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ZOOPLANKTON INVESTIGATIONS IN THE SEA WATER LAKES »MALO JEZERO« AND »VELIKO JEZERO« ON THE ISLAND OF MLJET (1952–1953)

ISTRAŽIVANJA ZOOPLANKTONA U MALOM I VELIKOM JEZERU NA OTOKU MLJETU (1952—1953)

T. Vučetić

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by

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INTRODUCTION

In the complex of hydrographic, geological, and biological investigations, undertaken by the Institute in the sea water lakes on the Island of Mljet, investigations on zooplankton were also performed. The data, given in this paper, refer mainly to the zooplankton taken during the period extending from February 1952 till February 1953, but some results of investigations carried out in 1951 and 1953 have also been included.

The investigations on zooplankton in the Mljet lakes had the purpose to record the conditions prevailing in the water of those lakes in order to make the research into the degree of their productivity possible. All these proceedings were closely connected with the planned experiments aiming at an artificial increase of the productivity of organic matter in the lakes by applying the method of fertilization (Buljan, 1957). Within the framework of these proceedings the annual fluctuation of the total zooplankton biomass was observed and annual averages have been obtained. The fluctuation of individual groups and species and their annual propagation cycle were given particular attention. Diurnal and seasonal vertical migrations were also observed.

The author of this paper wishes to record her warm appreciation of the assistance rendered by Dr. M. Buljan, the leader of the hydrographic section of the Institute of Oceanography and Fisheries, Split, who is in charge of the Mljet investigations, by placing at her disposal his hereto unpublished hydrographic data.

Special thanks are also due to the Director of the Institute Dr. V. Cviić, and to the leader of the Biological section of the Institute Dr. A. Ercegović, as well as to the leader of the Oceanographic and Fisheries Station at Dubrovnik, Dr. T. Gamulin, for their cooperation with valuable suggestions.

The author also wishes to thank Mr. Z. Pintar, who preceded her in the same field, and who was kind enough to pass her the data on dry weight of zooplankton referring to 1951, and to her colleague J. Hoenigman, who lent her a hand in zooplankton sampling.

MATERIAL AND METHODS

The sampling of zooplankton took place at three permanent stations at fixed time intervals of 30 to 40 days. A number of data referring to other oceanographic disciplines (hydrography, phytoplankton, microbiology) was also collected at the same stations.

The sampling proceeded as follows:

Veliko Jezero	Malo Jezero	Gonoturska
22. II. 1952	21. II. 1952	21. II. 1952
2. IV. ,,	31. III. ,,	4. IV. ,,
6. V. ,,	5. V. ,,	8. V. ,,
9. VI. ,,	8. VI. ,,	8. VI. ,,
16. VII. ,,	17. VII. ,,	15. VII. ,,
20. VIII. ,,	19. VIII. ,,	19. VIII. ,,
25. IX. ,,	24. IX. ,,	25. IX. ,,
7. XI. ,,	6. XI. ,,	6. XI. ,,
12. XII. ,,	13. XII. ,,	11. XII. ,,
23. I. 1953	22. I. 1953	22. I. 1953

Three different depths are presented by the stations, 26 m being that of Malo Jezero, 45 m of Veliko Jezero, and 65—75 m of Gonoturska Station lying outside the island of Mljet, at the entrance into the lakes. (Fig. 1.). Occasional sampling, in addition, was also performed at the stations Jejevići (38 m), Pošta (28 m), and Pospile (15 m).

The samples ,in their majority, were taken at the stations Veliko Jezero and Gonoturska during the morning hours (about 10.00), while the sampling at the station Malo Jezero took place during the afternoon hours (about 16.00). All the quantitative samples were obtained by vertical hauls, and the depth intervals were usually from 24 m to the surface at the station Malo Jezero, from 42 m to the surface at the station

Veliko Jezero, and from 60 m to the surface at the station Gonoturska. The samples were taken by means of the Hensen net (4/73—100), while the Nansen (4/72) closing-net (Künne, 1933) was used for the investigations of vertical migrations.

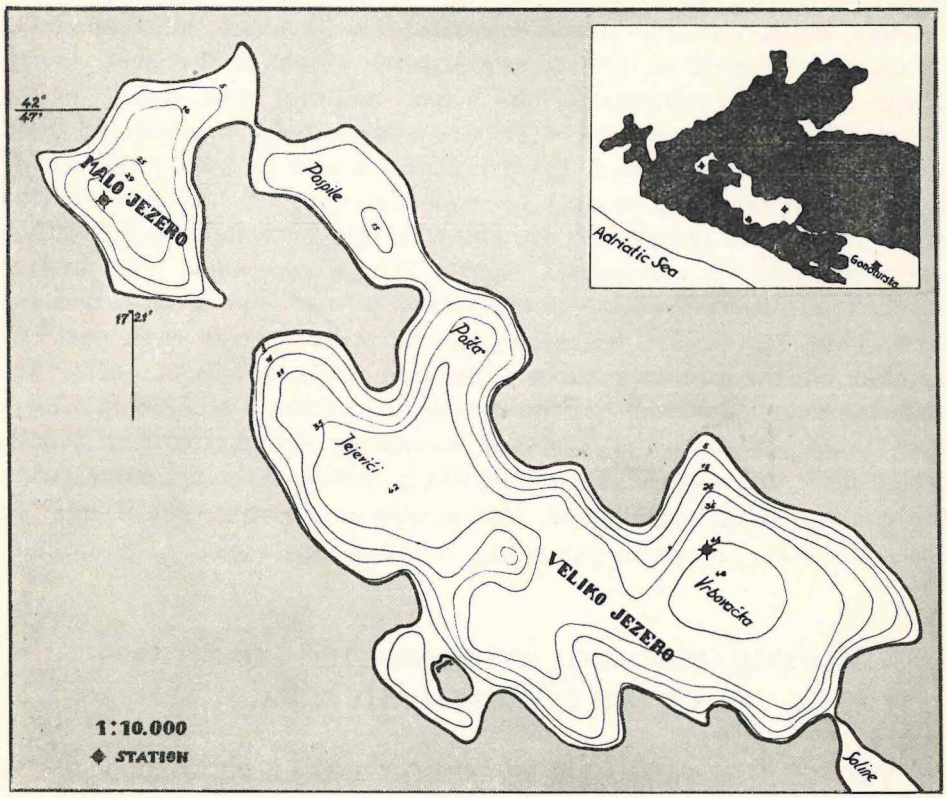

Figure 1. Sea water lakes on the Island of Mljet

The samples were fixed in 2,5% neutralized formalin. Two to three parallel vertical hauls were made at each station, and all the samples were separately preserved. Before measuring the catches taken at one station, they were examined both macroscopically and by means of a binocular microscope in order to obtain a rough quantitative and qualitative comparison of these parallel hauls. To find out the volume of sediment, the »wet« (semi-dry) weight and the dry one, a sample was set aside, which was first poured into a measuring cylinder and left there

for 24 hours to allow all the zooplankton to settle as to make the volume measurement possible. The sample was then drained off through a sieve of plankton silk No. 8 and placed on filter paper which absorbed all the remaining exterior water (i.e. the water lying on the surface of organisms). This was followed by the transfer of the material into a crucible which was left in the desiccator for 24 hours, whereupon the sample was weighed in order to establish the weight of the »wet« (semi-dried) plankton. Afterwards the same material was dried in the thermostat at a temperature of 110°C, and repeatedly weighed and dried until the constant weight of the dry plankton was found. At the second parallel haul the total number of organisms present was computed as soon as the entire sample was examined, the bigger organisms indentified and separated, e.g. chaetognat *Sagitta setosa* (the adult and juvenile ones), the copepod *Calanus helgolandicus* (♀, ♂, and V st.), decapod larvae, and fish-eggs and larvae. All the other species were partially counted on the counting table (Zähltisch nach Zwickert). After the material was well stirred, partial samples containing $^1/_{28}$ or $^1/_{43}$ of a haul, were taken, by means of a special measuring cylinder with a handle, designed for this purpose. The vessel which contained the plankton during the countnig had a graduated botton with marks for each 4 mm. In order to obtain the mean values the counting was repeated 2—3 times.

TOPOGRAPHIC AND HYDROGRAPHIC CONDITIONS IN THE INVESTIGATED AREA.

The Mljet sea water lakes are situated in the north-western part of the island, and are virtually a part of a bay running deeply into the island. (Fig. 1.). The bay is the outcome of a sunken valley of the upper Cretaceous limestone.

The total area covered by the lakes amount to 1691320 m², of which 241320 m² are occupied by Malo Jezero (the Small Lake) and 1450000 m² by Veliko Jezero (the Great Lake). Narrow and shallow passages provide intercommunication both between Malo Jezero and Veliko Jezero (width 2,5 m, depth 0,20 m) and between Veliko Jezero and Soline Bay (width 4,5 m, depth 0,60 m). Soline Bay, averaging in depth from 10 to 12 m, is exposed to the direct influence of the open Adriatic. (V u l e t i ć, 1953).

A lower salinity value and its more pronounced fluctuations were found in the water of the lakes than in the water of the open Adriatic. This is explained by the inflow of freshwater from little springs and of rainwater from the surrounding hills, and is particularly evident in the salinity value of the surface water (Fig. 2.). So the salinity of the surface water at Malo Jezero fluctuates between 27,9 and 35,8‰, while the water at a depth of 20 m yelds a different value, amounting from 35,4 to 37,9‰.

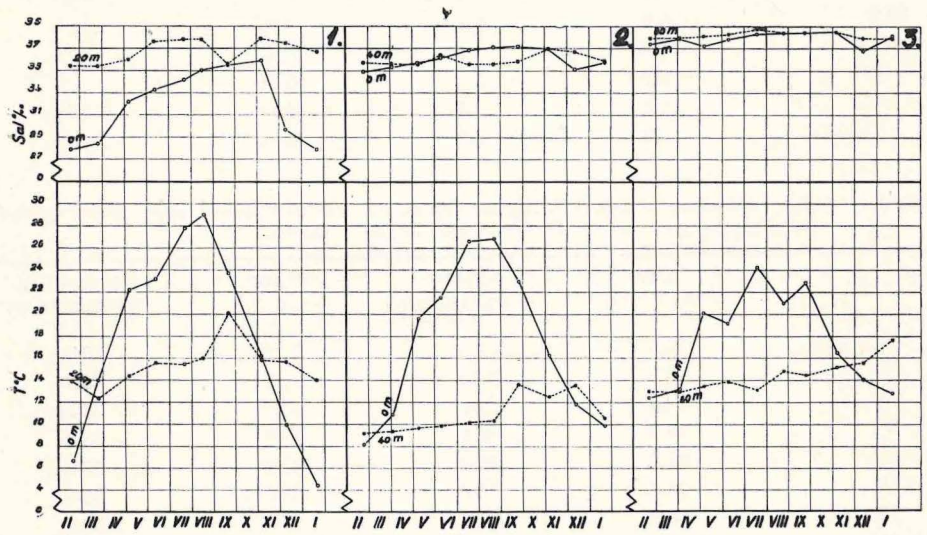

Figure 2. Surface — and bottom (- - -) temperature and salinity values recorded at the station Malo Jezero (1.), Veliko Jezero (2.), and Gonoturska (3.) from February 1952 to February 1953.

At the station Veliko Jezero, the salinity ranges between 34,9 and 37,2‰ in the surface layers, and between 35,6 and 36,9‰ at a depth of 40 m.

A zone of H_2S was found at Malo Jezero, lying under the 19 m (to 20 m) isobath (B u l j a n, 1956). Rapid flows occur in the areas of narrow passages, (a) between Malo and Veliko Jezero, and (b) between Veliko Jezero and Soline.

The temperature systems prevailing in the lakes and in the open Adriatic are distinctly different. The fluctuations are more pronounced at Malo Jezero where the winter surface temperature may drop to 4,5°C (January), and the summer temperature may rise to 29°C (August). The temperature ranges between 12,4 and 20,0°C at a depth of 20 m. At Veliko Jezero, the temperature of the surface layer may drop to 8,2°C

TABLE I. Dry Weights, »Wet« weights, Volumes of sediment, and Number of Organisms per m^3 at the Station Malo Jezero.

Date:	Dry Weight-mg/m^3	»Wet« Weight-mg/m^3	Volume ccm/m^3	Number of Organisms/m^3
21. II. 1952	1,0	—	0,07	158
31. III. „	2,6	2,9	0,17	369
5. V. „	3,0	3,3	0,15	622
8. VI. „	1,9	2,1	0,07	346
17. VII. „	4,4	5,0	0,19	1063
19. VIII. „	2,1	2,4	0,05	1055
24. IX. „	1,0	1,1	0,07	215
6. XI. „	0,9	1,1	0,14	186
13. XII. „	1,8	3,9	0,12	268
22. I. 1953	0,9	0,9	0,07	242

TABLE II. Dry Weights, »Wet« Weights, Volumes of Sediment and Number of Organisms per m^3 at the Station Veliko Jezero.

Date:	Dry Weight-mg/m^3	»Wet« Weight-mg/m^3	Volume ccm/m^3	Number of Organisms/m^3
22. II. 1952	10,0	—	0,38	2641
2. IV. „	19,6	125	0,79	2316
6. V. „	18,8	60	0,76	3884
9. VI. „	55,2	454	1,88	5618
16. VII. „	61,7	506	3,00	5044
20. VIII. „	70,9	173	2,00	8606
25. IX. „	58,8	546	2,35	4802
7. XI. „	6,2	320	1,17	936
12. XII. „	38,4	118	1,06	1657
23. I. 1953	12,8	64	0,58	953

TABLE III. Dry Weights, »Wet« Weights, Volumes of Sediment and Number of Organisms per m^3 at the Station Gonoturska.

Date:	Dry Weight-mg/m^3	»Wet« Weight-mg/m^3	Volume ccm/m^3	Number of Organisms/m^3
21. II. 1952	6,3	—	0,40	504
4. IV. „	15,9	121,0	0,50	763
8. V. „	7,7	20,5	0,30	913
8. VI. „	4,1	14,7	0,21	415
15. VII. „	5,3	23,5	0,22	515
19. VIII. „	4,2	4,3	0,30	506
25. IX. „	3,9	21,5	0,21	371
6. XI. „	2,2	15,3	0,22	213
11. XII. „	2,8	22,9	0,22	256
22. I. 1953	7,0	76,3	0,36	489

(February), or rise to 27°C in summer while it amounts from 9,2 to 13,7°C at a depth of 40 m. At Gonoturska — the station situated outside the island — the temperature values of the surface layer ranged between 12,5 and 24,2°C, and the salinity value between 36,8 and 38,5‰ during the year of investigations. (B u l j a n, in preparation).

THE ZOOPLANKTON

Variations in Volume, in Total Number of Organisms, and in »Wet« and Dry Weights of Zooplankton Collected from February 1952 to February 1953.

In order to obtain as accurate data as possible on the quantity of zooplankton present in the Mljet lakes, measurements were made of the volume of sediment, of the »wet« and dry weights, and all the zooplankton organisms of individual catches were counted. The data are shown in pictures No. 3, 4 and 5, and in tables I, II and III. All the values therein refer to 1 m³ of sea water.

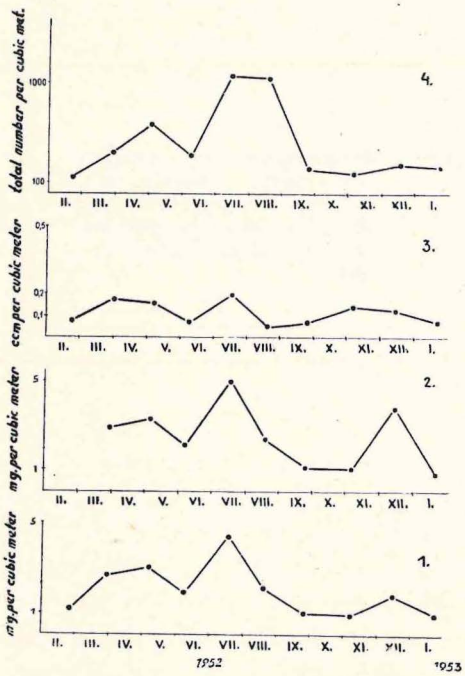

Figure 3. Zooplankton dry weights (1.), »wet« weights (2.), volume (3.), and number of organisms (4.) per m³ at the station Malo Jezero.

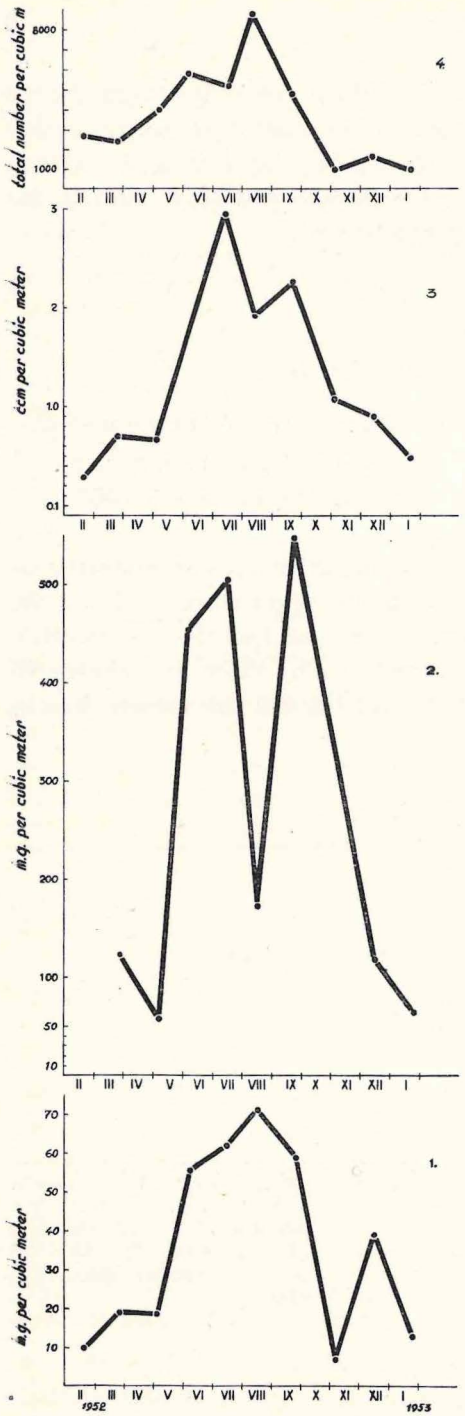

Figure 4. Zooplankton dry weights (1.), »wet« weights (2.), volume (3.), and number of organisms (4.) per m^3 at the station Veliko Jezero.

Station Malo Jezero. By making an analysis of the fluctuation of values of zooplankton dry weight we find that the first and lower maximum (3mg/m³) appears in May, which is followed first by a minor drop and then by a new rise leading to the principal maximum in July (4,4 mg/m³). (Table 1., Fig. 3). Afterwards the values begin to decrease to reach the minimum in November (0,9 mg/m³), but in December there is a slight increase, followed by a new drop in January. The »wet« weight of zooplankton present in Malo Jezero reaches its maximum in July (5 mg/m³), while the minimum value (0,9 mg/m³) is found in January. The volume of sediment presents the following picture: its maximum appears in July (0,19 ccm/m³) while the minimum takes place in August (0,05 ccm/m³). The total number of organisms ranges between 158 in February and 1063 per m³ in July.

Station Veliko Jezero. The maximum value of zooplankton dry weight appears in August (70,9 mg/m³) while the minimum value is found in November (6,2 mg/m³). (Table II, Fig. 4). The »wet« weight reaches its maximum value in September (546 mg/m³), while the minimum appears in May (60 mg/m³). The volume of zooplankton sediment shows its maximum value in July (3,0 ccm/m³), while the minimum value is found in February (0,38 ccm/m³). August is the month of the maximum number of organisms present (8606) and November ist the month of the minimum number (936 organisms per m³ of sea water).

Station Gonoturska. The maximum value of zooplankton dry weight is found in April (15,9 mg/m³), while its minimum value apears in November (2,2 mg/m³). (Table III, Fig. 5). The value of zooplankton »wet« weight reaches its maximum in April (121 mg/m³) and its minimum in August (4,3 mg/m³). The maximum value of the volume of sediment occurs in April (0,5 ccm/m³) and two minima (0,21 ccm/m³) appear in summer, one in June and another in September. May is the month of the maximum number of organisms present (913), and November is the month of the minimum number (213 organisms per m³).

By making an analysis of the data obtained by means of various methods applied in order to determine the zooplankton biomass, we find that their results do not always agree. The appearing variations are due to different compositions of zooplankton. As evident from the measuring made at the station Malo Jezero (Fig. 3.), the value curves of zooplankton biomass, obtained through various methods of measuring, are parallel

to a certain extent. This fact may be attributed to the uniformity of plankton composition. As shown by the result of the qualitative analysis, the zooplankton at the station Malo Jezero consisted mainly of copepods which have nearly a constant volume and percentage of water. (Fig. 12). There are pronounced discrepancies,however, in the value

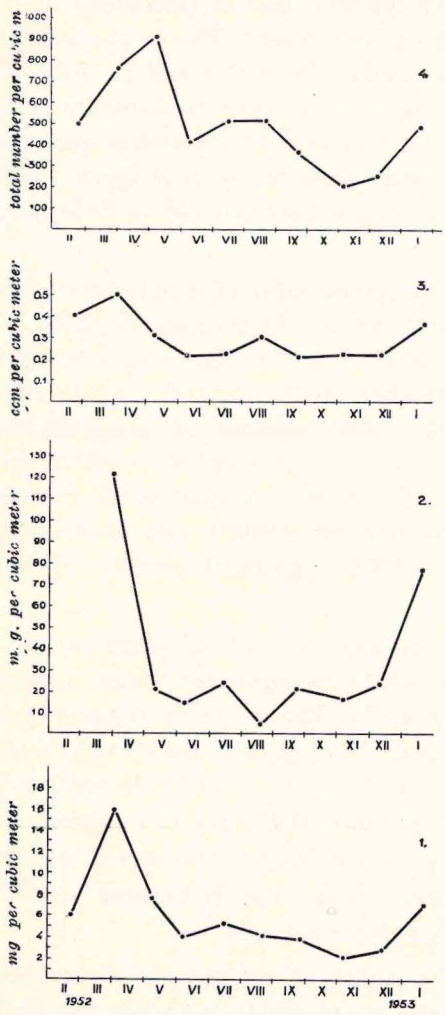

Figure 5. Zooplankton dry weights (1.), »wet« weights (2.), volume (3.), and number of organisms (4.), per m^3 at the station Gonoturska.

curves referring to the measurements of dry weight and volume for the station Veliko Jezero (Fig. 4), owing to varying compositions of zooplankton. The high values referring to volume and »wet« weight are due to the occurrence of adult *Sagitta* containing a large amount of

water, while the high dry weight values and low volume values are a consequence of the occurrence of larval stages of mollusks. These larvae are also responsible for the considerably large number of organisms. The pronounced difference between the number of organisms on the one hand, and the volume of sediment and the »wet« and dry weight on the other hand, found at the station Gonoturska in May, may be attributed to the occurrence of maximum quantities of younger copepodite stages at that time.

The annual mean values of zooplankton biomass in the investigated area, obtained by measuring the »wet« and dry weights and the volume of sediment as well as by counting, were the following for the period between February 1952 and February 1953:

Station:	Volume of Sediment	»Wet« Weight	Dry Weight	Number of Organisms
Malo Jezero	0,11 ccm/m³	2,5 mg/m³	1,96 mg/m³	452 n/m³
Veliko Jezero	1,39 „	262,8 „	35,2 „	3645 „
Gonoturska	0,29 „	35,5 „	5,94 „	494 „

Variations in Dry Weight of Total Zooplankton from March 1951 till February 1953.

During the investigations which followed in 1953 and 1954 special attention was paid to the values of zooplankton dry weight, since the weight of organic matter can approximatively be obtained from the dry weight and ashes.

From the data referring to dry weight measurements in 1951 and 1952, monthly averages (M) for this time period were computed. (Fig. 6, 7, 8). The pictures thus obtained allow the conclusion that rather regular variations in the volume of zooplankton biomass occur both at Veliko Jezero and at Malo Jezero, the maximum volume being always found there in summer, and the minimum one in winter. (December 1952 was an exception for Veliko Jezero, owing to insufficiency of data). At the outer station Gonoturska the maximum values of zooplankton biomass appears about the end of winter and the beginning of spring, and the minimum is reached in autumn.

Fig. 6

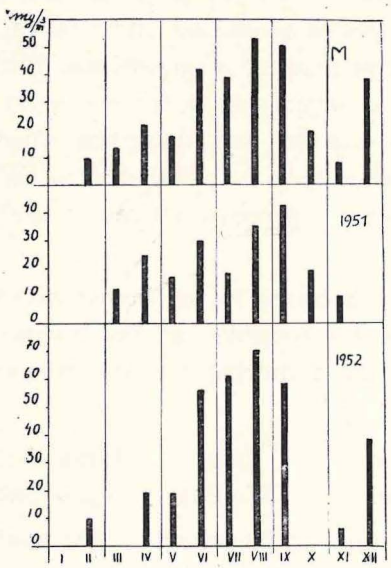

Fig. 7

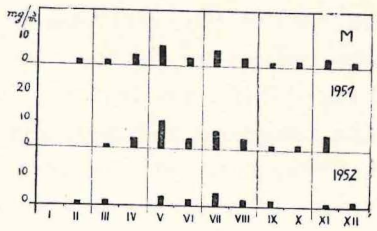

Fig. 8

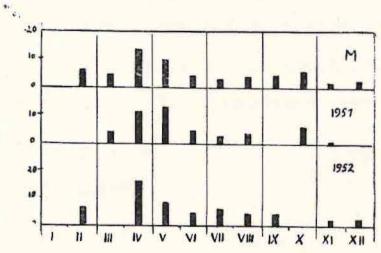

Figure 6. Variation of zooplankton dry weight (mg/m³) referring to the station Veliko Jezero from March 1951 till February 1953.

Figure 7. Variation of zooplankton dry weight (mg/m³) referring to the station Malo Jezero from March 1951 till February 1953.

Figure 8. Variation of zooplankton dry weight (mg/m³) referring to the station Gonoturska from March 1951 till February 1953.

Stations Compared with Respect to Zooplankton Values.

By comparing the zooplankton values referring to Malo Jezero, Veliko Jezero, and Gonoturska stations, we find that the station Veliko Jezero rates first with regard to the quantity of zooplankton, with Gonoturska following as second, and Malo Jezero as third. (Fig. 9). The dry weight values (1952) for Malo Jezero, Gonoturska, and Veliko Jezero show the ratio 1:3:17,7 which means that the values of zooplankton dry weight obtained for Veliko Jezero are almost six times higher than those referring to Gonoturska station, and about seventeen times higher than those resulting for Malo Jezero. Perhaps the method, or the fishing technique, applied by us suited best to the size of organisms present at Veliko Jezero, and had the samples been fished by means of a more close-grained silk, maybe that somewhat higher values would have resulted

for Malo Jezero since mainly smaller copepods *(Acartia, Paracalanus, Centropages)* and the larvae of benthonic organisms live there, whose immature stages were perhaps not filtered by the net. The values would

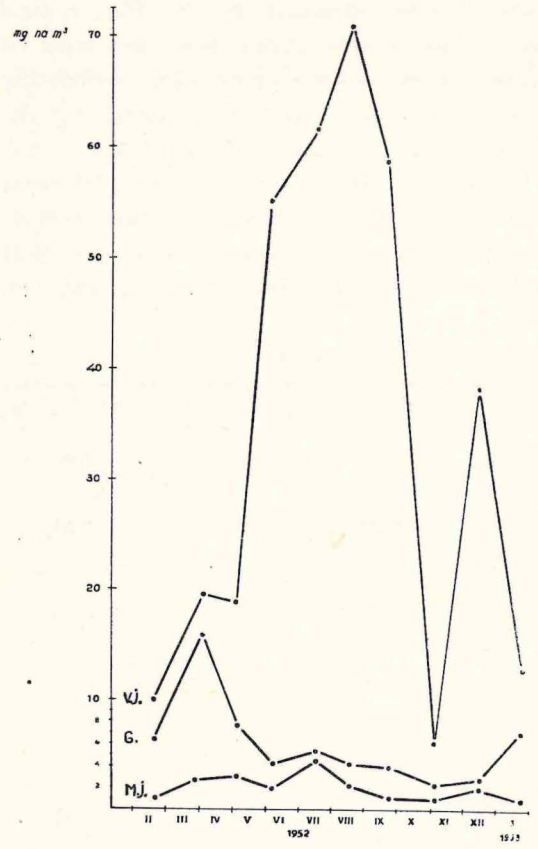

Figure 9. Zooplankton dry weights in mg/m³ referring to the stations Malo Jezero, Veliko Jezero and Gonoturska from February 1952 till February 1953.

likely have been somewhat higher for Gonoturska station too, if we had applied a less close-grained silk, as experienced by Gamulin (1954) at Komiža station.

A Comparison with Other Areas

An attempt was made, within the limits of feasibility, to determine the approximate productivity of the investigated lakes, and the obtained values of zooplankton biomass (Table IV) were compared with the values deriving from other investigations of the similar kind. This table contains

the average data for the stations concerned, covering the period from February 1952 to February 1953. The data on the volume referring to the Adriatic stations at Rovinj, Split, Pelegrin, and Komiža (Gamulin, 1954) were considered. The values obtained by F. Bernard (1950) for the station »D« near Algiers are given here by way of illustration. The data, resulting from Jespersen's (1923-35) investigations covering the »large d'Algerie«, are also quoted by the former author. Deevey's (1952) data on dry weight of the total zooplankton in the area of the Block Island Sound are likewise considered. It is evident from the above Table IV that the station Malo Jezero is not so rich in zooplankton biomass as Veliko Jezero, and that the former is much poorer on that score than the other Adriatic stations.

TABLE IV. — Mean Annual Zooplankton Biomass (Standing Crop)

Station:	Volume-ccm/m³	Dry Weight-mg/m³
MALO JEZERO	0,11	1,96
VELIKO JEZERO	1,39	35,2
GONOTURSKA	0,29	5,94
ROVINJ (Gamulin, 1954)	0,43	—
SPLIT (Gamulin, 1954)	0,26	—
PELEGRIN (Gamulin, 1954)	0,22	—
KOMIŽA (Gamulin, 1954)	0,19	—
ALGIERS (Bernard, 1950) Station »D«	0,31 (0,04—1,5)	
ALGIERS (Jespersen, 1923-35)	1,04 (0,08—2,0)	
BLOCK ISLAND SOUND (Deevey, 1952)		19,34

The mean value of the zooplankton dry weight (30,6) for the Veliko Jezero area referring to the period of time between March 1951 and February 1953 is somewhat lower than the one referring to February 1952 till February 1953 (35,2). The high values of zooplankton biomass found for the station Veliko Jezero, moreover, stand markedly out among all the values known so far for the Adriatic, and also among the values obtained by Deevey (1952) for the Block Island Sound. The volume mean value of the samples taken at Gonoturska station, i.e. in the unsheltered coastal Adriatic, is a little higher than the value obtained by Gamulin (1954) for Split station, and a little lower than the one found by Bernard (1950) for the station »D« near Algiers.

TABLE V. Checklist of Zooplankton Organisms Occurring at the Stations Malo Jezero and Veliko Jezero in 1952.

	Malo Jezero	Veliko Jezero
COPEPODA		
Calanus helgolandicus, Claus	—	+
Paracalanus parvus (Claus)	+	+
Pseudocalanus elongatus (Claus)	—	+
Centropages kröyeri, Giesbrecht	+	+
Isias clavipes, Boeck	—	+
Acartia clausi, Giesbrecht	+	+
Oitona nana, Giesprecht	+	+
Euterpina acutifrons Dana	+	+
PHYLLOPODA		
Penilia avirostris, Dana	—	+
Evadne tergestina, Claus	—	+
Evadne spinifera, P. E. Müller	—	+
DECAPODA — larvae	+	+
STOMATOPODA — larvae	—	+
MYSIDACEA		
Anchialina agilis G. O. Sars	—	+
Siriella clausi G. O. Sars	+	+
Siriella jaltensis G. O. Sars	+	+
Leptomysis lingura G. O. Sars	+	+
ISOPODA — larvae		
Gnathia maxillaris Smith-larvae praniza	+	+
CIRRIPEDIA — larvae	+	+
COPELATA		
Oikopleura dioica Fol.	—	+
CHAETOGNATHA		
Sagitta setosa J. Müller	+	+
HYDROMEDUSAE		
Obelia dichotoma Hinchs	—	+
Bougainvillia autumnalis Hartlaub	+	+
SCYPHOMEDUSAE		
Aurelia aurita Lam.	—	+
SIPHONOPHORAE		
Muggiaea kochii Vill.	—	+
MOLLUSCA — larvae		
Gastropod 1.	+	+
Lamellibranch 1.	+	+
PROTOZOA		
Acantharia sp.	—	+
SCOLECIDA (NEMERTINAE) — larvae		
Pilidium	+	+
ANNELIDA — larvae		
Spionid, mitraria — larvae	+	+
PHORONIDAE — larvae		
Actinotrocha	+	+
ECHINODERMATA — larvae		
Auricularia, pluteus	+	+
ACRANIA — larvae		
Amphioxus 1.	+	+
FISH EGGS AND LARVAE	+	+

THE COMPOSITION OF THE ZOOPLANKTON

Table V. contains all the species found at the stations Malo Jezero and Veliko Jezero. Since the abundance of occurrence is essential for the determination of group quantities or for finding out the relative frequence by means of counting, the quantitative and qualitative analyses of the zooplankton occurring in the area have resulted in the following grouping:

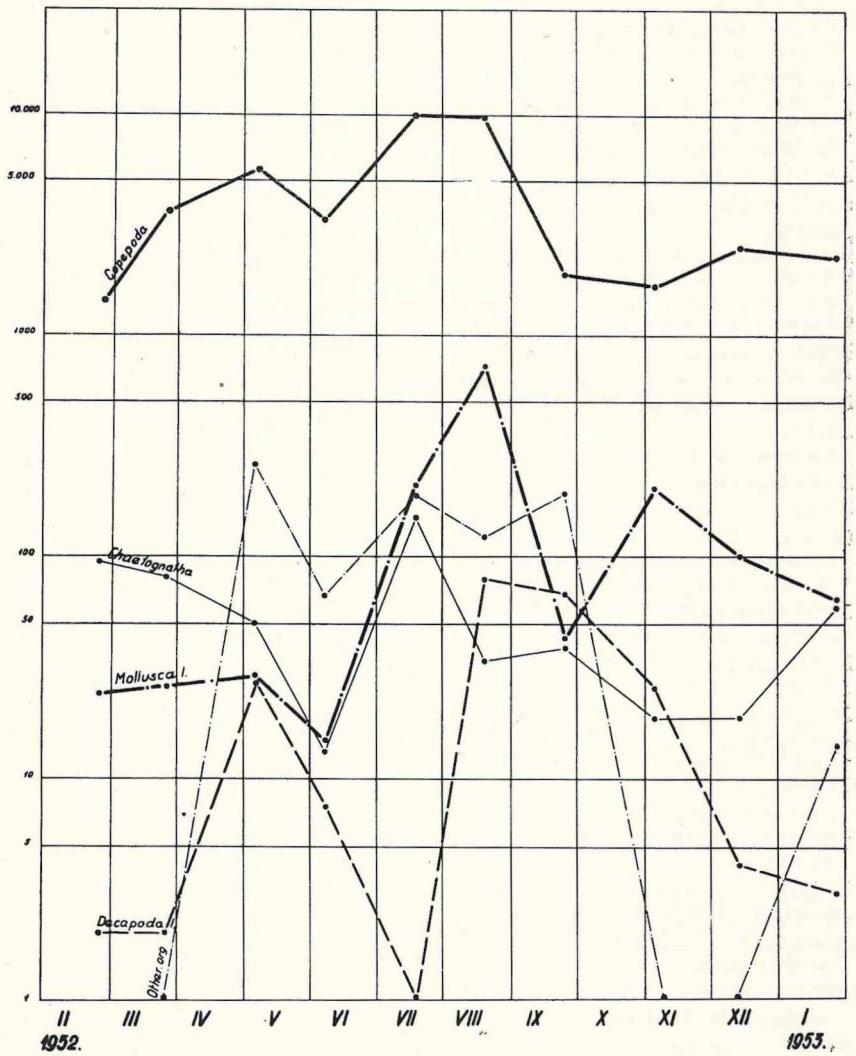

Figure 10. Number of zooplankton organisms for main groups present in a haul at the station Malo Jezero.

Copepoda
Chaetognatha
Decapoda — larvae
Mollusca — lamellibranch and gastropod larvae
Copelata
»Other species«.

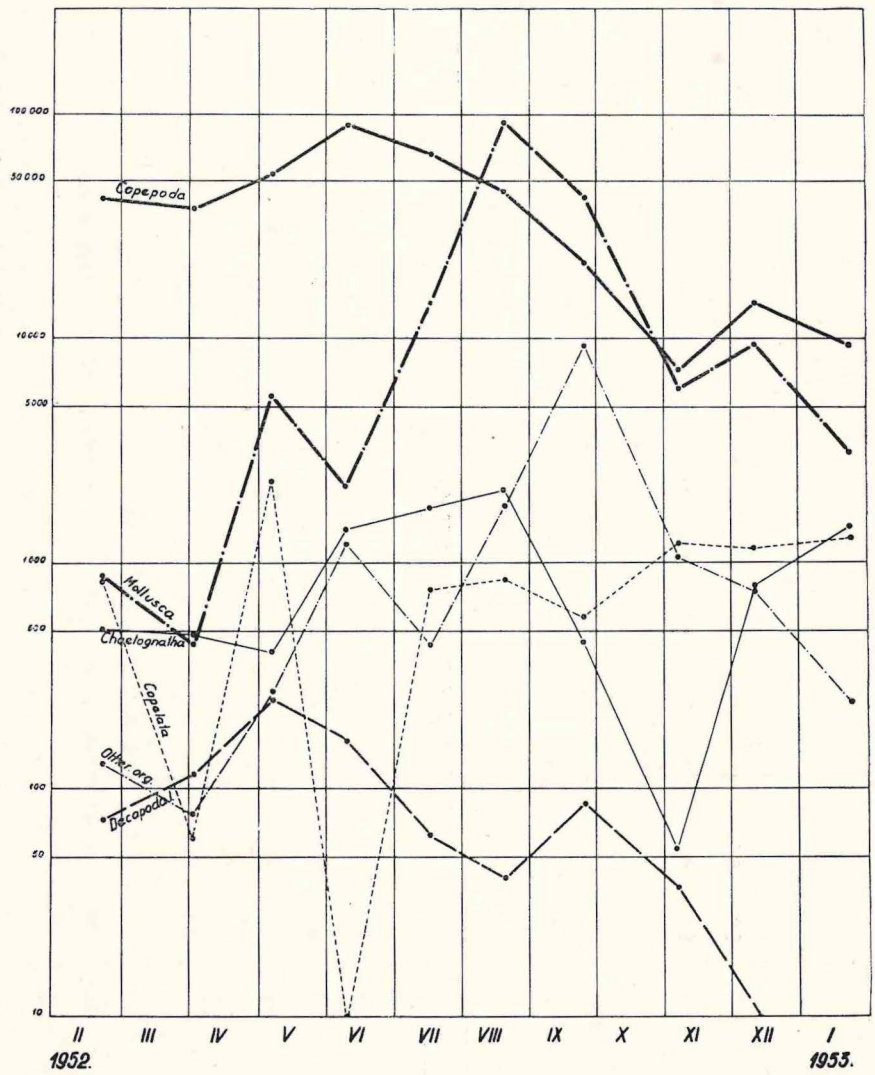

Figure 11. Number of zooplankton organisms for main groups present in a haul at the station Veliko Jezero.

TABLE VI. Composition Percentages of Various Zooplankton Groups at the Stations Malo Jezero and Veliko Jezero from February 1952 till February 1953.

Date	1952 Febr.	March	Apr.	May	June	July	Aug.	Sept.	Nov.	Dec.	1953 Jan.	Mean
MALO JEZERO												
Copepoda	92.4	97.7		94.0	97.0	95.0	91.2	84.0	86.68	96.0	95.0	92.89
Chaetognatha	5.9	2.1		0.8	0.4	1.4	0.3	1.8	0.96	0.7	2.3	1.66
Decapoda 1.	0.1	0.05		0.4	0.2	—	0.7	3.1	1.39	0.1	0.1	0.62
Mollusca 1.	0.9	—		0.4	0.4	2.1	6.7	2.0	10.95	3.6	2.0	3.40
»Other species«	—	—		4.0	2.0	1.7	1.2	9.1	—	—	0.5	1.95
VELIKO JEZERO												
Copepoda	94.56	97.0		86.12	94.63	79.40	32.2	27.9	46.6	55.3	59.4	67.71
Chaetognatha	1.14	1.2		0.62	1.51	2.05	1.5	0.6	0.3	2.9	9.2	2.10
Decapoda 1.	0.16	0.3		0.38	0.17	0.07	0.02	0.1	0.2	0.01	0.03	0.14
Mollusca 1.	1.99	1.1		8.83	2.39	17.01	64.5	58.8	37.9	34.7	21.7	24.89
Copelata	1.84	0.2		3.66	—	0.9	0.6	0.7	7.9	4.3	8.1	2.82
»Other species«	0.29	0.2		0.36	1.1	0.5	1.2	11.9	6.9	2.8	1.6	2.78

The absolute values for the above groups, obtained by counting of zooplankton during the period of time from February 1952 till February 1953 are given in Figures 10 and 11. The item »other species« includes the organisms belonging to various groups but occurring in single specimens, e.g. Hydromedusae, Siphonophora, Phyllopoda, and various benthonic larvae (Echinodermata, Annelida, Phoronidae, etc.).

Group Variations in Zooplakton Composition

The composition of zooplankton varies considerably in the course of a year, as evident from the ratio of relative percentages of the above mentioned groups. (Table VI.).

The Copepoda group is numerically dominant, reaching the highest values both at Malo Jezero and at Veliko Jezero. The values range from 84% in September to 97,7% in March (i.e. end of March and the beginning of April) for Malo Jezero, and from 27,9% in September to 97% in April for Veliko Jezero. The latter station shows lower Copepoda values owing to the occurrence of Mollusca larvae.

The Chaetognatha group occurs regularly both at Malo Jezero and at Veliko Jezero, in quantities ranging from 0,3% in August to 5,9% in February in the former, and from 0,3% in November to 9,2% in January in the latter.

The occurence of Decapoda at the station Malo Jezero reaches its maximum (3,1%) in September, and its minimum (0,05%) in March, while the maximum values for Veliko Jezero result in April-May (0,38%) and the minimum ones in December (barely 0,01%).

Mollusca occur at the station Malo Jezero in quantities of 0,04% in May-June and 10,95% in November. The minimum occurrence at Veliko Jezero results in April (1,1%) and the maximum one in August (64,5%).

There was no trace of the Copelata group at the station Malo Jezero during 1952, but it appeared at the station Veliko Jezero in quantities from 0,2% in April to 8,1% in January.

The group entitled »other species«, embracing various organisms belonging to the above mentioned groups, reaches some values at the station Malo Jezero in May and September, and at Veliko Jezero in September and November.

It results from the annual mean values that the Copepoda group, with the occurrence of 67,7% at the station Veliko Jezero and 92,8% at the station Malo Jezero, represents the dominant group at both stations and that the Mollusca group follows next with the occurrence of 24,8% at the station Veliko Jezero and 3,4 at the station Malo Jezero. The rest are less represented since their mean values do not exceed 3%.

Distribution of Organisms with Respect to Topographic and Hydrographic Conditions Prevailing in the Lakes

The peculiarity of the topographic and hydrographic conditions prevailing in the investigated area evidently influences the zooplankton populations, both qualitatively and quantitatively. The organisms which usually live in the deeper sea water layers, cannot thrive in the water of Malo Jezero, where only kinds of specimens were found which are known as surface organisms, belonging to eurythermic and euryhaline. It is generally known that higher salinity values favour the multiformity and abundance of living forms, while great variations in salinity are unfavourable to them. This accounts for the small number of speceis encountered in the water of Malo Jezero, and a somewhat larger number of species found in the water of Veliko Jezero, although the richness of forms in the latter is inferior to the waters of the open Adriatic.

As evident from Table V, the copepods occurring in the water of Malo Jezero include, beside *Acartia clausi* and *Centropages kröyeri*, also *Paracalanus parvus* and *Oitona nana*. The same species are also found in the water of Veliko Jezero, along with *Calanus helgolandicus, Pseudocalanus elongatus*, and *Isias clavipes*. A small number of *Calanus helgolandicus* (adult specimens, and individuals of immature copepodite stages) occurred in the water of Malo Jezero only about the end of 1954. Their presence there could perhaps, be explained by the airing of the deeper water layers of Malo Jezero and by the decreasing of the H_2S zone, providing thus more suitable conditions for these organisms, so that they succeeded to survive in the mentioned layers after penetrating from the water of Veliko Jezero. Adult specimens of the species *Calanus* and *Sagitta* are sometimes found in the shallow passage between Malo Jezero and Veliko Jezero, called Pospile, but they do not occur regularly there. The shallow Soline Bay makes it difficult for the organisms living

in the waters of the open Adriatic to enter the lakes. This particularly applies to species from the deeper water layers.

In distinction from the zooplankton found at the stations Veliko Jezero and Malo Jezero, all the species typical for the open Adriatic were recorded at Gonoturska stations. So the following species of the copepods were recorded: *Calanus helgolandicus* Claus, *Eucalanus elongatus* (Dana), *Euchaeta hebes* Giesbrecht, *E. marima* (Prestandrea), *E. acuta* Giesbrecht, *Paracalanus parvus* (Claus), *Calocalanus styliremis* (Giesbrecht), *Clausocalanus arcuicornis* (Dana), *C. furcatus* (Brady), *Centropages typicus* Kröyer, *Acartia clausi* Giesbrecht, *Mecynocera clausi* J. L. Thompson, *Candacia armata* Boeck, *C. bispinosa* Claus, *Copilia quadrata* Dana, *Haloptilus longicornis* (Claus), *Heterorhabdus papilliger* (Claus), *H. spinifrons* (Claus), *Euchirella messinensis* (Claus), *Lubbockia squillimana* (Claus), *Pleuromamma abdominalis* Lubb., *Lucicutia clausi* Giesbrecht, *L. ovalis* (Wolf), *Pontellina plumata* (Dana), *Temora stylifera* (Dana), *Oitona plumifera* (Baird), *Oncea* sp., *Euterpina acutifrons* (Dana) i *Coriceus* sp.

COPEPODA

Variations in the Composition of the Copepoda Stock

The Copepoda group, as already shown, is almost the most important zooplankton group in the investigated area, particularly in the water of Malo Jezero, where the maximum number of Copepoda corresponds to the maximum total of all organisms present. At the station Veliko Jezero the maximum number of Copepoda occurs in June and the maximum total of all organisms is found in August (Fig. 12). The number of Copepoda per catch amounts to 1580—10633 specimens at the station Malo Jezero, and 7400—90089 specimens at the station Veliko Jezero.

It follows from Table VII. that the adult specimens of *Calanus helgolandicus* occurred in quantities ranging between 0,9% of the catches taken in February, and 12,4% of those taken in January. The copepodite stages of *Calanus helgolandicus* ranged between 0,04% in July and 58,1% in December. None was found at the station Malo Jezero in 1952.

TABLE VII. Composition Percentages of Various Copepoda Stock at the stations Malo Jezero and Veliko Jezero from February 1952 till February 1953.

Date	1952 Febr.	March	Apr.	May	June	July	Aug.	Sept.	Nov.	Dec.	1953 Jan.	Mean
						MALO JEZERO						
Paracalanus parvus	11.3	65.1		32.3	20.8	0.91	0.87	10.0	5.3	15.8	13.1	17.54
Acartia clausi	83.9	33.3		50.9	40.0	46.3	31.1	29.4	64.4	52.5	77.0	50.88
Centropages kröyeri	2.5	1.5		16.7	38.0	52.7	67.6	60.4	29.7	31.6	9.7	31.04
Oitona nana	2.1	—		—	0.4	—	0.2	—	0.4	—	—	0.31
Other copepods	0.06	—		0.01	0.4	—	—	—	—	—	—	0.04
						VELIKO JEZERO						
Calanus helgolandicus (♀, ♂)	0.9		3.7	2.5	3.6	3.4	3.0	5.4	6.6	9.2	12.4	5.0
„ „ copepodites	13.1		7.4	1.1	0.06	0.04		2.3	10.1	58.1	2.8	9.47
Pseudocalanus elongatus	22.9		37.3	41.9	19.5	50.9	54.0	75.6	59.0	8.3	13.7	43.30
Paracalanus parvus	28.9		10.7	6.9	30.5	3.5	4.1	1.7	8.9	2.6	16.5	11.42
Paracalanus, Pseudocalanus copepodites	28.9		32.2	41.3	43.7	39.5	36.6	11.3	9.7	4.6	52.0	29.98
Acartia clausi	2.9		8.0	2.5	1.0	0.5	0.1	—	1.2	—	—	1.62
Centropages kröyeri	—		—	—	0.1	0.9	1.2	1.5	—	—	—	0.94
Oitona nana	1.8		0.3	3.5	1.4	1.0	0.9	2.2	4.4	16.6	1.9	0.34
Other copepods	0.3		—	0.2	0.06	—	—	—	—	—	0.6	0.11

The values of the species *Pseudocalanus elongatus* varied at the station Veliko Jezero from 8,3% in December to 75,6% in September. No specimen of this species was found at the station Malo Jezero.

Paracalanus parvus occurred at both stations, with values ranging between 1,7% in September and 30,5% in June for Veliko Jezero, and between 0,87% in August and 65,1 in March for Malo Jezero.

At the station Veliko Jezero, immature copepodite stages of copepods *Paracalanus parvus* and *Pseudocalanus elongatus* occurred in quantities ranging between 4,6% in December and 52,0 in January.

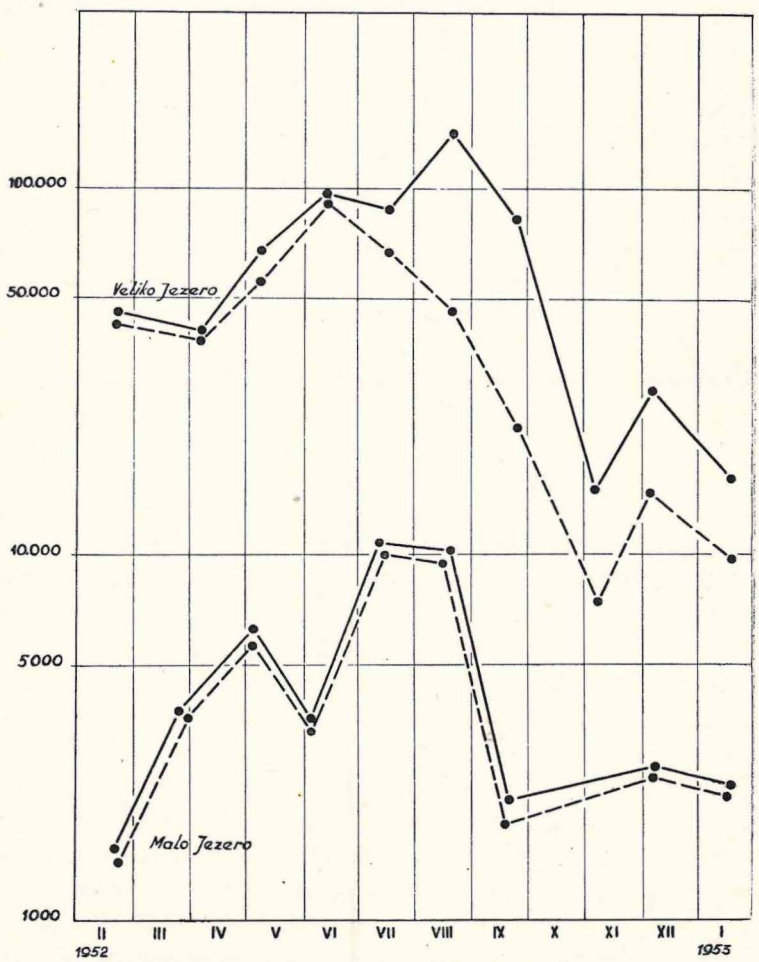

Figure 12. Number of Copepods (- - -) compared with the number of all organisms (——) present in a haul at the stations Malo Jezero and Veliko Jezero.

Acartia clausi was abundant at the station Malo Jezero, with values from 29,4% in September to 83,9 in February, thus contrasting with the station Veliko Jezero where it constituted only 0,1% of the total catch in August to 8,0% in April.

The occurrence of *Centropages kröyeri* at the station Veliko Jezero varied from 0,1% in June to 1,5 in September. At the station Malo Jezero, this species was found in percentages ranging between 1,5% in March and 67,6% in August.

Oitona nana was found at both stations in quantities ranging between 0,2% in August and 2,1% in February at the station Malo Jezero, and between 0,3% in April and 16,6% in December at the station Veliko Jezero.

It is evident from the data on percentages of occurrence of the most important copepod species, that *Acartia clausi* is foremost at the station Malo Jezero (50,88%), and that *Centropages kröyeri* (31,04%) is the next to follow. Then comes *Paracalanus parvus* (17,54%). The rest of the copepods constitutes scarcely 1%. At the station Veliko Jezero the first place is held by *Pseudocalanus elongatus* (43,3%), and then, according to quantities present, follow the copepodite stages of *Pseudocalanus elongatus* and *Paracalanus parvus* (29,9%). *Calanus helgolandicus* (14,54%) and *Paracalanus parvus* (11,4%) come next while the rest of the Copepoda amounts to about 3%.

Calanus helgolandicus Claus

This copepod species, found at various localities in the Adriatic area, constitutes the most important species at the station Veliko Jezero, but was not found at the station Malo Jezero in the course of these investigations (1952). The water temperture in which this species was found, ranged between 8,2 and 26,9°C for the surface layer, and between 9,2 and 13,7°C for the bottom layer, while the salinity range of the surface layer extended from 34,9 to 37,2‰.

The numbers of ♀, ♂, and copepodite stages of entire samples are graphically shown, at the logarithmic scale, in Figure 13. The largest total quantity was found in December (owing to the largest quantities of copepodites present), and the smallest total quantity was observed in November. Females had their maximum occurence in September and the minimum one in December. The males reached their maximum in August and their minimum in September. This approximately corresponds

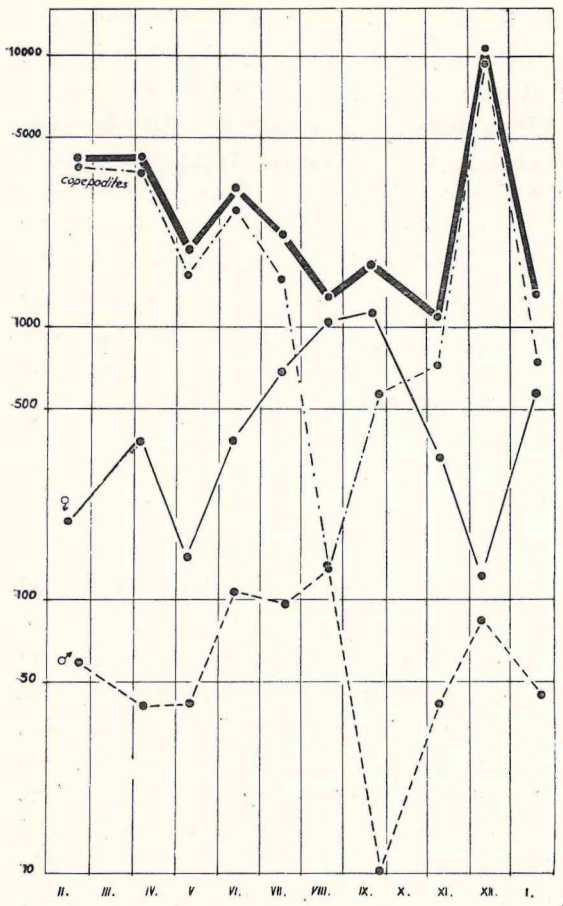

Figure 13. *Calanus helgolandicus* from Veliko Jezero. Total number in a haul, plotted on logarithmic scale (♀ ——, ♂ - - -, copepodites —.—.—.—, total ▬).

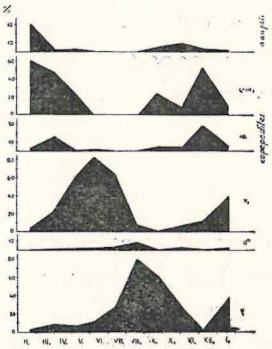

Figure 14. Percentage distribution of femeles, males, copepodites, and nauplii of *Calanus helgolandicus* from Veliko Jezero.

to L e d e r ' s finding (1914) for the Bay of Trieste (July and August maxima), and to the results of G a m u l i n ' s (1939) investigations in the Bay of Kaštela near Split. At the stations situated in the open Adriatic however, larger quantities occurred in February and March. (G a m u l i n, 1939, H u r e, 1955).

It results from Fig. 14, containing a diagram of relative percentages of all stages, that the highest occurrence of nauplii was in February, i.e. during the early spring or late winter, and that this stage was present in the investigated area till June. None was found there in June, July and August, but its presence was again observed from September till January. A less pronounced maximum occurred in November.

Earlier copepodite stages (I—III) appear in February, April, and May, but there are none present in June and July, although they are found again from September till January. The maximum relative quanties of the stages IV and V were observed a little later than it was the case with the stages I—III. These data seem to suggest that at least two generations are produced within a year's time, a winter-spring one and an autumn one. As to *Calanus finmarchicus*, several generations may be produced, in some other seas, during a year's period as stated by various authors (1—3 generations according to Kamshilov, 1952).

The investigations at the station Veliko Jezero have shown that only adult individuals take part in the daily vertical migrations. They keep to the layers below 20 m by day, and rise closer to the surface by night. The younger copepodite stages, as already noted, were always found in the surface layers.

Paracalanus parvus (Claus)

Being a typical neritic form, *Paracalanus parvus* is widely distributed all over the Adriatic sea, but its occurence is more abundant in the sheltered waters of the channels than in the open sea. We can see from Figures 15 and 16 that this species occurs in higher numbers at both stations, Malo Jezero and Veliko Jezero, all the year round. The maximum quantities at the station Malo Jezero were found in March, and the minimum ones in August. At the station Veliko Jezero two maxima were recorded, the first and smaller one in February, and the second and main one in June, while the minimum occurred in September. These data considerably differ from the earlier ones referring to the Adriatic area. According to some previous investigations, the maximum occurrence of this copepod species in the Adriatic takes place in autumn, (Gamulin, 1939) as it is the case with some other seas (Rose, 1925—35, Wiborg, 1940, Deevey, 1952). It was found by Hure (1955) that the maximum quantities in the open Adriatic occur in April. Considerable quantities of this species were observed in the English Channel by Dygby (1950) in the period from April till December, and their greatest numbers occurred from May till June and from August till October.

At the station Malo Jezero (Fig. 15) the maximum number of females occurred in March, and the minimum one in July. Te males were most numerous in May, and scarce in November. Copepodites were found

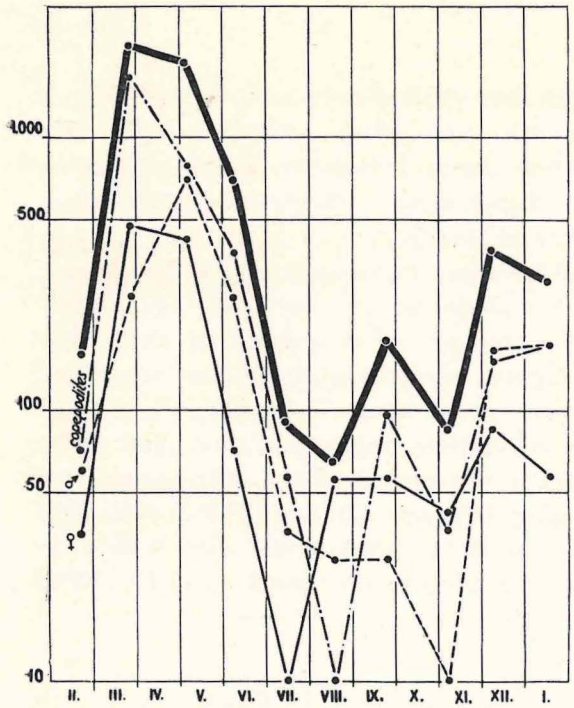

Figure 15. *Paracalanus parvus* from Malo Jezero. Total number in a haul plotted on logarithmic scale (♀ ——, ♂ - - -, copepodites —. —. —, total ▬).

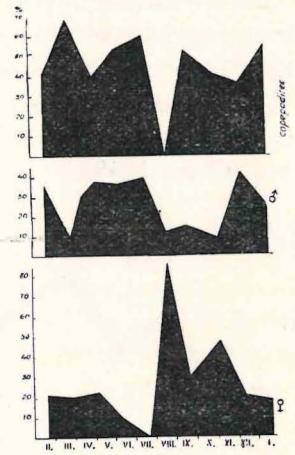

Figure 17. Percentage distribution of females, males, and copepodites of *Paracalanus parvus* in Malo Jezero.

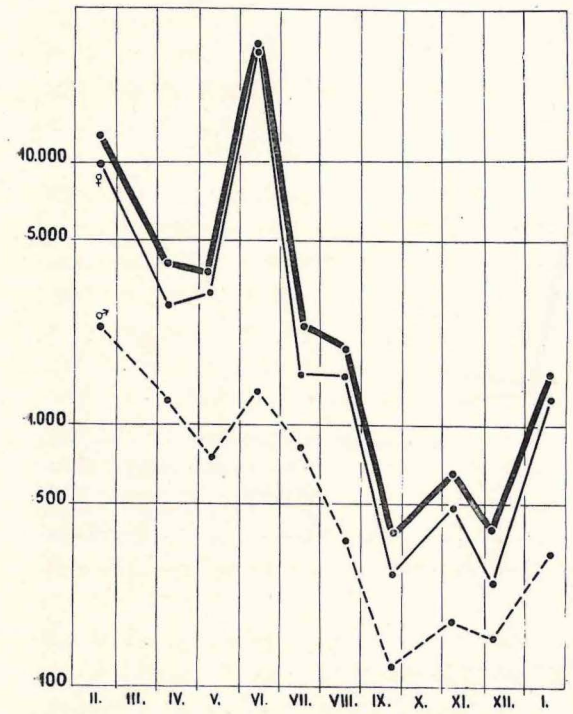

Figure 16. *Paracalanus parvus* from Veliko Jezero. Total number in a haul plotted on logarithmic scale (♀ ——, ♂ - - -, total ▬).

in the highest proportion in March, and their numbers were the lowest in August. At the station Veliko Jezero the highest number of males was observed in February and the lowest one in September, while the number of females culminated in June, dropping to a minimum in December. Egg-carrying females were noticed in March.

The relative percentages of females, males and copepodite stages at the station Malo Jezero (Fig. 17) show that the copepodites are nearly always present there (with the exception of August) and that their maximum occurs in March. The highest percentage of females was found in August while the males were most numerous in December.

The results of investigations of vertical migrations show that *Paracalanus parvus* was always present in the surface layers. The species was found at the temperatures ranging between 4,5 and 29,0°C and with salinity values varying from 27,9 to 37,1‰, while some earlier data on its occurrence in the Adriatic put the temperature range at 11,4—26,0°C (G a m u l i n, 1949).

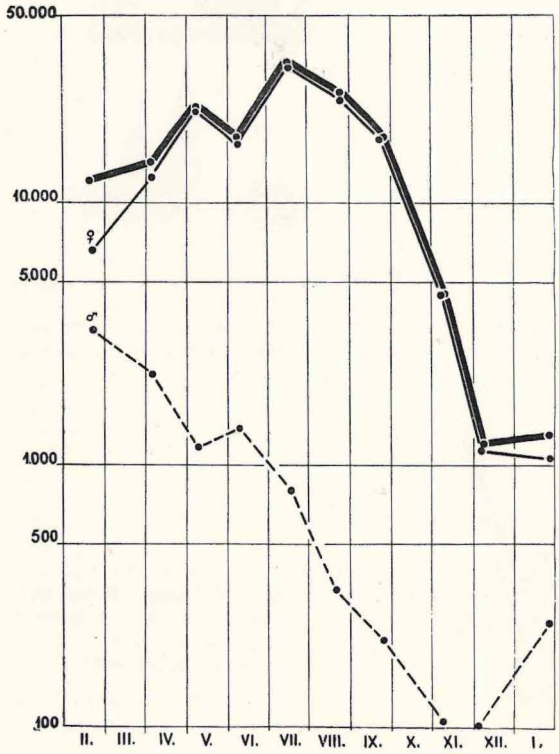

Figure 18. *Pseudocalanus elongatus* from Veliko Jezero. Total number in a haul plotted on logarithmic scale (♀ ——, ♂ - - -, total ▬).

Pseudocalanus elongatus Boeck

Sporadic individuals of this species were found all over the Adriatic, but only in the waters of the North Adriatic the species occurs in higher numbers. Only several specimens were found in the Bay of Kaštela (in May and June), but none occurred at Maslinica and at other stations in the vicinity of Split (Gamulin, 1939).

In the course of our investigations, the species was taken throughout the year at the station Veliko Jezero only. The highest proportion was found in July, and the lowest in December. According to Digby (1952), it is abundant in the English Channel from March to October, and it occurs in higher numbers from April till August.

The maximum of females at the station Veliko Jezero was found in July and the minimum in January, while the highest proportion of males occurred in February and the lowest ones in November. (Fig. 18). Egg-carrying females were noticed from January to July. Similar data are given by Deevey G. B. (1952) for the Block Island Sound.

As shown by the investigations of vertical migrations of zooplankton at the station Veliko Jezero, *Pseudocalanus elongatus* Boeck occurred only in deeper water layers within the temperature range from 9,4 to 21,0°C.

Acartia clausi Giesbrecht

As a neritic surface species which is distributed all over the Adriatic, the *Acartia clausi* occurs also at the stations Malo Jezero and Veliko Jezero. At the former it is found in higher numbers all the year round, and at the latter its less abundant occurrence is limited to the period between February and September (Fig. 19, 20). The maximum quantities of the species at the station Malo Jezero occurred in July, while the minimum ones were noticed in September. At the station Veliko Jezero the species was most numerous in April. Similar results were also obtained during the some earlier investigations in the Adriatic. The occurrence of higher numbers in Bay of Kaštela was found in March, April, and May, and at the station Maslinica in May (Gamulin, 1939).

Our investigations have shown that, at the station Malo Jezero, the females had their maximum in May, and their minimum in September while the maximum of the males coincided with that of females, but the occurence of their minimum fell later (in November). Copepodites were

Fig. 19

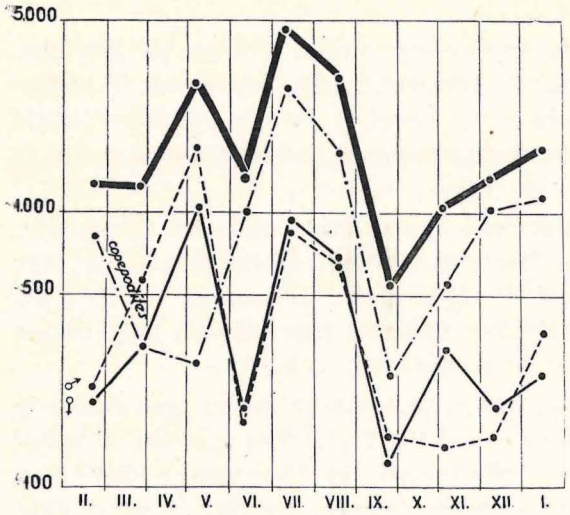

Fig. 20

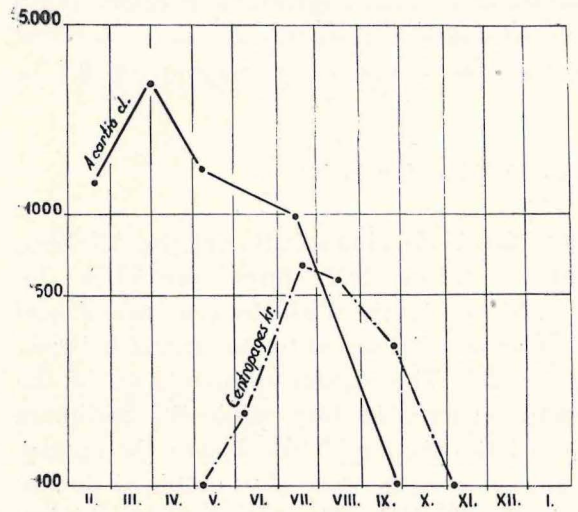

Fig. 21

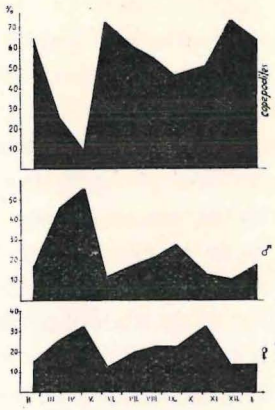

Fig. 22

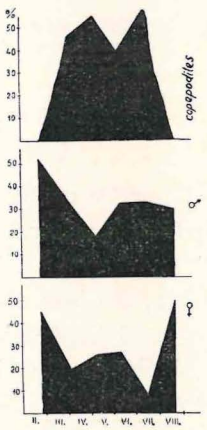

Figure 19. *Acartia clausi* from Malo Jezero. — Total number in a haul plotted on logarithmic scale (♀ ——, ♂ - - -, copepodites — . — . —, total ▬).

Figure 20. *Acartia clausi* and *Centropages kröyeri* from Veliko Jezero. — Total number in a haul plotted on logarithmic scale.

Figure 21. Percentage distribution of females, males, and copepodites of *Acartia clausi* from Malo Jezero.

Figure 22. Percentage distribution of females, males, and copepodites of *Acartia clausi* from Veliko Jezero.

the most numerous in July and scarce in September. April was the month of the highest numbers of both females and males at the station Veliko Jezero, and August was the month of their scarcity. Younger copepodite stages had their maximum occurrence in April and the minimum one in July.

It results from the relative percentages of females, males and immature copepodite stages at the station Malo Jezero (Fig. 21) that the females reached higher values in May and November, and the males in May and September. Copepodites regularly appeared in higher numbers, with the exception of May when their percentage was a low one. The occurrence of adult specimens at the station Veliko Jezero (Fig. 22) was regularly abundant, while copepodites appeared only from March till July.

As shown by the investigations of vertical migrations of zooplankton at the station Veliko Jezero, adult specimens as well as copepodite stages of *Acartia clausi* were always present in the surface layers.

Centropages kröyeri Giesbrecht

This copepod species is also known as a typical neretic form which is widely distributed in the Adriatic. It follows from Figures 20 and 23 that this species occurs at both stations — at Malo Jezero all the year round, and at Veliko Jezero from June till September. The species reached its maximum occurrence at Malo Jezero in July and August, and at Veliko Jezero in July. These data correspond to Gamulin's (1939) findings for the Bay of Kaštela where he noticed that the species was scarce from October till February and abundant in summer.

The numbers of both females and males culminated at the station Malo Jezero in August, and they were the lowest in February and March. July was the month of the highest percentage of copepodite stages which dropped to a minimum in February.

At the station Veliko Jezero, the females had their maximum in August, and their minimum in July. The numbers of males had also their maximum in August, but their minima occurred in June and September.

Relative percentages are given in Fig. 24 for males, females and copepodite stages at the station Malo Jezero. The lowest percentage of females was found in March, and the highest one in December. The males occurred in somewhat higher numbers in May, July, and November. The

Fig. 23

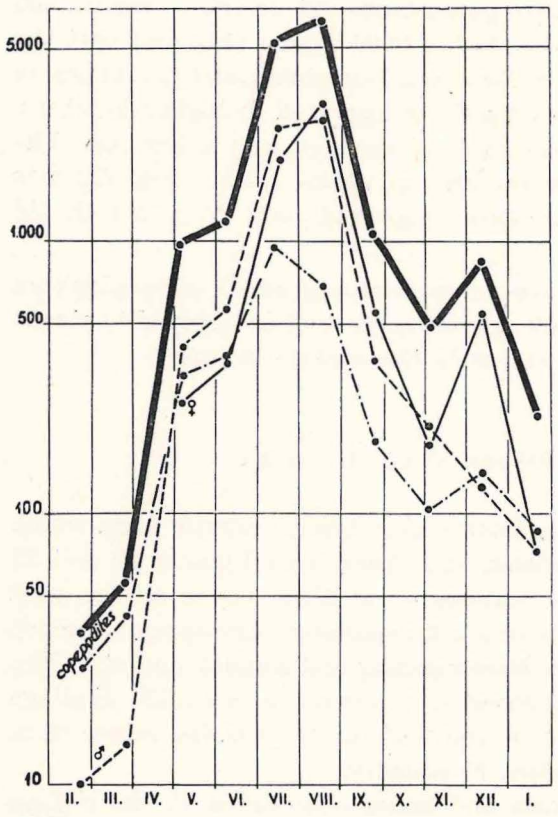

Fig. 24

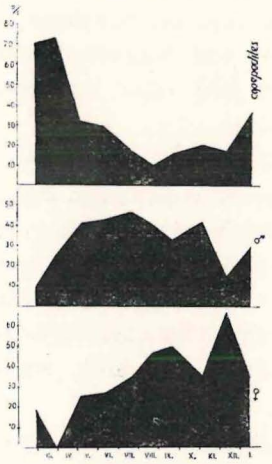

Fig. 25

Figure 23. *Centropages kröyeri* from Malo Jezero. Total number in a haul plotted on logarithmic scale (♀ ——, ♂ - - -, copepodites — . — . — . —, total ▬).
Figure 24. Percentage distribution of females, males, and copepodites of *Centropages kröyeri* from Malo Jezero.
Figure 25. Percentage distribution of females, males, and copepodites of *Centropages kröyeri* from Veliko Jezero.

highest occurrence of copepodite stages was noticed in February and in March. The percentage of females at the station Veliko Jezero was at its highest in September, and at its lowest in June, while the percentage of males culminated in July. The copepodites were most numerous in June and August. (Fig. 25).

As resulting from the investigations of vertical migrations, *Centropages kröyeri,* in all its stages, was regularly found in the surface layers of the waters of both Mljet lakes.

PHYLLOPODA

Evadne spinifera Müller and *Evadne tergestina* Claus occur in somewhat higher numbers at the station Veliko Jezero during the summer months (May, June, August, September). This finding is in agreement with the data given by Bernard M. (1955). Only two individuals of the species *Penilia avirostris* Dana were found at the station Veliko Jezero, and that in September 1952. A few more were again taken in August 1953. According to M. Bernard (1955), the species is present in the Bay of Algiers from May to November.

DECAPODA

The larvae of decapoda crabs,*) *Processa edulis* (Risso), *Athanas nitescens* Leach., *Alpheus ruber* M. Edwards, *Philocheras bispinosus* (Hailstone & Westwood), *Spirontocaris cranchii* (Leach), *Spirontocharis sp., Lysmata seticaudata* Risso, *Galathea strigosa* Linnaeus, *Galathea dispersa* sp. Bate, *Galathea intermedia* Lilljeborg, *Calianassa subterranea* Leach, *Upogebia deltaura* Leach, *Anapagurus chiroacanthus* (Lilljeborg), *Ethusa mascarone* Herbst, ~~*Anapagurus chiroachanthus* (Lilljeborg), *Ethusa mascarone* Herbst,~~ *Ebalia cranchii* Leach, *Portunus depurator* (Linné), *Carcinus maenas* Pennant, *Gonoplax rhomboides* (Linné) were abundant at both stations — Malo Jezero and Veliko Jezero — all the year round. Their occurrence culminated at Malo Jezero in summer-time August), and dropped to a minimum in winter-time. Their maximum occurrences at Veliko Jezero were found in May and June, and the minimum one in December. (Fig. 10, 11). While the majority of the above species was most numerous at the station Veliko Jezero in spring (May), their maxima in the open Adriatic were delayed for 30 or 40 days, since the lakes grew more quickly warmed than the waters of the main sea. (Kurian, 1956).

*) As set by Kurian (1956).

STOMATOPODA

Single stomatopod zoeae larvae of *Squilla* sp. were found at the station Veliko Jezero in July and August.

MYSIDACEA

Beside *Leptomysis lingura* G. O. Sars, the species *Siriella clausi* G. O. Sars and *Siriella jaltensis* G. O. Sars have an abundant occurrence along the shores of the two lakes, Malo Jezero and Veliko Jezero. The species *Anchialina agilis* G. O. Sars was yielded by the night catches.

ISOPODA

Single specimens of *Gnathia maxillaris* Smith praniza larvae occured in the samples taken at Malo Jezero and Veliko Jezero.

COPELATA

At the station Veliko Jezero, the species *Oikopleura dioica* Fol. was present throughout the year, but it was most abundant in May, and again in November, December, and January (Fig. 11). Uebel (1912) put this species as third as regards its abundance in the waters of the North Adriatic. Gamulin (1948) considers it rather rare in the Middle Adriatic. During our later investigations (1953) the species was numerous in November which caused the water at the station Veliko Jezero to appear »dusty«.

CHAETOGNATHA

Out of this group, the species *Sagitta setosa* (Müller), found in the Adriatic already by Baldasseroni (1914) and Teodoro (1924), was also present in the investigated area. Higher numbers occurred at both stations — Malo Jezero and Veliko Jezero — throughout the year. (Fig. 10, 11). Adult specimens were abundant at the station Malo Jezero in July, and at the station Veliko Jezero in June and July. Juvenile specimens were found in higher numbers at the station Malo Jezero in February, August, and January. Only smaller individuals of this species were known until now. According to Ghirardelli and Scaccini (1941), their size, noticed in the Adriatic, did not exceed 8

mm, while the size found at Villefranche (Ghirardelli, 1950) was 11—12 mm. The size of the individuals taken in the waters of Algiers ranged between 5,8 and 9 mm. (Hamon, 1952). The size of our specimens exceeded all the sizes so far known since our samples yielded individuals measuring up to 9 mm and even up to 16—17 mm in length. Sexually mature specimens sized 7 mm were found at the station Malo Jezero in March and May.

HYDROMEDUSAE

Hydromedusae *Obelia dichotoma* (Hincks, 1868) and *Bougainvillia autumnalis* Harlaub occured in somewhat higher numbers at the station Veliko Jezero in May and September.

SCYPHOMEDUSAE

Of the scyphomedusae, the species *Aurelia aurita* L. (1746) was noticed at the station Veliko Jezero, being particularly numerous in September, November, and December.

SIPHONOPHORA

Higher numbers of the diphyd siphonophora *Muggiaea kochii* Will. occurred at the station Veliko Jezero in August and September.

MOLLUSCA

Lamellibranch and Gastropod larvae were found at both stations — Malo Jezero and Veliko Jezero — but they were considerably more numerous at the latter station. The Gastropoda larvae, regularly present in the plankton samples taken at the stations Veliko Jezero and Malo Jezero, occurred in somewhat higher numbers in August. Small quantities of Lamellibranchiata larvae were present at the station Malo Jezero in February, November, December, and January only, while higher numbers of these larvae occurred almost regularly — with the exception of May and June — at the station Veliko Jezero. At this station their numbers culminated in August. (Fig. 26).

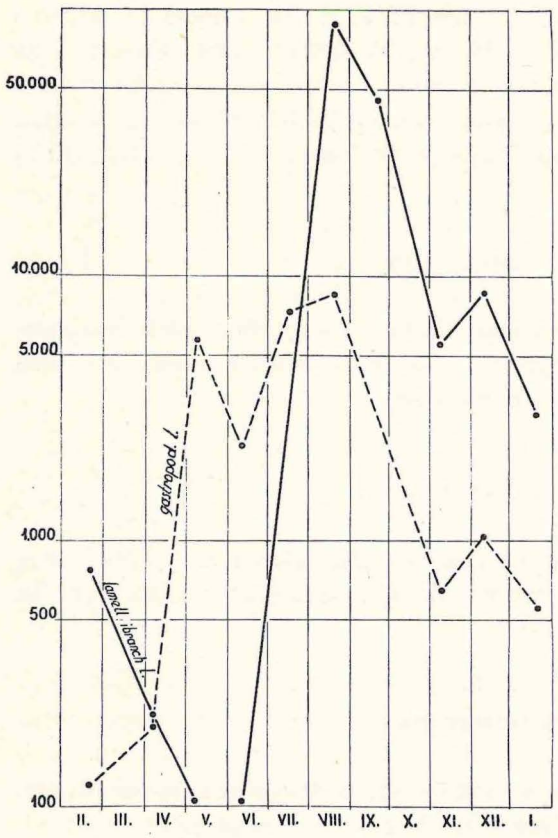

Figure 26. Mollusca larvae from Veliko Jezero. Total number in a haul plotted on logarithmic scale.

OTHER SPECIES

Echinoderm (auricularia, pluteus) larvae were found all the year round, but they were most numerous in May and September. Polychaete larvae (spionid, mitraria) and Nemertin (pilidium) larvae were present in the samples taken at both stations — Veliko and Malo Jezero. During the summer months, fish-eggs and larvae were abundant at both stations. Considerable numbers of eggs of *Engraulis encrasicholus* occurred in the catches taken from May till September (V u č e t i ć, 1956).

SUMMARY

The investigations upon which the present study is based were an integral part of a complex research work aimed at recording the prevailing conditions in the area of the two sea water lakes on the Island of Mljet in order to find out the degree of their productivity.

The samples obtained by vertical hauls with the Hensen net at two permanent stations, Malo Jezero and Veliko Jezero, during the time span from February 1952 to February 1953, were used for the quantitative and qualitative analyses of zooplankton. To make a comparison possible, additional investigations were made at a station situated at the entrance from the offing (Gonoturska).

In order to obtain as accurate data as possible, measurements were made of both the »wet« (semi-dried) and dried zooplankton, as well as of the volume of sediment, and the counting of total zooplankton was also performed.

(1) No pronounced variations of the quantitative data result from the value curves of the above measurements for the station Malo Jezero. It has been found that this was due to a rather regular zooplankton composition, made up mainly of copepods whose volume and water content do not manifest great variations.

Owing to pronounced variations of the zooplankton composition, the quantitative data differed considerably at the station Veliko Jezero. It has been established that the high values of zooplankton volume and »wet« weight are due to the occurrence of adult *Sagitta* which contain a high percentage of water, while the high values of zooplankton dry weight and the low values of volume are caused by the abundance of mollusca larvae.

At the station Gonoturska, considerable differences appeared in May between the number of organisms on the one hand, and the volume of sediment, the »wet« and the dry weight on the other hand, due to the numerous occurrence of copepodite stages.

(2) By comparing the dry weight values referring to zooplankton biomass at the stations Malo Jezero, Gonoturska and Veliko Jezero, the ratio 1: 3: 17,7 has been obtained.

(3) It has been established that the high values of zooplankton biomass, found for the station Veliko Jezero, stand markedly out among all the values known so far for the Adriatic.

(4) It is evident from the monthly averages of zooplankton dry weight that the maxima at both Malo Jezero and Veliko Jezero have a regular occurrence during the summer months, i.e. when the surface temperature culminates, while the minima are found during the winter. At the outer station Gonoturska, on the contrary, the maximum dry weight values were noticed by the end of winter and during the early spring, while the minimum ones took place in autumn.

(5) Another result of the investigations is the observation that the Copepoda group is by far the most numerous group in the investigated area, occurring in percentages ranging between 27 and 97% at the station Veliko Jezero, and between 94 and 97% at the station Malo Jezero. — It has also been found that the species *Acartia clausi* (50,88%) ranks first in abundance at the station Malo Jezero, with *Centropages kröyeri* (31,04%) following next, while the most numerous species at the station Veliko Jezero is *Pseudocalanus elongatus* (43,3%), followed by *Calanus helgolandicus* (14,5%) and *Paracalanus parvus* (11,4%).

(6) In connection with the hydrographic and topographic conditions prevailing at the station Malo Jezero (which, being a shallow basin, is subject to great annual temperature and salinity fluctuations, beside having a H_2S zone which lies at a depth of 19—20 m) it has been established that but a small number of eurythermal and euryhaline species occurred in the area, such as copepods *Acartia clausi, Paracalanus parvus, Centropages kröyeri, Oitona nana,* and chaetognath *Sagitta setosa.* A few specimens of the species *Calanus helgolandicus* were noticed at the station Malo Jezero, but only in August and September 1954. A more pronounced airing of the lake water and a decrease of the H_2S zone preceded that same year, in July and August. Being considerably deeper than the station Malo Jezero, the station Veliko Jezero had low temperatures in the bottom layers during the summer months. Conditions like these seem to favour the development of the species *Pseudocalanus elongatus* and *Calanus helgolandicus* which were present in higher numbers, particularly during the summer months. As to *Pseudocalanus,* it has been observed that this species regularly keeps to cooler bottom layers, not participating in any daily vertical migrations as it is the case with *Calanus helgolandicus.* The zooplankton samples taken at the outer station Gonoturska differed from the samples taken in the Mljet lakes, having the characte-

ristics of the zooplankton of the open Adriatic. It has been found that the influence of the open Adriatic on the station Veliko Jezero is considerably diminished owing to the shallow Soline Bay which hinders the entering of the open sea organisms, particularly of those prevailing in the deeper layers.

(7) The qualitative anlyses in this paper have shown the composition of species encountered in the course of our investigations, and their occurrence during the year of investigations.

BIBLIOGRAPHY

Babić, K. 1913. Planktonički celenterati iz Jadranskog mora. »Rad« J. A. (Knjiga 200), Zagreb. (Plankton Coelenterata in the Adriatic).

Baldasseroni, V. 1914. I Chetognathi raccolti nell'Adriatico dalla R. N. »CICLOPE« nelle crociere III—VII. R. Com. Tal. Ital. Mem. 38.

Bigelow, H. B. 1926. Plankton of the offshore waters of the Gulf of Maine. Bull. Bur. of Fish. Vol. XL. Part. 2.

Bigelow, H. B. and M. Sears. 1939. Studies of waters of the continental shelf Cape Cod to Cheasapeake Bay III. A volumetric study of the zooplankton. Memoirs of the Mus. of Comp. Zool. Harv. Coll. Vol. LIV. No. 4.

Bernard, F. 1950. Note sur la distribution du plancton au large d'Alger (Arch. Zool. Exp. Gén. N. et R. t. 86. No. 3.).

Bernard, M. 1955. Étude préliminaire quantitative de la répartition saisonière du zooplacton de la baie d'Alger 1. — Année 1950-51. Bull. de l'Inst. Océanog. Monaco No. 1065.

Buljan, M. 1956. Prvi nalazi sumporovodika (H_2S) u Jadranu. Posebni otisak iz »Mornaričkog glasnika«. (First findings of H_2S in the Adriatic. »Mornarički Glasnik« — separate print).

Buljan, M. 1957. Izvještaj o rezultatima gnojenja Mljetskog jezera novim postupkom. (Report on the results obtained by a new method of fertilization experimented in the marine bay »Mljetska jezera« — Acta Adriatica. Vol. VI. No. 6.

Cushing, D. H. 1950. The vertical migration of planktonic Crustacea Biol. Reviews, Vol. 26. No. 2.

Cushing, D. H. 1955. Production and a Pelagic Fishery. Fishery Investigation Series II. Vol. XVIII. No. 7.

Deevey, G. B. 1948. The zooplankton of Tisbury Great Pond. Bull. Bingham Oceanogr. Coll. Vol. XII. Art. 1.

Deevey, G. B. 1952. A Survey of the zooplankton of Block Island Sound 1943 to 1946. Bull. Bingham oceanogr. Coll. Vol. XIII. Art. 3.

Deevey, G. B. 1952. Quantity and composition of the zooplankton of Block Island Sound 1949. Bull. Bingham oceanogr. Coll. XIII. Art. 3.

Digby, P. S. B. 1950. The biology of the small planktonic Copepods of Plymouth. Journ. Mar. Biolog. Assoc. Vol. XXIX No. 1.

Ercegović, A. 1935. Une contribution à la connaissance des conditions hydrographiques et biologiques du lac de l'île de Mljet (Meleda). Acta Botanica, Vol. X. Zagreb.

Gamulin, T. 1939. Kvalitativna i kvantitativna istraživanja planktonskih kopepoda u istočnim obalnim vodama srednjeg Jadrana 1936/37. (Qualitative und

quantitative Untersuchungen über die Plankton-Kopepoden in östlichen Küstengewässern der mittleren Adria) Prirod. istraž. Jug. Akad. Znan. i Umj. svezak 22, Zagreb. (In Croatian with a German summary).

Gamulin, T. 1948. Prilog poznavanju zooplanktona srednjedalmatinskog otočnog područja. (Contribution à la connaisance du zooplancton de la zone insulaire de la Dalmatie Moyenne) — (In Croatian with a French summary) — Acta Adriatica Vol. III. No. 7.

Gamulin, T. 1954. La ponte et les aires de ponte de la sardine (*Sardina pilchardus* W.) dans l'Adriatique de 1947 a 1950. Izvješća — Reports. Vol. IV. No. 4C.

Ghirardelli, E. 1950. Osservazioni biologiche e sistematiche sui Chetognathi della Baia di Villefranche-sur-Mer. Boll. di Pes. Pis. e Idrobiol. t. XXVI, p. 1.

Graeffe, E. 1900. Übersicht über die Fauna des Golfes von Triest (Arb. Zool. Inst. Wien. Bd. XIII).

Hamon, M. 1952. Note Complementaire sur les Chetognathes de la baie d'Alger. Bull. Soc. Hist. Nat. Afrique du Nord. T. 43 (pp. 50—52) Alger.

Harvey, H. V., Cooper, L. H., Lebour, M. V. and Russel, F. S. Plankton production and its Control. Journal. Mar. Biolog. Assoc. Vol. XX. No. 2.

Hure, J. 1955. Distribution annuelle verticale du zooplancton sur une station de l'Adriatique Meridionale. Acta Adriatica Vol. VII. No. 7.

Jespersen, P. 1923. On the quantity of macroplancton in the Mediterranean and the Atlantic. Rep. Danish Oceanogr. Expeditions 1908—1910. to Med. Vol. III. 7. pp. 1—17. (See Bernard, 1950).

Jespersen, P. 1935. Quantitative investigations on the distribution of macroplancton in different oceanic regions. Carlsberg Found., Dana Report., No. 7. pp. 1—44.

Kamshilov, M. M. 1952. Propagation cycle of *Calanus finmarchicus* (Gunner) along the east Murman coast. DOKLADI Tom. LXXXV. No. 4.

Kurian, C. V. 1956. Larvae of Decapod Crustacea from the Adriatic Sea. Acta Adriatica. Vol. VI. No. 3.

Künne, C. 1933. Weitere Untersuchungen zum Vergleich der Fangfähigkeit verschiedener Modelle von vertikalfischenden Plankton Netzen, Rapp. et Proc. Verb. Vol. 83. Copenhague.

Lebour, M. 1916. Stages in the life-history of *Calanus finmarchicus* (Gunnerus) experimentally reared by Mr. L. R. Crawshay in Plymouth Laboratory Journ. Mar. Biolog. Assoc. Vol. XI. No. 1.

Leder, H. 1917. Einige Beobachtungen über das Winterplankton im Triester Golf (1914), Internationale Revue. Bd. VIII.

Marschall, S. M. and A. B. Orr. 1948. Further experiments on the fertilisation of Sea Loch Craiglin. The effect of different plant nutrients on the phytoplankton. Journ. Mar. Biolog. Assoc. Vol. XXVII. No. 1.

Marshall, S. M. and A. B. Orr. 1955. The Biology of a Marine Copepod *Calanus finmarchicus* Gunnerus. Edinburgh.

Østvedt, O. J. 1955. Zooplankton investigations from weather ship M. in the Norwegian Sea, 1948-49. Hvalradets skriften No. 40. Oslo.

Pesta, O. 1920. Die Planktonkopepoden der Adria. Zool. Jahrb. Bd. 43.

Ranzoli, F. 1954. Il trofismo della Laguna Veneta e la vivificazione marina. II. Ricerche sulle variazioni quantitative dello zooplancton. Estratto dall'Archivio di Oceanografia e limnologia Vol. IX. 1954.

Riley, G. A. 1949. Quantitative ecology of the plankton of the Western North Atlantic Bull. Bingham oceanogr. Coll. Vol. XII. Art. 3.

Rose, M. 1933. Copépodes pélagiques. Fauna de France 26.

Scaccini, A. et E. Ghirardelli. 1941. Chetognathi del Mare Adriatico presso Rovigno. Note Ist. Biolog. Mar. Rovigno 11, 22.

Steuer, A. 1910. Planktonkunde, Leipzig.

Teodoro, G. 1923. Sulla prezenza nella Laguna Veneta della *Sagitta setosa* Müller. Atti. Acc. Veneto Trent. Istr. (See Gamulin, 1948.).

Uebel, E. 1912. Adriatische Appendiculairen. Sitzber. K. Akad. Wiss. Wien Bd. 121.

Vučetić, T. 1956. Quelques observations sur l'ecologie de la ponte de l'anchois (*Engraulis encrasicholus* L.) dans les lacs de l'île de Mljet. Conseil Général des Pêches pour la Méditerranée. 4-éme Réunion Istanbul. Document technique No. 30.

Vuletić, A. 1953. Structure géologique du fond du Malo et Veliko Jezero sur l'île de Mljet. Acta Adriatica Vol. VI. No. 1.

Wiborg, K. F. 1940. The production of zooplankton in the Oslo-Fjord 1933.-34. Hvalrådets skriften No. 21. Oslo.

Wiborg, K. F. 1944. The production of zooplankton in a landlocked fjord. Rep. on Norw. Fish. and Mar. Inv. Vol. VII. No. 7. Bergen.

Wiborg, K. F. 1954. Investigations on zooplankton in Coastal and Offshore Waters of Western and Northwestern Norway. Rep. on Norw. Fish. and Mar. Inv. Vol. XI. No. 1. Bergen.

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ISTRAŽIVANJA ZOOPLANKTONA U MALOM I VELIKOM JEZERU NA OTOKU MLJETU (1952—1953)

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Kratak sadržaj

Ispitivanja, koja se obrađuju u ovoj radnji, dio su kompleksnih istraživanja, poduzetih u namjeri da se registrira postojeće stanje u mljetskim jezerima i da se odredi stupanj njihove produktivnosti, što je bilo povezano s kasnijim pokusima umjetnog povećanja produktiviteta.

Istraživano područje obuhvaćalo je t. zv. jezera na otoku Mljetu (Veliko jezero, 1.4 km²; Malo jezero, 0.2 km²), koja su međusobno spojena uskim i plitkim kanalom. Prodorom kroz usku prevlaku povezano je Veliko jezero s otvorenim morem. U svrhu usporedbe, istraživanja su izvršena i na jednoj postaji pred ulazom u jezera (Gonoturska).

Za kvantitativnu i kvalitativnu analizu zooplanktona poslužile su lovine, koje su izvučene vertikalnom Hensenovom mrežom u vremenu od februara 1952. do februara 1953. Podaci o vertikalnim migracijama potječu od lovina, koje su dobivene upotrebom vertikalne Nansenove mreže sa zatvaračem.

Da bi se postigli što točniji kvalitativni podaci, mjerilo se težinu vlažnog i suhog zooplanktona, kao i volumen sedimenta, a vršilo se i brojanje sveukupnog zooplanktona.

1. Proučavanjem kvantitativnih podataka našlo se, da krivulje vrijednosti navedenih mjerenja u Malom jezeru ne pokazuju velikih variranja. Ustanovilo se, da je uzrok tome prilično stalan sastav zooplanktona, koji je zastupan uglavnom od kopepoda, pa ne pokazuje većih promjena u volumenu i sadržaju vode (Sl. 3, 10).

Za Veliko jezero se utvrdilo, da postoje znatno veće razlike uslijed jačeg variranja zooplanktonskog sastava. Ustanovilo se, da visoke vri-

jednosti volumena i vlažne težine prouzrokuje pojava odraslih sagita, koje sadrže velik postotak vode, dok visoke vrijednosti suhe težine, a niske vrijednosti volumena, izazivlju larve moluski (Sl. 4, 11).

Za postaju Gonoturska (sl. 5) opazilo se, da su u maju došle do izražaja znatne razlike između broja organizama s jedne strane, te volumena sedimenta, vlažne i suhe težine s druge strane, koje su nastale uslijed maksimalnih količina mlađih kopepodskih stadija.

2. Usporedba vrijednosti suhe težine zooplanktonske biomase u Malom jezeru, Gonoturskoj i Velikom jezeru pokazuje omjer 1:3:17,7 (Sl. 6).

3. Ustanovilo se nadalje, da Veliko jezero, po svojim visokim vrijednostima zooplanktonske biomase, mnogo otskače od svih do sada poznatih vrijednosti za područje Jadrana (Tabl. 4).

4. Iz mjesečnih srednjaka suhe težine zooplanktona utvrdilo se, da se maksimalne količine u Malom i Velikom jezeru stalno javljaju u ljetnim mjesecima, u doba najviših temperatura površinskih slojeva, dok se minimalne količine javljaju zimi (Sl. 7., 8.). Naprotiv, na vanjskoj postaji Gonoturska (Sl. 9) javljaju se maksimalne vrijednosti suhe težine zooplanktona tek koncem zime i početkom proljeća, a minimalne u jeseni.

5. Ispitivanja su pokazala, da su kopepoda procentno najjače zastupana skupina u Velikom jezeru (27—97%), kao i u Malom jezeru (84—97%). U Malom jezeru od kopepoda najbrojnije vrste su *Acartia clausi* (50,88%) i *Centropages kröyeri* (31,04%). U Velikom Jezeru prvo mjesto zauzimlje *Pseudocalanus elongatus* (43,3%), a zatim vrste *Calanus helgolandicus* (14,5%) i *Paracalanus parvus* (11,4%).

6. U vezi hidrografskih i topografskih prilika u mljetskim jezerima ustanovilo se, da u Malom jezeru — koje je kao plitki bazen podložno velikim godišnjim promjenama temperature i saliniteta, a ima i zonu H_2S (B u l j a n, 1956), koja leži na dubini od 19—20 m — živi samo mali broj euritermnih i eurihanilih vrsta, kao što su kopepodi *Acartia clausi, Paracalanus parvus, Centropages kröyeri, Oitona nana* i hetognat *Sagitta setosa*. Samo u augustu i septembru 1954. g. naišlo se na neke primjerke vrste *Calanus helgolandicus* u području Malog Jezera, a nešto jače provjetravanje toga jezera i smanjenje zone H_2S opazilo se još prije, u julu i augustu iste godine. U Velikom jezeru, koje je znatno dublje od Malog jezera, našlo se da u ljetnim mjesecima prevladava pri dnu niska temperatura, pa izgleda da ovakve hidrografske prilike pogoduju razvoju vrsta *Pseudocalanus elongatus* i *Calanus helgolandicus*, koje su nađene u većim količinama naročito za vrijeme ljetnih mjeseci. Za vrstu *Pseudo-*

calanus el. se utvrdilo, da se stalno zadržava u pridnenim hladnijim slojevima. Na vanjskoj postaji Gonoturska naišlo se na zooplankton, koji se bogatstvom vrsta razlikuje od planktona u jezerima. Ustanovilo se da je znatno ograničen utjecaj otvorenog Jadrana na Veliko jezero, a plitka uvala Soline da je očita zapreka za prelaženje organizama otvorenog Jadrana, naročito onih, koji žive u dubljim slojevima.

7. Kvalitativne analize u ovom radu daju uvida u sastav vrsta (Tabl. 5), na koje se naišlo u toku istraživanja, a prikazano je i njihovo pojavljivanje u toku godine.

Calanus helgolandicus javlja se u Velikom jezeru u maksimalnim količinama tokom augusta (♀) i septembra (♂), a u minimalnim količinama u maju (Sl. 13). Mlađi kopepoditski stadiji opažaju se u svim mjesecima osim u junu, julu i augustu, iz čega bi se moglo naslućivati da postoje najmanje dvije generacije tokom godine. Na adultne primjerke nailazilo se kroz ljetne mjesece, za dnevne svjetlosti, u sloju ispod 20 m, a u zimsko doba pri samoj površini.

Maksimalni broj adultnih primjeraka vrste *Paracalanus parvus* opažen je u Malom jezeru u maju (Sl. 15, 17), a u Velikom jezeru u junu (Sl. 16). Najveći broj kopepodita ulovljen je u Malom jezeru koncem marta i početkom aprila, a najmanji broj u augustu. Ova vrsta se stalno nalazi u površinskim slojevima, pri temperaturi od 4,5 do 29° C i salinitetu od 27,0 do 37,1‰.

Pseudocalanus elongatus u najvećim količinama javlja se u julu, a najmanjim u decembru (Sl. 18). Ova vrsta je stalno prisutna u dubljim slojevima, u granicama temperature od 9,4 do 21,0° C.

Kopepod *Acartia clausi* najbrojniji je u Malom jezeru u julu (Sl. 19, 21), a u Velikom jezeru u aprilu. (Sl. 20, 22). Živi stalno u površinskim slojevima.

Centropages kröyeri javlja se u Malom jezeru kroz cijelu godinu (Sl. 23, 24), a u Velikom jezeru samo od maja do novembra (Sl. 20, 25). Opazilo se da su maksimalne količine adultnih primjeraka nastupile u Velikom jezeru u julu, a u Malom jezeru u augustu. Utvrdilo se da ova vrsta živi stalno u površinskim slojevima.

Oitona nana prisutna je u Malom jezeru u manjim količinama, a u Velikom jezeru u nešto većim, koje su bile maksimalne u decembru.

Filopoda *Evadne spinifera* i *Evadne tergestina,* te *Penilia avirostris* prisutni su u manjim količinama u Velikom jezeru u junu, augustu i septembru.

Pojava dekapodnih larvi uslijedila je u maksimalnim količinama u Malom jezeru u augustu, a u Velikom jezeru u maju (Sl. 10, 11).

Oicopleura dioica pojavila se u većem broju na području Velikog jezera u maju (Sl. 11.).

Sagitta setosa dosiže najveće količine u Velikom jezeru u augustu, a u Malom jezeru u julu (Sl. 10, 11). Spolno nezreli primjerci prisutni su u Malom jezeru u većim količinama u januaru, februaru i julu, a u Velikom jezeru u januaru, februaru i augustu. U Velikom jezeru našlo se primjeraka od 17 mm, dok su najveći primjerci, do sada poznati iz jadranskog područja, iznosili samo 8 mm.

Manje količine larvi Lamellibranchiata pojavile su se u Malom jezeru u januaru, februaru, novembru i decembru, dok se u Velikom jezeru stalno nailazi na veće količine, osim u maju i junu. Pojava maksimalnih količina Gastropoda uslijedila je u augustu (Sl. 26).

Hidromeduze *Obelia dichotoma* i *Bougainvillia autumnalis,* skifomedusa *Aurelia aurita* i sifonofora *Muggiaea kochii* prisutne su u nešto većem broju u septembru.

Od ribljih jaja i larvi u Velikom, kao i u Malom jezeru, naročito su zastupana jaja *Engraulis encrasicholus,* na koja se nailazi od maja do septembra.

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