Abundance, metabolism and body composition of the euphausiid *Euphausia pacifica* and *Thysanoessa inspinata* during spring phytoplankton bloom in the Oyashio region

Hye Seon Kim, Atsushi Yamaguchi and Tsutomu Ikeda

Marine Biology Laboratory, Graduate School of Fisheries Sciences
Hokkaido University, Hakodate, 041-8611, Japan.
**Introduction**

- **Spring phytoplankton bloom** has been documented as a key mechanism to drive biological processes in high latitude seas.

- Euphausiids are one of keystone species in the high latitude seas.

- In the Oyashio region:
  - *Euphausia pacifica* is the most dominant euphausiids, followed by *Thysanoessa inspinata*.
  - Euphausiids are important prey of both pelagic and ground fishes.

- *E. pacifica* is the target species of krill fishery off northeastern Japan.
The aim of this study

- Evaluation of temporal features of euphausiids during spring phytoplankton bloom in the Oyashio region, such as
  - Abundance
  - Population structure
  - Metabolism
  - Body composition
Materials and methods

Field sampling

- **A5** (42°00’ N, 145°15’ E)
- 8-14 Mar. 2007 (Oshoro-Maru)
- 5 Apr.-1 May 2007 (Hakuho-Maru)
- Bongo nets
  (mouth diameter 75 cm, mesh 500 µm)
- 200 m depth-surface; oblique tow
- Fresh and preserved samples
Material and methods

Environmental parameters

- CTD (Sea-bird):
  Temperature, Salinity and Chlorophyll a pigment

On board treatments

- Metabolism:
  Oxygen consumption rate
  Ammonia excretion rate

- Body composition:
  Water contents
  Carbon and Nitrogen contents
  Ash
Analysis in the land laboratory

- Sorted and enumerated euphausiid species from entire samples
- Dominant *Euphausia pacifica* and *Thysanoessa inspinata* were separated into juveniles, adult males, and adult females without and with spermatophores

Females with spermatophores attached
Measurement of body length ($BL$: mm) and total length ($TL$: mm)

Allometric equations

*Euphausia pacifica*  
$TL = 1.2921BL + 0.0762 \ (r = 0.999, n = 67, p<0.01)$

*Thysanoessa inspinata*  
$TL = 1.5141BL - 0.5753 \ (r = 0.995, n = 91, p<0.01)$
Results
Hydrography

- Surface temperature 1.5-6.1°C
  - Oyashio water
    - (Temp. <3 °C, salinity 33.0-33.3 psu)
    - 5-8 April (upper 300 m)
    - 20-25 April (upper 200 m)
  - ‘Modified’ Oyashio water
    - 9-14 March (upper 200 m)
    - 13-19 April (upper 100 m)
- Chlorophyll a
  - March (0.2-1.0 mg m⁻³)
  - < April (0.5-6.3 mg m⁻³)
    - Peak: 7-8 April (6.3 mg m⁻³)
    - 23 April (4.5 mg m⁻³)
Table. Euphausiid abundance (individuals m$^{-2}$) during spring phytoplankton bloom in the Oyashio region

<table>
<thead>
<tr>
<th>Date</th>
<th>Euphausia pacifica</th>
<th>Thysanoessa inspinata</th>
<th>T. longipes</th>
<th>T. inermis</th>
<th>Tessarabrachion oculatum</th>
<th>Stylocheiron spp.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 Mar.</td>
<td>164.1 (72.7)</td>
<td>59.3 (26.3)</td>
<td>0.9 (0.4)</td>
<td>0 (0.2)</td>
<td>0.9 (0.4)</td>
<td>0.5 (0.2)</td>
<td>226</td>
</tr>
<tr>
<td>14 Mar.</td>
<td>109.2 (62.2)</td>
<td>64.1 (36.5)</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>0.3 (0.2)</td>
<td>1.4 (0.8)</td>
<td>65.7</td>
</tr>
<tr>
<td>7 Apr.</td>
<td>1039.8 (84.5)</td>
<td>185.6 (15.1)</td>
<td>2.5 (0.2)</td>
<td>1.9 (0.2)</td>
<td>0 (0.1)</td>
<td>0.6 (0.1)</td>
<td>1230</td>
</tr>
<tr>
<td>8 Apr.</td>
<td>965.5 (91.1)</td>
<td>92.1 (8.7)</td>
<td>1.5 (0.1)</td>
<td>0.6 (0.1)</td>
<td>0.6 (0.1)</td>
<td>0 (0.1)</td>
<td>1060</td>
</tr>
<tr>
<td>10 Apr.</td>
<td>40.9 (15.8)</td>
<td>174.6 (67.6)</td>
<td>37.0 (14.3)</td>
<td>4.9 (1.9)</td>
<td>0.8 (0.3)</td>
<td>0.8 (0.3)</td>
<td>258</td>
</tr>
<tr>
<td>12 Apr.</td>
<td>320.6 (66.5)</td>
<td>148.5 (30.8)</td>
<td>10.9 (2.3)</td>
<td>1.2 (0.3)</td>
<td>0.5 (0.2)</td>
<td>0.5 (0.2)</td>
<td>482</td>
</tr>
<tr>
<td>17 Apr.</td>
<td>219.4 (79.9)</td>
<td>50.4 (18.4)</td>
<td>3.7 (1.4)</td>
<td>0.5 (0.2)</td>
<td>0.5 (0.2)</td>
<td>0.6 (0.1)</td>
<td>275</td>
</tr>
<tr>
<td>20 Apr.</td>
<td>275.8 (63.7)</td>
<td>151.9 (35.1)</td>
<td>3.4 (0.8)</td>
<td>1.4 (0.3)</td>
<td>1.9 (0.8)</td>
<td>1.9 (0.8)</td>
<td>433</td>
</tr>
<tr>
<td>25 Apr.</td>
<td>134.6 (57.9)</td>
<td>89.6 (38.5)</td>
<td>5.5 (2.4)</td>
<td>0.8 (0.4)</td>
<td>1.6 (1.0)</td>
<td>1.6 (1.0)</td>
<td>233</td>
</tr>
<tr>
<td>29 Apr.</td>
<td>59.2 (38.9)</td>
<td>90.0 (59.2)</td>
<td>1.3 (0.8)</td>
<td>0 (0.3)</td>
<td>0.8 (0.2)</td>
<td>0.8 (0.2)</td>
<td>152</td>
</tr>
<tr>
<td>Mean</td>
<td>333</td>
<td>111</td>
<td>6.7</td>
<td>1.2</td>
<td>0.8</td>
<td>0.2 (0.04)</td>
<td>452</td>
</tr>
</tbody>
</table>
Abundance of *Euphausia pacifica*

- **Abundance**:
  - 44-1,040 (mean: 333 indiv. m^{-2})

- **Graph**:
  - 
  - Abundance (indiv. m^{-2})
  - Euphausia pacifica
  - Temperature
  - Chl. a

- **Table**:

<table>
<thead>
<tr>
<th>df</th>
<th>Temp. (0-100m)</th>
<th>Chl. a (0-100m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>-0.638*</td>
<td>0.687*</td>
</tr>
</tbody>
</table>

\[ df = n - 2, \ *: p<0.05 \]
Abundance of *Thysanoessa inspinata*

The abundance of *Thysanoessa inspinata* was measured from March 9 to April 29. The graph shows the abundance (indiv. m$^{-2}$) plotted against temperature (°C) and Chl. a (mg m$^{-2}$) for the 0-100 m depth layer. The abundance ranged from 50 to 186 with a mean of 111 indiv. m$^{-2}$.

### Table: Correlation between Abundance and Environmental Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>df</th>
<th>Temp. (0-100m)</th>
<th>Chl. a (0-100m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance (indiv. m$^{-2}$)</td>
<td>8</td>
<td>-0.679*</td>
<td>0.257$^{NS}$</td>
</tr>
</tbody>
</table>

$df = n - 2$, *: $p<0.05$, NS: not significant
Population structure of *Euphausia pacifica*

- Total length range: 5.2-25.4 mm
- Mean total length of the large size group: 
  March (13.8-14.0 mm), April (16.2-17.6 mm)
- Mean growth rate: 0.082 mm day$^{-1}$
Population structure of *Thysanoessa inspinata*

- Total length range: 3.7-26.7 mm
- Mean total length of the large size group:
  - March (16.5-16.7 mm), April (16.8-18.1 mm)
- Mean growth rate: 0.022 mm day\(^{-1}\)
**Euphausia pacifica**

Females with spermatophores occurred from 10 April (mean: 5% of total population)

**Thysanoessa inspinata**

Females with spermatophores occurred from the entire study period (mean: >40% of total population)
**Metabolism of *Euphausia pacifica***

- **Adjusted Metabolic Rate (AMR):**
  - No correlation with environmental parameters

### Correlation Table

<table>
<thead>
<tr>
<th></th>
<th>Temp.</th>
<th>Chl. a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiration</td>
<td>0.598&lt;sub&gt;NS&lt;/sub&gt;</td>
<td>-0.233&lt;sub&gt;NS&lt;/sub&gt;</td>
</tr>
<tr>
<td>Excretion</td>
<td>0.547&lt;sub&gt;NS&lt;/sub&gt;</td>
<td>-0.328&lt;sub&gt;NS&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

*NS: not significant*
Metabolism of *Thysanoessa inspinata*

- **Adjusted Metabolic Rate (AMR):**
  - No correlation with environmental parameters

<table>
<thead>
<tr>
<th>Correlation</th>
<th>Temp.</th>
<th>Chl. $a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiration</td>
<td>$0.536^{NS}$</td>
<td>$-0.349^{NS}$</td>
</tr>
<tr>
<td>Excretion</td>
<td>$0.616^{NS}$</td>
<td>$-0.183^{NS}$</td>
</tr>
</tbody>
</table>

NS: not significant

- **Surface temperature ($^\circ$C)**
- **Chl. $a$ (mg m$^{-3}$)**
- **Phytoplankton bloom**
## Euphausiid body composition

<table>
<thead>
<tr>
<th>Year</th>
<th>E. pacifica</th>
<th>No.</th>
<th>Water (%WM)</th>
<th>C (% DM)</th>
<th>N (% DM)</th>
<th>C:N</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>Females</td>
<td>4</td>
<td>77.90±1.08</td>
<td>33.66</td>
<td>9.47</td>
<td>3.55</td>
<td>14.67</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>3</td>
<td>77.53±0.82</td>
<td>35.13</td>
<td>9.56</td>
<td>3.68</td>
<td>10.96</td>
</tr>
<tr>
<td>April</td>
<td>Females</td>
<td>35</td>
<td>76.64±2.50</td>
<td>38.01</td>
<td>9.74</td>
<td>3.90</td>
<td>9.17</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>16</td>
<td>75.82±1.92</td>
<td>34.48</td>
<td>8.79</td>
<td>3.92</td>
<td>10.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>Females</td>
<td>8</td>
<td>78.75±1.12</td>
<td>36.20</td>
<td>9.76</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>6</td>
<td>77.44±1.22</td>
<td>36.98</td>
<td>10.09</td>
<td>3.66</td>
</tr>
<tr>
<td>April</td>
<td>Females</td>
<td>25</td>
<td>78.26±4.61</td>
<td>36.98</td>
<td>9.81</td>
<td>3.77</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>28</td>
<td>78.46±6.19</td>
<td>37.21</td>
<td>10.19</td>
<td>3.65</td>
</tr>
</tbody>
</table>

No appreciable difference between March and April was evident in both *Euphausia pacifica* and *Thysanoessa inspinata*. 
Summary (1)

Both *Euphausia pacifica* and *Thysanoessa inspianta* occurred throughout the entire study period (less effect of water mass changes).

Correlation between abundance and environmental parameters

*E. pacifica*: water temperature (-) and chlorophyll $a$ (+)
*T. inspinata*: water temperature (-)

Growth rates:

*E. pacifica* (0.082 mm day$^{-1}$)
* > *T. inspinata* (0.022 mm day$^{-1}$)

Proportion of females with spermatophores (an indicator of spawning activity)

*T. inspinata* (>40%) > *E. pacifica* (5%)

Allocation of energy ingested

*E. pacifica*: somatic growth,  *T. inspinata*: reproduction
Summary (2)

Metabolism:
Adjusted oxygen consumption and ammonia excretion rates of the two euphausiids were not correlated with environmental parameters (temperature and chl. a) in March (before the bloom) and April (in the bloom).

Body composition:
No appreciable differences were seen in water and ash contents, C and N composition, and C:N ratios of the two euphausiids in March (before the bloom) and April (in the bloom)
Thank you for your attention!