2014 PICES annual meeting

Responses in macrozooplankton population to water mass exchange and the spring phytoplankton bloom in the Oyashio region

Amphipods
(*Cyphocaris challengeri*)

Chaetognaths
(*Eukrohnia hamata*)

Hydrozoans
(*Aglantha digitale*)

Euphausiids
(*Euphausia pacifica*)

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Introduction

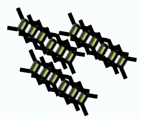
Oyashio region

- Dominant water masses were exchanged at the surface layer within a short period during spring (Kono and Sato 2010).
- Large phytoplankton bloom was occurred during spring (Isada et al. 2010).

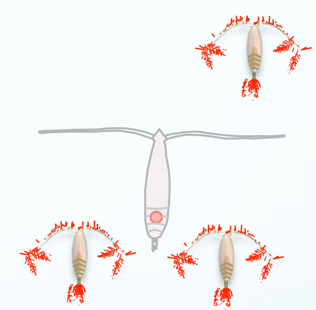
OECOS project

Under PICES endorsement, short-term observations were conducted during March-April 2007 (OECOS project, results were published in special issues of DSR II).

Changes in water mass and phytoplankton



Reproduction and growth of dominant copepods



Effect of water mass exchange and food condition on macrozooplankton taxa is less studied, except those of euphausiids (Kim et al. 2010). In this study, we evaluated short-term changes in another macrozooplankton taxa: amphipods, chaetognaths, hydrozoans, and discussed taxa-specific responses to the environmental factors.

Materials and Methods

➢ Field sampling

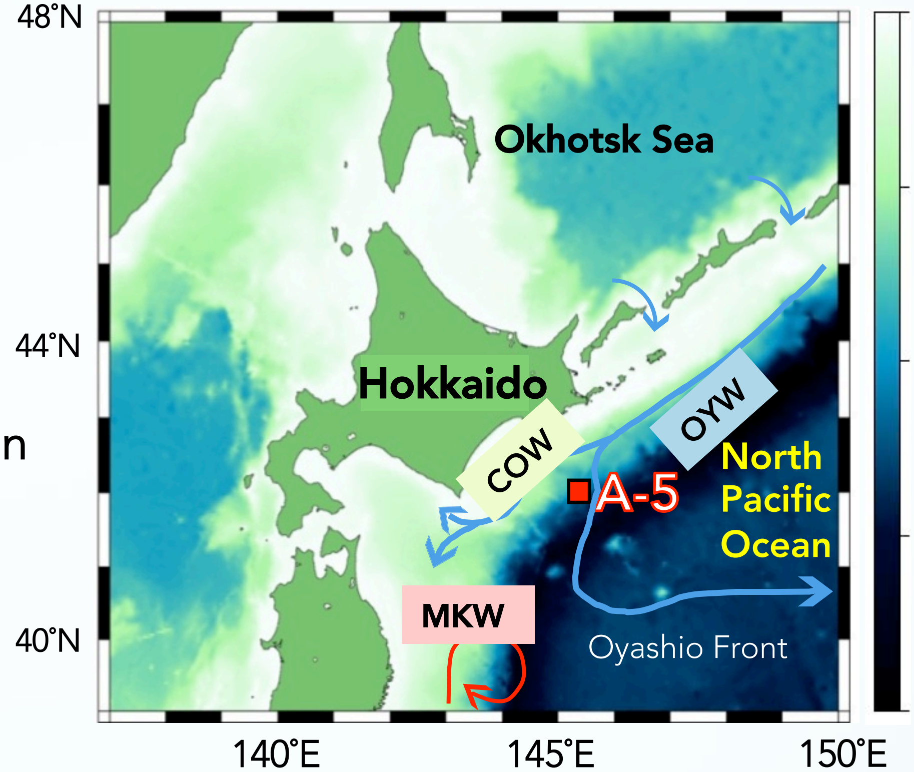
Oblique tow (0-200 m) of Bongo-net (0.335 mm mesh) were made at night from eleven occasions during 9 March-30 April 2007.

Samples were preserved with 5%-formalin seawater.

➢ Sample analysis

From entire sample, species identification and enumeration were made for macrozooplankton.

Body sizes were measured for up to 300 individuals in each sample.



Coastal Oyashio Water: COW

Oyashio Water: OYW

modified Kuroshio Water: MKW

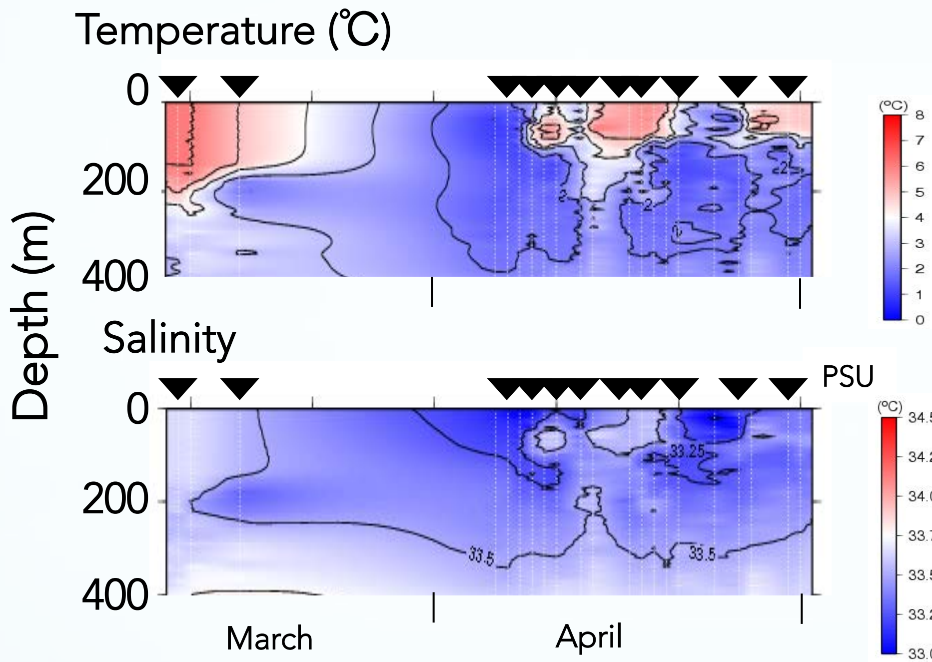
➢ Data analysis

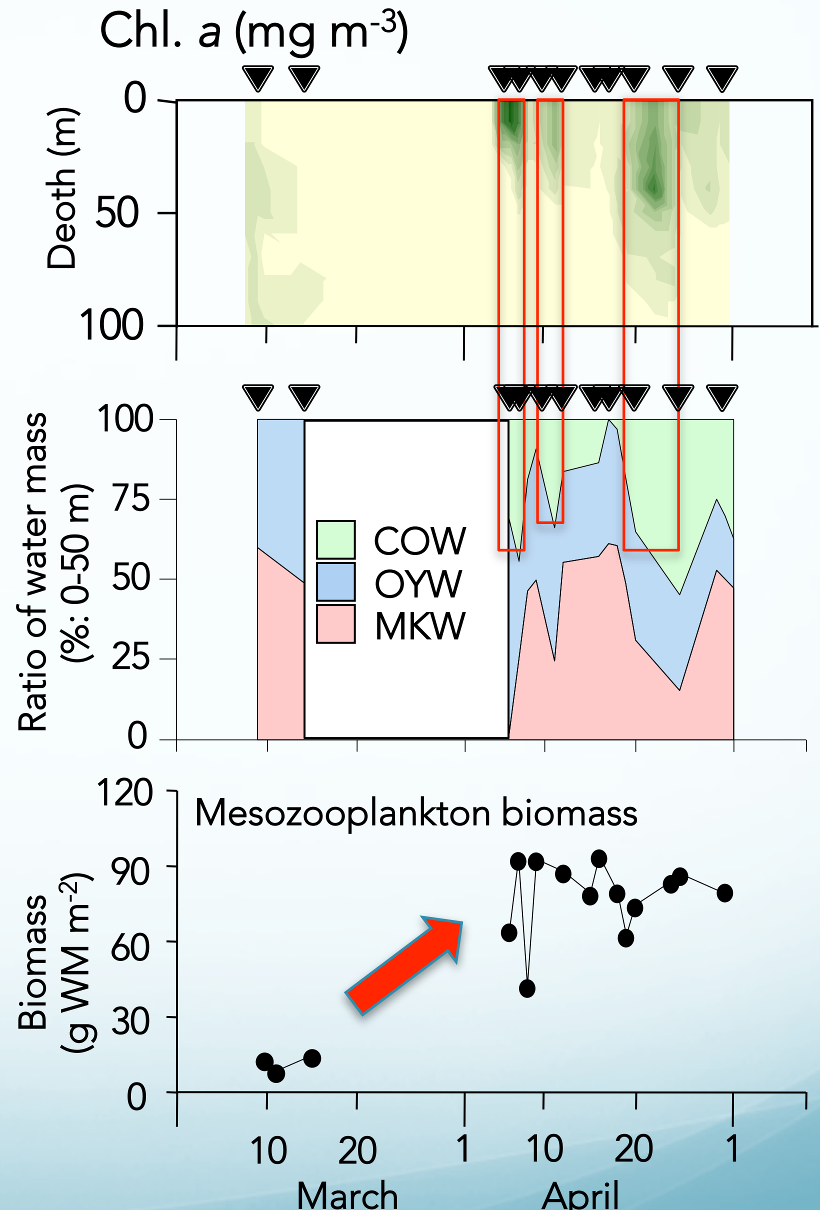
Using temperature and salinity data, mixing ratio of three water masses (COW, OYW and MKW, Kono and Sato 2010) in the upper 50 m was calculated.

Geographical origin of water mass at each sampling date was back-calculated by aid of FRA-ROMS.

From body size data, separation of cohort was made by aid of free-software R.

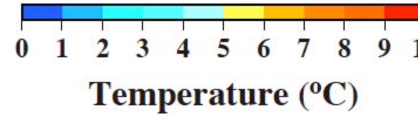
Results (Hydrography)



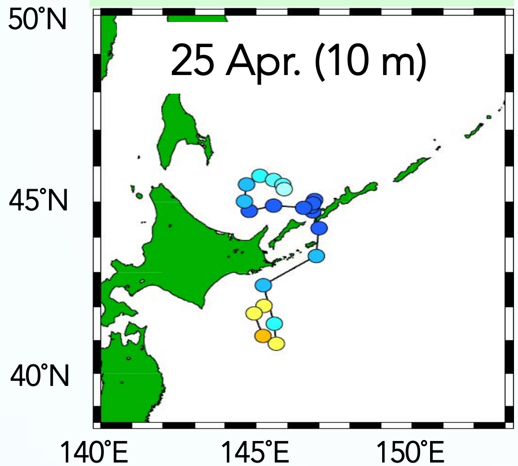


- **Water mass**
  Three water masses were occurred throughout the sampling period.
- **Phytoplankton bloom**
  Chl. *a* had three peaks (>10 mg m^{-3}) which corresponded with the timing of intrusion of COW.
- **Mesozooplankton**
  Mesozooplankton biomass evaluated by NORPAC net was increased in April.

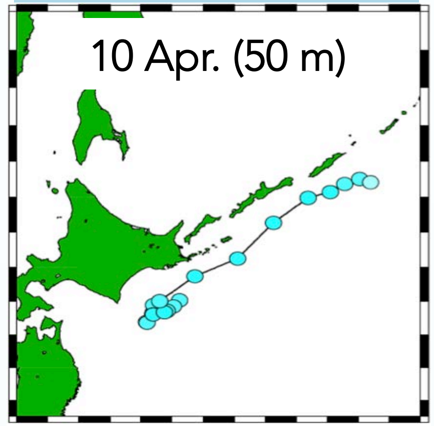
Results (FRA-ROMS)



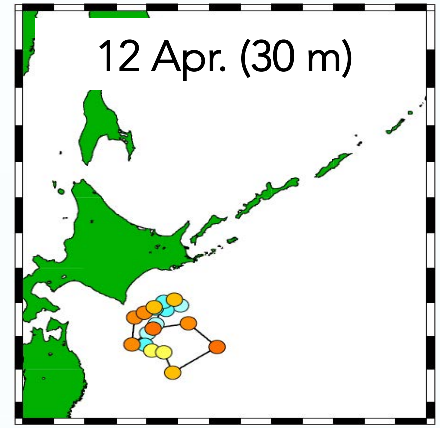
Coastal Oyashio Water: COW

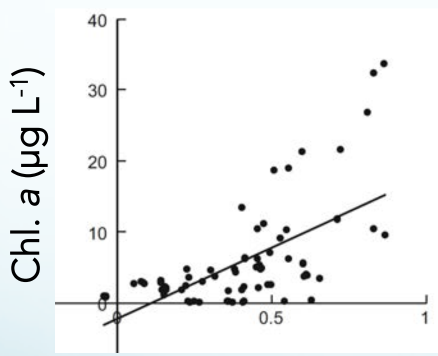


Oyashio Water: OYW



modified Kuroshio Water: MKW



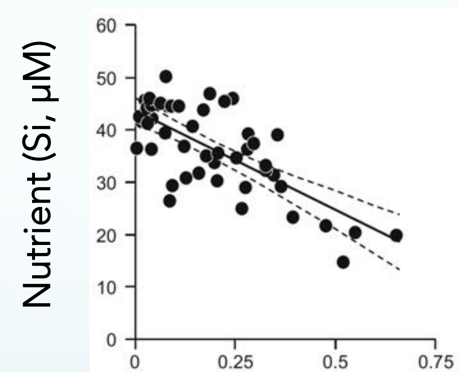


Mixing ratio of COW

Kono and Sato (2010)

Origins of three water masses were greatly varied geographically.

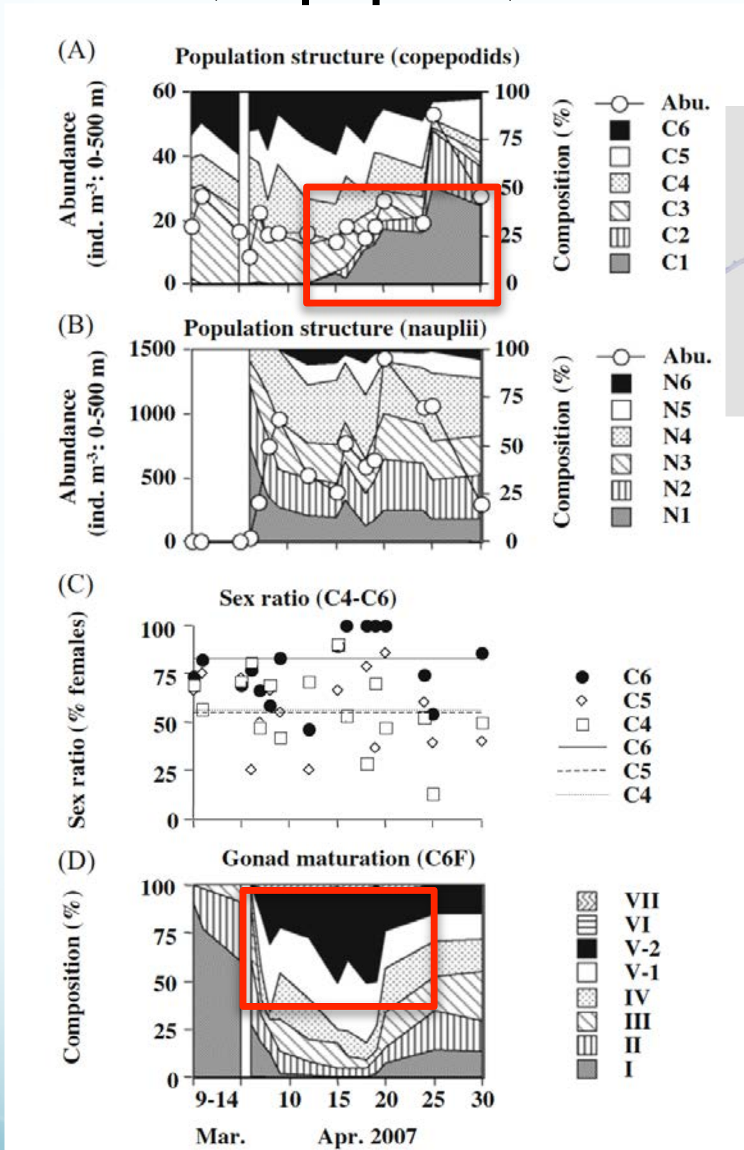
Magnitude of phytoplankton bloom and nutrient/iron concentration were correlated with the mixing ratio of water masses.



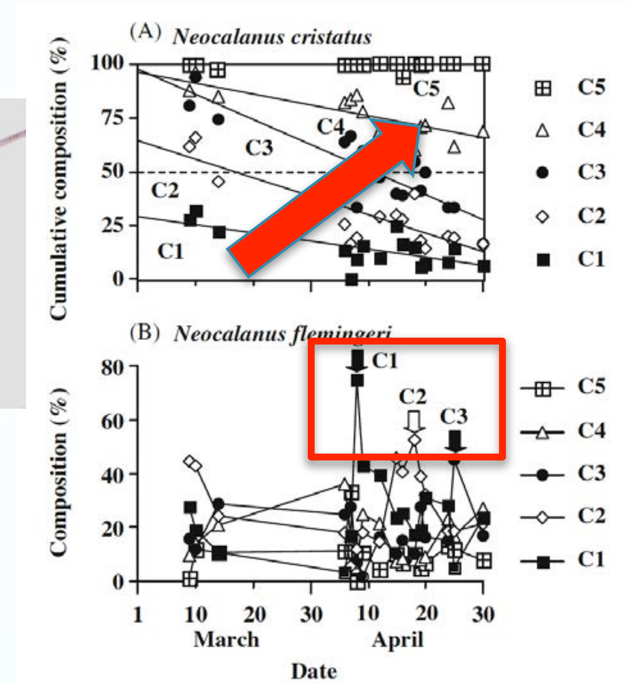
Mixing ratio of MKW

Sugie et al. (2010)

Results (Copepods)



E. bungii C5



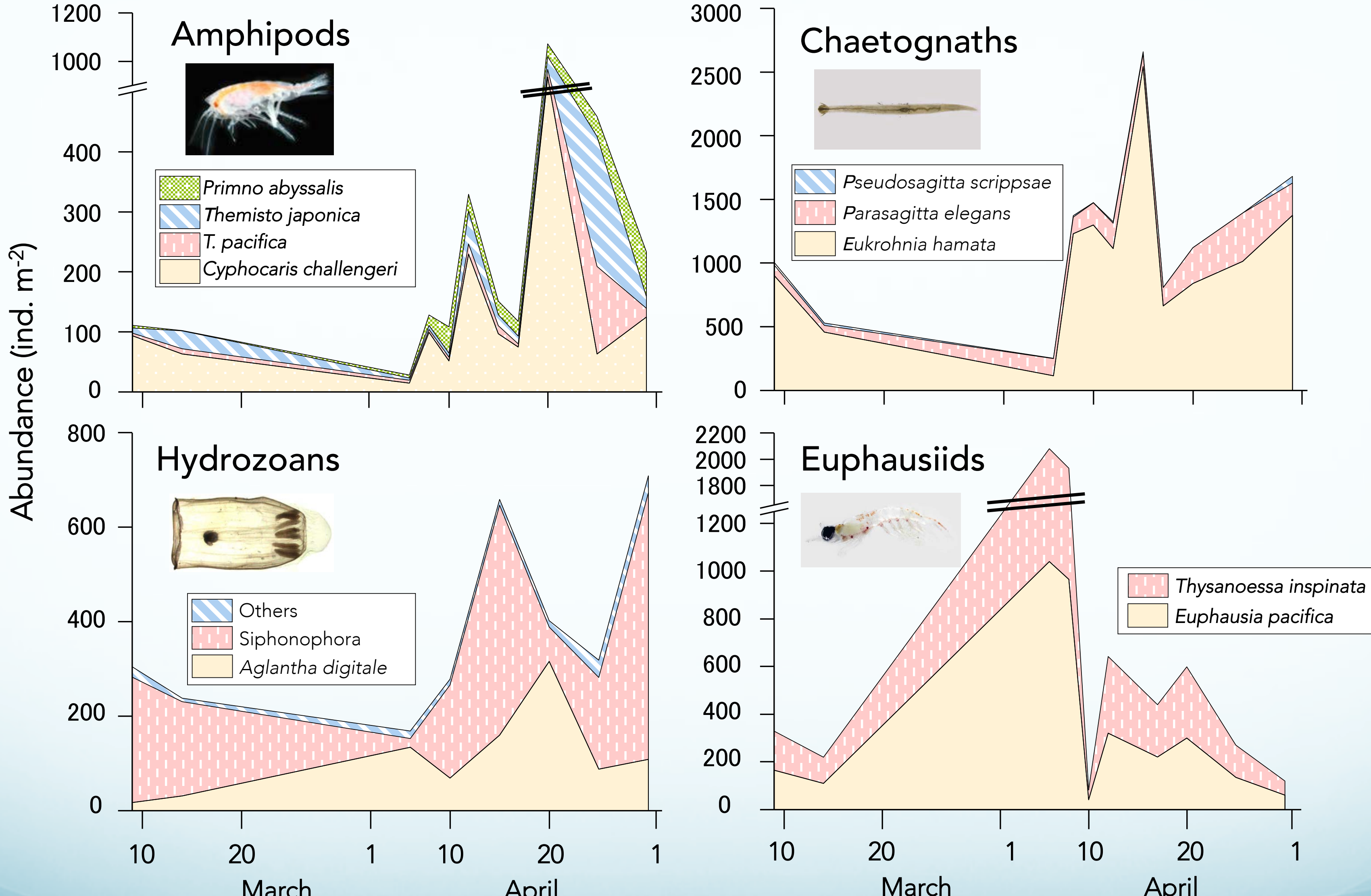
N. cristatus C5

N. flemingeri C5

- Dominant copepods achieved gonad maturation and reproduction during spring (*Eucalanus bungii*, left).
- Another dominant copepods performed massive development during spring (*Neocalanus cristatus* and *N. flemingeri*, upper panel).

Yamaguchi et al. (2010)

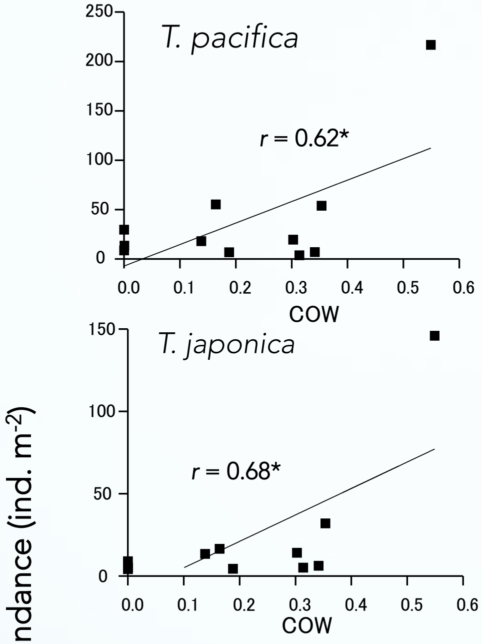
Results (Macrozooplankton abundance and species composition)



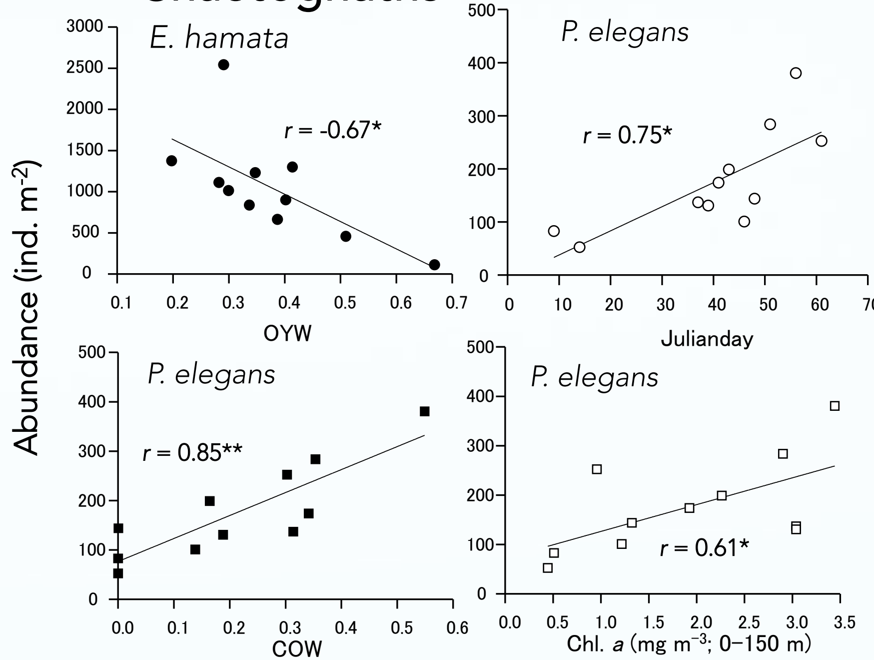
Within the macrozooplankton, their abundance showed taxa-specific pattern: thus, carnivorous taxa were higher in April, while euphausiids had peak in early April, which corresponded with the high chl. *a* period.

Results (Relationship between abundance and environmental parameters)

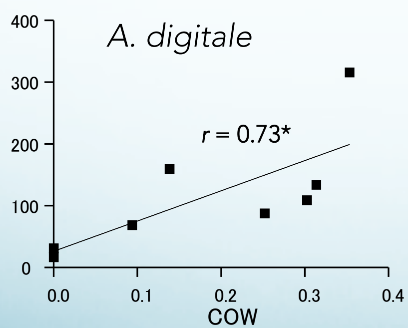
Amphipods



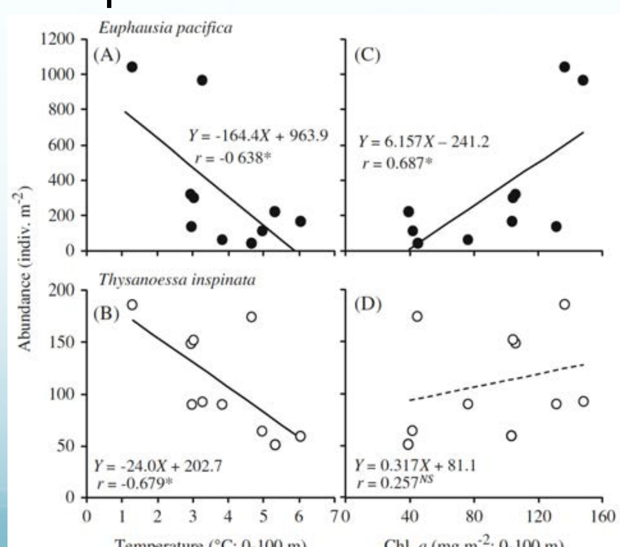
Chaetognaths



Hydrozoans



Euphausiids



Kim et al. (2010)

- **Abundance of macrozooplankton** had significant correlation with various environmental parameters: mixing ratio of COW, OYW, Julian day, temperature and chl. *a*.

Results (environmental parameters vs. macrozooplankton abundance)

(+ : positive correlation, —: negative correlation, *: $p<0.05$, **: $p<0.01$)
Chyphocaris challengeri (Cc), *Primno abyssalis* (Pa), *Themisto pacifica* (Tp), *Eukrohnia hamata* (Eh), *Parasagitta elegans* (Pe), *Euphausia pacifica* (Ep), *Thysanoessa inspinata* (Ti) and *Aglantha digitale* (Ad)

	Amphipods			Chaetognaths		Euphausiids		Hydrozoans
	Cc	Tj	Tp	Eh	Pe	Ep	Ti	Ad
Environmental parameters								
Julian day	0.247	0.4	0.365	0.329	0.751**			0.563
Temperature (0-50 m)	-0.113	-0.321	-0.329	0.34	-0.402	-0.638*	-0.679*	-0.352
Salinity (0-50 m)	-0.163	-0.41	-0.414	0.173	-0.542			-0.446
Mixing ratio of COW (0-50 m)	0.218	0.684*	0.626*	0.041	0.848**			0.735*
Mixing ratio of OYW (0-50 m)	-0.238	-0.278	-0.299	-0.678*	-0.476			-0.236
Mixing ratio of MKW (0-50 m)	0.042	-0.428	-0.362	0.395	-0.447			-0.472
Chl. *a* (0-150 m)	0.272	0.508	0.478	-0.168	0.609*	0.687*	0.257	0.524
Mesozooplankton wet weight (0-150 m)	0.038	0.189	0.175	0.059	0.494			0.438

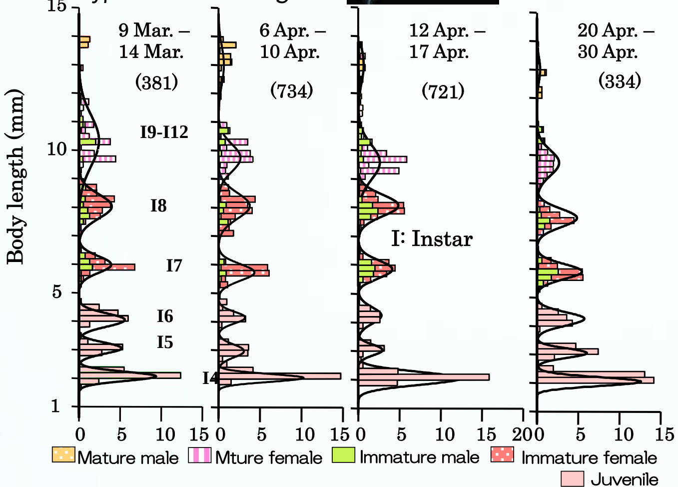
Data on euphausiids are from Kim et al. (2010)

- the mixing ratio of COW was the most important environmental parameter to govern the macrozooplankton abundance.
- While water mass mixing ratio analysis was not made for euphausiids, strong negative correlation with temperature and positive correlation with chlorophyll *a* suggest that both species may have positive correlation with the mixing ratio of COW.

Results (cohort analysis on body size spectra)

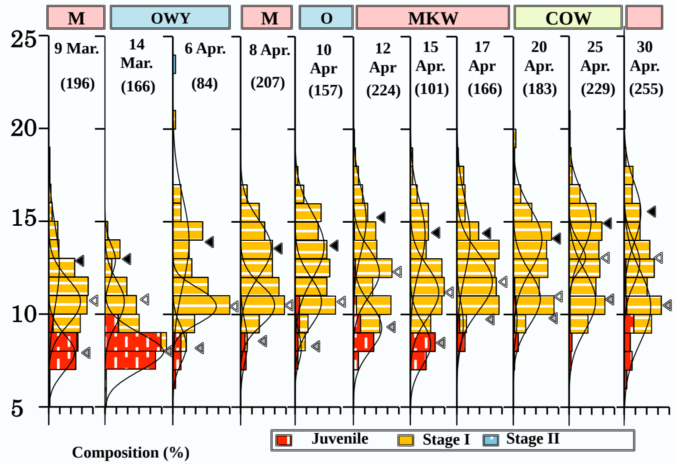
Amphipods

Cyphocaris challengeri



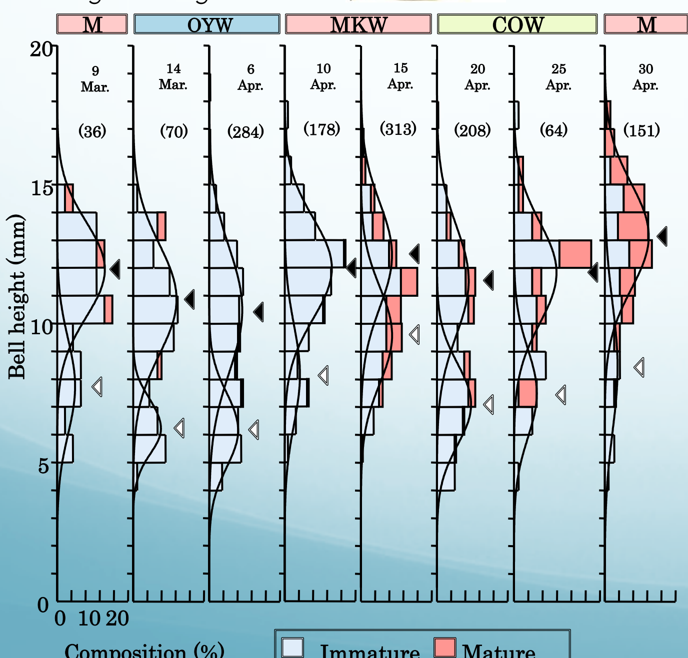
Chaetognaths

Eukrohnia hamata

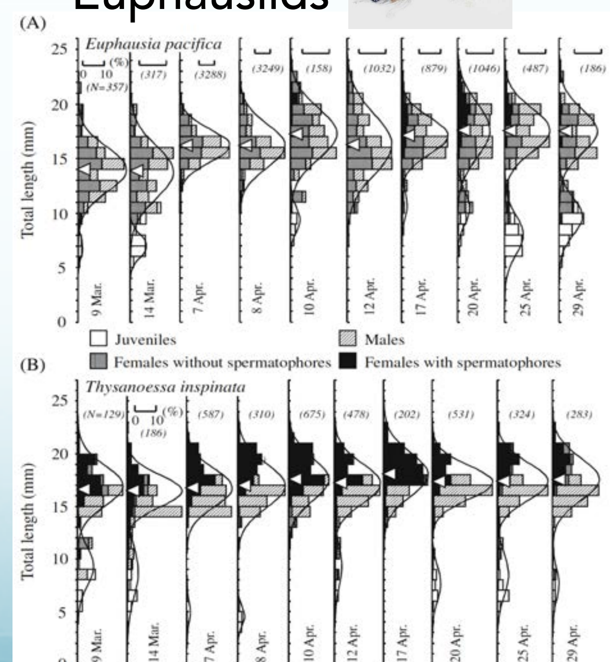


Hydrozoans

Aglantha digitale



Euphausiids

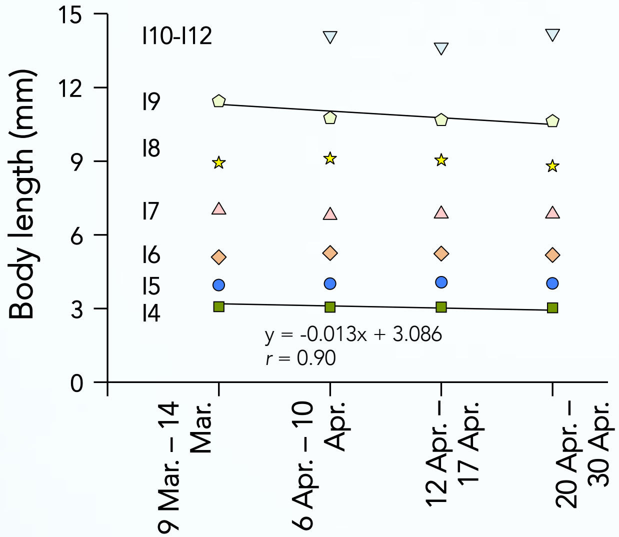


Kim et al. (2010)

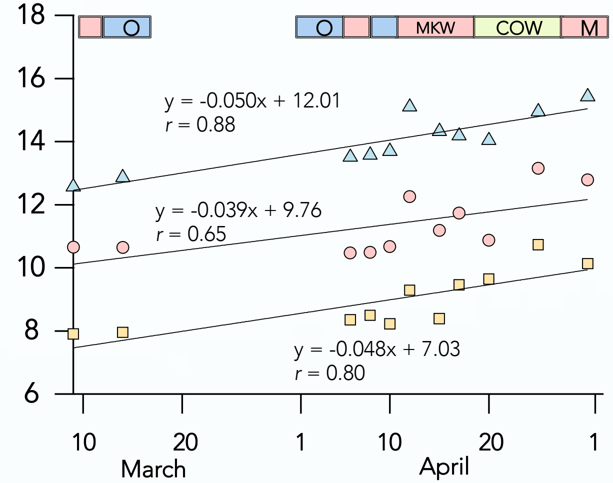
- Body size spectra of each macrozooplankton species showed clear modes which varied with species.
- From cohort analysis, two (hydrozoans) to seven (amphipods) cohorts were identified for each species at each sampling date.
- growth, maturation and reproduction has been observed by species.

Results (temporal changes in body size mode of each cohort)

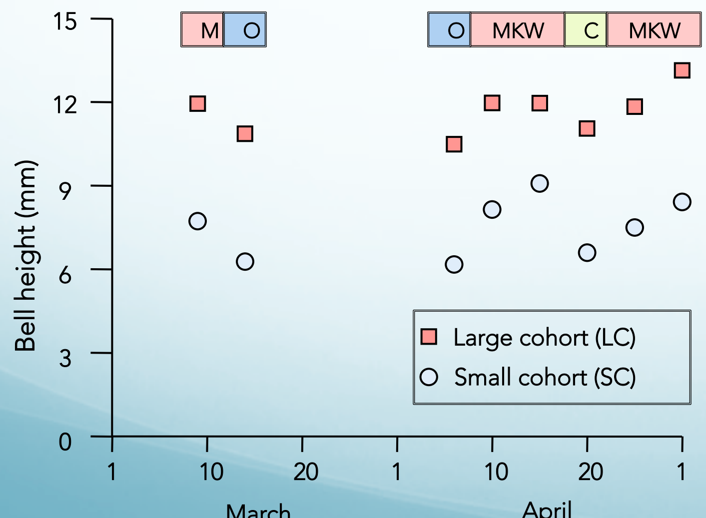
Amphipods



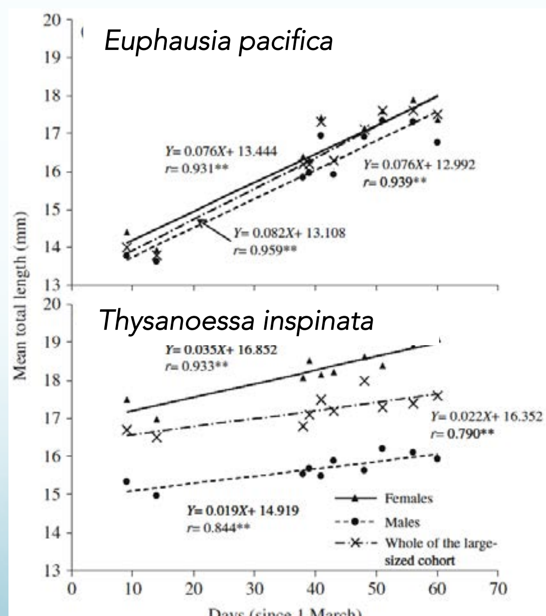
Chaetognaths



Hydrozoans



Euphausiids



Kim et al. (2010)

- Temporal changes in body size mode of each cohort showed taxa-specific pattern.
- Constant increase along time was the cases for chaetognaths and euphausiids

While

- Constant or slight decrease was for amphipods and no correlation with time was the case of hydrozoans

Summary (responses to spring environmental changes)

◎: strong correlated (*p*<0.05), ○: correlated (*p*<0.01) and △: not detected or not evaluated

	Effect of water mass change	Growth	Reproduction / Maturation	References
Macrozooplankton				
Amphipods	○	△	Reproduction	This study
Chaetognaths	◎	◎	Maturation	This study
Euphausiids	○?	◎	Reproduction	Kim et al. (2010)
Hydrozoans	○	△	Maturation	This study
Mesozooplankton				
Eucalanus bungii	△	○	High Reproduction	Yamaguchi et al. (2010)
Neocalanus spp.	△	◎	No detected	Yamaguchi et al. (2010)
Metridia pacifica	△	○	High Reproduction	Yamaguchi et al. (2010)
Mesopelagic copepods	△	○	Reproduction	Abe et al. (2012)

- As environmental changes in the Oyashio region during spring, →water mass exchange and phytoplankton bloom were remarkable.
- The responses to these changes were varied with taxa.

Mesozooplanktonic copepods

Effect of water mass change was small, and they achieved growth and reproduction

Macrozooplankton

greatly affected by water mass exchange, performed growth, while less reproductive activity than mesozooplanktonic copepods.

Thank you very much for your kindly attention!

Cyphocaris challengeri Mature female (Egg carrying)