Decadal scale variation of copepod community structure in the Oyashio based on the Odate Collection

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Advantage of Detailed Zooplankton Analysis for Climate-Ecosystem Change Studies

- Their community structure and biological states preserve a state of past events

- Their body may tell us...
  - “how was the ambient environmental condition”
  - “where are they from”

- There are some historical zooplankton collections waiting to be analyzed
Zooplankton samples taken in water adjacent to Japan 1950s - present

Odate collection station map (total # > 20,000)

Wet weight data were analyzed by Odate (1994) and archived by Tohoku Fisheries Research Institute.
To elucidate mechanisms of basin scale, multi-decadal change in marine ecosystems

Process study on long-term variation of lower trophic level ecosystem in the western North Pacific

The ODATE project 2003-2005 (6?) FY

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2Tokyo University
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4Frontier Research Center for Global Change/JAMSTEC
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Subject 1
establish Zooplankton database
*insemination of results

Microscopic analysis

Subject 2
Climate - Ocean interaction
*modeling ocean circulation
*construct climate-ocean data set

Subject 3
Physical environments & primary productivity
feedback

Subject 4
Variability of plankton community structure
feedback

Components of the Odate Project

1. Copepods community analysis
2. Quantitative and phenological changes of Target species
3. $\delta^{15}$N analysis of target species for basin scale comparison
Criteria for Oyashio
- T < 5°C at 100m depth
- Extensive spring bloom
- Efficient BCP function

\[(\Delta p\text{CO}_2)_{\text{bio}} = (p\text{CO}_2 \text{ at } T_{\text{mean}})_{\text{max}} - (p\text{CO}_2 \text{ at } T_{\text{mean}})_{\text{min}}\]

(Takahashi et al. 2002, DSR II, 49)
Selection of Data

- Target area: 37-43N, 142-147E
  Bottom depth > 500 m

- Year/Season: 1972-2001
  March – August
  (of Feb-Dec from 1960s)

- Number of samples analyzed: 578 (of >1300)

- Number of copepod species observed: 120

- Monthly mean abundance for each year for each species

Temporal distribution of Data

Number of copepod species observed: 120
Regime Shift & Oyashio Copepods

Time series of total copepods abundance $[\log (\text{inds.m}^{-3} + 1)]$
March-August, 1972-2001

1976/77 regime shift
productive season: elongated

1988/89 regime shift
productive season: short

1998 regime shift?
Spring production: small
Time series of abundance of dominant copepod species [inds. 1000 m$^{-3}$]
**Dominant species list**

> 1% abundance at any month

- **Species**
  - *Acartia omorii*
  - *Calanus pacificus* s.l.
  - *Clausocalanus parapergens*
  - *Corycaeus affinis*
  - *Ctenocalanus vanus*
  - *Eucalanus bungii*
  - *Mesocalanus tenuicornis*
  - *Metridia okhotensis*
  - *Metridia pacifica*
  - *Neocalanus cristatus*
  - *Neocalanus flemingeri*
  - *Neocalanus plumchrus*
  - *Oithona atlantica*
  - *Oithona similis*
  - *Paracalanus parvus*
  - *Pseudocalanus minutus*
  - *Pseudocalanus newmani*
  - *Scolecithricella minor*

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**Community classification**

- **Time series**
- **Species**
- **Raw Data**
  - inds. 1000 m$^2$
- **Transformed** (log(x+1))
- **Monthly Normalized**
  - Mar-Aug mean = 0, SD = 1 for each year, each species

- **Dissimilarity matrix**
- **Euclidean**
- **Cluster**
  - **UPGMA**
- **Ordination**
  - **NMDS**

**Abundance correction for DVM influence was made**
Community Analysis: Results

NMDS ordination plot of copepods cluster groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>spp. code</th>
<th>species</th>
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<tbody>
<tr>
<td>Group A</td>
<td>Pm</td>
<td><em>Pseudocalanus minutus</em></td>
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<td>Nc</td>
<td><em>Neocalanus cristatus</em></td>
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<td>Nf</td>
<td><em>Neocalanus flemingeri</em></td>
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<td>Os</td>
<td><em>Oithona similis</em></td>
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<td>Group B</td>
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<td>Mo</td>
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<td>Mp</td>
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<td></td>
<td>Pn</td>
<td><em>Pseudocalanus newmani</em></td>
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<tr>
<td></td>
<td>Np</td>
<td><em>Neocalanus plumchrus</em></td>
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<tr>
<td>Group C</td>
<td>Cp</td>
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<td>Ao</td>
<td><em>Acartia omorii</em></td>
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<tr>
<td>Outlier</td>
<td>Sm</td>
<td><em>Scolecithricella minor</em></td>
</tr>
</tbody>
</table>

Species list for each cluster group

Subarctic species
Temperate species
widely distributed species
by Chihara & Murano (1994)
Community Analysis: Results

Time series of normalized anomaly of average copepods abundance [$\log(\text{inds } m^{-3})$] for each cluster group (average = 0, SD = 1)

Timing of peak abundance
Productive season start LATE, end EARLY

Cold winter & light limited system

Deep wintertime mixing - delayed spring bloom?

P<0.1, Man-Whitney U
Mean monthly abundance of community groups

- Spring Community
- Early Summer Community
- Summer Community

1971-1976
1977-1988
1989-1999

Sporadic abundance increase in summer

Spring abundance: small

P<0.1, Man-Whitney U
Copepods community in the Oyashio varied in decadal scale, both in abundance and phonology. Regime shifts related?

But...community structure differed between the early 1970s and 1990s. - Variation was “one-way” (not oscillation)

Decadal scale variation pattern differed among the 3 seasonal communities. - Changes in the late 1970s were obvious only in the Spring Community and Early Summer Community: delayed and short productive season. - Changes in the late 1980s - early 1990s) were obvious only in the Early Summer Community and Summer Community: low spring production, sporadic abundance increase in summer

Environmental variation from Winter to Spring was responsible for the changes in the late 1970s Spring to Summer the late 1980s

Different mechanisms work for decadal scale variation of the lower trophic levels in Winter and Summer
To be continued
Decadal scale variation: winter vs. summer

Winter

~1976

1976/77~1988/89

1988/89~1998?

Summer

Wind weak

AL weak

Wind strong

AL strong

Wind strong

AL strong

AO

PDO
7. 補足資料
説
冬の十年スケール変動と夏の十年スケール変動をもたらす気候変化
とそれに伴うメカニズムは異なるものである

Fig. 2. February (top) and August (bottom) SST differences between 1977-86 and 1966-75. Large positive changes (warmer water in more recent regime are red; cooler water is blue) are widespread along the west coast during winter and summer, with largest differences during winter. (Figure courtesy of Franklin Stow.)

(Batchelder & Powell, 2000, Prog. Oceanog. 53: 105-114)
Time series of abundance of dominant copepod species [inds. 1000 m\(^{-3}\)]
Variation in timing of peak abundance for each cluster group

Fig. 10 各カイアシ類群集の月毎に正規化したLog平均密度, 年ごとに3-8月の平均 = 0 標準偏差が1とした）の時系列（オレンジが正偏差、緑が負偏差）

注）30年間の生物量のピーク時期のずれのみを示している。