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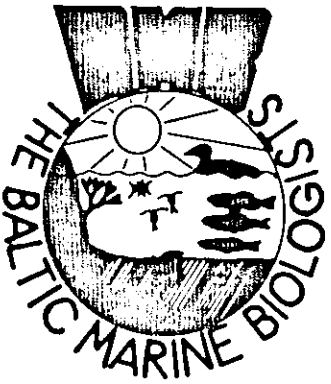

RECOMMENDATIONS ON METHODS FOR MARINE BIOLOGICAL STUDIES IN THE BALTIC SEA

MESOZOOPLANKTON BIOMASS ASSESSMENT

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Working Group 14
Edited by
L. Hernroth
1985

RECOMMENDATIONS ON METHODS FOR MARINE BIOLOGICAL STUDIES IN THE BALTIC SEA

MESOZOOPLANKTON BIOMASS ASSESSMENT

Individual volume technique

by

Baltic Marine Biologists Working Group 14

Edited by

Lars Hernroth

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CONTENTS

PREFACE

These recommendations are intended for mesozooplankton biomass assessment in monitoring work in the Baltic Sea area. They are intended to replace the interim recommendations which were based on the extended ashfree dry weight method (Hernroth & Viljamaa 1979).

In the interim recommendations, it was stated that the overall best method would be an individual volume method preferably combined with carbon content data. Reliable tables for individual volumes of the mesozooplankton of the Baltic were however lacking. This lack of data was the reason for the decision to use the interim recommendations until the task of our working group could be completed.

The recommendations now presented contain individual wet weights for the most common copepods and cladocerans of the Baltic Sea, i.e. the two groups of the planktonic fauna that usually dominate the mesozooplankton biomass. Since we anticipated both geographical and seasonal variations in individual volume of the different species and developmental stages, our analyses have covered six different areas of the Baltic and four seasons.

Information on the carbon content of different species and their developmental stages is gradually increasing but in our opinion it is presently not comprehensive enough to be included in these recommendations. However, since the tables on both length and weight have now been prepared for the dominating mesozooplankters of the Baltic, the carbon content or the relationships between carbon content and length/weight can at any time easily be added to these tables as supplements. Likewise, when additional data on the volume and weight of specific species and developmental stages are available, the present estimates can be revised.

This publication contains two sections. The first section contains the recommendations only. The second section gives a more comprehensive report on the activities of the Working Group, the material and methods used and the data upon which the recommendations are based. The purpose for doing so is to present one section that can easily be used for the routine calculations which are part of e.g. monitoring programmes.

Section II is written with the aim of providing methods and data necessary for more detailed analyses. A description of the procedures prior to the assessment of biomass e.g. gear, sampling, preservation and subsampling has been omitted in both sections. Information on these matters can be found in the revised zooplankton chapter of the BMB Recommendations (Lenz 1985).

Recommended values for individual wet weights of mesozooplankton in the Baltic Sea.

In tables 1-7, recommended values for individual wet weights of the most common copepods and cladocerans in the Baltic are presented. The tables have been compiled from the more extensive data presented in Section II and arranged in such a way that they will suit the analysis procedure recommended in the guidelines for the Baltic Monitoring Programme (Baltic Mar. Env. Prot. Comm. 1980). For copepods, each copepodite stage is therefore not treated separately but grouped into CI-CIII, CIV-CV, CVI ♀ and CVI ♂.

In order to investigate possible geographical differences in individual weight, samples were collected in six geographical areas of the Baltic (Bothnian Bay, Bothnian Sea, Gulf of Finland, Northern Baltic proper, Southern Baltic proper and Kattegatt & transition area). However, in those cases where no significant differences were found between areas, the recommended values in tables 1-7 are grouped to cover larger areas of the Baltic.

Our aim has also been to cover all four seasons. The plankton material available was however at times insufficient in regard to coverage of area, season or developmental stages. To complete the tables for recommended values, we therefore had to insert estimated values on those occasions when field samples or certain stages were missing. The estimates are based on the closest (in time and space) available values obtained by actual measurements.

These limitations must be kept in mind when the tables are used. When greater accuracy is needed, the biomass should therefore be calculated on the basis of actual measurements using the formulas given in Section II.

Literature values for additional taxa (table 8).

Although the recommended values ought to cover the majority of the organisms occurring in zooplankton samples from the Baltic, other mesozooplankters will from time to time appear. The Working Group has therefore decided to list literature values for the weight or volume of some additional organisms in order to facilitate a total biomass assessment for samples. In those cases where the authors did not express the biomass in wet weight but in dry weight or carbon content, the values have been converted to wet weight using the factors given by Mullin (1969). When only volume was given, the density of the organisms has been assumed to be 1.

µg wet weight	Kattegat & transition area				Southern Baltic proper				Remaining Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	4	4	4	4	4	4	4	4	4	9	4	4
C_{IV-V}	10	10	10	10	10	10	10	10	12	20	13	12
♂	15	20	20	20	15	20	20	20	15	20	20	20
♀	20	30	25	25	20	20	25	25	20	30	25	25

Table 1. Individual wet weight of Acartia bifilosa.

µg wet weight	Kattegat & transition area				Remaining Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	5	5	5	5	5	5	5	5
C_{IV-V}	12	12	11	9	12	12	11	9
♂	18	20	15	15	18	15	15	15
♀	20	20	20	20	20	20	20	20

Table 2. Individual wet weight of A. longiremis.

µg wet weight	Kattegat & transition area				Southern Baltic proper				Remaining Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	7	12	10	7	7	8	10	10	7	8	10	10
C_{IV-V}	20	35	30	20	20	20	20	20	20	20	20	20
♂	35	50	35	35	30	30	35	50	35	30	35	50
♀	50	60	50	55	50	45	50	55	50	45	50	55

Table 3. Individual wet weight of Pseudocalanus m. elongatus.

µg wet weight	Kattegat & transition area				Remaining Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	6	6	6	6	6	6	6	6
C_{IV-V}	17	15	15	17	17	15	15	17
♂	45	40	40	45	45	40	40	45
♀	55	70	45	50	55	50	45	50

Table 4. Individual wet weight of Centropages hamatus.

µg wet weight	Kattegat & transition area				Southern Baltic proper				Remaining Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	9	6	6	4	9	6	6	4	9	6	6	4
C_{IV-V}	18	15	15	14	18	15	15	14	18	15	15	14
♂	55	30	45	50	55	55	45	50	55	40	45	50
♀	60	50	40	50	60	65	40	50	60	65	60	50

Table 5. Individual wet weight of Temora longicornis.

µg wet weight	All the Baltic Sea			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
C_{I-III}	5	5	5	5
C_{IV-V}	13	14	14	13
♂	20	40	20	20
♀	25	50	25	25

Table 6. Individual wet weight of Eurytemora spp.

Length of animal mm	Wet weight ind.$^{-1}$ (µg)		
	Bosmina long. maritima	Podon spp.	Evadne nordmanni
< 0.3	2.5	2	2
0.3-0.4	7	6	6
0.4-0.5	15	13	10
0.5-0.6	25	25	20
0.6-0.7	45	40	30
0.7-0.9	80	70	50
0.9-1.1		140	90
> 1.1		200	140

Table 7. Individual wet weight of Bosmina long. maritima Podon spp. and Evadne nordmanni.

Species	Area/season		Size					References
		Cop. stg	Length mm ✪	Body volume (μm^3)	Wet weight (μg)	Dry weight (μg)	Carbon content (μg)	
Synchaeta spp.	Helsinki		0.25	3.0×10^6	3.0			13
-"-	-"-		0.25-0.30	3.5 x -"-	3.5			-"-
-"-	-"-		0.30-0.40	4.5 x -"-	4.5			-"-
-"-	-"-		0.40	5.5 x -"-	5.5			4
S. monopus	-"-		0.25	3.0 x -"-	3.0			13
Sagitta spp.	Baltic				250			2
Oikopleura dioica	Baltic				9			-"-
Fritillaria bor.	N. Baltic			10×10^6	10			1
-"- -"-	G. of Finl.			10×10^6	10			9
Oithona similis	Baltic	n			1.5			2
-"- -"-	-"-	cop			4.0			-"-
-"- -"-	-"-	ad			9.0			-"-
-"- -"-	-"- June	♀	0.48	8×10^6	10.2*	1.39		11
-"- -"-	-"- -"-	♂	0.45	7×10^6	6.0*	0.82		-"-
-"- -"-	Baltic	I-VI		3×10^6	3.0			1
Limnocalanus mac.	G. of Finl.	ad		1000×10^6	1000			5
-"- -"-	-"-	n		1×10^6	1			9
-"- -"-	-"-	cop		50×10^6	50			-"-
-"- -"-	-"-	ad		400×10^6	400			-"-
-"- -"-	-"- June	♀	1.7	590×10^6	590			12
-"- -"-	-"- -"-	♂	1.8	758×10^6	758			-"-
-"- -"-	-"- Sept.	♀	1.9	697×10^6	697			-"-
-"- -"-	-"- -"-	♂	1.7	517×10^6	517			-"-
-"- -"-	N. Baltic Jul.	♀	1.9	810×10^6	810			-"-
-"- -"-	-"-	♂	1.6	454×10^6	454			-"-
-"- -"-	Bothnian Bay	n	0.34		6*		0.3	7
-"- -"-	-"-	I-III	0.64		28*		1.4	-"-
-"- -"-	-"-	IV-V	1.19		90*		4.7	-"-
-"- -"-	-"-	♀	1.78		185*		9.6	-"-
-"- -"-	-"-	♂	1.72		169*		8.8	-"-
Pseudocalanus el.	Baltic	n			3			2
Centropages ham.	-"-	n			2.5			-"-
Temora longicor.	-"-	n			3			-"-
Eurytemora hir.	-"-	n			2			-"-
Acartia sp.	-"-	n			2			-"-

✪ Length of copepods = length of prosome

* Converted value assuming a carbon content of 5.2% and dry weight 13 % of wet weight (Mullin 1969).

Table 8. Additional values on individual volume and weight of mesozooplankton appearing in the Baltic Sea.

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Report from BMB Working Group 14 on Mesozooplankton Biomass Assessment.

INTRODUCTION

A prerequisite for a successful monitoring programme that involves several institutes and countries, such as the Baltic Monitoring Programme, is the availability of standardized methods. Regarding zooplankton, such methods have been agreed upon and available since 1976 (Dybern et al. 1976). However, the recommendations for the determination of zooplankton biomass have been unsatisfactory because of their inaccuracy and the need for additional analyses in order to obtain species composition. The advantages of basing the determination of biomass on individual volumes and simultaneously obtaining the qualitative and quantitative composition of a sample, are obvious. The reason for not adopting the method in previous recommendations has however been the lack of reliable tables on individual volumes. The task of BMB W.G.14 has been to prepare such tables for the most abundant mesozooplankton species of the Baltic. Practical and economical circumstances have limited the extent of our analyses but the tables presented are nevertheless substantially more comprehensive than those previously existing. Particular improvements are the separations into geographical areas and seasons and the statistical treatment of the data. Obvious limitations are the lack of samples from some seasons and areas of the Baltic and the meagre number of measurements upon which some of the recommended values are based. The recommendations should therefore be used with this in mind.

During the period 1980-83, four Working Group meetings have been held. Between these sessions, the recomendations have been prepared stepwise following analyses in each participating country and a close correspondance to follow up the results. The intended plan for the W.G. activities anticipated cooperation from all of the 7 Baltic nations. In practice, only 5 participated. This unfortunate situation reduced the number of geographical areas covered and thus also the basis for the calculations.

MATERIAL AND METHODS

Material used

This study has been restricted to the mezozooplankton of the Baltic Sea. The size-range (0.2-20mm) has been defined according to Sieburth et al. (1978).

The basis for the calculation of values for individual volume, consists of zooplankton samples collected by vertical hauls with WP 2-nets (100-200 µm) in the following areas:

1 Bothnian Bay	65°28'N, 22°30'E	
2 Bothnian Sea	60°45'N, 17°30'E	
3 Gulf of Finland	60°04'N, 26°20'E	
3* _ " _	60°07'N, 24°55'E	(Cladoceran samples)
4 Northern Baltic proper	59°17'N, 21°34'E	
5 S. Gotland Sea	55°38'N, 18°36'E	
6 Gdansk Deep	54°50'N, 19°20'E	
7 Slupsk Trough	55°15'N, 17°04'E	
8 Arkona Basin	55°00'N, 13°18'E	
9 Kiel Bight	54°42'N, 10°46'E	
10 Kattegatt	57°31'N, 11°31'E	

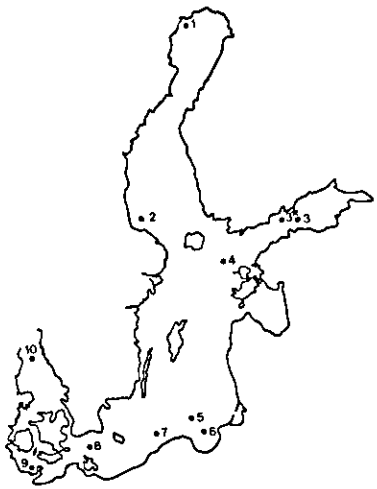

Figure 1. Chart illustrating the sampling stations.

Our aim has been to cover each area during winter, spring, summer and autumn. However, since financial reasons dictated the use of previously collected material, this aim could not always be achieved.

Preservation

All samples were preserved in 4% formaldehyde and stored for more than 3 months before the analyses were conducted.

Sample analysis

Measurements were made on 6 copepod species (Acartia bifilosa, A.longiremis, Centropages hamatus, Eurytemora sp., Temora longicornis, Pseudocalanus m. elongatus) and 3 cladocerans (Bosmina long. maritima, Evadne nordmanni, Podon sp.).These 9 genera greatly dominate the mesozooplankton biomass in the open Baltic (Hernroth and Ackefors 1979).

The copepods were analysed to species and developmental stages (C.I-VI) and copepodite-stage VI was also determined to sex. The cladocerans were only analysed to species.

When perfoming the measurements on the individual volumes of the copepods, 30 specimens of each developmental stage of each species were used. However, temporal differences in the lifecycles of the different species meant that the number actually measured was at times less than 30 (see appendixes 1-6). When calculating the confidence intervals (Figs. 6-12) and performing the cluster analyses, data based on less than 10 measurements were excluded.

The number of specimens used for determining the individual volume of cladocerans was always 50 or more (appendix 7).

Volume measurement

In our calculations we defined the total volume of a copepod as the sum of volumes for prosome, abdomen, antennae and legs (Chojnacki et al. 1980). The formula used was thus:

$$V = \pi [(Lc \times B \times H)/ 6 + (Lab \times Dab^2)/ 4 + (Lan \times Dan^2)/ 6 + (Lp \times Dp^2 \times N)/ 12]$$

where:

Lc = length of the prosome	Dab = diameter of abdomen
Lab = length of abdomen	Dan = diameter of antenna
Lan = length of antenna	Dp = mean diameter of legs
Lp = mean length of legs	V = volume
H = height of prosome	N = number of legs
B = width of prosome	

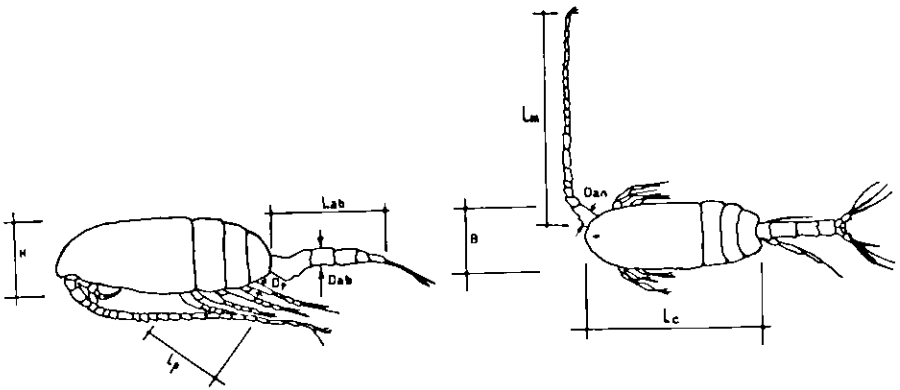

Figure 2. Location of measurements on copepods.

(For five copepod species, we separately investigated the contribution of antennae and appendages to the total volume. On no occasion did the combined volume of legs and antennae exceed 6.5% of the total volume. We therefore recommend the substitution of the volume calculations of legs and antennae by a fixed value of 3% of the body volume).

Regarding cladocerans, the volume of Bosmina can be calculated in the following way:

V = A x Cmean (Chojnacki and Janowski 1982)

A = projected lateral area of the animal.

Cmean = mean width of the animal calculated from an ellipse.

The projected lateral area can be calculated by placing the animal on glass with an engraved 0.1 mm grid. The length of Bosmina is measured as in figure 3.

The volume of Podon (P. intermedius, P. leuckarti and Pleopsis polyphemoides) can be calculated according to the same formula as that used for Bosmina. The length of Podon is measured as in figure 4.

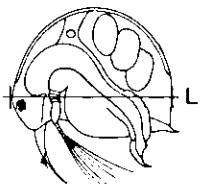

Figure 3. Location of measurements on Bosmina.

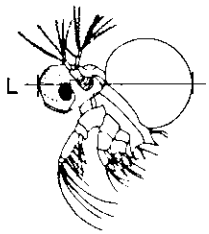

Figure 4. Location of measurements on Podon.

The volume of Evadne can be calculated using the formula for a flattened ellipsoid:

$V = \pi \times H \times L \times C / 6$

V = volume (mm^3)

H = hight (mm)

L = length max (mm)

C = width max (mm)

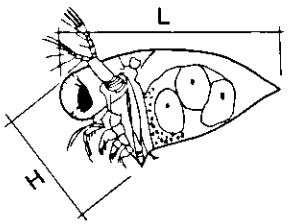

Figure 5. Location of measurements on Evadne.

Comparisons between the means for length and wet weight were made by examination of the 95% confidence intervals (figs. 6-12). If the confidence intervals did not meet, the difference was considered to be significant; if the confidence intervals overlapped, the difference was considered to be nonsignificant (Snedecor and Cochran 1980, Meyer 1981).

In the Clusteranalysis, only selected data were used. For Acartia bifilosa this included data from the Bothnian Sea, the Gulf of Finland, the Northern Baltic proper and Kiel Bight, for Eurytemora sp. this included data from the Bothnian Bay, the Bothnian Sea, the Gulf of Finland and the Northern Baltic proper, for Pseudocalanus m.elongatus this included data from the Kattegat, Kiel Bight and the Northern Baltic proper and for Temora longicornis data from the Arkona Deep, Kiel Bight and the Northern Baltic proper were used.

Histograms of lengths and wet weights were set up. The different classes were combined and compared using the Canberra matrix. This resulted in an affinity matrix which was clustered by the complete linkage method (recursion formula by Lance and Williams, 1967). The distances ranged from 0 (similarity) to 100 (dissimilarity). The threshold for the acceptance of clusters was mostly set at 50, while it was also set at 60 for Temora longicornis and at 40 for Eurytemora sp. (length only), (figs. 13-16).

RESULTS

The means and the confidence intervals for lengths and wet weights are presented in figs. 6-12. Dendograms based on the affinity matrixes for lengths and weights are presented in figs. 13-16. The primary data used in the different calculations are presented in appendixes 1-7.

Our results show that when lengths and weights from different areas and seasons were compared, there were significant differences on several occasions. However, no uniformity was obvious. When there were differences, a similar pattern was rarely found in all developmental stages. Thus, it has not been possible to single out any area or season that could be considered exceptional.

Such results are by no means surprising since the investigated species (both copepods and cladocerans) differ greatly in e.g. their temperature and salinity tolerance or in the time of reproduction and their reproductive strategy. The results do however illustrate the importance of temporal and spatial differences in the individual volume of the mesozooplankters when biomass is assessed by means of the individual volume technique.

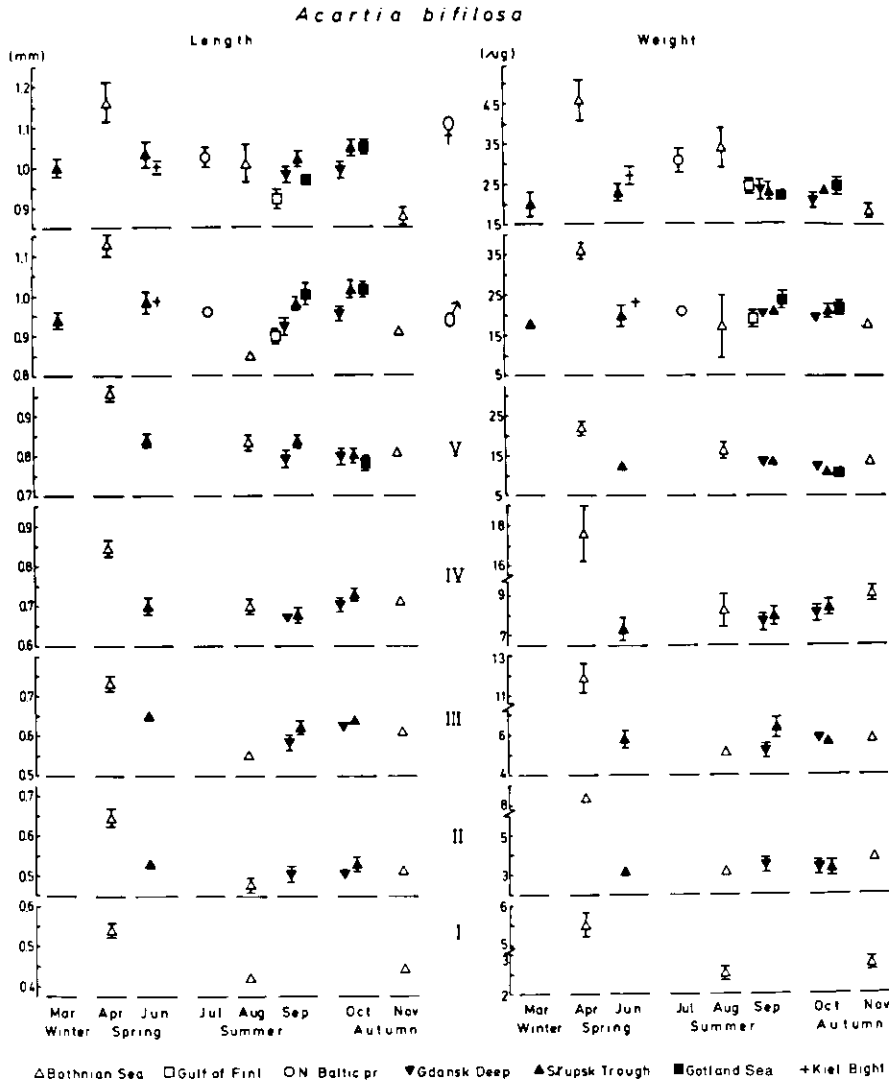

Figure 6. Means and 95% confidence intervals of length and weight of Acartia bifilosa.

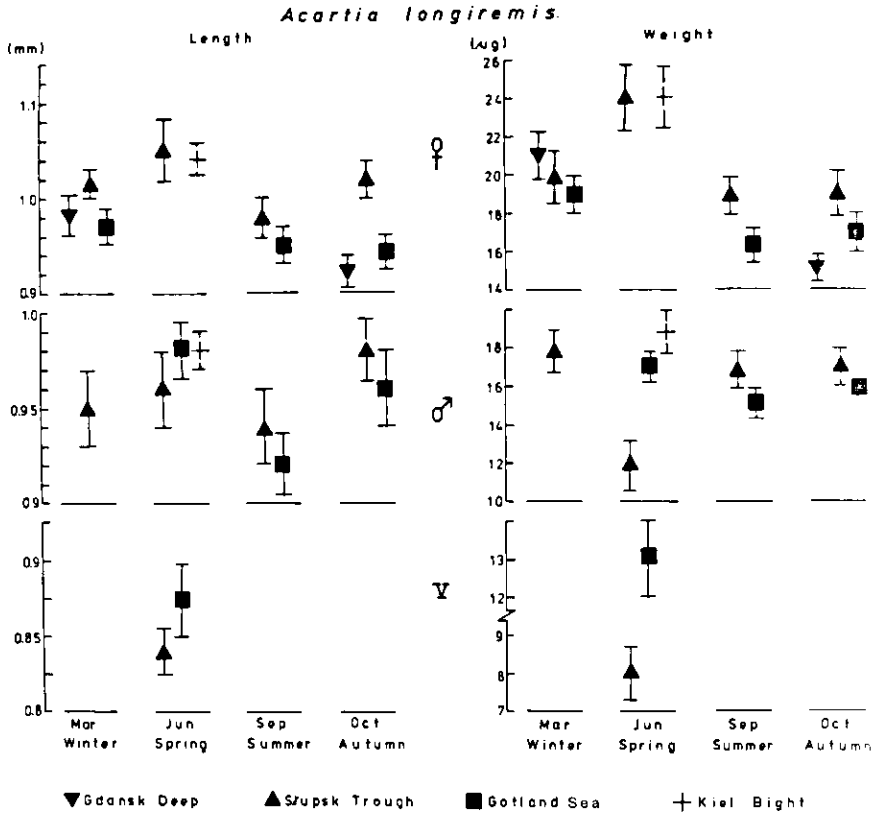

Figure 7. Means and 95% confidence intervals of length and weight of Acartia longiremis.

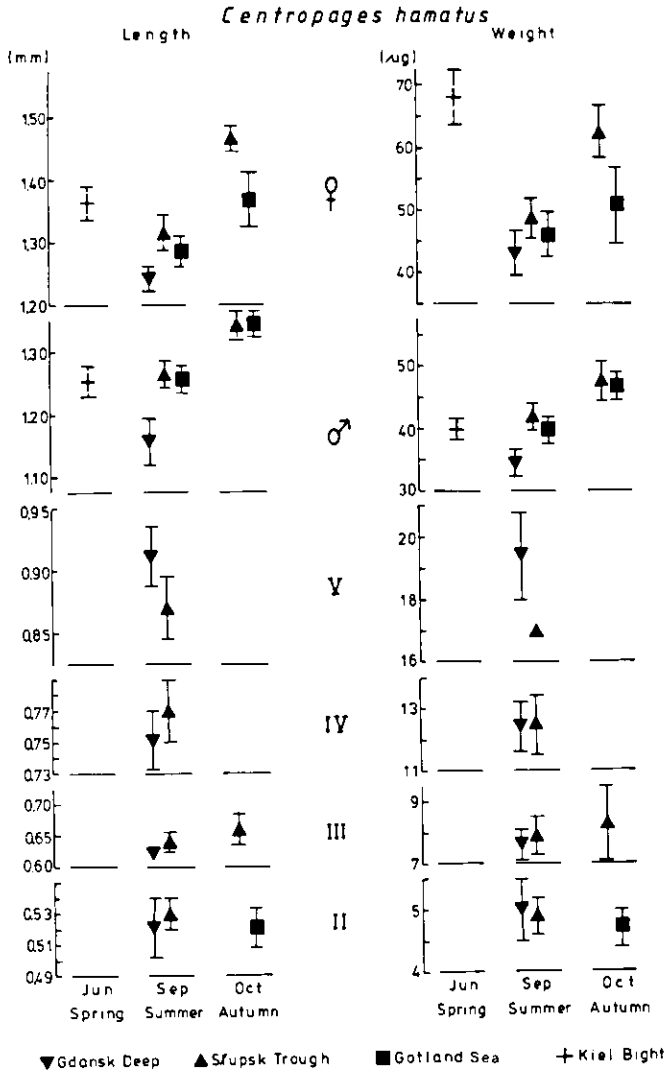

Figure 8. Means and 95% confidence intervals of length and weight of Centropages hamatus.

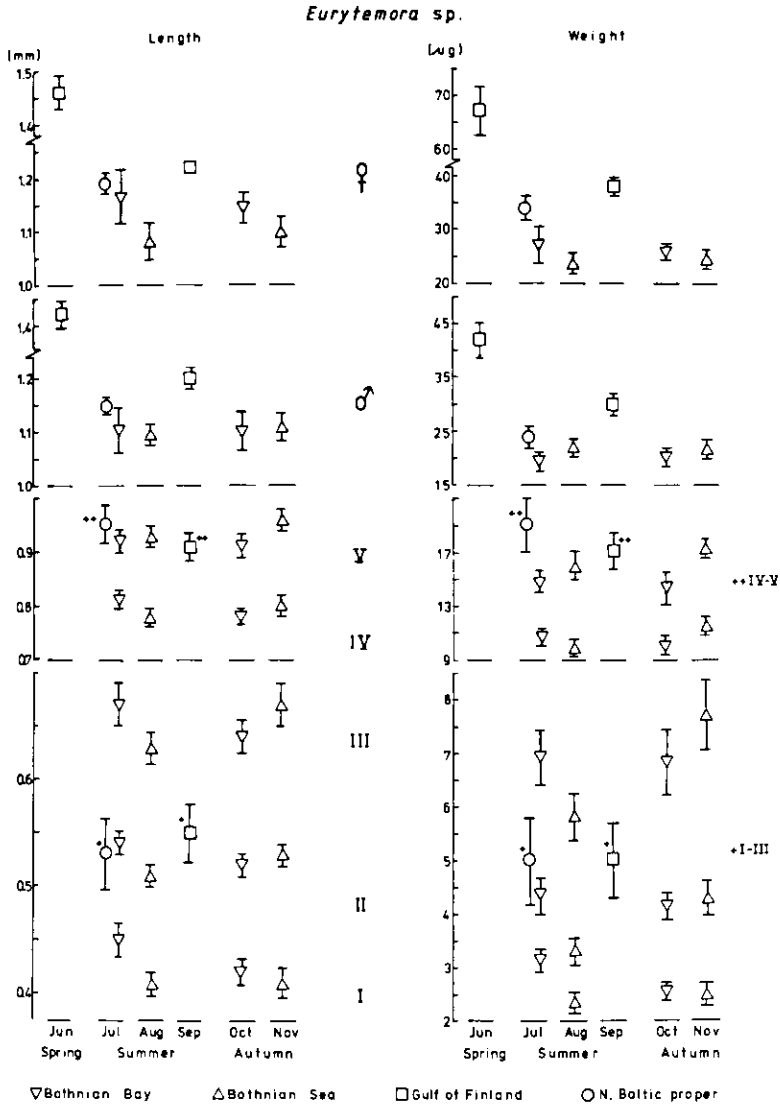

Figure 9. Means and 95% confidence intervals of length and weight of Eurytemora sp.

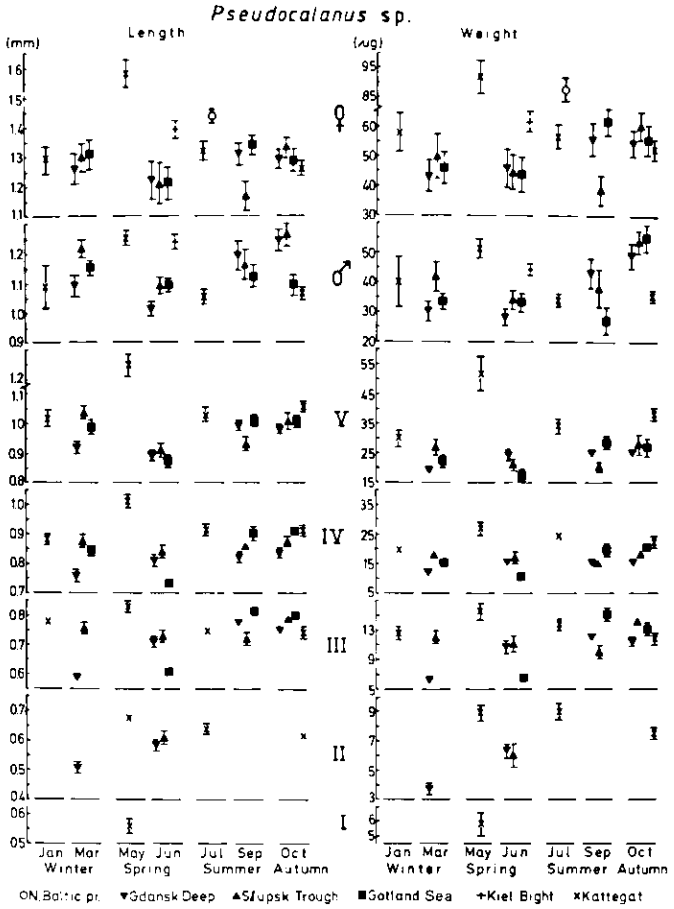

Figure 10. Means and 95% confidence intervals of length and weight of Pseudocalanus m. elongatus.

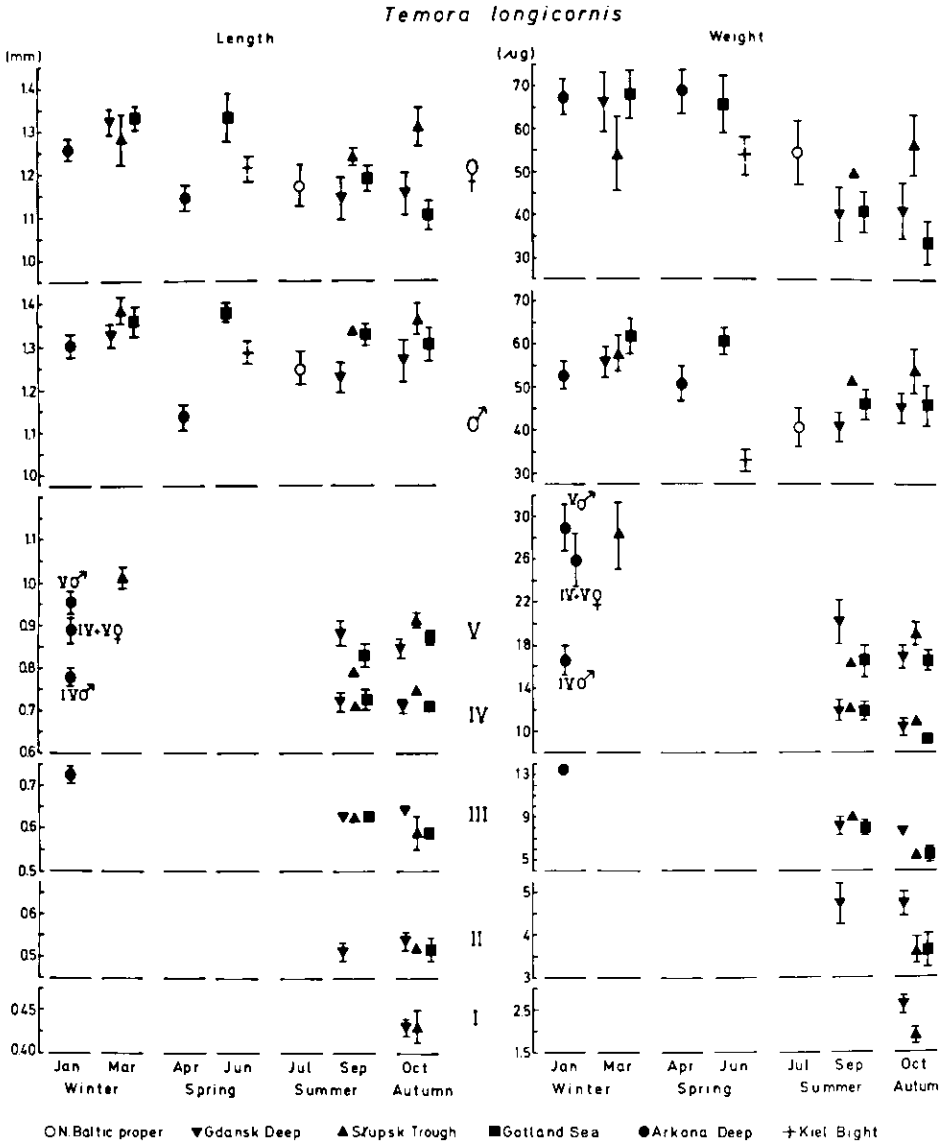

Figure 11. Means and 95% confidence intervals of length and weight of Temora longicornis.

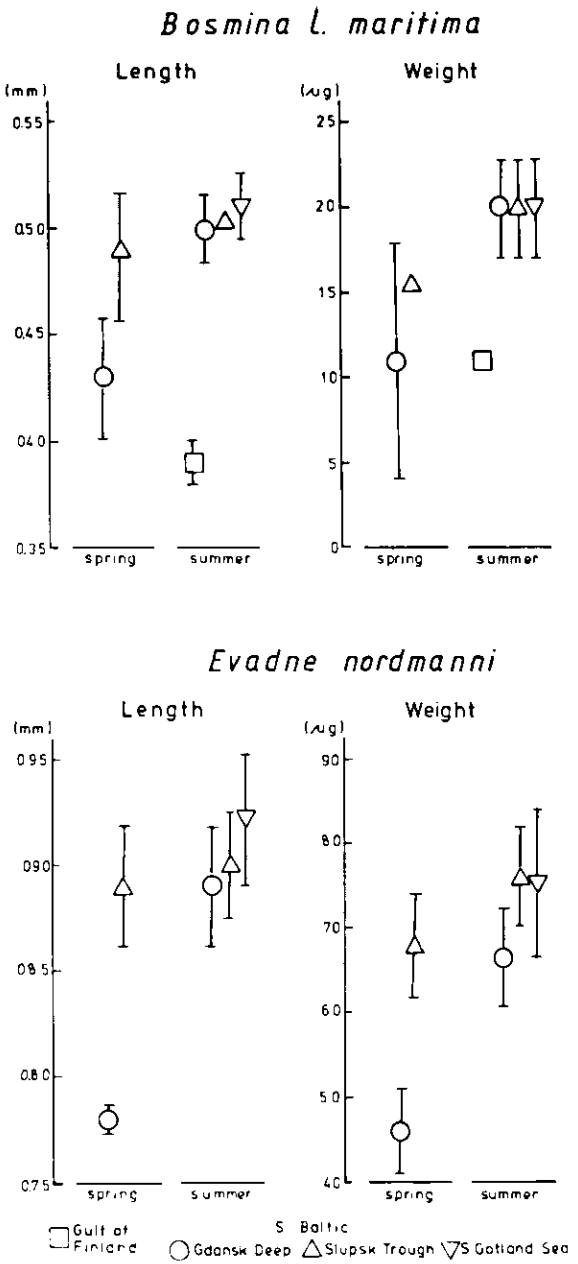

Figure 12. Means and 95% confidence intervals of length and weight of Bosmina long. maritima and Evadne nordmanni.

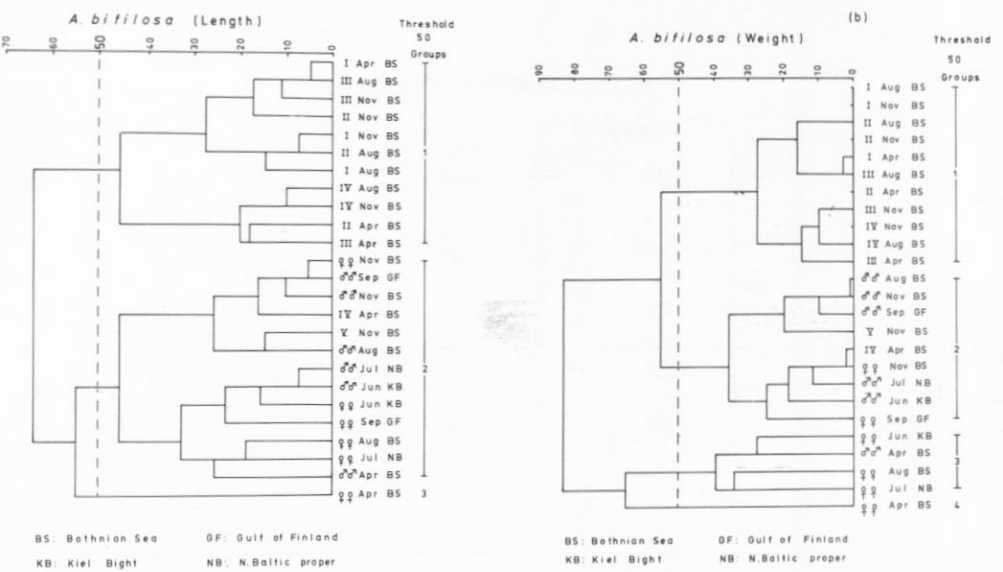

Figure 13. Dendogram of the affinity matrix of length (a) and weight (b) of Acartia bifilosa.

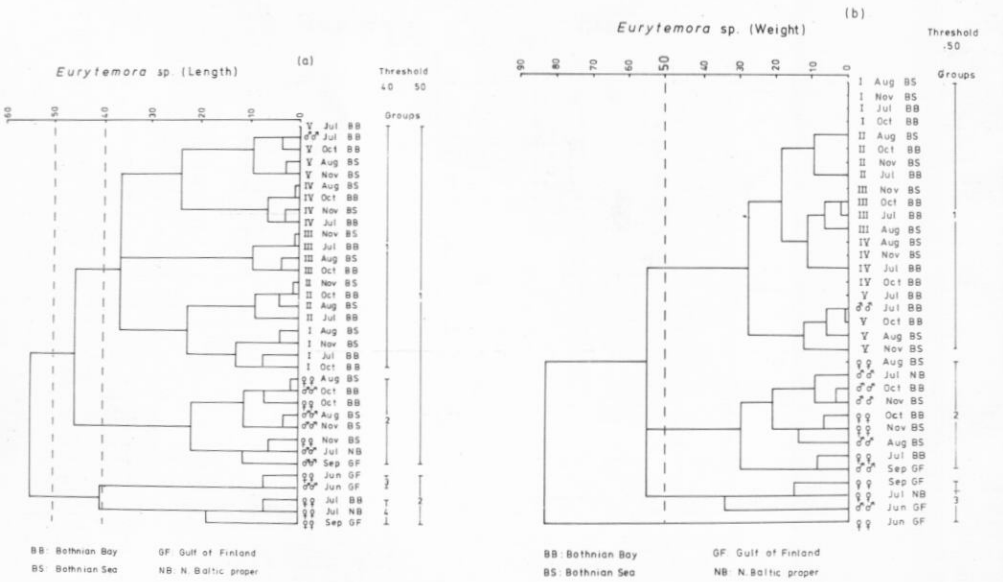

Figure 14. Dendogram of the affinity matrix of length (a) and weight (b) of Eurytemora sp.

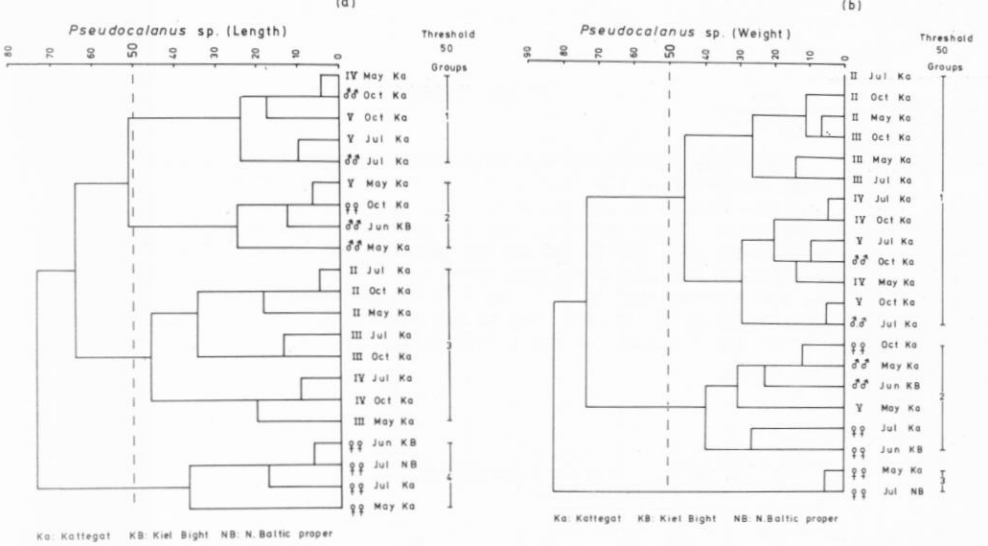

Figure 15. Dendogram of the affinity matrix of length (a) and weight (b) of Pseudocalanus m. elongatus.

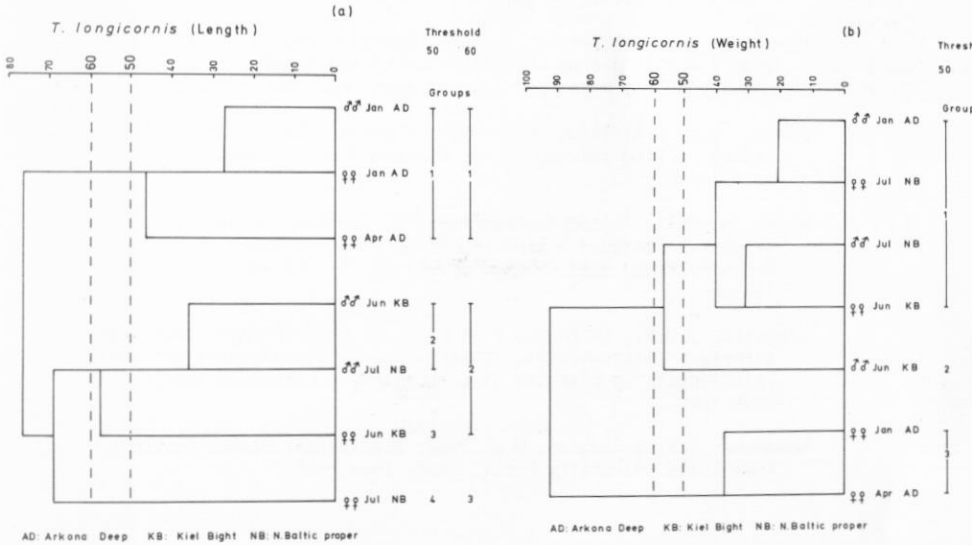

Figure 16. Dendogram of the affinity matrix of length (a) and weight (b) of Temora longicornis.

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Appendix 1. Primary data regarding Acartia bifilosa.

	AREA	Bothanian Sea			G.Fin.	N.Bal.	Gdansk Deep				Slupsk Trough				S. Gotland Sea			Kiel B.
	SEASON	Apr.	Aug.	Nov.	Sep.	July	Oct.	Mar.	June	Sep.	Oct.	Mar.	June	Sep.	Oct.	June	Sep.	June
C_I	n	20	20	20			1						3		3			
	mm	.54	.42	.44			.41						.41		.43			
	sd	.03	.02	.01			-						.03		.01			
	µg	5.5	2.5	2.7			1.9						1.5		1.9			
	sd	.68	.33	.32			-						.45		.98			
C_{II}	n	20	20	20			30			30	30		30	5	5		1	
	mm	.64	.48	.51			.50			.50	.53		.53	.51	.50		.58	
	sd	.04	.02	.02			.03			.04	.04		.03	.04	.02		-	
	µg	8.3	3.2	3.8			3.3			3.4	3.3		3.2	3.8	2.8		5.7	
	sd	.46	.48	.42			.73			.85	.76		.55	.74	.45		-	
C_{III}	n	20	20	20			30			30	30		30	30	5			
	mm	.73	.56	.61			.62			.58	.64		.65	.62	.60			
	sd	.04	.02	.02			.03			.04	.03		.03	.04	.02			
	µg	11.8	5.2	5.8			5.8			5.2	5.7		5.8	6.4	5.0			
	sd	1.5	.48	.47			.63			.69	.56		.99	1.4	.28			
C_{IV}	n	21	20	20			30			30	30	2	30	30	7			
	mm	.85	.66	.71			.70			.67	.73	.95	.70	.68	.66			
	sd	.05	.04	.02			.04			.02	.04	.03	.05	.04	.03			
	µg	17.6	8.2	9.1			8.1			7.7	8.4	18.2	7.3	8.0	6.4			
	sd	3.0	1.6	.70			1.0			.93	1.0	5.9	1.7	1.2	.83			
C_V	n	24	20	20			30		2	30	30	3	30	30	30			
	mm	.95	.84	.81			.80		.83	.79	.80	.94	.84	.84	.78			
	sd	.05	.05	.03			.05		.04	.05	.04	.07	.04	.04	.04			
	µg	22	16.7	14.0			12		14	13	11	18	12.7	13.6	10.4			
	sd	3.2	3.9	1.5			2.0		4.6	2.2	5.3	2.0	2.0	2.3	1.8			
♀	n	20	20	20	25	25	30		3	30	30	30	30	30	30	5	30	46
	mm	1.16	1.02	.88	.92	1.03	.99		1.06	.98	1.05	1.00	1.03	1.02	1.05	1.10	.97	1.00
	sd	.10	.10	.05	.05	.05	.06		.05	.06	.06	.05	.08	.05	.06	.03	.03	.06
	µg	46	34	18.2	24	31	21		26	23	24	20	23	23	25	27	22	27
	sd	10.3	10.7	2.9	5	8	5.5		1.7	6.2	3.1	7.0	4.6	5.7	5.7	3.0	3.0	5.8
♂	n	20	20	20	27	25	30	2	3	30	30	30	30	30	30	5	30	49
	mm	1.12	.87	.91	.90	.96	.95	.96	.97	.92	1.01	.94	.98	.98	1.01	1.09	1.0	.98
	sd	.07	.02	.02	.04	.03	.04	.03	.03	.05	.05	.05	.07	.04	.06	.01	.08	.06
	µg	36	17.2	17.9	19	21	19	21	21	20	21	17.7	20	21	22	27	24	23
	sd	5.3	17.2	2.2	4	3	2.8	.95	5.4	3.7	3.7	2.4	6.5	3.4	4.4	2.8	6.8	3.6

Appendix 2. Primary data regarding Acartia longiremis.

	AREA	Gdansk Deep		Słupsk Trough				S. Gotland Sea				Kiel B.
	SEASON	Oct.	Mar.	Oct.	Mar.	Jun.	Sep.	Oct.	Mar.	Jun.	Sep.	Jun.
C_I	n											
	mm											
	sd											
	µg											
	sd											
C_{II}	n									3		
	mm									.49		
	sd									.04		
	µg									3.2		
	sd									1.6		
C_{III}	n									2		
	mm									.63		
	sd									.04		
	µg									5.8		
	sd									.4		
C_{IV}	n			1		6				2		
	mm			.66		.71				.71		
	sd			.-		.03				.04		
	µg			7.		21.				7.7		
	sd			.-		1.5				.7		
C_V	n	2		1		30		1	2	17	3	
	mm	.81		.83		.84		.76	.85	.87	.80	
	sd	.02		.-		.04		.-	.02	.04	.05	
	µg	10.		12.		8.		8.1	13.	13.	11.4	
	sd	.78		.-		1.9		.-	4.1	1.8	3.0	
♀	n	30	30	30	30	30	30	30	30		30	50
	mm	.92	.98	1.02	1.01	1.05	.98	.94	.97		.95	1.04
	sd	.05	.05	.05	.05	.08	.06	.05	.05		.04	.05
	µg	15.	21.	19.	20.	24.	19.	17.	19.		16.3	24.
	sd	1.3	3.1	3.2	3.7	4.8	3.5	2.9	2.5		2.2	5.3
♂	n	3		30	30	30	30	30		30	30	50
	mm	.95		.98	.95	.96	.94	.96		.98	.92	.98
	sd	.04		.04	.05	.05	.05	.05		.04	.04	.04
	µg	14.		17.	18.	12.	17.	16.		17.	15.1	19.
	sd	2.4		3.0	2.7	3.7	2.8	3.1		1.9	2.0	3.4

Appendix 3. Primary data regarding Centropages hamatus.

	AREA	Gdansk Deep		Slupsk Trough				S. Gotland Sea		Kiel B.
	SEASON	Oct.	Sep.	Oct.	Mar.	Jun.	Sep.	Oct.	Sep.	Jun.
C_I	n	5						6		
	mm	.41						.41		
	sd	.02						.02		
	µg	2.7						2.7		
	sd	.69						.23		
C_{II}	n	6	30	5			30	11		
	mm	.52	.52	.52			.53	.52		
	sd	.02	.05	.05			.03	.02		
	µg	4.6	5.0	4.7			4.9	4.7		
	sd	.49	1.39	.79			1.02	.46		
C_{III}	n	9	30	12		2	30	2	1	
	mm	.66	.62	.66		.54	.64	.65	.65	
	sd	.05	.03	.04		.03	.04	.02	.-	
	µg	8.4	7.6	8.3		5.8	7.9	8.2	7.5	
	sd	1.13	1.40	2.1		.04	1.65	.93	.-	
C_{IV}	n	2	30				30	1	3	
	mm	.83	.75				.77	.72	.69	
	sd	.05	.05				.05	.-	.03	
	µg	14.6	12.3				12.4	10.7	8.8	
	sd	1.25	2.3				2.4	.-	.76	
C_V	n	1	30	1		1	30		3	
	mm	1.05	.91	.90		.99	.87		.87	
	sd	.-	.07	.-		.-	.07		.04	
	µg	26.	19.4	18.3		26.	16.9		16.4	
	sd	.-	3.8	.-		.-	4.8		4.0	
♀	n	3	30	30	4	5	30	12	30	50
	mm	1.32	1.24	1.47	1.34	1.29	1.32	1.37	1.29	1.36
	sd	.02	.06	.06	.05	.14	.07	.07	.07	.09
	µg	45.	43.	63.	53.	50.	49.	51.	46.	68.
	sd									
♂	n	9	30	30	1	1	30	17	30	50
	mm	1.25	1.13	1.32	1.44	1.25	1.24	1.32	1.23	1.23
	sd	.04	.09	.07	.-	.-	.06	.04	.05	.08
	µg	40.	34.	48.	70.	46.	42.	47.	40.	40.
	sd	3.2	6.0	7.8	.-	.-	5.8	3.7	4.2	9.6

Appendix 4. Primary data regarding Eurytemora sp.

	AREA	Bothnian Bay		Bothnian Sea		Gulf of Finl.		Balt.P.
	SEASON	July	Oct.	Aug.	Nov.	June	Sep.	July
C_I	n	20	20	20	20			
	mm	.45	.42	.41	.41			
	sd	.03	.02	.02	.03			
	µg	3.1	2.5	2.3	2.5			
	sd	.38	.31	.36	.45			
C_{II}	n	20	20	20	20		50	25
	mm	.54	.52	.51	.53		.55	.53
	sd	.02	.02	.02	.02		.10	.08
	µg	4.3	4.1	3.3	4.3		5	5
	sd	.62	.54	.49	.64		2	2
C_{III}	n	20	20	20	20			
	mm	.67	.64	.63	.67			
	sd	.04	.03	.03	.04			
	µg	6.9	6.8	5.8	7.7			
	sd	1.08	1.30	.98	1.36			
C_{IV}	n	20	20	20	20		50	25
	mm	.81	.78	.78	.80		.91	.95
	sd	.03	.03	.03	.04		.08	.09
	µg	10.6	10.0	9.7	11.6		17	19
	sd	1.4	1.22	1.20	1.2		5	5
C_V	n	20	20	20	20			25
	mm	.92	.91	.93	.96			1.19
	sd	.04	.04	.04	.04			.05
	µg	14.5	14.3	16.1	17.3			34
	sd	2.3	2.3	2.3	1.4			5
♀	n	20	20	20	20	22	100	25
	mm	1.16	1.14	1.08	1.10	1.46	1.22	1.16
	sd	.09	.06	.07	.05	.07	.06	.06
	µg	27	26	24	25	67	38	24
	sd	7.1	3.3	3.4	2.9	10	8	4
♂	n	20	20	20	20	25	50	
	mm	1.10	1.10	1.10	1.10	1.11	1.20	
	sd	.09	.07	.04	.05	.06	.07	
	µg	19.4	20	22	22	42	30	
	sd	3.4	2.9	4.6	2.8	7	7	

Appendix 5. Primary data regarding Pseudocalanus m. elongatus.

	AREA	Gdansk Deep				Slupsk trough				S. Gotland Sea				Kiel B	Kattegat			
	SEASON	Oct.	Mar.	June	Sep.	Oct.	Mar.	June	Sep.	Oct.	Mar.	June	Sep.	June	Jan.	May	July	Oct.
C_I	n			1												12		
	mm			.42												.56		
	sd			.-												.04		
	µg			2.6												5.8		
	sd			.-												1.31		
C_{II}	n		31	30	1		3	30	1			3	4			26	30	30
	mm		.48	.58	.51		.66	.61	.51			.54	.52			.68	.64	.62
	sd		.04	.04	.-		.02	.07	.-			.02	.08			.03	.04	.02
	µg		3.6	6.3	8		8	6	3.6			4.5	4			8.9	8.9	7.3
	sd		1.1	1.3	.-		2.1	2.0	.-			.35	.24			1.6	1.4	.95
C_{III}	n	30	30	30	30	30	30	30	30	30	5	30	30		30	30	30	30
	mm	.75	.59	.71	.77	.79	.76	.73	.72	.80	.78	.61	.82		.77	.83	.75	.74
	sd	.02	.03	.04	.03	.018	.04	.06	.04	.03	.04	.04	.04		.03	.04	.03	.06
	µg	11.2	6.1	10.7	12	14	12	11	9.8	13	12	6.5	15		12.5	15.8	13.6	11.6
	sd	1.39	1.15	2.5	1.35	1.44	2.0	2.5	1.83	2.0	2.3	1.18	2.1		1.9	3.2	1.7	2.0
C_{IV}	n	30	30	30	30	30	30	30	30	30	30	30	30		30	30	30	30
	mm	.83	.76	.81	.82	.87	.88	.84	.86	.91	.85	.73	.90		.88	1.01	.91	.91
	sd	.04	.05	.05	.04	.04	.05	.05	.03	.03	.04	.03	.07		.04	.06	.04	.04
	µg	15.2	11.6	15.5	15	18	18	17	15.2	20	15	10.5	19.6		19.4	27	24	22
	sd	2.5	2.2	2.8	1.97	1.97	2.5	4.8	2.2	2.8	2.3	1.32	4.9		2.5	5.4	3.4	4.8
C_V	n	30	30	30	30	30	30	30	30	30	30	30	30		30	30	30	30
	mm	.98	.92	.89	.99	1.01	1.04	.91	.93	1.01	.99	.87	1.01		1.02	1.25	1.03	1.06
	sd	.04	.05	.04	.05	.08	.06	.07	.06	.06	.05	.05	.04		.07	.10	.06	.05
	µg	25	19.1	24	25	28	27	21	20	27	22	17.2	28		30	52	34	38
	sd	3.1	3.1	4.2	3.8	8.7	6.5	5.4	3.5	8.0	4.3	4.0	4.7		7.8	16.1	5.9	5.7
♀	n	30	30	30	30	30	30	30	30	30	30	30	30	50	30	30	30	30
	mm	1.29	1.26	1.22	1.31	1.33	1.30	1.21	1.17	1.29	1.31	1.21	1.34	1.39	1.29	1.58	1.32	1.26
	sd	.08	.13	.17	.09	.09	.14	.19	.13	.09	.13	.15	.10	.10	.12	.12	.08	.07
	µg	55	43	46	56	61	50	45	39	56	46	44	62	62	58	92	57	53
	sd	12.0	14.4	18.1	14.1	13.0	19.7	17.0	13.9	12.6	15.0	15.6	11.8	14.4	17.2	16.8	10.5	9.8
♂	n	30	30	30	30	30	30	30	30	30	30	30	30	50	15	30	30	30
	mm	1.24	1.09	1.01	1.19	1.27	1.22	1.09	1.16	1.09	1.15	1.09	1.24	1.24	1.09	1.25	1.05	1.06
	sd	.10	.09	.07	.13	.07	.08	.08	.14	.08	.07	.06	.08	.08	.12	.07	.07	.05
	µg	49	30	28	43	54	42	34	38	55	33	33	44	44	40	51	34	35
	sd	12.0	7.6	7.3	13.3	11.2	14.6	7.2	17.3	11.4	6.0	8.5	7.7	7.7	14.7	8.3	5.3	5.6

Appendix 6. Primary data regarding Temora longicornis.

	AREA	N.Balt.	Gdansk Deep				Słupsk Trough				S. Gotland Sea				Arkona Deep		Kiel B.
	SEASON	July	Oct.	Mar.	Jun.	Sep.	Oct.	Mar.	Jun.	Sep.	Oct.	Mar.	Jun.	Sep.	Jan.	Apr.	Jun.
C_I	n		30			1	11				9						
	mm		.43			.50	.43				.47						
	sd		.03			.-	.03				.03						
	µg		2.6			4.5	1.9				2.9						
	sd		.49			.-	.25				.39						
C_{II}	n		30			30	30			2	12			5			
	mm		.54			.51	.52			.45	.52			.49			
	sd		.06			.05	.03			ns	.04			.04			
	µg		4.7			4.7	3.6			3.9	3.6			4.5			
	sd		.62			1.26	.84			ns	.63			.70			
C_{III}	n		30	1	1	30	30	3		30	30			30	30		
	mm		.64	.57	.44	.63	.59	.56		.62	.59			.63	.70		
	sd		.03	.-	.-	.04	.03	.014		ns	.03			.03	.05		
	µg		7.8	5.7	1.9	8.1	5.4	5.2		8.7	5.4			7.9	13.7		
	sd		.71	.-	.-	1.73	.92	.85		ns	1.40			1.40	.33		
C_{IV}	n		30	1	1	30	30	1		30	30			30	30 ♂	50 ♀	
	mm		.71	.82	.74	.72	.75	.80		.71	.71			.73	.78	.89	
	sd		.04	.-	.-	.05	.02	.-		ns	.03			.05	.05	.10	
	µg		10.2	16.2	10.5	11.9	10.9	14.3		12.2	9.3			11.9	16.6	26.	
	sd		2.0	.-	.-	2.5	1.57	.-		ns	1.14			2.3	4.0	8.3	
C_V	n		30	7		30	30	11	1	30	30		3	30	30		
	mm		.84	1.03		.88	.91	1.01	.86	.79	.87		.99	.83	.95		
	sd		.05	.06		.08	.04	.04	.-	ns	.04		.07	.07	.06		
	µg		16.8	31.7		20.1	19.0	28.2	18.1	16.2	16.5		18.9	16.5	29.		
	sd		2.9	4.0		5.8	2.9	4.6	.-	ns	2.5		2.8	4.4	5.6		
♀	n	19	30	30	3	30	30	30	1	30	30	30	30	30	30	30	50
	mm	1.17	1.15	1.32	.96	1.14	1.31	1.28	1.36	1.24	1.10	1.33	1.33	1.19	1.26	1.14	1.21
	sd	.10	.13	.08		.13	.12	.16	.-	ns	.10	.07	.08	.08	.07	.08	.11
	µg	55	41	66	25	40	57	54	44	49	34	68	66	41	67	69	54
	sd	16	16.3	18.4	10.1	15.8	19.1	23.3	.-	ns	14.0	14.8	9.8	12.5	10.9	13.4	14.1
♂	n	25	30	30	1	30	30	30	8	30	30	30	11	30	30	20	50
	mm	1.17	1.19	1.25	.94	1.15	1.29	1.31	1.27	1.26	1.23	1.28	1.30	1.25	1.23	1.06	1.21
	sd	.10	.12	.08	.-	.09	.09	.09	.08	ns	.09	.09	.06	.07	.07	.06	.11
	µg	41	45	56	23	41	54	58	38	52	46	62	61	46	53	51	33
	sd	11	9.3	9.2	.-	7.8	13.9	11.0	3.2	ns	11.3	11.6	7.2	8.4	7.9	11.9	9.1

Appendix 7. Primary data regarding Bosmina long. maritima, Podon sp. and Evadne nordmanni.

		Gulf of Finland	Southern Baltic				
		Coastal	Coastal (Gdansk Deep)		Open Area		Both Areas
Species		Summer	Spring	Summer	Spring	Summer	All Seasons
Bosmina	n	300	10	52	10	101	173
	L_t *	0.41	0.43	0.50	0.49	0.51	0.50
	SD	0.06	0.04	0.06	0.05	0.04	0.06
	Vol_t °	0.012	0.011	0.02	0.016	0.02	0.02
	SD	0.005	0.01	0.01	0.001	0.01	0.015
Evadne	n	50	70	50	50	101	271
	L_t *	-	0.78	0.89	0.89	0.91	0.876
	SD	-	0.02	0.10	0.10	0.10	0.115
	Vol_t °	0.06	0.046	0.066	0.068	0.076	0.066
	SD	0.02	0.02	0.02	0.02	0.02	0.023
Podon	n	90+					94£
	L_t *	0.43					0.70
	SD	0.04					0.18
	Vol_t °	0.0086					0.064
	SD	-					0.049
	n	86+					
	L_t *	0.42					
	SD	0.09					

* mm, ° mm^3, + Pleopsis polyphemoides £ Podon spp.

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