Continuous Plankton Recorder measurements at the Iberian Margin

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Abstract
Continuous Plankton Recorder data have been collected from the Iberian margin between 1958 and 1990 and a route has been restarted in May 1997 to collect samples during the OMEX II,II field programme. Initial analyses of the historical data are described together with the proposed methodology that will be employed later in the project. Historical analyses show that the degree of upwelling may influence the mesozooplankton biomass and possibly the type of organisms present. Dominant zooplankton taxa show seasonal variability in their distribution patterns within the Work Package II area of study and seasonal cycles of abundance are described for this, and other areas of the Iberian margin.

Introduction
Both contemporary and historic CPR data will be used in OMEX II,II, the former to compare with the field programme and provide data for Work Packages I,II and IV and the latter to set the contemporary studies of Work Packages I and II in an historic perspective. 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 for large phytoplankton and zooplankton species abundances 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 (Figure 1) it is possible to calculate an average seasonal cycle of abundance for key species or taxonomic groups. Latitudinal variability in the seasonal cycles can also be investigated.
Contemporary CPR tows will collect samples both on and off the shelf at the Iberian margin and will be instrumented to collect data on temperature, salinity and fluorescence which can be used to examine the physical environment of the plankton communities. Undamaged, preserved specimens of mesozooplankton will be collected from OMEX cruises for individual biomass determinations which will be used to convert the CPR sample abundances to biomass and to estimate grazing pressure. An additional contribution (to Work Package I) is the experimental determination of the grazing of microzooplankton by mesozooplankton, a potentially important link in the transfer of production.

Methods

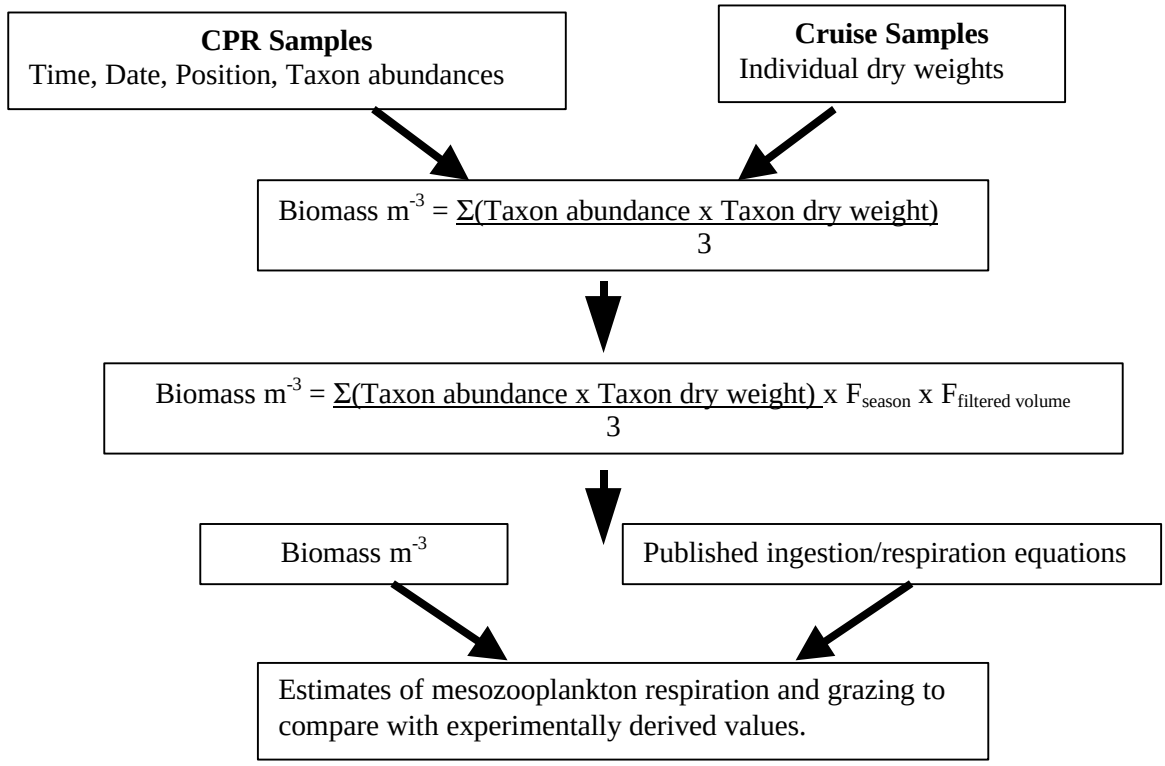
Tasks I.4 (g), II.1.5, II.8.1, II.10.1, **& II.11.2.** An instrumented CPR route was restarted in May 1997 to collect samples south of 44°N along the length of the Iberian margin, both on and off shelf. Owing to changes in the merchant ship schedules between the submission of the proposal and the start of the project the route has altered from that indicated in the proposal. However, the route still collects samples from the shelf, slope and deeper waters within the area so that the deliverables can still be met. Samples are analysed for phytoplankton colour, phytoplankton taxa relative abundance and zooplankton taxa abundance as described in Warner and Hays (1994).

Task I.4 (i). No WPI cruises have yet taken place, therefore, the mesozooplankton grazing of microzooplankton experiments have not been started. However, discussion meetings with OMEX partners have taken place and the experimental protocol has been determined:

1. Determine dominant copepod species from CPR records and WPII hauls .
2. Slow, vertical haul (WPII with a solid cod end) to catch zooplankton
3. Sort undamaged actively swimming copepods. Allow to acclimatize for 18 hours in the dark at constant temp.
4. Collect incubation water from surface just prior to experiment
5. Transfer to grazing jars and add acclimatized copepods (2 size fractions, species selected according to dominance) also controls with no copepods.

6. Take 2 x 200 ml aliquot and preserve in Lugols (T0). Top up jars.
7. Incubate, including controls, for 24 hours (to include diel feeding rhythms) on deck with flow-through water, rotating every 4 hours.
8. Take 2 x 200 ml aliquots and preserve in Lugols. (T24)
9. Filter and preserve copepods.
10. On return, determine biomass of copepods and count microzooplankton T0 and T24 samples. This will be done in conjunction with PMLb.

Tasks I.4 (h), Task II.5.5 & II.10.2. 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 1. CPR abundance data 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. The methodology will be as follows:



Results

As at the end of April 1998 ten successful CPR tows have been undertaken, with approximately 30 samples on each. Plankton abundances have been determined for all samples collected in 1997. The tows were instrumented to record temperature, conductivity and fluorescence and all data, both biological and physical, collected during 1997 have been banked at BODC by the end of the first year. First comparisons of the plankton data with the historical data will be carried out once the first year's samples have been analysed.

Task 1.4 (i). No WPI cruises have yet taken place, therefore, there are no results yet on the mesozooplankton grazing of microzooplankton.

Task II.1.5

Physical data from the instrumented CPR tows have been banked with BODC and are shown graphically in Figure 2. These data are from approximately 7m depth and are collected every 15 minutes. The September samples show the greatest variability with temperature structure clearly evident. Peaks in chlorophyll coincide with areas of lower temperature. Chlorophyll rises sharply as the ship approaches the port of Leixões and salinity declines.

Task II.5.5
As detailed above, samples have been collected to allow determination of mesozooplankton biomass.

Task II.8.1
The samples collected during OMEX II,II are also being analysed for large phytoplankton abundance. All samples collected in 1997 have been analysed and will be used to determine their spatial and temporal distribution. Historic data are also available for comparison. This work will be carried out in year 3.

Task II.10.1
Analysis of historic CPR samples

Figure 1 shows the location of the midpoint of each historic CPR sample and the distribution of the samples through time. 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 for key species or taxonomic groups. Latitudinal variability in the seasonal cycles has also been investigated and Figure 3 shows the cycles of copepod abundance and phytoplankton colour for the entire margin and for 1° latitudinal boxes. It can be seen that highest levels of phytoplankton colour are found in the southern-most boxes but the highest copepod abundances occur in the north. The WP2 box has the highest copepod abundances of the whole margin, with a particularly strong autumn peak. The seasonal cycle of phytoplankton colour shows a spring peak in the WP2 box in March, a second in June and a gradual decline through summer and autumn. It is possible that this bimodal spring peak is an artefact of combining 30 years of data, for example there may be years where upwelling is late, or not intense, and the spring bloom is delayed. Further investigations will be carried out to see if this is a realistic interpretation of the phytoplankton seasonal pattern.
The data can be used to show the distribution of the plankton from the shelf to deeper waters in the WP2 box and how this may change seasonally. Five key taxa were selected; total copepods, *Acartia* spp. and the *Para-Pseudocalanus* spp. group as examples of the most dominant small copepods, *Calanus helgolandicus* which is the most dominant large copepod and Euphausiids, the most dominant non-copepod group. Abundances were averaged for bands of longitude representing the transition from shelf to slope within the WP2 box for each of the four seasons and are shown in Figure 4. During spring the abundance of copepods appeared fairly constant across the shelf edge, however the individual groups do show differences. *C. helgolandicus* was more abundant on the shelf whilst the *Para-pseudocalanus* group had highest spring abundances at the shelf break. Within group differences occurred throughout the year, for example, during autumn *Acartia* spp. was most common on the shelf whilst during summer its abundance peak occurred at the shelf break and in spring both shelf and deeper waters had highest numbers. Such differential distributions have important consequences for the transfer of production, and will be discussed further, later in the project, when biomass values are available.

Relationships between Copepods and Upwelling.
The Iberian margin is an area of seasonal upwelling, and it is probable that the extent of upwelling each year may affect the mesozooplankton biomass present in that year. A time series of an upwelling index exists from 1966 (Lavin *et al.*, 1991), offering an opportunity to test this hypothesis against the CPR time series of copepod abundances. The upwelling season typically runs from April to September, therefore, mean abundances were calculated for this period for each year. Monthly means were first calculated, then a mean of these means (if any months were not sampled then abundances were interpolated before calculating the mean) to avoid introducing any seasonal bias through lack of sampling. Figure 5 shows the two time series plotted against each other. A linear regression of copepod abundance on upwelling showed a significant relationship ($p > 0.05$) supporting the hypothesis that the greater the strength of the upwelling the greater the numbers (and probably, therefore, biomass) of copepods. Given that the abundance of copepods shows a relationship with upwelling it can also be hypothesised that the species composition of the copepod community may be

affected. To test this, a multivariate analysis was carried out on the mean annual (from April to September) copepod species community using MDS (Multi-Dimensional Scaling). Figure 6 shows the resulting plot, whereby years that are most similar in their community composition appear closest together. Although there is not always a difference between years when upwelling was low or high (eg 1966 and 1969) the low upwelling years form a cluster, and therefore have similar community compositions. High upwelling years have a much more variable species composition, sometimes similar to low years, sometimes to high years. No temporal trend is obvious.

Task II.10.2 & Task 1.4 (h)

The CPR historical data has been examined and all taxa occurring on at least 5% of the samples extracted. This list comprises 28 taxonomic groups and the number of individuals within these groups amounts to 95.11% of the total number of individuals caught by the CPR between 1958 and 1990. These taxa will, therefore, be sufficient to accurately estimate the biomass on each CPR sample. Cruise samples for individual biomass determination have been obtained from three cruises so far, in June 1997, January 1998 and March 1998. As yet, only June 1997 samples have been worked through, however, 22 of the 28 taxa were present in the samples and length/weight measurements have been obtained. These and further cruise samples will allow a seasonal factor to be included in the biomass estimation (F_{season}). The true filtered volume of the sample will be determined according to information from electro-magnetic flowmetres that have been fitted to CPRs, allowing $F_{filtered\ volume}$ to be applied. The average filtered volume of a CPR sample is $3m^3$.

Task II.11.2

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.

Summary

The contemporary sampling has begun successfully, with biological and physical data already available. The initial historical analyses have been completed, although further investigations will doubtless take place as the project progresses. It is apparent that the degree of upwelling may influence the mesozooplankton biomass and probably the type of organisms present. Close liaisons have taken place with the microzooplankton group (PMLb) to determine the grazing experimental protocols and maximise integration of results. The first experiments will be carried out (assuming cruise schedule is as intended) on *Charles Darwin* in August 1998.

References

Lavin, A., Diaz del Rio, G., Canamas, J.M. and Casas, G. (1991) Afloramiento en el noroeste de la peninsula Iberica. Indices de afloramiento para el punto 43°N 11°W periodo 1966-1989. *Informes Tecnicos Instituto Espanol de Oceanografia.*

Warner, A.J. and Hays, G.C. (1994). Sampling by the Continuous Plankton Recorder survey. *Progress in Oceanography*. **34**, 237-256.

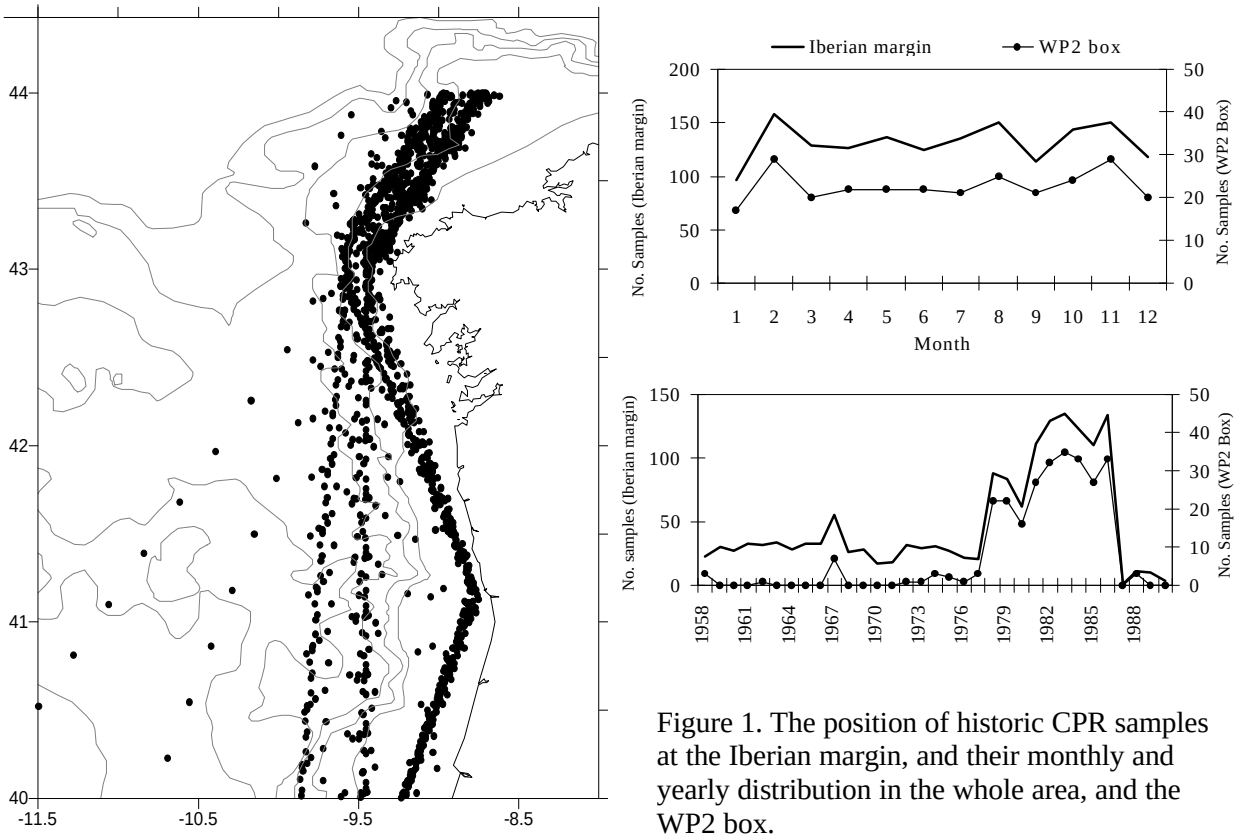


Figure 1. The position of historic CPR samples at the Iberian margin, and their monthly and yearly distribution in the whole area, and the WP2 box.

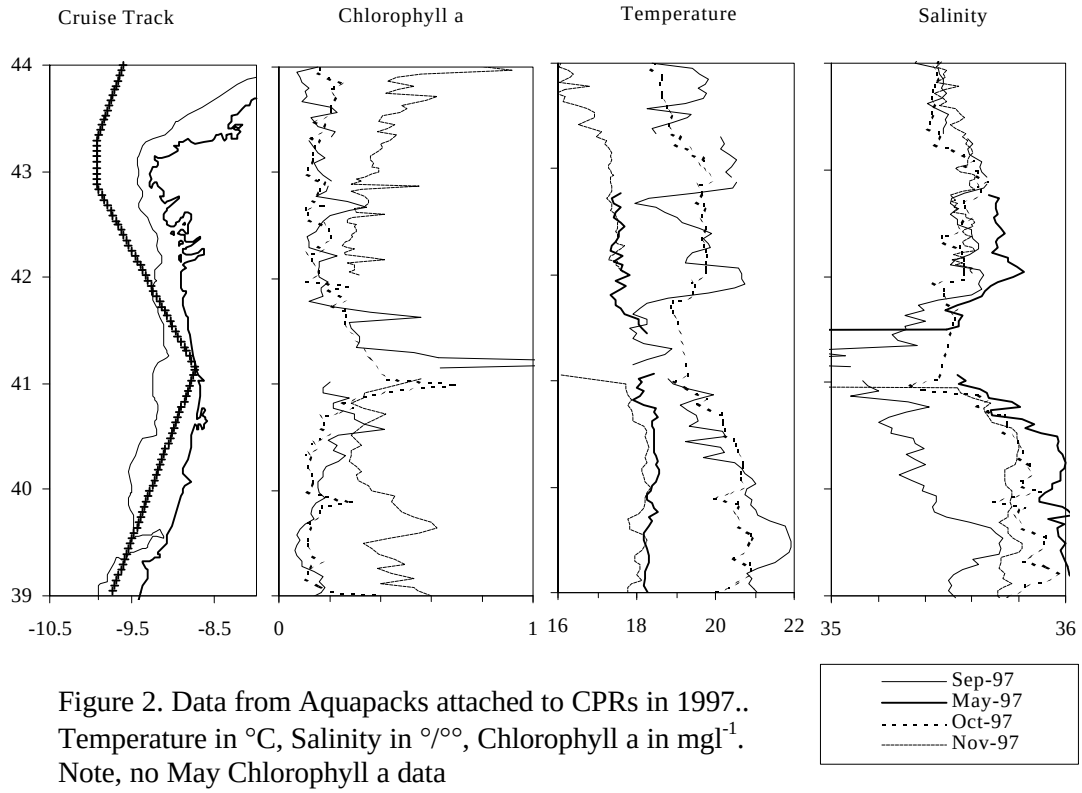


Figure 2. Data from Aquapacks attached to CPRs in 1997.. Temperature in °C, Salinity in °/°°, Chlorophyll a in mgl^{-1}. Note, no May Chlorophyll a data

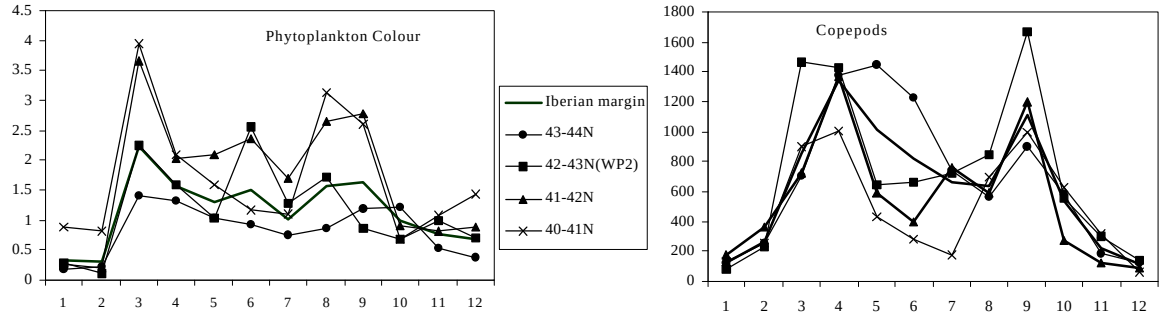


Figure 3. Mean seasonal cycle of phytoplankton colour and copepod abundance (numbers per sample) for the entire Iberian margin area and 1° latitudinal boxes. The WP2 box covers 42-42°N.

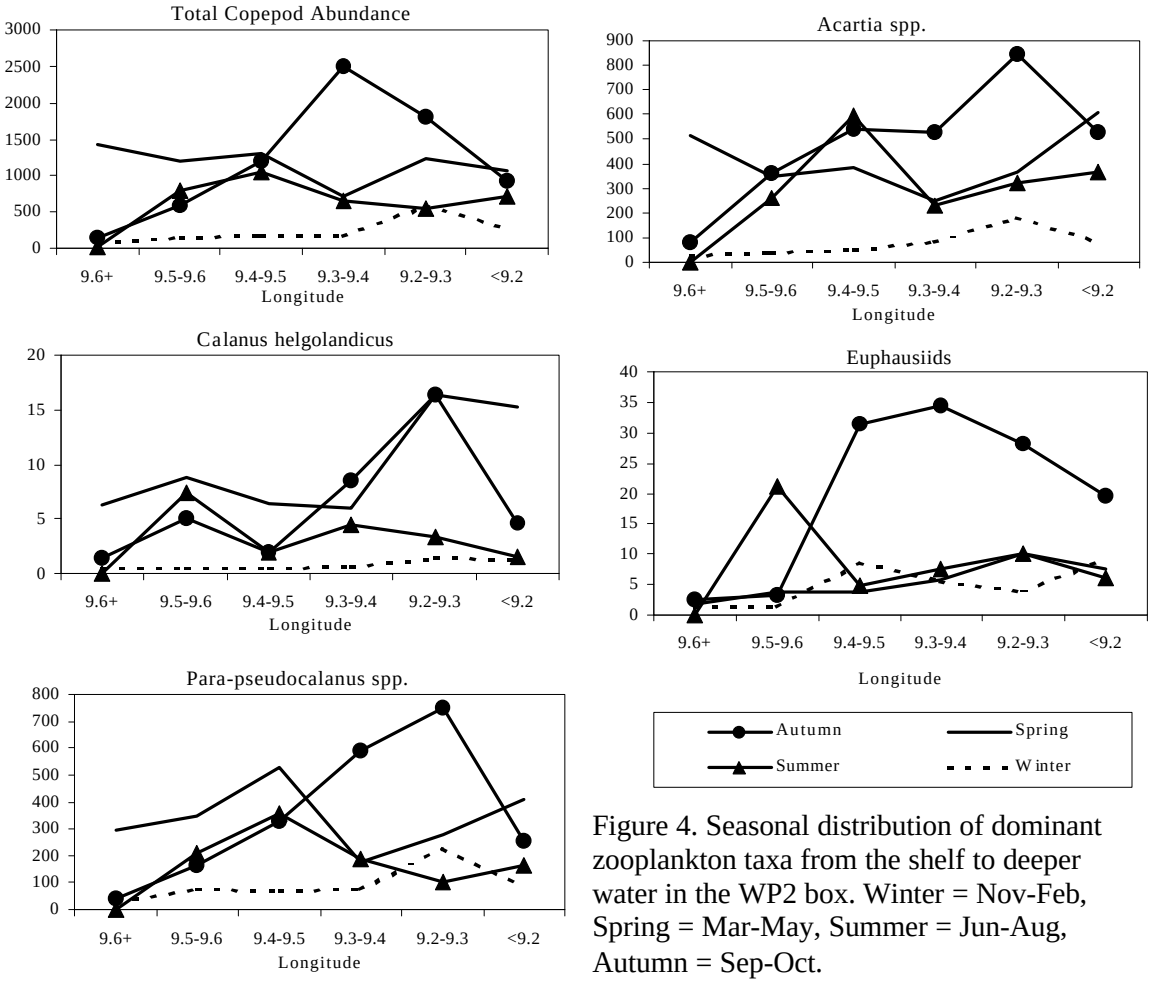


Figure 4. Seasonal distribution of dominant zooplankton taxa from the shelf to deeper water in the WP2 box. Winter = Nov-Feb, Spring = Mar-May, Summer = Jun-Aug, Autumn = Sep-Oct.

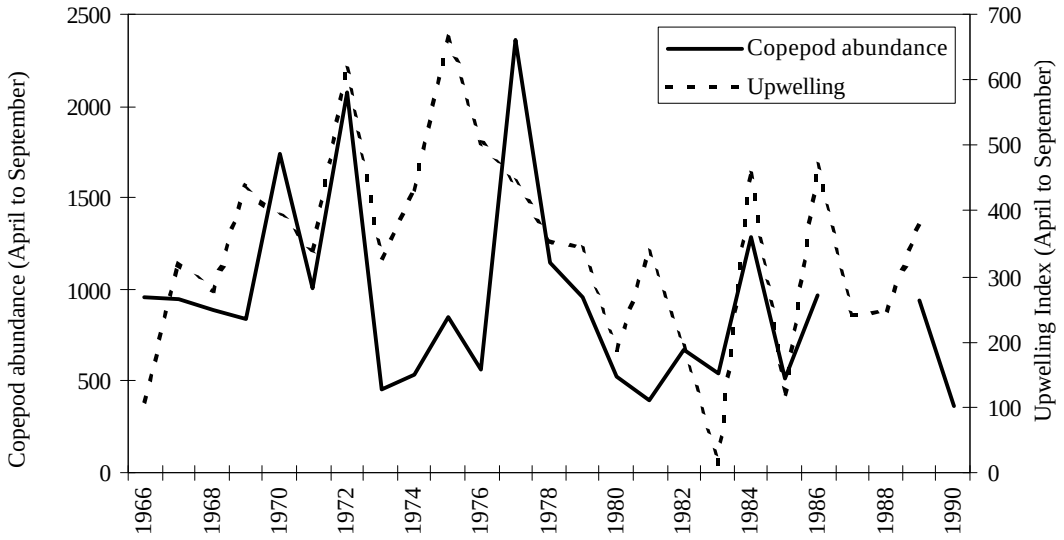


Figure 5. Time series of mean copepod abundance and upwelling (from Lavin *et al.*, 1991).

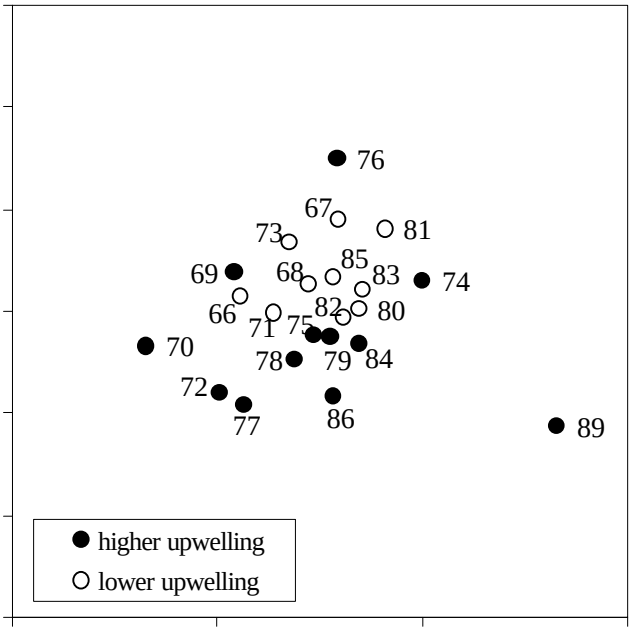


Figure 6. MDS plot showing copepod species composition similarities (April to September). Years are coloured according to whether the upwelling index (April to September) was higher or lower than the mean index (1966-1990).