Year-to-year variations in developmental timing of large grazing copepods at Site H in the Oyashio region

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Copepods and its copepodid stages identified (samples from 0.1 mm mesh):

- *Metridia pacifica* (C1-C6)
- *Eucalanus bungii* (N, C1-C6)
- *Neocalanus cristatus* (C1-C6)
- *Neocalanus flemingeri* (C1-C6)
- *Neocalanus plumchrus* (C1-C6)

Mean stage: \[ S = \frac{\sum nA}{\sum An}, \] where \( An \) is abundance of \( n \)-th stage

Copepod wet mass = integrating individual wet mass over copepodid stages

Phase I
- 60-cm ring closing net
- 0.1 mm mesh
- 0-500 m vertical haul

Phase II
May 2002 - Mar. 2004
- Twin-NORPAC net (45-cm ring)
- 0.1 mm mesh, 0.35 mm
- 0-150 m, 0-500 m vertical haul
Inter-annual changes were greater in winter.
Very high temperature seen in May 2003 is due to the effect of warm core ring.
Chlorophyll $a$

With regard to season, inter-annual changes in chlorophyll $a$ were most marked in spring. The magnitude of spring bloom was greatest in 1997.
Large grazing copepods composed of $52\pm 22\%$ (mean $\pm 1$ sd) of total zooplankton mass. Salpida bloom was recorded in May-June 2003.
Typically two peaks of recruitment of early copepods in a year. The recruitment season variable with year.
Only one peak of recruitment of early copepodids in a year.
The recruitment season of early copepodids stable across the years studied.
Salpida bloom (May-June 2003) reduced the abundance of Eucalanus bungii.
One peak of recruitment of early copepodids in a year.
The recruitment season was in December-January in each year studied.
Neocalanus flemingeri

One peak of recruitment of early copepodids in a year.
The recruitment season was March across the years studied.
One peak of recruitment of early copepodids in a year. 
The recruitment season was May across the years studied. 
Salpida bloom (May-June 2003) reduced abundance of *Neocalanus plumchrus*.
Apparent population growth rate  \( g = (\ln W_{t1} - \ln W_{t0}) \cdot D^{-1} \)

**M. pacifica**

\[ g = 0.053-0.070 \]

**N. cristatus**

\[ g = 0.023-0.050 \]

**E. bungii**

\[ g = 0.013-0.026 \]

**N. flemingeri**

\[ g = 0.049-0.062 \]

**N. plumchrus**

\[ g = 0.068-0.134 \]

Growth rates of a given copepod less variable with year.

*: Stage-specific dry mass data from Kobari et al. (2003), Shoden (unpublished), Padmavati (unpublished).
### Environmental condition vs. recruitment timing

#### Recruitment season

<table>
<thead>
<tr>
<th>Year</th>
<th>Metridia pacifica</th>
<th>Eucalanus bungii</th>
<th>Neocalanus cristatus</th>
<th>Neocalanus flemingeri</th>
<th>Neocalanus plumchrus</th>
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</thead>
<tbody>
<tr>
<td>1997</td>
<td>June, August</td>
<td>January</td>
<td>March</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>July</td>
<td>May-June</td>
<td>December</td>
<td></td>
<td>May</td>
</tr>
<tr>
<td>2003</td>
<td>May, August</td>
<td>May-June</td>
<td>December</td>
<td>March</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>March</td>
<td>January</td>
<td>March</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Generation per year**: 1
- **Diapause**: Yes, Yes, Yes, Yes, Yes

#### Environmental variables

<table>
<thead>
<tr>
<th>Year</th>
<th>Temperature</th>
<th>Chlorophyll a</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Warm</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>Warm</td>
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</tr>
<tr>
<td>2002</td>
<td>Cold</td>
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</tr>
<tr>
<td>2003</td>
<td>Cold</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Warm</td>
<td>No data</td>
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</tr>
</tbody>
</table>
Summary

1. Temperature appeared to affect little to the developmental timing and growth rates of copepods (especially one-year life cycle species).

2. The incidence of salp blooms in 2003 reduced the abundance of *N. plumchrus* and *E. bungii*, suggesting possible food competition between young copepodids of these two species and salps.

3. Abundance of *N. plumchrus* and *E. bungii* was correlated with magnitude of spring phytoplankton bloom of that year, indicating that food supply is an important factor which determine the population size of these copepods.

4. The presence of interannual variations in the recruitment season in *M. pacifica* may be interpreted by the shorter generation length, no diapause phase, and close coupling of feeding and spawning of this species as compared with the other species.