Mesozooplankton abundance, biomass and processing

Richard Lampitt (1), Philippe Guyard (1) and Andrew Hirst (2)

(1) Southampton Oceanography Centre, Empress Dock, Southampton, SO14 3ZH, United Kingdom
(2) Heriot-Watt University, Edinburgh EH14 4AS, United Kingdom

Abstract

This report describes the status to date of work carried out at the Southampton Oceanography Centre as part of the OMEX II-II project concerning the abundance, biomass, taxonomic composition and role of mesozooplankton in the OMEX II-II area. Preliminary results of size distribution, taxonomic composition and abundance of mesozooplankton are given; progress regarding the measurement of weight-specific growth and herbivorous grazing are detailed. The main points from a new global model, to be applied to the OMEX II-II data subsequently, which may be used to predict growth and production from size distributed biomass are summarised.

Introduction

Mesozooplankton are the dominant trophic link between primary production and fish. They are the principal metazoan grazers in the World's oceans and play an important role with respect to carbon and nutrient cycling, and their loss from the upper mixed layer. The objectives of the SOC deliverables are to quantify the biomass carbon **(Task II.5.5)**, abundance and taxonomic composition of the mesozooplankton, with spatial and seasonal coverage **(Task II.10.1)**. Herbivorous grazing measurements are also to be completed to assess feeding impact, and the growth and production of the mesozooplankton are also to be assessed **(Task II.10.2)**.

Methods

Mesozooplankton samples were collected over 3 cruises: *CD105b* (29/05/97 to 22/06/97; 10 WP2 samples and 6 LHPR samples), *CD110b* (05/01/98 to 19/01/98; 5 WP2 samples) and *Belgica BG9815* (27/06/98 to 06/07/98; 7 WP2 samples). Details of collection dates and locations are given in Table 1. Two quantitative sampling methods were used:

1) WP2 nets, for discrete, high resolution sampling. Vertical tows were taken over the top 200 m of the water column (in waters shallower than 200 m, collection was restricted to ~90% of water column depth). Samples were immediately preserved in 5% borax-buffered formaldehyde sea water and upon return to the laboratory screened through a 2 mm mesh to remove macrozooplankton.
2) Longhurst-Hardy Plankton Recorder system (LHPR): these allow a larger scale view of zooplankton composition and abundance, without however the resolution of WP2 depth-integrated sampling. Samples were immediately preserved in 5% borax-buffered formaldehyde sea water, and upon return to the UK allotted into their collection depths and sorted and identified under a binocular microscope.

For cruises *CD105b* and *CD110b*, taxonomic analysis was done on the whole sample for non-copepod taxa, and 100 copepods were identified down to species level when possible. Because of time constraints, for *Belgica BG9815* samples subsampling was done as appropriate using a Stempel pipette and identification was done as in Table 2.

Size measurements were taken using a calibrated eyepiece micrometre; for copepods, prosome length was taken from the anterior end of the cephalosome to the posterior lateral edge of the metasome segment 5. 100 individuals were measured from each sample. To date these measurements are complete bar one sample. Length values are to be converted to biomass carbon using length-weight relationships compiled from the literature. This procedure is currently under way.

The protocol and experimental design for the herbivorous grazing experiments were decided upon in collaboration with Tromsø (UITØ-b). Live copepods were collected on cruise *CD114b* over the top 200 m of the water column using a 20-l cod-end net, whilst following a water mass drogue, in an offshore filament. Animals were anaesthetised, size fractionated and filtered on GF/C filters, then frozen at -20°C in the dark. Gut content is then analysed in the laboratory for chlorophyll and phæopigments. Laboratory analysis of the samples is under way by the Tromsø group, to include Southampton at a later date.

Egg production experiments to be used to determine weight-specific growth were to be conducted on *CD110b* but this work was severely disrupted as a result of the bad weather. Experiments were however carried out on *CD114b*. Live animals were collected using a drifting net deployed to 10 m. Live adult females were then selected and incubated for 24 hrs at 13°C in 64 µm-filtered sea water. The working up of these samples is still in progress and final results are not available at this time.

Results

II.5.5 Carbon biomass

The size distribution histograms of mesozooplankton collected during cruises *CD105b*, *CD110b* and *Belgica BG9815* are displayed in Figure 1. They show typical copepod-dominated distributions, strongly skewed to the left; only small variations in pattern and magnitude of size distribution can be distinguished between cruises: average size is *ca.* 630-640 µm, with a strong mode around 750-800 µm in all three cruises. There is of course more intra-cruise variation between samples (not shown here). The final result, carbon biomass, will however depend strongly on the contribution of each species to the size distributions, and the length-weight relationships chosen.

II.10.1 Zooplankton distribution and seasonality

The results of the taxonomic analysis are displayed in Table 3 (breakdown of copepod abundance is not shown here). There is a marked decrease in overall abundance between the first cruise (*CD105b*, average abundance 964 ind.m^{-3}) and the 1998 cruises (*CD110b* and *Belgica BG9815*, 216 and 324 ind.m^{-3} respectively). However preliminary analyses do not show marked differences in taxonomic composition, as shown in Figure 2: no clear clusters appear according to cruises; however these results have only just been completed and should be considered as a preliminary analysis only.

II.10.2 Zooplankton grazing, exudation and faecal export

We have been working on the development of empirical models that will enable us to predict the growth and production of mesozooplankton within the OMEX area from the measurements made (i.e. from size distributed biomass and in situ temperature). First a new global model of copepod growth was formulated (Hirst AG, Lampitt RS, 1998: ‘Towards a global model of in situ weight-specific growth in marine planktonic copepods', *Marine Biology*, 132:247-257). For this, ~1000 measurements of copepod growth were collected from tropical to polar, and estuarine to oligotrophic open ocean environments using specific criteria to ensure the data included were comparable and sympathetic to natural conditions in order to arrive at quasi-in situ estimates of growth. Runge and Roff's (in press) review of zooplankton growth methods states 'The Hirst-Lampitt equations therefore provide the best representation to all available data… [and] have obvious applications, for example in the spatial mapping of secondary production'. Preliminary analysis suggest that on >95% of occasions growth predictions using the Hirst-Lampitt equations are within a factor of 5 of measured values, and on 40% of occasions within a factor of 2.

More recently we have extended this to encompass all marine planktonic metazoans, as although copepods typically comprise 80% of mesozooplankton biomass, other groups can be important at other times in the year. Syntheses of growth in other marine zooplanktonic taxa including crustaceans, chaetognaths, ctenophores, cnidarians, larvaceans and thaliaceans have been undertaken to varying extents in the past (e.g. Banse and Mosher, 1980; Banse, 1982; Alldredge, 1984; Ikeda et al., 1985; Madin and Deibel, 1998). However, many of these previous studies only addressed very limited taxonomic groups; or made no attempt to explore the roles of temperature and body size; or are now incomplete, as more data has been published. In this investigation our aims were: 1. Extract and synthesise information from the published literature on rates of weight-specific growth of epi-pelagic invertebrate zooplankton; 2. Examine inter- and intra-specific patterns in growth with respect to temperature and body weight (as carbon) and; 3. Examine the possible causes and implications of these patterns. To this aim we have been synthesising and developing our ideas further based upon larger data sets and more taxa. This work is still in progress, and we hope to submit this soon to Advances in Marine Biology (Hirst AG, Roff J, Lampitt RS: 'A synthesis of growth in marine planktonic metazoans'. (In prep.)).

II.11.2 Seasonal vertical fluxes from biogeochemical & morphometric analyses of suspended and sediment trap material

Our role to aid IfM in understanding vertical fluxes of faecal pellets will follow later in the project once appropriate results are available both from our group and from the other appropriate partners.

Conclusions

With the exception of the egg production work, which was severely hampered by bad weather on *CD114b*, work is progressing well and on target. For most sections the working up of samples is near complete and detailed analysis can start; we have now a coherent data set which can adequately answer the questions raised in the OMEX II-II framework: In particular, the development of the zooplankton growth model will give us an unprecedented view of the dynamics and impact of zooplankton at larger time and space scales.

Cruise	Station	Lat	Long	Date	Collection Device	Integrated Depth	Abundance Determined	Size distribution
CD105b	**CD007**	43º00.9N	09º23.5W	11/06/97	WP2	110	yes	yes
	N700	43º00.0N	09º38.6W	11/06/97		200	yes	yes
	N2300	42º59.9N	09º49.8W	12/06/97		200	yes	yes
	N3300	42º59.9N	10º17.3W	12/06/97		200	yes	yes
	O200	42º50.0N	09º23.7W	13/06/97		120	yes	yes
	"NO NAME"	41º58.2N	10º08.8W	14/06/97		200	yes	yes
	Q2500	42º29.8N	10º00.8W	14/06/97		200	yes	yes
	V2600	41º24.8N	09º40.1W	15/06/97		200	yes	yes
	T200	42º00.0N	09º17.4W	17/06/97		150	yes	yes
	Q100	42º29.6N	09º13.4W	20/06/97		110	yes	yes
CD105b	Start	43.000ºN	09.655ºW	11/06/97	LHPR	-	no	no
	end	42.999ºN	09.565ºW	11/06/97		-	no	no
	Start	42.99ºN	10.279ºW	12/06/97		-	no	no
	end	42.932ºN	10.285ºW	12/06/97		-	no	no
	Start	41.978ºN	19.154ºW	14/06/97		-	no	no
	end	41.946ºN	10.156ºW	14/06/97		-	no	no
	Start	41.425ºN	09.715ºW	14/06/97		-	no	no
	end	41.429ºN	09.686ºW	15/06/97		-	no	no
	Start	41.997ºN	09.375ºW	17/06/97		-	no	no
	end	41.995ºN	09.348ºW	17/06/97		-	no	no
	Start	42.154ºN	09.229ºW	17/06/97		-	no	no
	end	42.164ºN	09.257ºW	17/06/97		-	no	no
CD110b	**O3100**	42º50.19N	10º17.02W	8/01/98	WP2	200	yes	yes
	T1000	42º00.18N	09º27.94W	9/01/98		200	yes	yes
	V110	41º25.40N	09º05.81W	10/01/98		90	yes	yes
	P200	42º40.10N	09º29.28W	14/01/98		165	yes	yes
	P1000	42º40.18N	09º36.11W	15/01/98		120	yes	yes
Belgica 98/15	**S02**			28/06/98	WP2	140	yes	yes
	P20			30/06/98		120	yes	yes
	P23			1/07/98		200	yes	yes
	N36			3/07/98		200	yes	yes
	N36			3/07/98		200	yes	yes
	N38			4/07/98		200	yes	yes
	N38			4/07/98		200	yes	yes
	P26			5/07/98		200	yes	yes
	N35			6/07/98		200	yes	yes

Table 1: Samples collected and status regarding taxonomic and size analyses

CD105b	*CD110b*	*Belgica BG9815*
min: 117.5 µm	min: 97.9 µm	min: 195.8 µm
max: 2.59 mm	max: 2.94 mm	max: 2.41 mm
average: 630.3 µm	average: 641.5 µm	average: 644.8 µm
Std error: 13.61	Std error: 25.33	Std error: 47.03

Table 2: Sumary statistics for mesozooplankton size frequency data of cruises *CD105b*, *CD110b* and *Belgica BG9815*.

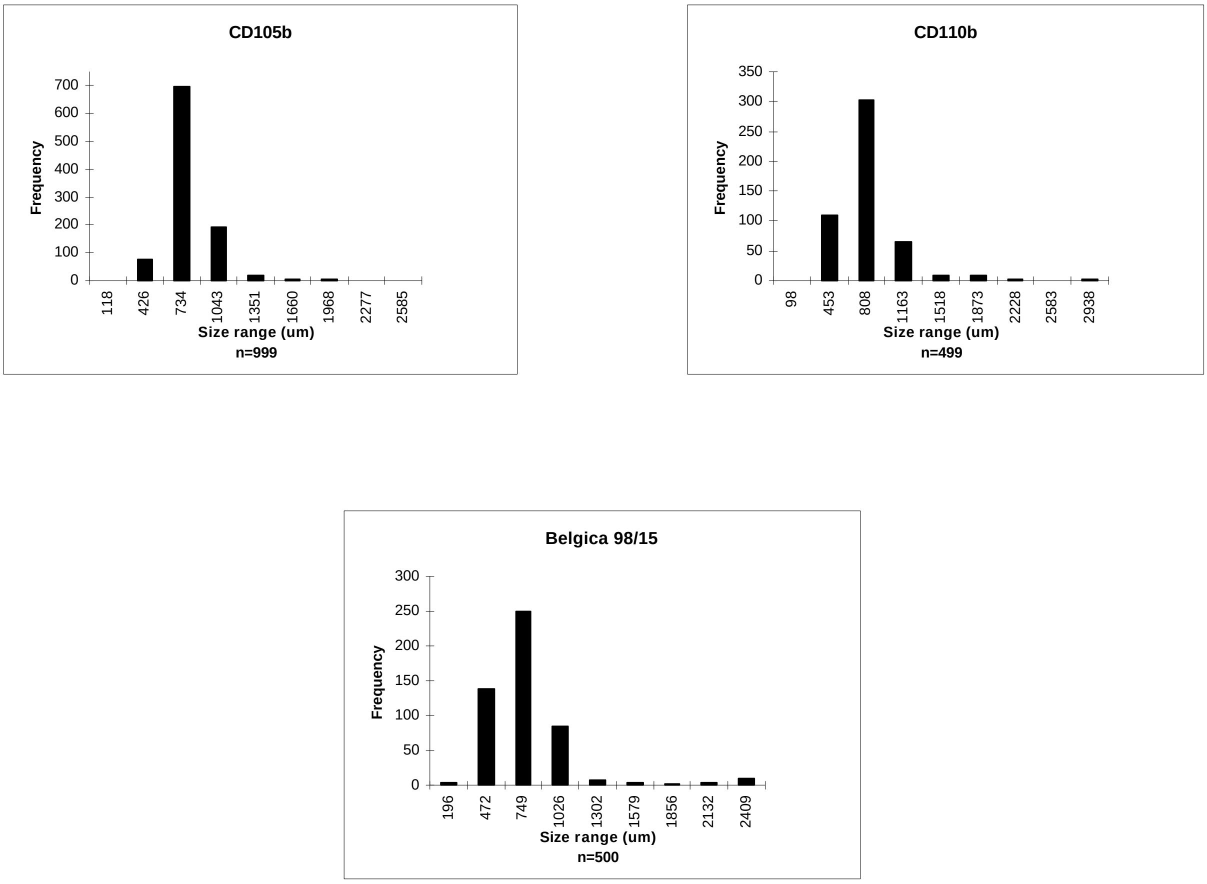

Figure 1: Size distribution histograms for mesozooplankton collected on cruises *CD105b*, *CD110b* and *Belgica BG9815*.

Integrated depth:	110	200	200	200	120	200	200	200	160	150	200	110	200	200	90	165	200	140	120	200	200	200	200
Station	CD007	N700	N3300	N2300	O200	Nname	Q2500	V2600	S200	T200	S500	Q100	O3100	T1000	V110	P200	P1000	SO2	P20	P23	N38	P26	N35bis
Cruise:	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD105b	CD110b	CD110b	CD110b	CD110b	CD110b	Belgica 98/15	Belgica 98/15	Belgica 98/15	Belgica 98/15	Belgica 98/15	Belgica 98/15
LAT:	43 00.9N	43 00.0N	42 59.9N	42 59.9N	42 50.0N	41 58.2N	42 29.8N	41 24.8N	42 08.8N	42 00.0N	42 09.7N	42 29.6N	42 50.19N	42 00.18N	41 25.40N	42 40.10N	42 40.18N	42 09.01N	42 40.10N	42 40.01N	43 00.10N	42 38.33N	43 00.04N
LONG:	09 23.5W	09 38.6W	10 17.3W	09 49.8W	09 23.7W	10 08.8W	10 00.8W	09 40.1W	09 19.6W	09 17.4W	09 26.5W	09 13.4W	10 17.02W	09 27.94W	09 05.81W	09 29.28W	09 36.11W	09 08.17W	09 21.58W	09 42.42W	10 18.36W	10 17.26W	09 38.55W
Date:	11/06/97	11/06/97	12/06/97	12/06/97	13/06/97	14/06/97	14/06/97	15/06/97	17/06/97	17/06/97	19/06/97	20/06/97	08/01/98	09/01/98	10/01/98	14/01/98	15/01/98	28/06/98	30/06/98	01/07/98	04/07/98	05/07/98	05/07/98
Barnacle cypris												7.13							2.09				
Chaetognath	14.25														4.35				2.61				
Cladocerans (Evadne)			1.96	3.92			15.68					3.56											
Cladocerans (Podon)	10.69					1.96			2.45			3.56											
Coelenterate planula larvae					3.27																		
Copepod eggs				19.59								3.56								0.31			2.51
Copepod nauplii		17.63	5.88	3.92		3.92	7.84	1.96	4.90										0.52			0.63	0.94
Copepods	2305.01	593.71	807.29	662.29	623.75	421.28	1397.08	427.16	1249.14	577.38	323.31	1506.98	84.26	193.98	474.62	114.00	148.92	503.57	470.26	315.39	110.71	253.94	189.05
Cyphonautes larvae	7.13																						
Decapod larvae	21.38				6.53							7.13			21.77	11.88	1.96		0.52				
Doliolids												21.38											
Echinoderm larvae										7.84		10.69											
Euphausiid					3.27													0.28	3.66				
Euphausiid nauplii	17.81				22.86		5.88	1.96	14.70	7.84		3.56						15.40	44.94	0.63	0.39	1.72	6.27
Fish egg	7.13	7.84	1.96															0.28					0.31
Foraminifera	3.56						1.96								4.35	2.38	3.92						
Lamellibranch													1.96										
Larvaceans	14.25	23.51	9.80	35.27	42.45	1.96	5.88	3.92	7.35		5.88	24.94	1.96					3.64	2.09	0.63	0.98		1.25
Ostracod																	1.96				0.20		0.31
Polychaete				1.96						2.61		3.56			4.35	2.38							
Siphonophores	28.50				26.13					13.06	3.92	92.63				2.38							
Thecosome	7.13																						
Gastropod Larvae																		0.28	2.61	0.31			3.14
Amphipoda																		0.28			0.20	0.31	
Bivalve larvae																		0.28				0.16	
hydrozoa																						1.57	

Table 3: Results of the taxonomic analyses completed to date (n.m^{-3}); breakdown of copepod abundances not included.

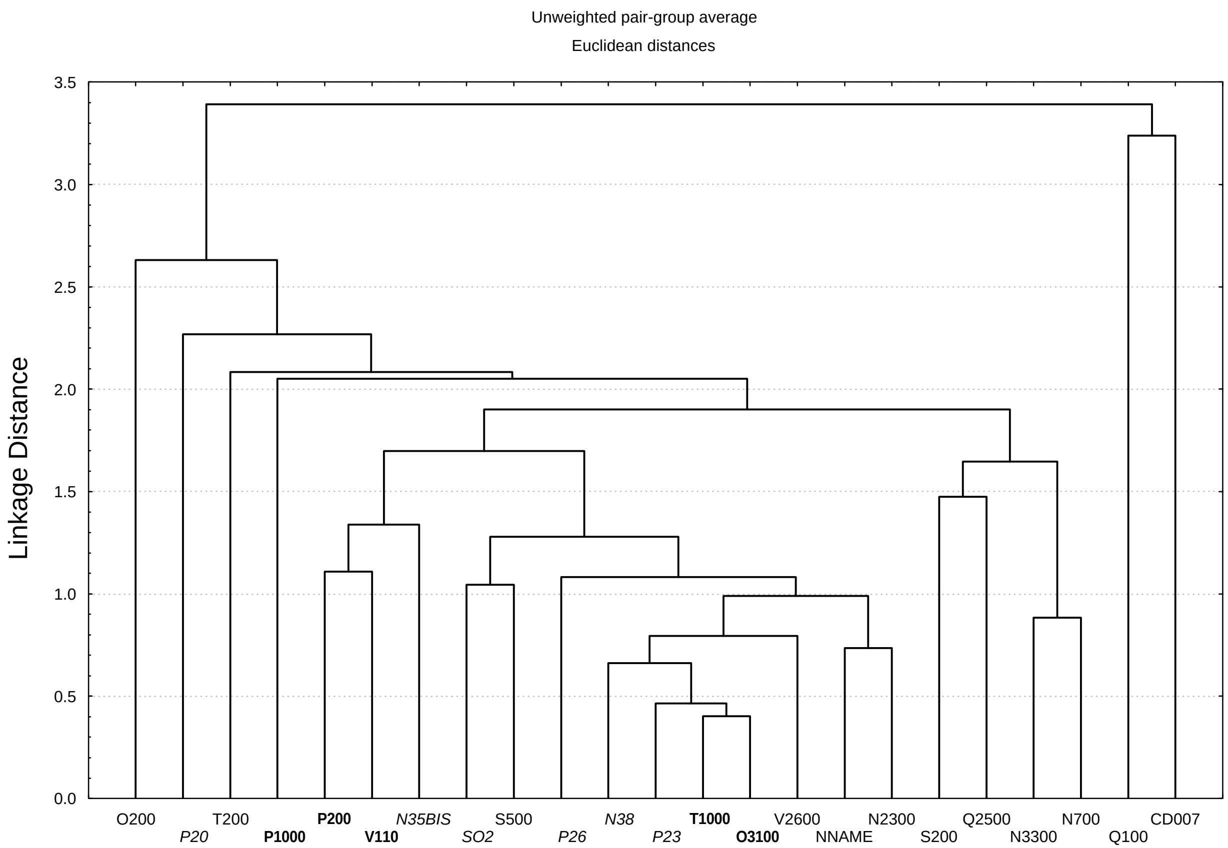

Figure 2: Cluster Analysis (unweighted pair-group average, eucledian distance) on log(x+1) abundance data for *CD110b* (**bold**), *CD105b* (*italics*) and *Belgica BG9815* (normal).