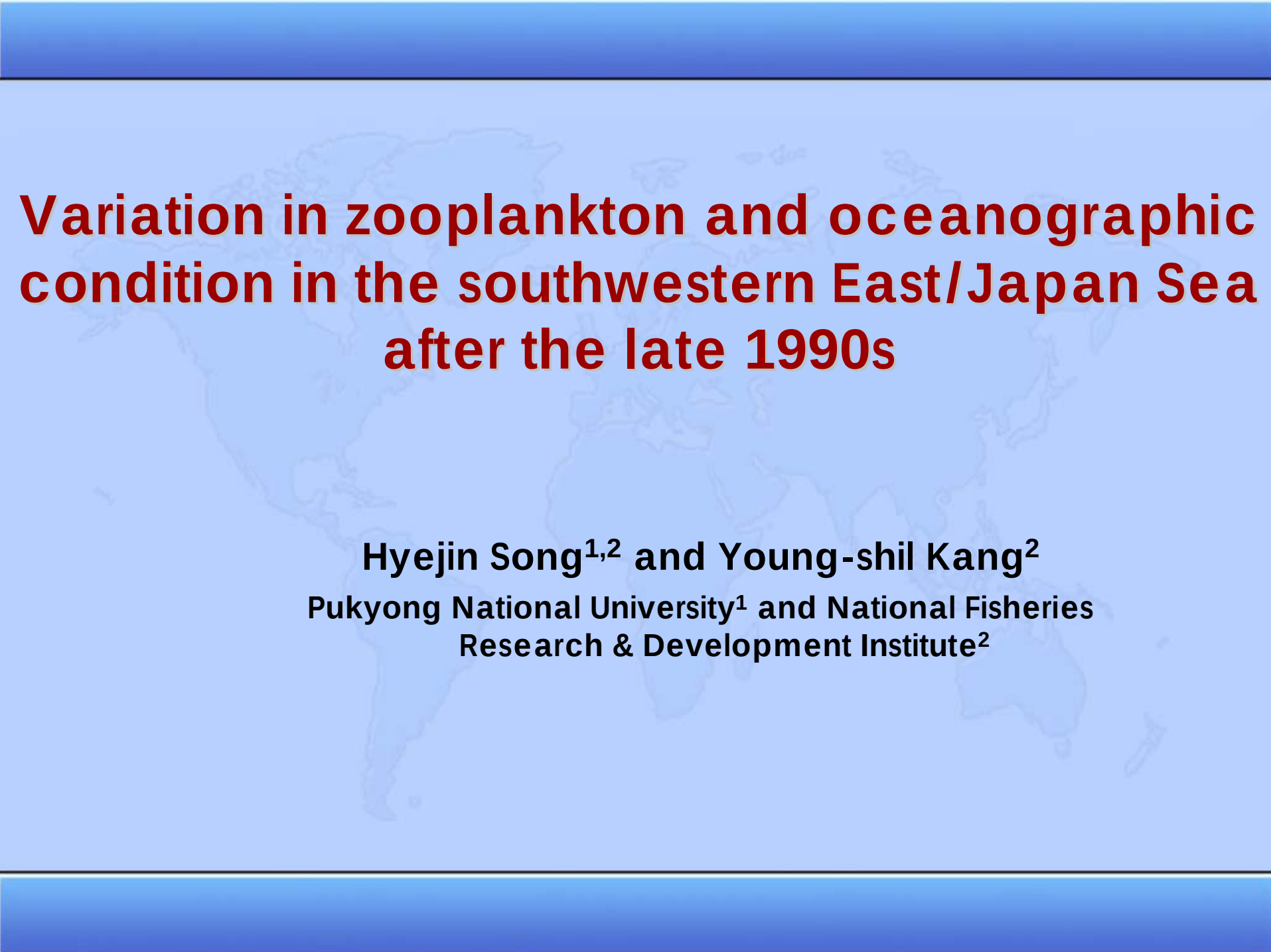


A faint, light blue world map is visible in the background of the slide, centered behind the text.

Variation in zooplankton and oceanographic condition in the southwestern East/Japan Sea after the late 1990s

Hyejin Song^{1,2} and Young-shil Kang²

**Pukyong National University¹ and National Fisheries
Research & Development Institute²**

Introduction

Environmental changes

Physical properties

- Average SST
- Salinity
- Mixed layer depth
- Mean sea level



Biological characteristics

- Distribution
- Productivity
- Abundance of organisms

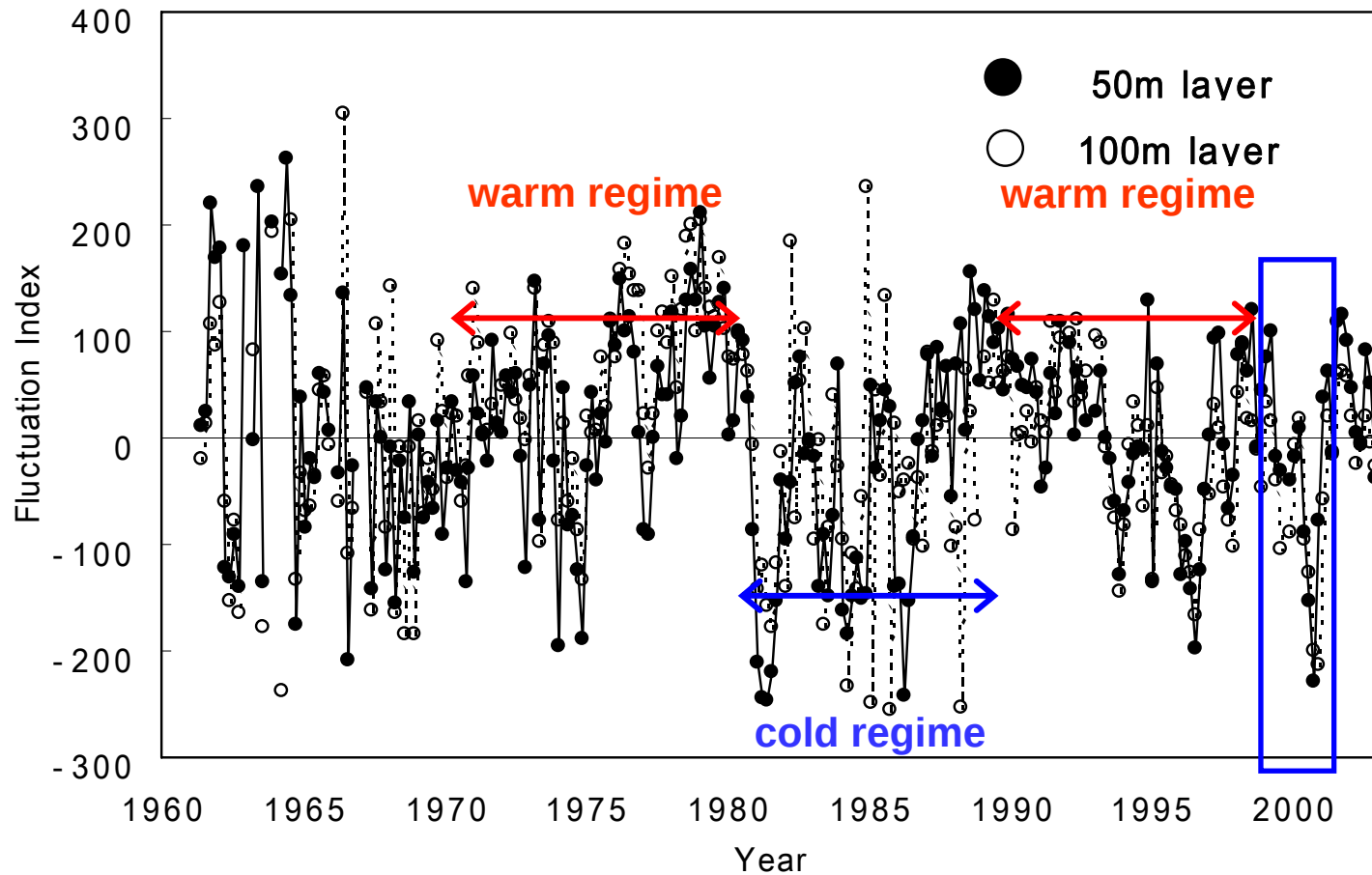
Introduction

- **Regime shifts of 1976/77 and 1988/89 in the North Pacific Ocean** (Mackas, 1995; Sugimoto & Tadokoro, 1998; Brodeur et al., 1999; Hare & Mantua, 2000; Minobe, 1999, 2000; Zhang et al., 2000)
- **Minobe(2000) suggested that one more regime shift occurred in the late 1990s.**

East/Japan Sea

- The western marginal area of the Kuroshio Current
- Physical and biological changes around the 1976 and 1989 (Zhang et al., 2000)
 - decrease in spring primary production until late 1980s
 - increase in the mixed layer depth and primary production in fall after 1976
 - increase in the primary production and zooplankton after 1989



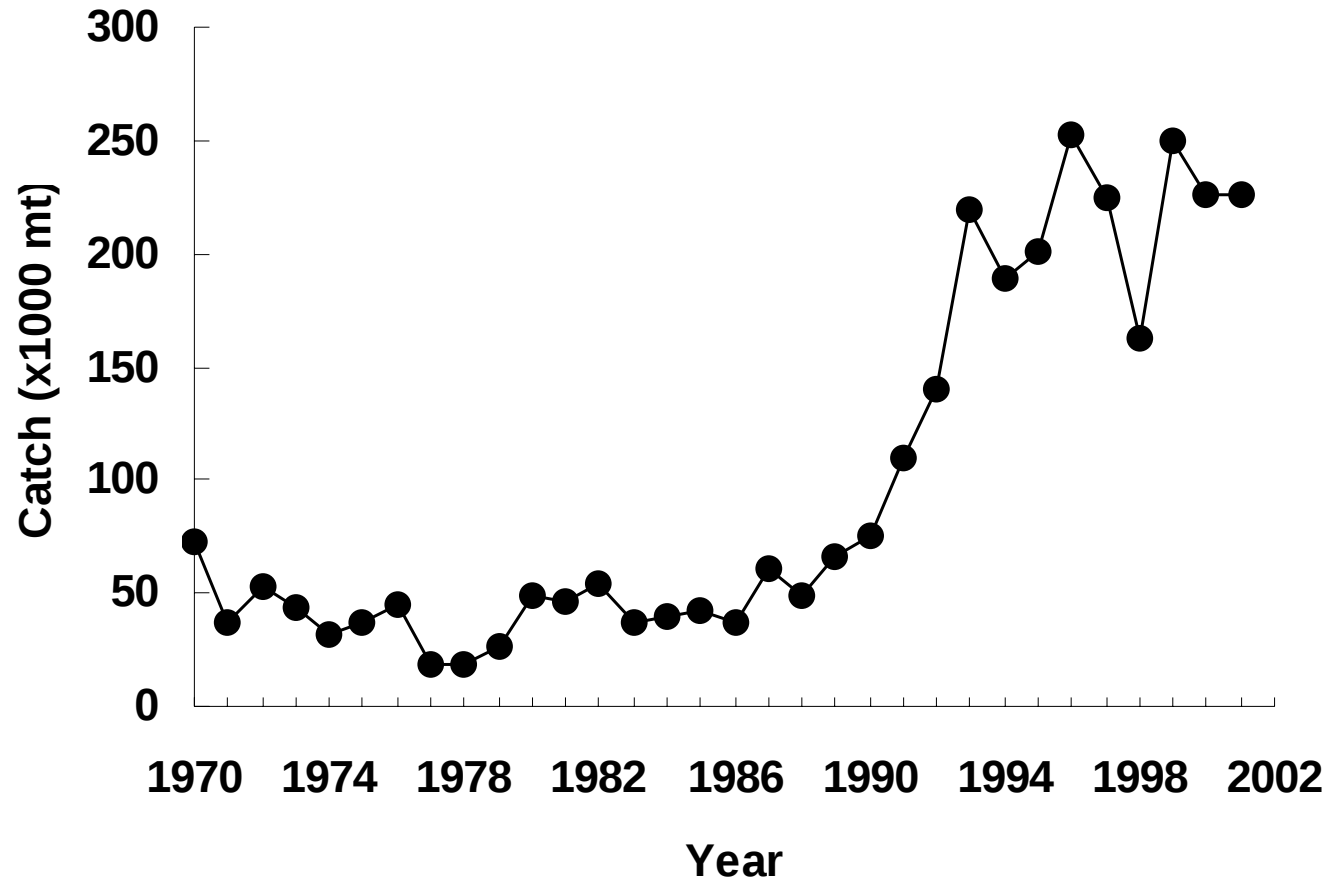


Temperature anomalies of 50m and 100m layer
in the East Sea of Korea, 1960-2002.

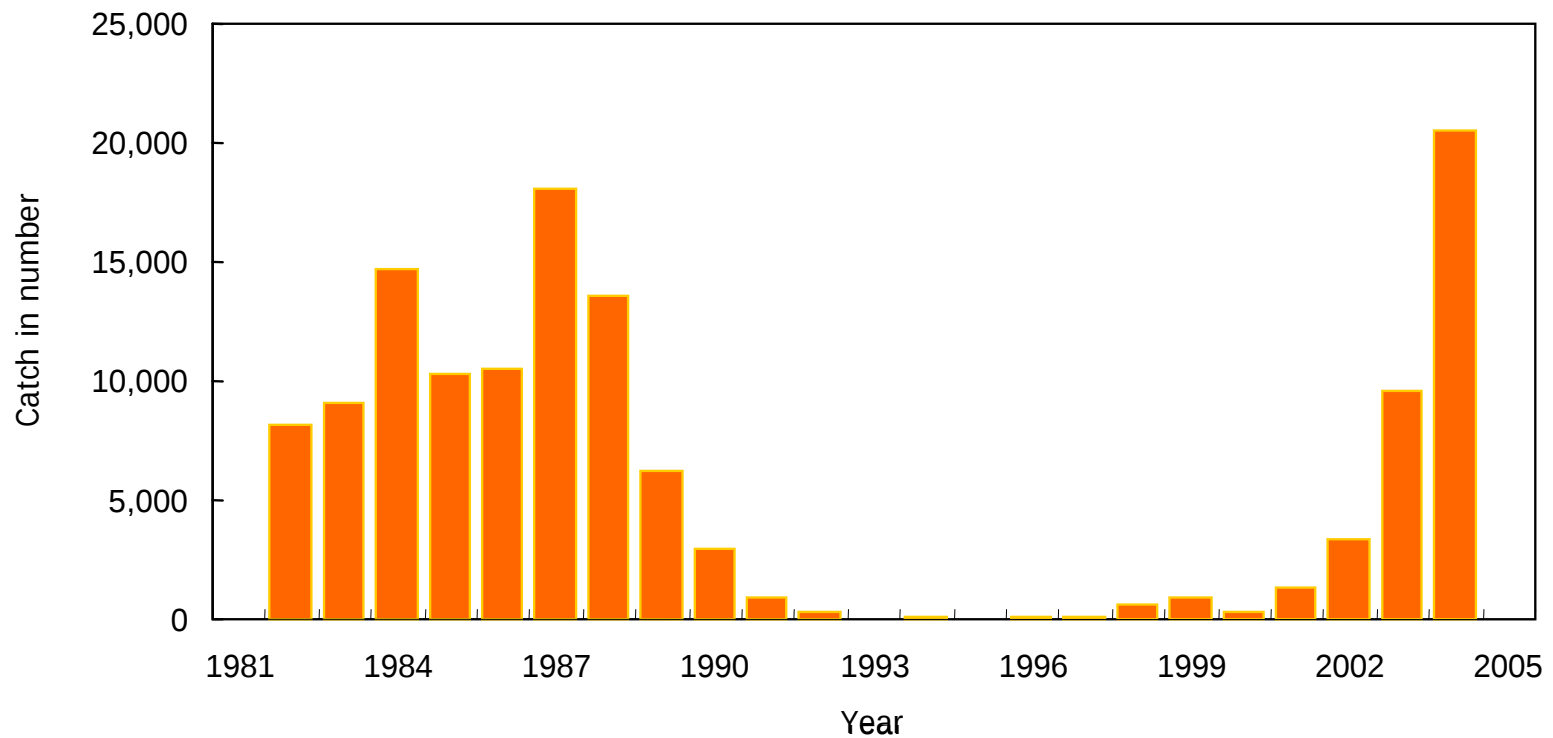
*Fluctuation Index = $100(x - \bar{x}) / \sigma$ (x: temperature, σ : standard deviation)

(from Choi, 2005)

Annual catch of common squid in Korean waters



Pacific cod in the ECS of Korea



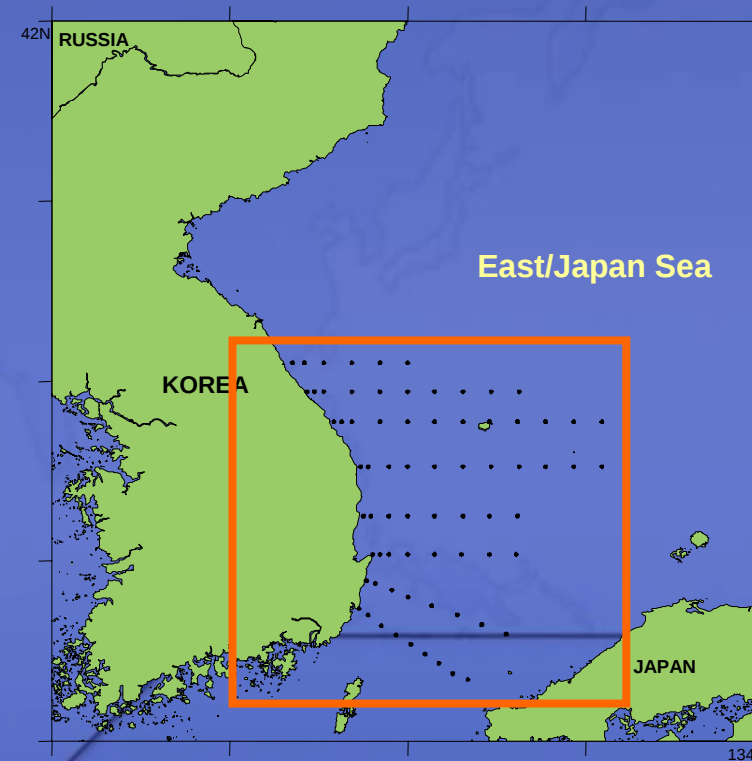
Objective

**To examine what happened
in the zooplankton
community of the East/Japan
Sea ecosystem in the late
1990s ?**



Data and Methods

- Bimonthly data collected using NORPAC net (45 diameter): SST, salinity, and zooplankton
- Analysis for four major zooplankton groups (Copepod, Amphipod, Chaetognath, Euphausiid) since 1978

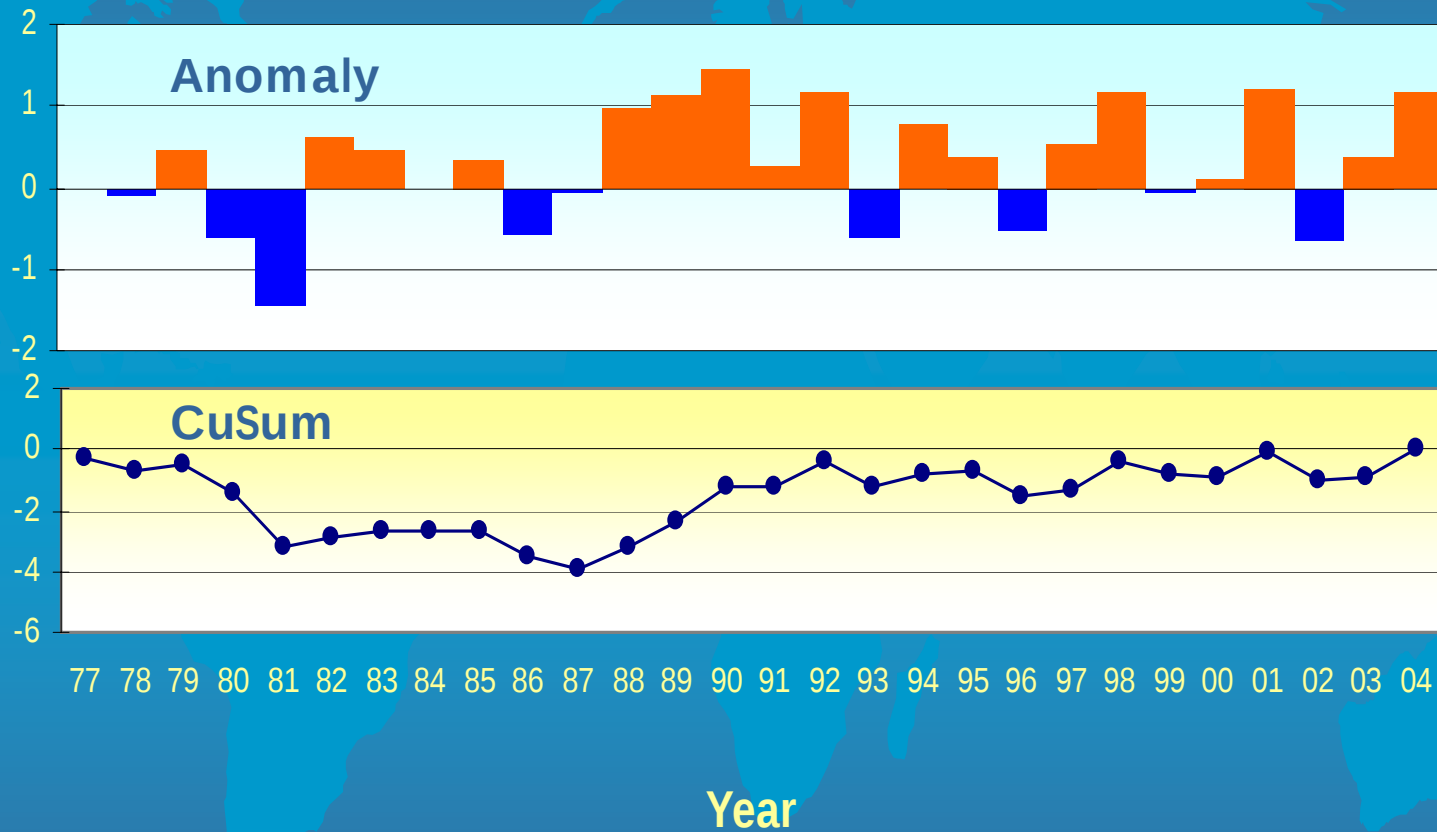


Results

- I. Annual and seasonal changes in SST and salinity
- II. Variations of seasonal cycle of zooplankton groups

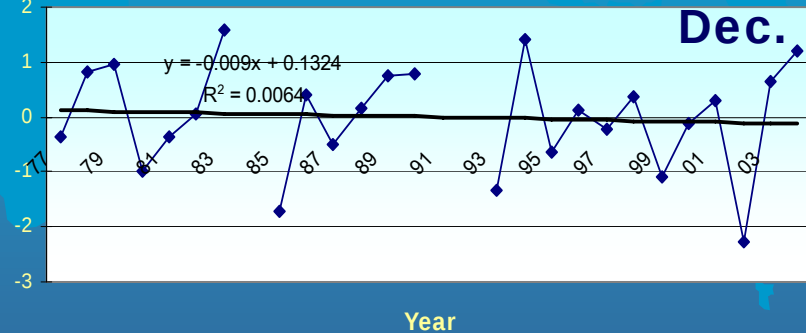
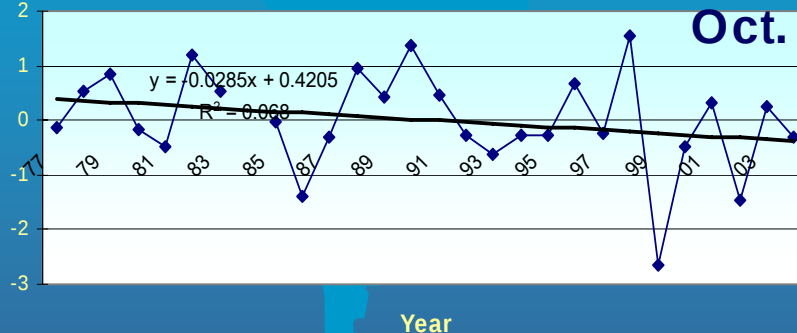
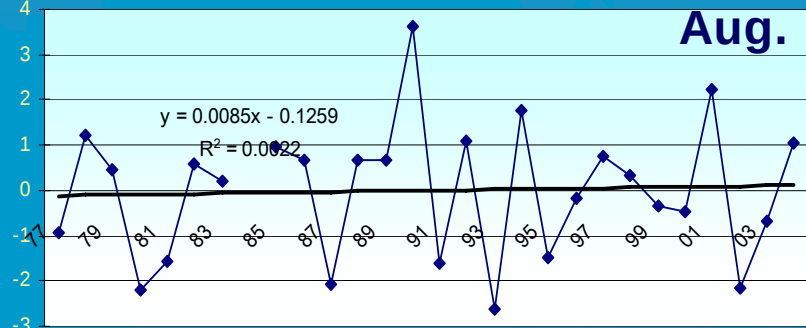
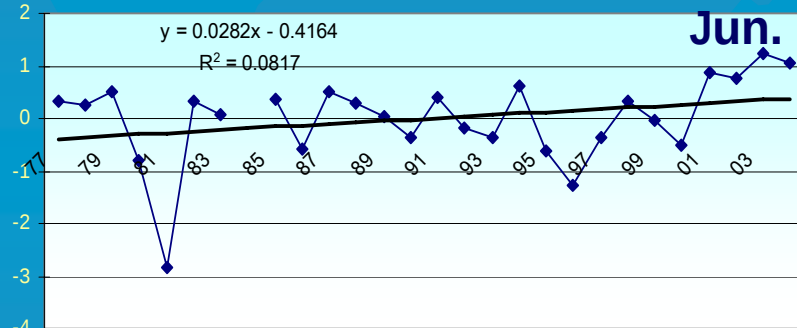
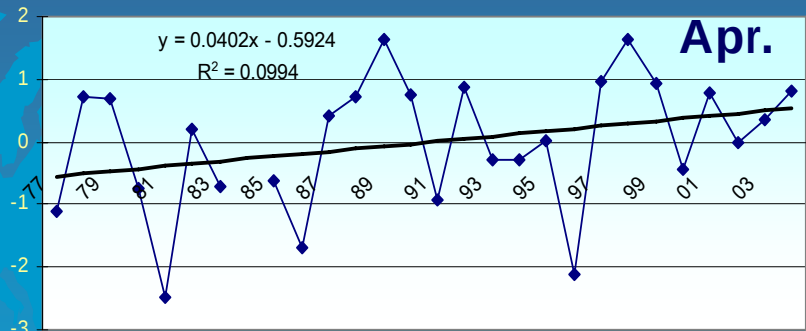
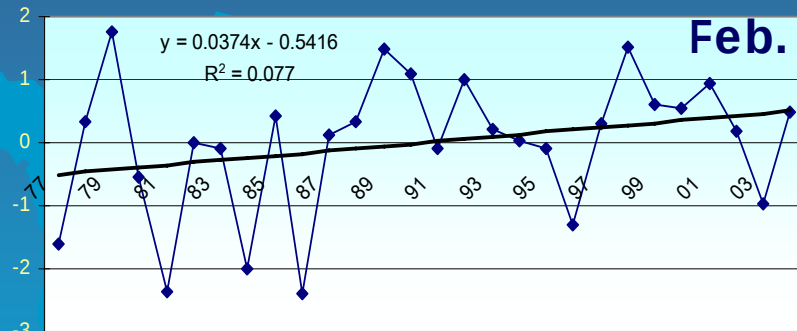


Changes in annual mean SST



Anomaly and cumulative sum plots of annual mean SST

Seasonal changes in SST



Year

Year

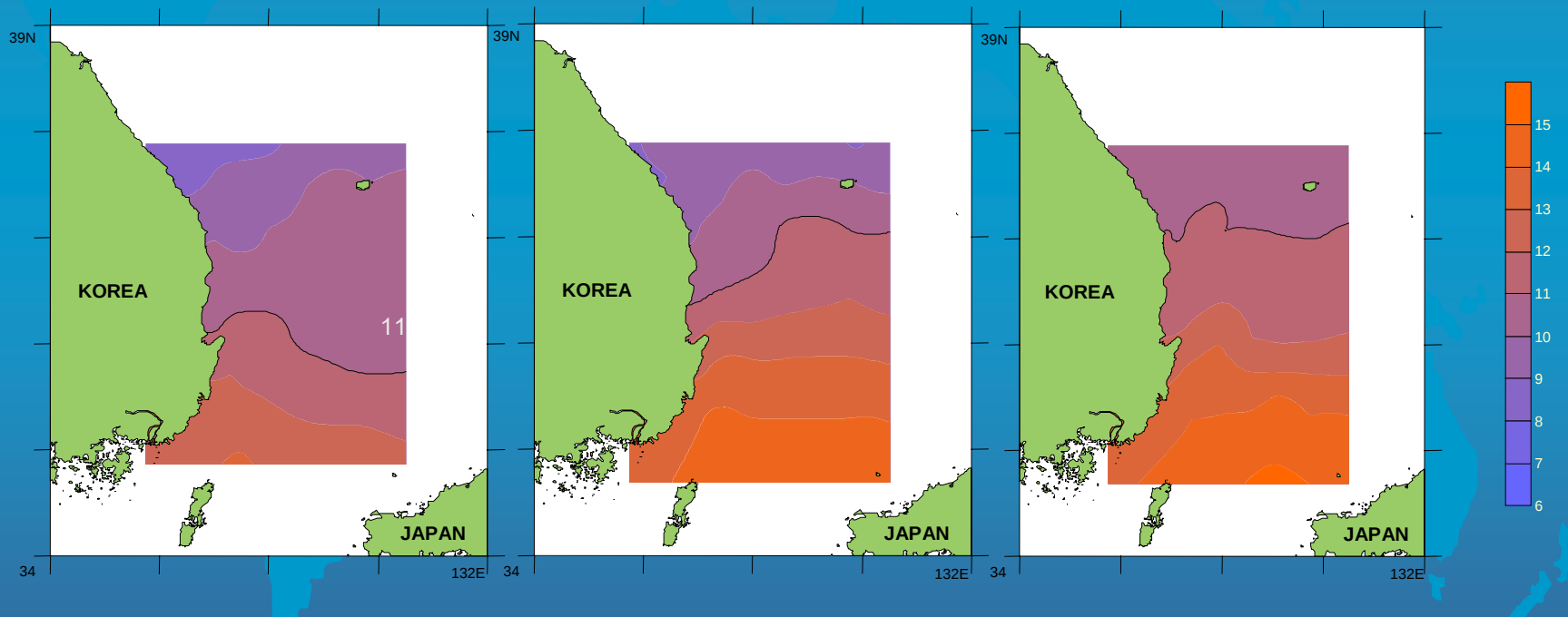
Bimonthly anomaly plots of sea surface temperature ($P < 0.05$)

Spatial distribution of average SST

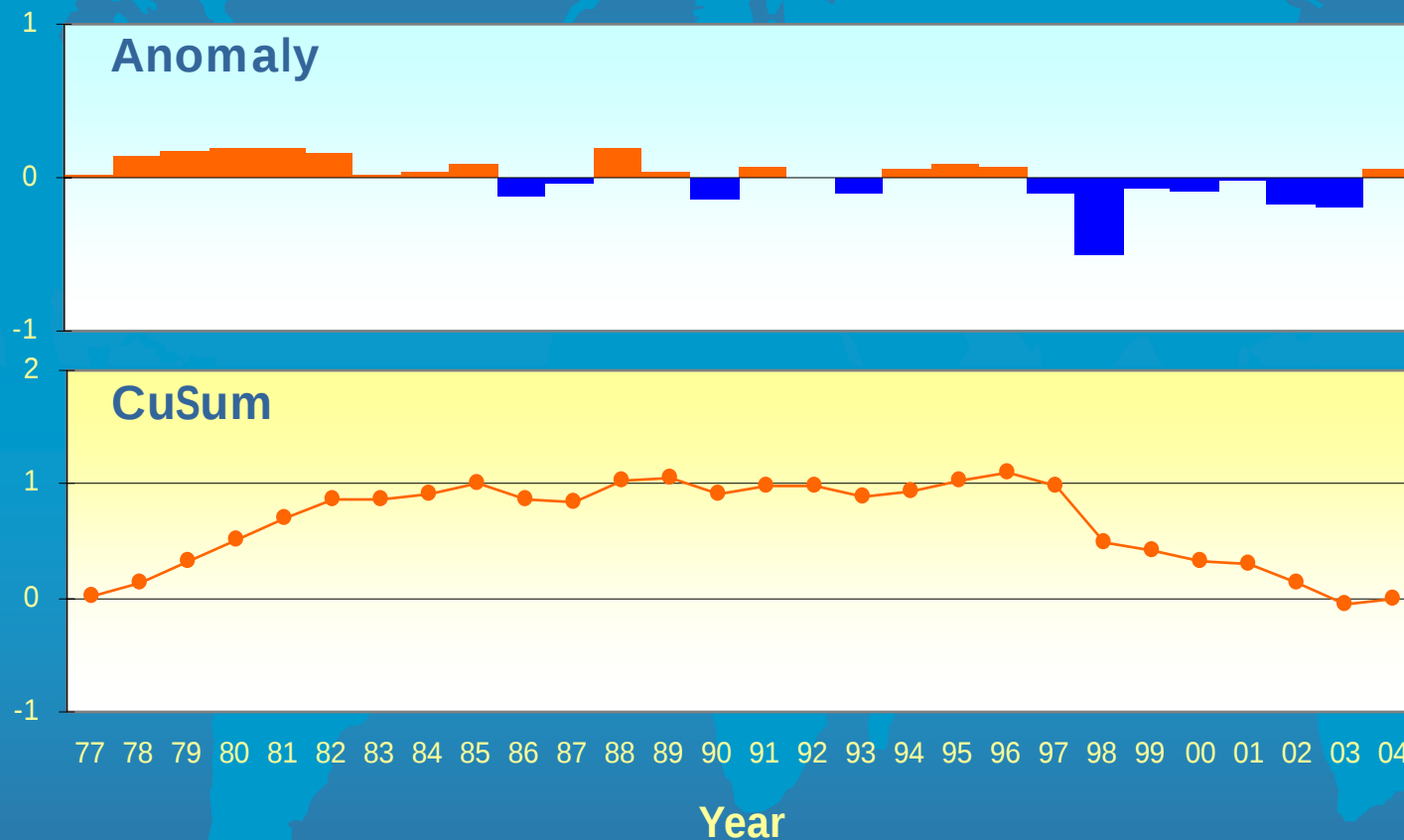
February (1977-88yrs)

February (1989-97yrs)

February (1998-04yrs)

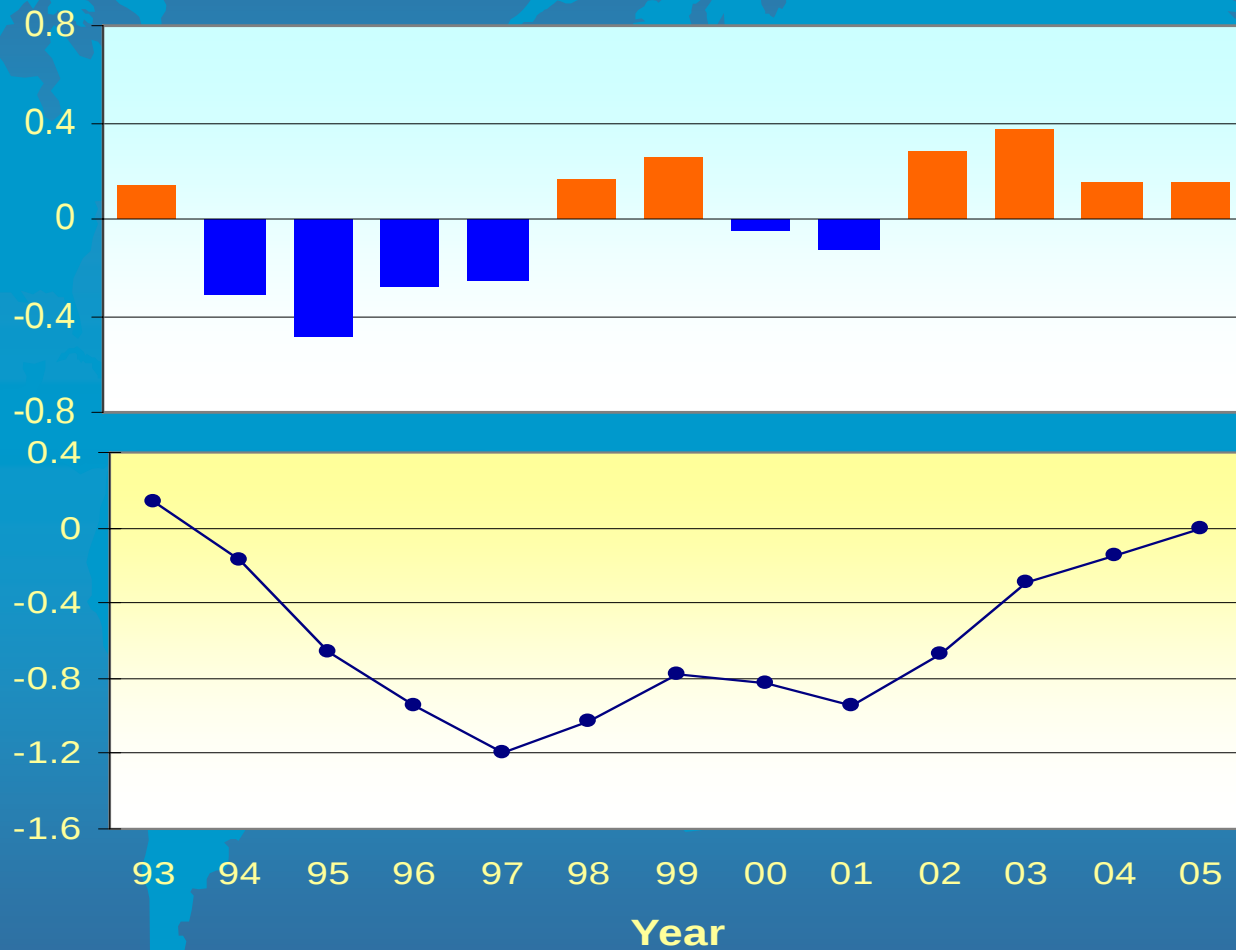


Changes in annual mean salinity (depth 10m)



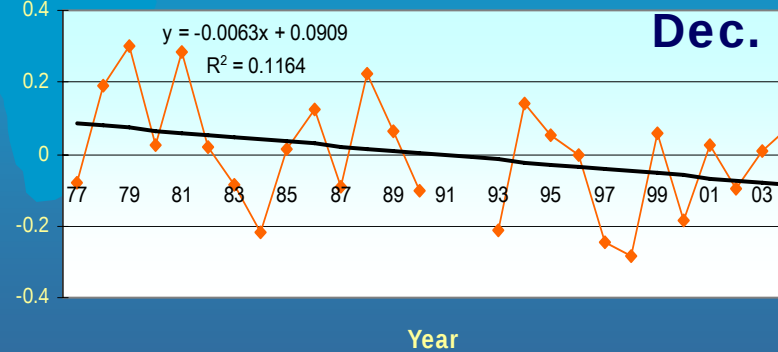
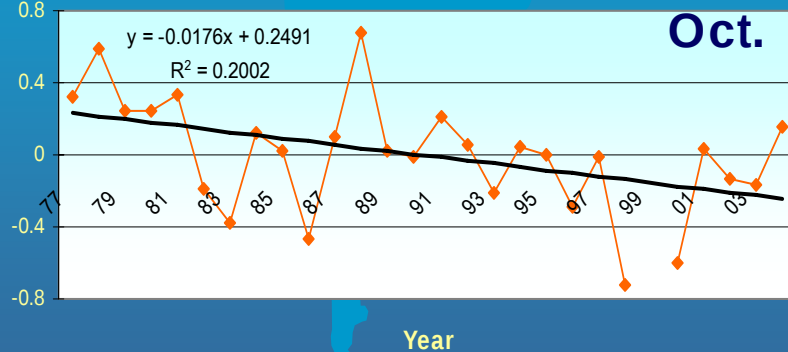
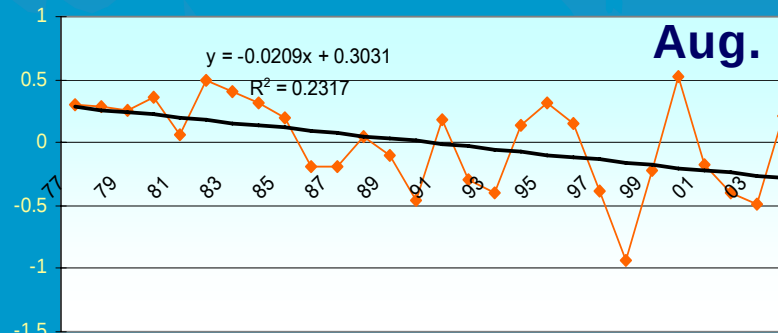
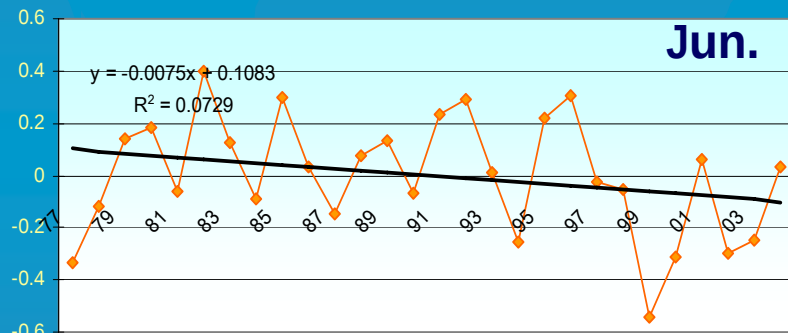
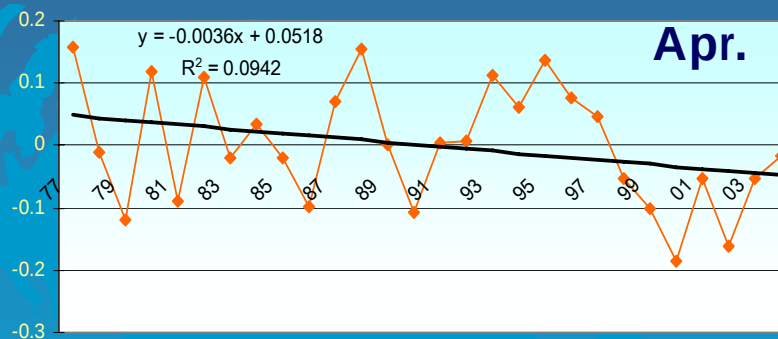
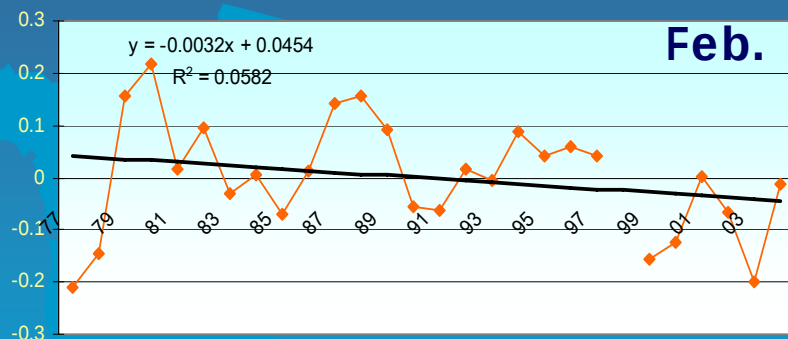
Anomaly and cumulative sum plots of annual mean Salinity

Annual changes of Precipitation



Anomaly and cumulative sum plots of annual mean precipitation

Seasonal changes in salinity (depth 10m)



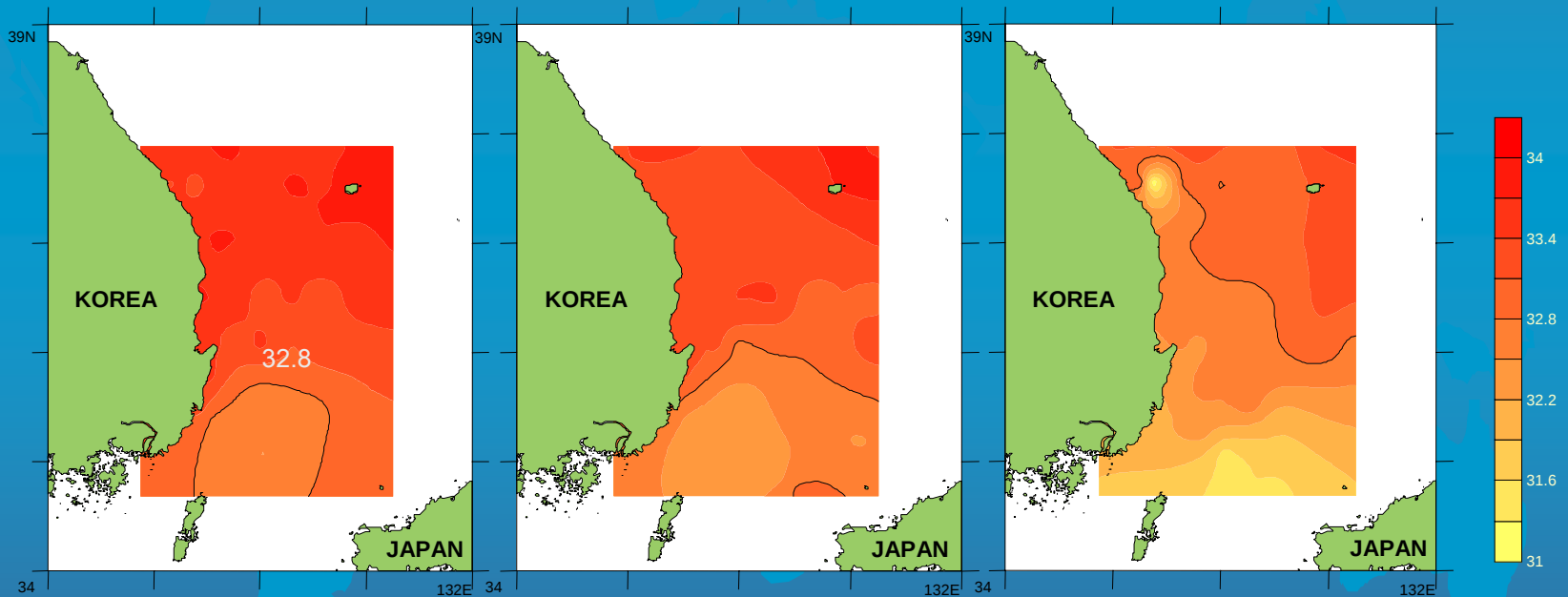
Bimonthly anomaly plots of salinity (depth 10m) ($P < 0.05$)

Spatial distribution of salinity (10m)

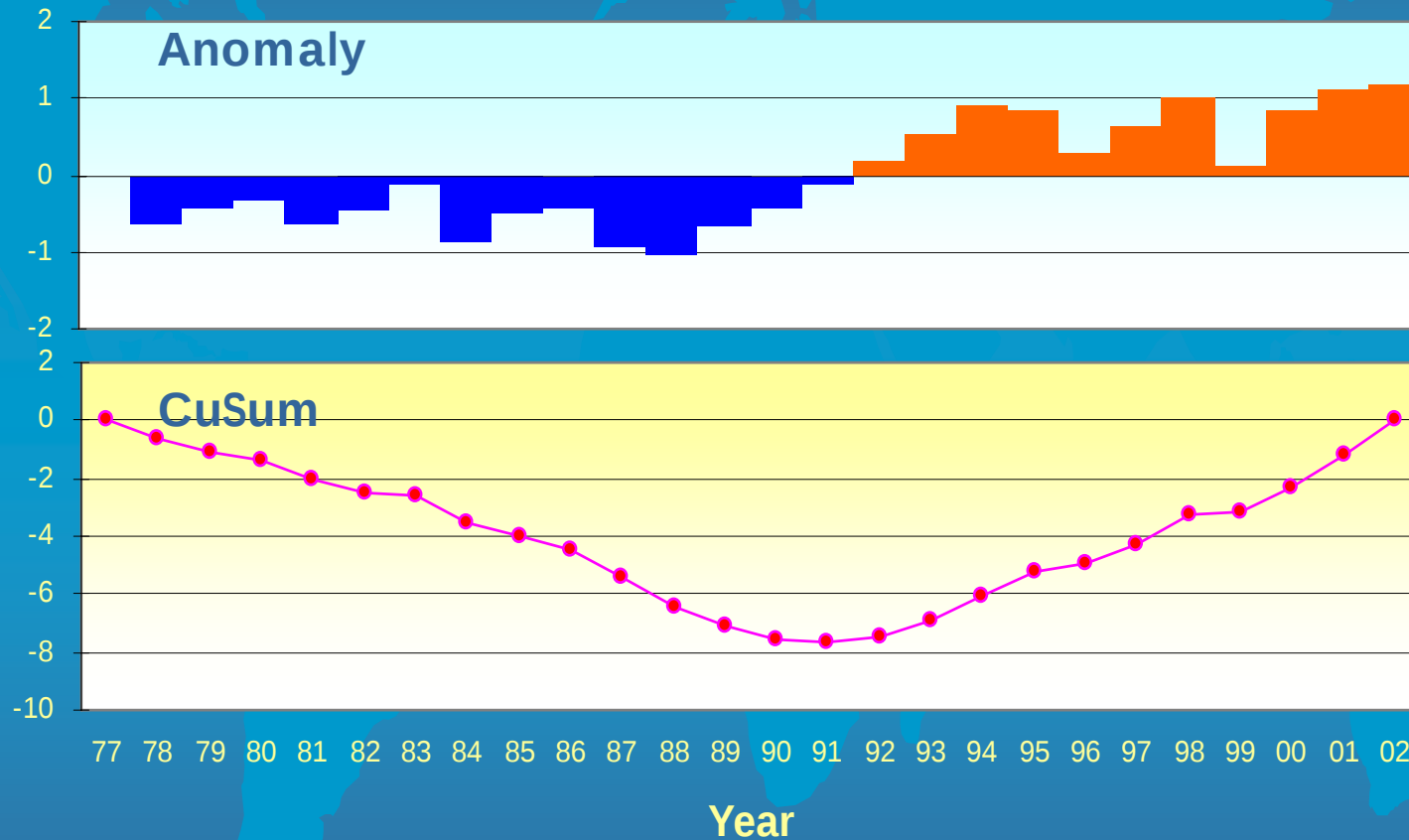
August (1977-88yrs)

August (1989-97yrs)

August (1998-04yrs)

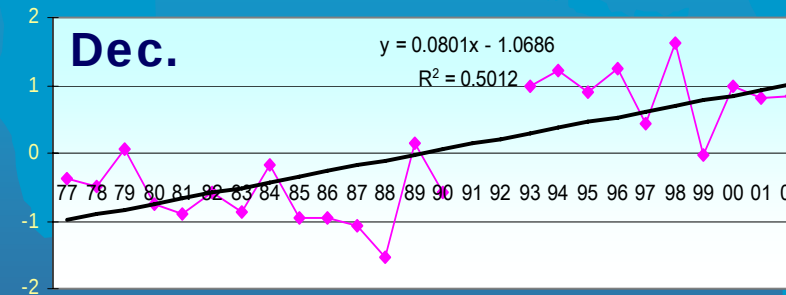
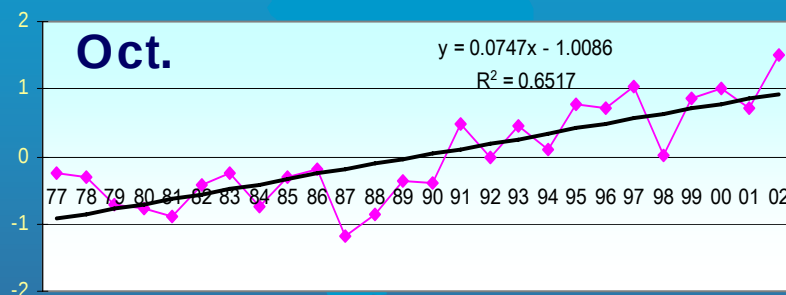
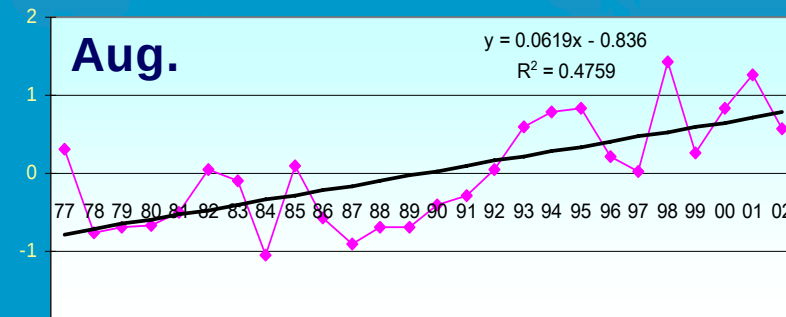
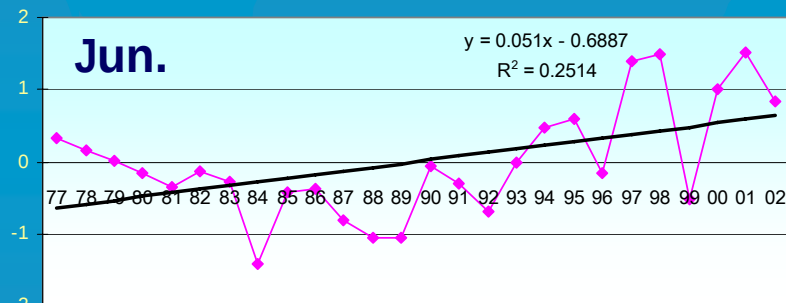
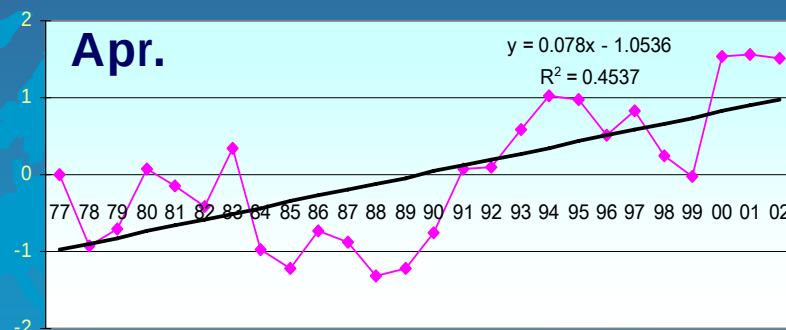
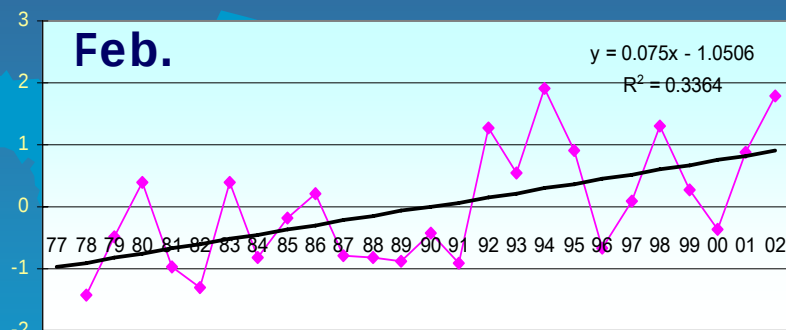


Long-term changes in zooplankton biomass



Anomaly and cumulative sum plots of zooplankton biomass

Seasonal changes in zooplankton biomass

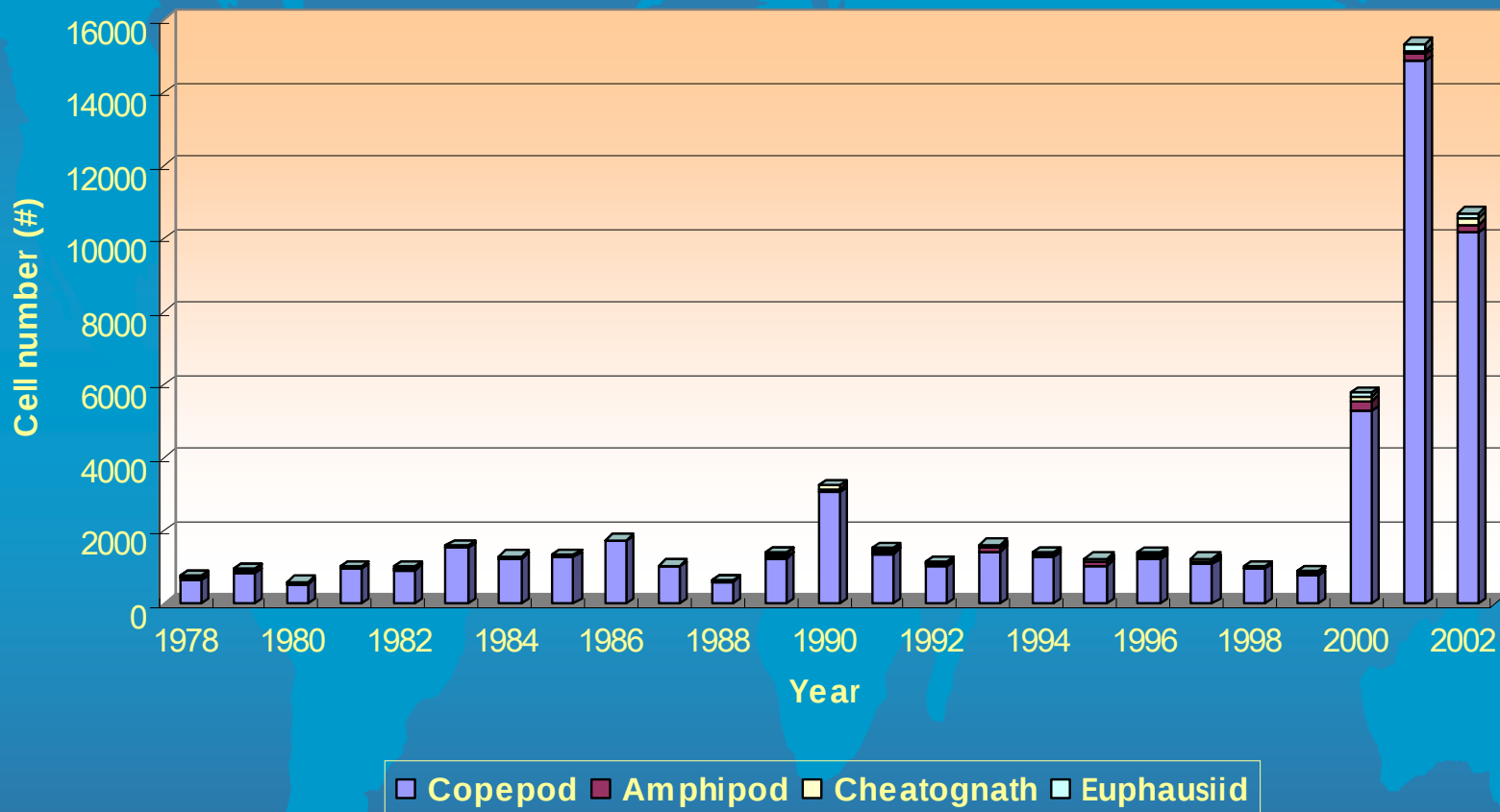


Year

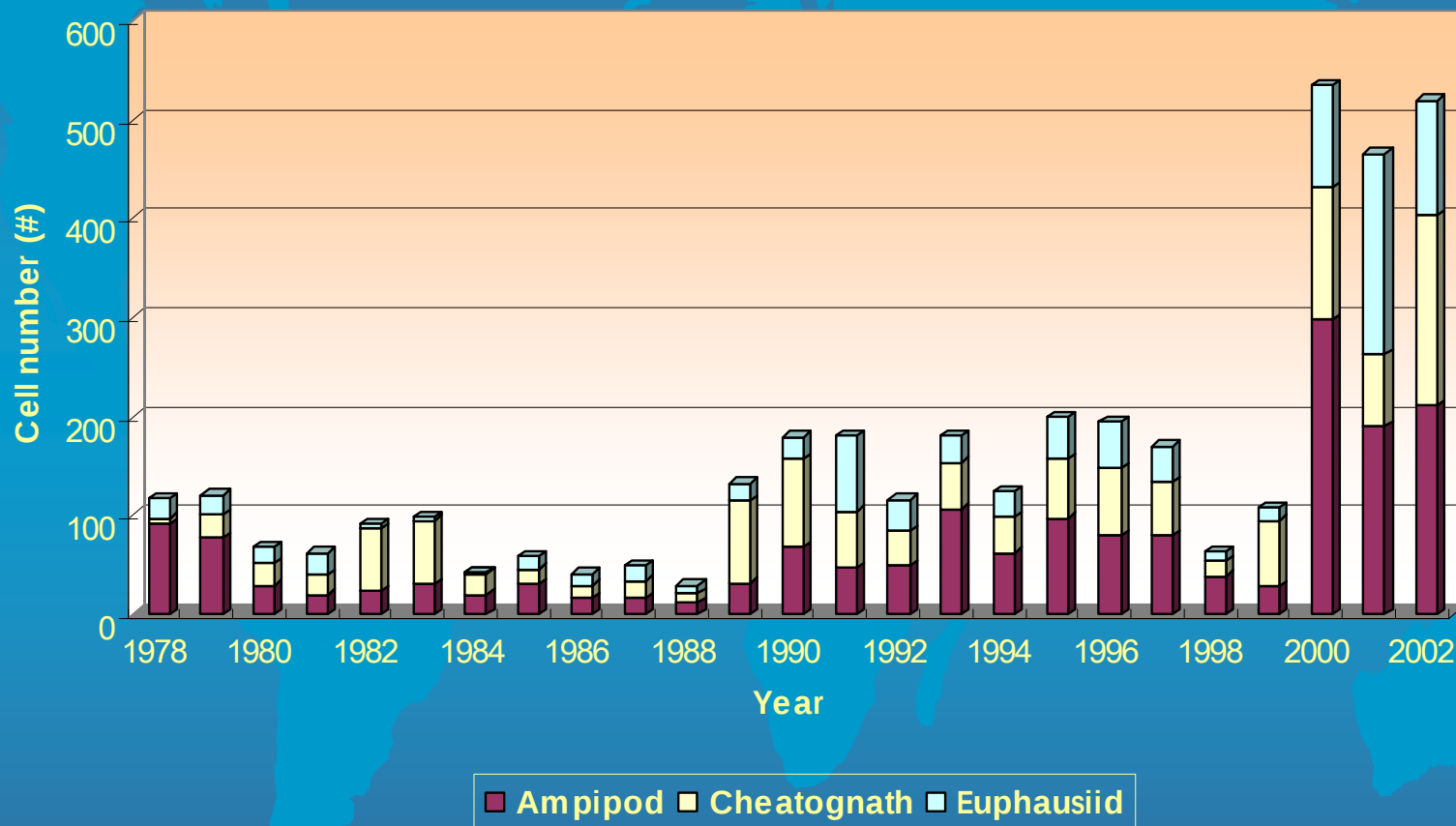
Year

Bimonthly anomaly plots of zooplankton biomass ($P < 0.05$)

Composition change of major zooplankton



Composition change of major zooplankton

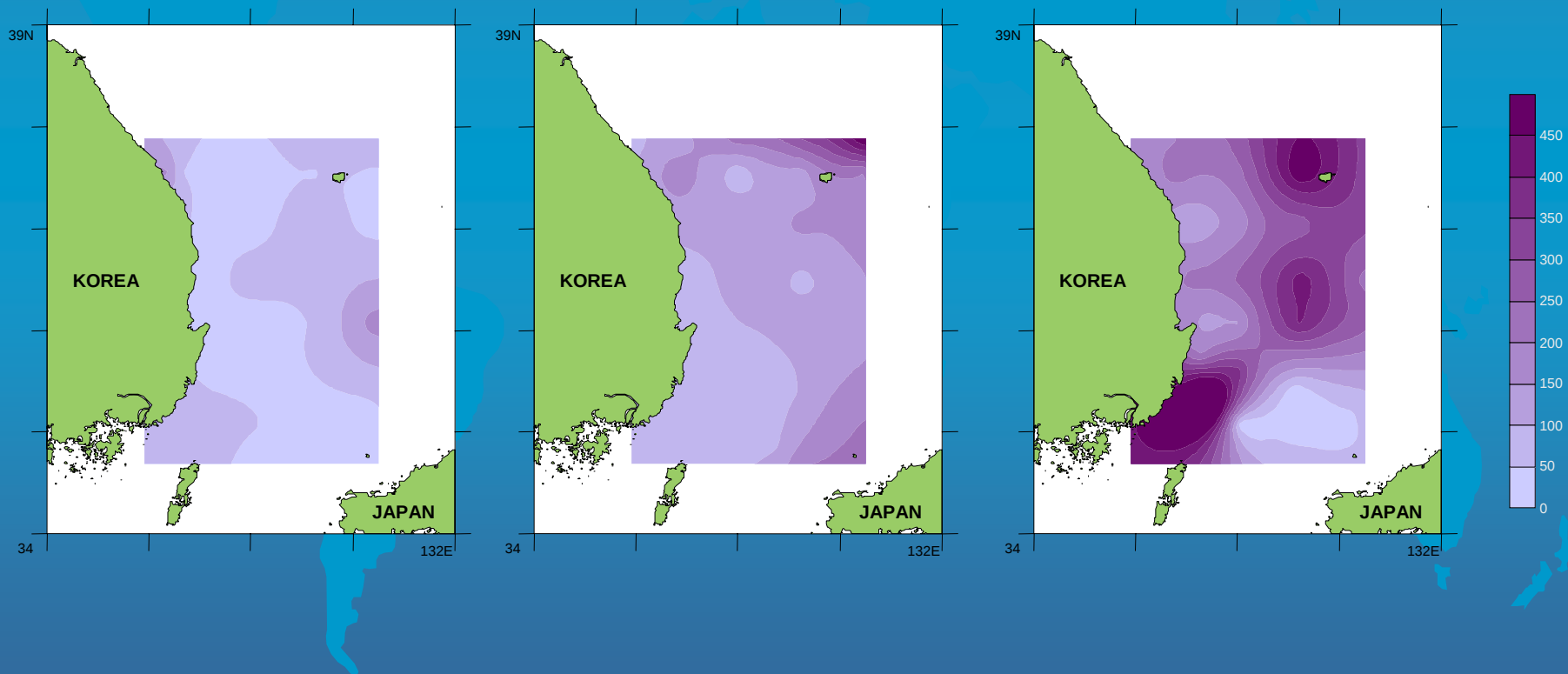


Spatial distribution of zooplankton biomass

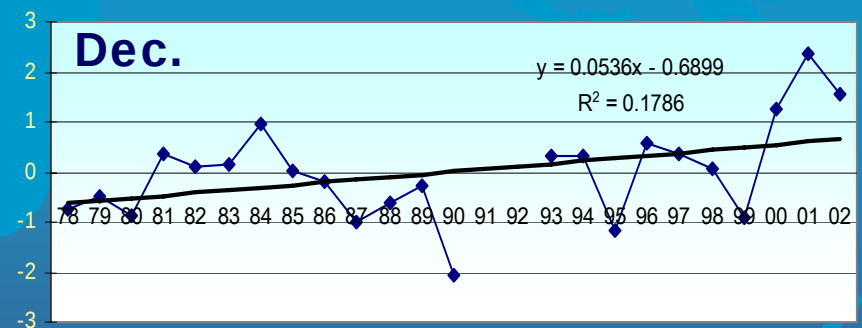
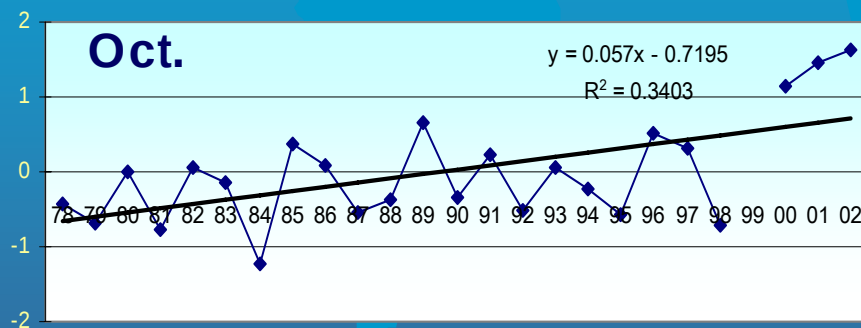
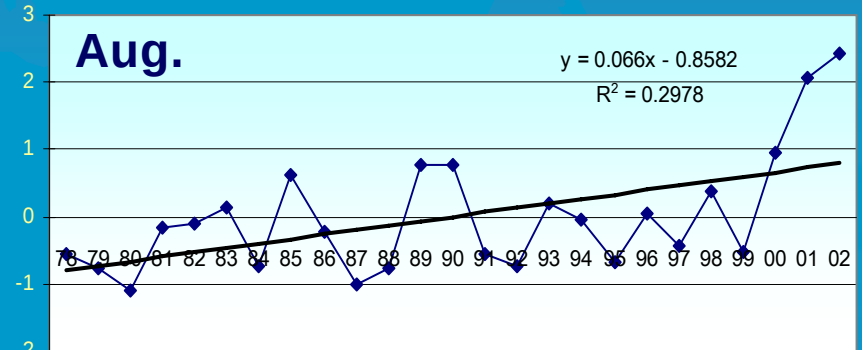
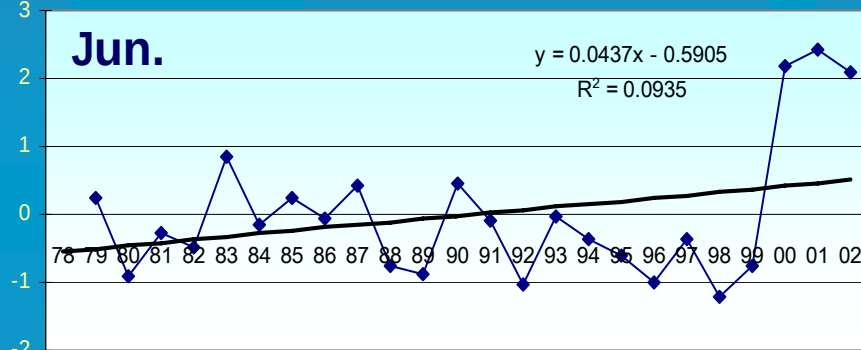
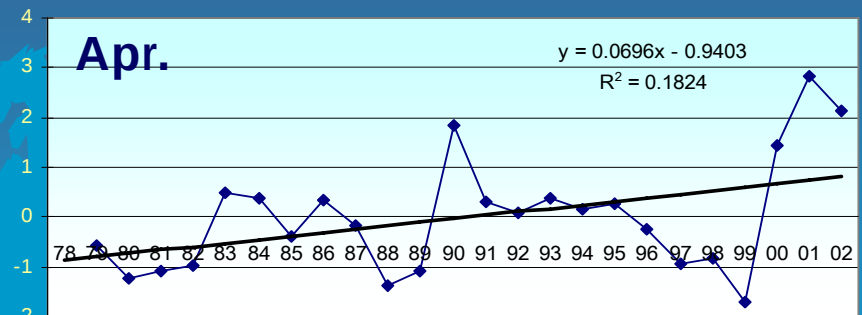
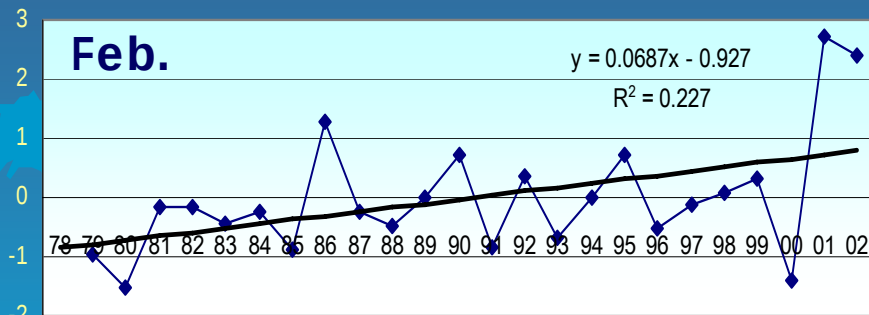
April (1978-88yrs)

April (1989-97yrs)

April (1998-02yrs)



Seasonal changes in Copepod

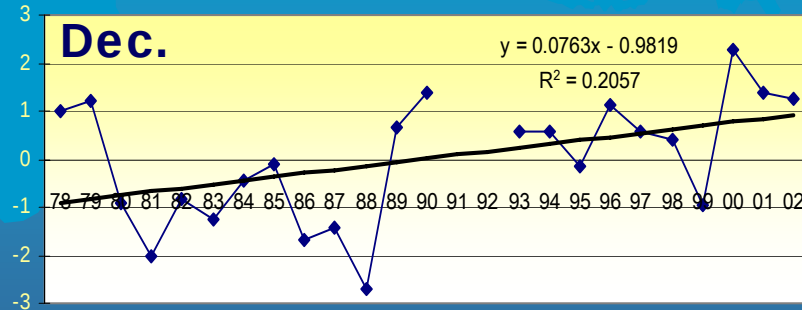
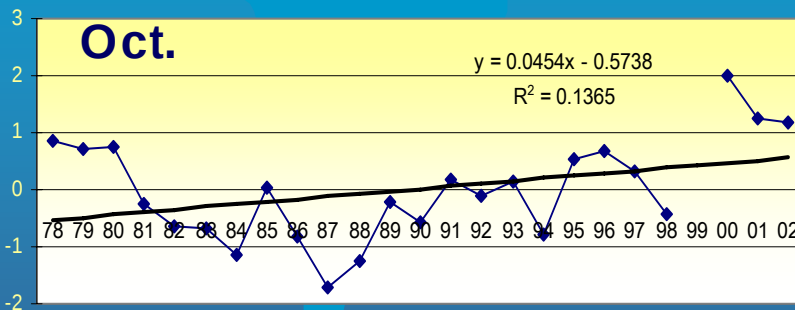
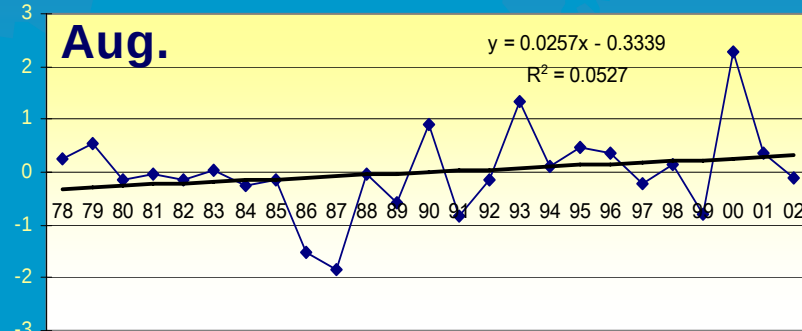
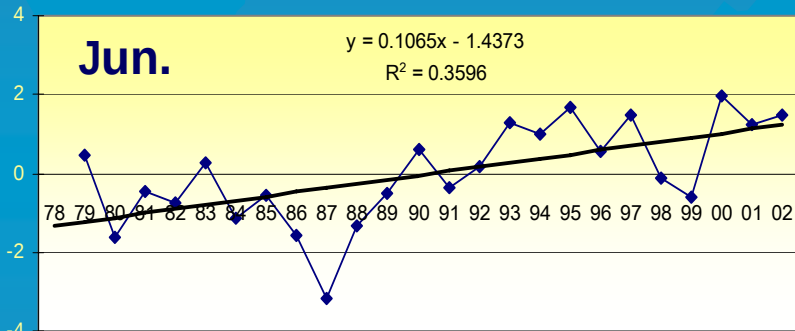
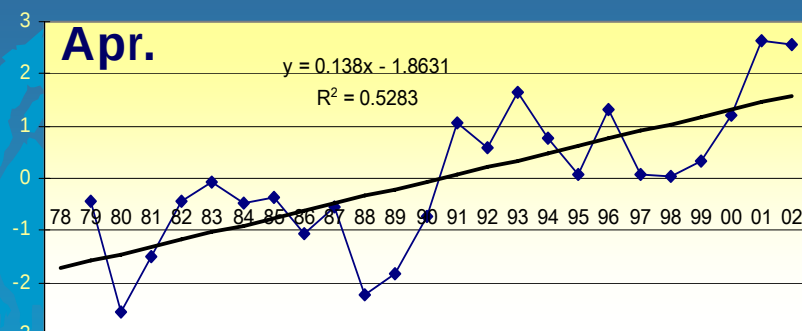
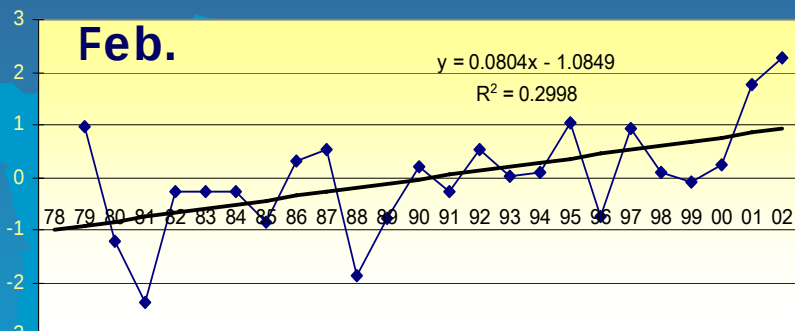


Year

Year

Bimonthly anomaly plots in abundance of Copepod ($P < 0.05$)

Seasonal changes in Amphipod

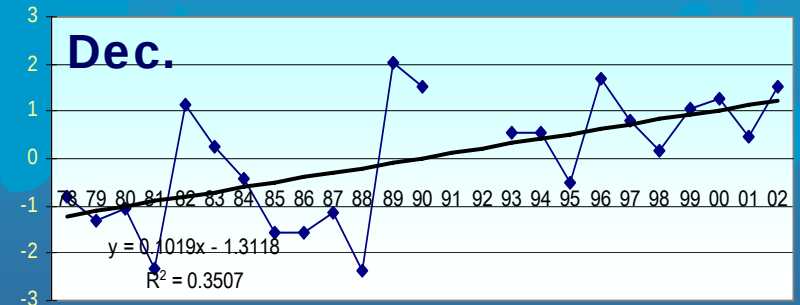
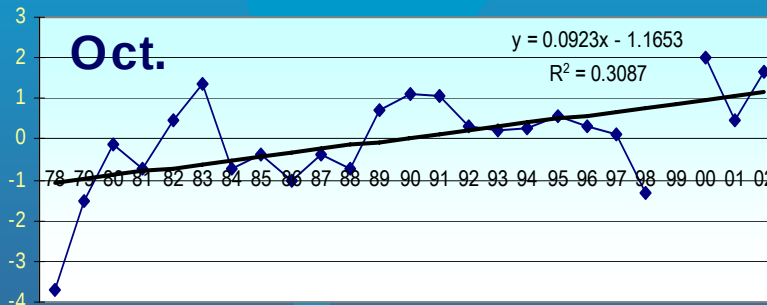
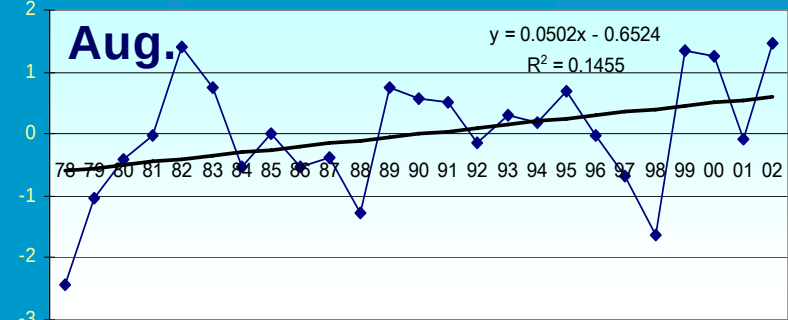
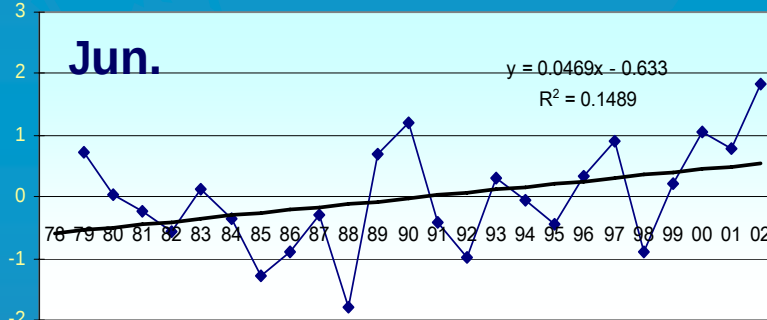
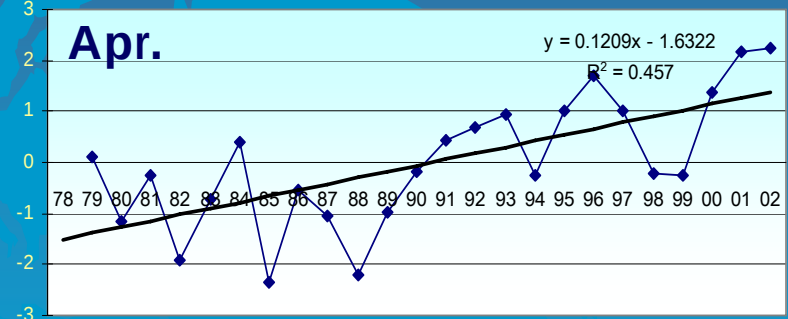
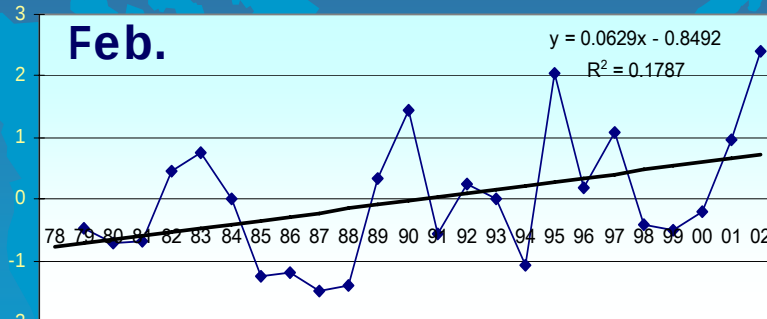


Year

Year

Bimonthly anomaly plots in abundance of Amphipod ($P < 0.05$)

Seasonal changes in Chaetognath

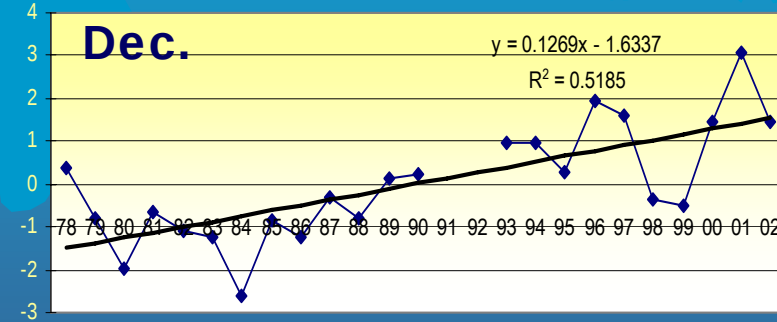
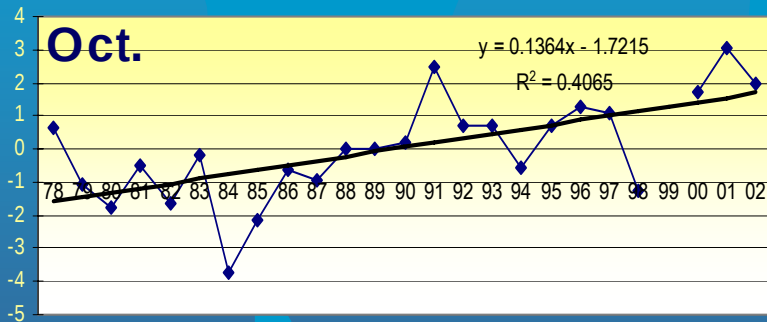
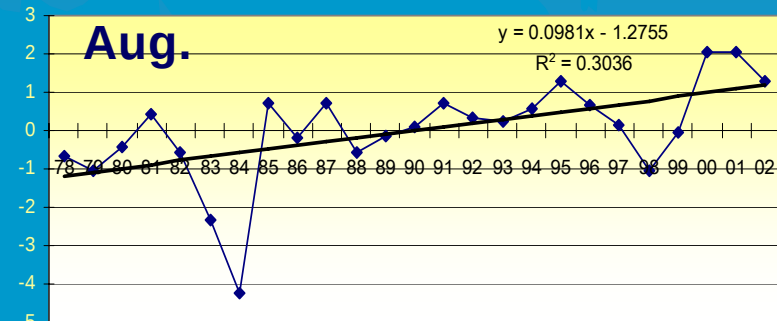
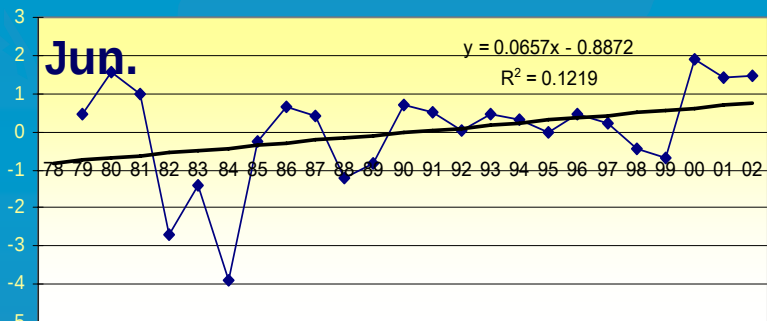
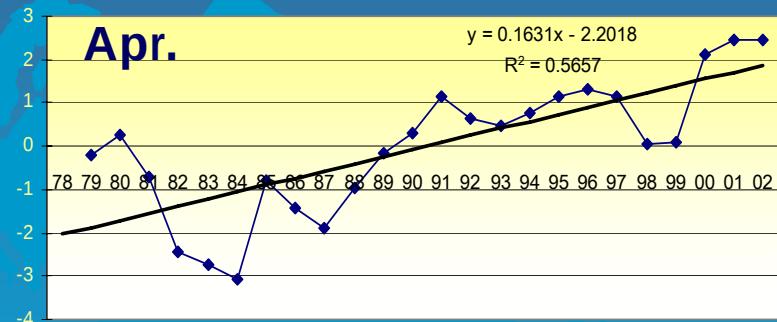
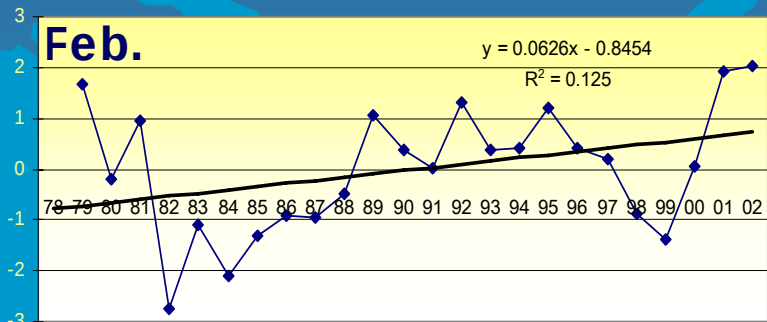


Year

Year

Bimonthly anomaly plots in abundance of Chaetognath ($P < 0.05$)

Seasonal changes in Euphausiid



Year

Year

Bimonthly anomaly plots in abundance of Euphausiid ($P < 0.05$)

Selected zooplankton groups that are significantly correlated with environments

Salinity	Copepod			Amphipod				Chaetognath			Euphausiid	
	Jun	Aug	Oct	Jun	Aug	Oct	Dec	Jun	Aug	Dec	Jun	Aug
February	-0.52	-0.46	-0.47	-0.54	-0.50	-0.43	-0.52	-0.43	-0.47	-0.66	-0.29	-0.50
April	-0.57	-0.49	-0.48	-0.26	-0.37	-0.49	-0.60	-0.60	-0.29	-0.53	-0.52	-0.39
June	-0.45	-0.38	-0.35	-0.45	-0.39	-0.36	-0.46	-0.54	-0.17	-0.50	-0.54	-0.39
August	-0.09	-0.37	-0.23	-0.03	0.25	0.25	0.05	-0.43	0.19	0.12	0.02	0.05
October	-0.30	-0.15	-0.31	-0.41	-0.46	-0.40	-0.44	-0.22	-0.50	-0.57	-0.23	-0.31
December	-0.28	-0.22	-0.33	-0.49	-0.38	-0.31	-0.36	-0.40	-0.36	-0.53	-0.23	-0.27

Summary & conclusion

- Annual mean SST increased abruptly in the late 1980, and then stabilized at higher temperature since 1990, while salinity continuously has decreased since 1997.
- Total zooplankton biomass increased continuously since 1992.
- In general, the abundance of 4 major taxa tend to increase with time. However, no zooplankton groups were significantly correlated with SST.
- Rather, zooplankton groups often have negatively significant correlations with salinity.

Future study

In the future, we need to

- **Identify warm- and cold-water species, and get the changes in proportion with time.**
- **Divide the size fraction of zooplankton for prey-predator relationship in ecosystems.**

Thank you for attention!!

