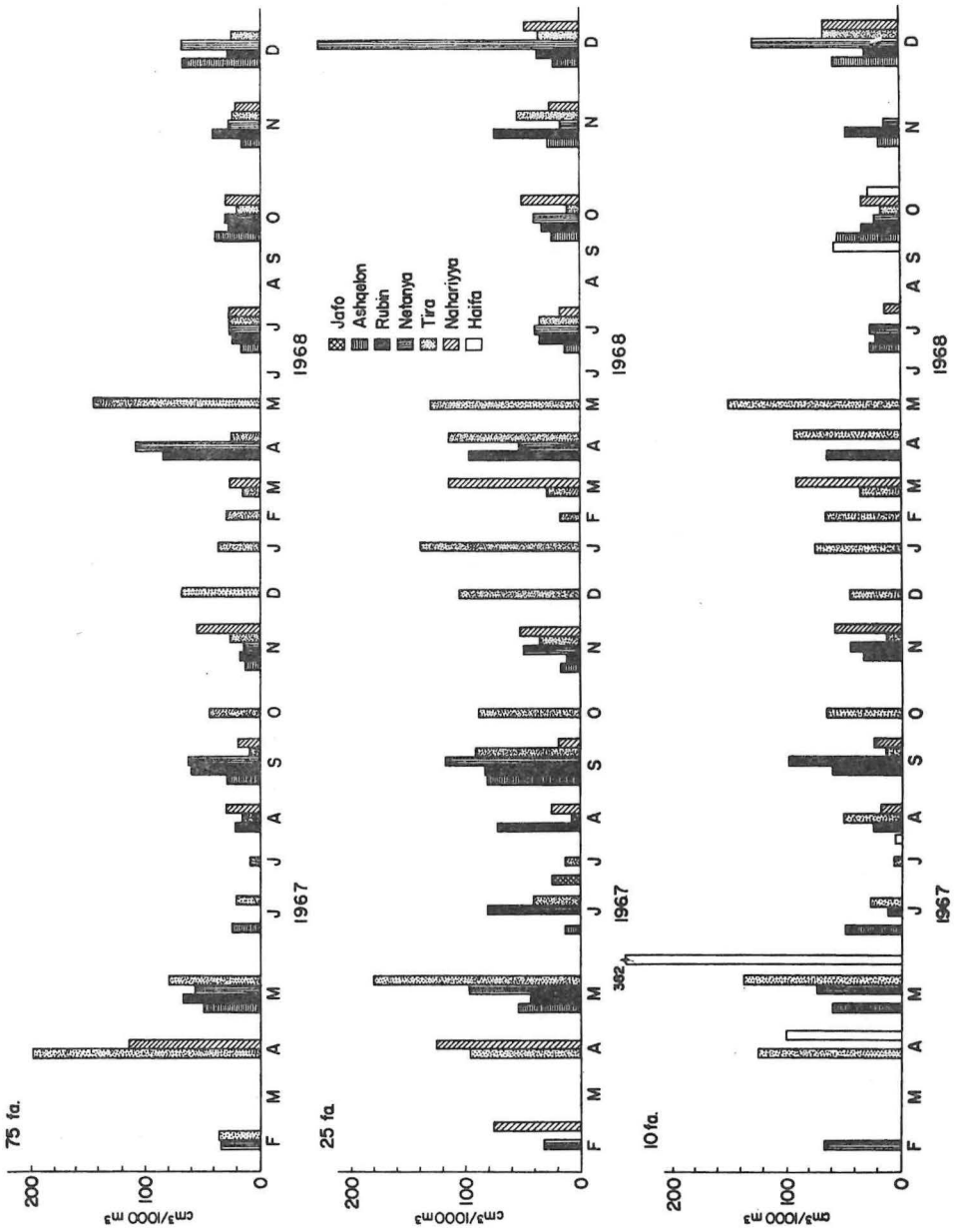


Fig. 4 — Displacement volume (cc/1000 m^3) of total inshore zooplankton for 7 profiles for 1967—68.

parvus and *Centropages kröyeri, Acartia clausi* was quite numerous, while a marked decline was observed in the numerical abundance of *Isias clavipes.*

The second peak in December was characterized not only by the high numerical abundance of the members of this group, but also by the number of species. The number of calanoid species reached 20 compared to 7 in April.

The main species of copepods making up the December peak were *Paracalanus parvus, Clausocalanus furcatus,* and *Temora stylifera* of the Calanoida; *Corycaeus* sp. and *Oncoea* sp. of the Cyclopoida; and *Euterpina acutifrons* of the Harpacticoida. In addition to the principal species there were others that occurred in low numbers and characteristic of deeper water layers which were recorded in the subsurface layer. This fact may be explained in the light of homothermic conditions prevailing at this time of the year. Among such species were *Lucicutia flavicornis* and *Euaetideus giesbrechti.*

From the point of view of the seasonal distribution, the species of Copepoda may be grouped as a) present throught the year *(Paracalanus parvus, Temora stylifera, Clausocalanus furcatus* and *Corycaeus* sp.); b) present mainly during spring *(Centropages kröyeri* and *Isias clavipes);* c) present mainly during November-December *(Calocalanus styliremis, Oncaea* sp. and *Euterpina acutifrons;* the latter present also during July).

2. Cladocera. The Cladocera were represented by species belonging to the two genera, *Evadne* and *Podon;* the former by *E. spinifera* and *E. tergestina,* and the latter by *P. polyphemoides.* All these species are known as mainly neritic and particularly abundant during the summer months. There were no specific differences in the distribution of these species along the coast. The highest numerical values were recorded during July, when the total number reached 454,000/1000 m^3. A lower peak was recorded in April off Tira at the 25 fm contour when the number of cladocerans reached 122,000/1000 m^3.

The pronounced decline in the abundance of Cladocera was recorded in October (to about 25,000/1000 m^3) and dropped still further during the following month, and disappeared almost completely from the plankton in December.

Although no data are available from the coastal waters of Israel for the months of August and September, the virtual disappearance of the Nile flood from the Eastern Mediterranean as a result of the operation of the Aswan High Dam is apparent. Previously, the drop in the salinity of the seawater as a result of the arrival of the Nile flood caused an almost immediate rise in the abundance of the cladoceran *Podon polyphemoides,* a typically euryhaline species, to a state of mass development (Komarovsky, 1952; Oren and Komarovsky, 1961). *Evadne spinifera* and *E. tergestina* occurred together in varying proportion, as was the case during the first peak in April-May, while *Podon polyphemoides* occurred mainly during the summer peak in July.

3. Chaetognatha. The group was represented by the two species most common in the neritic waters of this region, *Sagitta friderici* and *S. enflata.* Both species are known as neritic and epipelagic, although *S. friderici* was found to be more common in at the 10 and 25 fm contours, whereas *S. enflata* was more common at the 75 fm contour.

Two seasonal peaks could be detected in the abundance of Chaetognatha which coincide fully with the seasonal peaks of April-May and December recorded for the plankton as a whole. These peaks consisted of *Sagitta friderici* as the dominant species during the late spring maximum, and of both *S. friderici* and *S. enflata* as an additional species in the early winter one. The number of specimens, including immature stages, reached 122,000/1000 m^3 in May and 44,000/1000 m^3 in December. A number of individual specimens of *Sagitta bipunctata* were recorded during the October cruise off Ashkelon.

As the two main peaks (April-May and December) were caused mainly by large populations of copepods, the parallel trend in the maxima of Chaetognatha seems more than coincidental, especially if the respective data are examined for all the cruises carried out during this particular year. As the copepods are known to be important as food for *Sagitta,* it can be assumed that the chaetognaths are favored in their development by the rise in the populations of the copepods. This is especially true of *Corycaeus* sp., which was frequently observed either in the digestive tracts of *Sagitta,* in transparent specimens or in the process of being swallowed. This may indicate not only that copepods are important as food items for the chaetognaths, but also that there may be a certain measure of feeding selectivity of individual species.

4. Mollusca. The pelagic Mollusca recorded belong to two orders of Gastropoda, Pteropoda and Heteropoda. Among the easily identified genera of Pteropoda, all of which belong to the suborder Thecosomata, were *Creseis* and *Limacina,* both of which were quite common in the coastal waters of Israel. For the assessment of numerical abundance, counts were made of all representatives of this group, including unidentified genera and species.

One peak was observed in July with values just exceeding 200,000 individuals/1000 m^3 along the Tira-Nahariya 25 fm contour. October and November showed low values not exceeding 14,000/1000 m^3, while in December there was a steep rise off Netanya between the 10 and 25 fm contours.

The order Heteropoda included representatives of the two families Pterotracheidae and Atlantidae. The two most common genera *Pterotrachea* and *Atlanta,* whenever present, occurred only in small numbers.

Larval stages of Lamellibranchiata were also found to be quite common in most of the samples, with a peak in December off Netanya between the 10 and 25 fm contours.

5. Decapoda. On the basis of the data for 1968, the representatives of the order Decapoda, consisting largely of larval stages of many meroplanktonic groups, as well as mature and larval stages of the holoplanktonic *Lucifer,* were recorded in all eight cruises carried out during that year. Although no data are available for some of the summer months, when the decapod larvae are known to abound in the plankton, the data showed a distinct increase in numbers during the months of October and December. In October, the number of Decapoda reached a maximum of 125,000/1000 m^3 in the Haifa Bay area and decreasing values towards the south, consisting mainly of *Lucifer.* At those stations where *Lucifer* was not predominant, the prevailing types of decapod larvae belonged to Anomura, Brachyura and Macrura, occurring in varying proportions from place to place.

The December maximum in the occurrence of Decapoda coincided with the total zooplankton peak, consisting largely of Macrura and Anomura and, to a lesser extent, of Brachyura. The genus *Leptochela* was the main representative of the suborder Macrura.

The numerical abundance of the Decapoda larvae during the earlier month of 1968 was far more limited, with values not exceeding 5600/1000 m^3. In April the Decapoda consisted mainly of Brachyura zoea and megalopa, and in July, of all the other groups mentioned above. An exception, however, was recorded off El Arish, when the total number of decapod larvae reached 30,000/1000 m^3 at the beginning of July.

The Macrura Natantia included the families Penaeidae, Sergestidae, Pasiphaeidae, Palaemonidae, Alphaeidae, Hippolytidae and Processidae. The material also included representatives of a number of families hitherto unidentified. The Macrura Reptantia included the families Upogebiidae and Callianassidae. In addition, Phyllosoma larvae were also recorded in the plankton which could be related to either or both of the families Palinuridae and Scyllaridae.

6. Foraminifera. The most common species was *Globigerina bulloides*. Although generally present in low numbers, it occasionally reached high abundance at individual stations, such as at Tira in July (54,000/1000 m^3) and in October (14,000/1000 m^3). Representatives of other genera, such as *Tretomphalus*, also showed a sporadic occurrence at most profiles along the 25 fm contour.

7. Coelenterata. The species of Hydromedusae from the collection identified by Dr. Marta Vannucci in 1969 included *Liriope tetraphylla, Aglaura hemistoma* and *Geryonia proboscialis*. These species were found in low numbers without any definite pattern of distribution. Of the species, *L. tetraphylla* was by far the most common. Komarovsky (1959) reported *L. tetraphylla* as a dominant element of the plankton causing widespread depletion of other zooplankton groups.

Additional samples containing Hydromedusae were checked by Dr. Hans-Eckart Schmidt in 1970 and he noted the sporadic occurrence of *Rhophalonema velatum* and *Eirene viridula* in addition to the more common species identified by Dr. Vannucci.

The Siphonophora recorded in the collections belonged to the order Calycophora, which included colonies of pneumatophores. Generally, they occurred in low numbers as nectophores, mostly in fall and early winter. Alvarino (1974) reported on the siphonophores from the area considered in the present paper.

8. Ostracoda. The Ostracoda were found to be very rare during spring and summer and increased in numbers (up to 1700/1000 m^3) only in December.

9. Peracarida. The two groups of Peracarida, Amphipoda and Mysidacea, were present in the plankton in low numbers. No special trends in their distribution were detected.

10. Echinodermata larvae. These larvae showed, like the preceding groups, only a sporadic occurrence during the summer months, reaching a somewhat

higher concentration in December (11,000/1000 m^3) along the Netanya and Ashkelon profiles.

General Characteristics of the Neritic Epizooplankton. — The plankton is characterized by the presence of two main annual peaks consisting in both cases of large populations of copepods. This is generally consistent, with the results of the survey along the coast of Israel in 1967. The December maximum, however, consisted also of large populations of other zooplankton groups, chiefly Chaetognatha, Pteropoda and larval Decapoda. The 1968 December peak in zooplankton production was unusual if compared to data from the previous year on the population dynamics of Copepoda (Berdugo, 1969a) and to semi-quantitative data from earlier years. No explanation can be offered for the steep rise in zooplankton production in December 1968 neither from the data from previous years nor from the physical data collected simultaneously with the plankton samples.

The Offshore Plankton

Displacement Volumes and Numerical Abundance. — The displacement volumes for the three cruises showed higher numbers for the May-June cruise than for those of September and November-December as seen in Table 1. Even considering the fact that in individual cases the high figures obtained for the May-June cruise (198 cc at station 5 and 146 at station 47) may have been the result of night sampling, the trend indicating a higher zooplankton standing crop during this cruise as compared to the latter is quite obvious. This can be shown by the mean values for the displacement volumes for these cruises, which were 52 cc during May-June, 23 cc during September and 27 cc during November-December. A similar trend can be observed in the actual numerical abundance of the organisms during these cruises, when the highest numbers dropped considerably, although not in the same seasonal sequence due to the actual size of the dominating organisms in the plankton.

The displacement volumes of the plankton samples collected during the cruises are given in Table 1, and represented in Figures 5, 6 and 7 as circles whose radii are calculated on the basis of the logarithmic numbers of the actual values. In the circles, the relative proportion of the major zooplankton groups is based on percentages of the total zooplankton.

Components of Zooplankton. — The following discussion is limited only to the major zooplankton groups more or less in the order of their numerical abundance in the plankton.

1. Copepoda. The Copepoda constituted the main component of the 300 plankton samples of the three cruises, reaching at times up to 85 percent of the numerical composition of some of the samples. As in the case of the inshore waters discussed above, the Calanoida were the main element in the Levant Basin samples, although in some cases the Cyclopoida represented by one or several species of *Corycaeus* were dominant.

For cruise C-08 (May-June), the numerical abundance of the Copepoda was highest, although consisting of a small number of species (Figure 8). For the following cruise, C-10 in September, the average numerical abundance of

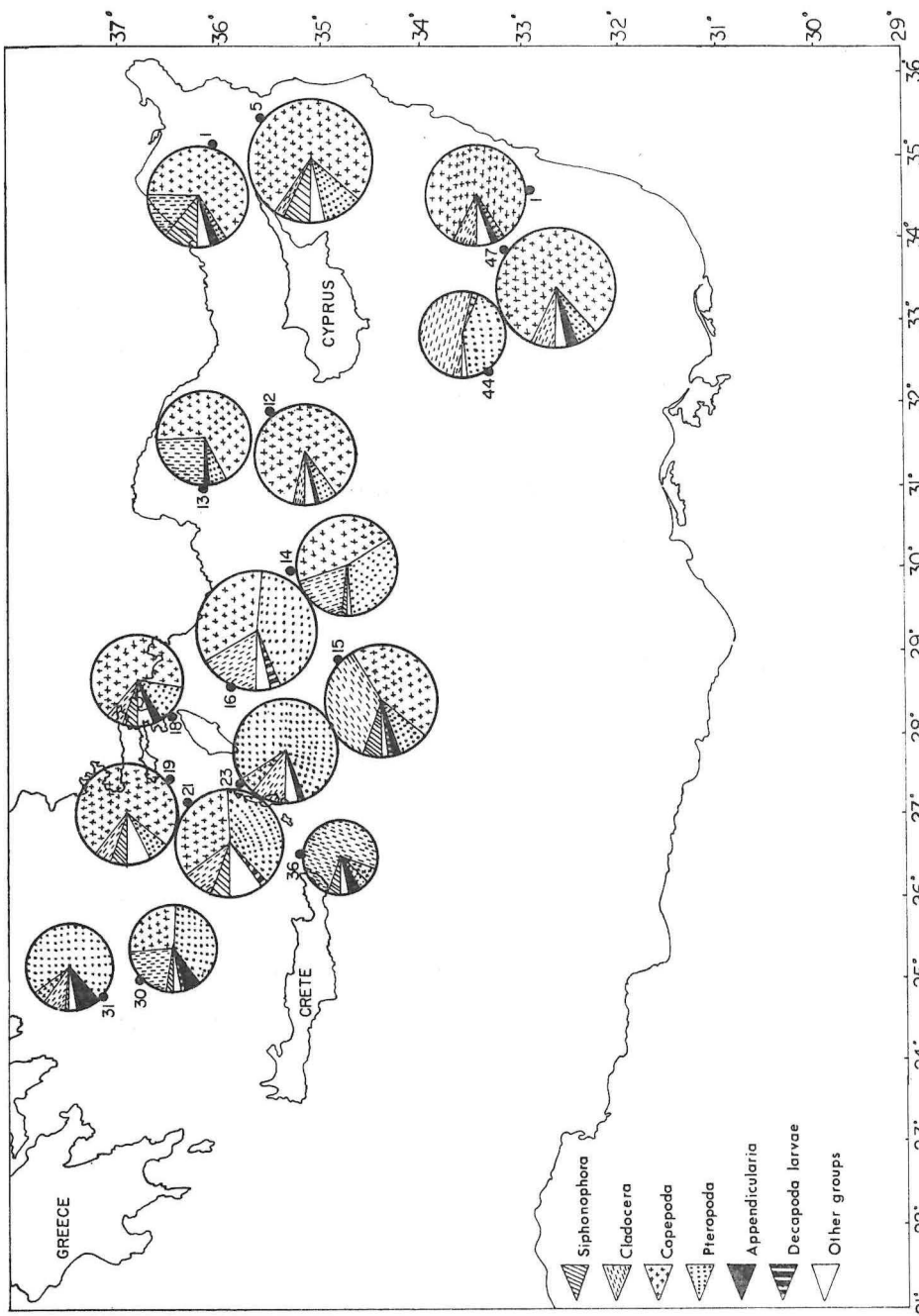


Fig. 5 — Displacement volume of total zooplankton (circles, cc/1000 m³) and relative percent of main zooplankton groups (divisions within circles) for stations of offshore cruise C-08, May-June 1968.

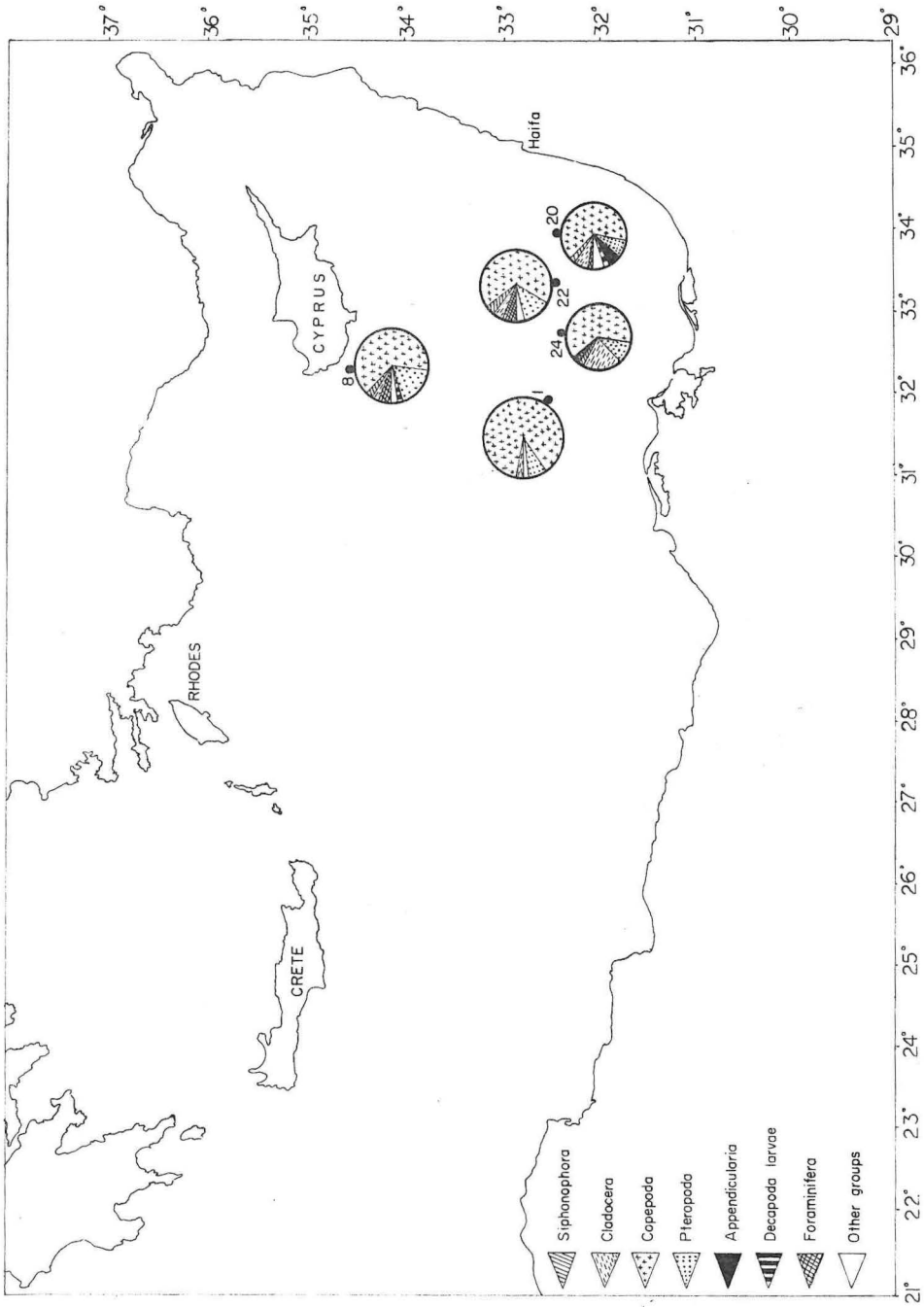
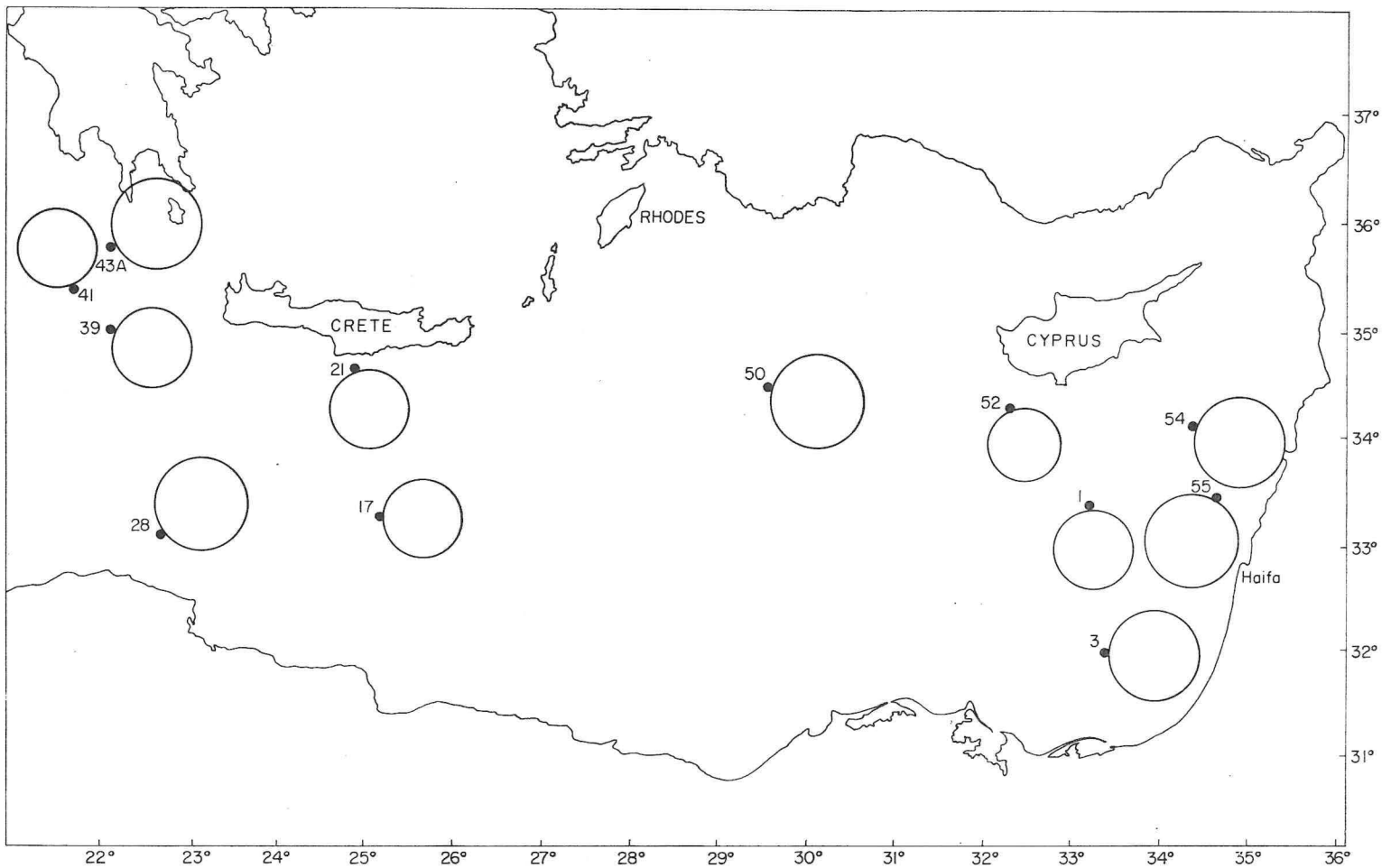


Fig. 6 — Displacement volume of total zooplankton (circles, cc/1000 m³) and relative percent of main zooplankton groups (divisions within circles) for stations of offshore cruise C-10, August, 1968.


RHODES
CRETE
CYPRUS
Haifa
43A
41
39
21
50
52
54
55
1
28
17
3
37°
36°
35°
34°
33°
32°
31°
22°
23°
24°
25°
26°
27°
28°
29°
30°
31°
32°
33°
34°
35°
36°

the Copepoda was lower, with the exception of station 1 (the sample may have been collected with a finer net, thus retaining the larval stages), but consisting of a larger number of species. The downward trend in the numerical abundance continued in C-11 (December) to an even greater extent.

The dominant species of Copepoda recorded in these cruises were as follows. *Clausocalanus furcatus* was found to be present in all the samples and especially abundant in C-08 and less so in C-10 and in C-11. *Temora stylifera* occurred in lower numbers than *C. furcatus*, but was recorded at all stations in May-June and at a few only in September and December. *Paracalanus parvus*, a neritic species which was among the most important constituents of the littoral plankton of the Mediterranean coast of Israel, was recorded only in the C-08 cruise, close to the coast or several of the islands, thus confirming its neritic character. At these localities, the occurrence of *C. furcatus* was more limited. *Corycaeus* spp. were recorded in all samples, especially during C-08.

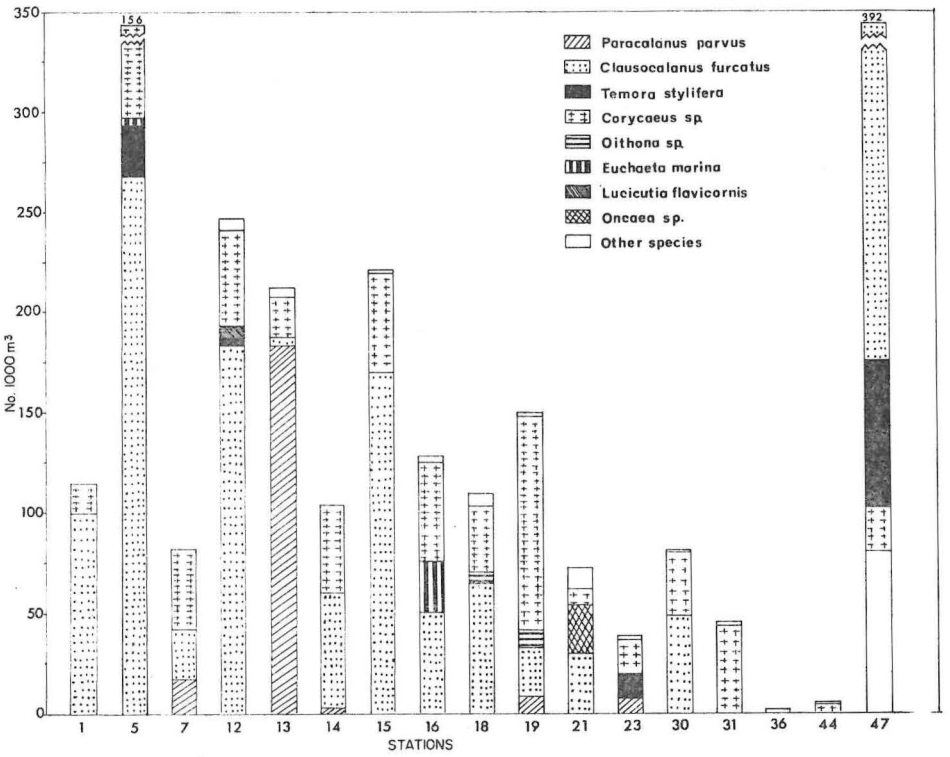


Fig. 8 — Abundance (no/1000 m³) of the most common species of adult Copepoda for stations of offshore cruise C-08, May-June 1968.

← *Fig. 7 — Displacement volume of total zooplankton (circles, cc/1000 m³) for stations of offshore cruise C-11, November 1968.*

Species of lesser importance as constituents of the Copepoda fauna in the Levant Basin, though common in some of the cases, included *Calanus minor, Acartia negligens, Centropages violaceus* and *Euchaeta marina,* the latter almost never recorded in the inshore samples.

2. Cladocera. The Cladocera were the most abundant during the May-June cruise, when they constituted up to 21 percent of the numerical composition of the total zooplankton. At individual stations (15 and 44 of cruise C-08), however, where the copepods were less numerous, the cladocerans constituted a higher proportion, reaching values of 35 to 75 percent although the actual numerical abundance of the species was higher than in other areas.

During the September cruise, there was a drop in the abundance of Cladocera, with values not exceeding 3 to 7 percent except at station 24 where the group reached 20 percent. In December, the Cladocera were found at their lowest numerical abundance, thus confirming their thermophilic character.

The two main species recorded in the Levant Basin were *Evadne tergestina* and *E. spinifera,* which generally occurred together, although *E. spinifera* was dominant in the offshore samples.

The absence of *Penilia avirostris* both from the inshore and the offshore areas of the Levant Basin is conspicuous and confirms earlier unpublished data.

3. Chaetognatha. As in previous cruises carried out in the Eastern Mediterranean, many of the specimens recorded in the plankton samples were immature stages which did not allow for identification to specific level. During the May-June cruise, adult specimens of *Sagitta* enflata were recorded at stations 1, 5 and 47, all fairly close to the Eastern Mediterranean coastline. This confirms the semineritic and epipelagic character of this species reported by Furnestin (1960).

From the point of view of numerical abundance, the Chaetognatha constituted only a small part in the general composition of the offshore zooplankton, up to 4 percent in C-08 cruise, 2 percent in C-10 and still less in C-11. However, the role of this group in the trophic cycles in the sea cannot be measured only in terms of numbers, in view of the predatory and highly competitive character of some of the species of which *Sagitta enflata* is an outstanding example.

Low numbers of *Sagitta bipunctata* and *S. serratodentata* were recorded in June and December respectively. The occurrence of *S. serratodentata* (a mesopelagic species) in December, and of *S. bipunctata* (an oceanic species) at offshore stations confirms their normal pattern of distribution.

4. Mollusca. The Pteropoda, represented mainly by the *Limacina,* constituted an important element of the zooplankton of the Levant Basin. At some of the stations in the vicinity of Rhodes Island, they formed 30 to 40 percent of the zooplankton by number of individuals and in exceptional cases such as at stations 23 and 34 up to 75 percent. The numerical abundance of the pteropods dropped noticeably in September to 7 to 18 percent, and reached its lowest value in December. In addition to *Limacina,* the order also included representatives of *Creseis* and *Styliola.*

The order Heteropoda included representatives of both families Atlantidae and Pterotracheidae in limited numbers, the latter mainly at stations fairly

close to the Israeli and Syrian coastlines. The genus *Atlanta* occurred on the whole at more stations and in higher numbers than *Pterotrachea*. The occurrence of larval stages of Lamellibranchiata was noticed at most stations during the May-June cruise and to a lesser extent during the September cruise.

5. Decapoda. The decapod larvae in the offshore plankton stations considered in this section belonged chiefly to the family Sergestidae, with representatives of *Sergestes* in larval stages and *Lucifer* in both larval stages and adults. The total number reached 12,000/1000m^3 in May-June, consisting mainly of *Sergestes*. The data for September and December showed considerably lower values. Of the three suborders of Decapoda, the Macrura Natantia were found to be most common. The representative genus *Lucifer* occurred mainly in larval stages during September, and as adults in December. The family Penaeidae was represented among others by *Gennadas elegans*, which was recorded at all open sea stations during the February cruise. This record confirms previous information regarding the distribution of this species in the eastern basin of the Mediterranean Sea as reported by Holthuis and Gottlieb (1958).

Additional representatives of Macrura Natantia, which occurred in low numbers, belonged to the families Alphaeidae, Palaemonidae and Pasiphaeidae *(Leptochela)* in addition to other unidentified families. The plankton samples of the 1968 cruises to the Levant Basin also included low numbers of decapod larvae of Macrura Reptantia of the Phyllosoma type, Anomura and Brachyura (zoea and megalopa stages), the latter in higher numbers at the coastal stations.

6. Other groups. In contrast to the preceding taxa, in which special trends could be ascertained due either to horizontal distribution or to numerical abundance, the remaining groups did not allow for an assessment of their specific role in the plankton communities. However, some of the groups did in fact reach higher numbers at individual stations, thus forming a noticeable constituent of the total zooplankton. For example, the Appendicularia were fairly numerous during May-June (C-08) especially at offshore stations and the Mysidacea and Sihponophora at individual stations.

General Characteristics of the Offshore Epizooplankton. — A certain similarity between the composition of the epizooplankton of the Levant Basin and the coastal areas of the Eastern Mediterranean could be detected. In both regions, the Copepoda formed the main constituent, with the Calanoida dominating the plankton communities both in numerical abundance and species diversity. The two additional groups of importance as biomass formers were the Pteropoda during all the cruises and the Cladocera during the summer months.

For obvious reasons, the larval stages of sedentary organisms were far more restricted in their distribution in the offshore stations than in the neritic waters.

DISCUSSION

In considering the various aspects of zooplankton production presented in this report, a number of facts and problems emerge. There seems to be

a certain periodicity in the seasonal cycles of zooplankton production if the data obtained from 1968 are compared to those of the preceding year. This is especially true of the coastal waters of Israel (to the 75 fm contour) where two distinct maxima in zooplankton production exist, one in late spring and early summer following the phytoplankton blooms, and a second one in fall. A peak was recorded in the coastal waters during December 1968, consisting of unusually high numbers of several zooplankton groups. This remarkable peak came after a moderate one in September-October, which seemed to coincide with the regular late summer peaks and which were stimulated in earlier years by the arrival of the Nile floods along the Mediterranean coast of Israel.

A salient feature of these peaks in zooplankton production, both in the inshore and offshore waters of the Levant Basin, is the predominance of large populations of Copepoda in the samples. With a number of exceptions, the copepods formed up to 85 percent of the total zooplankton standing crop. Among the representatives of this group, the calanoids were the most common as well as the most abundant at most of the stations.

The study of Copepoda as a major factor in zooplankton production provided information on the predominately neritic and oceanic species. The calanoids *Paracalanus parvus, Centropages kröyeri, Isias clavipes, Acartia clausi* and the harpacticoid *Euterpina acutifrons* are considered as strictly neritic while *Euchaeta marina* and *Calanus gracilis* are chiefly oceanic. Other species of importance among this group are equally distributed in coastal as well as in offshore waters including *Clausocalanus furcatus, Temora stylifera, Centropages violaceus* and *Acartia negligens*. These data confirm and add further weight to earlier findings regarding the distribution patterns of the Copepoda reported by Berdugo (1969b).

Similar examples may be quoted from the distribution of Chaetognatha, Cladocera and decapod larvae. A distinction between neritic and oceanic species was found in the coastal waters of Israel, and also in the coastal waters of other areas in the Levant Basin, including the Anatolian coast of Turkey and nearby islands. Thus a number of indicator species was ascertained based on occurrence in sufficient numbers in the same water masses. Examples of such indicator species of Chaetognatha, Copepoda and Cladocera, include species previously established as indicators.

An important feature which emerged from this study is the occurrence of mesopelagic species in the surface waters during the winter. Typical examples included species of copepods belonging to the genera *Lucicutia, Euaetideus* and *Pleuromamma,* and the chaetognath *Sagitta serratodentata,* all known as mesopelagic, which were recorded in the surface waters in December. This phenomenon has been repeatedly pointed out with regard to several taxa of the microzooplankton by Jörgensen (1920), and more recently by Kimor (1971) with regard to the distribution of Acantharia and Radiolaria.

The mixing processes taking place in winter in the Levant Basin take as long as three months in order to induce conditions of total homothermy in the upper layers of the sea. These processes involve water strata to a depth of 200 m in Marsden Square 141 (east of Meridian 30° E) and, to 400 m in

Marsden Square 142 (west of Meridian 30° E (O r e n, personal communication). This seems to fit with data reported here regarding the zooplankton distribution. During the rest of the year, when stratification of the water layers sets in, the meso- and bathypelagic elements are found only in the deeper strata.

The present report tends to confirm earlier data on the structure and characteristics of the plankton communities on both sides of the Suez Canal. The extensive surveys and analyses of neritic and offshore plankton in the Levant Basin considered in this report confirm earlier data on the existence of sufficient species of chaetognath populations in the Levant Basin and in the Red Sea, while other groups, such as the cladocerans (with one exception), include species which are common to both areas (K i m o r, 1972). The exception is *Penilia avirostris* which is present in the Red Sea and the Suez Canal but, so far, never recorded from the Eastern Mediterranean. The process of immigration of species from the Red Sea into the Eastern Mediterranean through the Seuz Canal is a dynamic one, apparently going on continuously. Recent evidence has been provided by some copepod species previously known only from the Red Sea and the Suez Canal, which were recorded at Eastern Mediterranean stations in the course of the present research program. The occurrence of the calanoid *Acartia centrura,* known as a species of Indo-Pacific origin, in the neritic waters of Israel in 1968 (B e r d u g o, 1974) supplements the information already reported on of the occurrence of *Calanopia elliptica* and *C. media* along the Mediterranean coast of Israel (B e r d u g o, 1969b).

All these species considered as fairly new immigrants into the Eastern Mediterranean were, so far, recorded only in the coastal waters of Israel, and not in the offshore region of the Levant Basin or in the vicinity of the different islands. This is also true of the *Leptochela* (Decapoda) which includes species of Indo-Pacific origin, which was similarly recorded near the coastal waters of Israel.

SUMMARY

An analysis of the plankton of the Eastern Mediterranean was carried out on a quantitative basis within the framework of a five-year research programme on the »Biota of the eastern Mediterranean and the Red Sea«. The present report refers both to the coastal as well as to the offshore epizooplankton communities of the Eastern Mediterranean recorded and analyzed over a one-year period in 1968.

The results of the neritic zooplankton analysis of the Eastern Mediterranean indicated the presence of two main annual peaks, in April-May and Decemeber 1968, both consisting of large populations of pelagic copepods. The December peak, however, consisted also of large populations of other zooplankton groups, chiefly chaetognaths, pteropods and larval decapods. A similar trend relating to the dominance of pelagic copepods was also observed in the offshore zooplankton communities of the Eastern Mediterranean.

Among the pelagic copepods, the calanoids dominated the plankton communities both in the coastal as well as in the offshore waters of the Eastern Mediterranean. In the offshore waters, the pteropods and the cladocerans constituted elements of major importance next to the copepods as biomass formers.

The qualitative examination of the zooplankton in the coastal and offshore waters enabled the selection of organisms characteristic of the two areas which may be used as indicator species.

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ABUNDANCIJA, SASTAV I SEZONSKA RASPODJELA EPIZOOPLANKTONA U UNUTRNJIM I VANJSKIM VODAMA ISTOČNOG MEDITERANA

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KRATAK SADRŽAJ

Iznose se rezultati jednog dijela petogodišnjeg programa planktonskih istraživanja istočnog Mediterana i Crvenog mora.

Rad tretira epizooplanktonske zajednice unutarnjih i vanjskih voda istočnog Mediterana u 1968. godini.

Zabilježena su dva glavna godišnja maksimuma (travanj-svibanj i prosinac) neritskog zooplanktona koje sačinjavaju pelagijski kopepodi. U drugom maksimumu sudjeluju, međutim, i populacije drugih zooplanktonskih grupa, prvenstveno hetognata, pteropoda i larvalnih dekapoda. Pelagijski kopepodi prevladavaju i u zooplanktonskim zajednicama otvorenih voda istočnog

Mediterana. Među pelagijskim kopepodima, u oba područja, prevladavaju kalanoidi, a osim njih u otvorenim vodama i pteropodi i kladoceri sačinjavaju elemente od najvećeg kvantitativnog značenja.

Kvalitativna opažanja zooplanktona unutarnjih i vanjskih voda omogučila su izbor karakterističnih organizama za oba područja, koji mogu da budu upotrebljeni kao indikatorske vrste.