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Response of neritic copepod, *Acartia omorii* to climate related changes in Tokyo Bay, Japan

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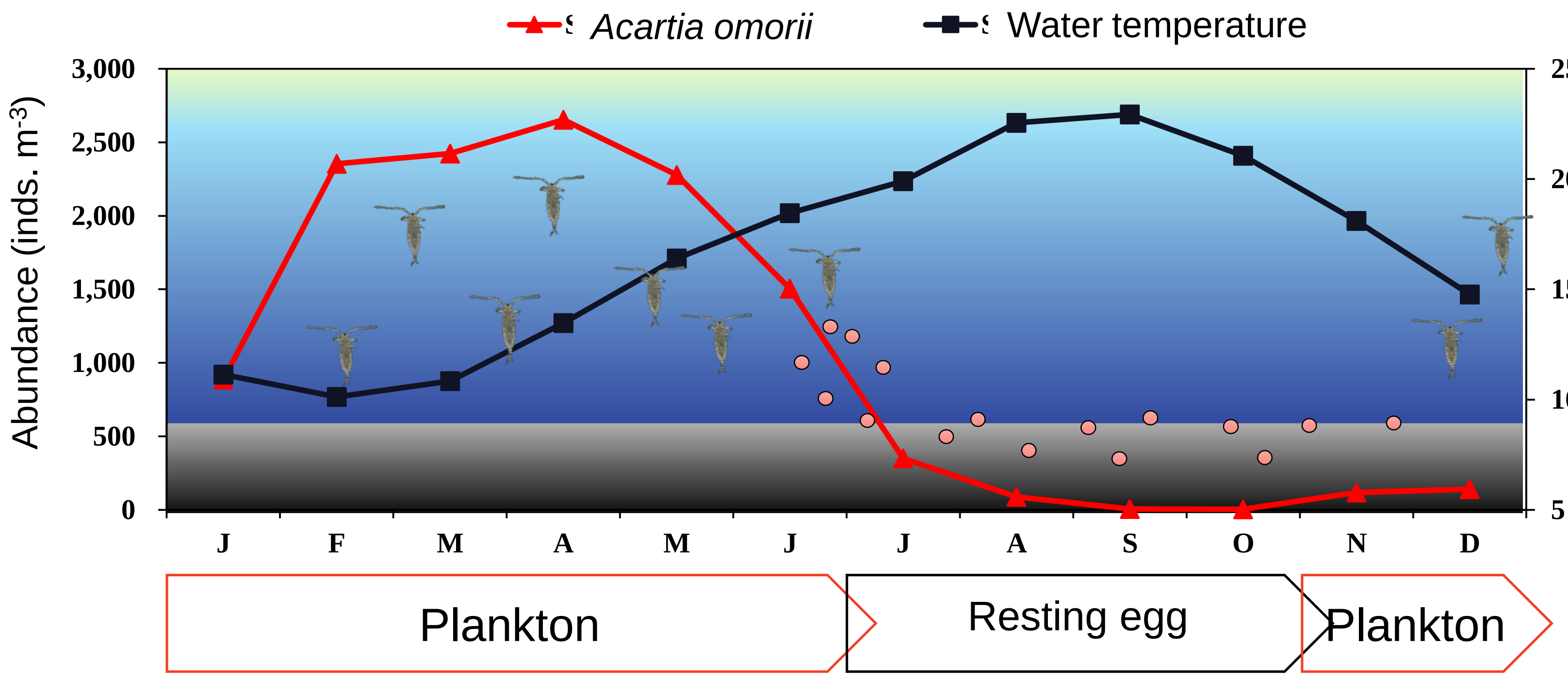
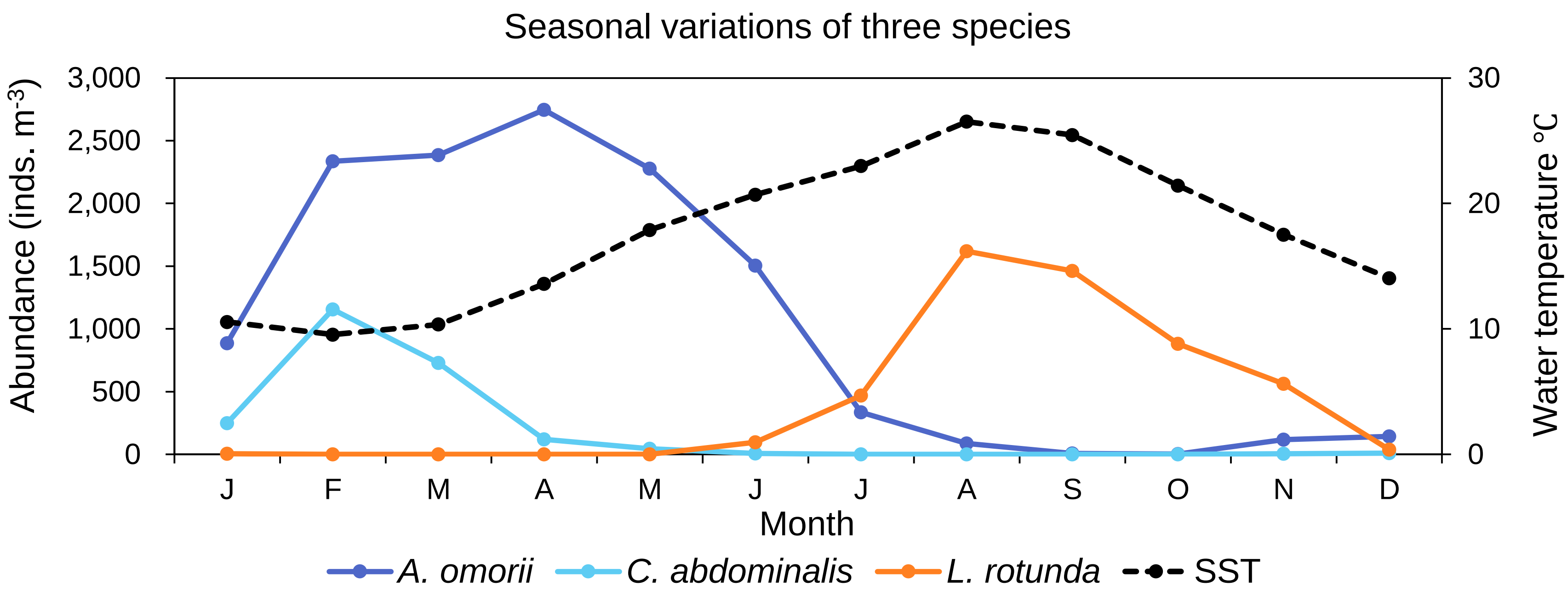
Dormancy in neritic copepod

- ✓ Dormancy is a life history strategy adaptation to unstable environment
- ✓ About 50 species of marine calanoid copepods produce resting eggs and belong to the superfamily of Centropagoidea (Marcus 1996; Engel and Hirche 2004; Alistair 1992)
- ✓ They also includes most of the abundant species in neritic and coastal zone
- ✓ Habitats is large environmental variations. Ex. temperature, salinity, dissolved oxygen



The producer of resting eggs in Tokyo Bay



	Plankton	Resting egg
Acartia omorii	Winter ~ early summer	Mid summer ~ fall
Centropages abdominalis	Winter ~ spring	Summer ~ fall
Labidocera rotunda	Summer ~ fall	Winter ~ spring

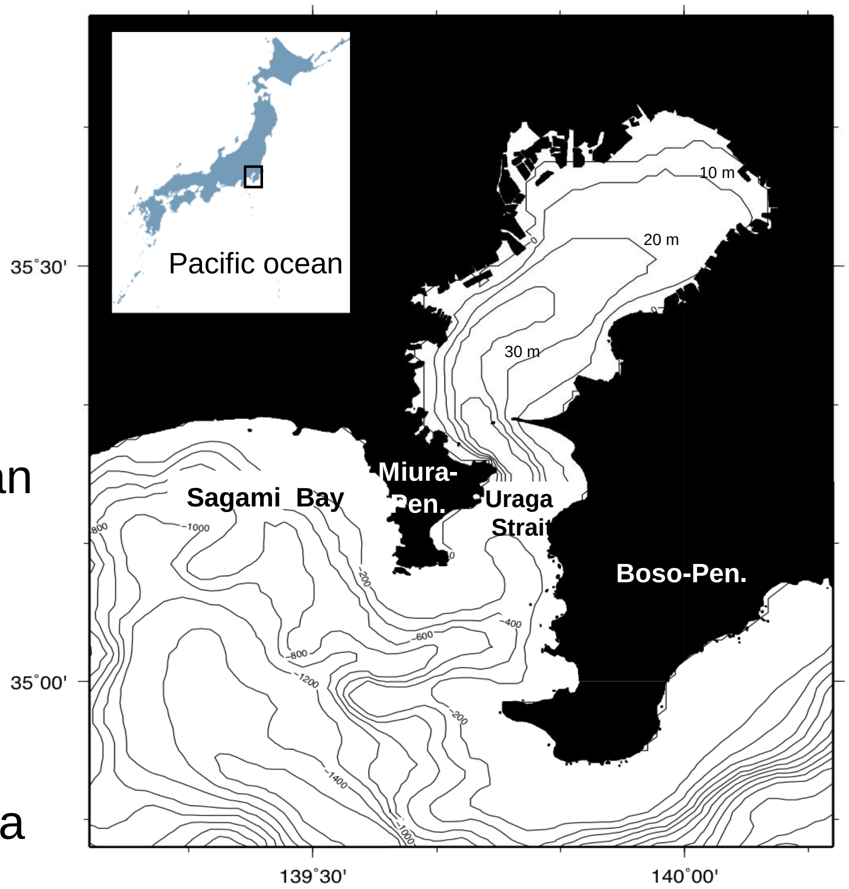
Environmental changes in Tokyo Bay

Tokyo Bay is surrounded by metropolitan city

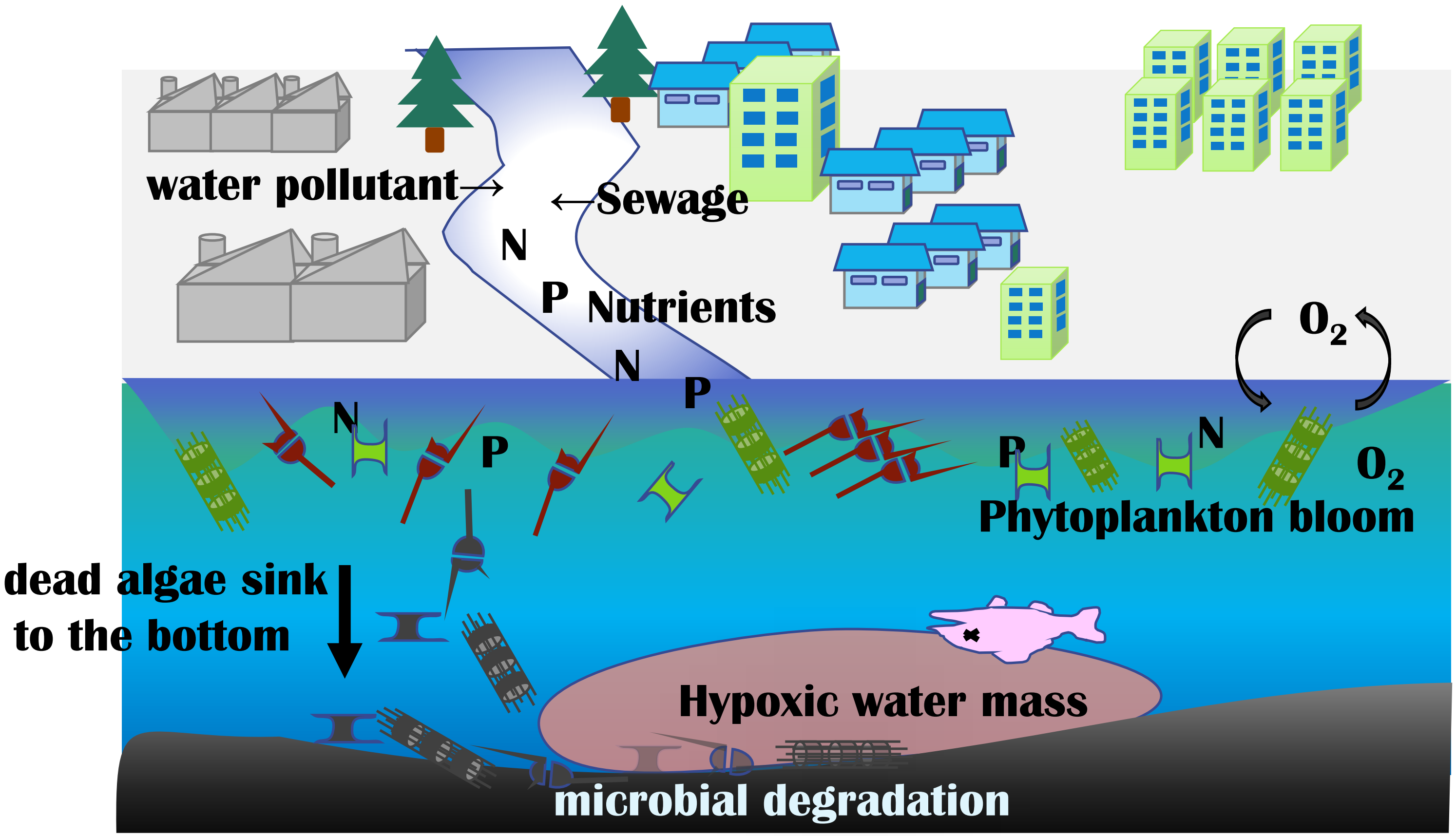
One of the most highly eutrophicated inlets in Japan.

Tokyo Bay extends 80 km north to south, and is an estuarine environment due to discharge from the large River in the innermost area

Connects with the Pacific oceanic environment via the entrance area.



Environmental changes in Tokyo Bay



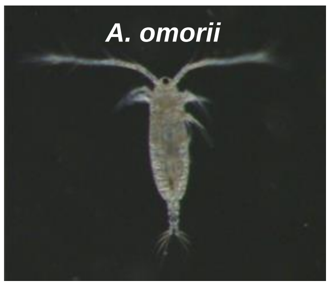
Water pollution increased through the 1960s with a nutrient peak
Red tide and hypoxic water mass occurred by high primary production with increase of nutrients

Nutrients condition and chl. *a* concentration has shown a recovery in recent years (Kanda et al., 2008)
However, anoxia in the bottom layer continue to the present (Unoki 2011)

These results imply that long term environmental change may influence the copepod population.

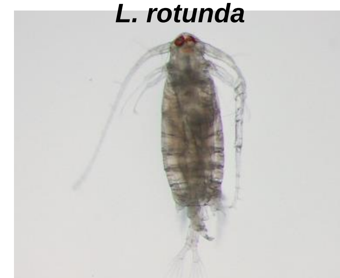
Our object …

We examined the monthly abundance of three resting egg production copepods collected in Tokyo Bay to clarify the mechanisms of species specific response is related to climatic and hydrographic conditions.



C. abdominalis

L. rotunda

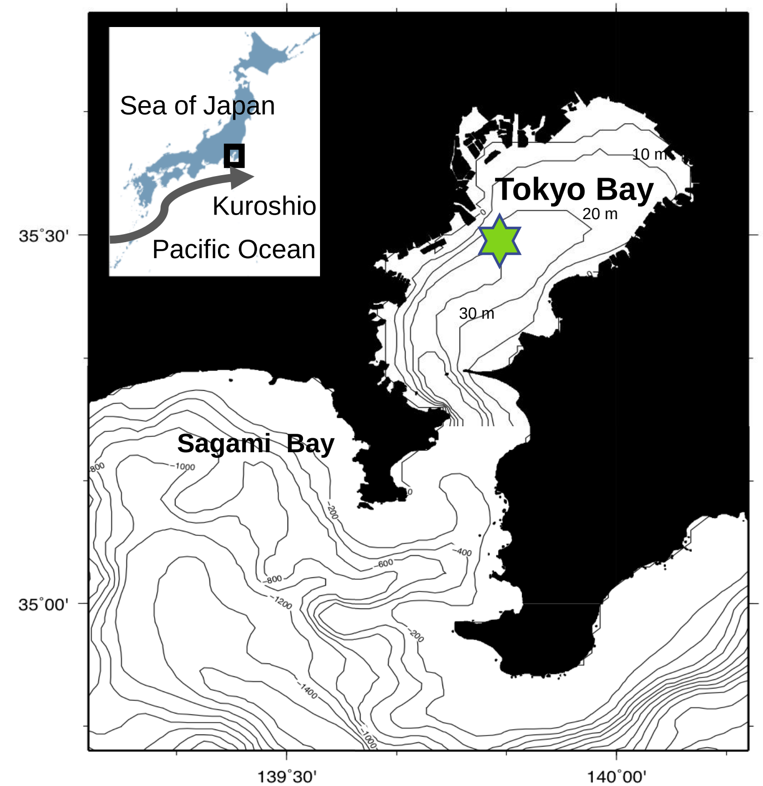


I. phenology shift of three species
II. Long term trend for 30 years

Comparison with hydrographic condition and climate change

Our goal of this study was to reveal the regional copepod response linking the climate and environment in the neritic and coastal zone

Materials and Methods



Monthly collection : Jar 1980- Dec 2010

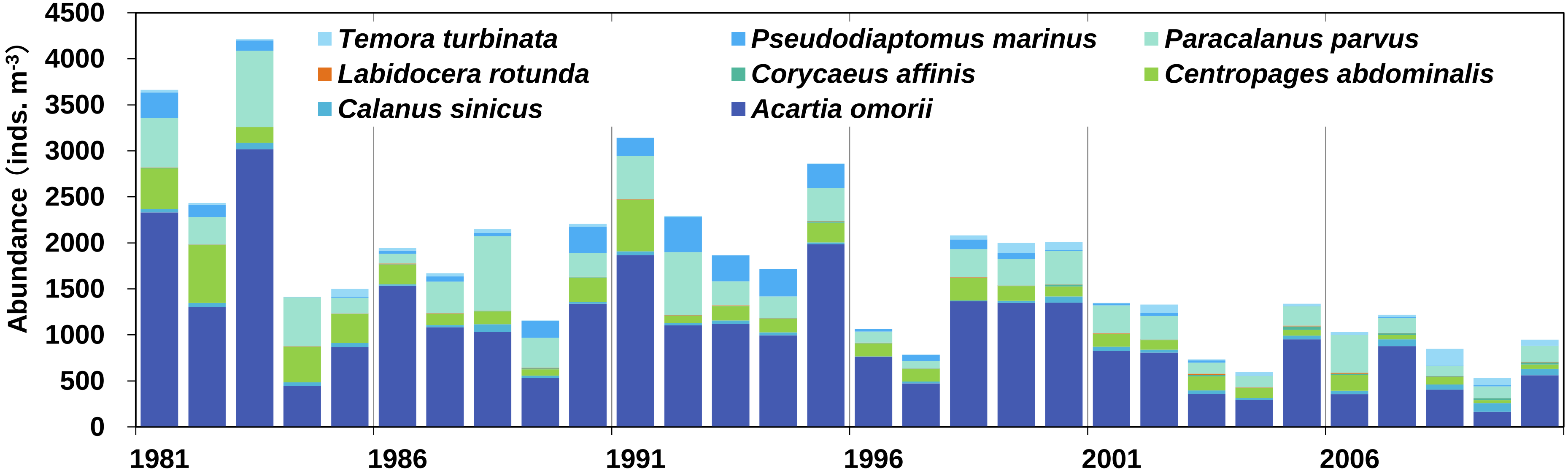
Location : Stn. F6　28 m depth
（35°25′11N，139°47′48E）

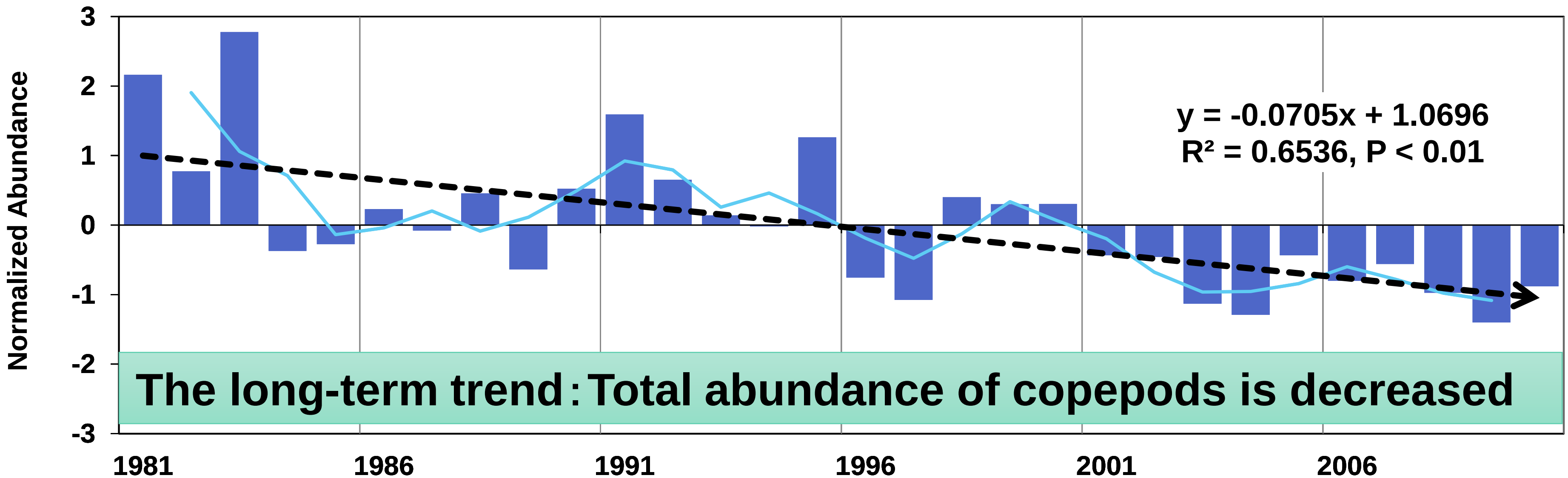
Sampling gear : NORPAC-net
- Mouth diameter; 45 cm
- Mesh size; 330 µm
- Vertical hauls from 1 m above to the surface

Environmental factors

- PDO (pacific decadal oscillation)
- SST (Sea surface temperature) in each season
- SBT (Sea bottom temperature) in each season
- Stratification

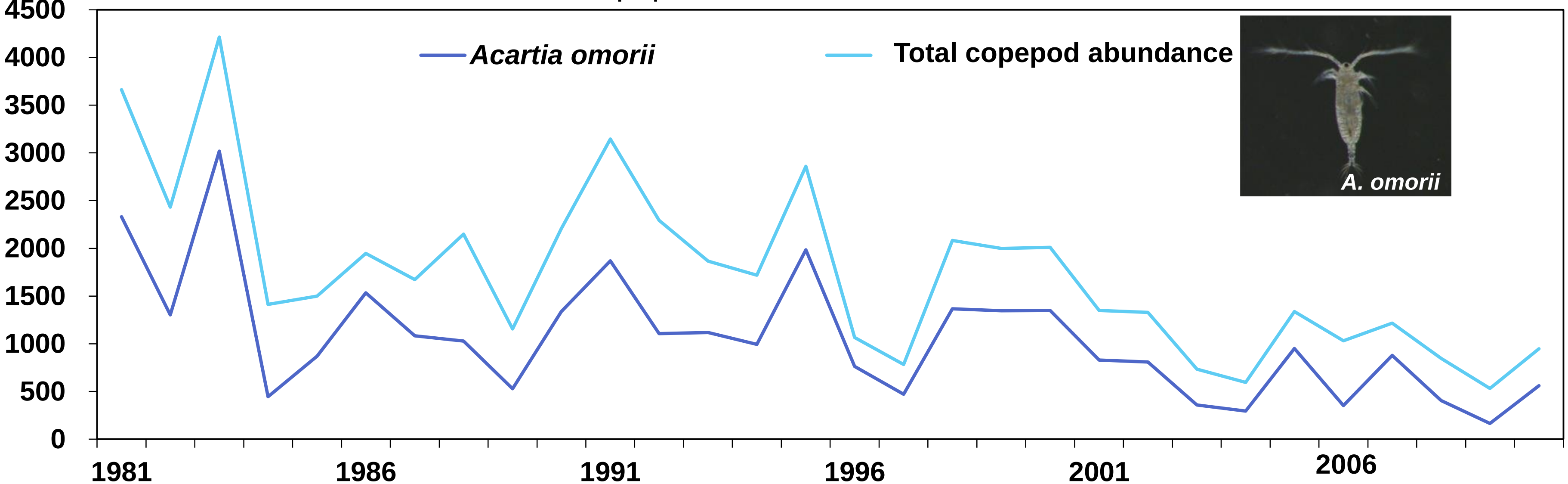
Long-term trend of total copepod abundance



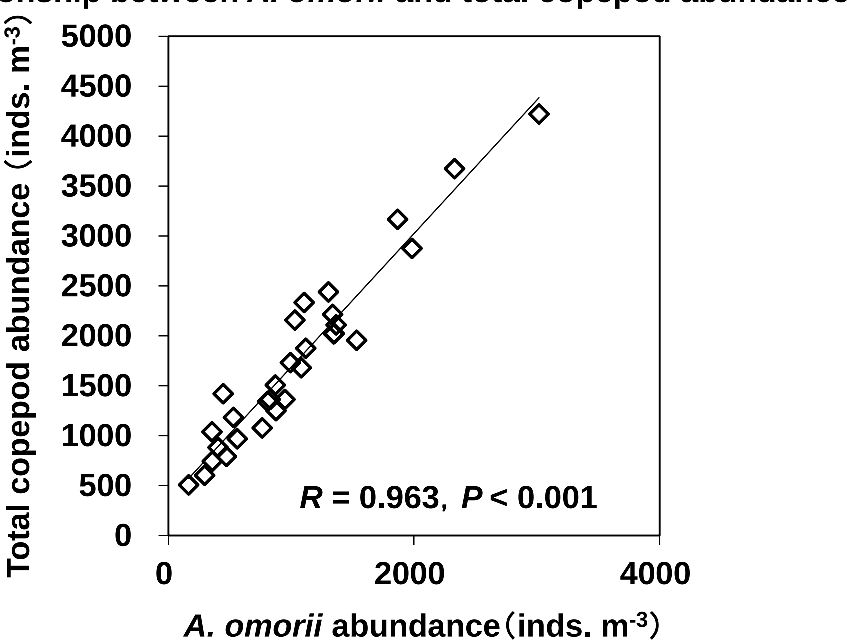


Long-term trend of total copepod abundance

Annual mean abundance of total copepod and *A. omorii*



Relationship between *A. omorii* and total copepod abundance

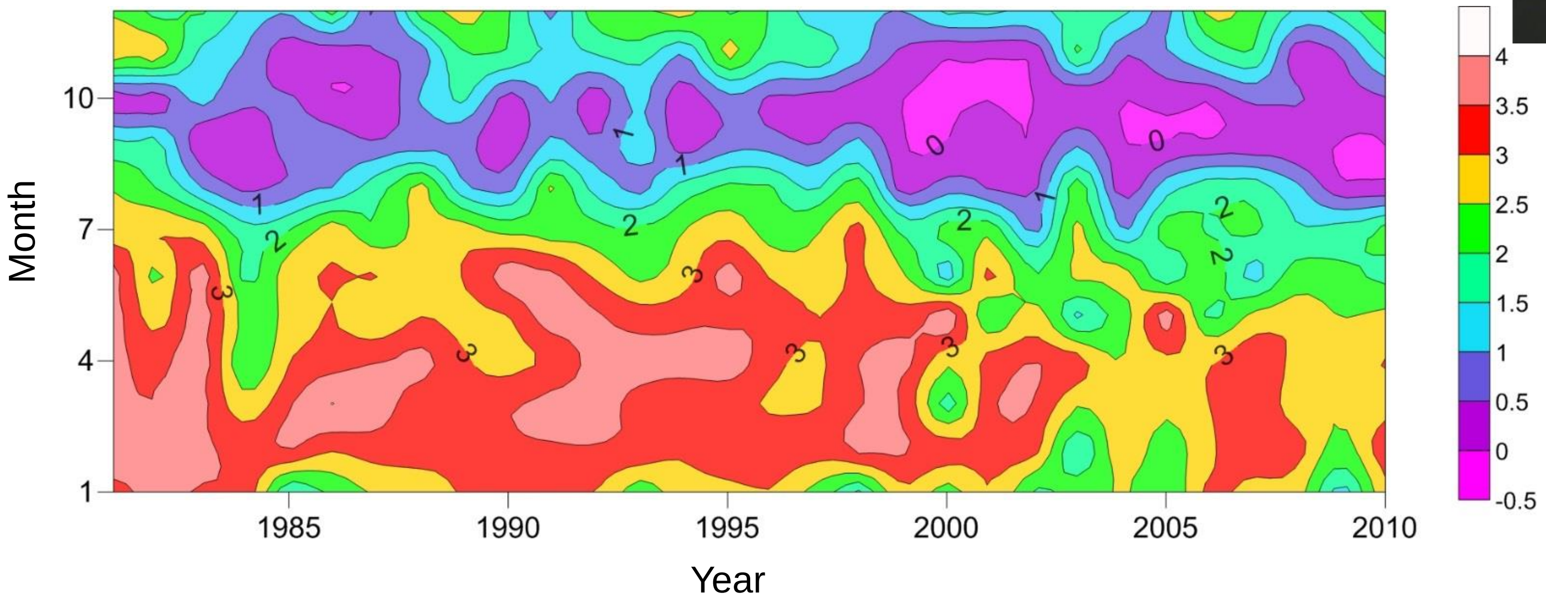


A. omorii **accounted for 60-90% of the total copepod abundance.**

Total copepod abundance had high significant positive correlation with *A. omorii*.

Inter-annual variation of total copepod abundance reflects that of *A. omorii*

Phenology shifts in *A. omorii*



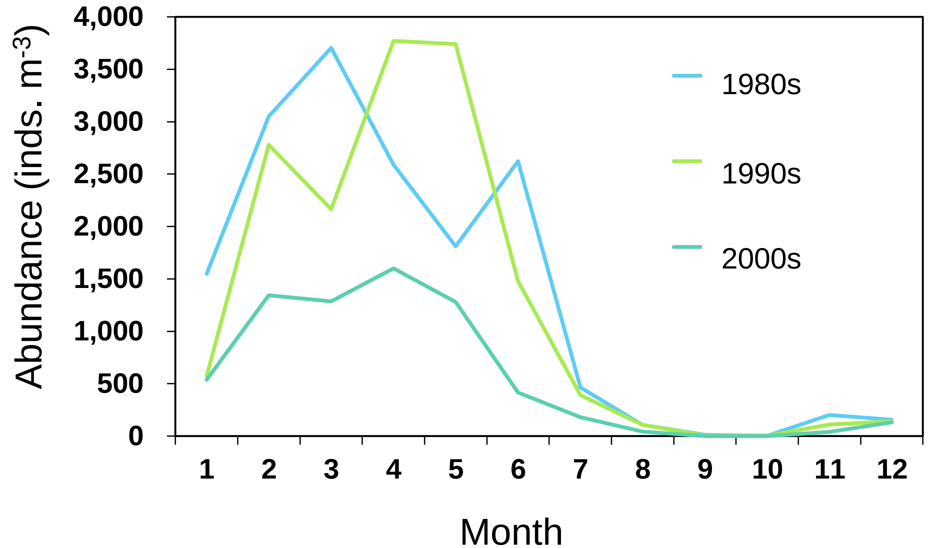
80s

90s

00s

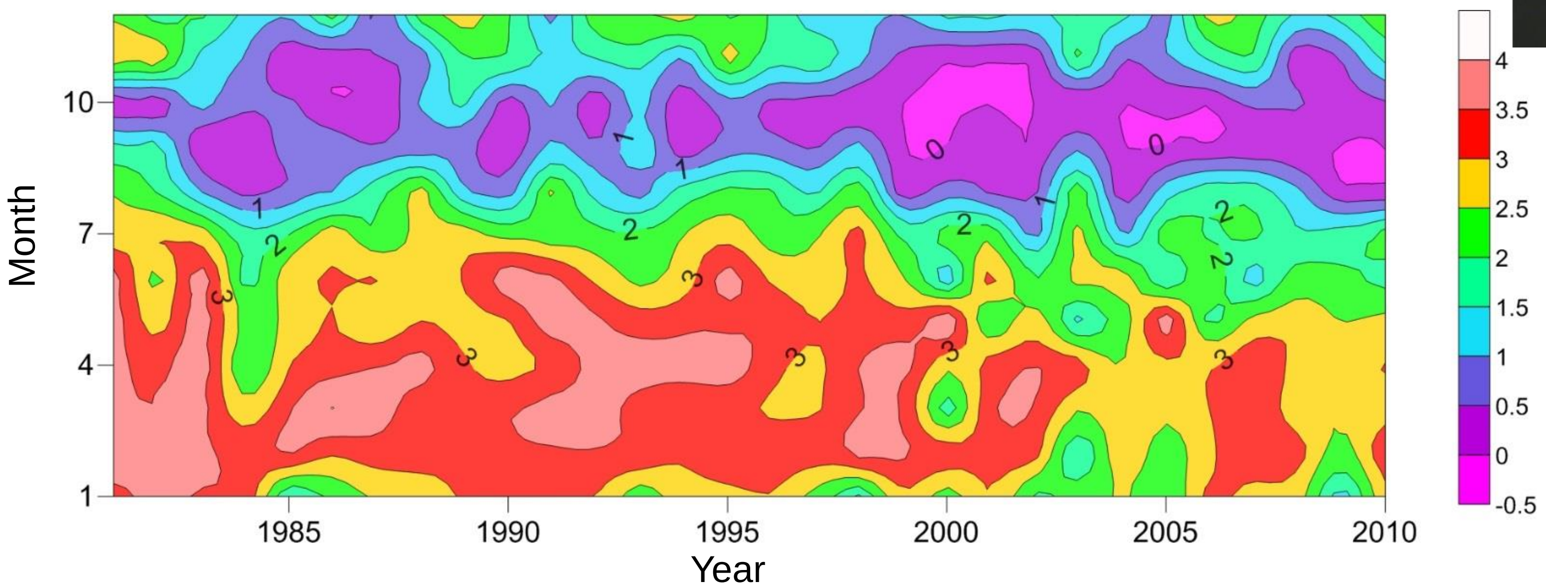
Shift of peak month
March → April

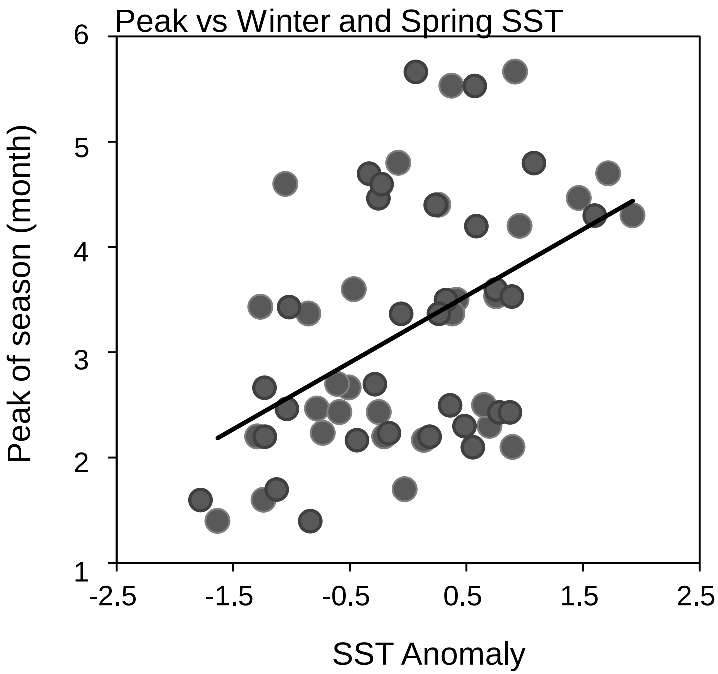
Decrease of abundance
&
Extend disappearance period

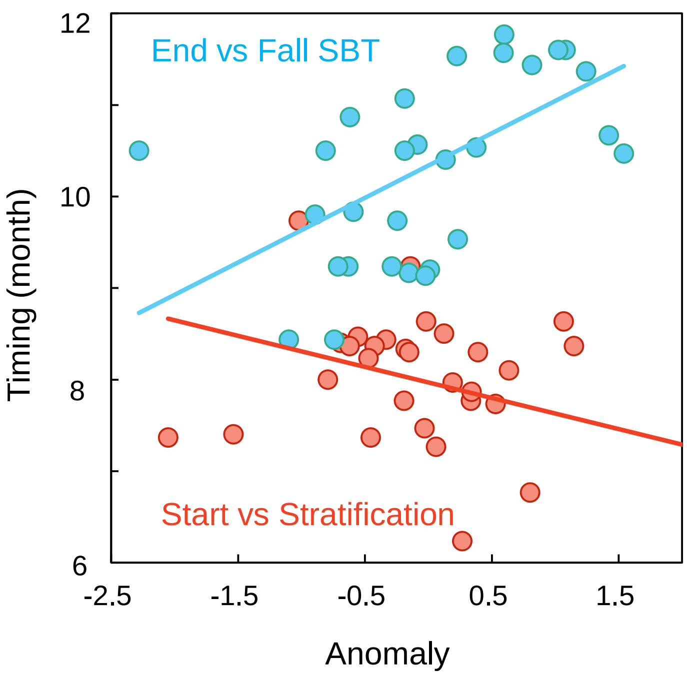


Seasonal variation of *A. omorii* abundance in each decade

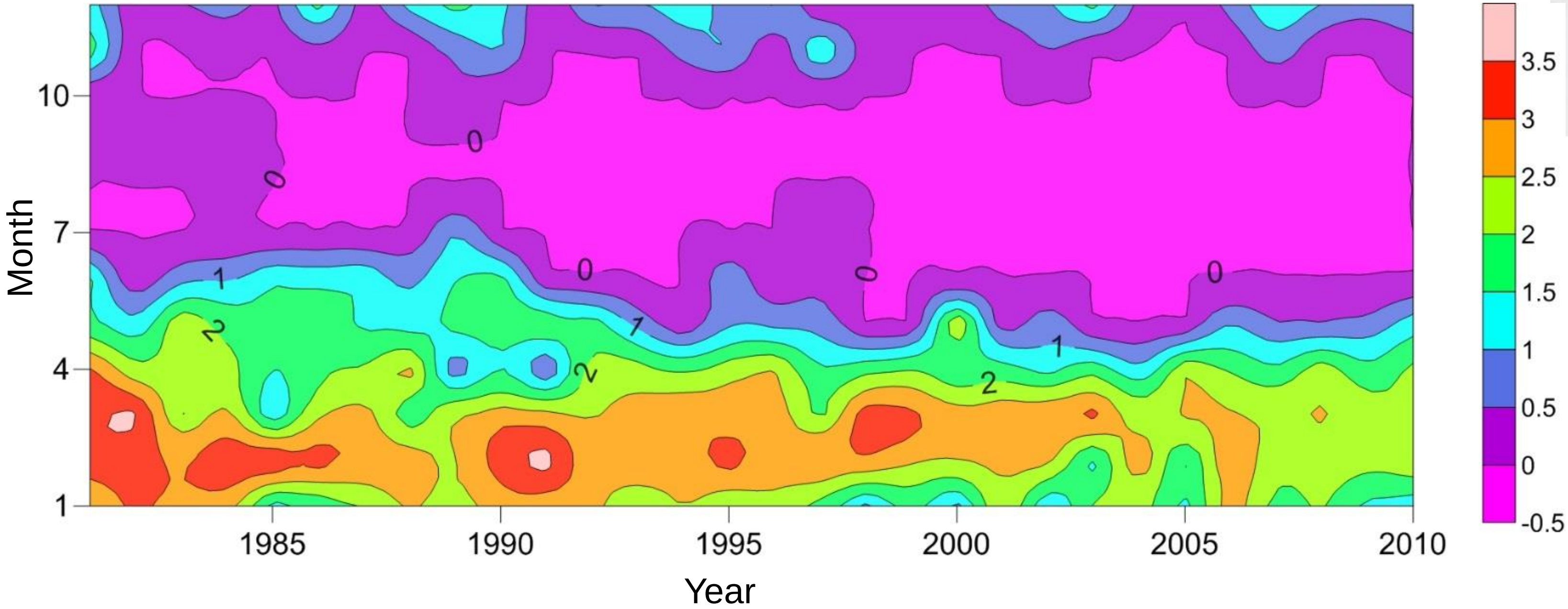
Phenology shifts in *A. omorii*







Phenology shifts in *C. abdominalis*



C. abdominalis

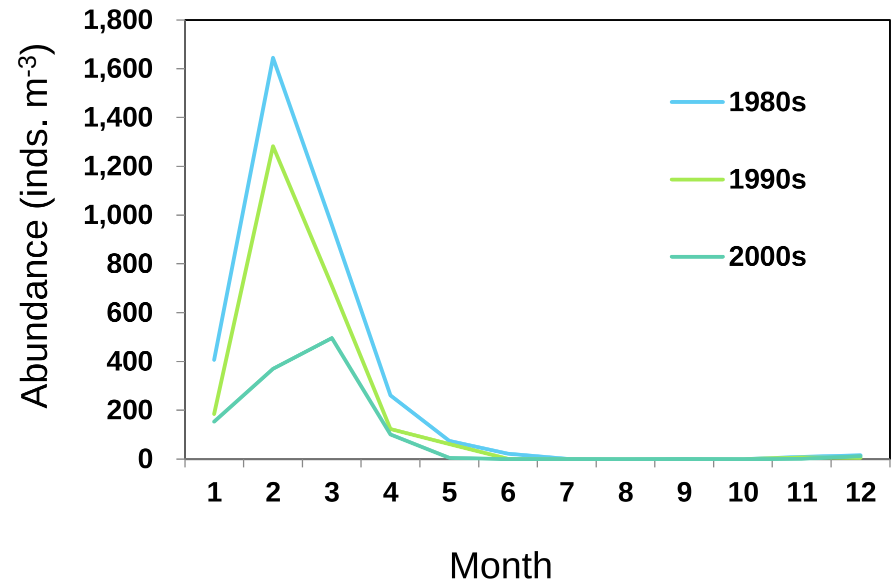
80s

No change of peak month
&
Extend disappearance period

90s

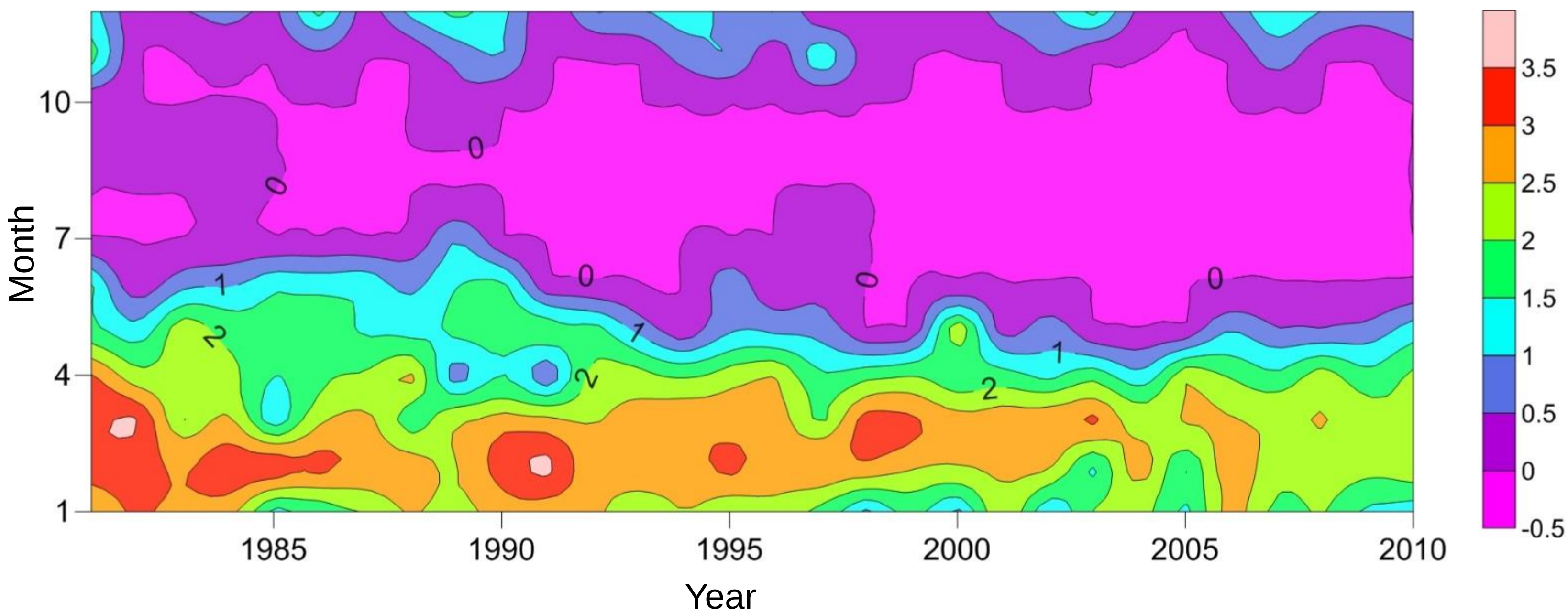
Decrease of abundance
&
Shift of peak timing

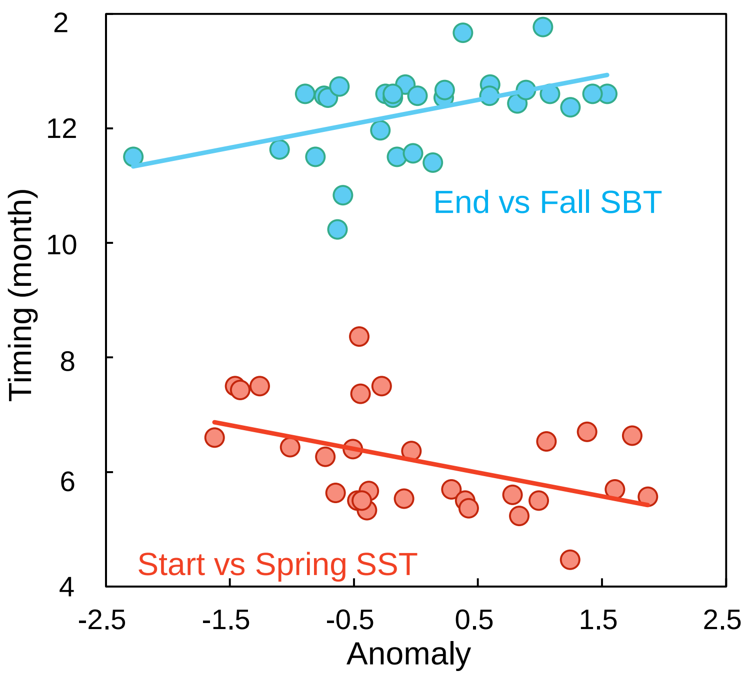
00s



Phenology shifts in *C. abdominalis*

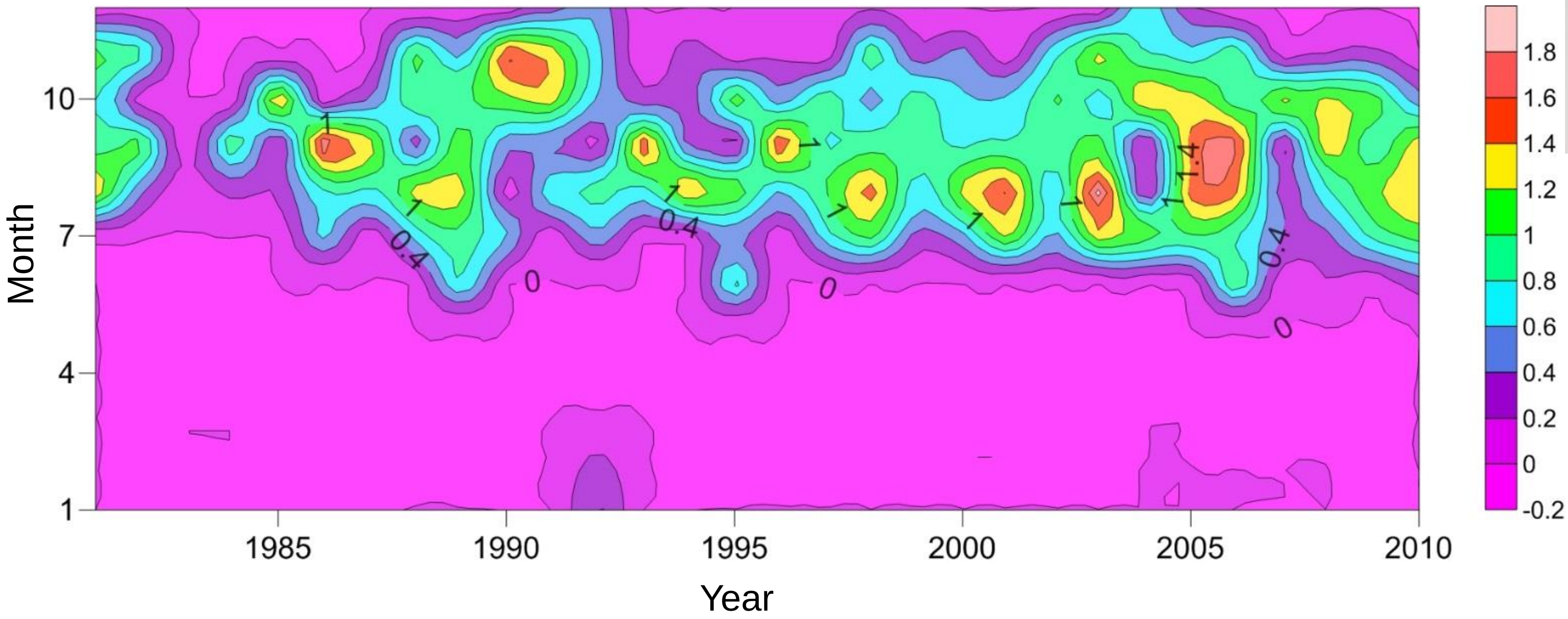
C. abdominalis





- ✓ No significant correlation was detected between peak month and environments
- ✓ Start timing of resting egg was early with warm spring
- ✓ End timing of resting egg was late with warm fall

Phenology shifts in *L. rotunda*



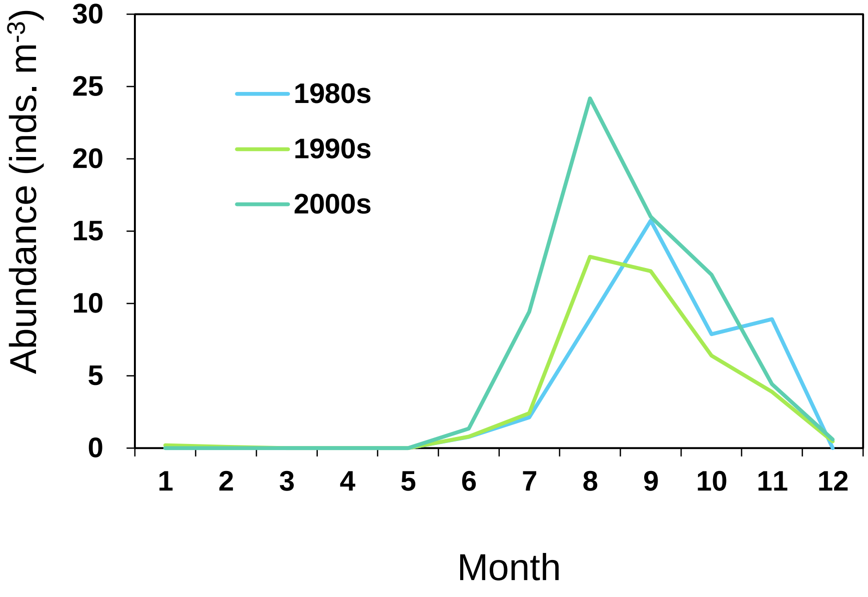
80s

90s

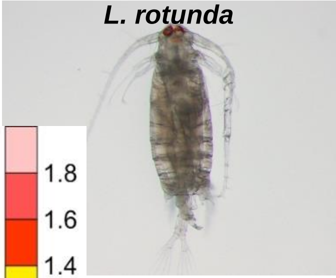
00s

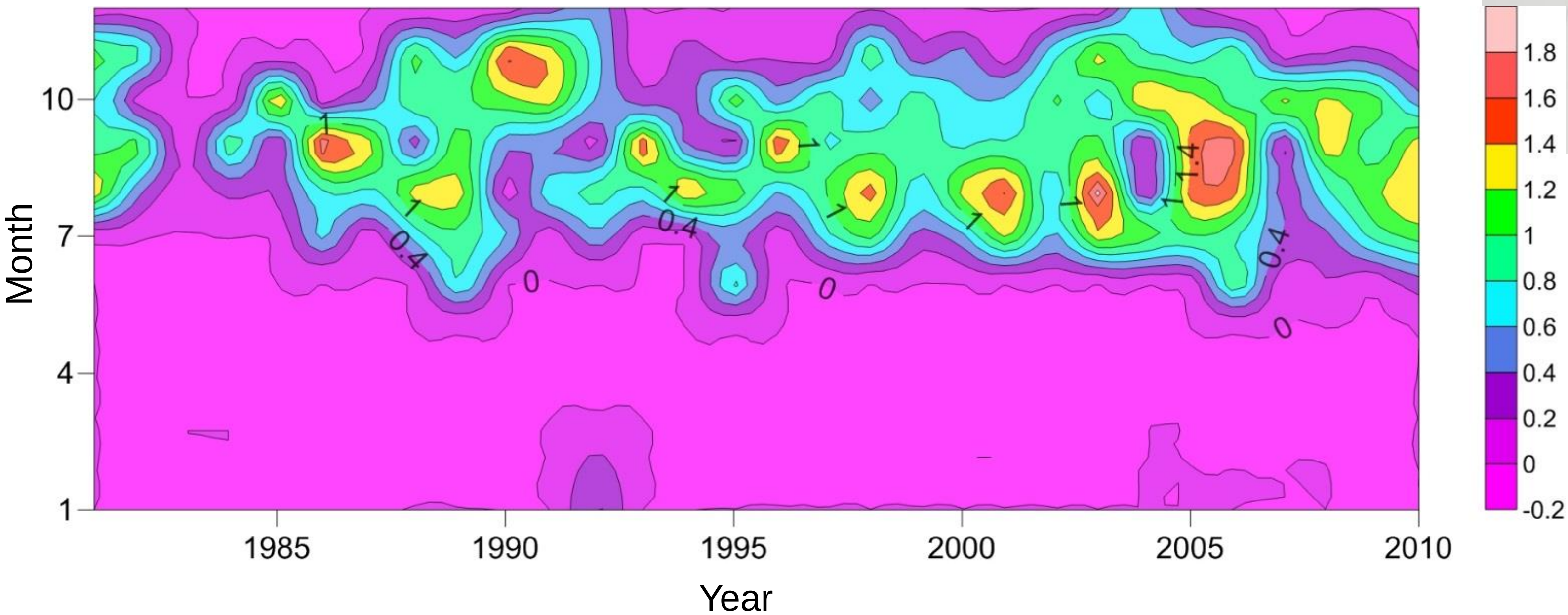
Shift of peak month
September → October

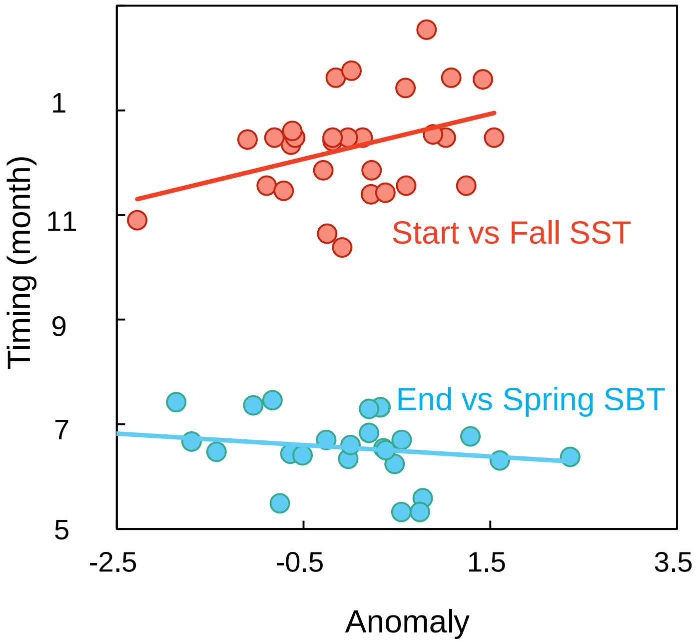
Increase of abundance
&
Shorten disappearance period



Phenology shifts in *L. rotunda*

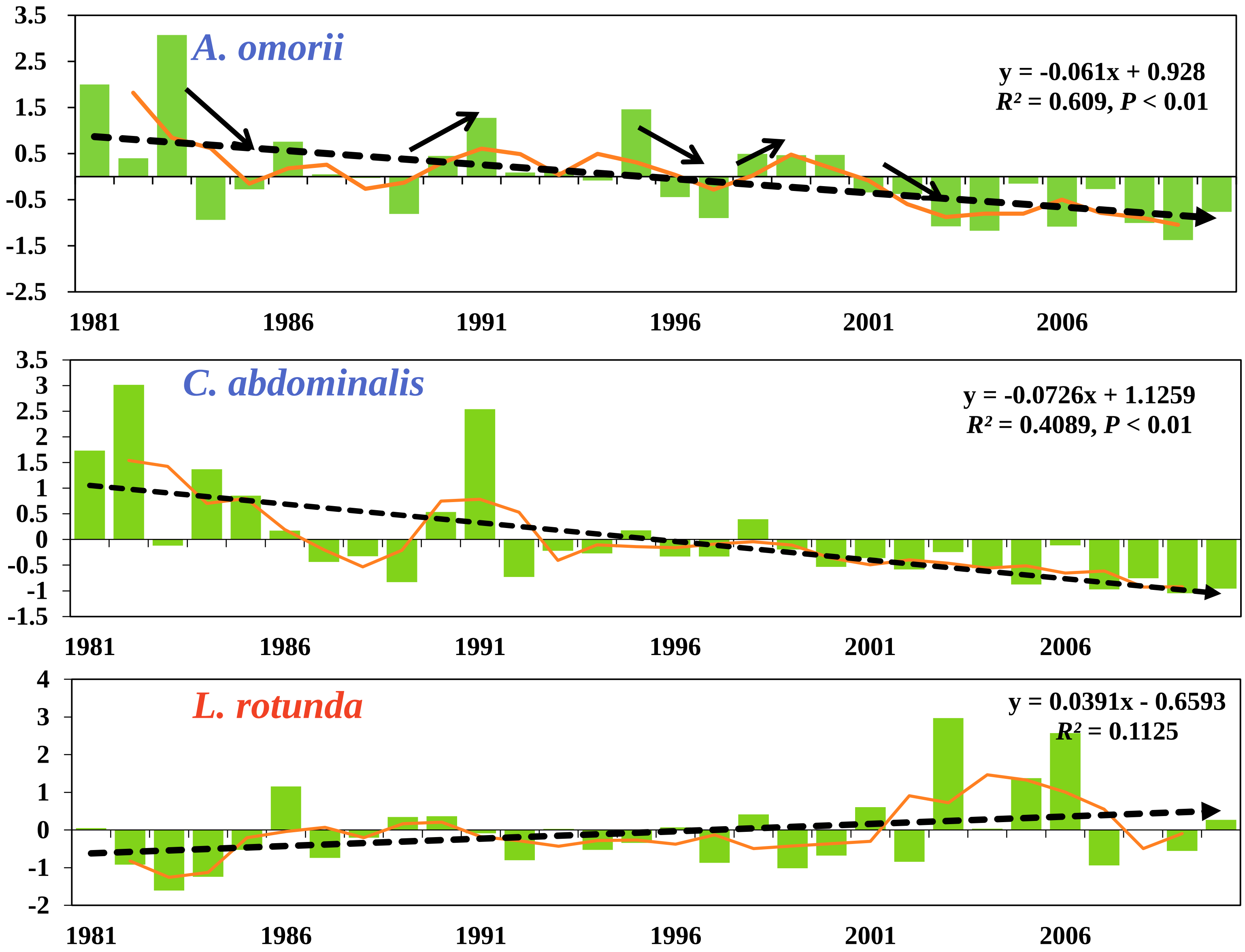




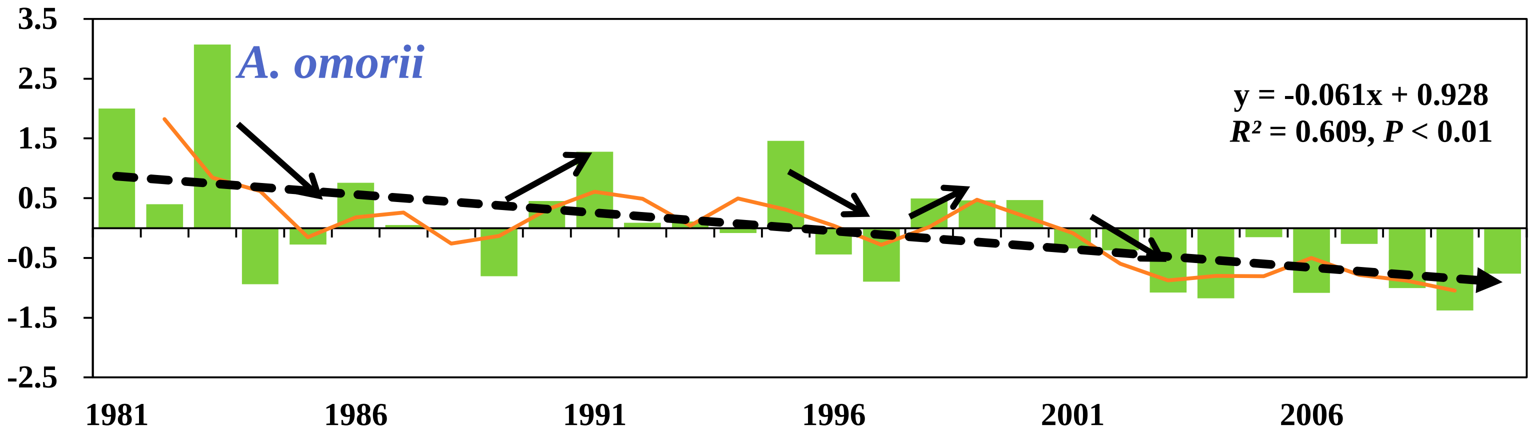


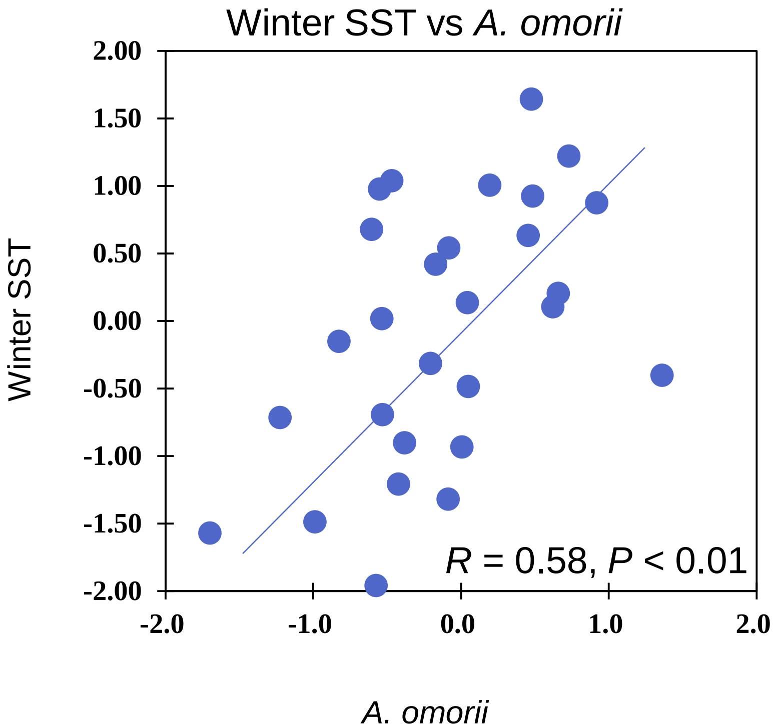
- ✓ No significant correlation was detected between peak month and environments
- ✓ Start timing of resting egg was late with warm fall
- ✓ End timing of resting egg was early with warm spring

Long term trend of three species



Comparison with winter SST





To focus on fluctuation for a few years, we removed decrease trend from anomaly of annual mean abundance.

A. omorii fluctuation had a significant positive correlation with winter SST, suggested that abundance increased with warm winter

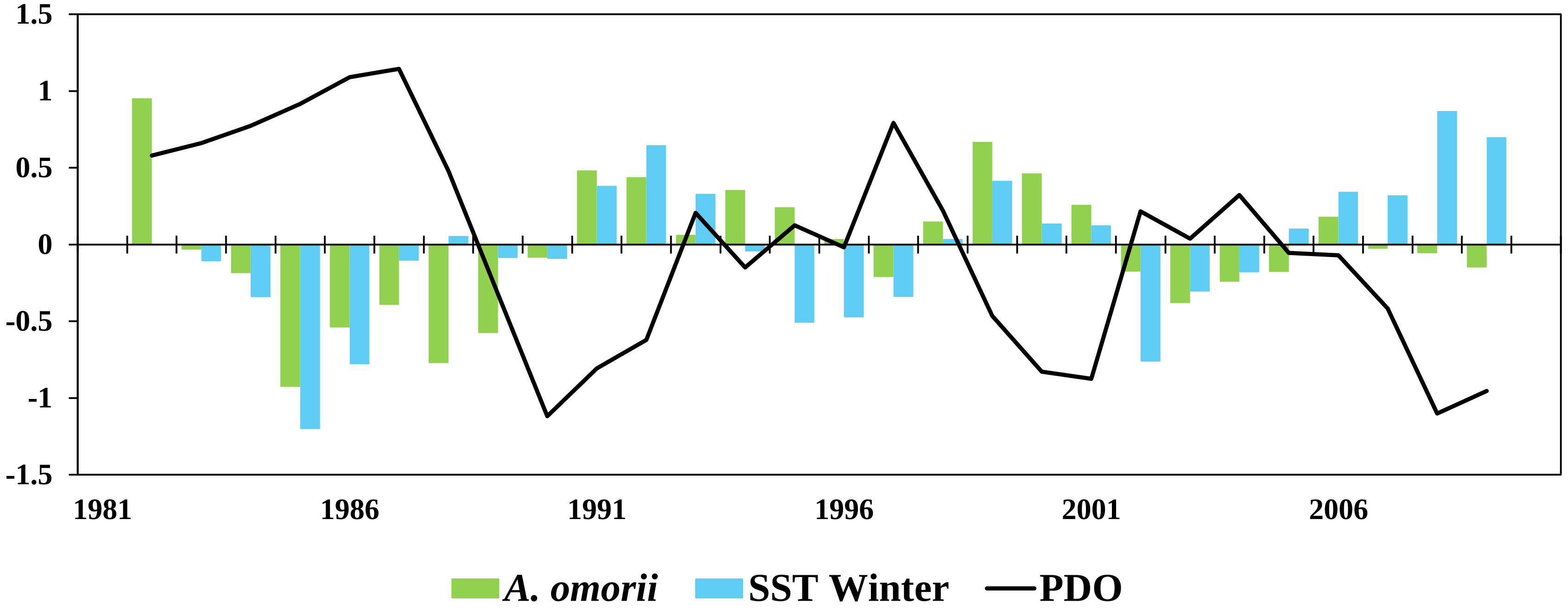
Previous study indicate Temperature govern the A. omorii growth rate without food limitation

(Uye and Shimazu., 1997)

Periodical fluctuations of *A. omorii* abundance is conformed to that of water temperature.

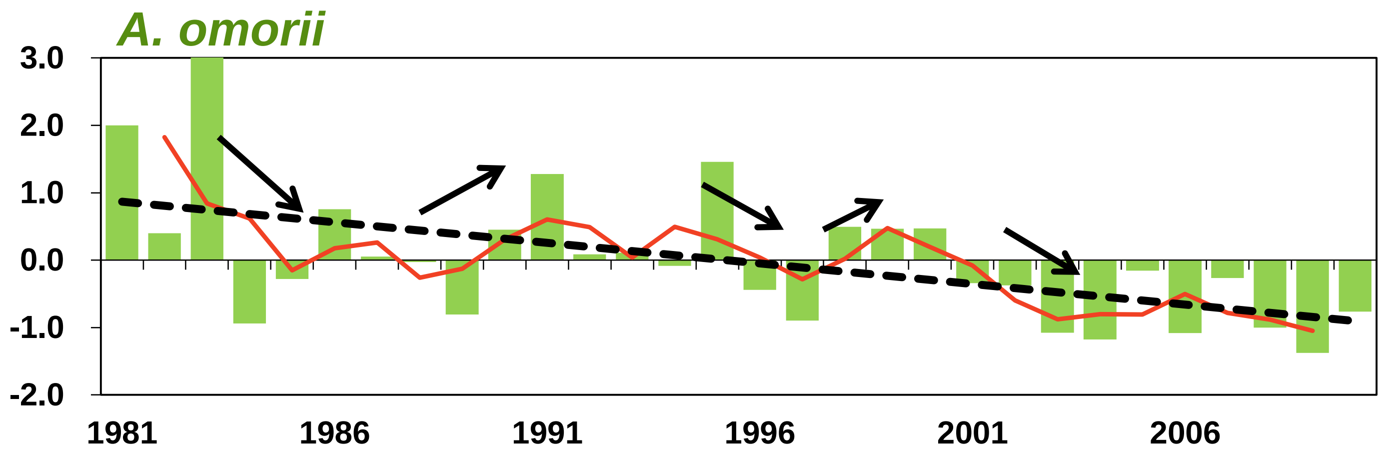
Comparison with climate index

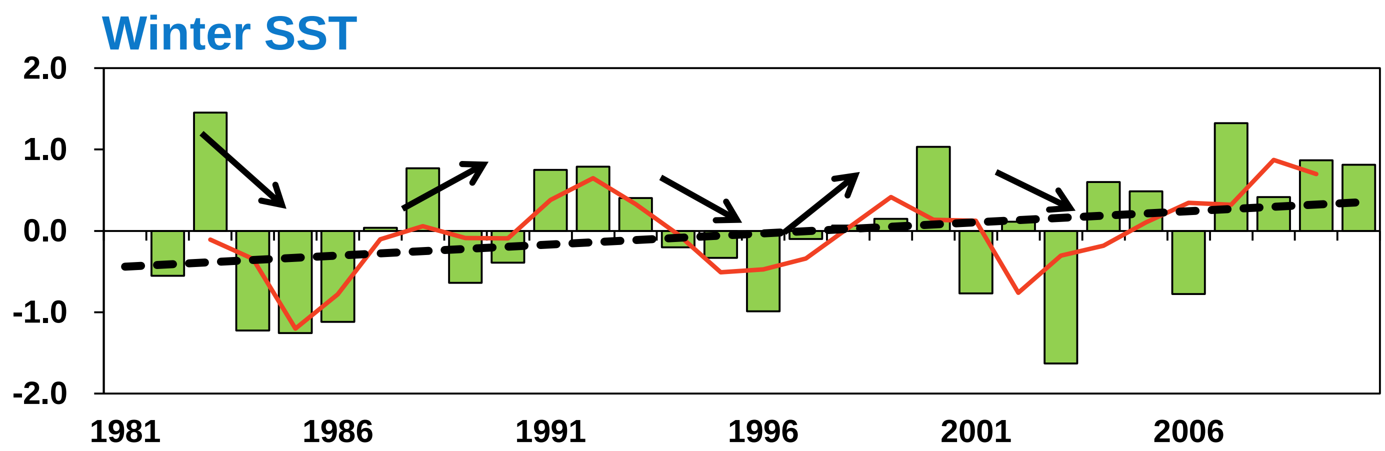
	Winter SST	Spring SST	Summer SST	Fall SST	Stratification
PDO	-0.680**	-0.667**	n.s.	n.s.	-0.515**



Short-term fluctuation of *A. omorii* and winter SST had a high negative correlation with PDO.

Long-term trend and Periodicity





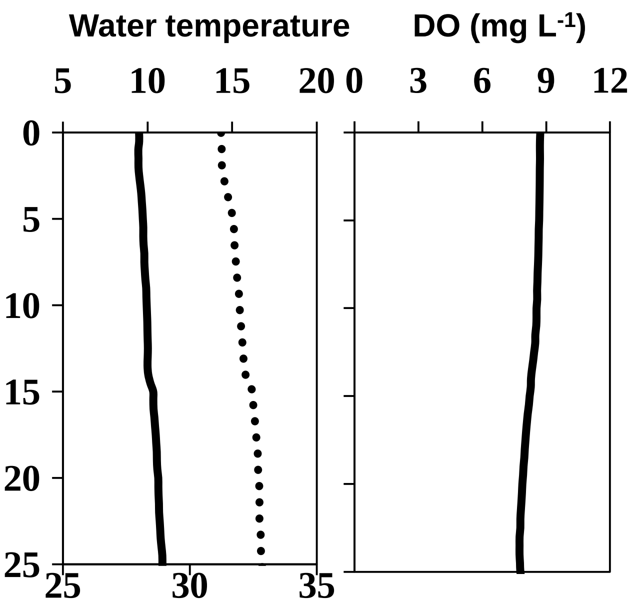
Periodicity：Fluctuation of *A. omorii* coincide with that of winter SST

Discrepancy

Long-term trend ： *A. omorii*･･･decrease

SST･･･increase

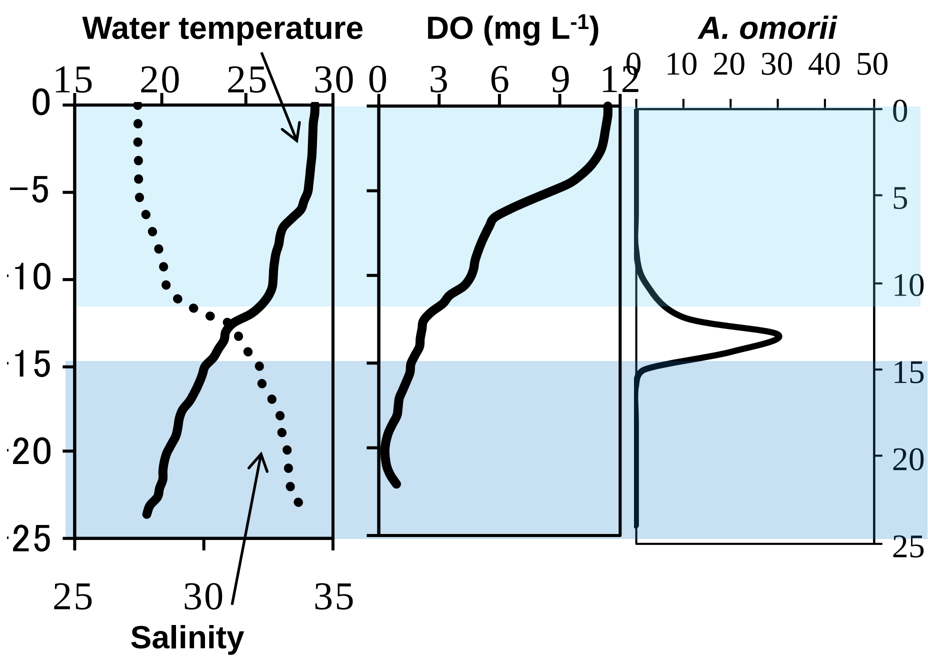
Vertical distribution of Temperature, DO & *A. omorii*



In winter : Temperature & DO conc. well mixing from surface to bottom

increase of temperature

Develop the thermocline, then decrease of DO below thermocline



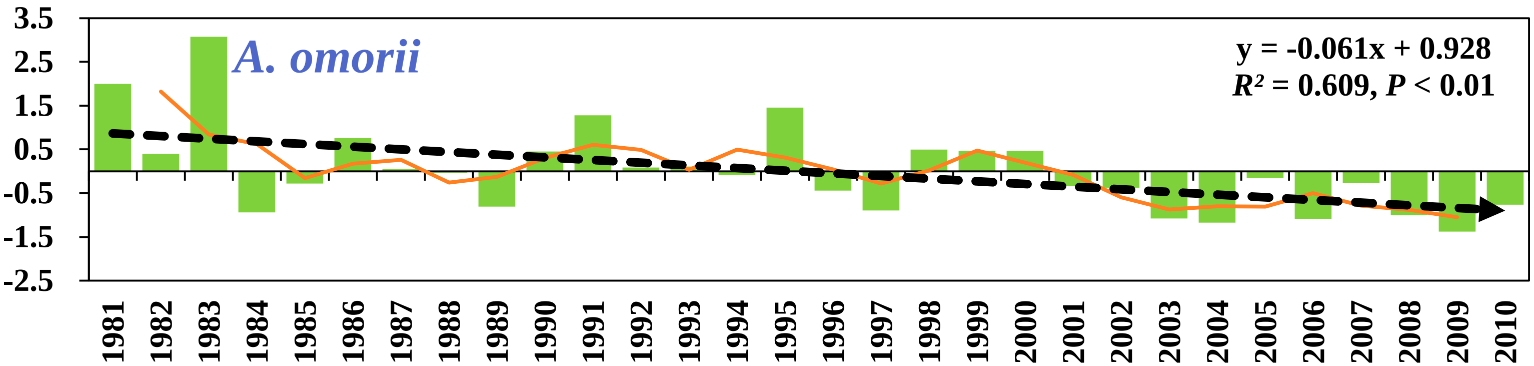
←High water temperature zone
Upper thermal limit of *A. omorii*

←Hypoxic water mass develops below thermocline
A. omorii cannot stay
&
Subitaneous egg become resting egg to expose in hypoxic water (Uye 1980)

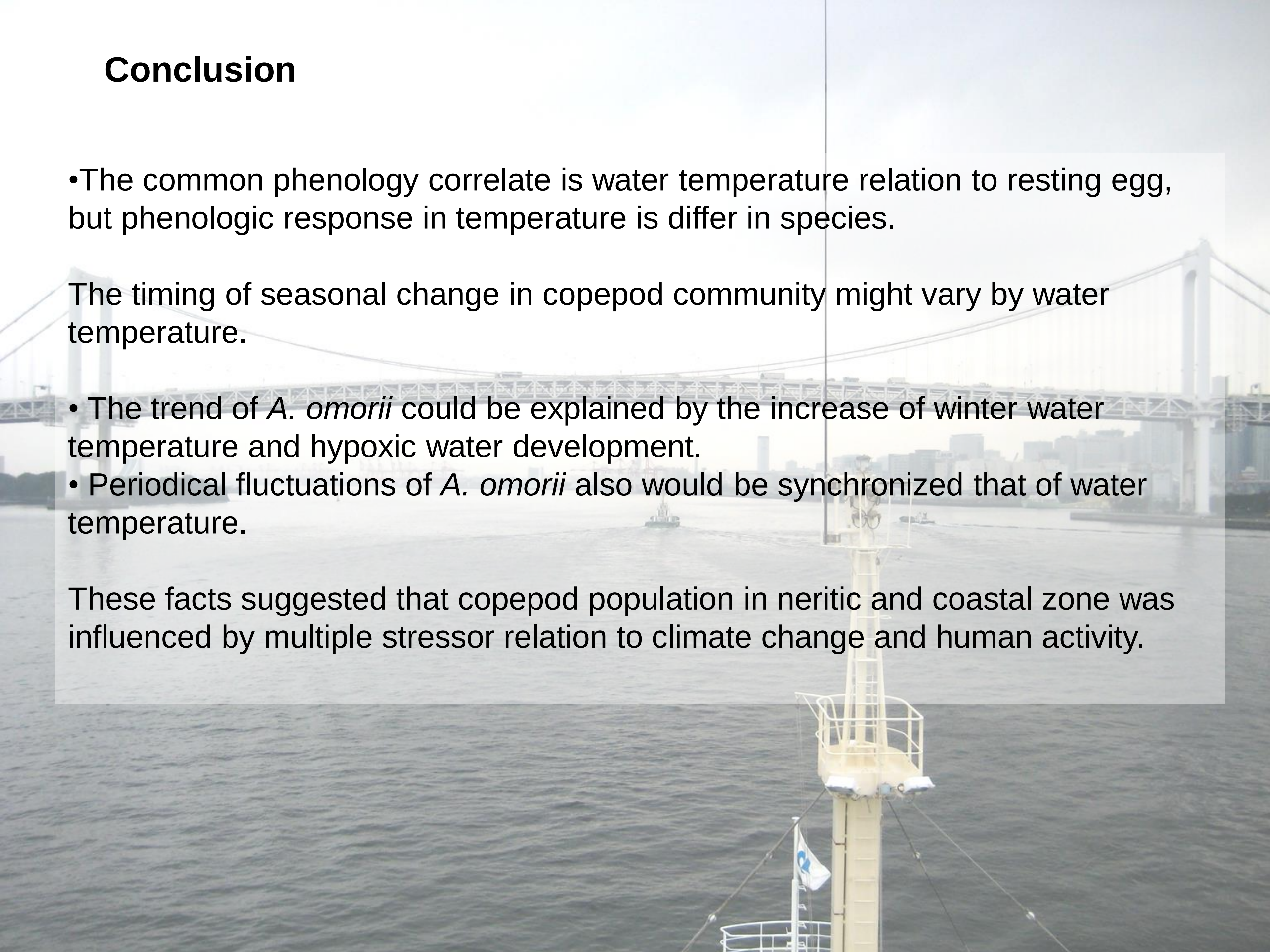
Process of long term decrease in *A. omorii* abundance

1. Warm winter in a year
2. Formation of stratification is early
3. Hypoxic water mass develops is early
4. Extend of duration of resting egg population

Long term expose in hypoxic water mass caused heavy damage to resting egg population in warming season



Warming trend also changed start and end timing of resting egg.
Climate warming caused strong impact to resting egg production copepod



Conclusion

•The common phenology correlate is water temperature relation to resting egg, but phenologic response in temperature is differ in species.

The timing of seasonal change in copepod community might vary by water temperature.

• The trend of *A. omorii* could be explained by the increase of winter water temperature and hypoxic water development.
• Periodical fluctuations of *A. omorii* also would be synchronized that of water temperature.

These facts suggested that copepod population in neritic and coastal zone was influenced by multiple stressor relation to climate change and human activity.