Response of neritic copepod, *Acartia omorii* to climate related changes in Tokyo Bay, Japan

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Dormancy in neritic copepod

- Dormancy is a life history strategy adaptation to unstable environment
- About 50 species of marine calanoid copepods produce *resting eggs* and belong to the superfamily of *Centropagoidea* (Marcus 1996; Engel and Hirche 2004; Alistair 1992)
- They also includes most of the *abundant* species in *neritic and coastal zone*
- Habitats is *large environmental variations*. Ex. temperature, salinity, dissolved oxygen

![Graph showing the abundance of *Acartia omorii* and water temperature over time.](image)
The producer of resting eggs in Tokyo Bay

Seasonal variations of three species

### Plankton
- **Acartia omorii**: Winter ~ early summer
- **Centropages abdominalis**: Winter ~ spring
- **Labidocera rotunda**: Summer ~ fall

### Resting egg
- **Acartia omorii**: Mid summer ~ fall
- **Centropages abdominalis**: Summer ~ fall
- **Labidocera rotunda**: Winter ~ spring

![Graph showing seasonal variations of three species.](image-url)
Environmental changes in Tokyo Bay

Tokyo Bay is surrounded by metropolitan city
One of the most highly eutrophicated inlets in Japan.

Tokyo Bay extends 80 km north to south, and is an estuarine environment due to discharge from the large River in the innermost area

Connects with the Pacific oceanic environment via the entrance area.
Water pollution increased through the 1960s with a nutrient peak. Red tide and hypoxic water mass occurred by high primary production with increase of nutrients.

Nutrients condition and chl. a concentration has shown a recovery in recent years (Kanda et al., 2008). However, anoxia in the bottom layer continue to the present (Unoki 2011).

These results imply that long term environmental change may influence the copepod population.
Our object …

We examined the monthly abundance of three resting egg production copepods collected in Tokyo Bay to clarify the mechanisms of species specific response is related to climatic and hydrographic conditions.

I. phenology shift of three species
II. Long term trend for 30 years
Comparison with hydrographic condition and climate change

Our goal of this study was to reveal the regional copepod response linking the climate and environment in the neritic and coastal zone
Materials and Methods

Monthly collection: Jar 1980- Dec 2010

Location: Stn. F6 28 m depth
(35°25′11N, 139°47′48E)

Sampling gear: NORPAC-net
Mouth diameter; 45 cm
Mesh size; 330 μm
Vertical hauls from 1 m above to the surface

Environmental factors

PDO (pacific decadal oscillation)

SST (Sea surface temperature) in each season

SBT (Sea bottom temperature) in each season

Stratification
Long-term trend of total copepod abundance

The long-term trend: Total abundance of copepods is decreased

\[ y = -0.0705x + 1.0696 \]

\[ R^2 = 0.6536, \ P < 0.01 \]
A. *omorii* accounted for 60-90% of the total copepod abundance.

Total copepod abundance had high significant positive correlation with *A. omorii*.

Inter-annual variation of total copepod abundance reflects that of *A. omorii*.
Phenology shifts in *A. omorii*

- **80s**: Shift of peak month from March to April
- **90s**: Decrease of abundance and extend disappearance period
- **00s**:

Seasonal variation of *A. omorii* abundance in each decade
Phenology shifts in A. omorii

Peak vs Winter and Spring SST

Start vs Stratification

End vs Fall SBT

Timing (month)

SST Anomaly

Anomaly
Phenology shifts in *C. abdominalis*

- **80s**
  - No change of peak month
  - Extend disappearance period
- **90s**
  - Decrease of abundance
  - Shift of peak timing
- **00s**
Phenology shifts in *C. abdominalis*

- No significant correlation was detected between peak month and environments.
- Start timing of resting egg was early with warm spring.
- End timing of resting egg was late with warm fall.
Phenology shifts in *L. rotunda*

- **80s**
  - Shift of peak month
  - September → October

- **90s**
  - Increase of abundance
  - &
  - Shorten disappearance period

- **00s**

![Graph showing abundance changes](image)
Phenology shifts in *L. rotunda*

- No significant correlation was detected between peak month and environments
- Start timing of resting egg was late with warm fall
- End timing of resting egg was early with warm spring
Long term trend of three species

**A. omorii**

\[ y = -0.061x + 0.928 \]

\[ R^2 = 0.609, P < 0.01 \]

**C. abdominalis**

\[ y = -0.0726x + 1.1259 \]

\[ R^2 = 0.4089, P < 0.01 \]

**L. rotunda**

\[ y = 0.0391x - 0.6593 \]

\[ R^2 = 0.1125 \]
Comparison with winter SST

To focus on fluctuation for a few years, we removed decrease trend from anomaly of annual mean abundance.

*A. omorii* fluctuation had a significant positive correlation with winter SST, suggested that abundance increased with warm winter.

Previous study indicate Temperature govern the *A. omorii* growth rate without food limitation (Uye and Shimazu., 1997)

Periodical fluctuations of *A. omorii* abundance is conformed to that of water temperature.
Comparison with climate index

<table>
<thead>
<tr>
<th></th>
<th>Winter SST</th>
<th>Spring SST</th>
<th>Summer SST</th>
<th>Fall SST</th>
<th>Stratification</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDO</td>
<td>-0.680**</td>
<td>-0.667**</td>
<td>n.s.</td>
<td>n.s.</td>
<td>-0.515**</td>
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Short-term fluctuation of *A. omorii* and winter SST had a high negative correlation with PDO.
Long-term trend and Periodicity

Periodicity: Fluctuation of *A. omorii* coincide with that of winter SST

Discrepancy

Long-term trend: *A. omorii* decrease, SST increase
In winter: Temperature & DO conc. well mixing from surface to bottom

Increase of temperature

Develop the thermocline, then decrease of DO below thermocline

High water temperature zone
Upper thermal limit of *A. omorii*

Hypoxic water mass develops below thermocline
*A. omorii* cannot stay &

Subitaneous egg become resting egg to expose in hypoxic water (Uye 1980)
Process of long term decrease in *A. omorii* abundance

1. Warm winter in a year
2. Formation of stratification is early
3. Hypoxic water mass develops is early
4. Extend of duration of resting egg population

Long term expose in hypoxic water mass caused heavy damage to resting egg population in warming season

Warming trend also changed start and end timing of resting egg. Climate warming caused strong impact to resting egg production copepod
Conclusion

• The common phenology correlate is water temperature relation to resting egg, but phenologic response in temperature is differ in species.

The timing of seasonal change in copepod community might vary by water temperature.

• The trend of *A. omorii* could be explained by the increase of winter water temperature and hypoxic water development.
• Periodical fluctuations of *A. omorii* also would be synchronized that of water temperature.

These facts suggested that copepod population in neritic and coastal zone was influenced by multiple stressor relation to climate change and human activity.