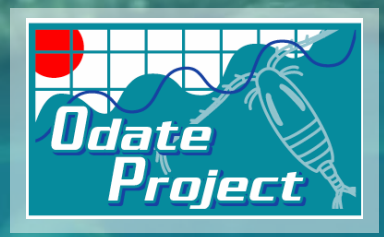
Decadal changes of the Oyashio and Kuroshio affected spatio-temporal variation of the copepod community in the western North Pacific

What copepod community change tells about:
Link between climate to lower trophic level ecosystem
- study based on the Odate Collection -



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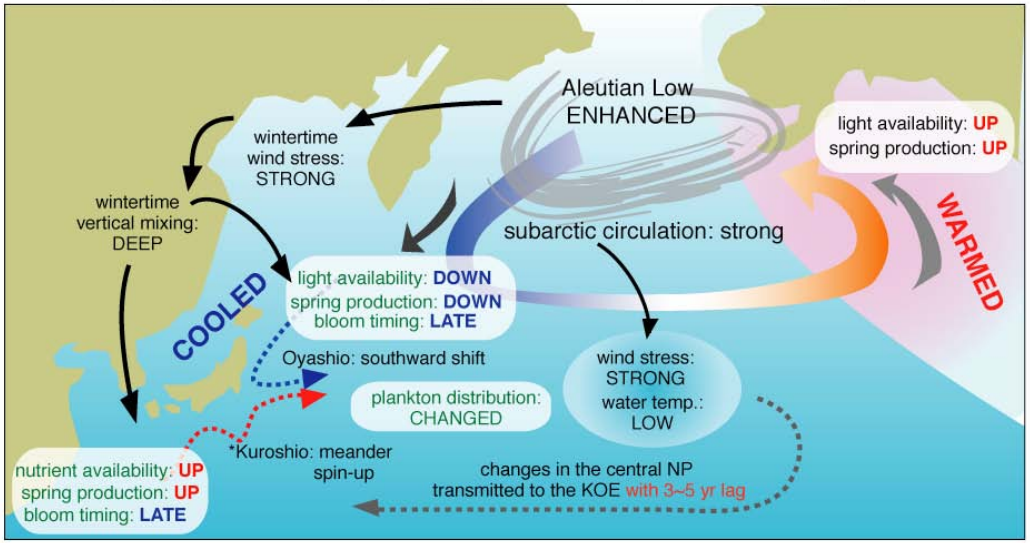
[1]FRCGC, JASMTEC, [2]NFRI, [3]Nagoya University

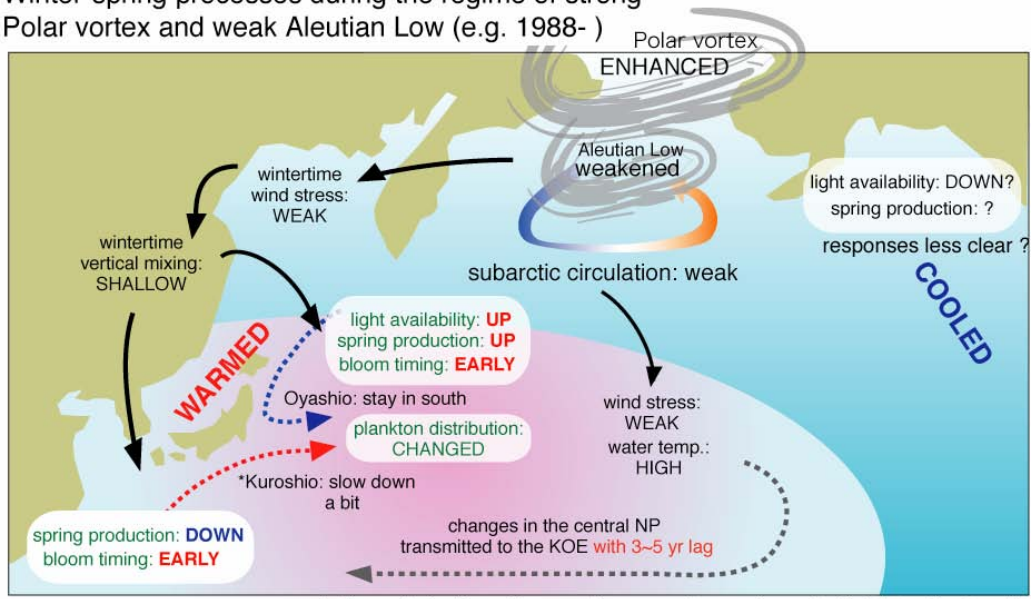
(Chibas@jamstec.go.jp)

Winter-spring processes during the regime of strong Aleutian Low (e.g. 1976 -)



* Change in the Kuroshio properties occurred several years behind that of the Oyashio

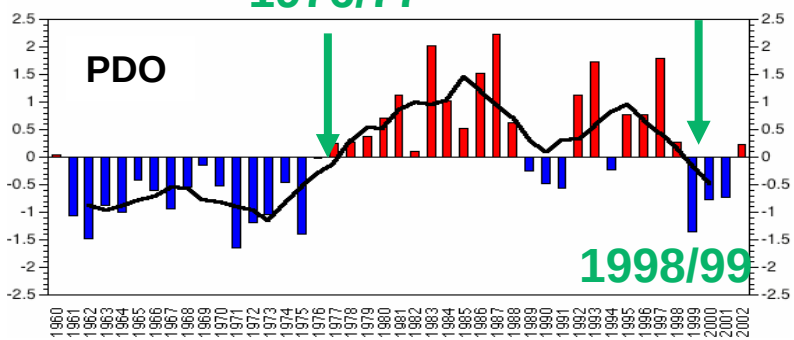
Winter-spring processes during the regime of strong
Polar vortex and weak Aleutian Low (e.g. 1988-)



* Change in the Kuroshio properties occurred several years behind that of the Oyashio

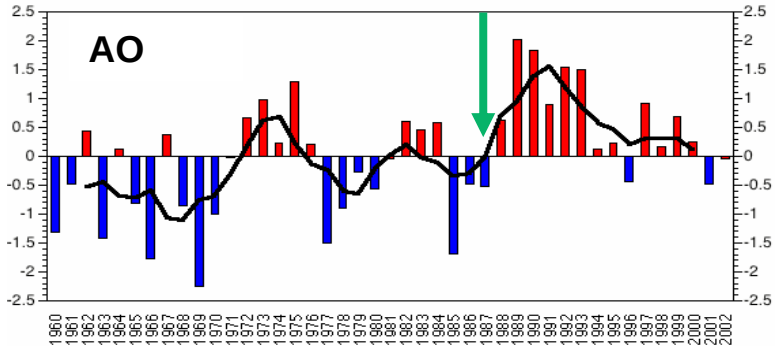
Regime shift

1976/77



(http://tao.atmos.washington.edu/pdo/)

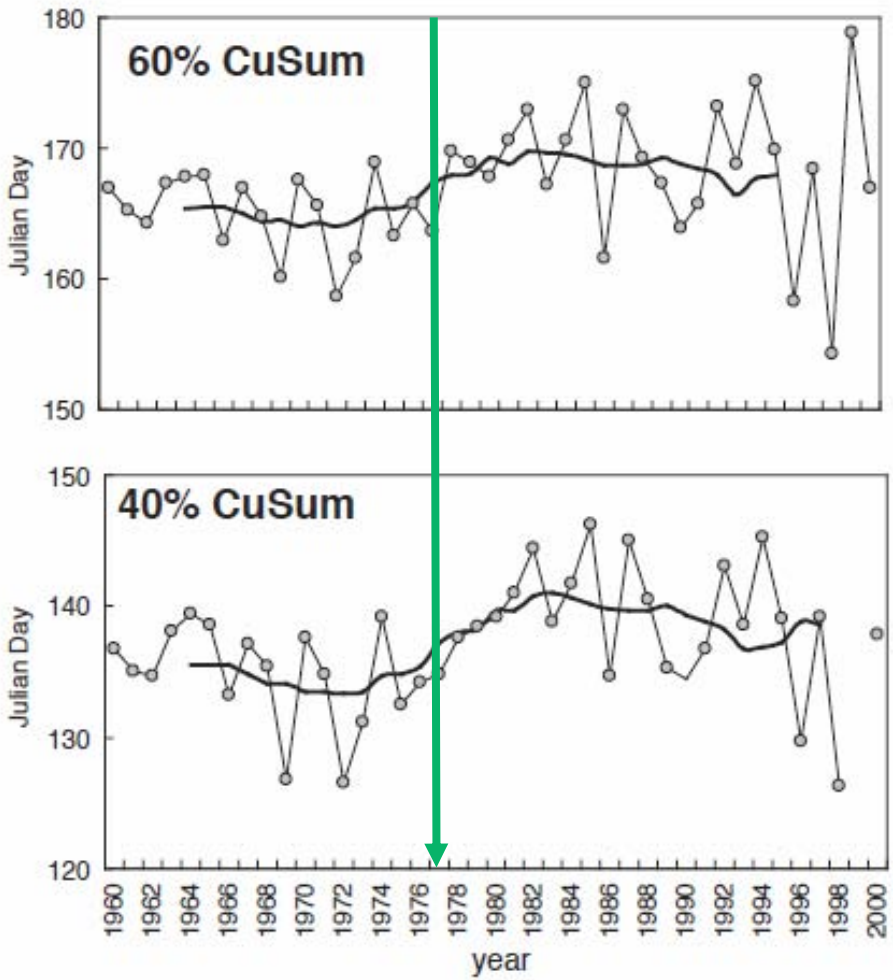
1988/89



(http://tao.atmos.washington.edu/ao/)

Timing of phytoplankton bloom (based on the modeled PP) in Oyashio

CuSum: Cumulative sum of annual primary production (Feb-Aug)(g C m^{-2} yr^{-1})

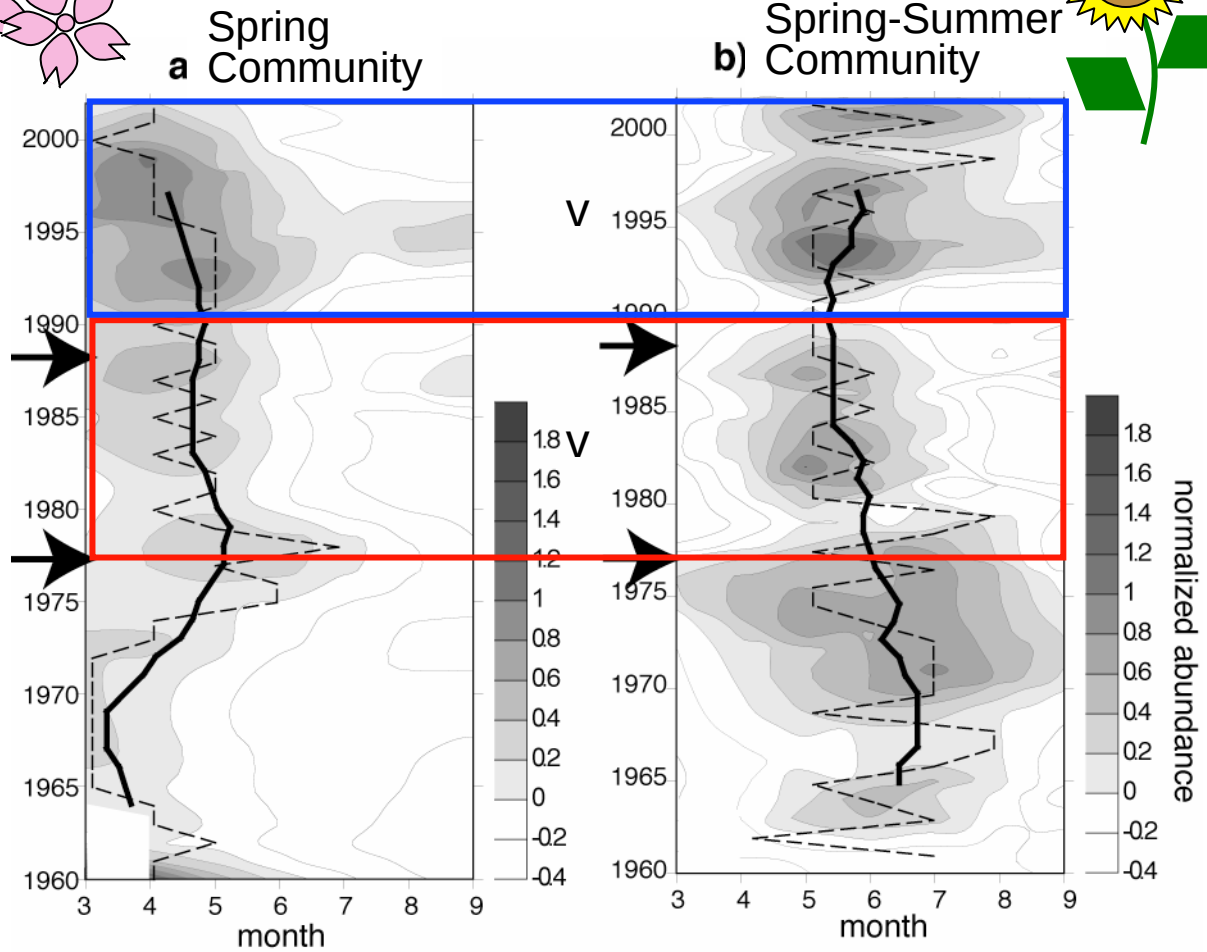


Up to 20 day delay in bloom timing after the 1970s RS

Abundance peak of copepods communities in Oyashio

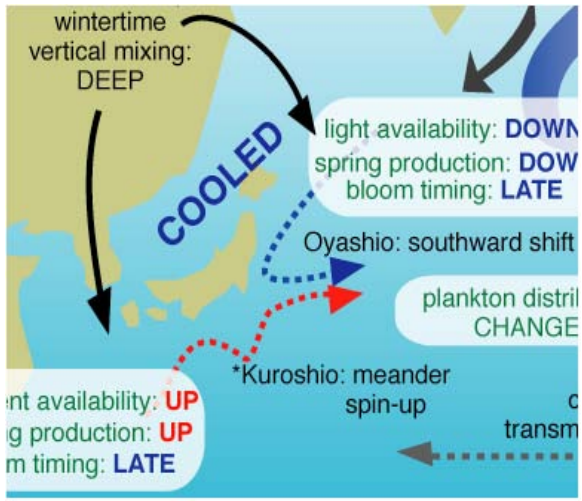
1990 -
Overlapping occurrence of Sp-Comm. and Sp-Sm Comm.

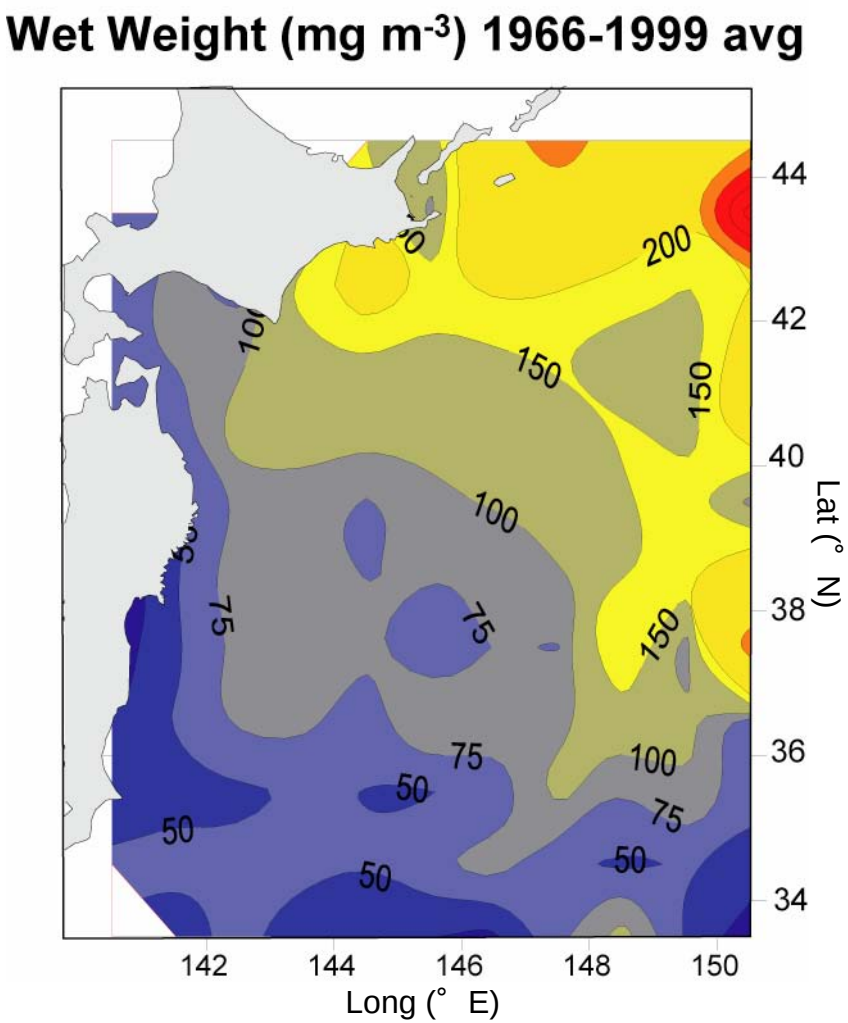
1976 -
Delayed and short productive season



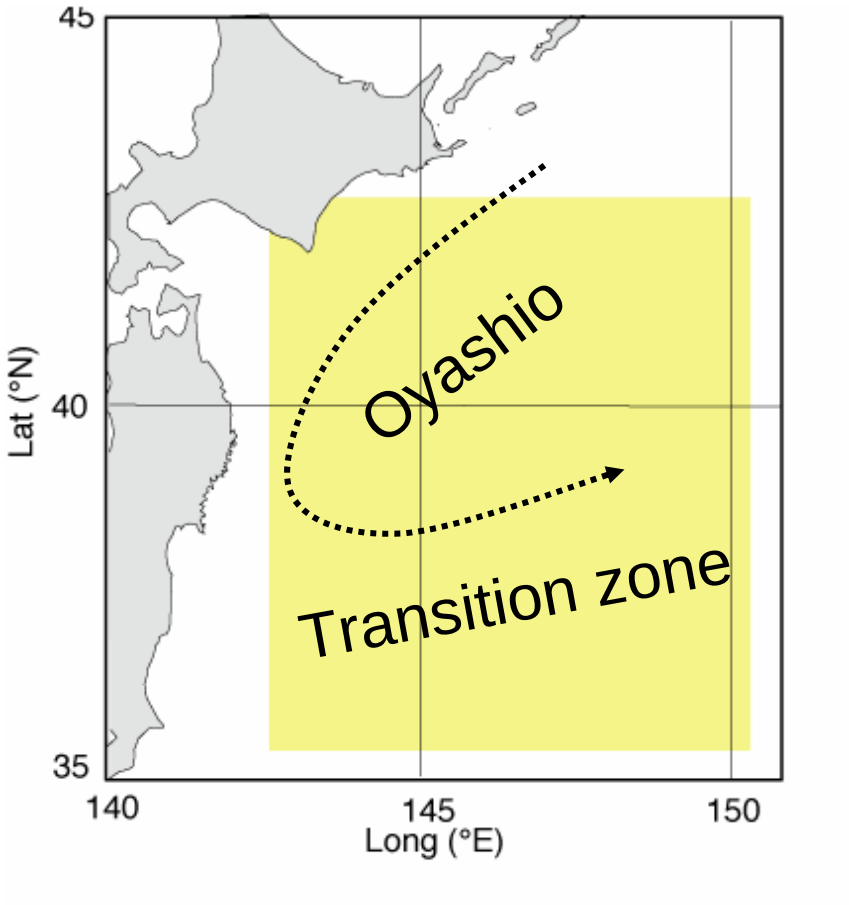
(Chiba et al, 2006, GCB)

Q: Did copepod distribution changed?





Influence of Oyashio & Kuroshio dynamics?



- Spatial coverage
  - 35-43° N, 142-150° E
  - Bottom depth > 500 m
- Temporal coverage
  - 1960-1999
  - May-September
- Definition of Regions
  - < 5° C at 100 m: Oyashio
  - > 5° C at 100 m: Transition
- Number of samples analyzed
  - Oyashio: 961
  - Transition zone: 969

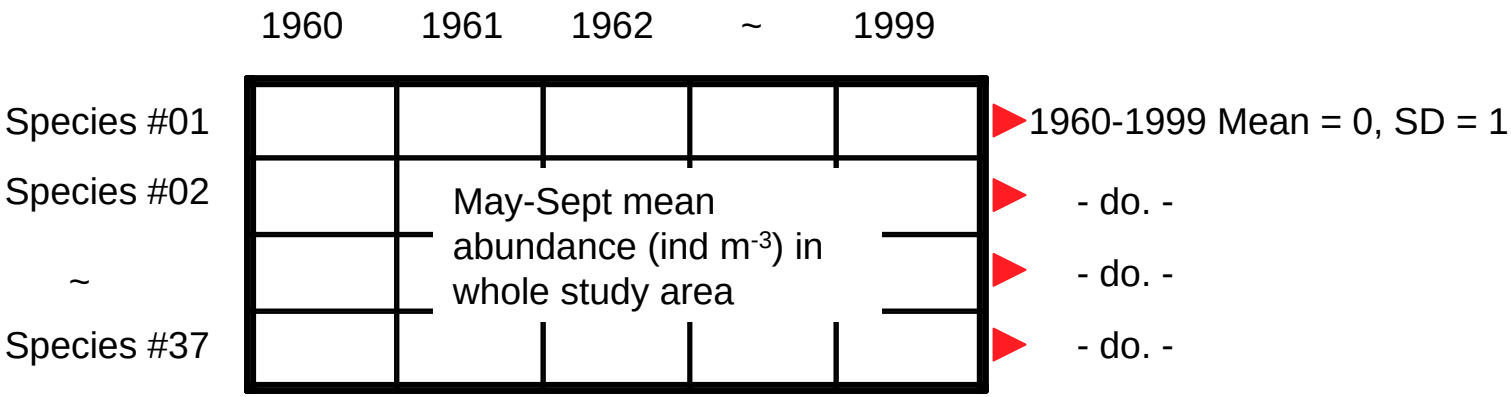
METHODS: Selection of Samples

1. Selection of the major species

> 30% occurrence at stations in Oyashio or/and Transition zone

37 species

2. Matrix of annual mean abundance of the major species

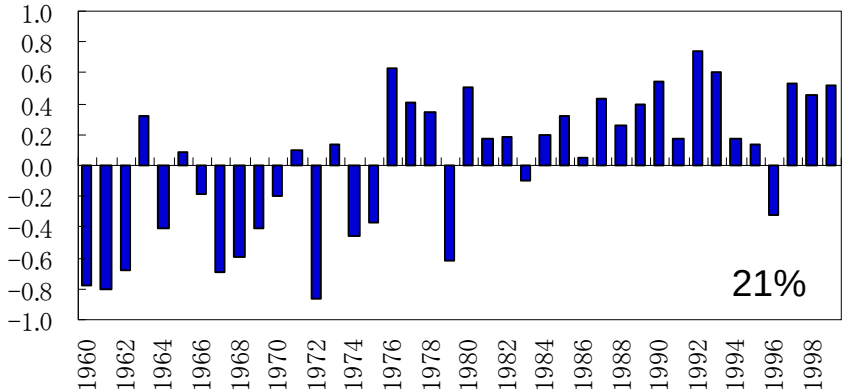


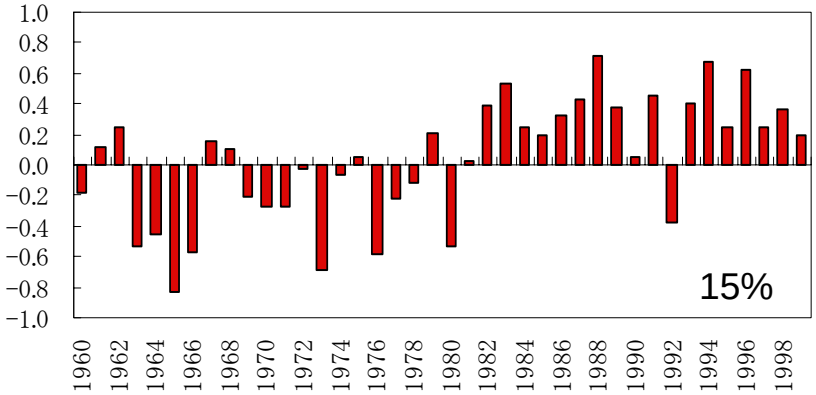
3. Principal Component Analysis

to see the most important TEMPORAL variations

and

compare PCA results with SPACIAL distribution pattern





Species which abundance varied as **PC1** ($P < 0.05$)

Oyashio assemblage = PC1 group

species	female size (mm)
Neocalanus cristatus	8.4-9.3
Metridia pacifica	2.6-3.5
Paraeuchaeta elongata	4.1-8.0
Pleuromamma scutullata	3.6-4.0
Neocalanus flemingeri	4.2-5.2
Metridia okhotensis	4.5-4.8
Eucalanus bungii	6.5-8.0
Acartia longiremis	1.0-1.4
Scolecithricella minor	1.1-1.5
Pseudocalanus minutus	1.4-2.1
Acartia omorii	1.0-1.4
Neocalanus plumchrus	4.3-6.3
Oithona atlantica	1.1-1.4
Pseudocalanus newmani	0.9-1.5

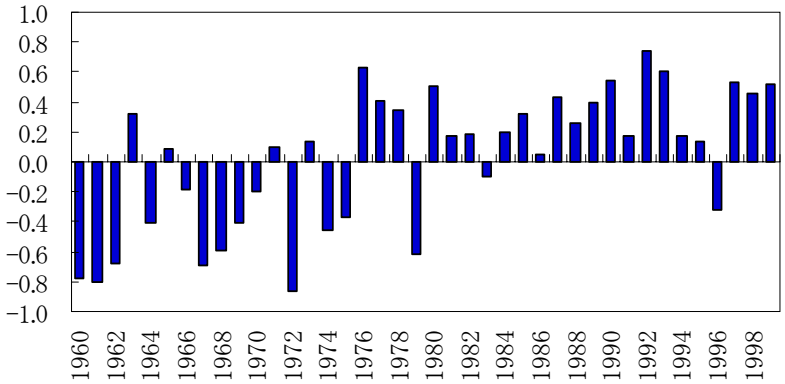
Transition zone assemblage = PC2 group

species	female size (mm)
Oithona atlantica	1.1-1.4
Oithona plumifera	1.1-1.4
Corycaeus affinis	1.0-1.3
Oithona setigera	1.1-1.9
Acartia omorii	1.0-1.4
Ctenocalanus vanus	0.9-1.3
Oncaea mediterranea	1.0-1.3
Oncaea conifera	0.9-1.2
Clausocalanus arcuicornis	1.2-1.6
Lucicutia flavicornis	1.3-2.2
Paracalanus aculeatus	1.0-1.4
Clausocalanus parapergens	1.0-1.4
Oithona longispina	0.9-1.1
Eucalanus californicus	5.7-7.0

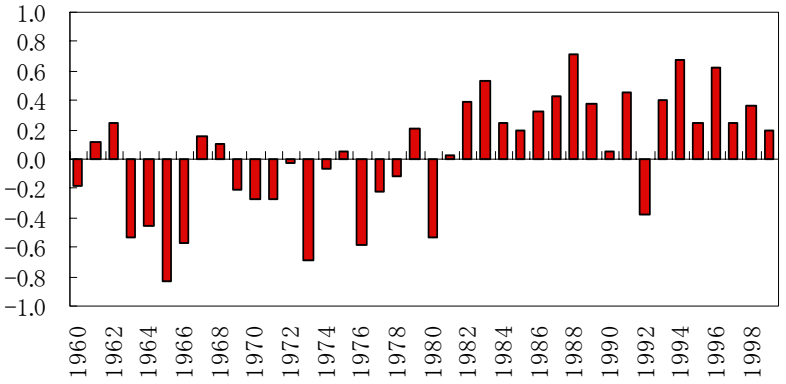
Species which abundance varied as **PC2** ($P < 0.05$)

cold water or mesopelagic species widely distributed species warm water species

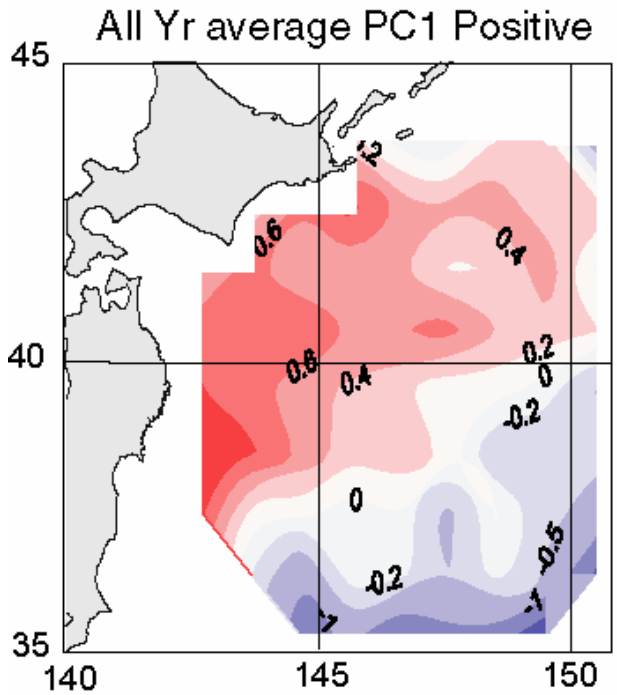
1st Principal Component (PC1)

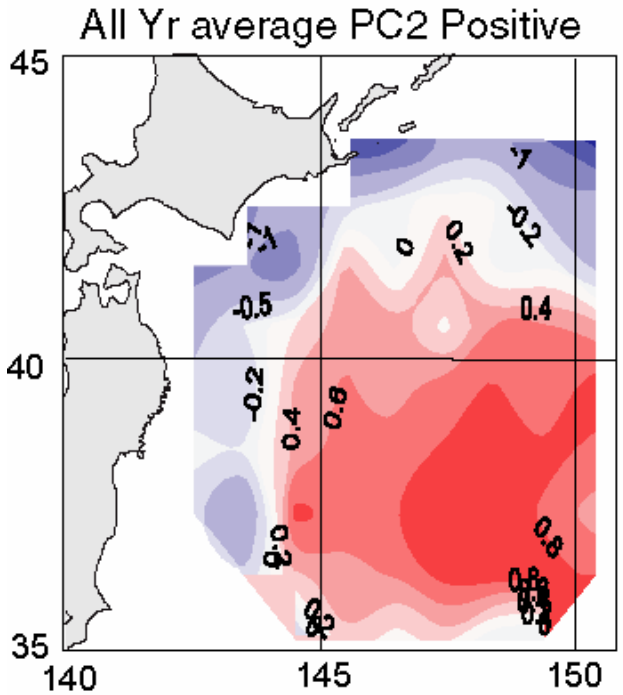


2nd Principal Component (PC2)



PC1 group
Large, Cold Water spp.

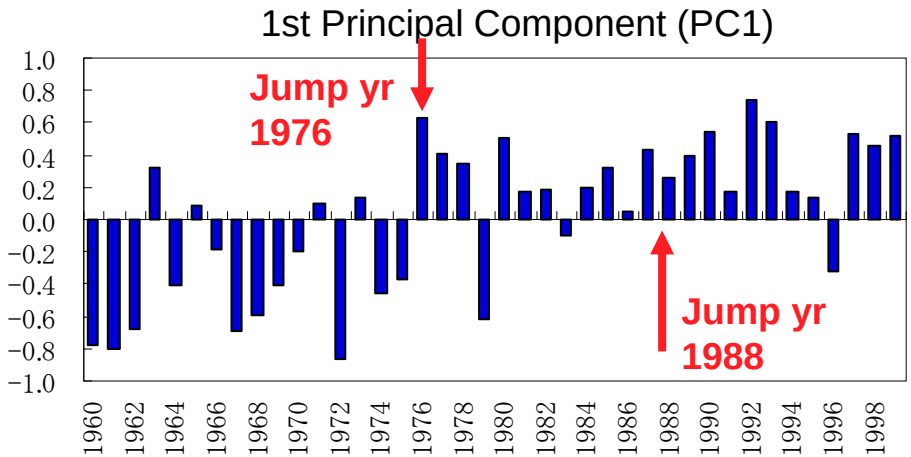




PC2 group
Small, Warm Water spp.

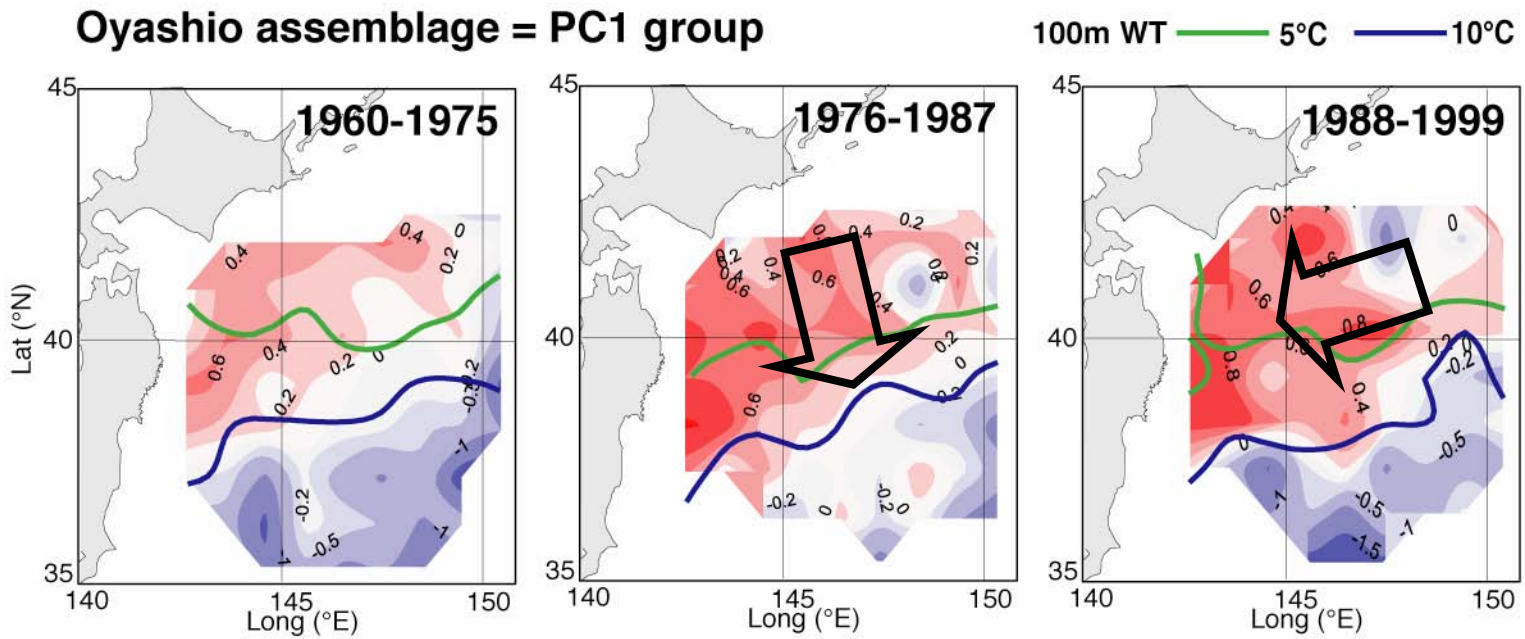
RESULTS: PC time-series & Copepod Distribution

Distribution shift of PC1 groups

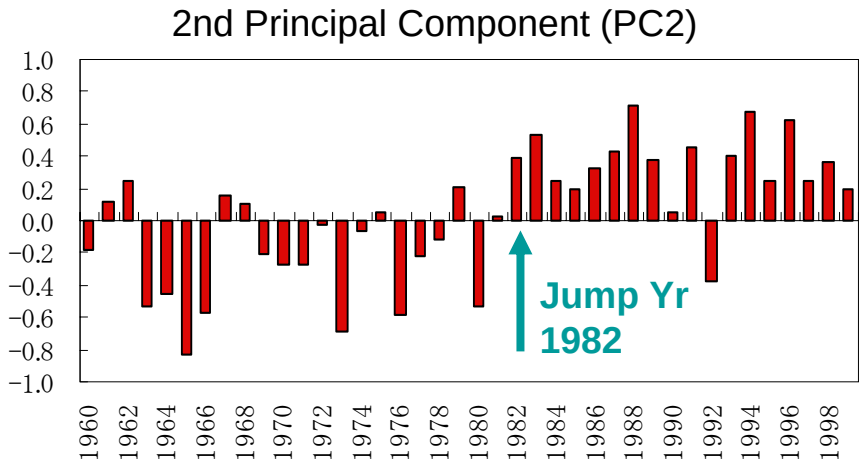


1. Jump years coincided with timing of the RS

2. Southwestward shift of distribution center

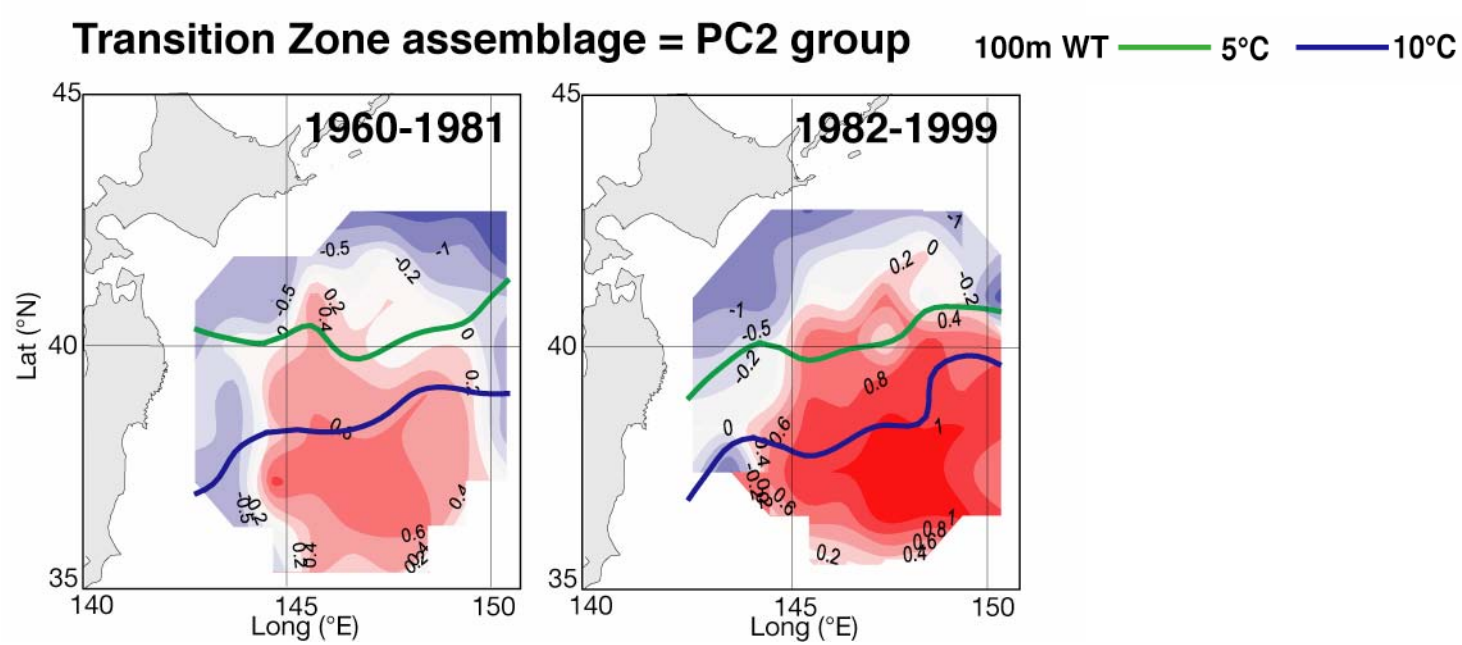


Distribution shift of PC2 groups

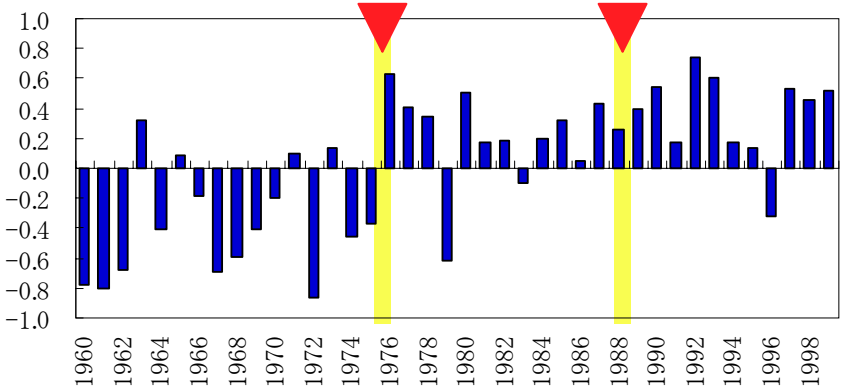


1. Jump years coincided with timing of the RS

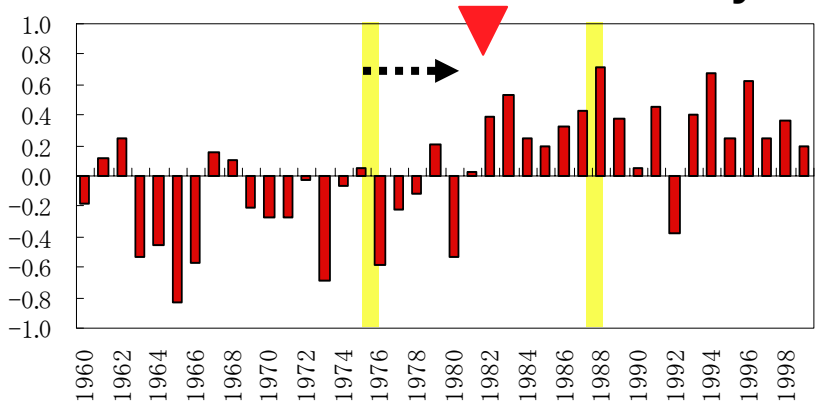
2. Marked increase in abundance



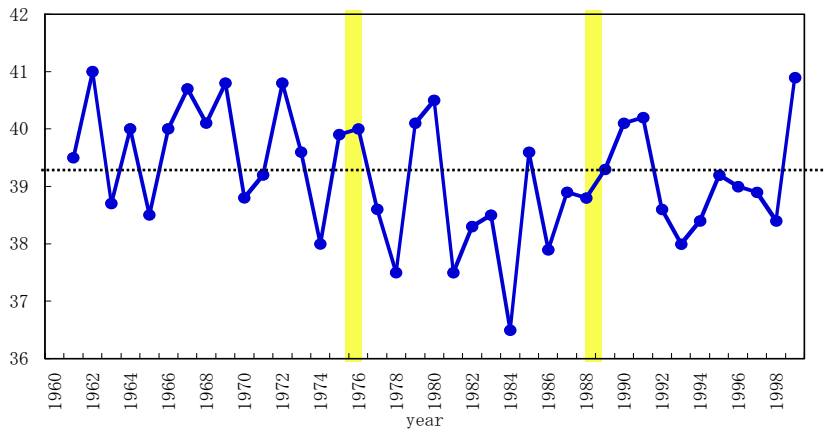
PC1: Cold Water Community



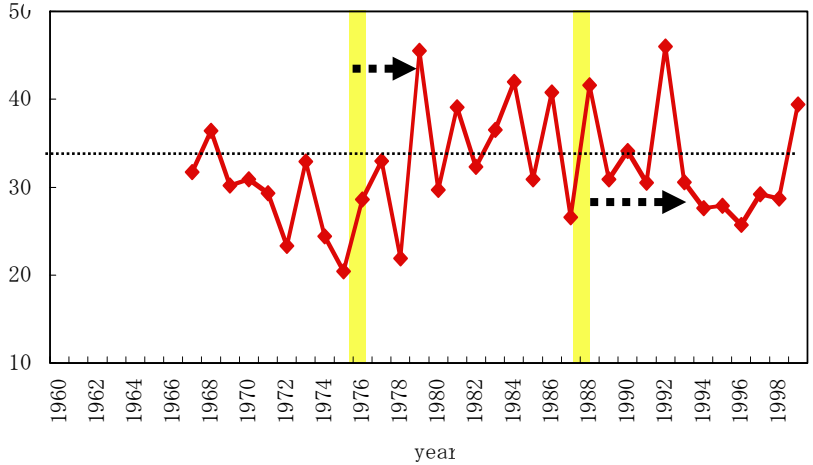
PC2: Warm Water Community



Southern Limit of Oyashio

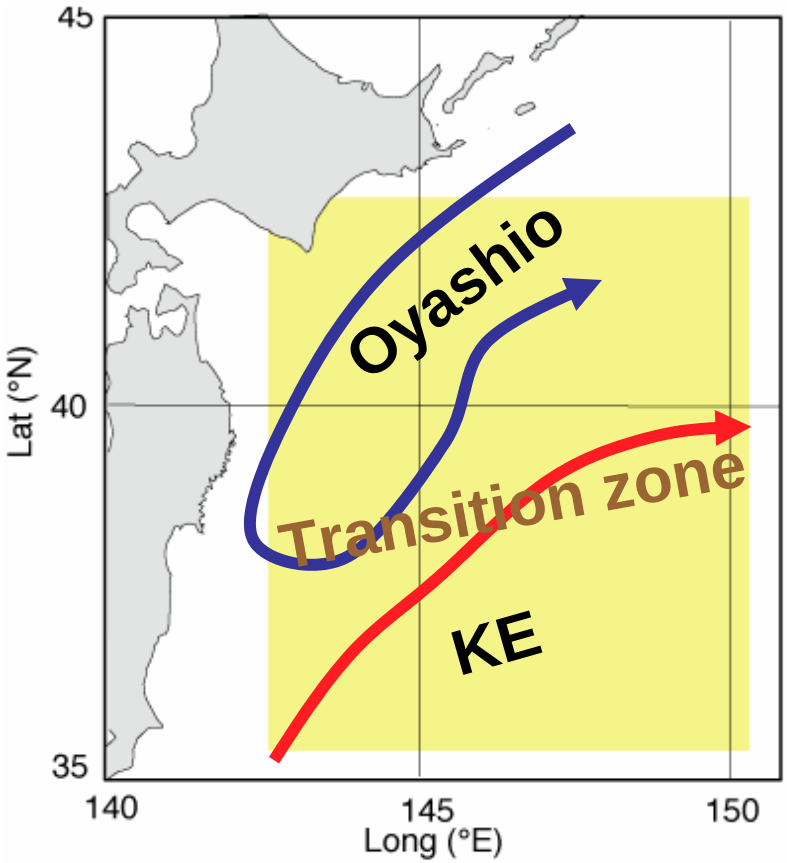


Geostrophic Transport of Kuroshio



Regime shift

Jump Year of PCs



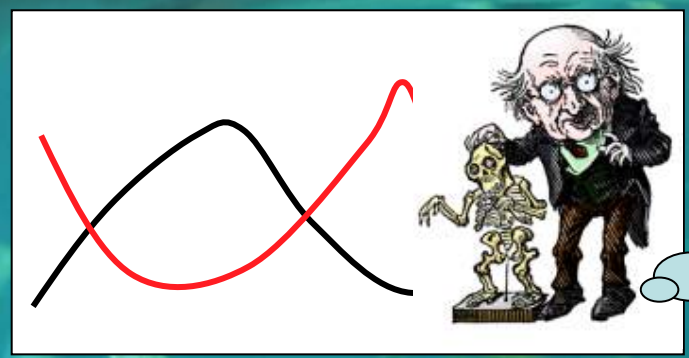
- Abundances of northern cold water species and southern warm water species varied in a different temporal scale.
- Distribution of northern community shifted southwestward as southern shift of the coastal Oyashio after the 1976 RS.
- Distribution of southern community shifted north and its abundance increased as spin-up of Kuroshio several years after the 1976 RS.
- These distribution pattern was consistent even after the 1988 RS
- Both northern and southern communities coexisted around the same latitude after the 1980s.

Odate Project

Summary

Implication

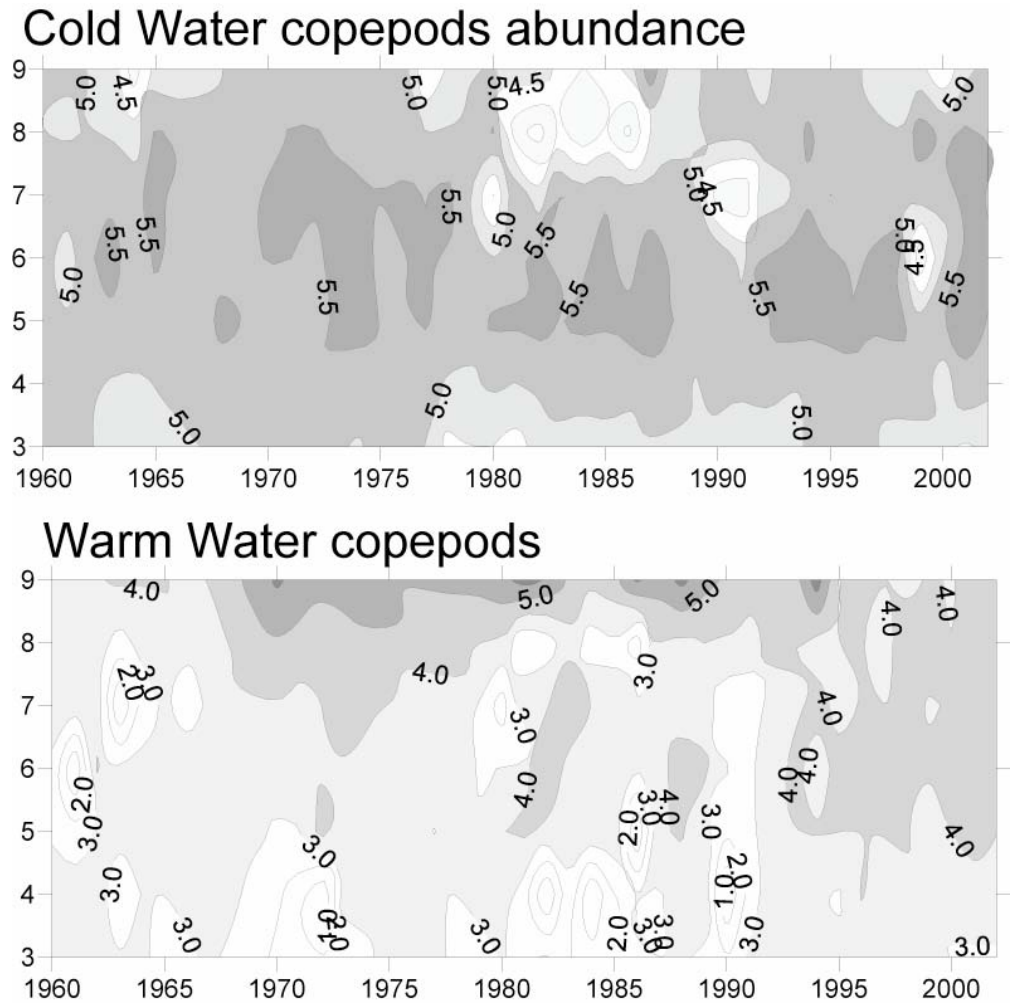
Change in the distribution pattern of copepod community might have affected fishery resources through spatial match-mismatch mechanism.



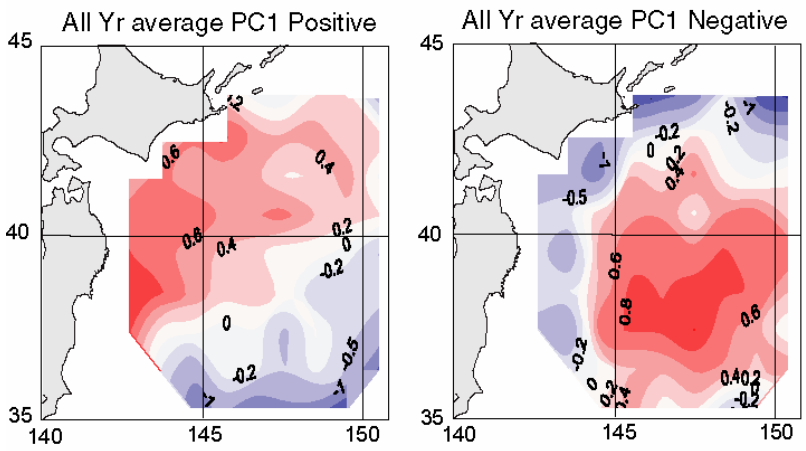
That mechanism is never detected by biomass-based time-series analysis …


Thank you
and
You can go to lunch now...
JAMSTEC

Increase of warm water zooplankton in the Oyashio



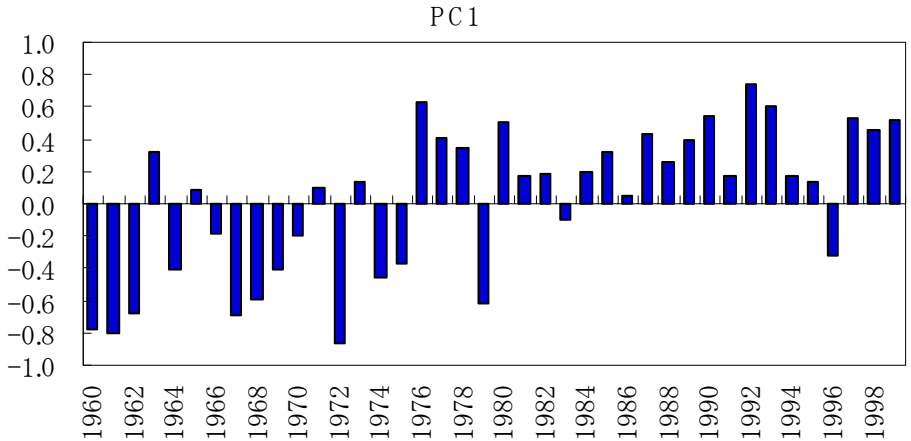
Distribution of copepod commuinities (1960-1999 avg)
(normalized)

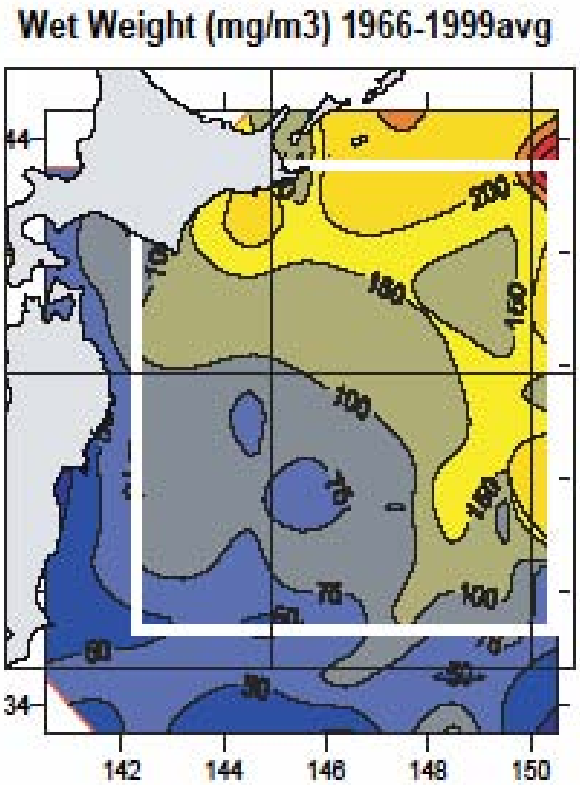


PC1 Positive Oyashio copepod	P	R	PC1 Negative Transition zone copepod	P	R
Neocalanus cristatus	0.000	0.612	*Ctenocalanus vanus*	0.037	−0.331
Metridia pacifica	0.000	0.607	*Clausocalanus furcatus*	0.031	−0.342
Paraeuchaeta elongata	0.000	0.578	*Oithona plumifera*	0.024	−0.356
Pleuromamma scutullata	0.000	0.570	*Clausocalanus pergens*	0.013	−0.390
Neocalanus flemingeri	0.001	0.521	*Paracalanus parvus*	0.012	−0.394
Metridia okhotensis	0.001	0.512	*Oncaea mediterranea*	0.004	−0.450
Eucalanus bungii	0.002	0.478	*Acartia danae*	0.003	−0.452
Acartia longiremis	0.002	0.470	*Oithona longispina*	0.003	−0.456
Scolecithricella minor	0.003	0.460	*Oncaea conifera*	0.001	−0.488
Pseudocalanus minutus	0.003	0.455	*Calocalanus tenuis*	0.001	−0.503
Acartia omorii	0.005	0.435	*Oncaea venusta*	0.001	−0.513
Neocalanus plumchrus	0.006	0.431	*Calocalanus styliremis*	0.000	−0.658
Oithona atlantica	0.018	0.372			
Neocalanus CI	0.018	0.372			
Pseudocalanus newman.	0.029	0.345			

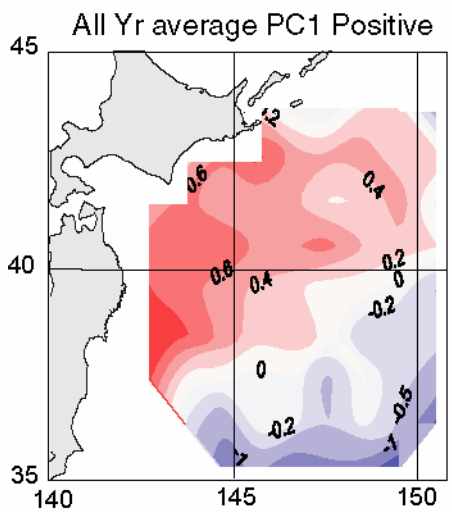
親潮・混合域カイアシ類群集の時空間変動

PCA on copepod communities (based on May-Sept avg abundance)

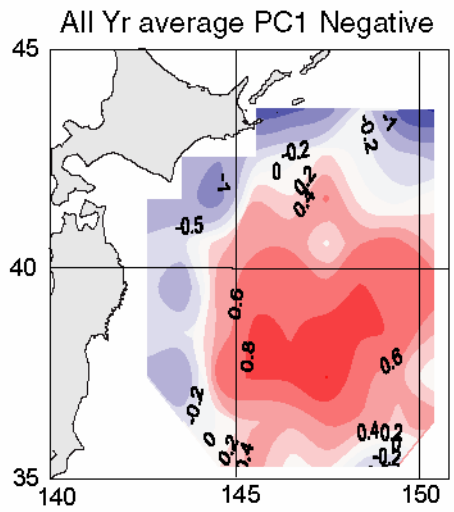




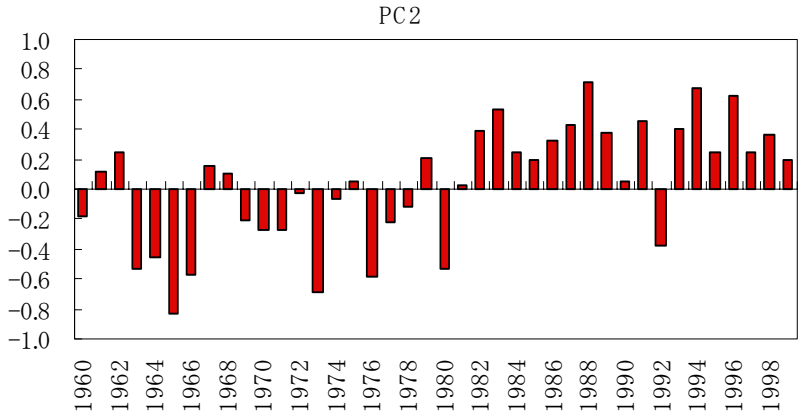
Distribution of copepod commuinities (1960-1999 avg)
(normalized)



Oyashio Copepods



Transition Copepods

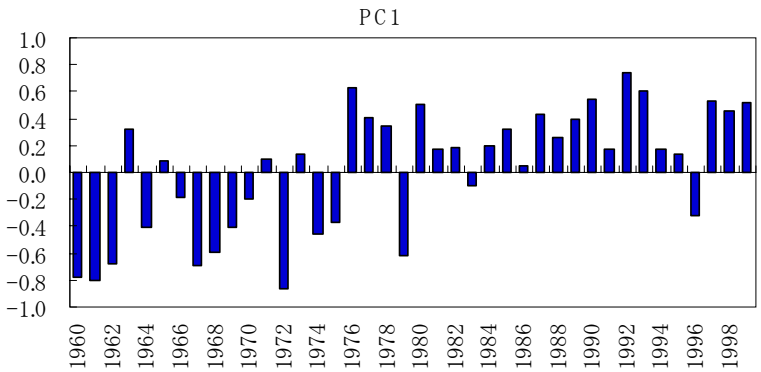


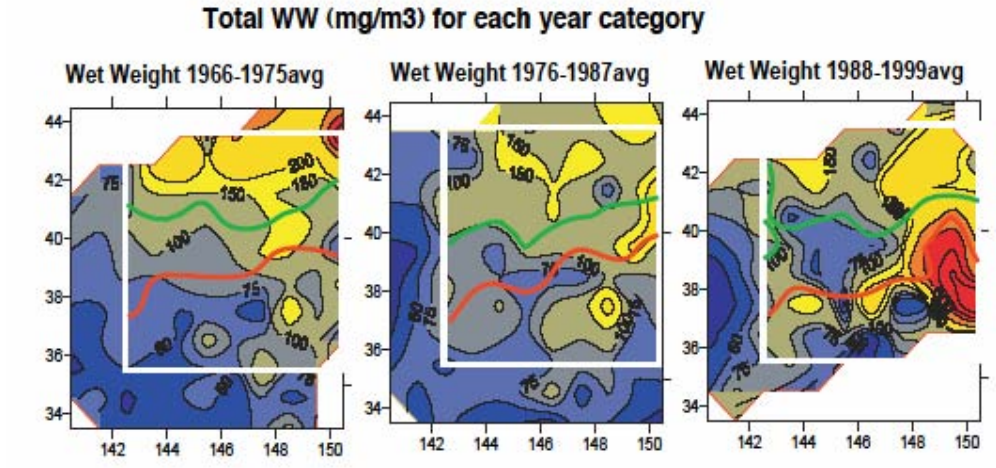
第2主成分(15%)時系列

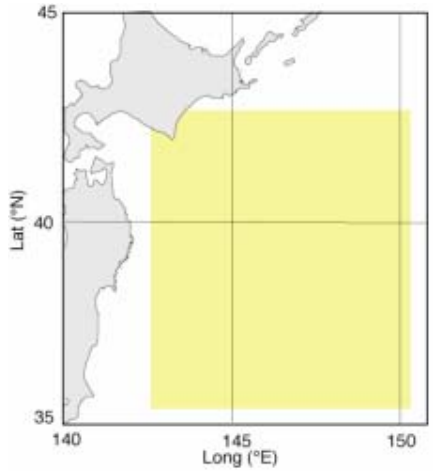
PC2 Positive	P	R
Oithona atlantica	0.000	0.648
Oithona plumifera	0.000	0.590
Corycaeus affinis	0.000	0.567
Oithona setigera	0.000	0.562
Acartia omorii	0.000	0.552
Ctenocalanus vanus	0.000	0.526
Oncaea mediterranea	0.001	0.513
Oncaea conifera	0.002	0.484
Clausocalanus arcuicornis	0.002	0.480
Lucicutia flavicornis	0.002	0.477
Paracalanus aculeatus	0.004	0.450
Clausocalanus parapergens	0.015	0.382
Oithona longispina	0.028	0.348
Eucalanus californicus	0.048	0.314

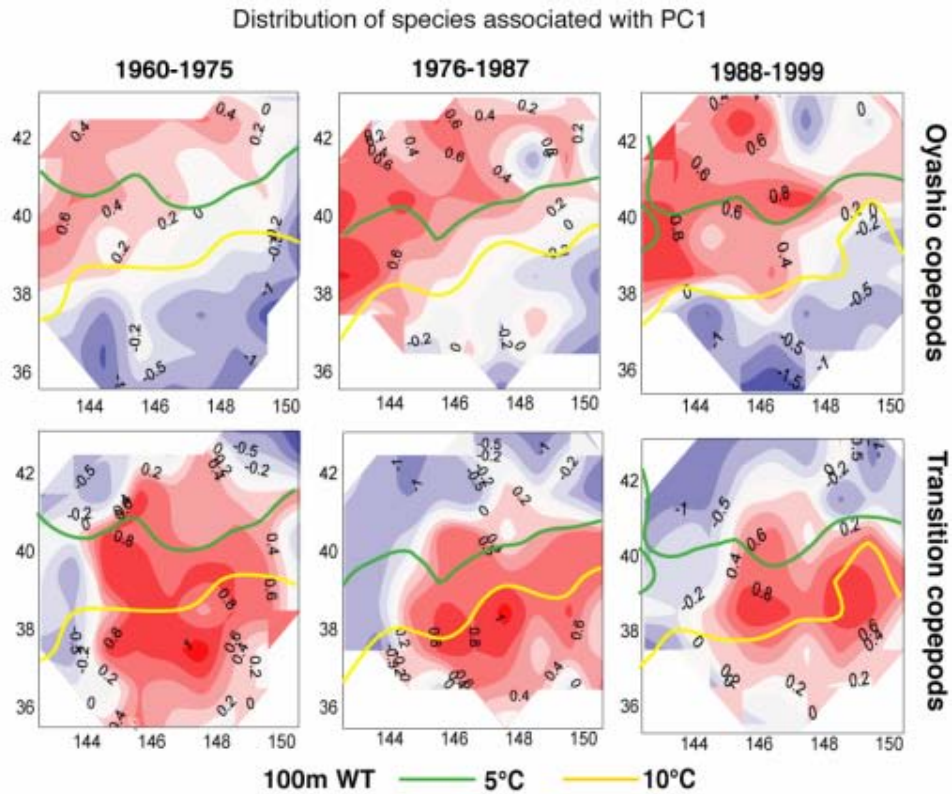
PC2 Negative Transition zone copepc	P	R
Calocalanus styliremis	0.020	-0.366
Oithona similis	0.000	-0.633

第2主成分の時系列と有意な変動を持つ種のリスト
青:混合域で出現頻度高
緑:親潮域と混合域の両方で出現頻度高

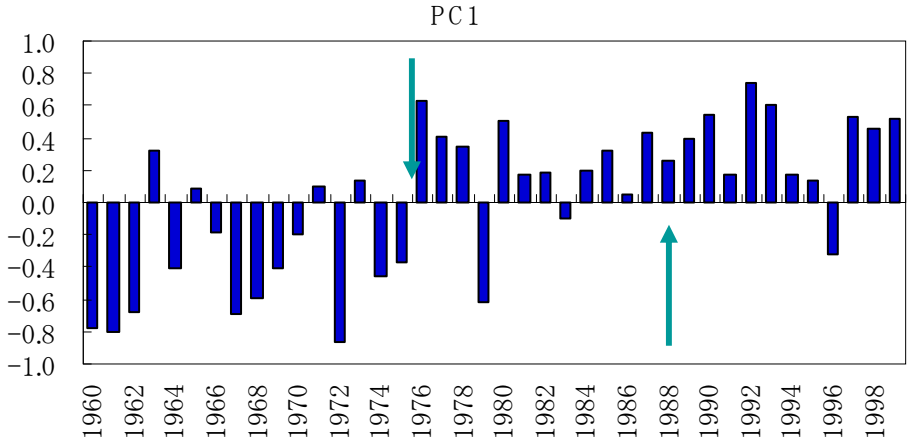

PC1
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998

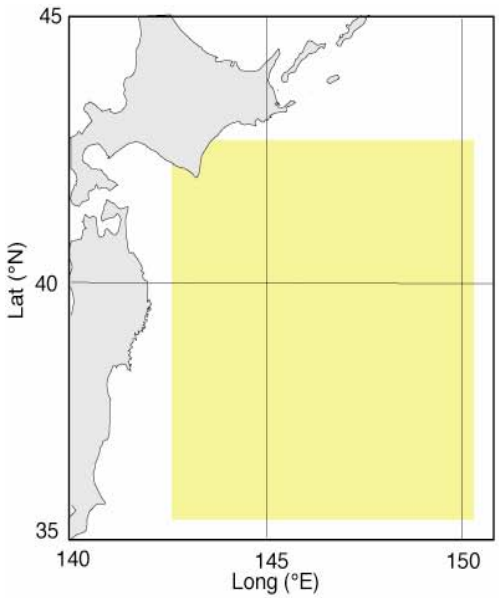

Total WW (mg/m3) for each year category
Wet Weight 1966-1975avg
Wet Weight 1976-1987avg
Wet Weight 1988-1999avg

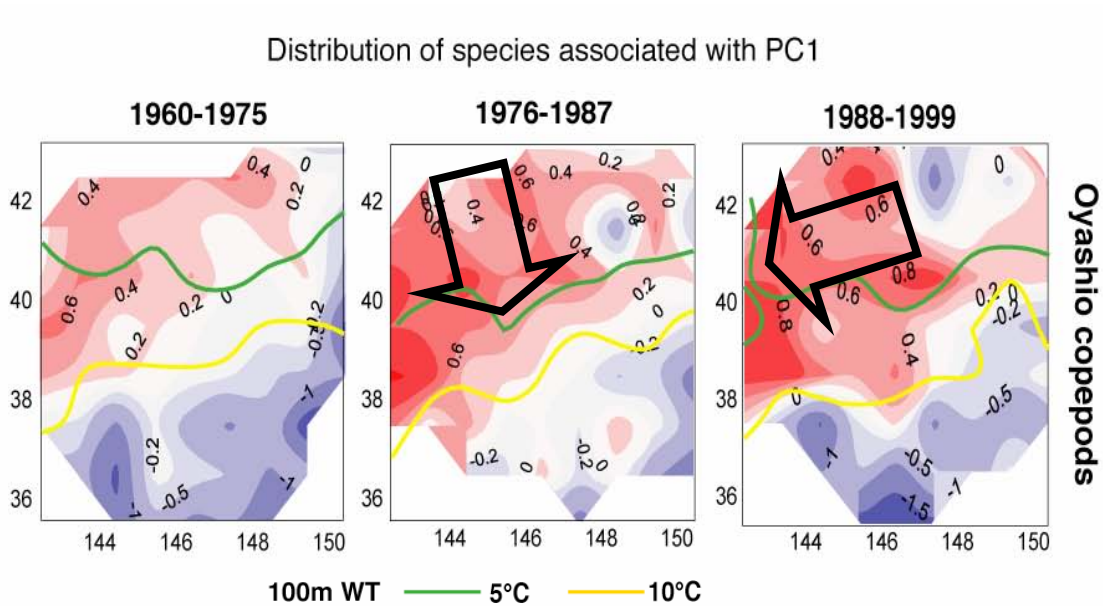

Lat (°N)
Long (°E)
45
40
35
140
145
150


Distribution of species associated with PC1
1960-1975
1976-1987
1988-1999
Oyashio copepods
Transition copepods
100m WT
5°C
10°C

PCA on copepod communities

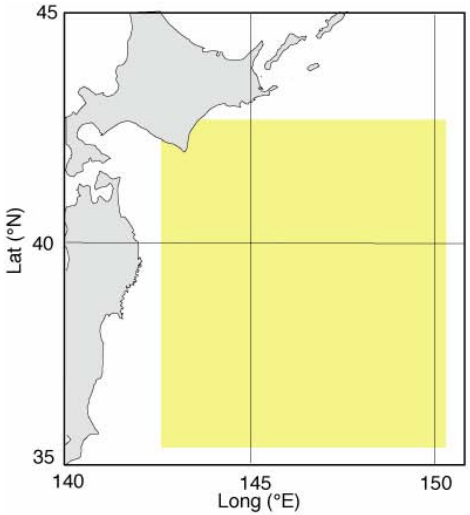


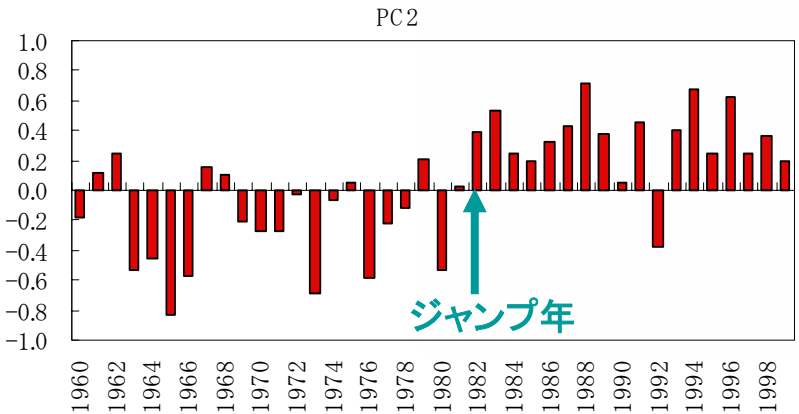




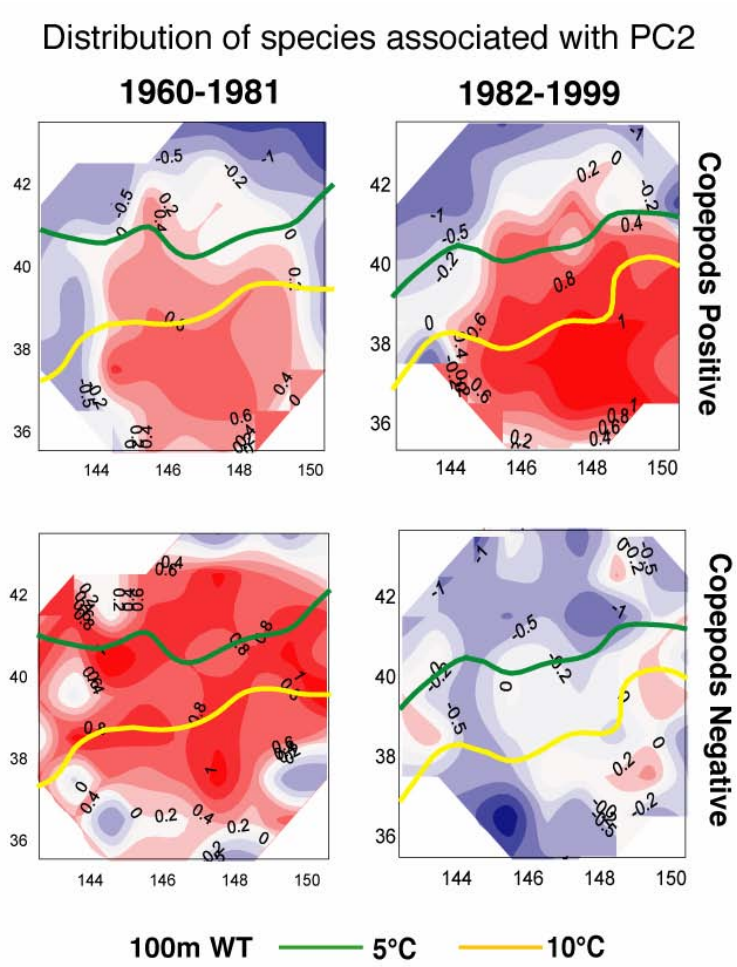
Changes in the distribution of cold water copepods (abundance normalized) in the Oyashio and the Transition regions before and after the regime shifts.

親潮域・混合域カイアシ類群集構造の時空間変動（主成分分析）





第2主成分時系列



第2主成分の時系列と有意な変動を持つ種の分布をジャンプ年の前後で比較してみた。多くの混合域種の個体群密度が1982年以降増加していることを示す。