Variation in assimilation efficiencies of dominant *Neocalanus* and *Eucalanus* copepods in the subarctic Pacific: consequences for population structure models

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Introduction

Summer zooplankton community in the subarctic Pacific

*Neocalanus* spp.
*Eucalanus* spp.

predominant and form 85-90% of the total zooplankton biomass
(Vinogradov, 1970)

play an important role in energy transfers to higher trophic organisms (Nemoto, 1963; Hunt et al., 1998; Beamish et al., 1999; Ikeda et al., 2008)

Assimilation efficiency of copepods

Assimilation efficiency is an essential parameter required to estimate the energy transfer to higher trophic levels in marine ecosystems

**Assimilation efficiency = (F—E) / F**

- **Feeding (F₁)**
- **Evacuation (E)**
- **Metabolism (M)**
- **Growth (G)**

**Phytoplankton**
**POM**
**Microsized organisms**
**Ciliates • Flagellates**
Introduction

Little information is available for assimilation efficiency of large oceanic copepods (Neocalanus and Eucalanus species) dominated in the subarctic Pacific. Even in marine ecosystem models such as NEMURO, a constant value (70%) is applied for the copepod assimilation efficiency (Kishi et al., 2007; Terui and Kishi, 2008; Terui et al., 2012).

Objective of this study

Assimilation efficiencies of three large oceanic copepods (N. cristatus, N. flemingeri and E. bungii), were measured by applying the Ratio method applying eight phytoplankton species (diatoms, dinoflagellates and a raphidophycean) as food.

By applying the observed assimilation efficiency of N. cristatus, the effects of changes in the assimilation efficiency on copepod population structure were evaluated using the population model (Lagrangian ensemble model; LEM).
Material and Methods

Copepods

- *N. cristatus* C5
- *N. flemingeri* C5
- *E. bungii* C5

Collected in the subarctic Pacific during May-August of 2011 or 2012

Field sampling

- **80 cm ring net** (80 cm mouth diameter, 330 µm mesh)
- →0-30, 0-150 m vertical hauls

Live *N. cristatus*, *N. flemingeri* and *E. bungii* were sorted

- Seawater was collected from 20 m depth using Niskin bottles, filtered through a GF/F filter and used in the subsequent experiments.
- Live specimens were transferred into a 1-L bottle filled with filtered seawater (FSW)
- Up to 100 specimens of each species were kept at 2°C and then carried to the land laboratory
To obtain sympatric phytoplankton species, 5 ml of unfiltered seawater was added to a flask containing 300 ml of modified SWM-3 medium → Three diatoms were isolated. (Chaetoceros sp., Ditylum brightwellii and Thalassiosira nordenskioeldii)

Incubate condition • • modified SWM-3 medium, 15°C, 14 h L:10 h D light/dark photocycle, illumination 100–120 μmol photons m⁻² s⁻¹
Material and Methods: Experiments of assimilation efficiency

Copepods × 3
Phytoplankton (5.0 × 10²–1.0 × 10⁴ cells ml⁻¹)
(110–2577 µg C L⁻¹)

Phytoplankton

Chamber

3°C under dark condition

Faecal pellets were pipetted using sterile Pasteur pipettes and rinsed well (5-10 times) with FSW to avoid phytoplankton contamination

Faecal pellets
Phytoplankton
blank

60 °C, 5 h

Dry weight (DW) was measured

480 °C, 5 h

ash weight (ASH) was measured

• Ratio Method (Conover 1966a, b)

\[
U' (\%) = \left( \frac{F' - E'}{(1 - E') \times (F')} \right) \times 100
\]

\(U'\): Assimilation efficiency
\(F'\): the organic fraction of the food
\(E'\): the organic fraction of the faecal pellets
Results and Discussion: \(N.\ cristatus\)

Assimilation efficiencies: 45%–66% varied with the phytoplankton species.
Results and Discussion: *N. flemingeri* and *E. bungii*

### N. flemingeri

- **D. brightwellii**
  - Assimilation efficiency: 43.6%
- **Skeletonema sp.**
  - Assimilation efficiency: 66.2%
- **Th. nordenskioeldii**
  - Assimilation efficiency: 62.2%

### E. bungii

- **Chaetoceros sp.**
  - Assimilation efficiency: 55.6%
- **D. brightwellii**
  - Assimilation efficiency: 33.6%
- **Skeletonema sp.**
  - Assimilation efficiency: 64.9%
- **Th. nordenskioeldii**
  - Assimilation efficiency: 59.2%

**Average of assimilation efficiency**

- **N. flemingeri**: 44%~66%
- **E. bungii**: 34%~65%

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*Ash contents of phytoplankton (%)*
Among the phytoplankton species, the highest ash content was observed for diatoms.

Diatom cell walls are made with silica = inorganic material.

Although silica is ingested by copepods, 79-90% of the silica is egested as faecal pellets (Tande and Slagstad, 1985; Conover et al., 1986; Cowie and Hedges, 1996) → copepods can not assimilate silica.

A common trend for the three copepod species was that the assimilation efficiencies had a significant negative correlation with the ash contents of the food phytoplankton.
The large-sized copepod *N. cristatus* had a high assimilation efficiency for large-sized phytoplankton.

*N. cristatus* • Changes in assimilation efficiency with the phytoplankton cell size were not detected.

*N. flemingeri* and *E. bungii* • Negative correlation between assimilation efficiency and phytoplankton cell size was detected (*p* < 0.001).
Results and Discussion: Population model

Changes in the assimilation efficiency affected development time and population maintenance.

A constant value (70%) is applied for the copepod assimilation efficiency. The assimilation efficiency of large oceanic copepods was varied (34-66%).

We tested the effects of changes in assimilation efficiency by applying the LEM for *N. cristatus* Terui et al. (2012).

- 66% • • • *N. cristatus* could maintain the population
- 45% • • • *N. cristatus* could not maintain its population
- 70% • • 139 days were required for individuals to reach C5 (solid)
- 66% • • 150 days were required for same hatch date individuals
Summary

Assimilation efficiencies of dominant *Neocalanus* and *Eucalanus* copepods in the subarctic Pacific

- had a significant negative correlation with the ash contents of the food phytoplankton
- varied with the phytoplankton species and the ash contents of the food phytoplankton

Marine ecosystem model

- Variations in assimilation efficiency should be incorporated into marine ecosystem models in the future
- Copepod assimilation efficiency is highly correlated with the inorganic content of food
  - Assimilation efficiency in the model should be estimated using parameters based on the composition of the food phytoplankton taxa
Thank you very much for your kind attention!

By Oshoro-Maru  The 216th North Pacific Cruise