A Method for the Analysis and Comparison of Plankton Samples

by

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This article does not concern the collection of plankton samples nor the idea of obtaining quantitative figures for the plankton-content per unit of volume or weight of seawater or freshwater.

Hjort has previously[1]) expressed his views concerning this problem and still holds the opinion that the ideal quantitative method of investigating small plankton animals must aim at the filtration of a sample of water or of water of a known volume from a definite depth. Several experiments have been made by him in recent years in employing large water-bottles (Fig. 1) of a volume of 1 hectolitre, but such instruments had the inconvenience of catching too scanty a material, besides being very difficult to manoeuvre especially in a heavy sea.

The "water-bottles" may be improved upon by making the walls of wire-netting covered by silk net, which would make them much lighter and have the advantage of filtering the water out of the bottle before the apparatus is hauled on board. Time and circumstances have, however, not permitted experiments of this kind.[2])

It is, however, obvious that nets in any case will play a great rôle in the study of plankton for many years to come, and that it is of importance to establish a method for the treatment of material from hauls with nets, horizontal tow-nets or vertical nets. It has, as is well known, for a long time been customary to apply a rough quantitative method, employing certain signs or letters, such as r, +, ++, etc., for the frequency of the species concerned within the samples. From all sides it has been acknowledged that this method is inaccurate and

[1]) Sir John Murray and Dr. Johan Hjort: The Depths of the Ocean, Macmillan, London 1912, pag. 771 to 777.

[2]) See also the new interesting apparatus by V. J. Petterson: Svenska Hydrografisk-Biologiska Kommissionens Skrifter. Ny serie: Hydrografi. II. No. 2. 1926.

might even be quite arbitrary, but the method has nevertheless been much in use because of the general feeling that the counting of the different species would require an enormous amount of work, out of all

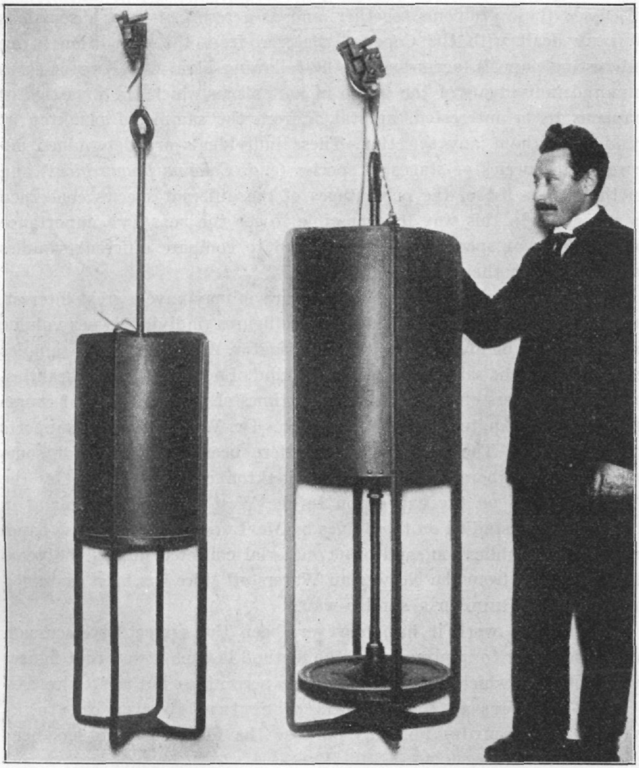

Fig. 1.

proportion to its results, because it would not really achieve the ideal, viz. the determination of the precise number of individuals per volume of water. An analysis of the samples according to Hensen's method, viz. to count the number of individuals within a known part of the known volume, has on the other hand met with practical difficulties, especially for samples consisting of the larger Copepods. It is not very easy to disperse these animals equally through a fluid, and to take out samples of this fluid of some cubic centimeters with their contents of Copepods.

During the Canadian expedition in 1915, HJORT and ARTHUR WILLEY discussed these problems together, and as a result of these discussions WILLEY dealt with the Copepod material from the expedition in an interesting paper[1]), according to the following plan. One, two or three hundred individuals of the group of animals in which the investigator happens to be interested, are taken from the sample of plankton at random, without any selection. These individuals are determined according to species or stages of species (e. g. *Calanus finmarchicus*) and in this way a list of the percentages of the different species concerned is prepared. In this way it is possible to see the relative importance of the different species in a sample and to compare different samples with regard to their composition.

It is quite obvious that such a comparison may have a great interest, irrespective of the fact that the absolute figures (individuals per volume of water) may be unknown to the investigator. A comparison of samples collected with the same net or the same kind of net, at different localities, in different layers of water, at different times of the year, may of course give much and quite reliable information. Dr. WILLEY's paper supports this statement. The method has therefore been in practice for some years in this laboratory. The large plankton collection made by the "Michael Sars" on the expedition to the West Coast of Greenland in 1924, has been studied on these lines by Mr. LEIF STØRMER, whose paper is ready for publication, and other material collected during the years 1925 and 1926 from the Norwegian Waters off Møre has been examined by JOHAN T. RUUD in a similar way.

During this work it has, however, been the subject of discussion and experiment to improve upon the method in such a way that figures were obtained which not only gave the percentage but also the absolute numbers of individuals of certain species or stages within the sample. For this purpose the following plan has been adopted:

1) The percentages (*npc*) of the species of a certain group of animals e. g. Copepoda, or of the stages of one especially interesting species, e. g. *Calanus finmarchicus*, are determined according to the method described above.
2) By means of an analytical balance the weight of the whole sample of plankton (*W*) and of a smaller part of the same (*w*) is obtained.

[1]) The Canadian Fisheries Expedition 1914—1915. Ottawa 1919.

3) By counting all the individuals of the group concerned within the part of the sample, a figure is obtained for the number within this part (n). The number within the whole sample of plankton is then found according to the equation $N = n \frac{W}{w}$.

Table 1.

St. 68 Date $^{2}/_{6}$ 26 Hour 12^{30} V.H. 20—0 m. Vol. 14 cc No.

	npc	npc	npc
Calanus finmarchicus VI ♂	3	4	3
— — VI ♀	16	17	14
— Stage: V	52	46	50
— — IV	3	9	4
— — III	..	..	1
— — II	..	..	..
— — I	..	..	..
Calanus hyperboreus	..	..	..
Euchaeta norvegica	..	..	..
Metridia longa	..	..	..
— lucens	..	..	..
— copepodits	3	6	7
Macrocalanoids, nauplii	..	..	..
— copepodits	..	..	..
Pseudocalanus elongatus VI ♂	..	1	..
— VI ♀	2	3	2
— Stage: V } — — IV }	2	2	3
— — I—III	1	..	..
Microcalanus pusillus	7	6	6
Acartia longiremis	..	..	..
— Clausii	..	..	1
— copepodits	..	..	..
Temora longicornis	..	..	..
Microcalanoids nauplii	..	..	..
— copepodits	..	..	..
Oithona similis	6	3	4
— spinirostris	..	1	..
— copepodits	5	2	5

4) Having thus obtained the total number of all the individuals concerned within the sample, the total number of any one group, e. g. of a certain species (NS) is found by the equation $NS = npc \frac{N}{100} = npc \cdot f$.

The application of this method is very simple, and takes very little time if the species are well known to the investigator.

A sample of plankton is well shaken in the bottle, and the contents are then distributed as evenly as possible over a disc made of silk (of the same mesh as the tow-net) and a copper wire. We use discs some 17 cms. in diameter. The fluid (water, formalin, alcohol) being well filtered off the silk, the plankton is placed in a small (light) glass dish and weighed. Then a part of the sample is weighed, and the animals concerned counted under a binocular. The same discs are also used when samples are taken for the determination of the percentages of the different species.

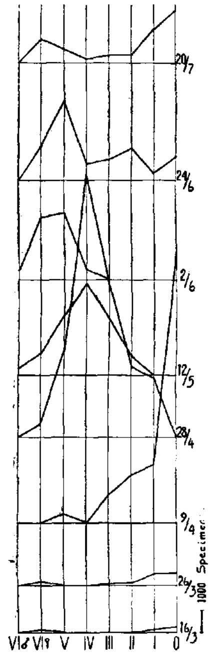

Fig. 2.

Table 1 gives an example of three different countings of the same sample. In each case one hundred individuals were selected at random. The figures thus obtained give an illustration of the accuracy of the method. We find it quite superfluous to treat the question of accuracy by the usual statistical methods, and believe that an inspection of the Table will convey the impression that the method is sufficiently accurate for comparisons of this kind.

In Table No. 2 an example is given of a series of samples taken at one and the same station at different times with the same net[1]). This station (depth 80 metres) is situated on the coastal bank 17 miles off

[1]) Our net is of the construction described in the "Depths of the Ocean" page 46 fig. 29. The diameter of the net was 70 cms. The net itself consists of three parts. 1) a cylindrical net 65 cms. long of 7 mm. mesh, 2) a cylindrical part 100 cms. long ($15^1/_2$ thread per cm., mark OXX), 3) a conical part 165 cms. long ($32^1/_2$ thread per cm., mark OXXX).

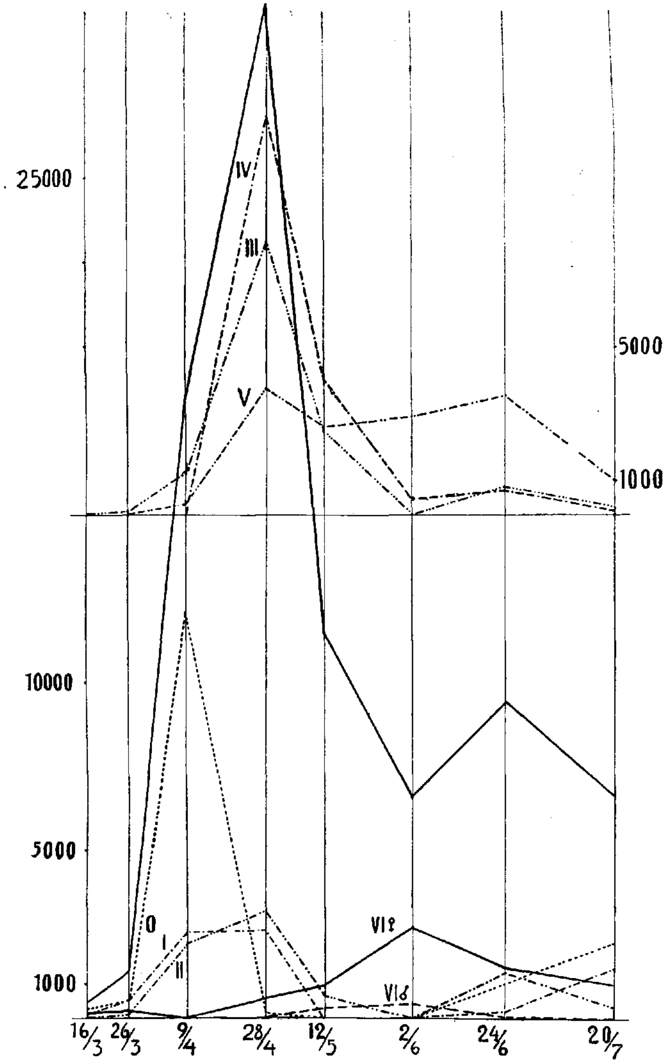
25000
10000
5000
1000
5000
1000
IV
III
V
0
I
II
VI♀
VI♂
16/3
26/3
9/4
28/4
12/5
2/6
24/6
20/7
Fig. 3.

Table 2.

1926	St. 37 16/3		St. 45 28/3				St. 48 9/4				St. 54		
	80—0 m.		20—0		75—20		20—0		75—20		20—0		
	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	n
Calanus finmarchicus VI ♂ .	..	..	..	..	..	..	..	..	..	..	..	..	.
— — VI ♀ .	3	137	..	..	5	229	..	..	..	..	2	582	.
— Stage: V....	..	..	..	..	..	..	..	..	1	314	12	3493	
— — IV...	..	..	..	..	..	..	..	..	..	..	36	10479	1
— — III ..	..	..	2	57	..	..	1	11	4	1255	21	6113	1
— — II ...	..	..	3	86	..	..	1	11	7	2196	9	2620	
— — I	2	91	13	372	3	137	3	32	8	2510	5	1455	1
Macrocalanoids nauplii	5	228	5	143	8	366	45	477	37	11607	..	..	
Calanus hyperboreus	..	..	..	..	..	..	..	..	..	..	..	..	.
Euchaeta norvegica	..	..	..	..	..	..	..	..	..	..	..	..	.
Metridia longa	..	..	..	..	..	..	..	..	..	..	..	..	.
— lucens	1	46	..	..	..	..	..	..	..	..	..	..	.
— copepodits	..	..	..	..	..	..	..	..	..	..	..	..	.
Macrocalanoids copepodits..	..	..	..	..	..	..	..	..	..	..	..	..	.
Pseudocalanus elongatus VI ♂	1	46	2	57	..	..	..	..	1	314	..	..	.
— — VI ♀	16	729	9	257	8	366	1	11	1	314	..	..	
— Stage: IV—V ..	9	409	18	515	3	137	6	64	6	1882	3	873	
— — I—II—III	..	..	12	343	3	137	7	74	2	628	1	291	
Microcalanus pusillus	4	182	..	..	5	229	..	..	1	314	..	..	
Acartia longiremis	..	..	..	..	..	..	..	..	..	..	..	..	.
— Clausii...........	1	46	1	29	..	..	1	11	..	..	2	582	
— copepodits	..	..	8	229	17	778	4	42	..	..	1	291	.
Temora longicornis........	2	91	2	57	..	..	2	21	..	..	..	..	
Scolecithricella minor......	..	..	..	..	..	..	..	..	..	..	..	..	
Centropages { hamatus .... / typicus ..... }	..	..	..	..	..	..	..	..	..	..	..	..	.
Microcalanoids nauplii	22	1002	4	114	5	229	17	180	31	9725	..	..	
— copepodits..	21	957	14	400	..	..	..	..	..	..	..	..	.
Oithona similis	9	409	7	200	43	1969	7	74	1	314	5	1455	
— spinirostris	..	..	..	..	..	..	..	..	..	..	..	..	1
— copepodits........	4	182	..	..	..	..	5	53	..	..	3	873	1
Weight (whole sample)	0,638		0,451		0,601		0,776		3,808		14,635		
Weight (part of sample)...	0,022		0,030		0,040		0,060		0,133		0,259		
Number (part of sample) ..	157		190		305		82		1096		515		
Number (whole sample) ...	4553		2857		4582		1060		31370		29110		
Factor	45,53		28,57		45,82		10,6		313,7		291,1		
Volume cc...............	1,5		1,5		2,0		2,5		11,0		48,0		

Table 2.

St. 62 $^{12}/_{5}$			St. 68 $^{2}/_{6}$				St. 80 $^{24}/_{6}$				St. 87 $^{20}/_{7}$			
	75—20		20—0		75—20		20—0		75—20		20—0		75—20	
NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS
..	3	296	4	195	4	250	1	61	..	..	..	..	..	..
593	4	394	17	828	32	2003	17	1035	5	499	1	506	4	519
951	7	690	46	2238	16	1001	14	852	27	2696	..	..	8	1038
290	18	1775	9	438	2	125	4	243	5	499	..	..	1	130
272	13	1282	..	..	..	..	4	243	6	599	..	..	2	260
124	3	296	..	..	..	..	5	304	11	1098	..	..	3	389
..	..	..	..	..	..	..	2	122	1	100	3	1517	..	..
..	..	..	..	..	..	..	18	1096	..	..	4	2023	2	260
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	2	122	2	200	..	..	..	..
..	3	296	6	292	10	626	..	..	..	..	..	..	1	130
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	4	394	1	49	..	..	..	..	..	..	1	506	..	..
85	6	592	3	146	19	1189	..	..	4	399	..	..	4	519
69	8	789	2	97	4	250	1	61	8	798	28	14157	26	3375
.	4	394	..	..	1	63	1	61	3	299	..	..	..	..
85	6	592	6	292	3	187	..	..	10	998	..	..	2	260
.	..	..	..	..	..	..	..	..	2	200	..	..	..	..
69	..	..	..	..	..	..	1	61	..	..	7	3540	1	130
.	1	99	..	..	..	..	2	122	1	100	12	6067	4	519
..	..	..	..	..	..	..	1	61	..	..	1	506	5	649
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..	1	506	1	130
..	..	..	..	..	..	..	2	122	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
38	4	394	3	146	..	..	16	974	1	100	30	15168	5	649
.	4	394	1	49	5	313	1	61	2	200	1	506	6	779
06	12	1183	2	97	4	250	8	486	12	1198	11	5562	25	3245
	3,392		5,463		6,932		4,116		7,819		2,181		4,390	
	0,160		0,202		0,155		0,165		0,271		0,096		0,165	
	465		180		140		244		346		2225		488	
	9860		4867		6261		6085		9984		50560		12980	
	98,6		48,67		62,61		60,85		99,84		505,6		129,8	
	12,5		14,0		19,0		11,5		22,0		10,0		14,0	

the coast of Møre. Table No. 2 gives the figures for the percentages (*npc*) of different species of Copepods, and, so far as the species *Calanus finmarchicus* is concerned, also for the different stages (according to the well-known proposal by D. DAMAS[1]). Then the total numbers of these species (*NS*) the figures for *W*, *w*, the factor *f* and the volume of the sample.

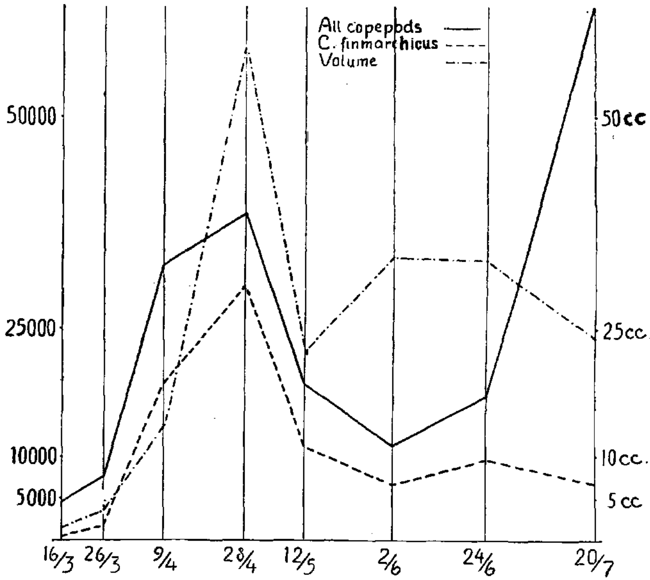

Fig. 4.

In Figures 2 and 3 an illustration is given of the variation of the numbers of different stages of *Calanus finmarchicus* at different times of the year. In Figure 2 we see the variation within each sample separately. In Figure 3 the total number of this species as well as of the different stages have been represented by separate curves.

Fig. 4 illustrates the relation between the total number of Copepods and the total number of *Calanus finmarchicus*. It will be seen from

[1]) D. DAMAS: Notes biologiques sur les Copépodes de la mer norvégienne. Publications de Circonstance No. 22. 1905.

Table 2 that the percentages of *Calanus finmarchicus* of all stages within the samples may vary from 5 to 85. A third curve gives the volume of the different samples. The figure illustrates the importance of the *Calanus finmarchicus* at different seasons, further the importance of this species for the volume of the sample, as long as this is a more or less pure Copepod sample. When other admixtures (such as medusae) become important (as in the summer) the correspondence between the curves for *Calanus finmarchicus* and the volume will of course be less marked.

These examples give only one amongst many applications of the method. The figures give a comparison between the hauls from one station, and in each case from the whole column of water. Other examples might compare hauls from different stations, different depths, different hours of the day etc. etc. Such samples will be found in the paper on the last year's collections which will be published by RUUD.

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October 1926.