# Relationships between zooplankton communities and mesoscale physical features during the summer 2000 Mesoscale cruises

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## Introduction

A primary objective of the GLOBEC NEP Mesoscale program is to investigate the effect of mesoscale physical features on the distribution and production of zooplankton in the California Current.

Two 3-week cruises were conducted during summer 2000 – an early summer cruise in May/June and a late summer cruise in July/August. Three ships were involved in each cruise: The R/V Wecoma towed SeaSoar and bioacoustics packages, The R/V New Horizon was dedicated to CTD casts and net tows for zooplankton sampling, and the F/V Sea Eagle studied juvenile salmon distributions. Here we report on relationships found between the physics and the zooplankton communities during the cruises.

## Methods

Data collection:

- Newport OR (44º 39.1'N ) to Crescent City CA (41º 54'N)
- 1 to 45 miles from shore
- Zooplankton collected with ½-m, 202µm mesh vertical tows from 100m
- CTD data
  - Temperature
  - Salinity
  - Fluorescence
- SeaSoar (Temperature) data from Jack Barth

Analysis:

- Copepods and common taxa sorted to species, others to larger taxonomic groups
- Species density x sample location matrix created
- Biomass values from length-weight relationships found in the literature
- Cluster analysis
- Indicator Species Analysis

## Results:

Mesoscale physical activity was relatively low and temperatures were relatively uniform in early summer as compared to late summer. Physical gradients paralelled the bathymetry in early summer, but eddies and filaments were well-developed by late summer.

Copepod biomass was relatively low during early summer. In late summer, biomass was higher with some hot spots nearshore, over Heceta Bank, and offshore in the cool filament off Cape Blanco.

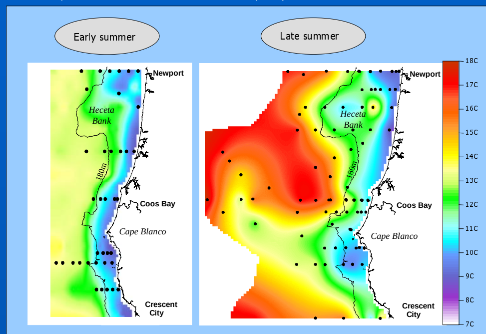


**Figure 1.** Sampling area during each cruise showing sea surface temperature (color) and locations of vertical net tows. Note that coverage over Heceta Bank and offshore of Cape Blanco was somewhat better during the late summer cruise than during early summer.

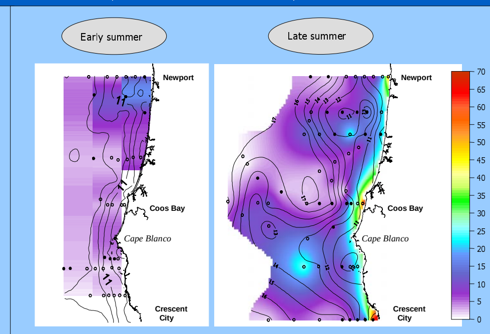


**Figure 2.** Copepod biomass (color) overlayed with temperature contours (lines) to show distribution of biomass in relation to physical features. Stations are coded by Day (open circles) or Night (filled circles).

Distributions of many of the dominant taxa were strongly influenced by the physics.

- Figure 3 top row: Warm-water taxa which are found throughout the study area during winter when downwelling brings offshore animals onto the shelf. But during upwelling in summer, these animals are displaced off the shelf, out of the upwelling system. All of these taxa are in lower abundance over Heceta Bank and in the cool tongue south of Cape Blanco. Warm-water taxa were not found in the cool upwelled water or in the cool filament surrounding the warm eddy.
- Figure 3 bottom row: Boreal neritic taxa are dominant nearshore in cool upwelled water. Many of them (like *Pseudocalanus mimus* and *Acartia longiremis*) were retained over Heceta Bank and displaced offshore in the cool filament. Some taxa (like *Calanus marshallae*) did not appear to be displaced offshore.

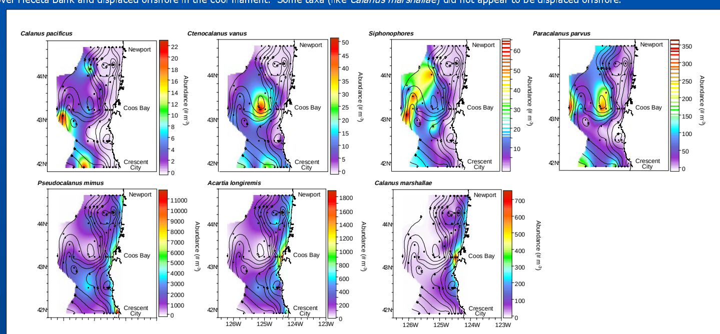


**Figure 3.** Distribution of some of the dominant taxa. Color represents abundance pattern; lines are temperature contours to represent the physical system.
Top row: Warm-water taxa normally present on the shelf during winter and offshelf during upwelling.
Bottom row: Cool-water taxa not present during winter (or in low numbers), but in high densities on the shelf during upwelling.

In cluster analysis (Figure 4), the early summer cruise completely separated from the late summer cruise. Within the early summer cruise, two lower groups are identified (Clusters 1a and 1b). Within the late summer cruise, several community-types are identified. (See Figure 5).

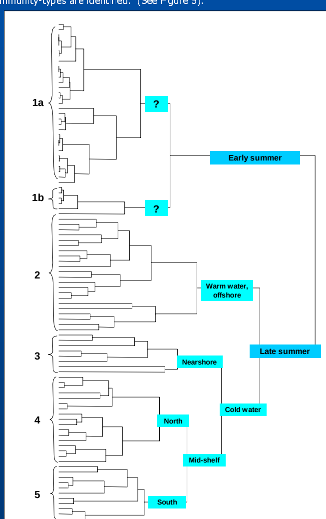


**Figure 4.** Dendogram showing results of cluster analysis on zooplankton community composition.

**Table 1.** Abundances (# m$^{-3}$) of taxa that were indicative ($\alpha<0.01$) of a community-type as determined by Indicator Species Analysis. Abundance in the cluster that the taxa is indicative of is in **yellow**.

| | Early summer Cluster 1 | Offshore Late summer Cluster 2 | Nearshore Late summer Cluster 3 | North Midshelf Late summer Cluster 4 | South Midshelf Late summer Cluster 5 |
|---|---|---|---|---|---|
| *Calanus marshallae* | 4.6 | 8.6 | **300.1** | 49.4 | 53.9 |
| *Calanus pacificus* | 0 | **4.2** | 0 | 0.3 | 0.8 |
| *Mesocalanus tenuicornis* | 0.4 | **8.5** | 0 | 0.5 | 2.8 |
| *Ctenocalanus vanus* | 1.7 | **14.4** | 1.7 | 0 | 7.5 |
| *Paracalanus parvus* | 0.9 | **117.3** | 15.5 | 13.9 | 12.2 |
| *Pseudocalanus mimus* | 91.9 | 726.7 | **5693.5** | 1398.3 | 2182.2 |
| *Clausocalanus arcuicornis* | 0 | **12.6** | 0 | 0 | 2.4 |
| *Acartia longiremis* | 4.1 | 94.0 | **920.3** | 330.0 | 245.4 |
| *Acartia hudsonica* | 0 | 0 | **722.2** | 1.9 | 11.4 |
| *Calocalanus styliremis* | 0.3 | **5.7** | 0 | 0 | 0.5 |
| *Corycaeus anglicus* | 0.2 | **1.8** | 0 | 0 | 0.3 |
| *Centropages abdominalis* | 0.3 | 1.1 | **284.1** | 9.1 | 2.0 |
| *Oncaea sp.* | 0.2 | **7.4** | 0 | 1.2 | 0.4 |
| *Neocalanus plumchrus* | **0.8** | 0 | 0 | 0 | 0 |
| Euphausiid eggs | 15.9 | 4.7 | **166.6** | 143.4 | 1.7 |
| Euphausiid nauplii | 4.4 | 1.0 | **288.2** | 34.5 | 1.1 |
| Euphausiid calyptopes | 0.1 | 101.9 | **262.3** | 12.9 | 92.3 |
| Euphausiid furcilia | 0.1 | 7.6 | **30.6** | 2.2 | 1.8 |
| *Vibilia spp.* | **0.6** | 0 | 0 | 0 | 0 |
| Salps | **0.6** | 0.4 | 0 | 0 | 0 |
| Doliolids | 0 | **22.0** | 0 | 0 | 0 |
| Siphonophores | 0 | **20.1** | 0 | 0 | 3.8 |
| Chaetognaths | 0.2 | **1.5** | 0 | 1.5 | 0.6 |
| Larvaceans | 0 | **0.2** | 0 | 0 | 0 |
| *Tomopteris spp.* | 0 | **0.7** | 0 | 0 | 0.3 |
| Bivalves | 0.2 | 0.2 | **217.9** | 0.2 | 0.1 |
| *Evadne sp.* | 0.1 | 0 | **232.3** | 0.2 | 0.9 |
| *Podon sp.* | 0 | 0 | **237.4** | 0 | 0.5 |
| Radiolarians | 1.1 | **13.4** | 0 | 0.7 | 3.1 |

We identified 6 zooplankton communities from the cluster analysis (see Figure 4); two communities in early summer and five in late summer.

- In early summer, it isn't apparent what caused the separation between communities (Clusters A and B in Figure 5) though community-type B seems to be more prevalent in the south than in the north. The communities don't occupy distinct regions related to the hydrography.
- During the late summer cruise, the zooplankton communities were clearly distributed in relation to the physics of the system:
  - The community represented by Cluster 3 was only found in cold upwelled nearshore water.
  - Cluster 4 was found in the moderately cool mid-shelf waters, primarily in the north over Heceta Bank.
  - Cluster 5 was the community found in the moderately cool midshelf water in the south – the community that is displaced offshore in the cool filament.
  - Cluster 2 was only found in the warm offshore water and the warm water being entrained into the eddy off of Cape Blanco.

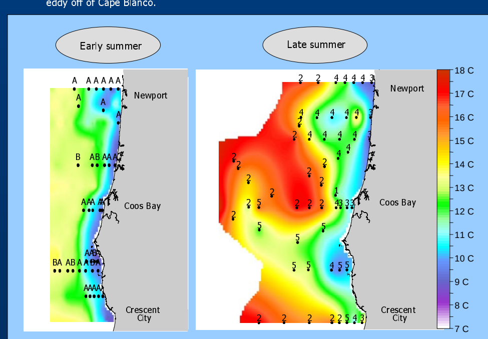


**Figure 5.** Cluster that each sample fell into (from dendogram above) overlayed onto sea surface temperature (color) to show relationship between zooplankton community type and hydrography.

## Discussion:

Early in the upwelling season, sea surface temperatures were moderate and mesoscale physical features were not well developed (Figure 1). The hydrography tended to parallel the bathymetry. Later in the summer, mesoscale features, such as meanders of the upwelling jet and filaments and eddies like that sampled off of Cape Blanco, were well developed and were temporally persistent. The effect of the physics on the zooplankton can easily be seen : copepod biomass was low and fairly uniform throughout the early-summer study area (Figure 2) with the retentive area over Heceta Bank the only area of relatively high biomass; copepod biomass was higher in late summer, especially nearshore and in the cool water advected offshore in the cool filament.

Distributions of individual taxa were also related to the hydrography. Warm-water taxa found throughout the area during winter were held offshore by the upwelling system in late summer. These taxa were in high numbers only well offshore and in the warm eddy off Cape Blanco (Figure 3 top row). Cool-water taxa (the typical nearshore dominants during summer upwelling) were found in high abundance in the retentive area over Heceta Bank; several cool-water taxa were also advected offshore in the cool filament off Cape Blanco. Some taxa (like *Calanus marshallae*) were not found in the cool filament. Possibly those nearshore species that weren't found in the filament had different vertical distributions or migration patterns that helped keep them only on the shelf, were too deep offshore for our nets to catch (>100 m depth), or were advected offshore but weren't able to survive due to temperature tolerances, predation pressure, or inadequate prey fields.

Cluster analysis confirmed that zooplankton communities differed in relation to the physics. The early summer cruise, when biomass was low and the hydrography was fairly uniform, completely separated from the late summer cruise (Figure 4). Within the late-summer cruise, 4 different communities were identified that were closely related to water temperature. Nearshore (Cluster 3) and offshore (Cluster 2) communities were the most unique; several taxa were good indicators of those communities (Table 1) indicating that they were found most consistently, and in highest abundances, in those communities. Mid-shelf communities north (over Heceta Bank) and south of Cape Blanco (Clusters 4 and 5) separated from each other, but examination of the densities of animals in those clusters (Table 1) reveals few differences: euphausiid eggs and nauplii were in higher abundance over Heceta Bank (Cluster 4) whereas euphausiid calyptopes were in highest abundance south of Cape Blanco (Cluster 5), but other densities were similar.

## Conclusions:

**Patterns of zooplankton distribution were related to physical features.**

- In early summer, mesoscale physical features were not well developed and cross-shelf differences in zooplankton communities were not strong
- By late summer, mesoscale features were well developed; cross-shelf differences in zooplankton communities were pronounced and matched the physics
  - Warm-water species were displaced offshore by the upwelling system
  - Many coastal taxa were advected offshore in eddies and filaments

Thanks to Jack Barth for providing SeaSoar temperature data and to the scientists and crew of the R/V New Horizon for assistance with data collection.