Plankton distributions and mesozooplankton carnivory at the Iberian margin

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INTRODUCTION

The Continuous Plankton Recorder (CPR) survey is operated by SAHFOS and deploys a monthly tow along the Iberian margin. In addition to collecting plankton samples the CPR is instrumented with sensors to record temperature, salinity and chlorophyll (as fluorescence). With almost 18 months of data completely analysed it is now possible to make preliminary comparisons between the OMEX project samples and historic samples collected over the last 30 years, to describe plankton abundance and distribution.

A second focus in the second year has been the study of mesozooplankton carnivory since it is thought that microzooplankton may make a significant, usually underestimated, contribution to the diet of mesozooplankton. In order to quantify this contribution experiments were carried out during cruise *CD114* Leg b with the aim of estimating the copepod community grazing pressure. This Lagrangian experiment presented the opportunity to make these measurements in conjunction with primary productivity and microzooplankton and mesozooplankton herbivory processes measured by other OMEX partners at the same time, and in the same body of water. During each experiment replicates of single copepod species or size were incubated so that an allometric relationship between grazing rate and copepod size could be constructed. From this relationship and from measured copepod abundances the community grazing pressure could be calculated. Preliminary estimates are shown here, but may be refined as further data become available.

METHODS

Tasks I.4 (g), II.1.5, II.8.1, II.10.1, and II.11.2. CPR data. An instrumented CPR route was restarted in May 1997 to collect samples south of 44°N along the length of the Iberian margin, both on and off shelf. Samples are analysed for phytoplankton colour, phytoplankton taxa relative abundance and zooplankton taxa abundance as described in previous reports.

Task I.4 (i). Mesozooplankton carnivory. During cruise *CD114* Leg b experiments were carried out to determine the grazing pressure on microzooplankton by the mesozooplankton, with the aim of estimating the copepod community grazing pressure. Six experiments were carried out on successive days. Experiments one to five took place during the second leg drift experiment (15th to the 19th August) with experiment six taking place in waters closer to the shelf (19th August). Figure 1 shows the location. Copepods were collected with a WP2 net with a solid cod end, hauled vertically at slow speed to reduce damage. The copepods were anaesthetised with carbonated seawater, sorted under a binocular microscope and undamaged, active adult or sub-adult individuals transferred to 2-l acclimation jars. Approximately five *Calanus* sized copepods, or 20-30

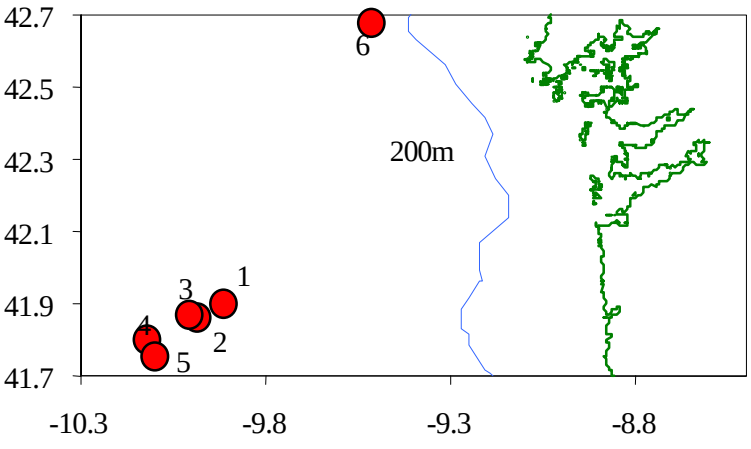


Figure 1. Location of experiments during *CD114*

Parapseudocalanus sized, were introduced to each bottle and, where possible, triplicate bottles of a particular species (*e.g.*, *Calanus tenuicornis* or *Acartia clausi)* or size category (*e.g.*, the *Parapseudocalanus* species group) were set up. These jars contained unfiltered surface seawater as a food source and were incubated in a flow through, on-deck incubator, screened to represent 10-m depth light intensity for 18 hours. Experimental water was collected from 10-m depth with a GoFlo and passed through a 200-μm mesh, to exclude copepods, into 1-l experimental bottles. Aliquots were preserved or filtered for T_0 measurements and then the acclimated copepods transferred to the experimental jars. Three jars were set up with just experimental water and no copepods, as controls, and all controls and experimental bottles were placed in the incubator for 24 hours and manually rotated every 4 hours. At the end of the experiment the copepods were removed and T_{24} water samples were filtered or preserved from each bottle; 100 ml was filtered for fluorometric determination of chlorophyll and 200 ml was preserved in acidified Lugol's solution for subsequent microscopic analysis of microzooplankton. The copepods were checked for mortality (which proved to be negligible) and preserved in formaldehyde solution. In the laboratory the copepods from each bottle were counted, identification checked and their metasome length measured. Aliquots of the Lugol's preserved water were settled and the microzooplankton identified into broad taxonomic or size categories and enumerated. Clearance rates were calculated from the changes in cell densities from initial concentrations to those in the 24-hour incubations, incorporating a growth factor from the control incubations with no copepods, according to Frost (1972). Biomass values were calculated by converting the cell measurements and counts to biomass using PML-b's measurements of Leg 2 microzooplankton. Ingestion rates were then calculated from clearance rates and biomass.
Since both large and small copepods were incubated in each experiment it was possible to construct a relationship between copepod size and ingestion, and from this relationship together with quantitative copepod abundances from UITØ-b, to calculate the community grazing pressure.

Tasks I.4 (h), Task II.5.5 and II.10.2. Mesozooplankton biomass and grazing. Length and dry weight measurements have been made on individuals of key species collected on cruises in the area according to the methodology described in OMEX I. CPR abundance data collected during the project will be converted to biomass and from this estimates will be made of mesozooplankton rate processes to compare with the experimentally derived grazing and respiration rates. This work will be completed in year 3.

RESULTS

As at May 1999 21 successful CPR tows have been undertaken, with approximately 30 samples on each. Plankton abundances have been determined for all samples collected in 1997 and 1998. The tows were instrumented to record temperature, conductivity and fluorescence and all data, both biological and physical, collected during 1997 and up to July 1998 have been banked at BODC. The remainder of the 1998 data will be delivered imminently once quality control procedures are complete.

Task 1.4 (i) Mesozooplankton carnivory. Initial chlorophyll determinations showed that chlorophyll levels were very low in the drift experiment (Leg b, *CD114*), typically 0.2-0.3 μg Chl l^{-1} and were approximately an order of magnitude higher in experiment six. Initial ciliate and heterotrophic dinoflagellate biomass were determined and showed little variation between the experiments, typically 1.5 μg C l^{-1} for ciliates and 0.4 μg C l^{-1} for the dinoflagellates.
The figure below (Fig. 2) shows the relationship between copepod size and ingestion of microzooplankton for each experiment. This relationship does differ between experiments, which may be caused by differing food concentrations and which will be examined further, however in order to initially estimate community grazing all of the experiments have been combined (Fig. 3). These relationships were applied to the copepod abundances measured by UITØ-b, by assigning a size per copepod group, calculating the relevant rate from the line of best fit shown in Fig. 3 and multiplying the rate by the group's abundance. The resulting summed rates are shown in Fig. 4.

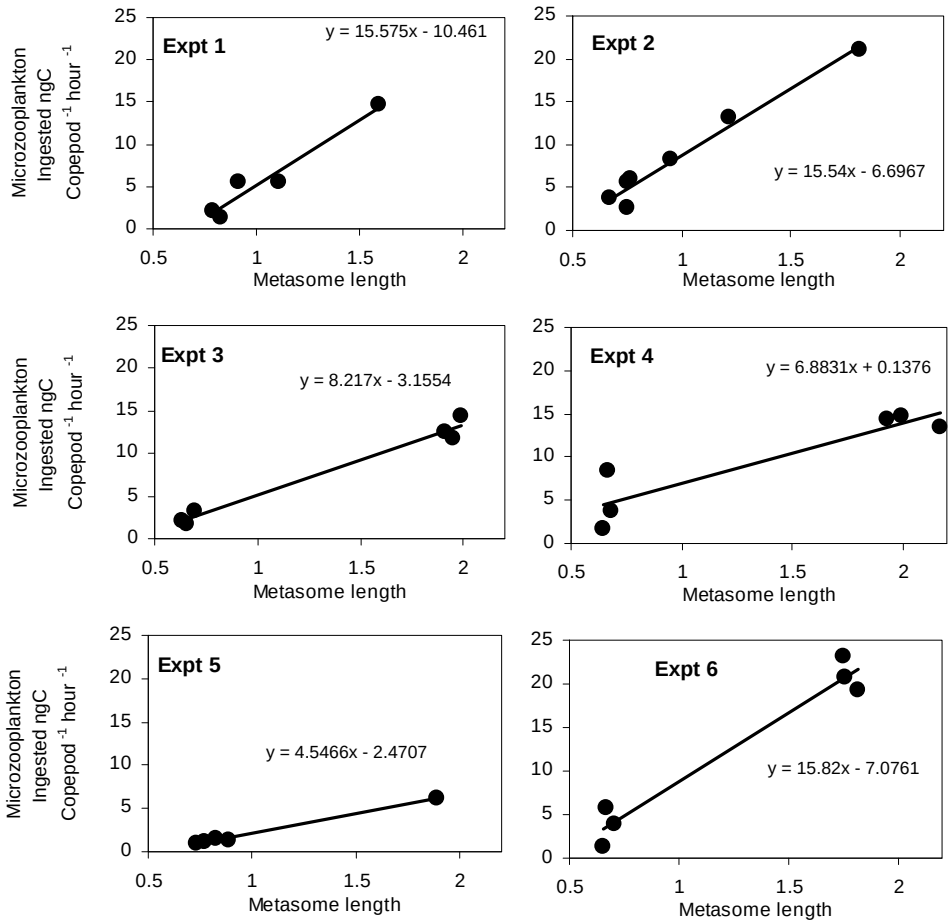


Figure 2. Ingestion rates for calanoid copepods, for each experiment.

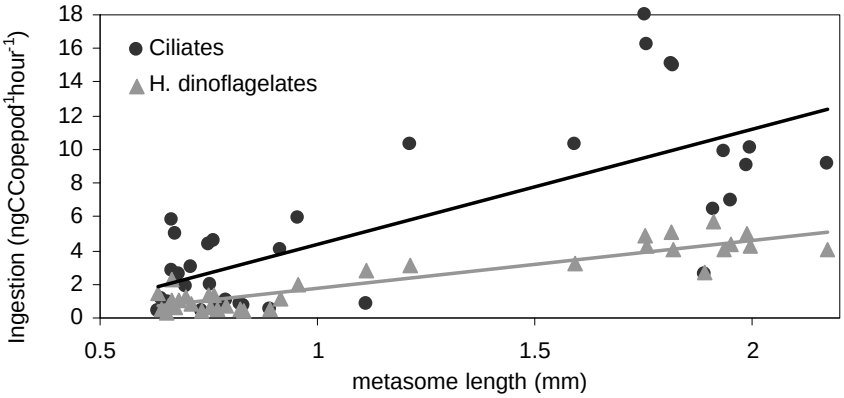


Figure 3. Combined ingestion rates

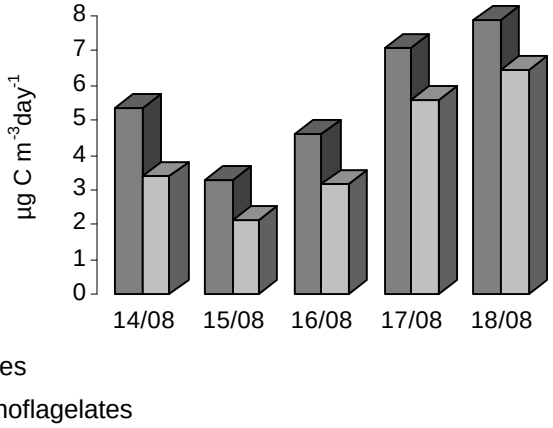
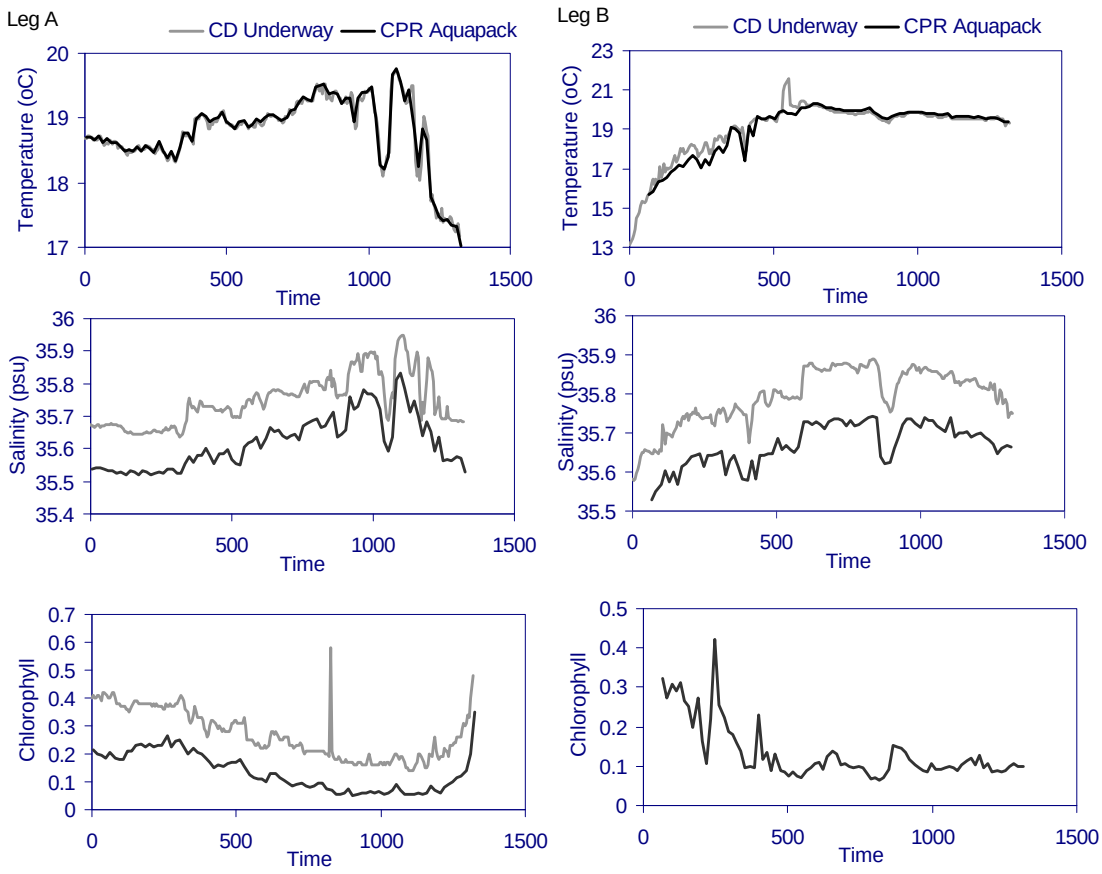


Figure 4. Copepod community ingestion per day.

These results suggest that the copepod community consumed a very small percentage of the initial standing stocks of microzooplankton, *e.g.*, 1.5% of the heterotrophic dinoflagellates. However, copepod numbers were found to be very low on this cruise and further work will be carried out to put these results into context. Further investigations will be carried out on these data, for example the nanoplankton have also been enumerated and their role in micro and mesozooplankton grazing has yet to be evaluated. Inter-specific differences in grazing rates and whether or not these rates are determined by food concentration will also be examined.

Task II.1.5 Sourcing Currents. The opportunity arose on cruise *CD114* in August 1998 to tow a CPR and thus compare its instrumentation with that collected by the ship's underway sensors. The plots below (Fig. 5) show this comparison for two, day long periods, within the first and second legs. There was a problem with fouling of the ship's sensors during Leg b, however despite some small differences in the absolute values of the parameters the patterns of change are virtually identical. At the end of the sampling period there will be a 30-month record of these variables, which will provide valuable supplementary information for understanding plankton distributions.

Figure 5. A comparison between the *Charles Darwin* underway measurements and the CPR instrumentation measurements for two sections of *CD114*.



Task II.5.5. Biomass. As detailed above, samples have been collected to allow determination of mesozooplankton biomass which will be completed in the coming months.

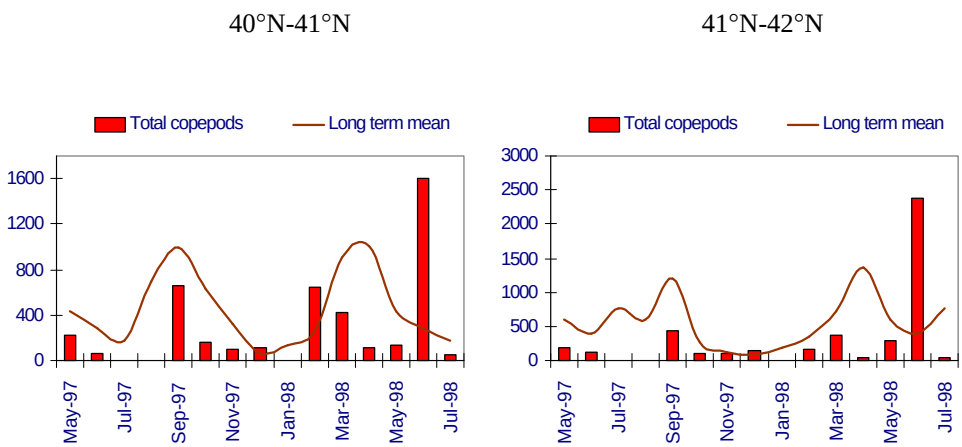
Task II.8.1 Phytoplankton species distributions. The samples collected during OMEX II-II are also being analysed for large phytoplankton abundance. All samples collected in 1997 and 1998 have been analysed and will be used to determine spatial and temporal distribution. Historic data are also available for comparison. This work will be carried out in year three. The table opposite lists the most common taxonomic groups, together with the percentage of samples that they have been found on.

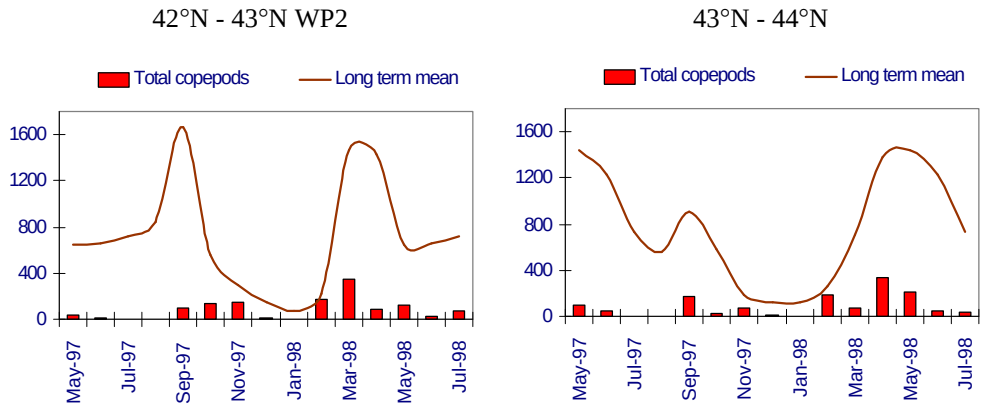
Table 1.

Species	% of samples
Ceratium furca	36.17
Ceratium fusus	33.74
Silicoflagellates	32.22
Thalassiosira spp	26.14
Chaetoceros (Hyalochaete)	24.32
Thalassionema nitschioides	22.49
Ceratium trichoceros	20.97
Ceratium macroceros	20.06
Gonyaulax spp	17.02
Chaetoceros (Phaeoceros)	15.50
Ceratium massiliense	15.20
Nitzschia seriata	14.89
Peridinium spp	14.59
Rhizosolenia alata alata	13.98
Ceratium horridum	11.85
Ceratium candelabrum	10.33
Dactyliosolens mediterraneus	10.03

Task II.10.1 Zooplankton species distributions. CPR samples have been collected off the Spanish and Portuguese coast between 1958 and 1990, although most intensively between 1978 and 1986. Over 1500 samples have been analysed between latitudes 40°N and 44°N. There is little difference in sampling intensity throughout the year and with between 100 and 150 samples per month in the area it is possible to calculate an average seasonal cycle of abundance. Figure 6 shows the mean copepod abundance each month compared with the long-term mean, for 1° of latitude boxes, including the Work Package 2 area of interest. It is noticeable that copepod abundances were much lower in the late summer/autumn of 97 and spring/summer of 98 than is historically recorded in the northern most boxes. It is possible that this is the result of relatively low numbers of samples per tow in each area, however the southern most box does show a similarity between OMEX II-II sampling and the historical mean.

Figure 6. Monthly mean copepod abundances, compared with the 30-year average, for different latitudes.





Task II.10.2 and Task 1.4 (h). Mesozooplankton grazing. This work will be completed in the coming year.

Task II.11.2 Vertical fluxes. Hard-shelled plankton retained in sediment trap material will be compared with the CPR contemporary samples as one aspect of the integration of water column and mooring data. This work will begin once the trap material has been analysed, however, contemporary CPR data are currently being processed, and the figure below (Fig. 6) shows the abundance per sample of tintinnids as an example. This group of hard-shelled ciliates are one of the most frequently recorded taxa on Iberian CPR samples, occurring every month and on over 36% of all the samples.

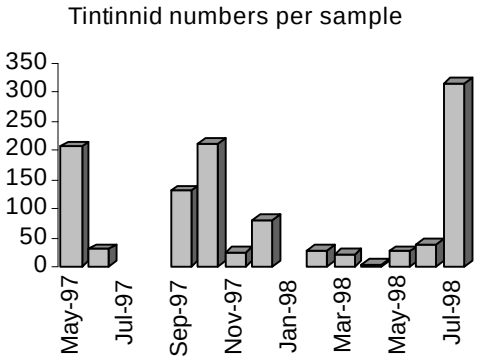


Figure 6. The number of tintinnids per CPR sample.

Future work

Collection and analysis of CPR data, both biological and physical, will continue until month 30. Once these data are complete then full analyses can be undertaken, and comparison with historical data completed. The physical data will be used to help interpret the plankton distributions. Many of the tasks detailed above, for example the comparison with sediment trap material and the estimation of biomass and grazing pressure, are dependent on the species abundance information.

There is much scope for further investigating the mesozooplankton carnivory relationships described above, as already discussed, and this will be explored. Two manuscripts are planned, and will be completed in the coming months, that will combine these data with microzooplankton and mesozooplankton herbivory, allowing a fuller understanding of the trophic interactions and transfer of carbon.

References

Frost, B.W. (1972). Effects of size and concentration of food particles on the feeding behaviour of the marine planktonic copepod *Calanus pacificus. Limnology and Oceanography*. **17**, 805.