Inter-annual and latitudinal changes in zooplankton abundance, biomass and size composition along 180° transect in the North Pacific during summers: analyses with an Optical Plankton Counter

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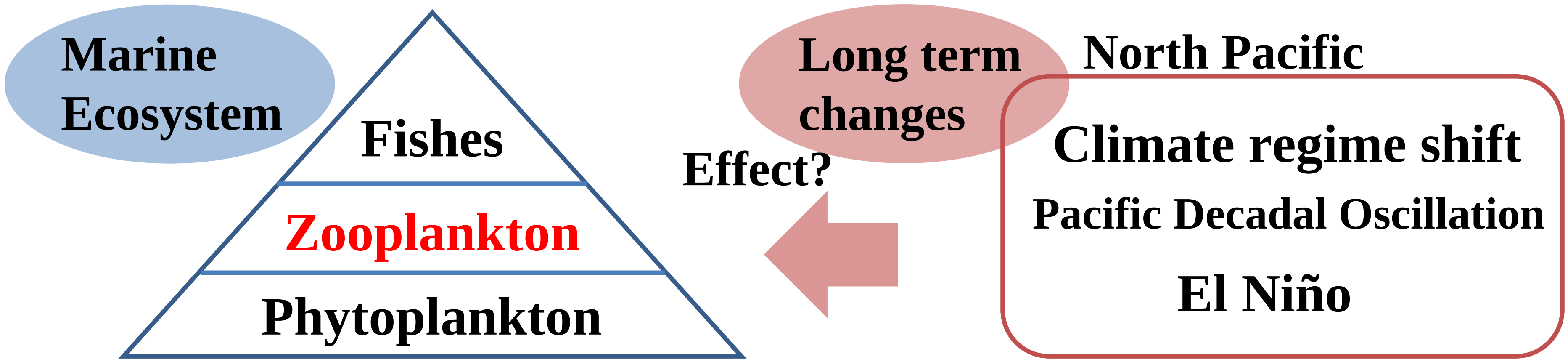
Background



Microscopic analysis:

Required taxonomic skill and time consuming

Optical Plankton Counter (OPC):

Accurate size and number of zooplankton quantified shortly

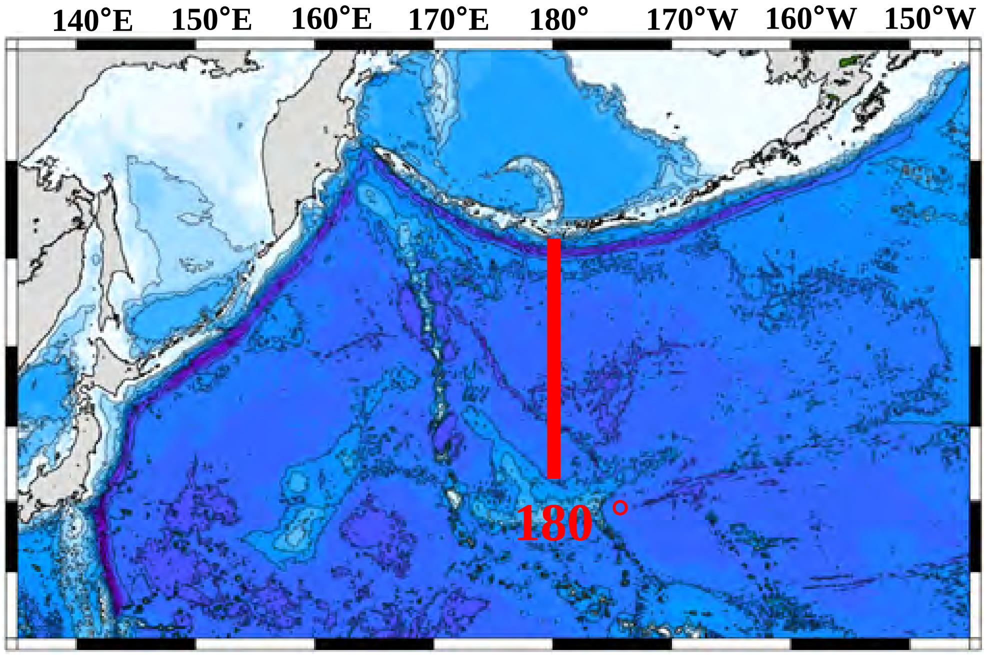
Normalized Biomass Size Spectrum (NBSS):

Index of structure of marine ecosystem

Object

To evaluate latitudinal and annual changes in zooplankton size stricture and NBSS along 180° in the central North Pacific

Materials and methods

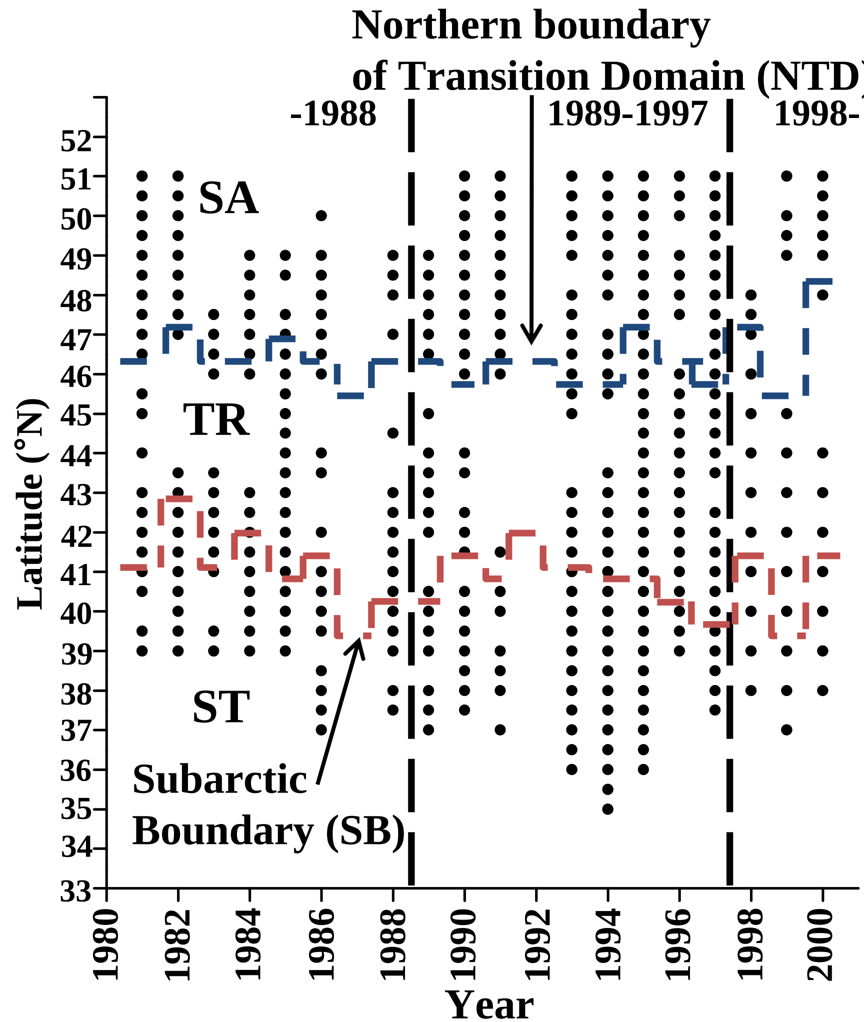


Period: 9-22 June of 1981-2000

Location: 35°N-51°N along 180°
(*n*=351, 12-31 in each year)

Sampling: Vertical tow of NORPAC net (335 μm mesh) from 150 m

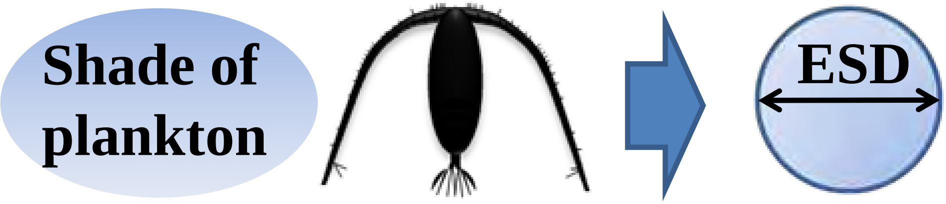
Hydrography: Temperature and salinity were measured with CTD



Region (3)	Regime (3)
Subarctic: SA	1981-1988
Transition: TR	1989-1997
Subtropical: ST	1998-2000

Methods (OPC measurement)

Size and number of zooplankton measured shortly (ca. 15 minutes per sample)



Equivalent Spherical Diameter

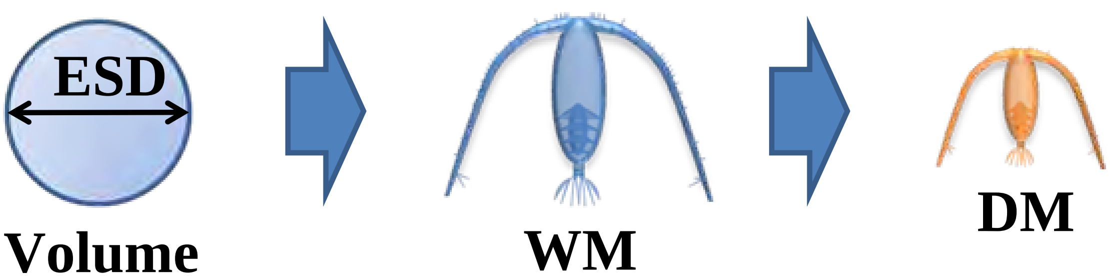
Biomass estimation

Wet mass (WM) of zooplankton estimated from ESD assuming density of zooplankton as equal to water

$$WM = \frac{1}{6} \times \pi \times ESD^3$$

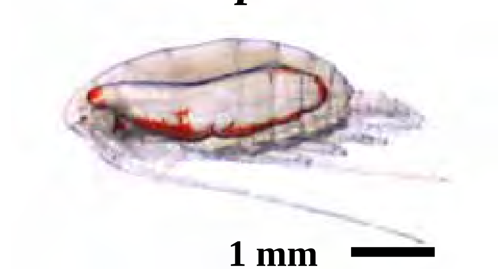
WM was converted to dry mass (DM) assuming water content as 90%

$$DM = WM \times 0.1$$



Laboratory OPC (OPC-1L)

Neocalanus plumchrus C5



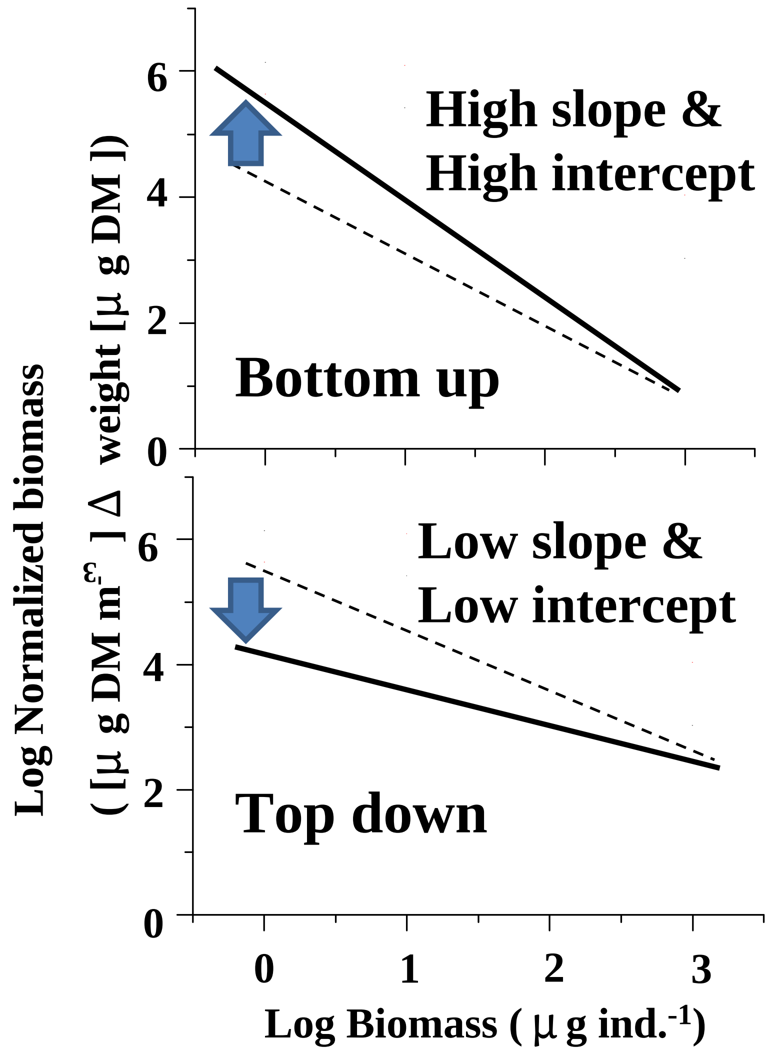
Method (NBSS: Normalized Biomass Size Spectra)

Slope and intercept of NBSS are indices of ecosystem structure

- ***X*-axis : Log biomass (µ g ind.$^{-1}$)**
- ***Y*-axis : Log normalized biomass ([µ g DM m^{-3}] Δ weight [µ g DM])**

NBSS: *Y* = *a X* + *b*
(*a* = slope, *b* = intercept)

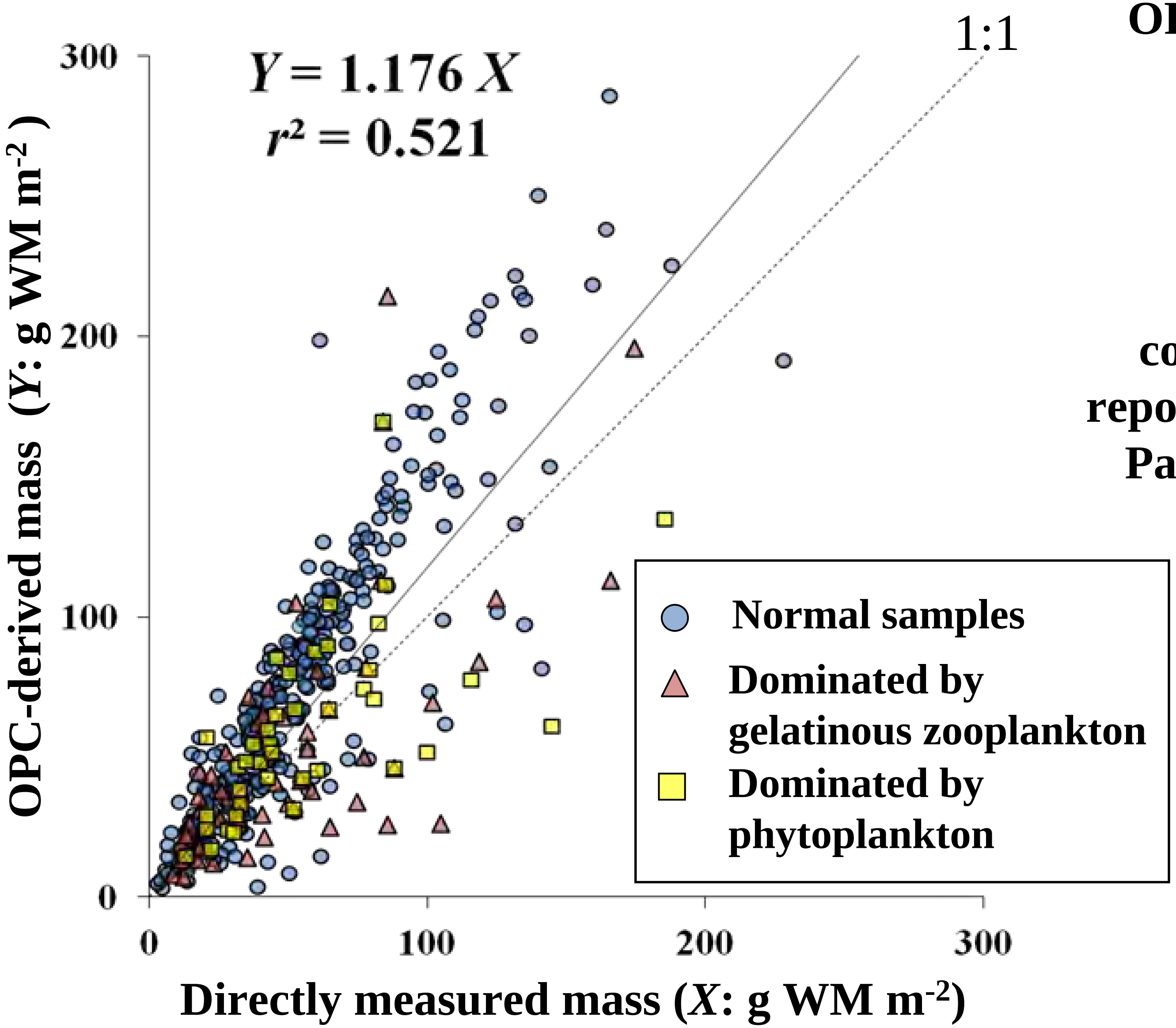
	Low	High
Slope (*a*)	**Low**	**High**
Intercept (*b*)	**Low**	**High**
Ecosystem	**Top down**	**Bottom up**



Data analysis

Latitudinal and annual changes in hydrography, zooplankton abundance, biomass and NBSS were tested by one-way ANOVA and Fisher's PLSD

Results: OPC calibration

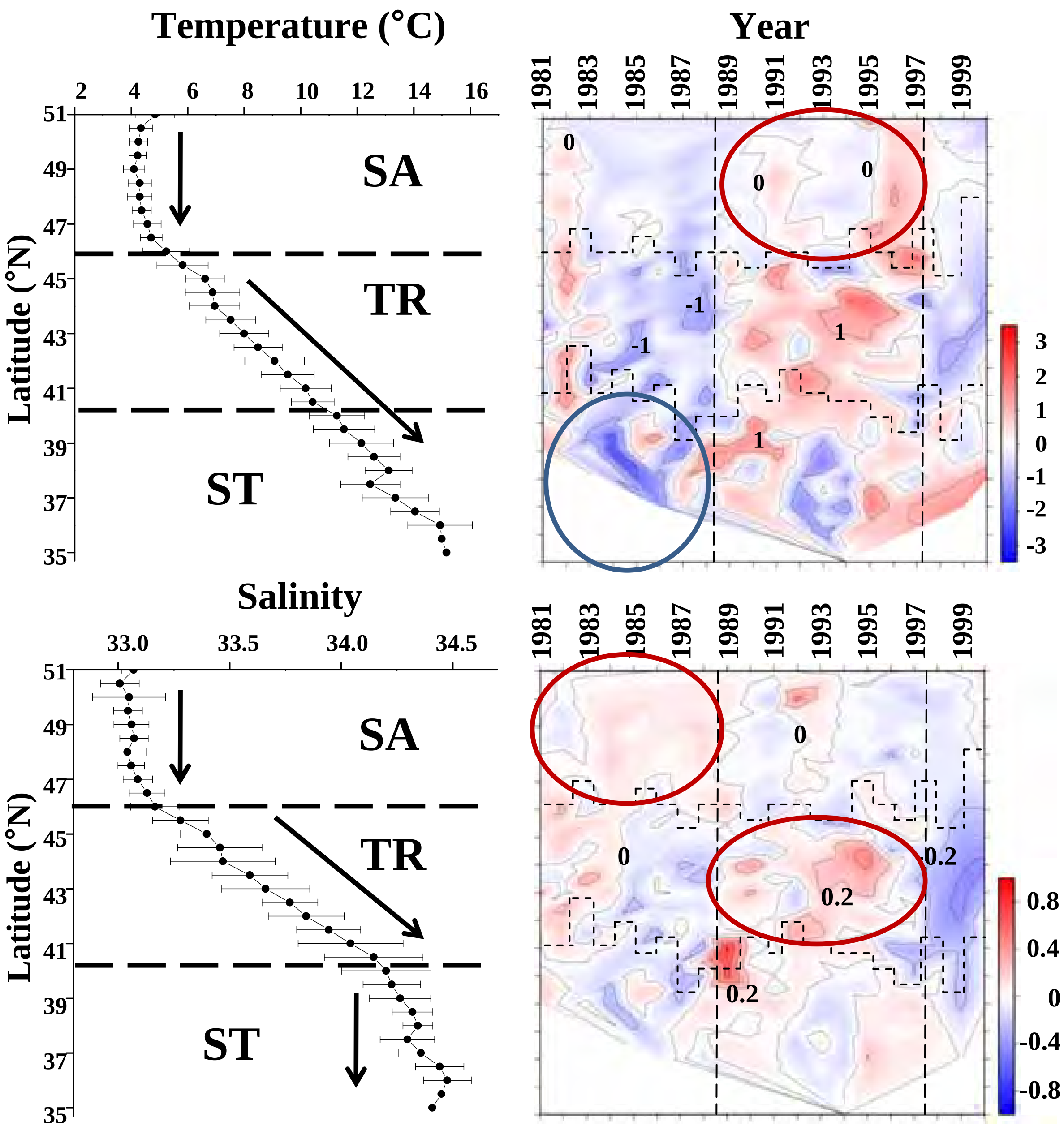


OPC slightly higher than measured values (1.176 times)

This factor is well corresponded with the reported values from North Pacific (0.96-1.16 times)

Biomass conversion (*X*/1.176) was made for OPC-derived mass

Results: Latitudinal and annual changes in hydrography



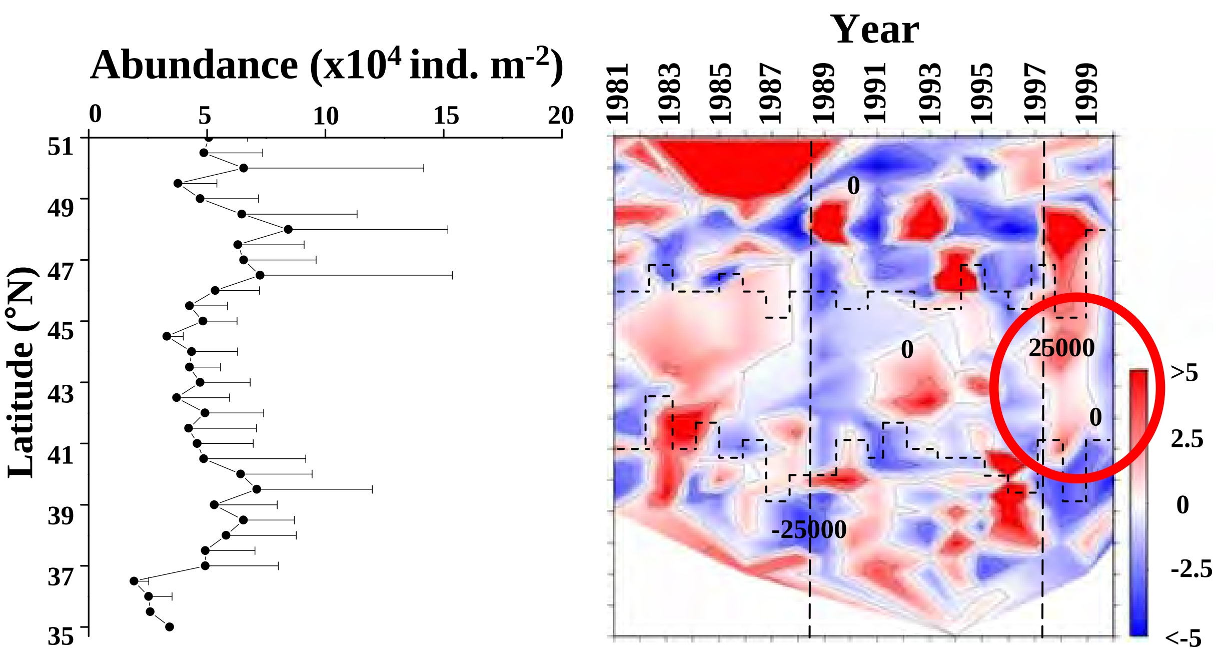
Temperature

<u>Latitudinal pattern</u>:
Little changes in SA, while increased to south in TR and ST.
<u>Annual pattern</u>:
Higher during 1989-1997
Lower during 1981-1988

Salinity

<u>Latitudinal pattern</u>:
Little changes in SA and ST, while increased to south in TR
<u>Annual pattern</u>:
Higher in SA and TR during 1981-1988 and 1989-1997, respectively

Results: Latitudinal and annual changes in zooplankton abundance and biomass



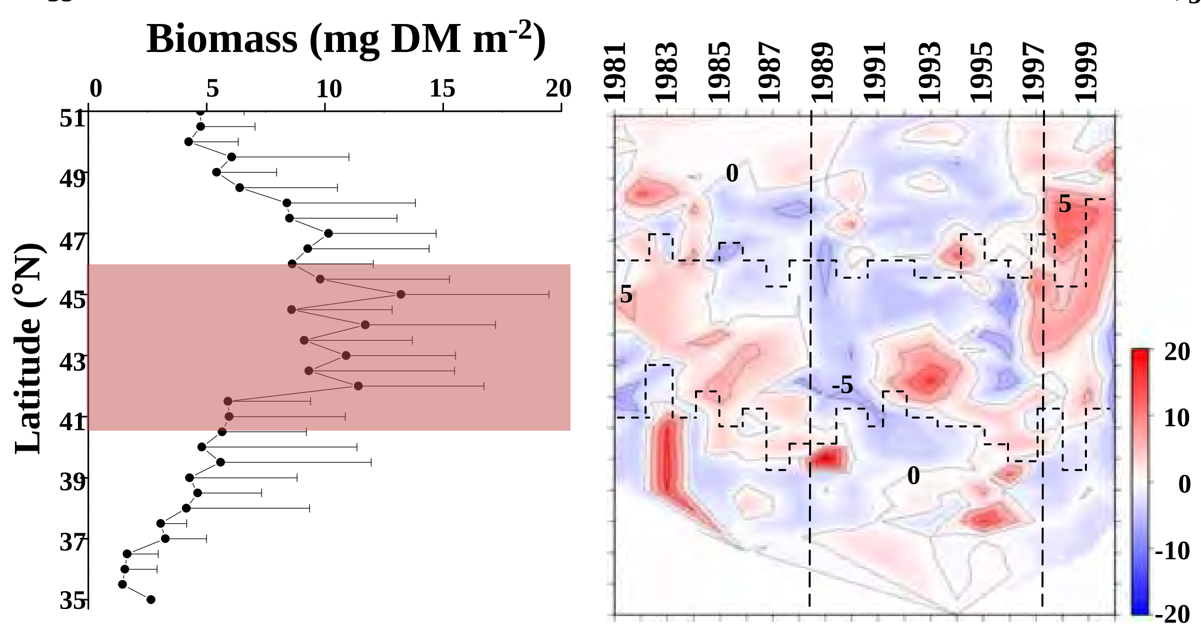
Abundance

Latitudinal pattern:

Little latitudinal change

Annual pattern:

Higher in TR during 1998-2000



Biomass

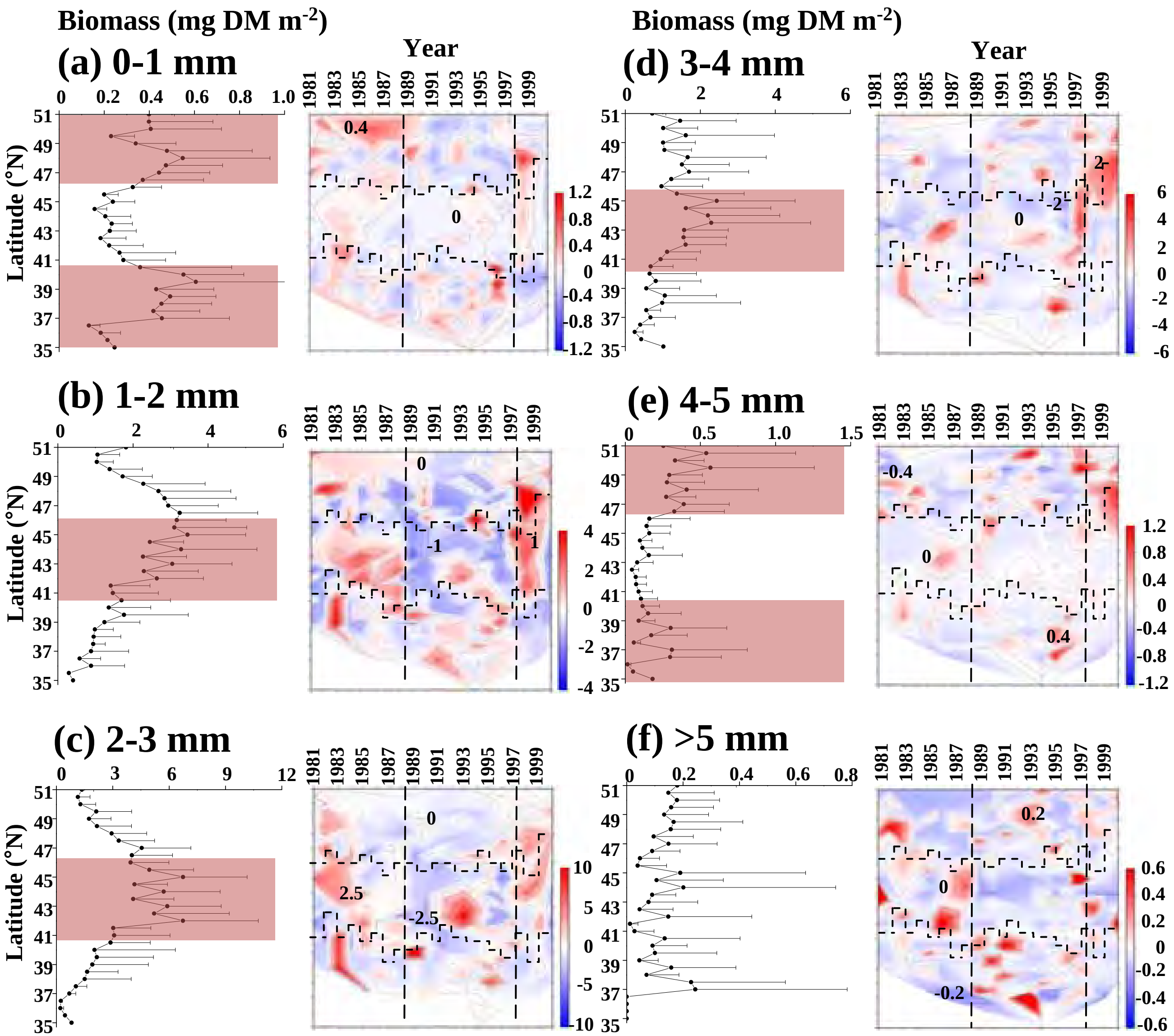
Latitudinal pattern:

Clear latitudinal changes: Highest in TR, followed by SA and least in ST (TR > SA > ST)

Annual pattern:

Higher in SA and TR during 1998-2000

Results: Latitudinal and annual changes in zooplankton biomass with size class

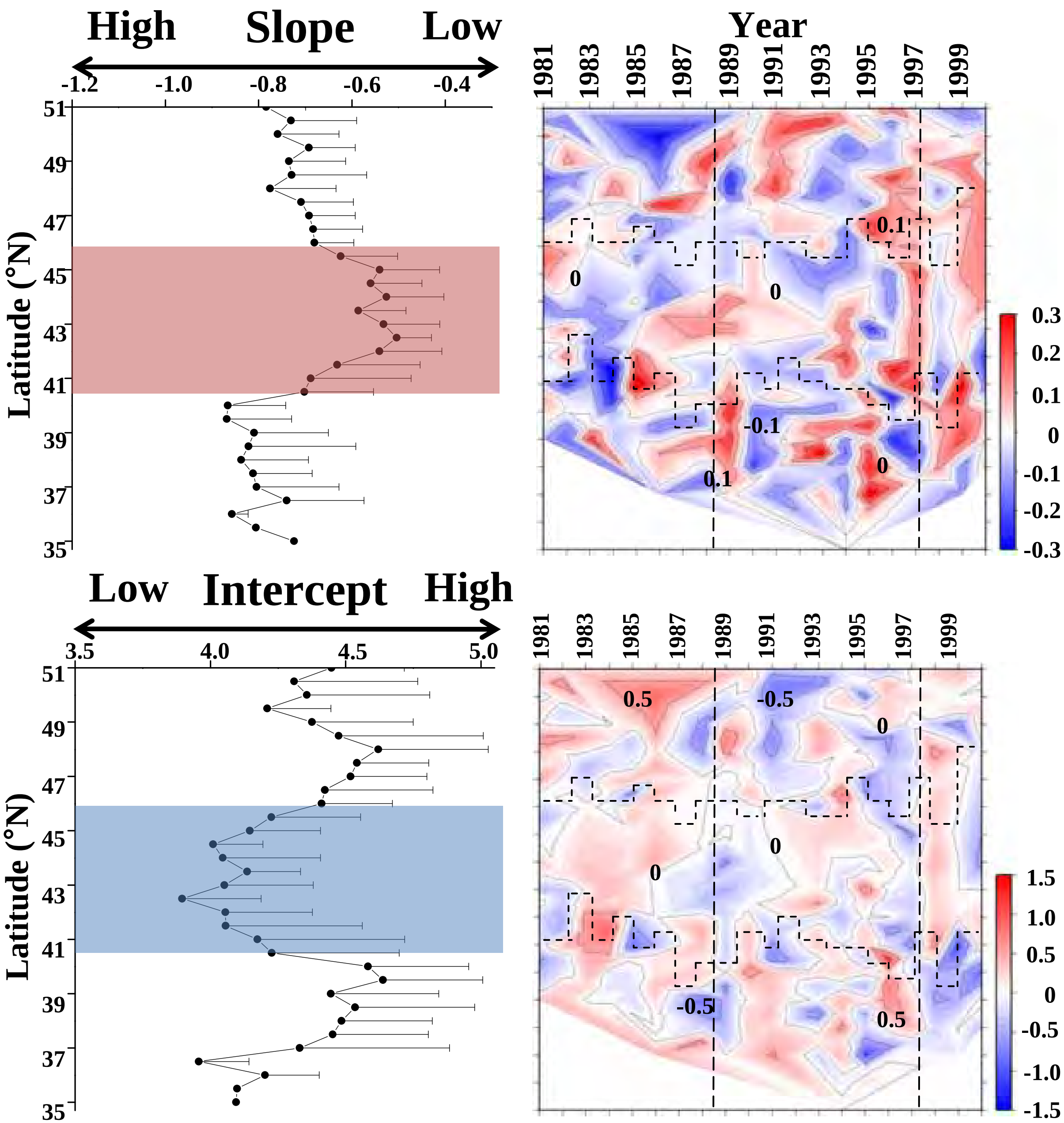


Biomass with size class

Latitudinal pattern:
Clear latitudinal pattern varied with size class:
Higher in SA and ST for 0-1 and 4-5 mm.
Higher in TR for 1-2, 2-3 and 3-4 mm.

Annual pattern:
No clear annual pattern was detected for biomass at each size class

Results: Latitudinal/annual changes in slope and intercept of NBSS



Slope of NBSS

__Latitudinal pattern__:
Clear latitudinal change, thus lower in TR.

__Annual pattern__:
There were no clear annual changes

Intercept of NBSS

__Latitudinal pattern__:
Clear latitudinal change, thus lower in TR.

__Annual pattern__:
There were no clear annual changes

Both slope and intercept of NBSS suggest __that top down control dominated in TR__

Summary

Latitudinal changes

All parameters in this study (hydrography, zooplankton biomass and NBSS) showed clear latitudinal changes.

Highest biomass in TR was made by dominance of large-sized *Neocalanus* spp. C5 (ESD: 2-3 mm).

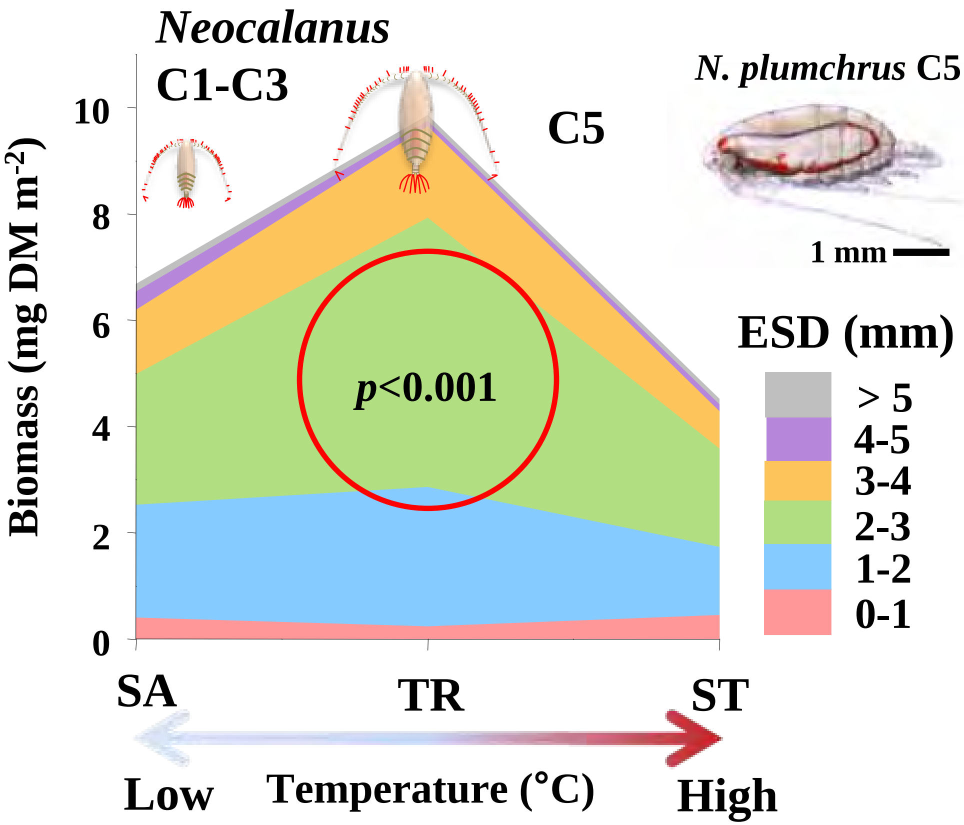
Highest biomass at TR region in the central North Pacific is corresponded with the cases in the western (Matsuno et al. 2009) and eastern (Saito et al. 2011) North Pacific.
NBSS analysis revealed that the top down control dominated in TR.

Annual changes

No clear annual patterns were detected for zooplankton in this study.

Variability in the central North Pacific zooplankton dominated by latitude, yet was apparently consistent over inter-annual time scales.

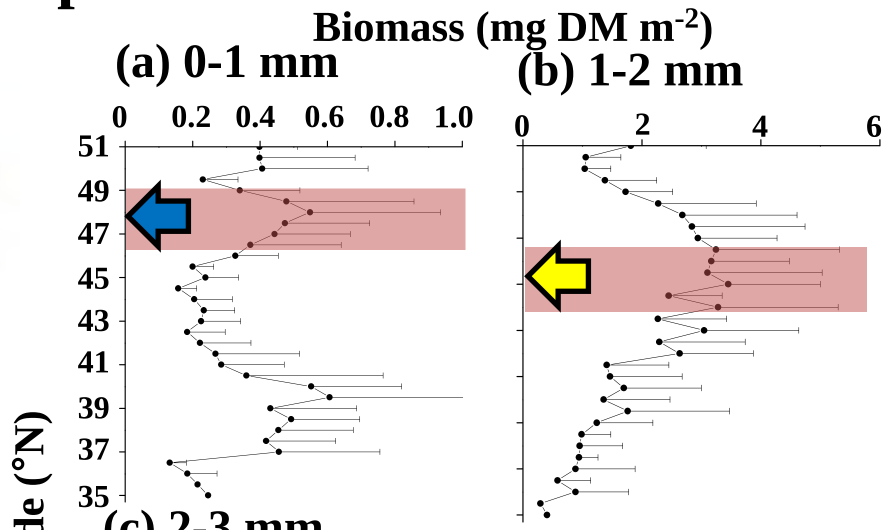
Discussion: Latitudinal changes in zooplankton biomass

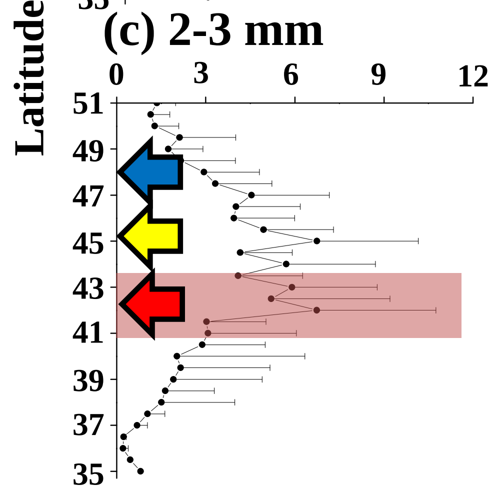


Biomass: ST < SA < TR

Reflect of 2-3 mm ESD

ESD 2-3 mm corresponds to *Neocalanus* spp. C5. They distributed both SA and TR, and higher temperature in TR may induce faster development.



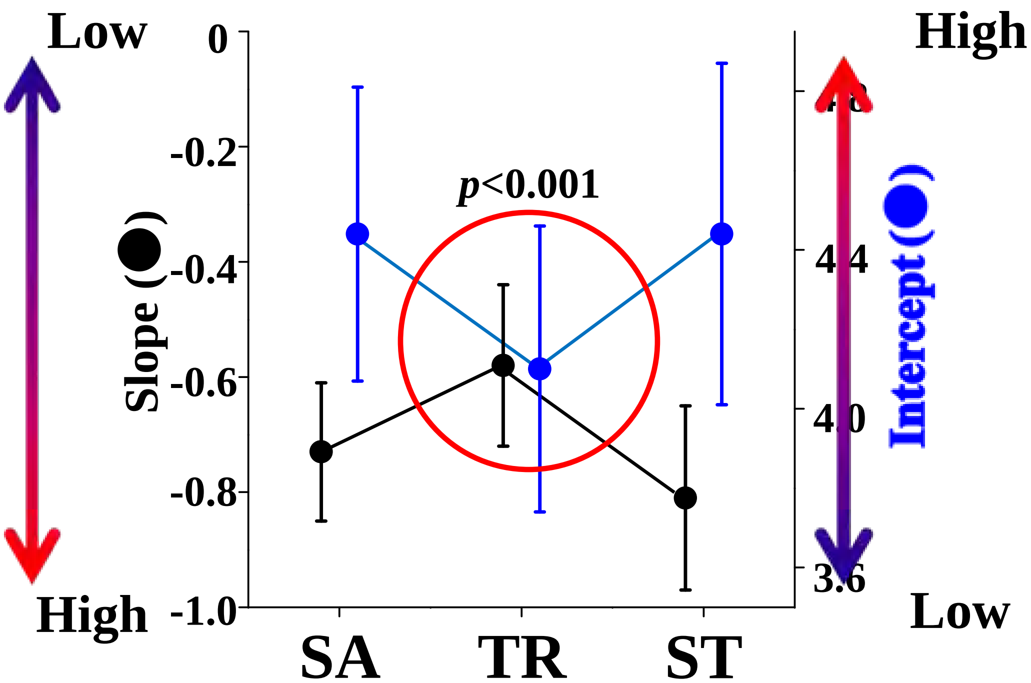


Peak latitude shifted to south for large size class

Reflect of faster development of *Neocalanus* in the south

Biomass was determined by what stage dominated for *Neocalanus*.

Discussion: Latitudinal changes in NBSS



NBSS in TR was characterized with low slope and intercept:
<u>Top down control dominated in TR</u>.

Top down control in TR was governed by dominance of *Neocalanus* spp. C5 there.