Ecosystem Changes under multi-stressors in the Yellow Sea

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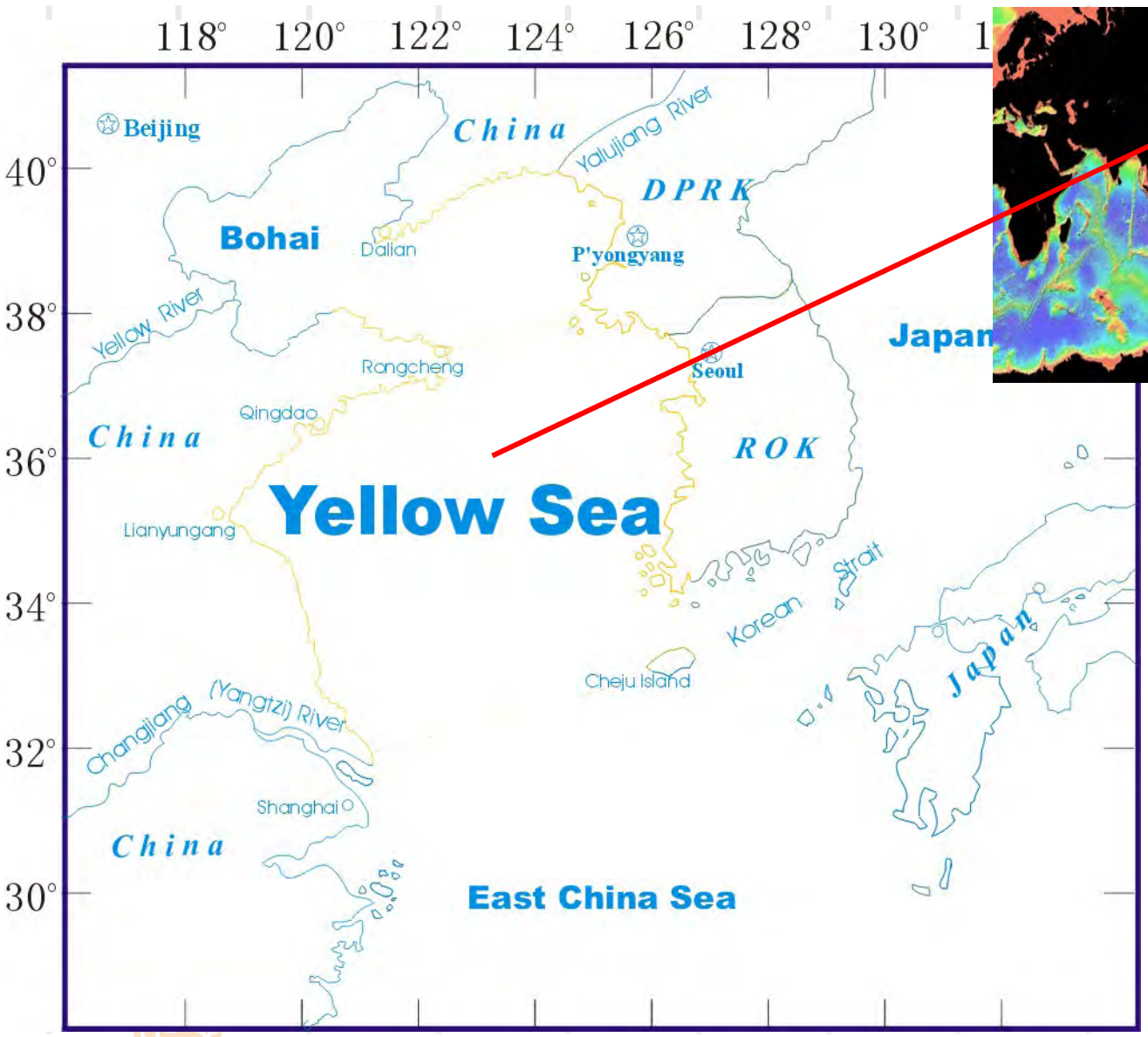
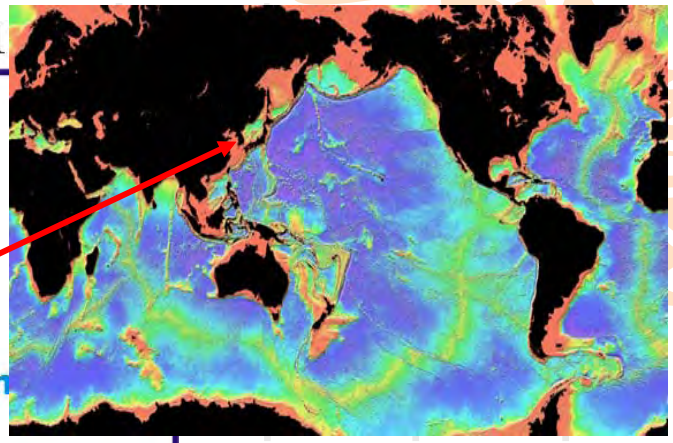
- I. Natural environment of Yellow Sea and East China Sea
- II. Multi-stressors
- III. Changes in pelagic and benthic community
- IV. Disruptive response of ecosystem
- V. Summary

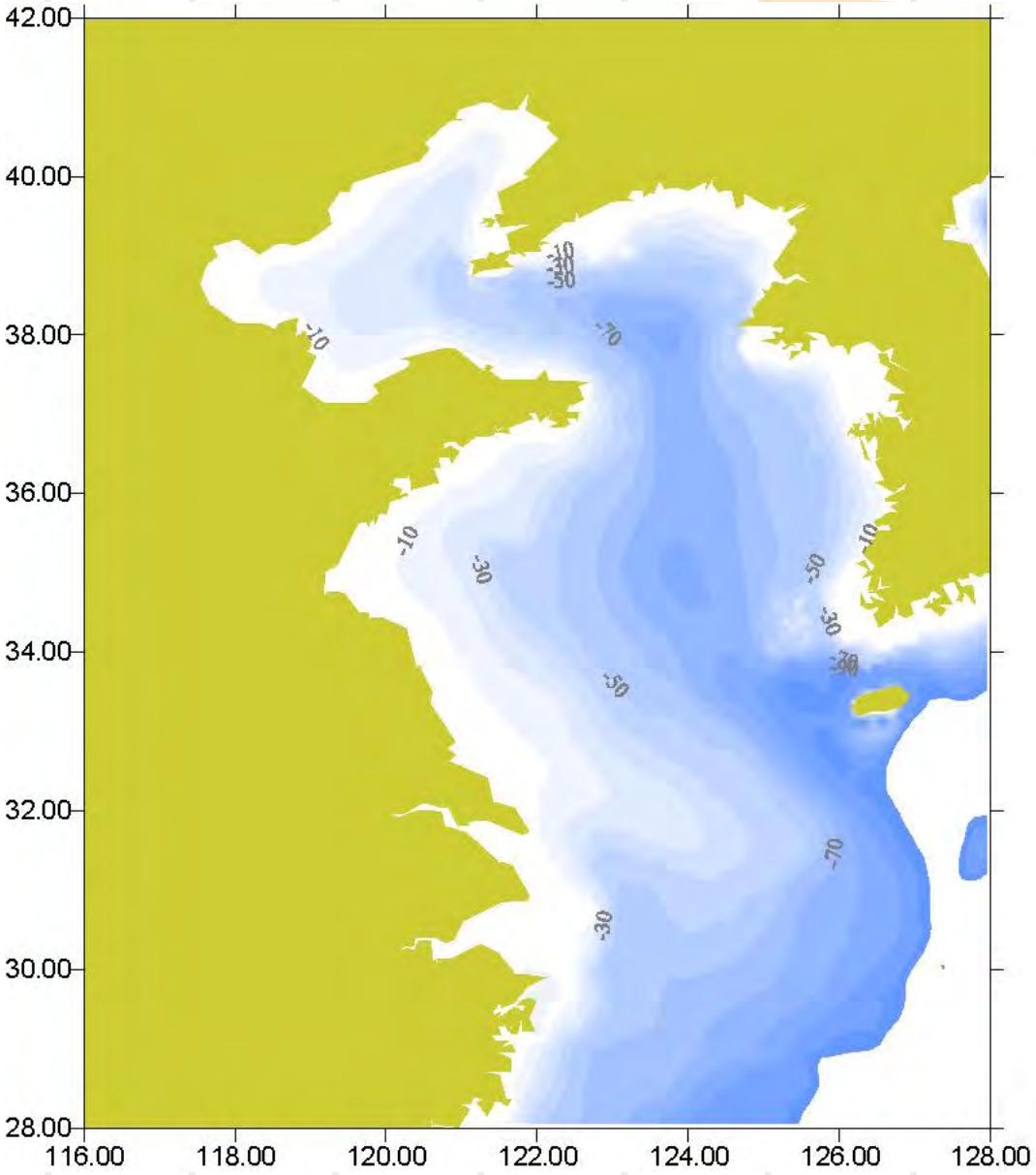
I. Natural environment of Yellow Sea (including Bohai Sea, North East China Sea)





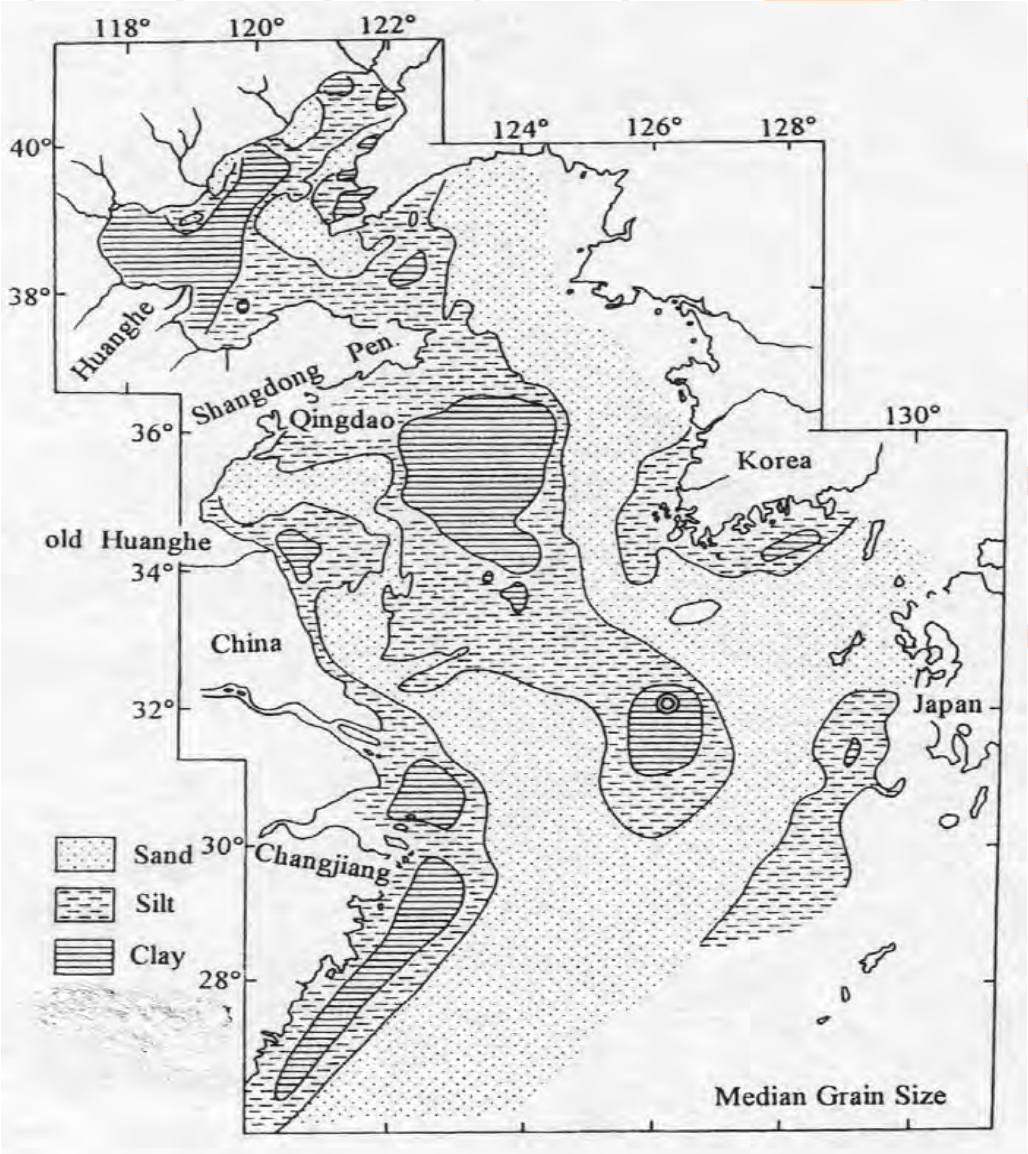
Yellow Sea and East China Sea are two of marginal and productive seas in North West Pacific Ocean.

Fig.1 Geography of Yellow Sea and North east China Sea



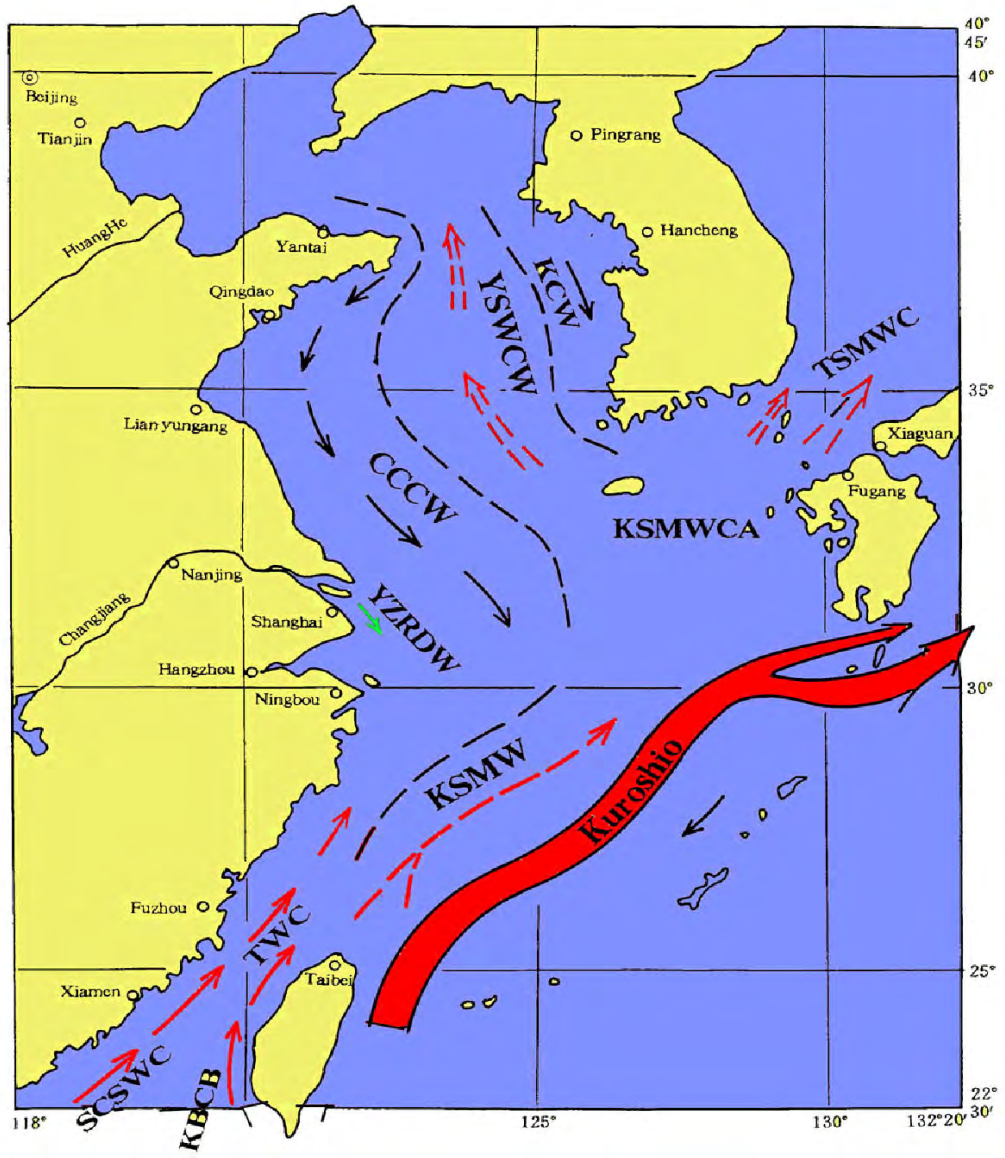
Continental shelf is quite wide here

Bathymetry of Yellow Sea and East China Sea

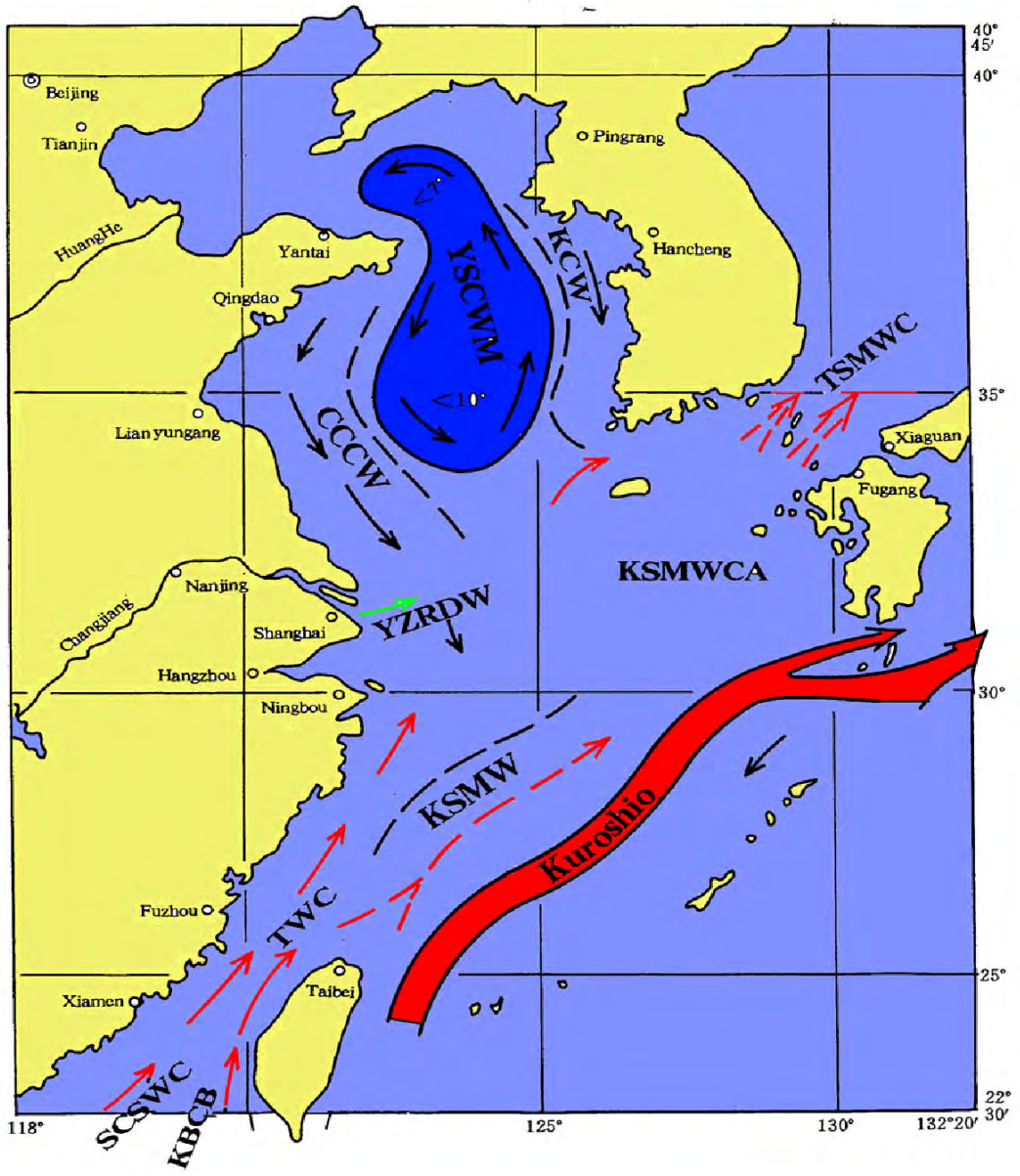


Sediment here consists of sand, silt and clay mainly.

Sediment of the Yellow Sea and East China Sea



Water circulation of the YS and ECS (winter)



Water circulation of the YS & ECS (summer)

II. MultiStressors in Yellow Sea

~ Temperature (Climate)

~ Salinity (Climate & Water-Use)

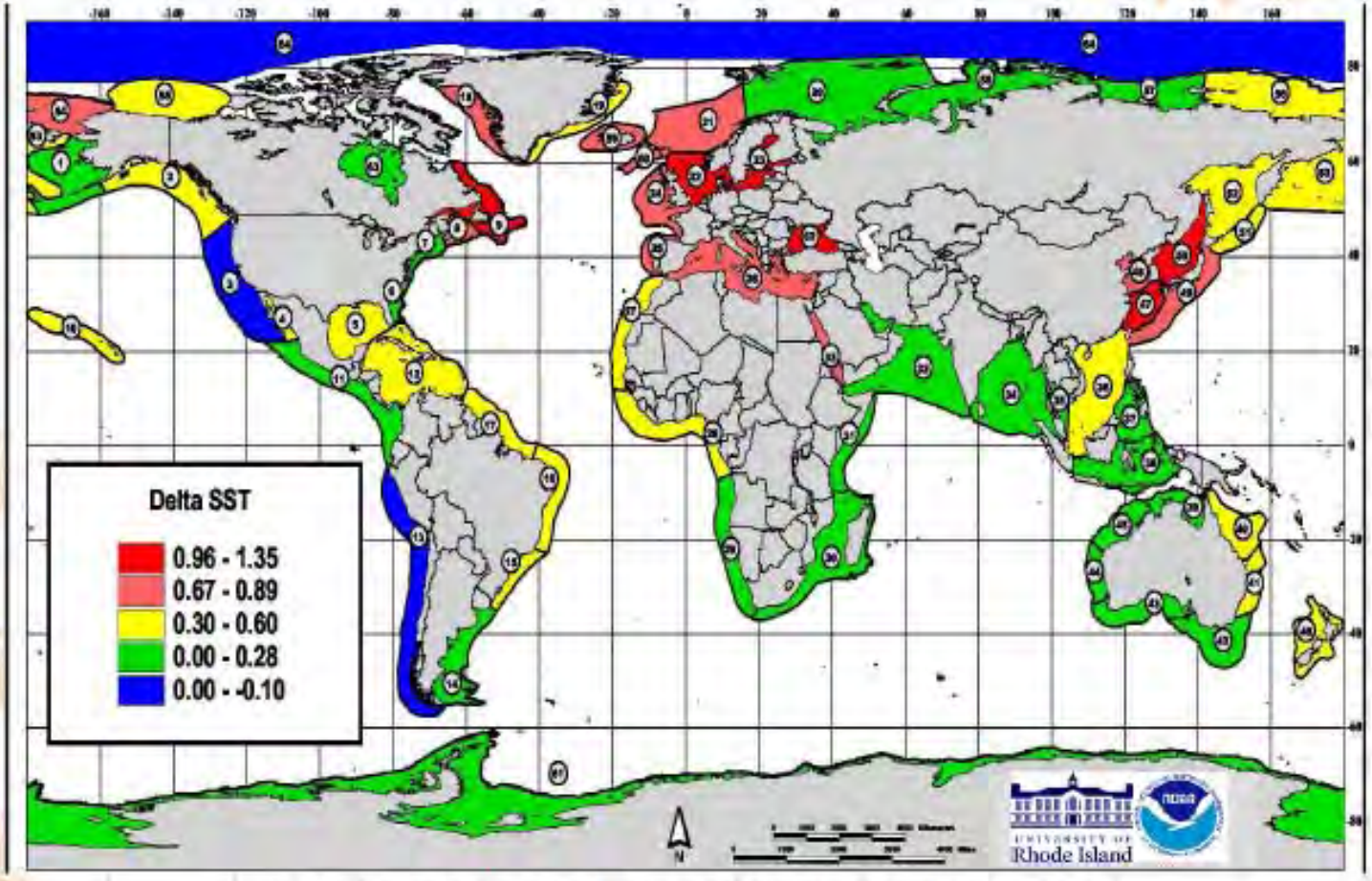
~ Nutrients

~ Over-fihing

~ Land Reclamation

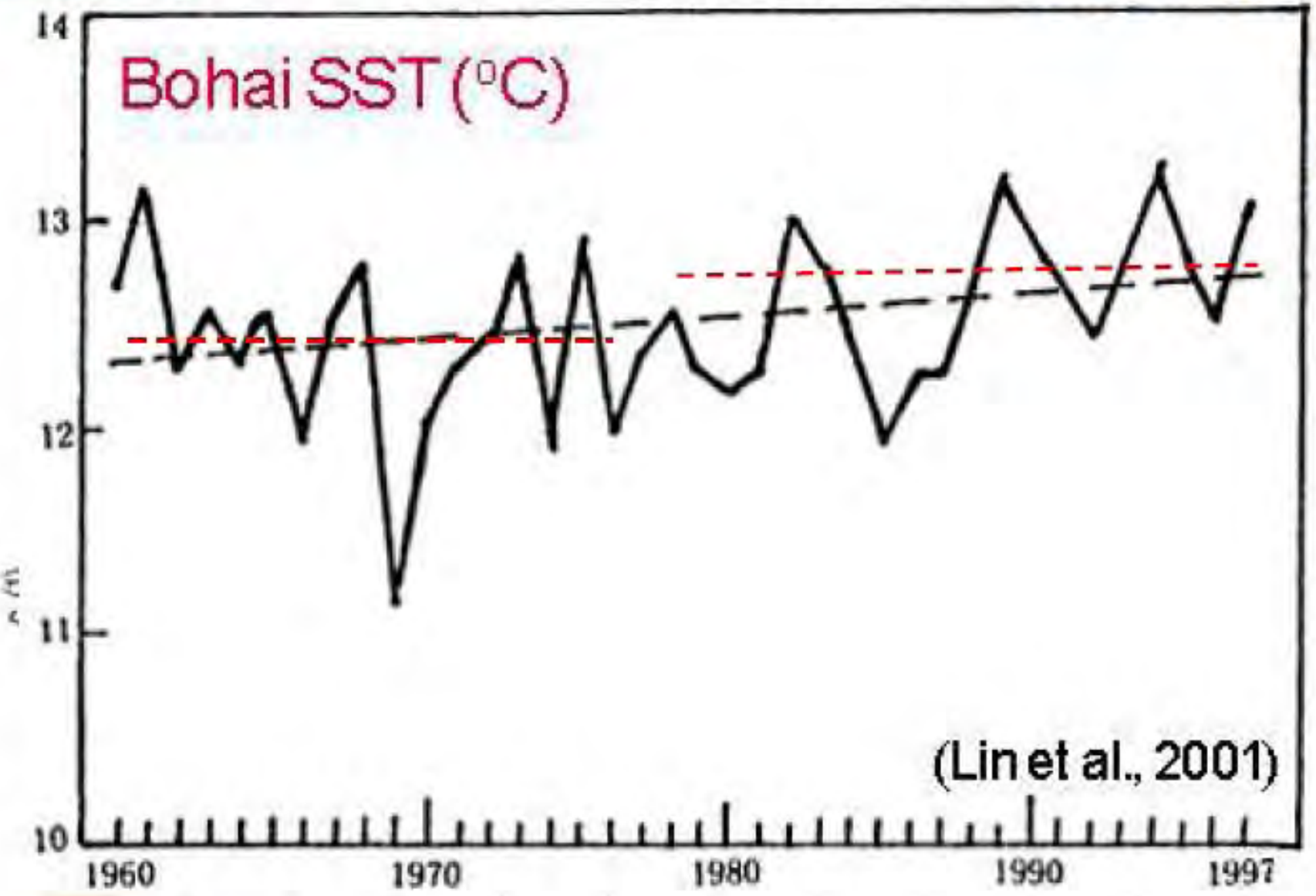
Temperature

Increasing SST trends over 1982-2006 in 59 out of 64 LMEs in the world



SST Trends, 1982-2006, in LMEs (Igor Belkin, 2007)

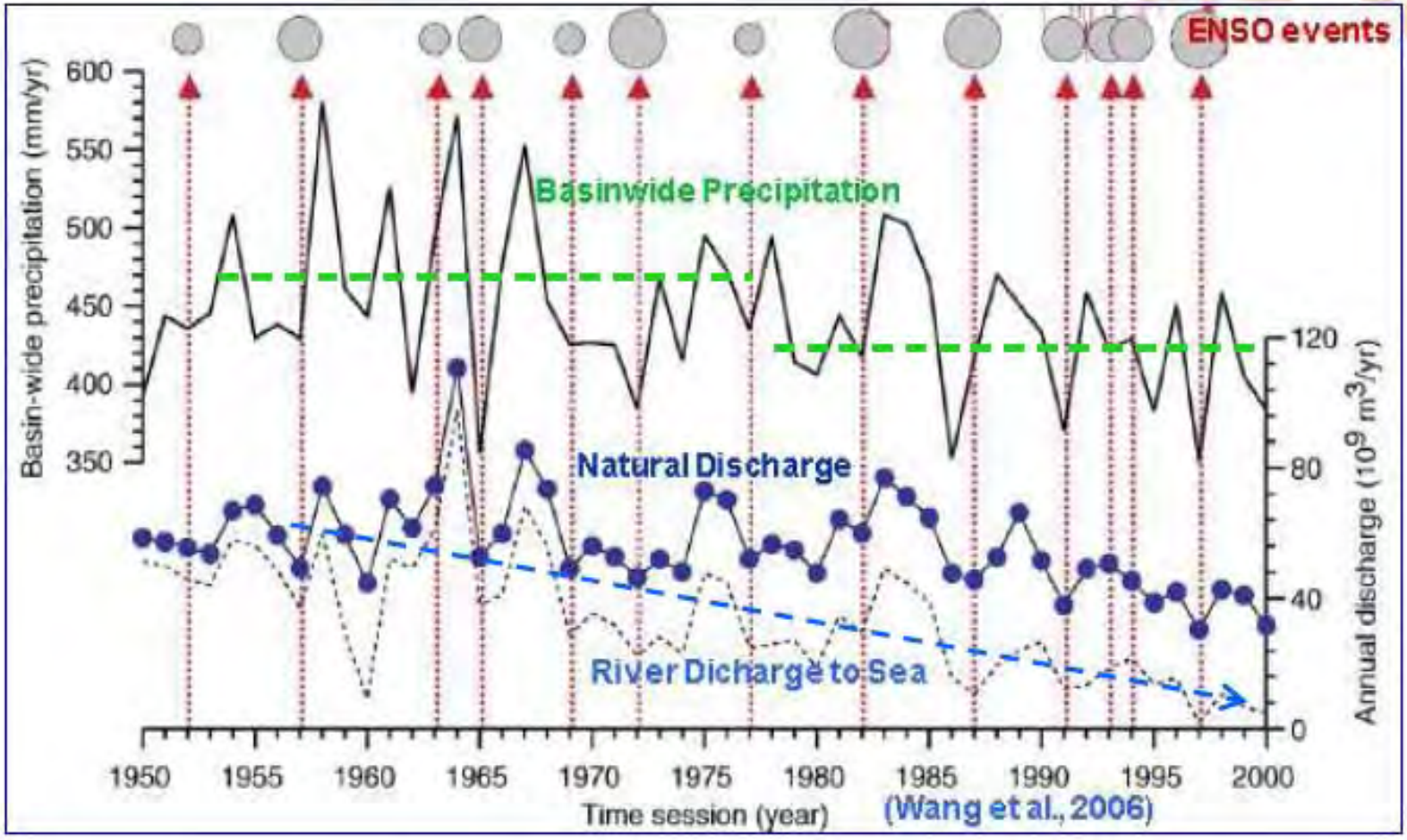
Temperature



Salinity

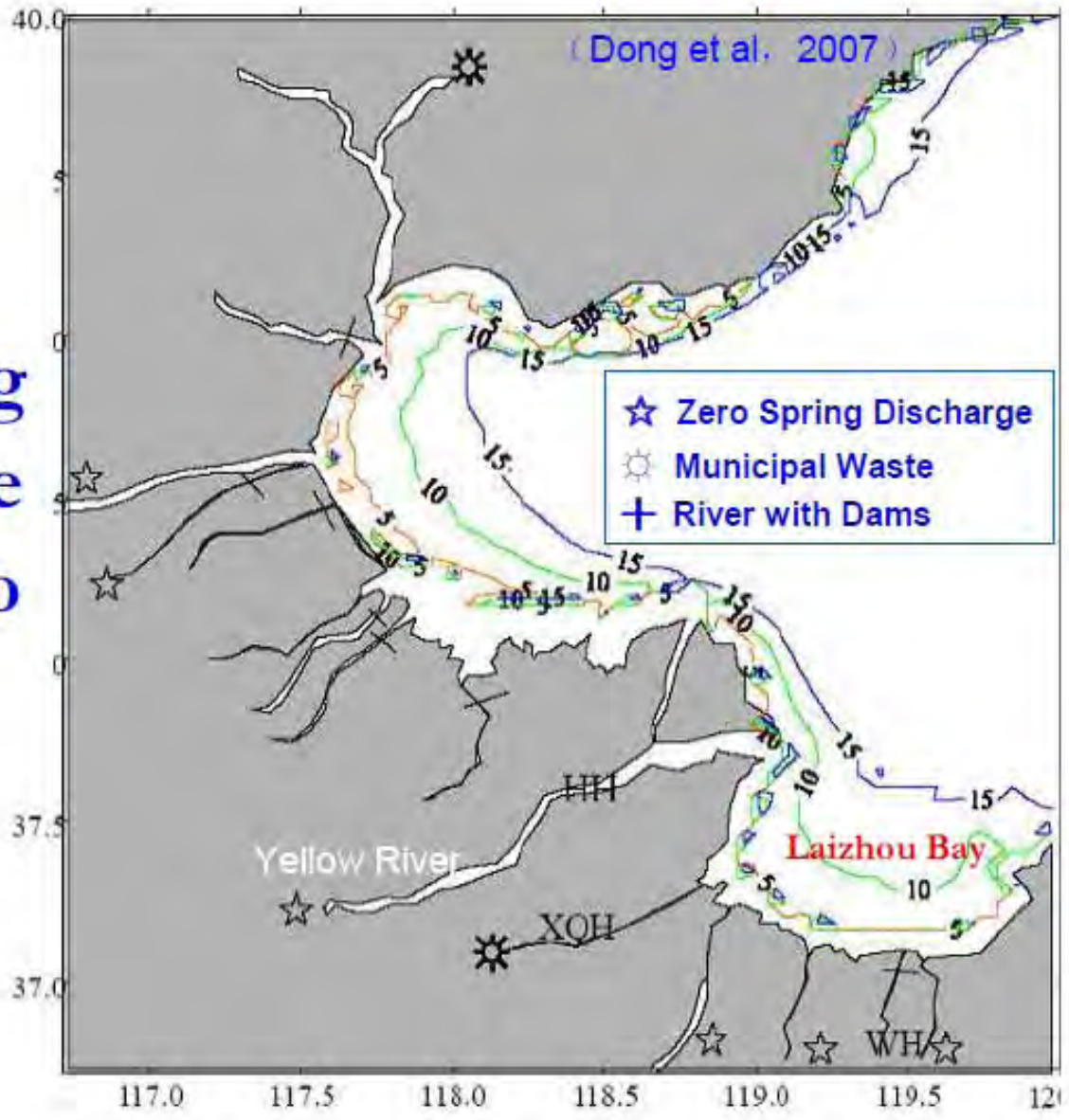
Reduced Freshwater to Bohai Sea

(Precipitation & Yellow River Discharge)

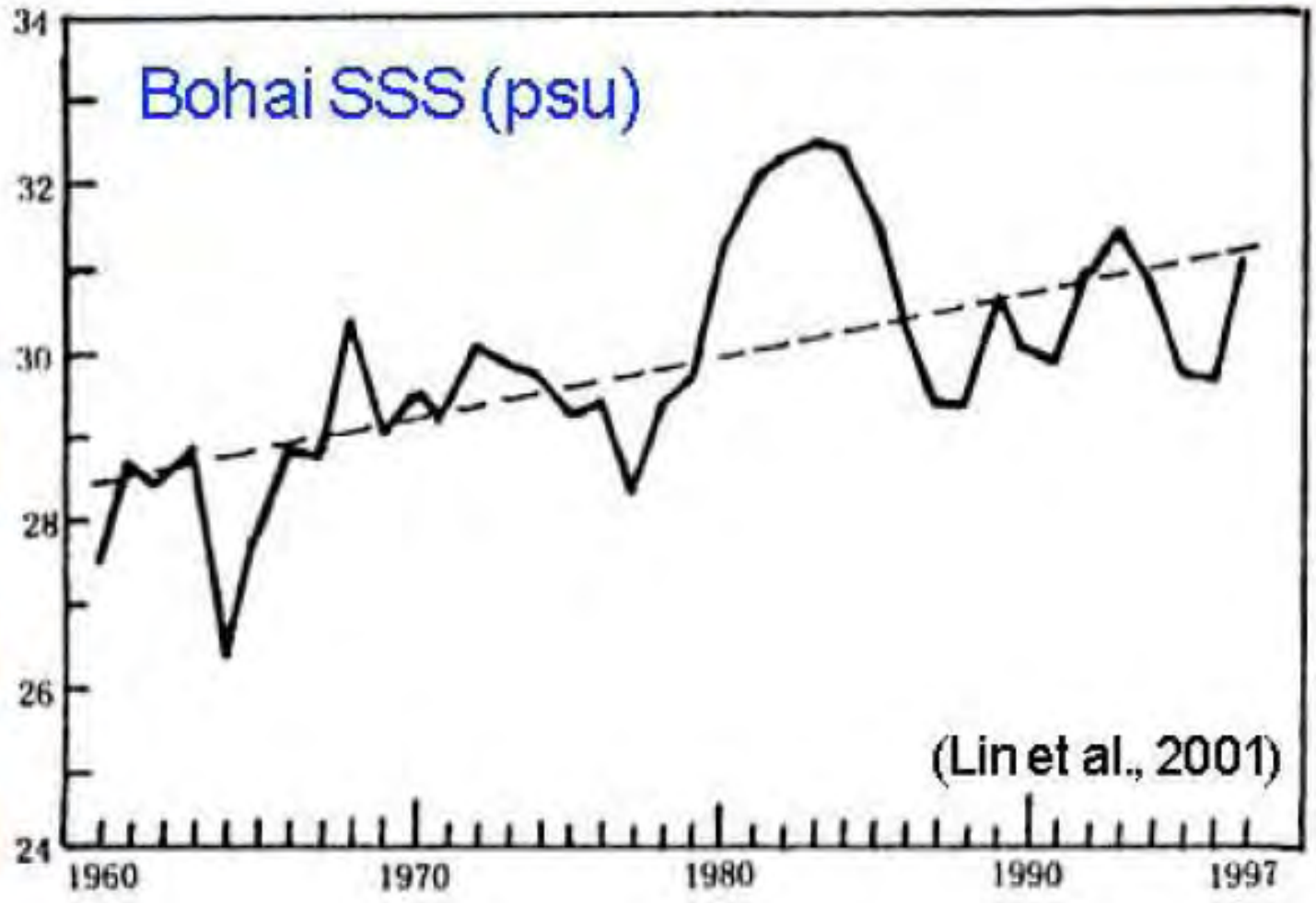


Salinity

Other factors contributing to discharge reduction to Bohai



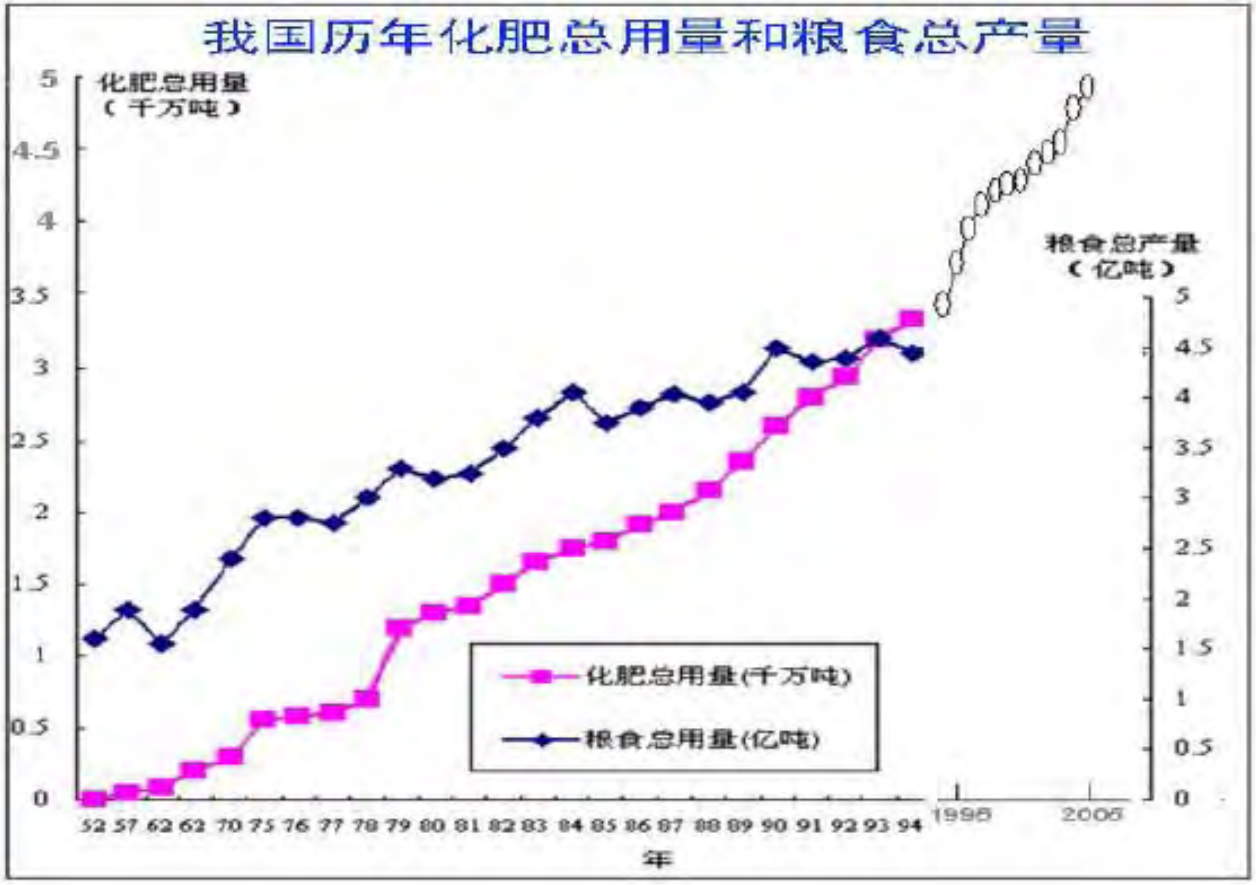
Increasing Salinity in Bohai Sea



Nutrients

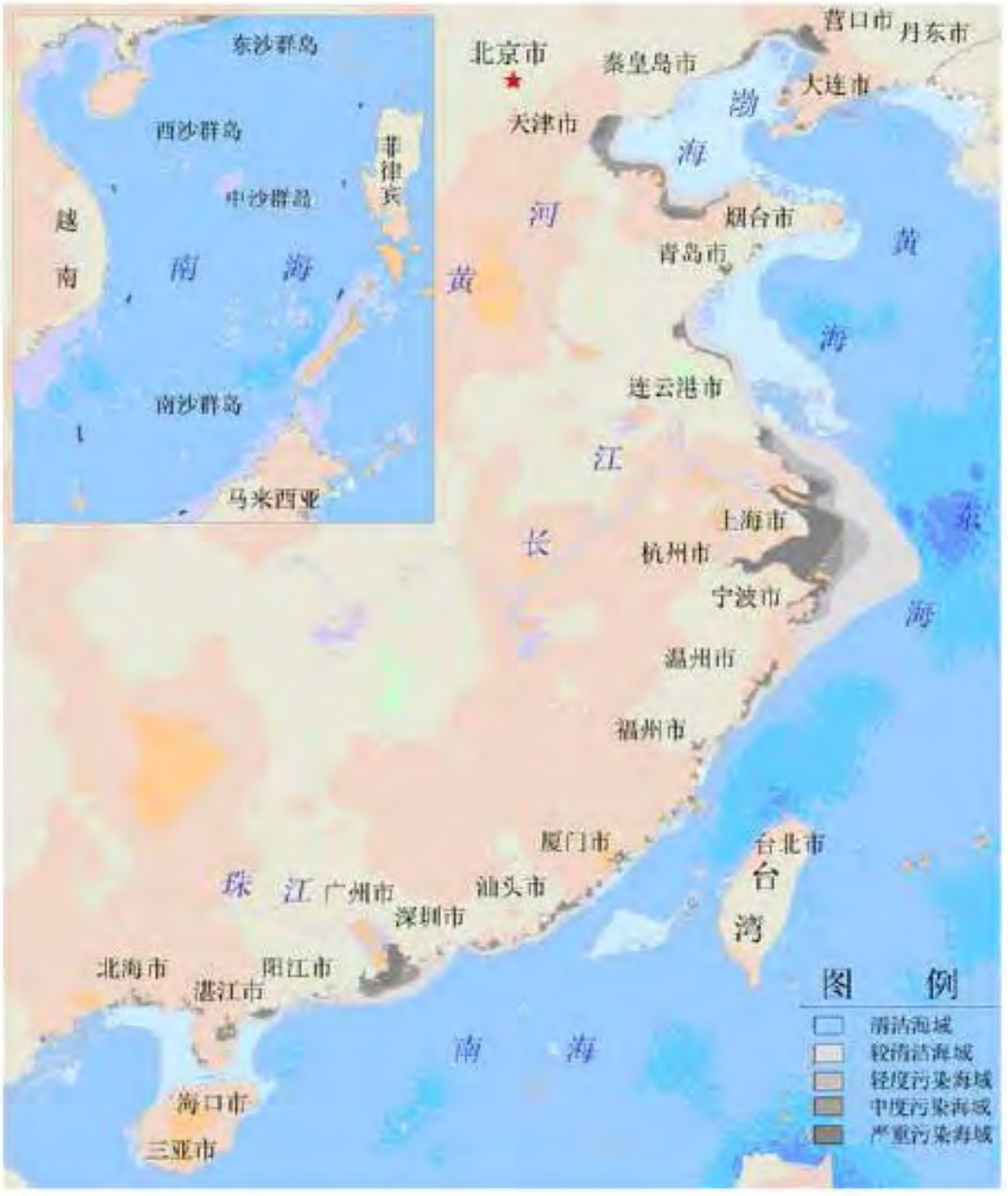
World's ¼ Nitrogen Use in China

(below optimal return)

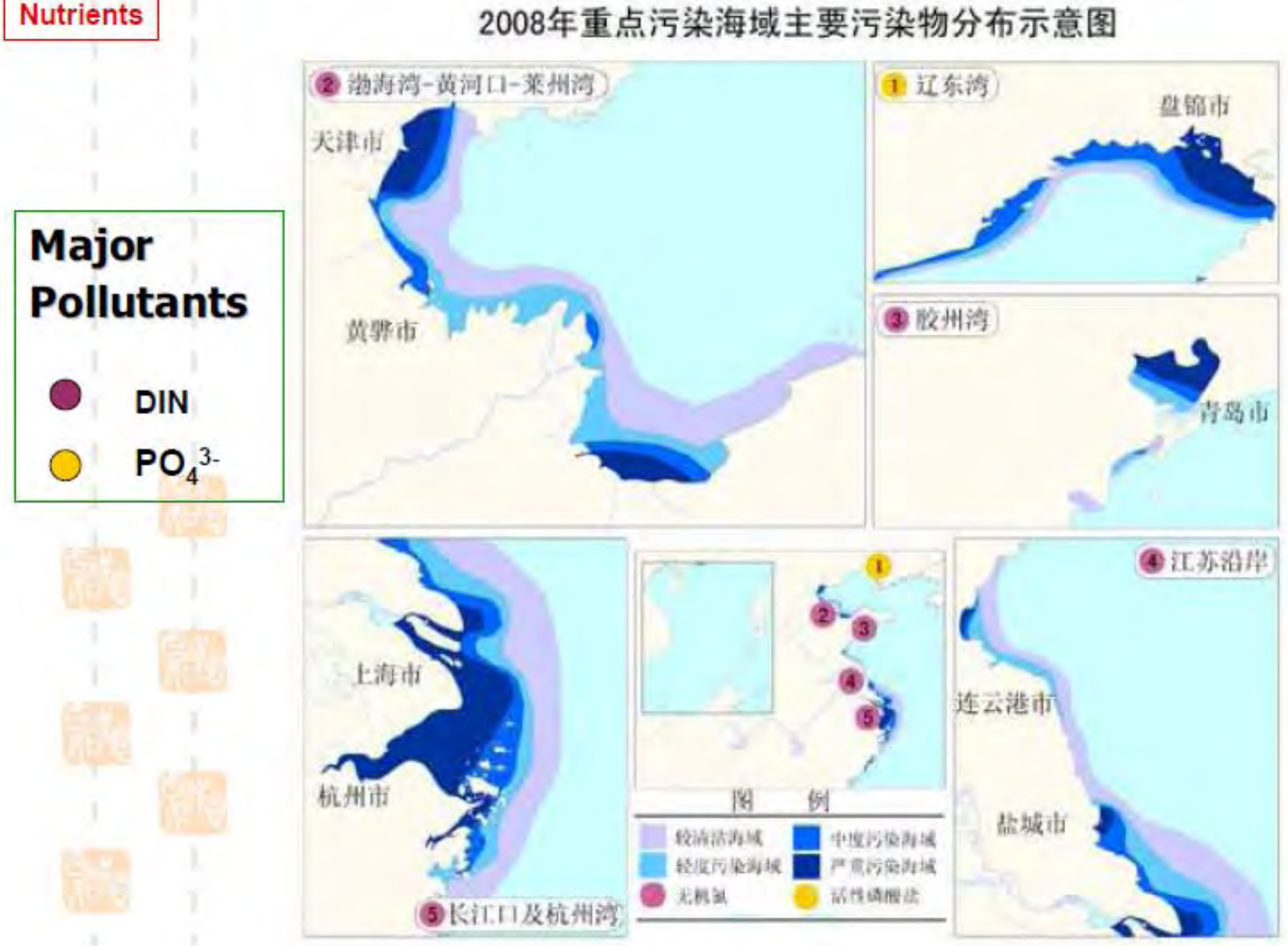


Nutrients

Large Areas along Coast of China Eutrophicated (2008)

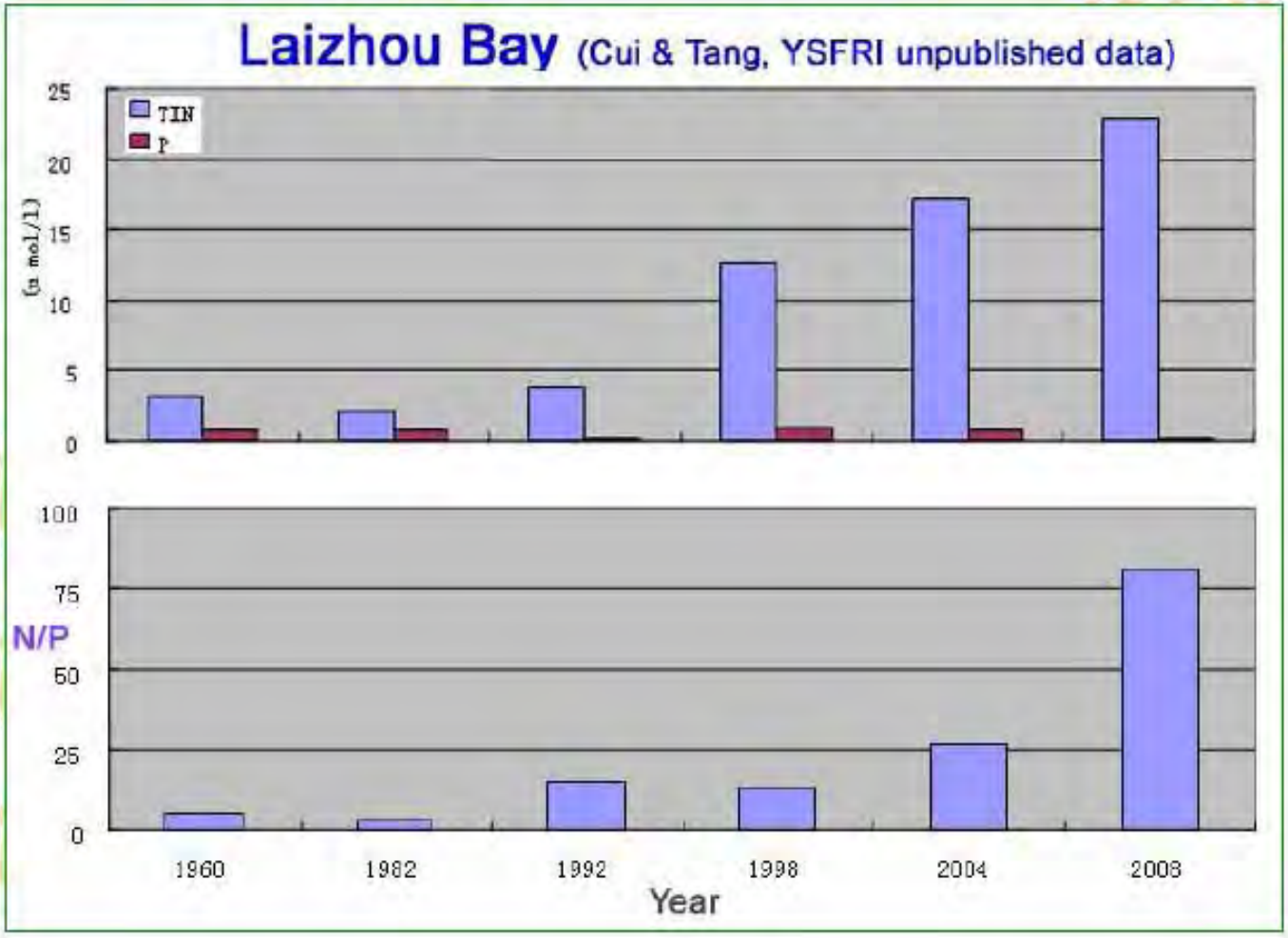


Nutrients


2008年重点污染海域主要污染物分布示意图
Major Pollutants
DIN
PO_4^{3-}
② 渤海湾-黄河口-莱州湾
天津市
黄骅市
① 辽东湾
盘锦市
③ 胶州湾
青岛市
上海市
杭州市
⑤ 长江口及杭州湾
图 例
较清洁海域
轻度污染海域
无机氮
中度污染海域
严重污染海域
活性磷酸盐
④ 江苏沿岸
连云港市
盐城市

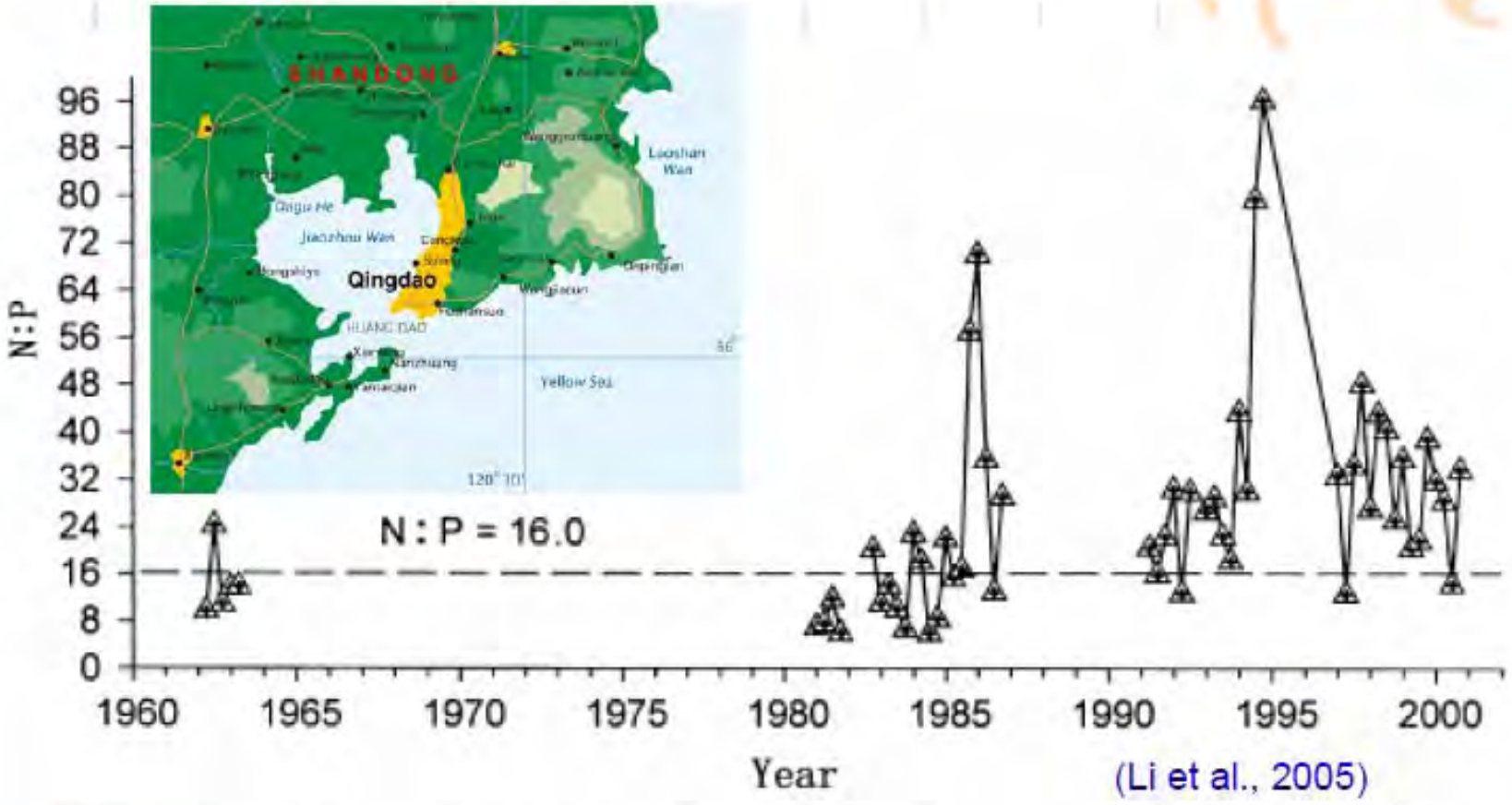
Nutrients

Large Changes of the N/P Ratio



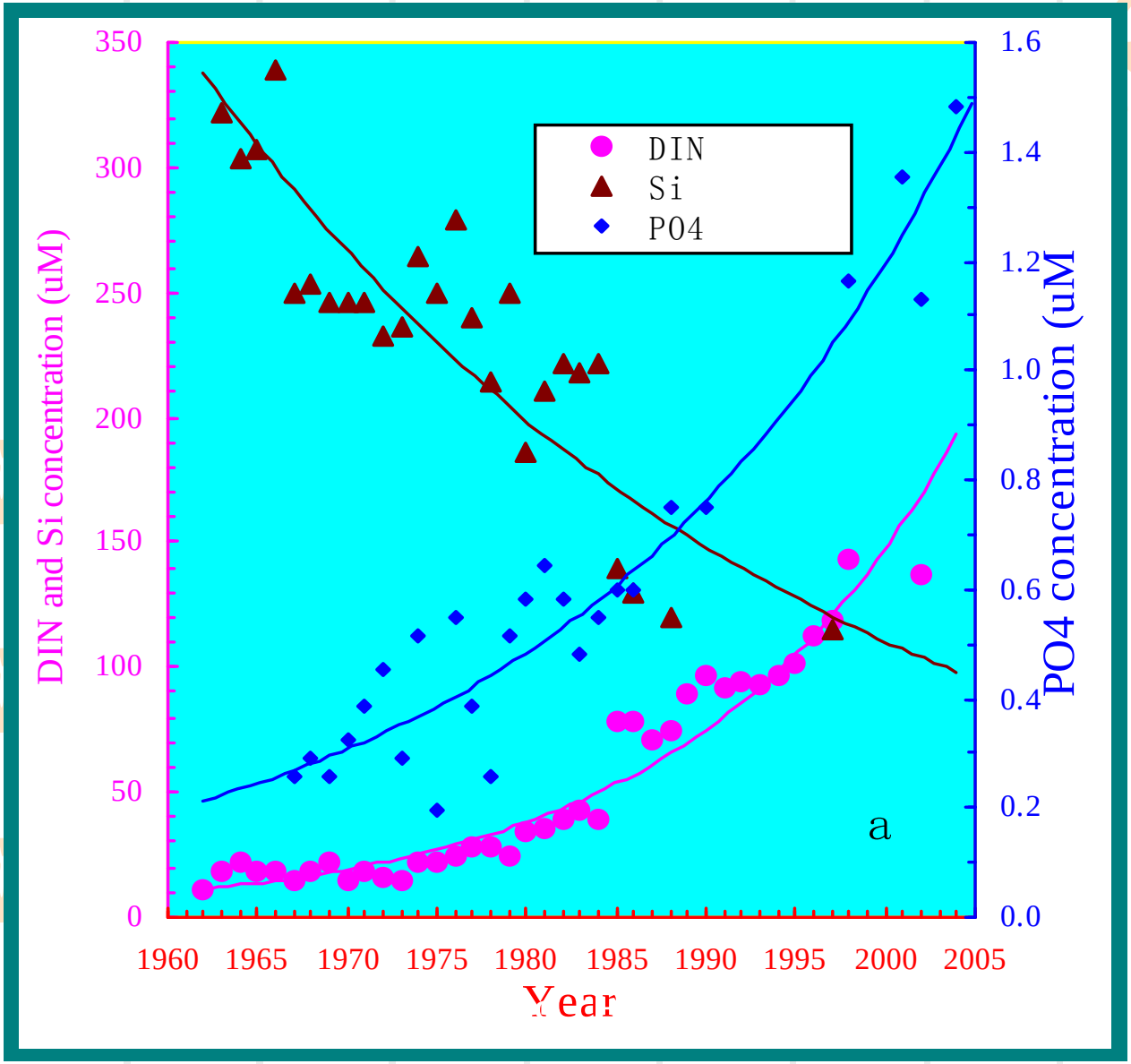
Nutrients

Large N/P as well in Jiaozhou Bay



(Li et al., 2005)

Nutrient concentration in Yangtze River Estuary



From B. Wang

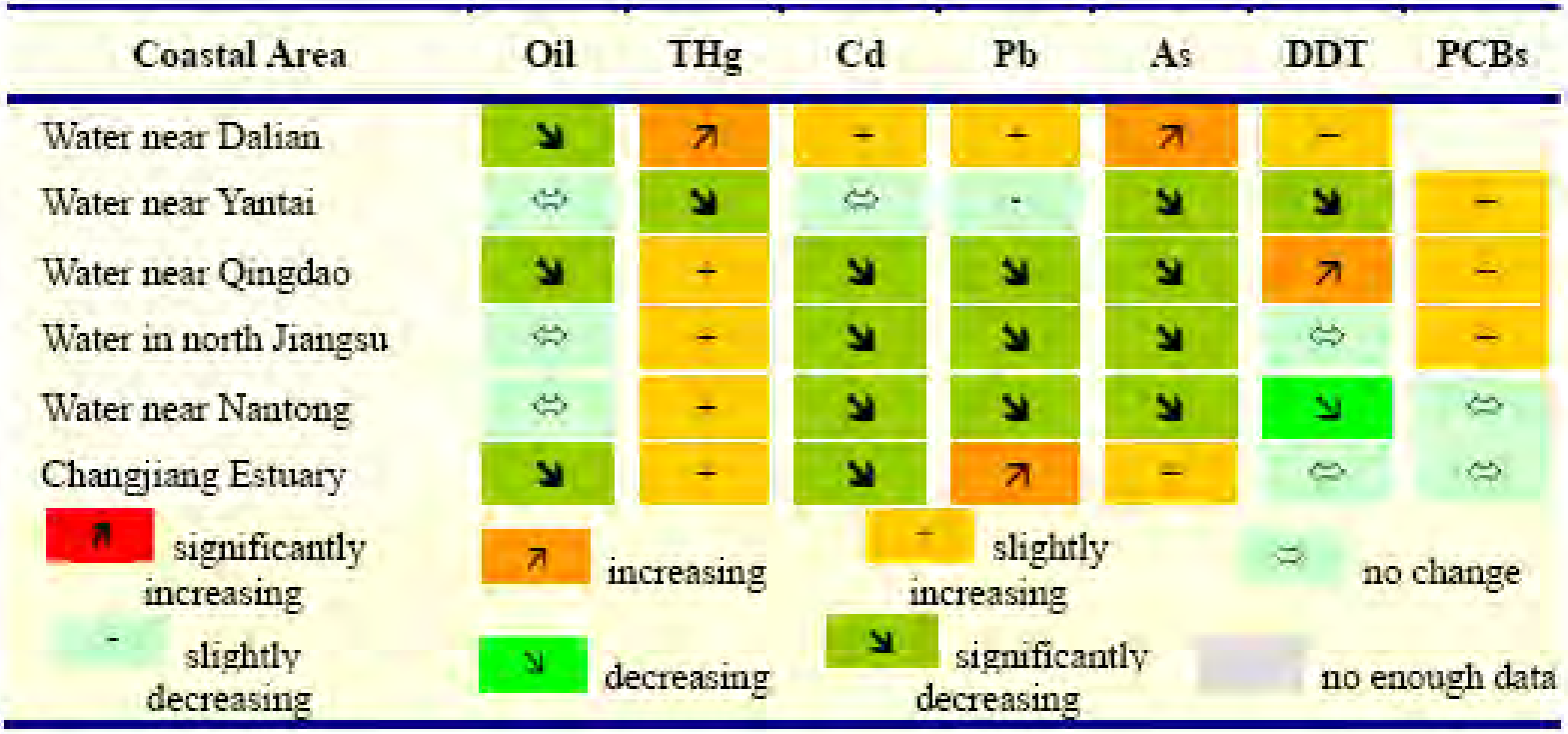
Trends of atmospheric deposit pollutants in area of Yellow Sea (1997-2006)

Areas	Fluxes of atmospheric deposit				Contents of pollutant in aerosol			
	TSP*	Cu	Pb	Cd	TSP*	Cu	Pb	Cd
near Dalian	-	⇨	–	⇨	-	–	–	-
near Qingdao	⇨	↗	↗	↘	⇨	↗	–	↘
Changjiang Estuary	-	↗	↗	↗	-	↗	↗	↗
All seas	⇨	↗	↗	↗	⇨	↗	↗	⇨

↗ significantly increasing
↗ increasing
– slightly increasing
⇨ no change
- slightly decreasing
↘ significantly decreasing

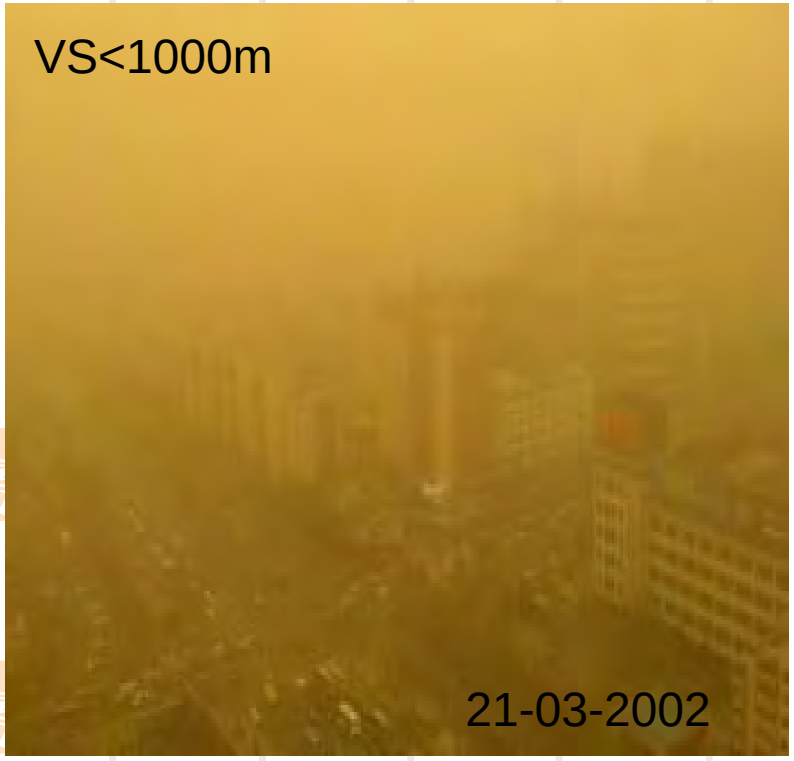
* TSP: Total suspended particles in atmosphere.

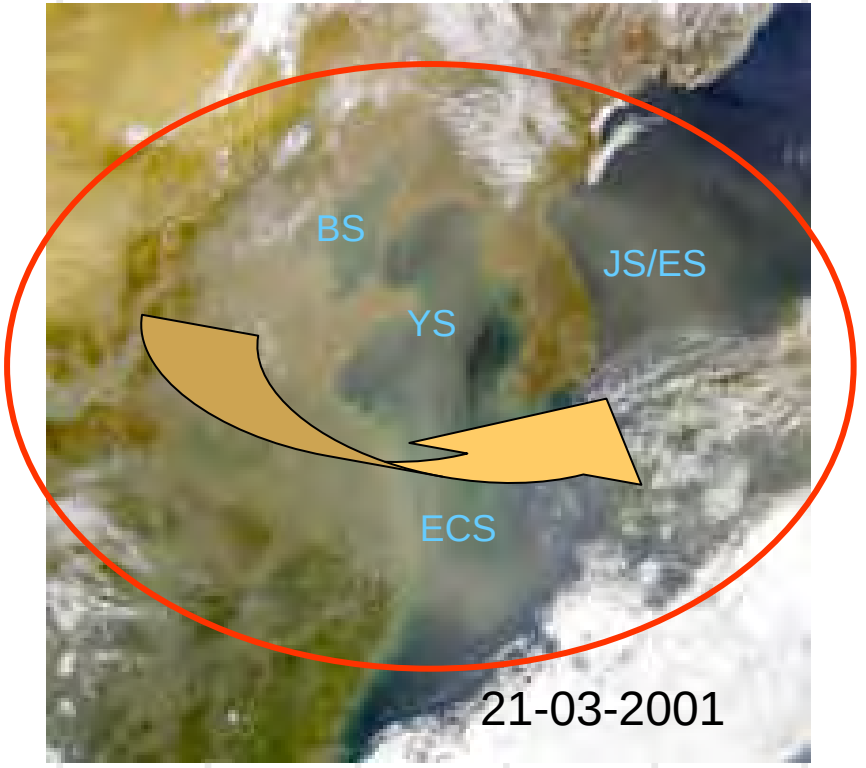
Change of content of pollutants in shellfish along coast of Yellow Sea (1997-2006)

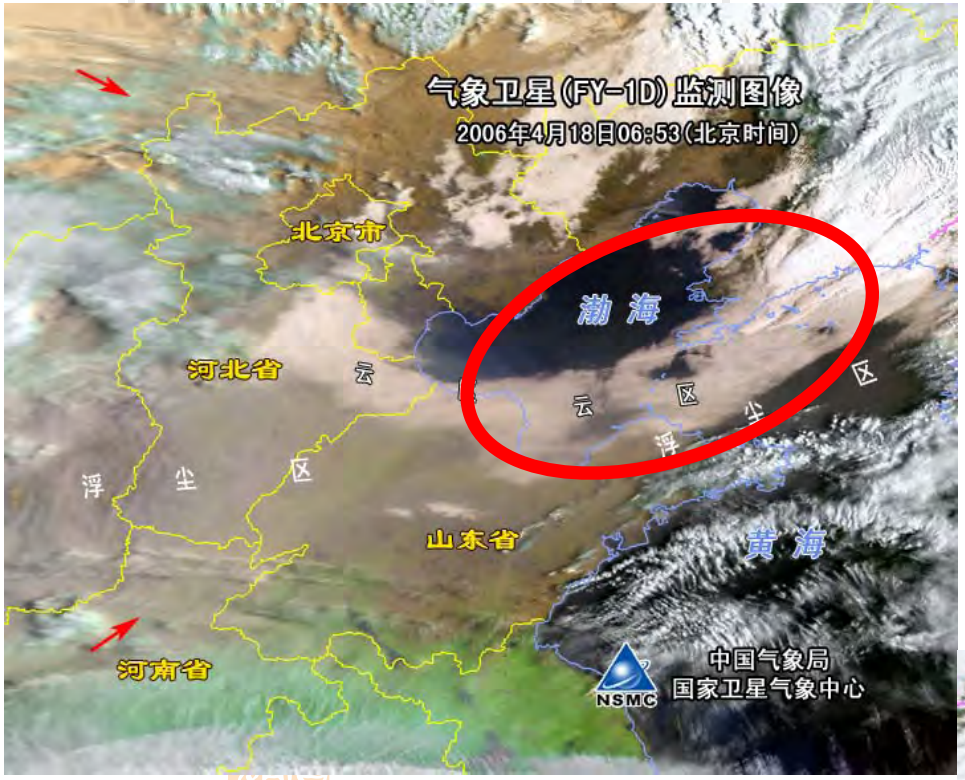


From Q. Wen

Dust storms in China

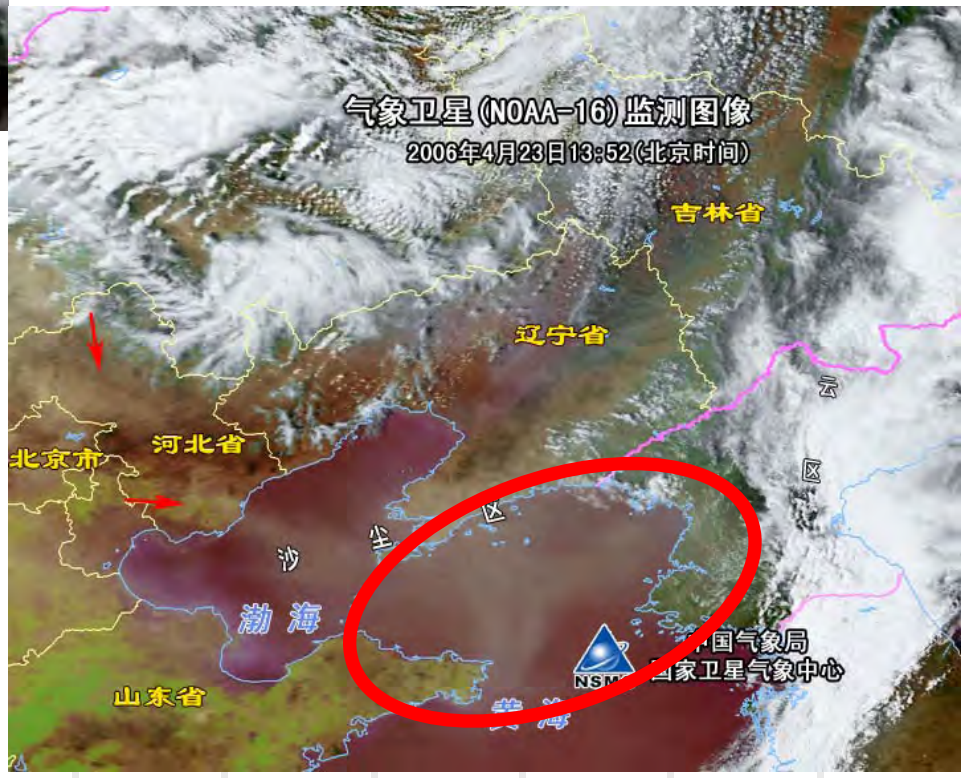




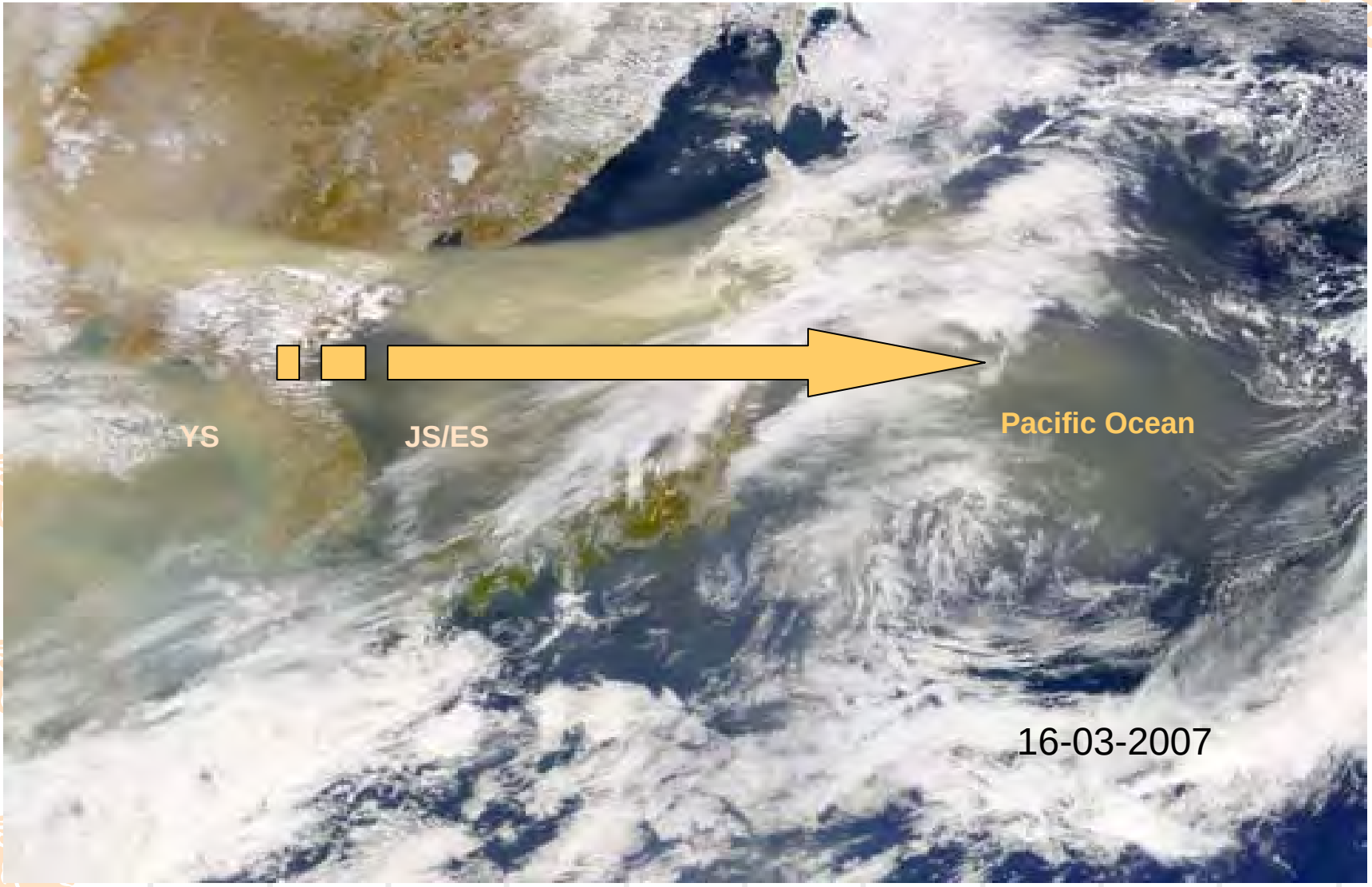


Chinese satellite image of dust storm
April 18, 2006

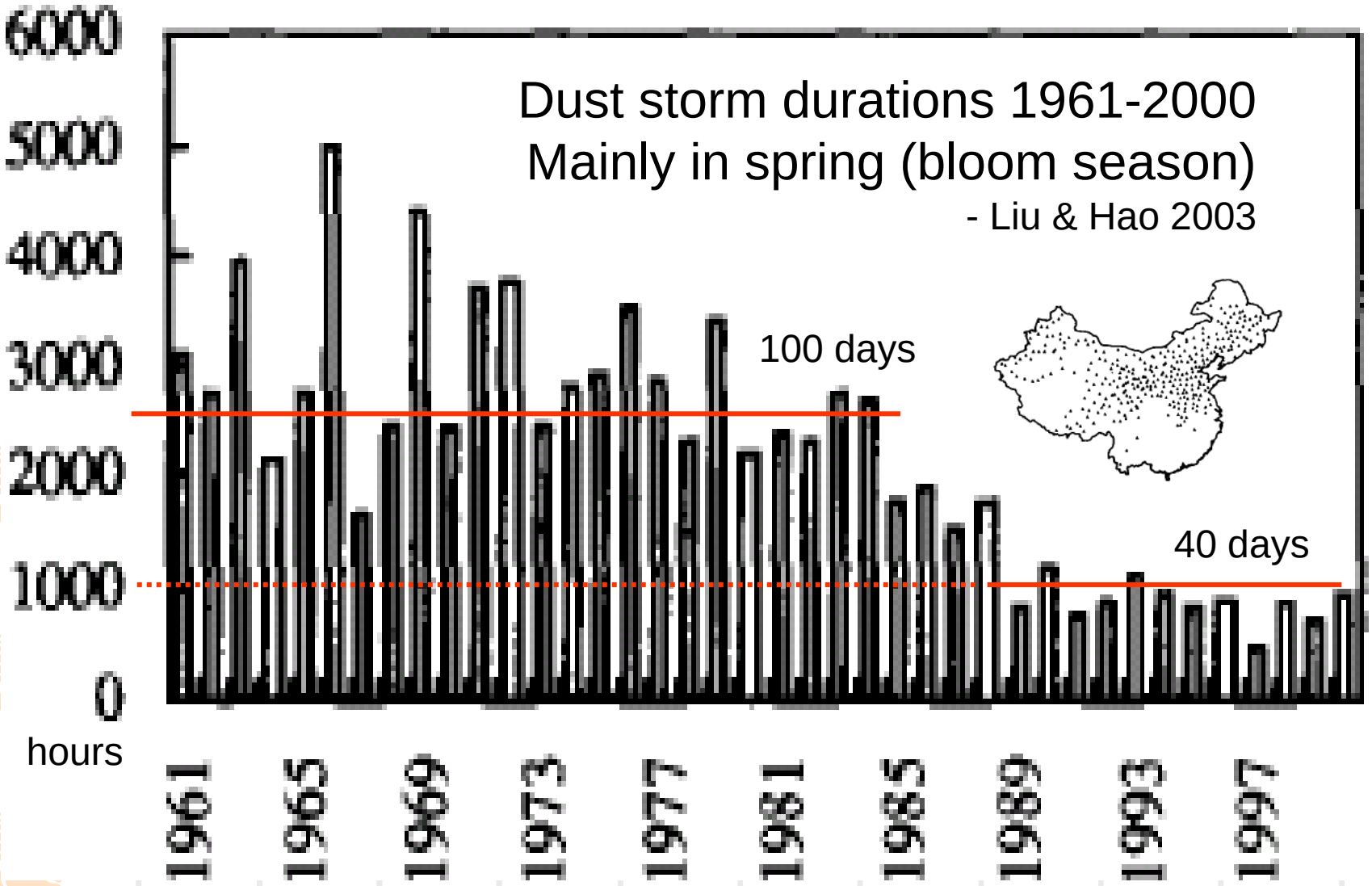
NOAA satellite image of dust storm
April 23, 2006

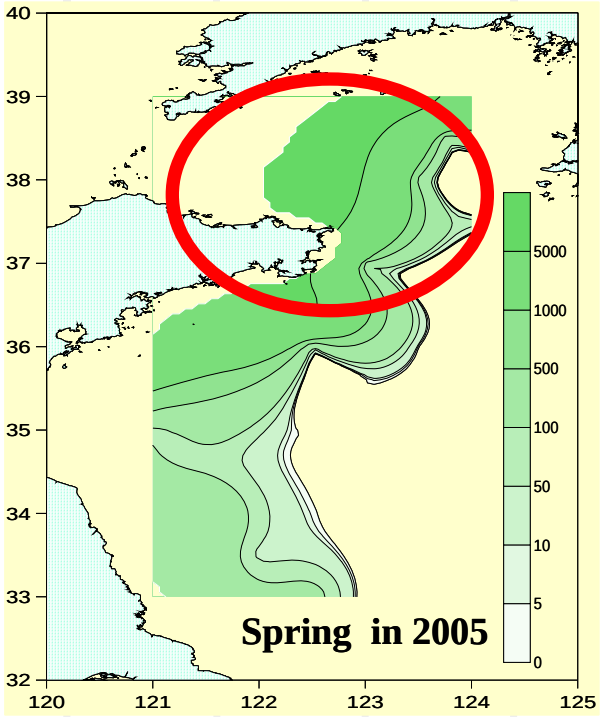


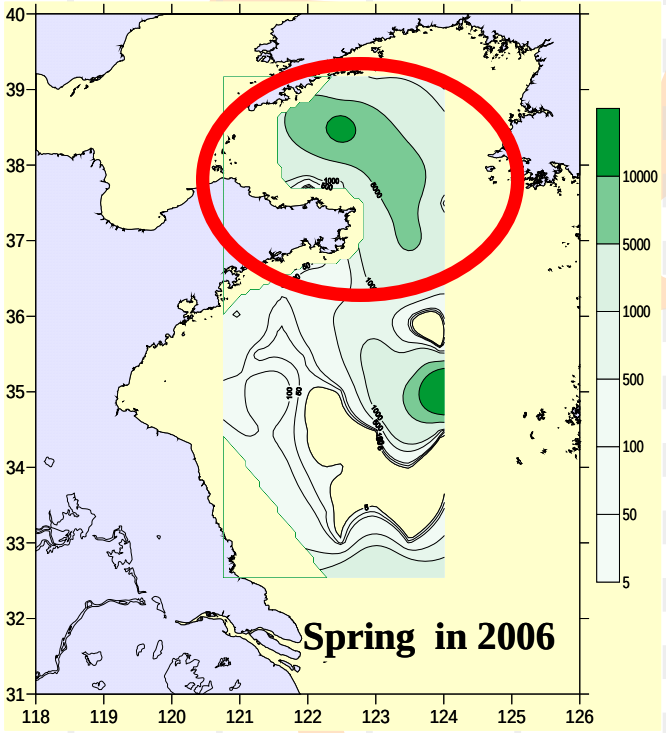
Dust storms in China



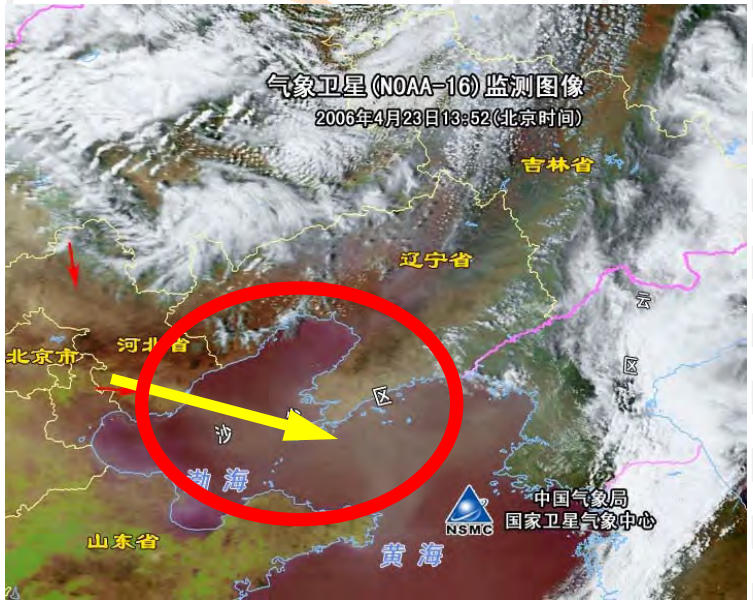
Dust storms in China





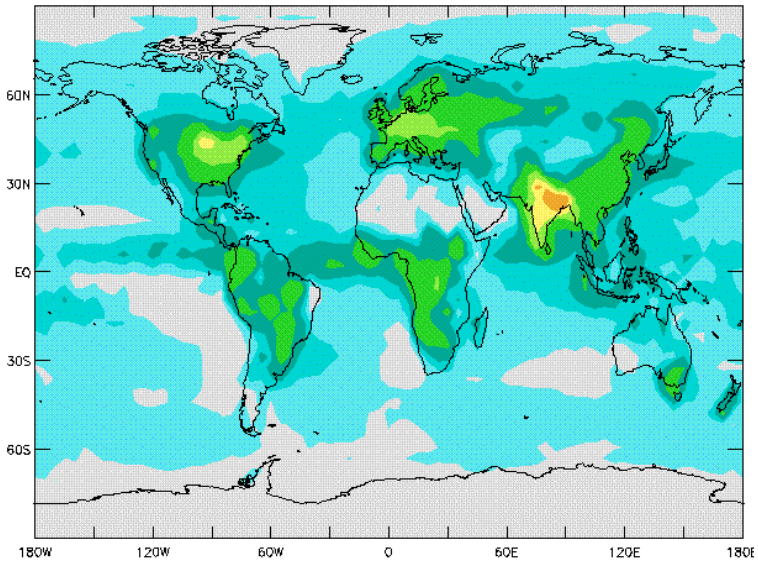


High abundance of phytoplankton situated in the pass way of dust

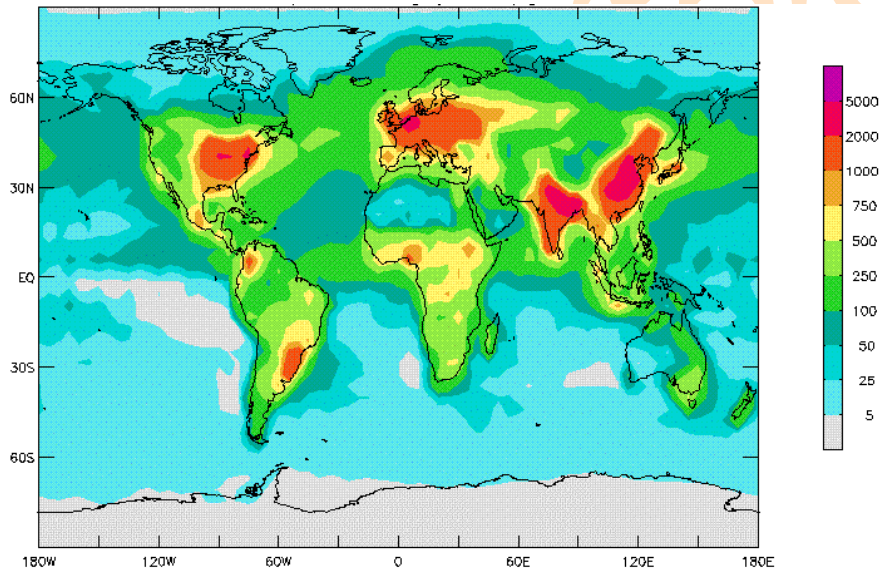


Distribution of Global Atmospheric Nitrogen Deposition

(mg N/m^2/yr)

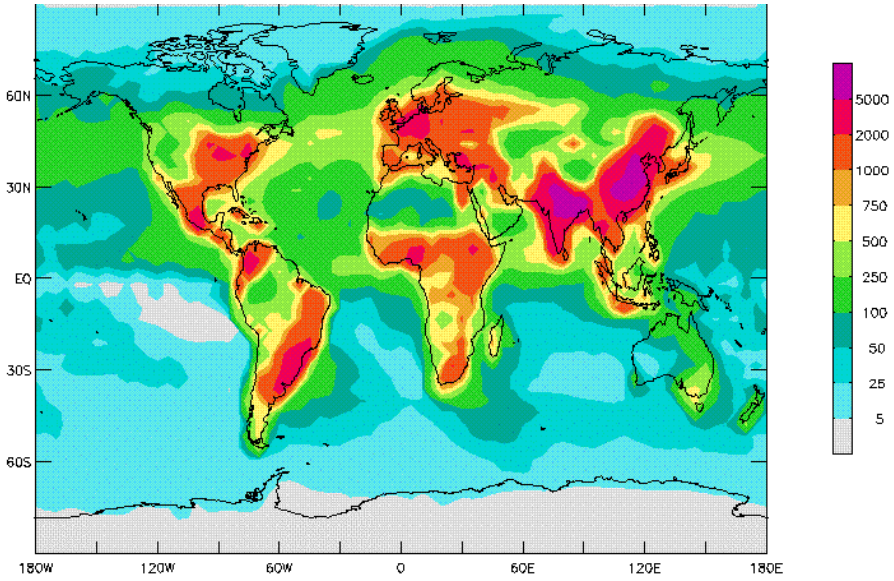


1860



early 1990s

2050



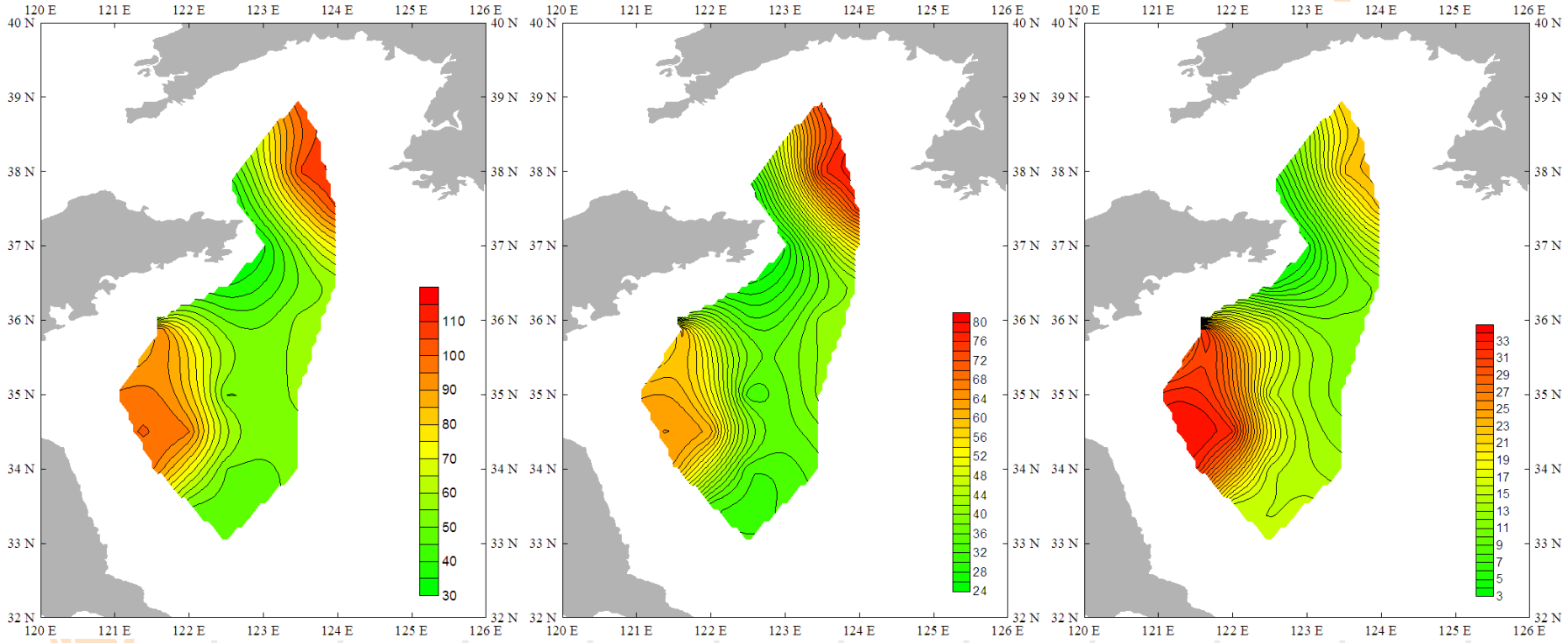
Galloway et al., 2004

Atmospheric nitrogen deposition

	Deposition Mmol $m^{-2}yr^{-1}$	deposition/ (deposition+river)	Reference
South North Sea	71	27%	Rendell *et al.*, 1993
Delaware Bay	75	5%	Russell *et al.*, 1998
Kattegat	69	30%	Asman *et al.*, 1995
North Atlantic coast	23	20%	Galloway *et al.*, 1996
Yellow Sea	90.5	42%	Bi, unpublished data

Note: The studies by Rendell et al. (1993) and Bi are the only ones to explicitly include ON. Cornell et al. (2003) suggest that organic nitrogen will enhance deposition total nitrogen by 10–20%, probably more in remote regions

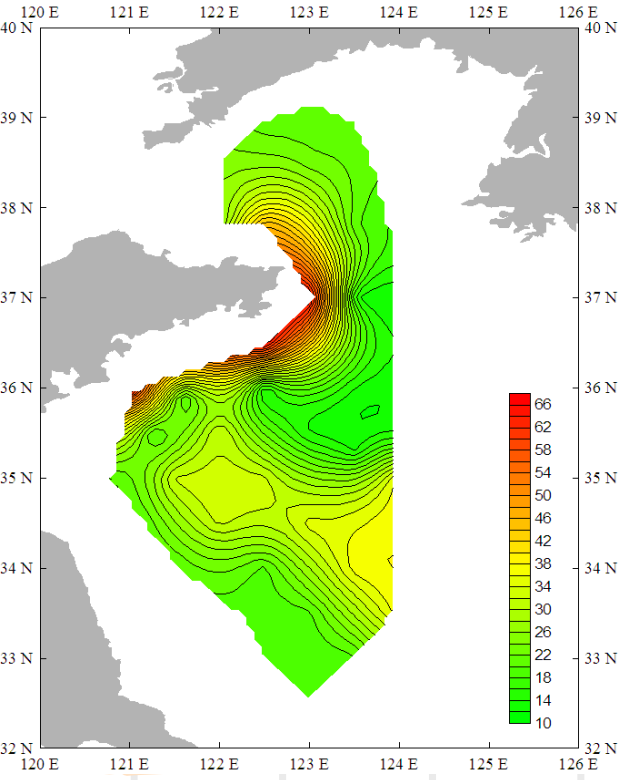
Atmospheric nitrogen deposition during China SOLAS cruise in YS in March 2005



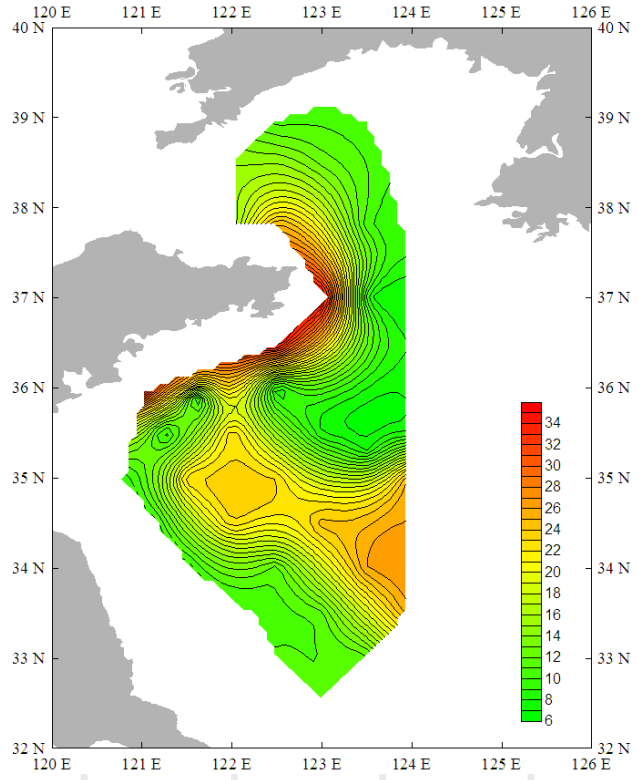
TN　　IN　　ON

（mgN/m^2/mon）

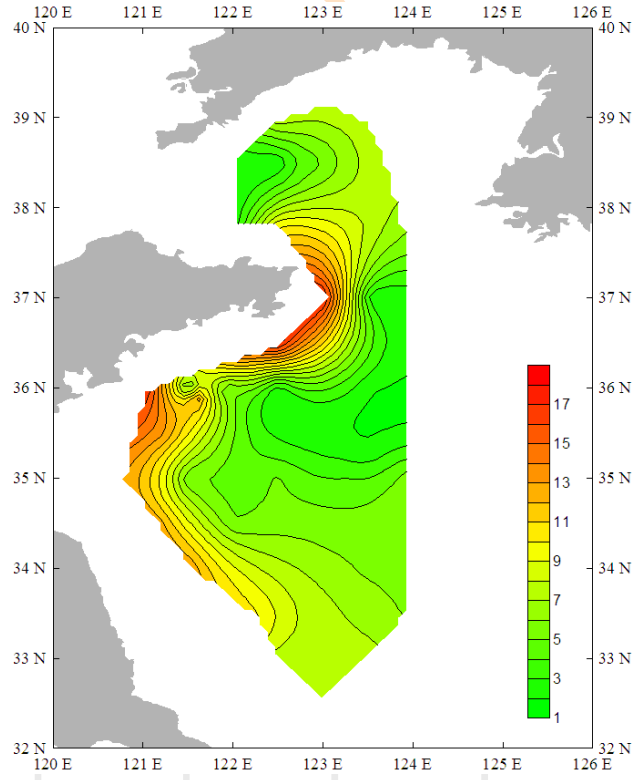
Atmospheric nitrogen deposition during China SOLAS cruise in April 2006



TN



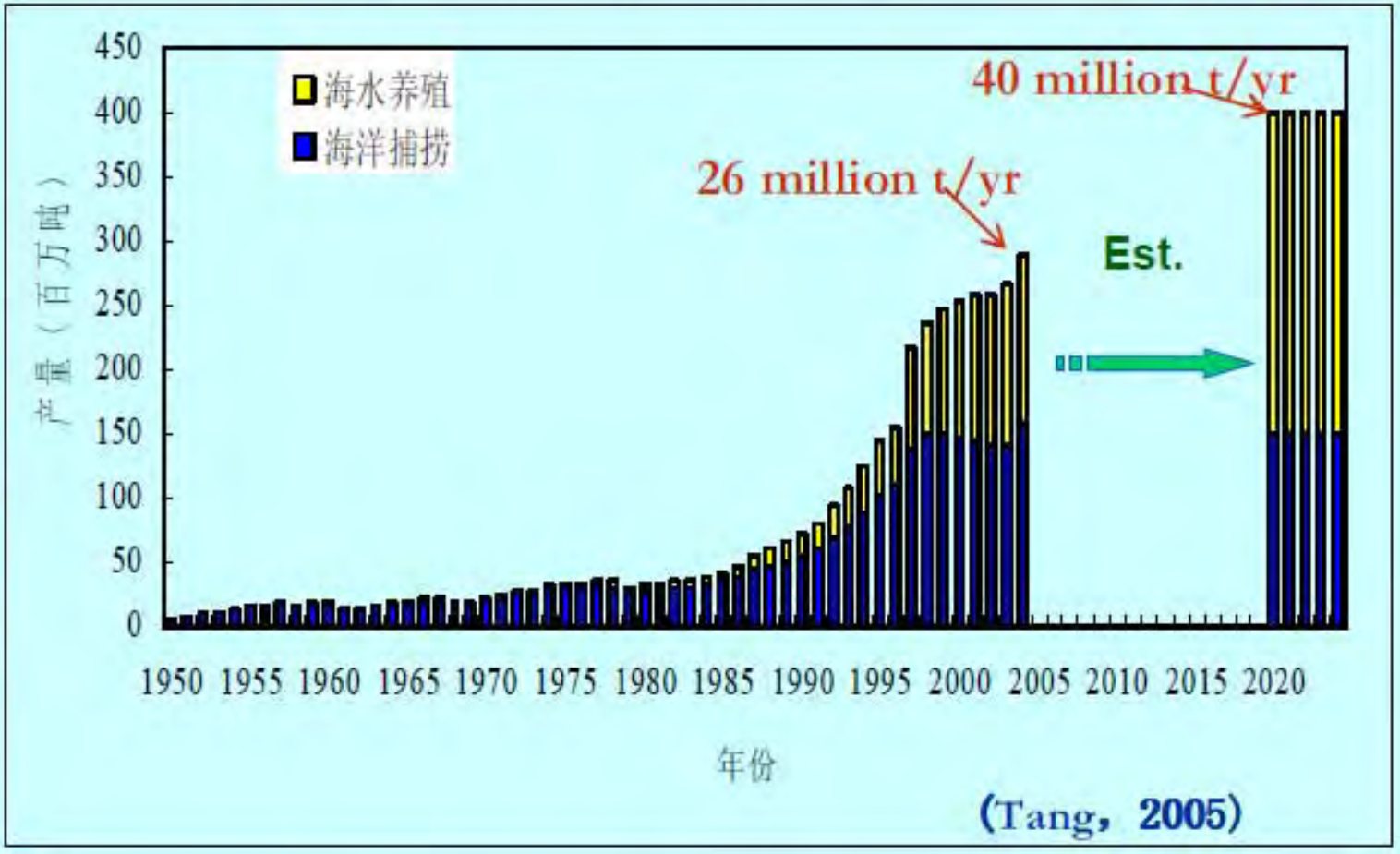
IN



ON

（mgN/m2/mon）

Overfishing & Over-Aquaculture



Overfishing: a fact since 1980's

- Over the last 50 years, biodiversity and productivity of the Yellow Sea ecosystems have undergone large changes. For example, on the dominant species, the commercially important high-valued long-lived, high trophic level, piscivorous bottom fish have been replaced by low-valued shorted-lived, low trophic level, planktivorous pelagic fish.

Land Reclamation

Large-scale land reclamation

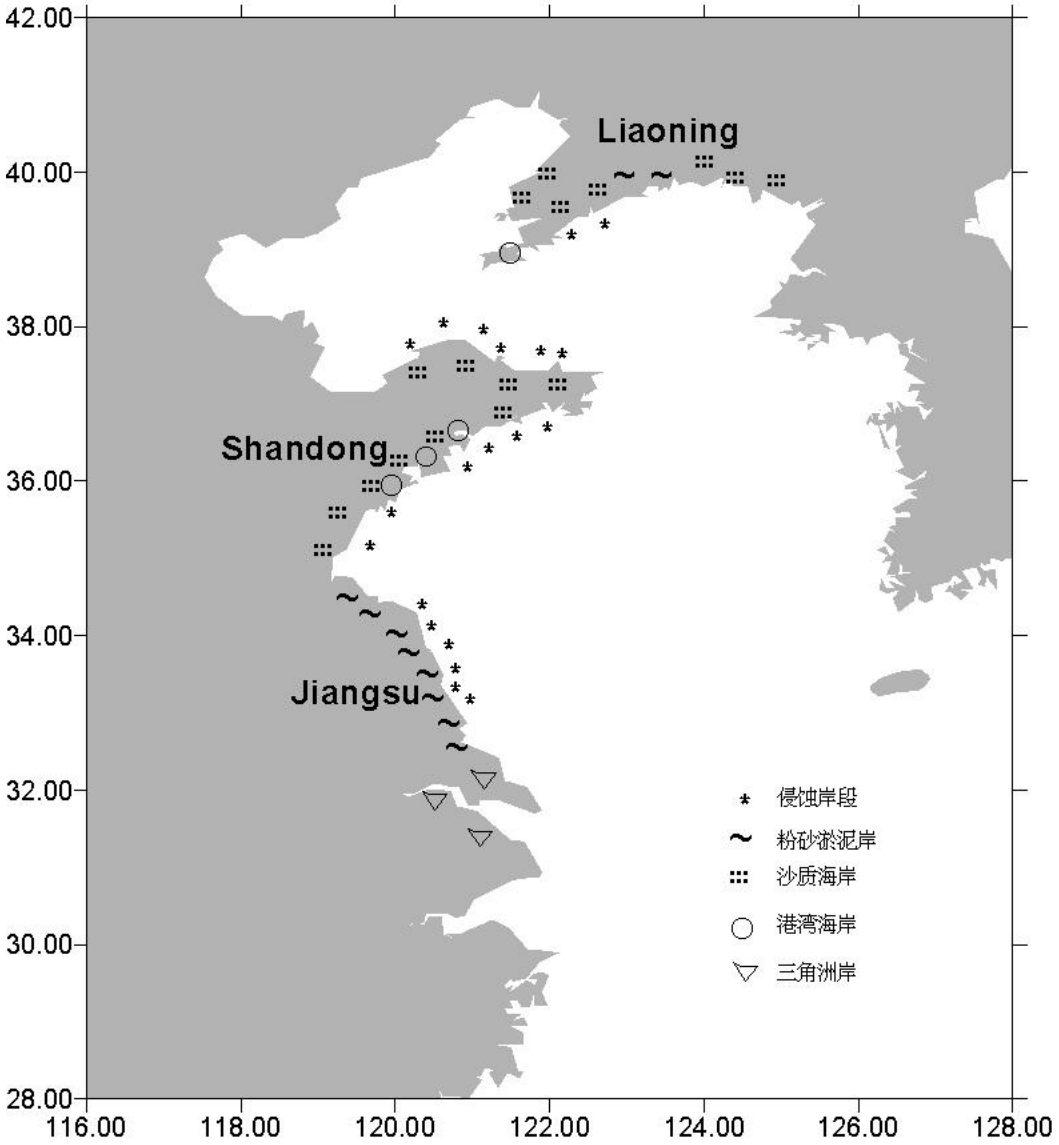
- During the last decades, China has lost ca. 1000 km^2 or 50% of total coastal wetlands to reclamation.
- In 2002~2007, the wetland loss rate increased from 20 km^2/yr to 134 km^2/yr

Land Reclamation

Reclamation in the Yellow Sea

Jiangsu Province

- Presently, over 5000 km² coastal wetlands, about one-fourth of China's total.
- Over 1300 km² coastal wetlands reclaimed over the past 15 years
- Plans to reclaim another 1800 km² by 2020



Coastal erosion of Yellow Sea.

 erosion coast; ~siltation coast; ::: sandy coast

0 embayment coast; ∇ delta coast

III.Change in planktonic and benthic community

1. Phytoplankton

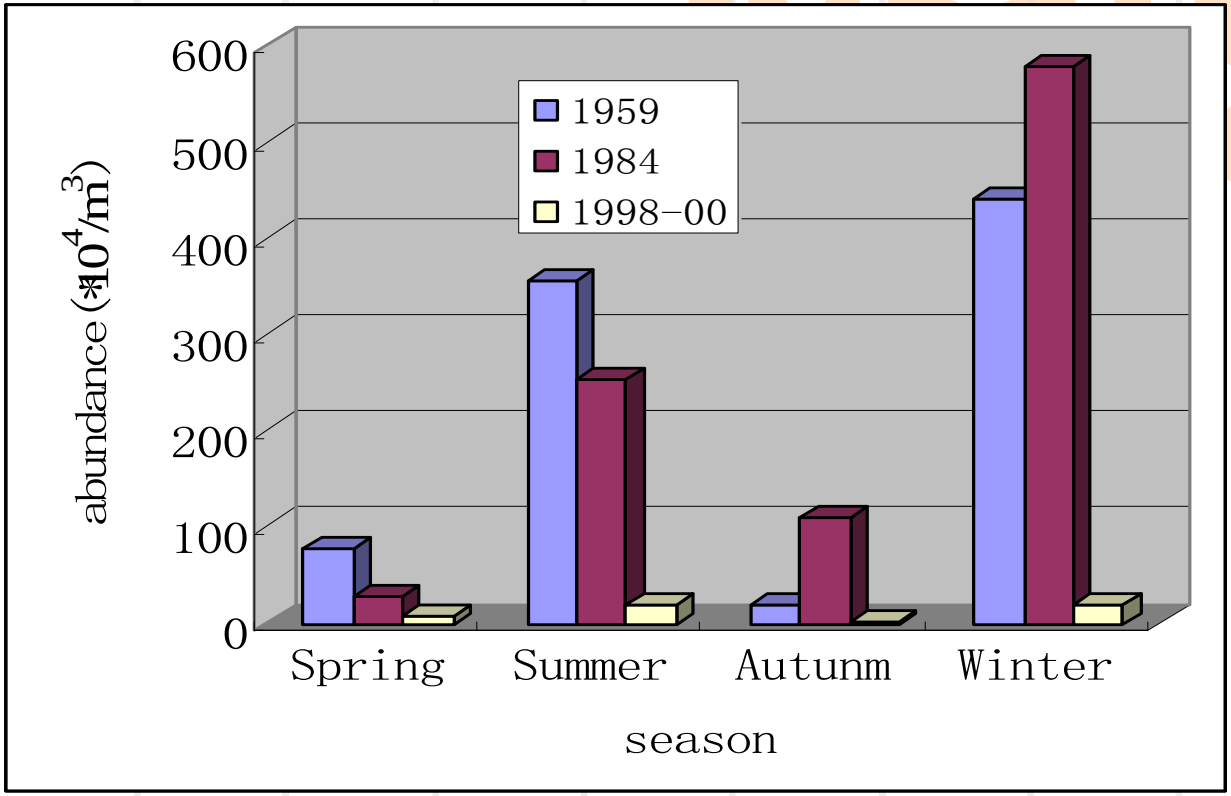
There was a decrease in species number of phytoplankton in last century

Number of phytoplankton species identified in Yellow Sea in different years

	spring			summer		autumn		winter		total		
	1984	1998	2005	1984	1998	1984	1998	1984	1998	1959	1984	1998
Bacillariophyta	78	22	99	89	44	85	42	109	42	168	160	55
Pyrrophyta	17	8	16	15	8	28	7	11	5	32	36	8

phytoplankton abundance

a significant decrease in phytoplankton abundance from 1959 through 1985 to 1998 .



The seasonal and interannual variation of phytoplankton abundance

Since 2001, the abundance of phytoplankton in spring became much higher than that in earlier years. It may attribute to the acceleration of eutrophication process and global warming.

Table 3. The cell abundance of phytoplankton in Yellow Sea In different years ($\times 10^4$ cells/m^3)

Year	Spring	Summer	Autunm	Winter	Mean	Data source
1959	77.29	354.90	20.40	441.53	223.53	[1]
1984-1985	27.6	254.0	109.4	577	242	[9, 11]
1998-2000	7.96	20.17	2.24	18.24	12.94	[18, 19, 25]
2000			9.54			FIO
2001	777.06					FIO
March 2005	1334.3					FIO
May 2005	2.59					FIO
April 2006	2027.66					FIO

Ratio of diatom to dinoflagellates

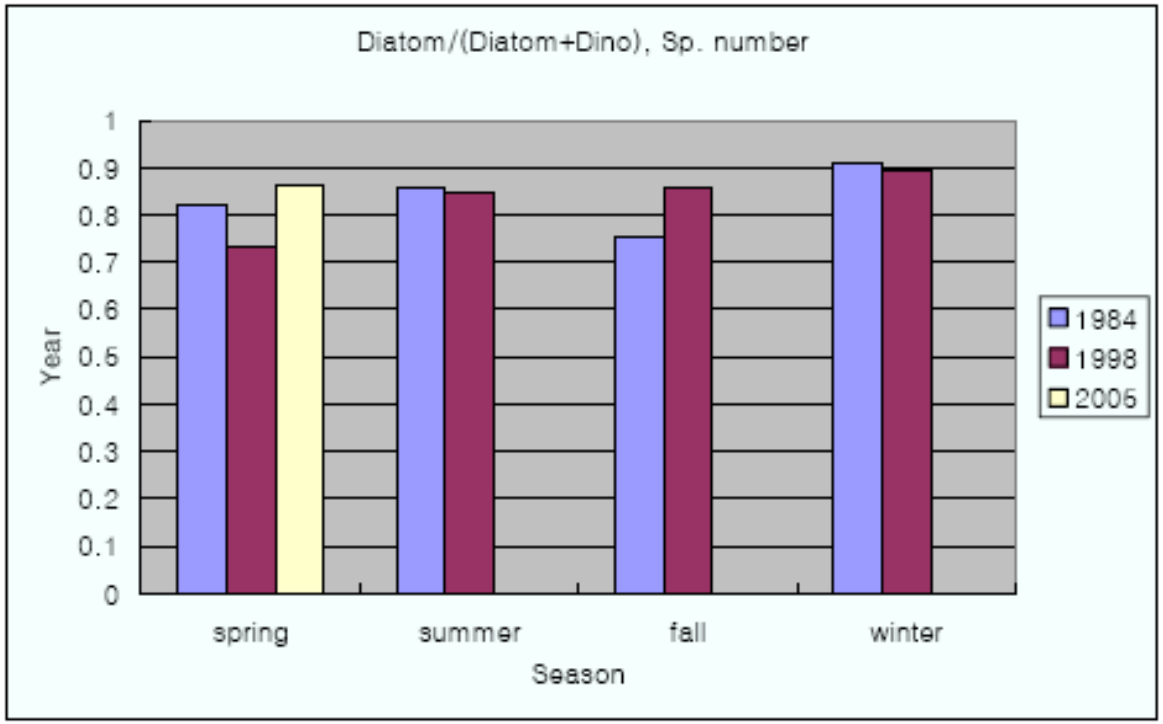


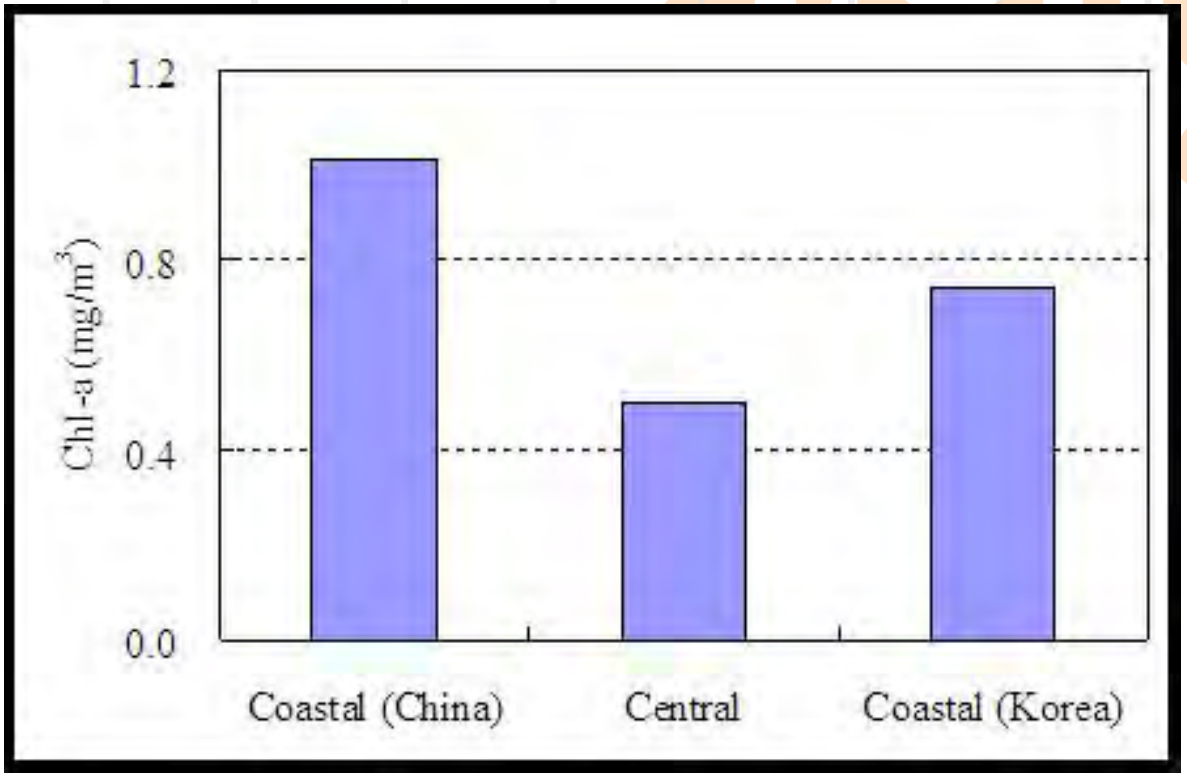
Figure 1. Ratio of diatoms/(diatoms+dinoflagellates) species number from Chinese surveys. Redrawn using the data from the Chinese report.

(From Sinjae Yoo)

Chlorophyll a (chl-a) and primary productivity

Chlorophyll-a

Chlorophyll-a concentrations in the surface water of the Yellow Sea in spring and autumn were in the range of 0.426~17.425 mg/m3 in Korean report.



The mean concentration of chl-a in Yellow sea in 1992

2. Zooplankton

Long-term change of 4 main zooplankton groups (from Korean data)

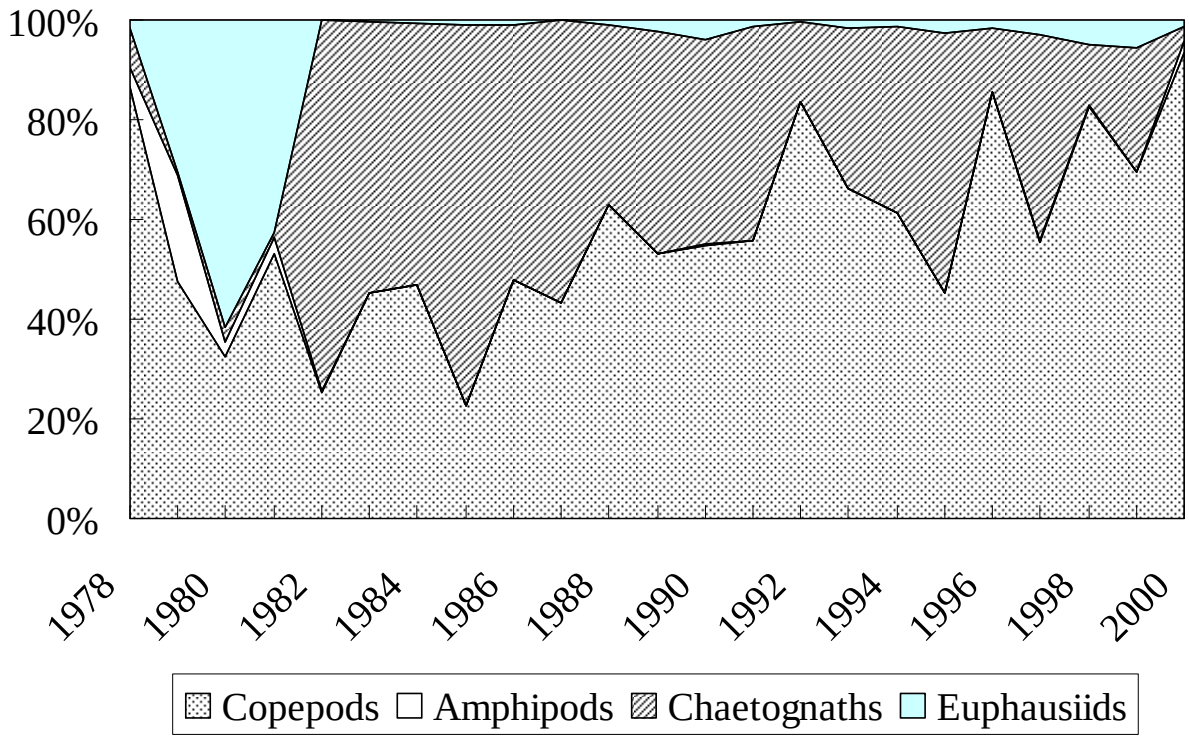
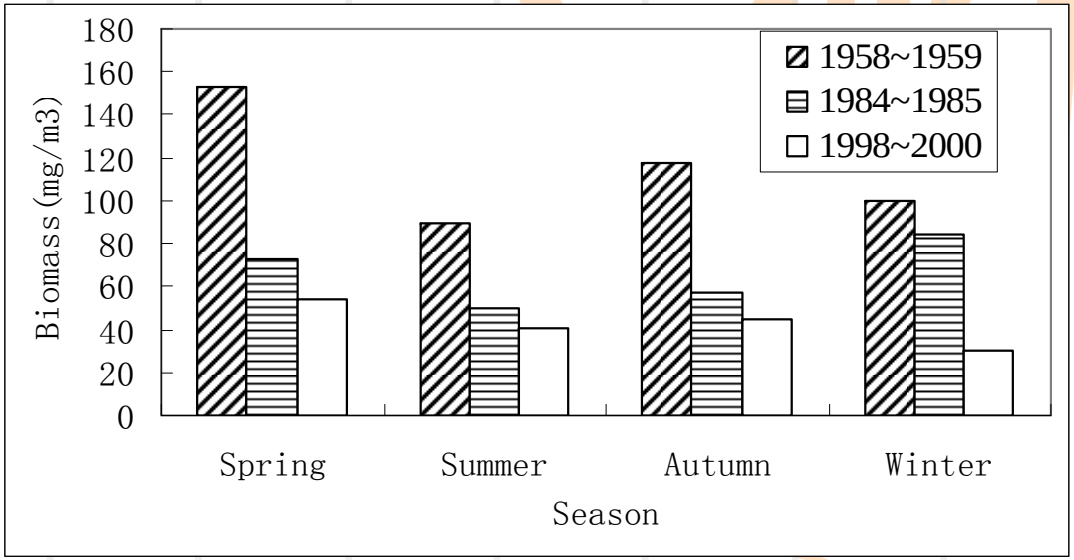


Figure 7. Long-term change in relative composition of four major zooplankton groups during 1978~2000 (KEWG, 2006). A net with a mesh size of 330㎛ was used to sample zooplankton.

Seasonal and long-term variation of zooplankton biomass (from Chinese data)



Seasonal variation of zooplankton biomass shows a double peak type. In general, the peaks occur in spring and autumn. But there is a winter peak in 1984-85. From results of these 3 survey, there were a trend of decrease of zooplankton biomass

Long-term variation of zooplankton biomass (from Korean data)

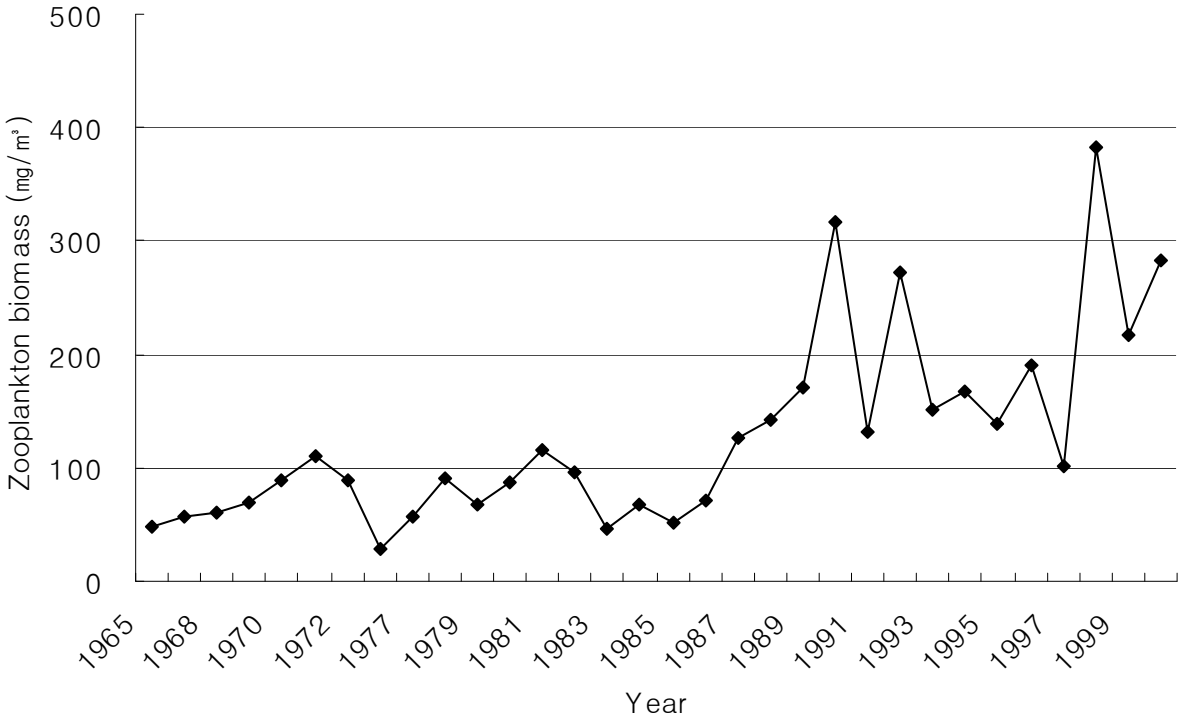
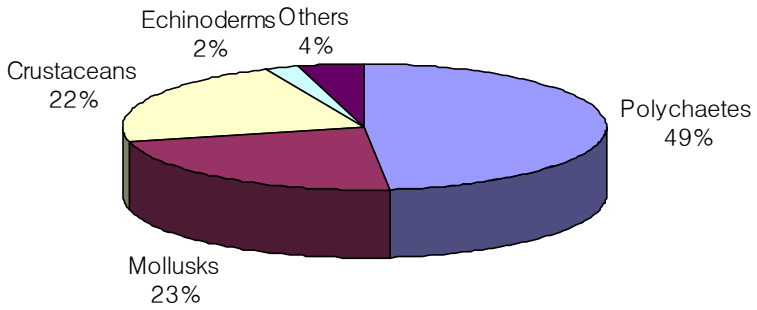


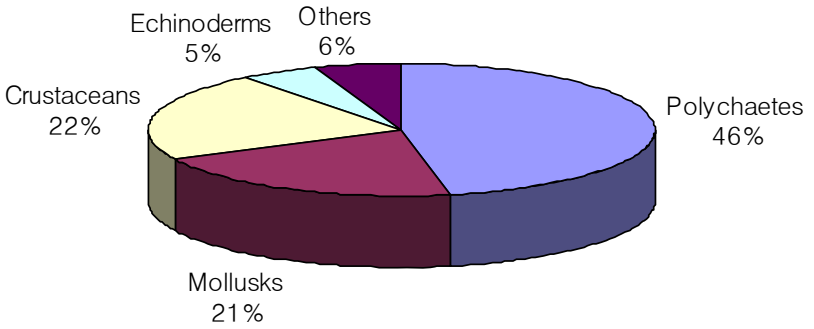
Figure 8. Long-term change in zooplankton biomass in wet weight in the Yellow Sea (KEWG, 2006).

3. Macrobenthos

Relative composition of major benthic groups in Yellow Sea (from D. Kang)

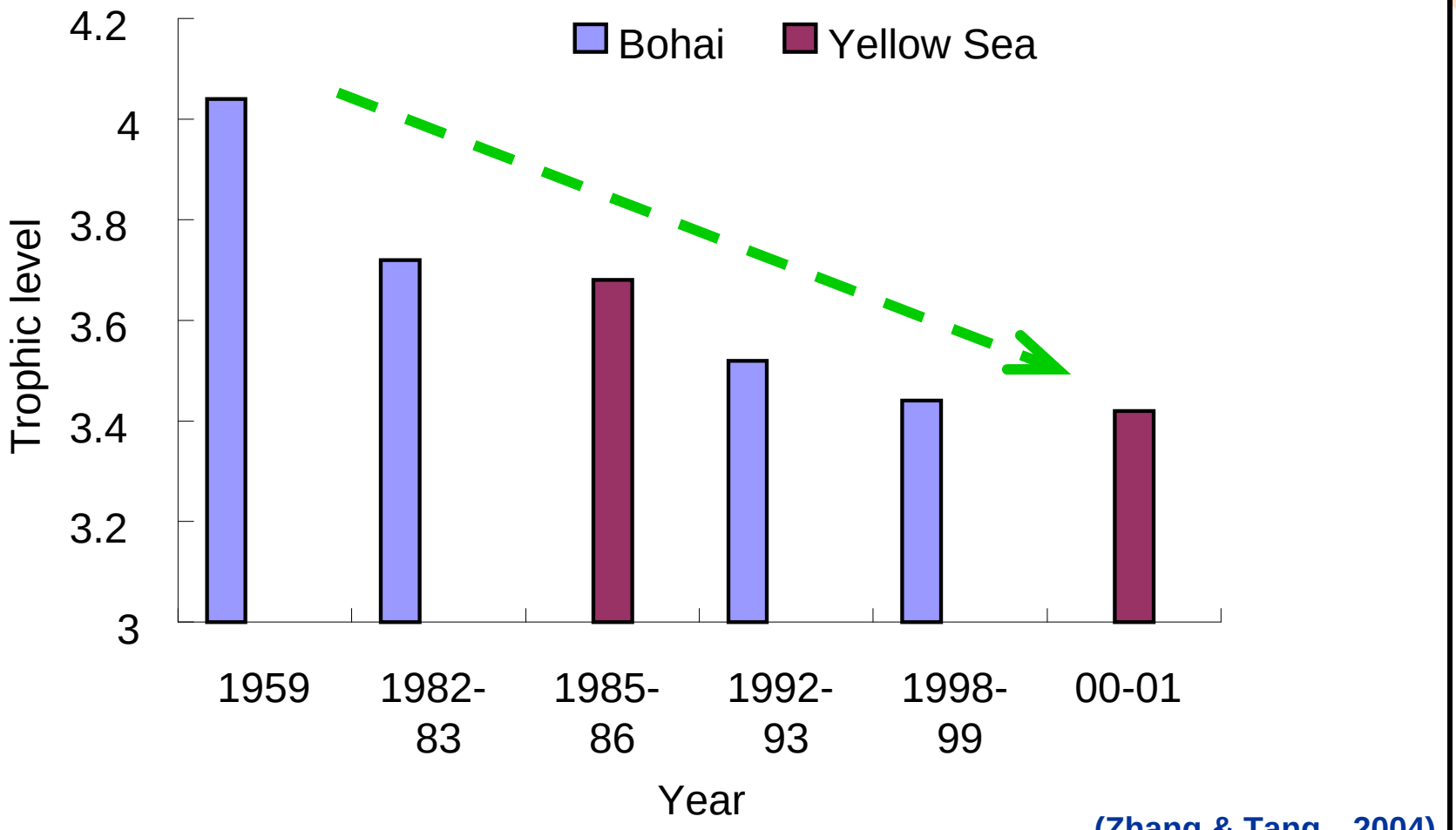


Relative composition of the major benthic groups in the Yellow Sea in September 1992 (data from KEWG(2006)).



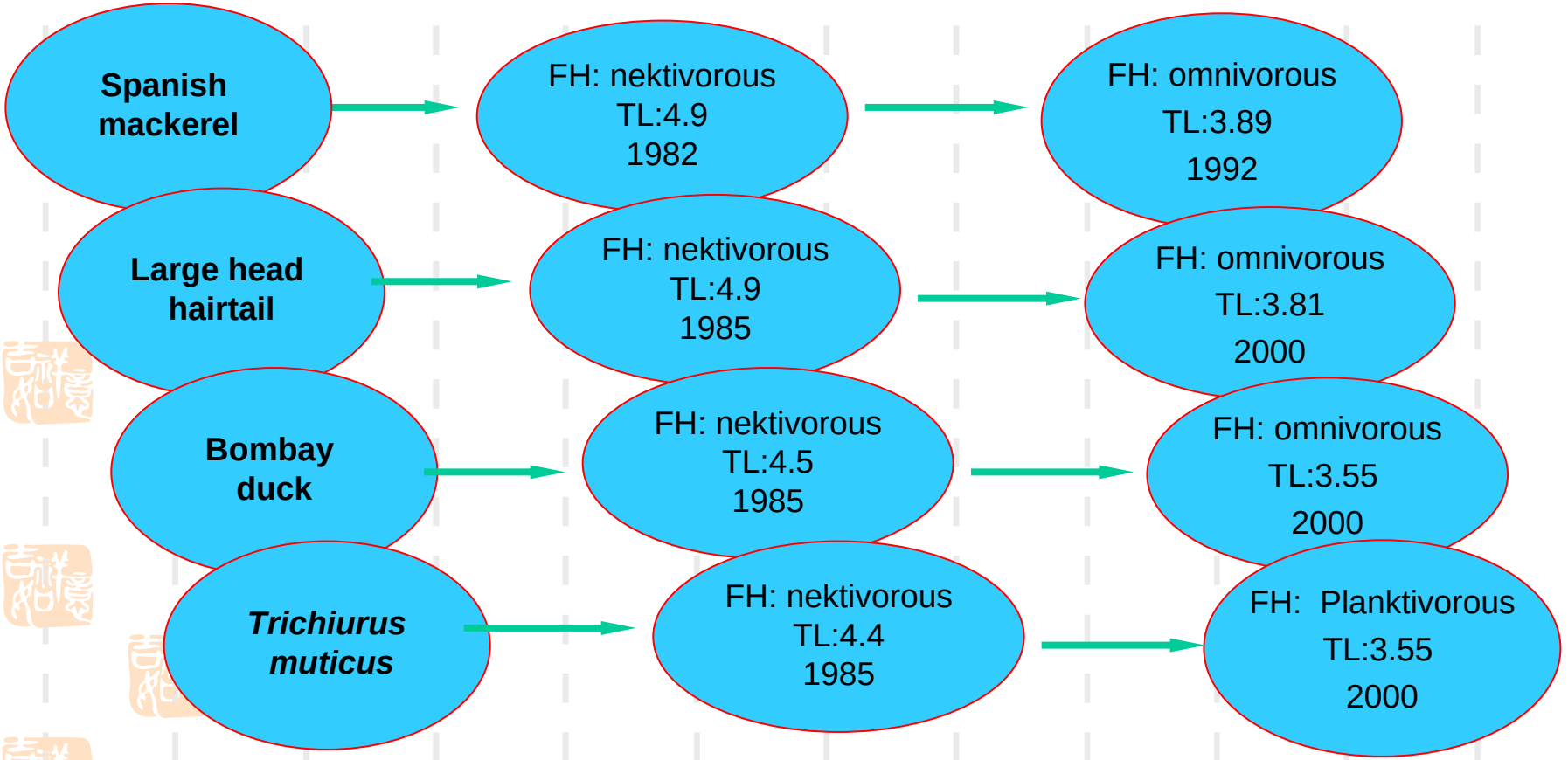
Relative composition of the major benthic groups in the Yellow Sea in 1998~2001 (data from CEWG(2006)).

Trophic level continuously lowering



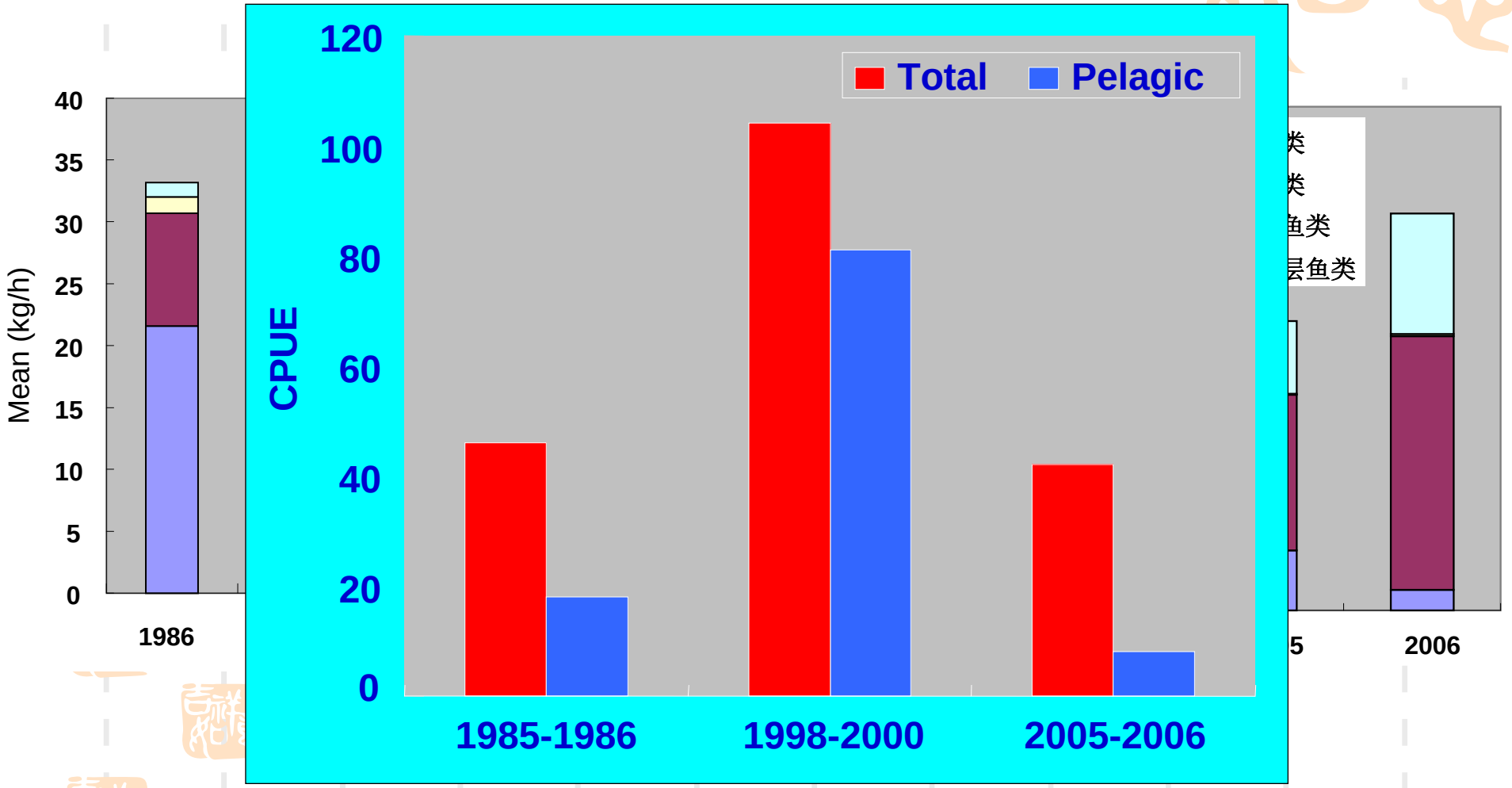
(Zhang & Tang，2004)

Species feeding habits in Yellow Sea changing over the past 20 years



(Zhen & Tang, 2007)

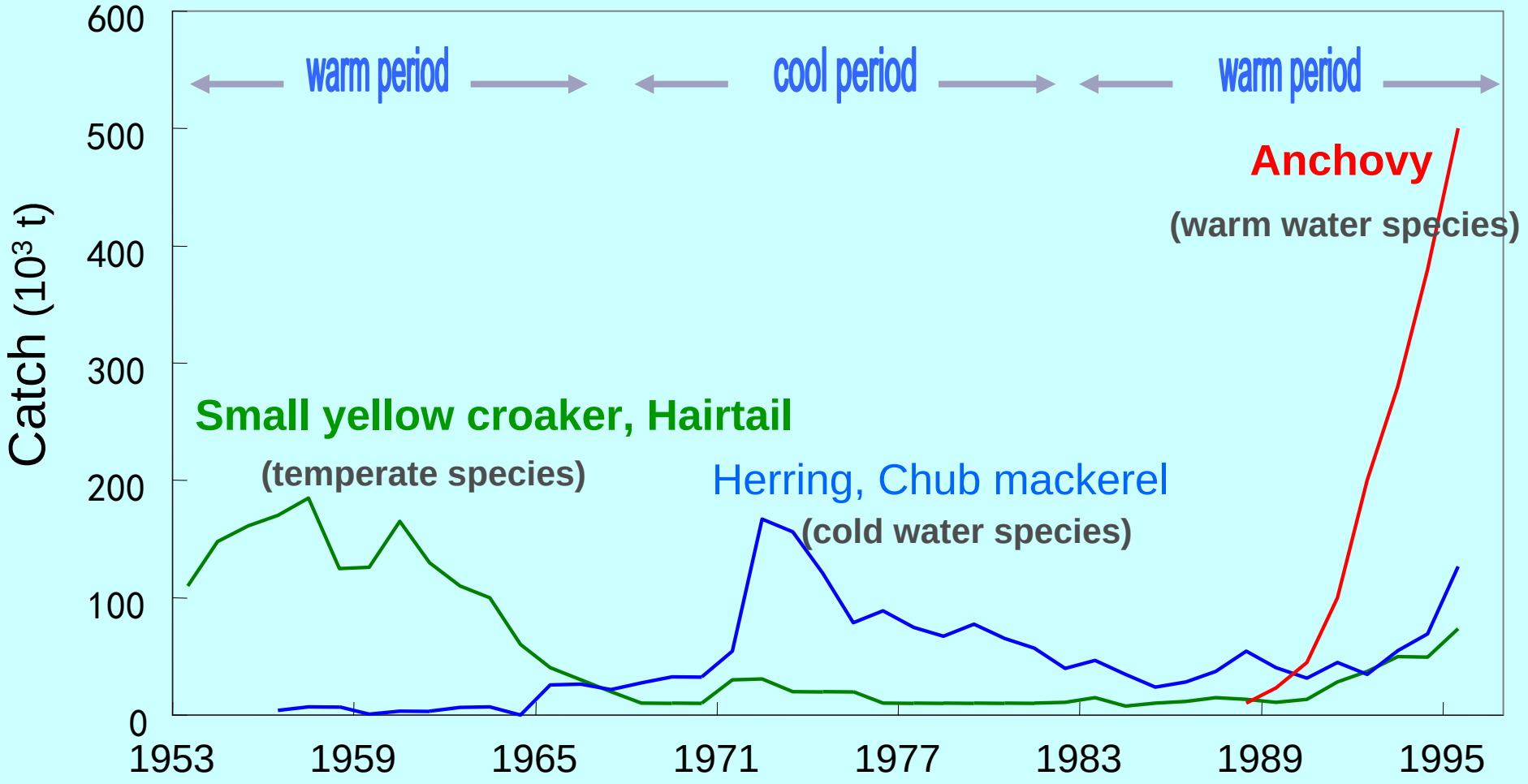
Community Structure Changes in Yellow Sea



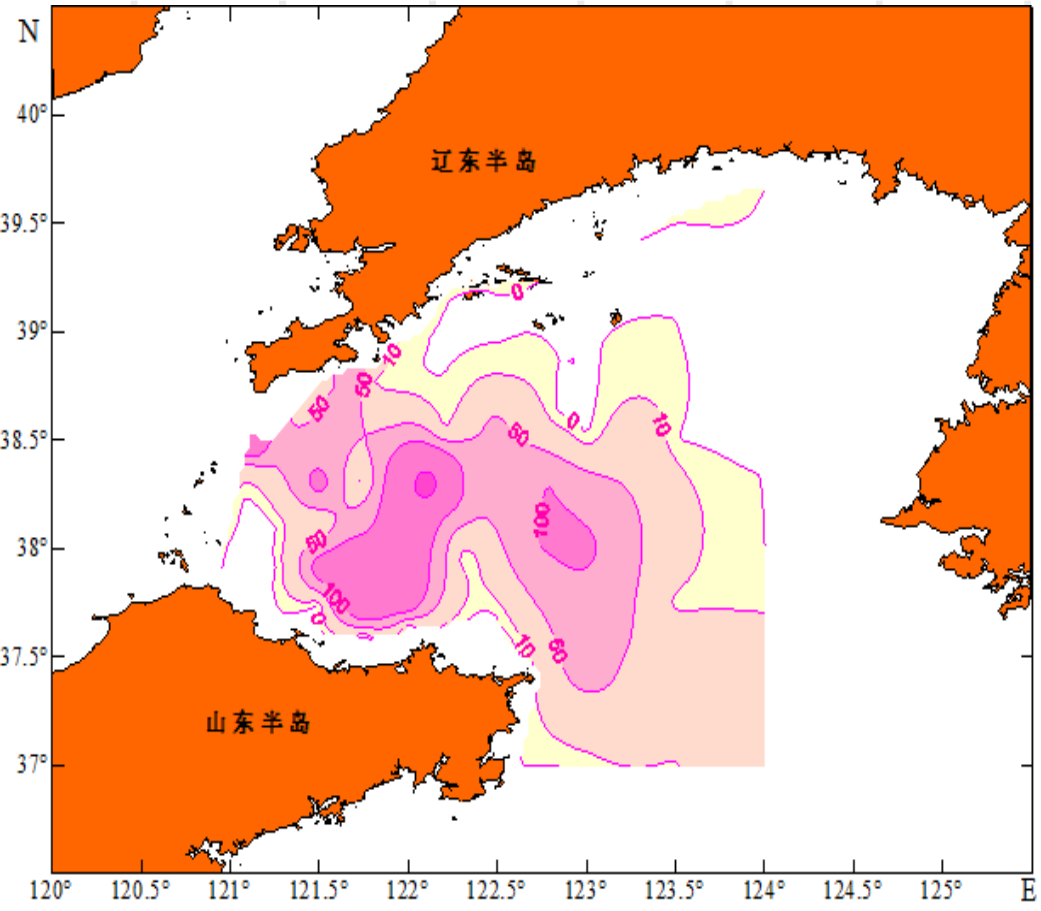
(Based on biomass yield data, YSFRI)

Shift of dominant species with climate

(Tang, 2003)



Warm water tunicate moving north



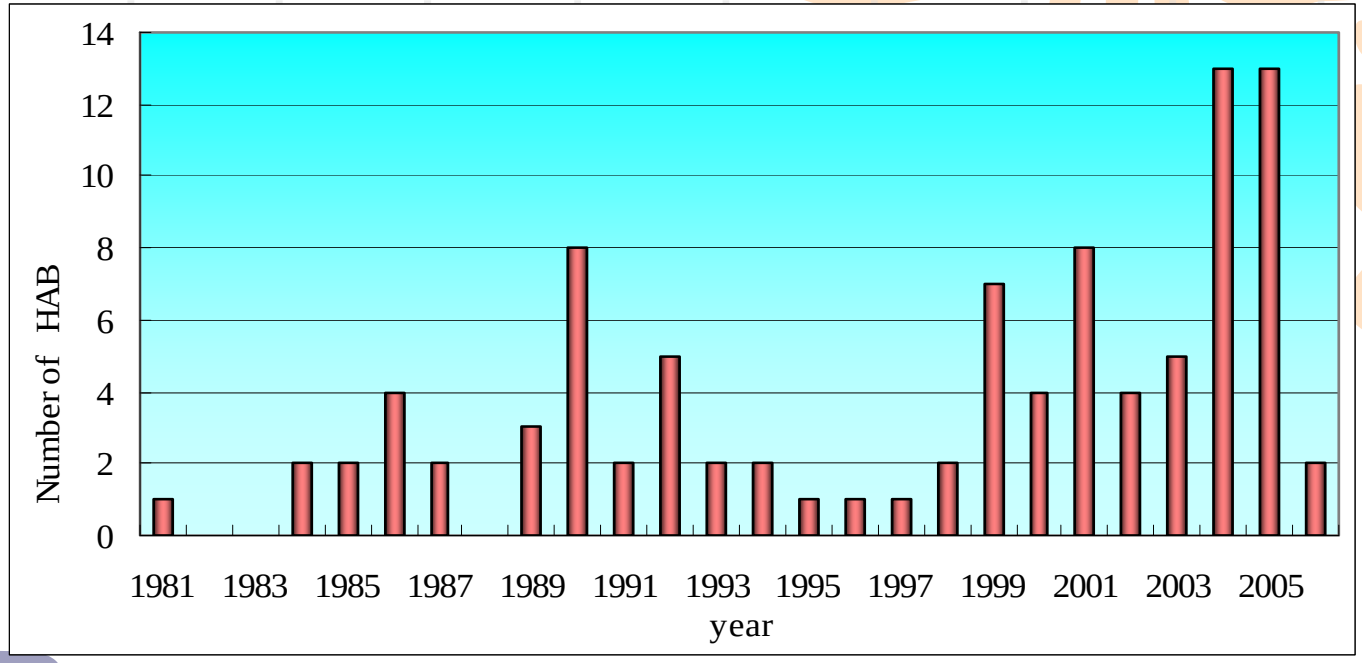
秋季小齿海樽丰度平面分布图

- ***Doliolum denticulatum***: a warm water species
- **In 1958/59, distribution limited to 32˚N.**
- **In 2007, becoming the dominant species in the Northern Yellow Sea (38-39˚N).**

IV.Disruptive response of ecosystem

1. **HAB**
2. **Jellyfish bloom**
3. **Hypoxia**

4.1 HAB events



From Chinese report, there is an increase of HAB events in Yellow Sea . During 2000-2005 the HAB events accounted for about 50% of total records. Although there were only two HAB events in 2006, this does not suggest that the environmental quality of Yellow Sea is being improved.

4.1 HAB events

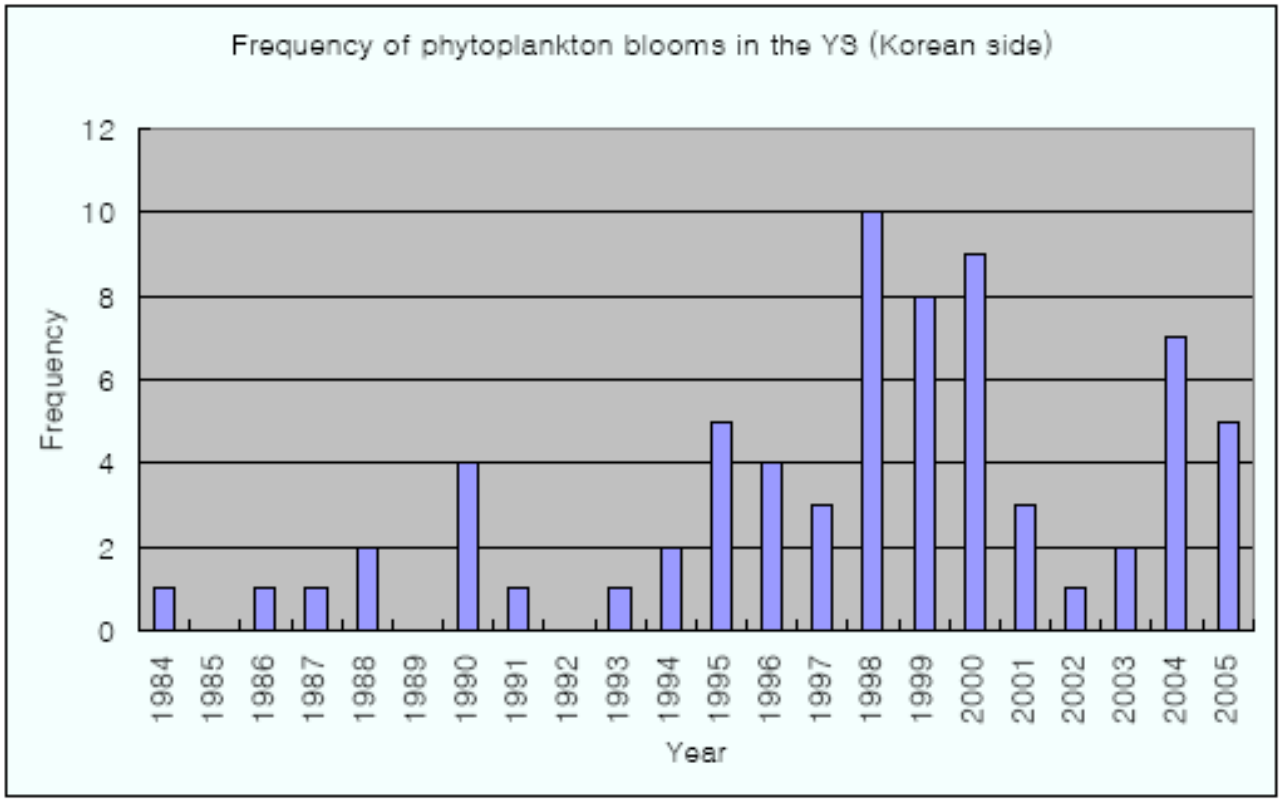
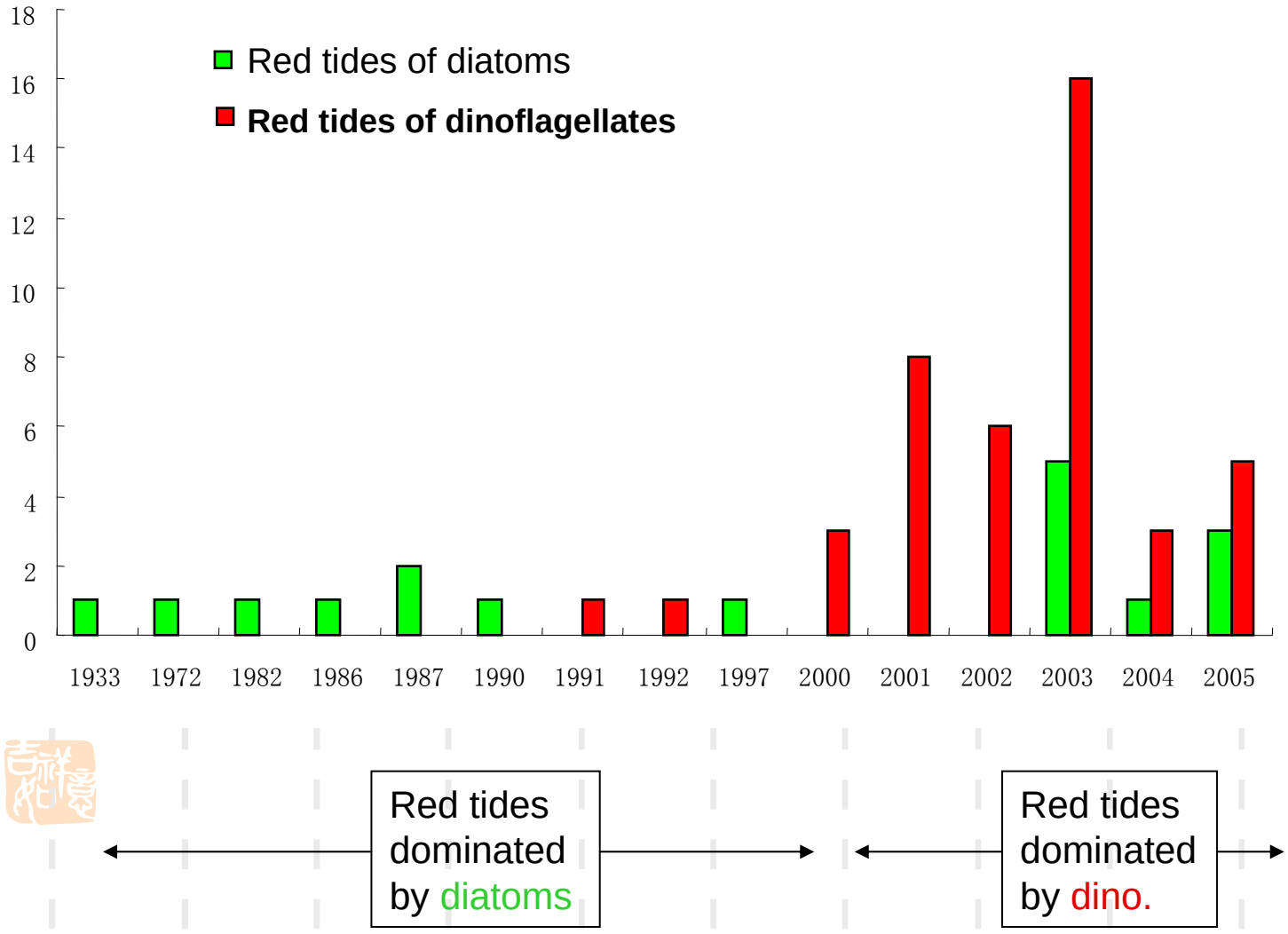
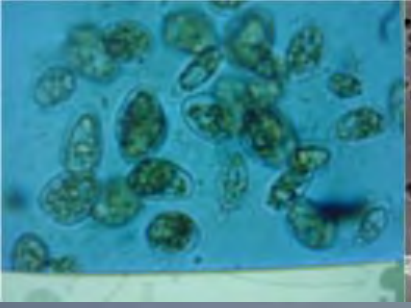
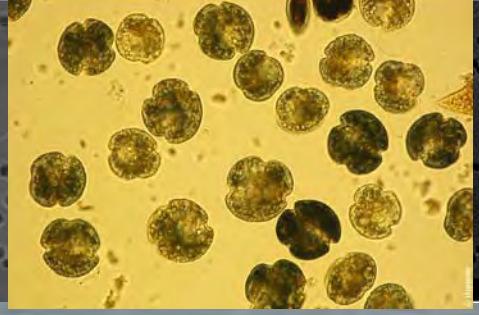


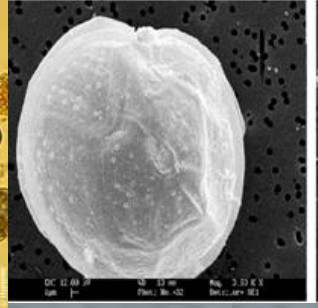
Figure 2. The trend in the purported HAB incidences from Korean side of the Yellow Sea. Here, identification of HABs was based on cell density (1,000 cells ml^{-1}).

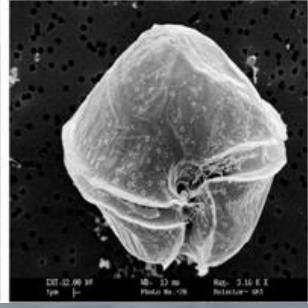
Records of red tides in the East China Sea





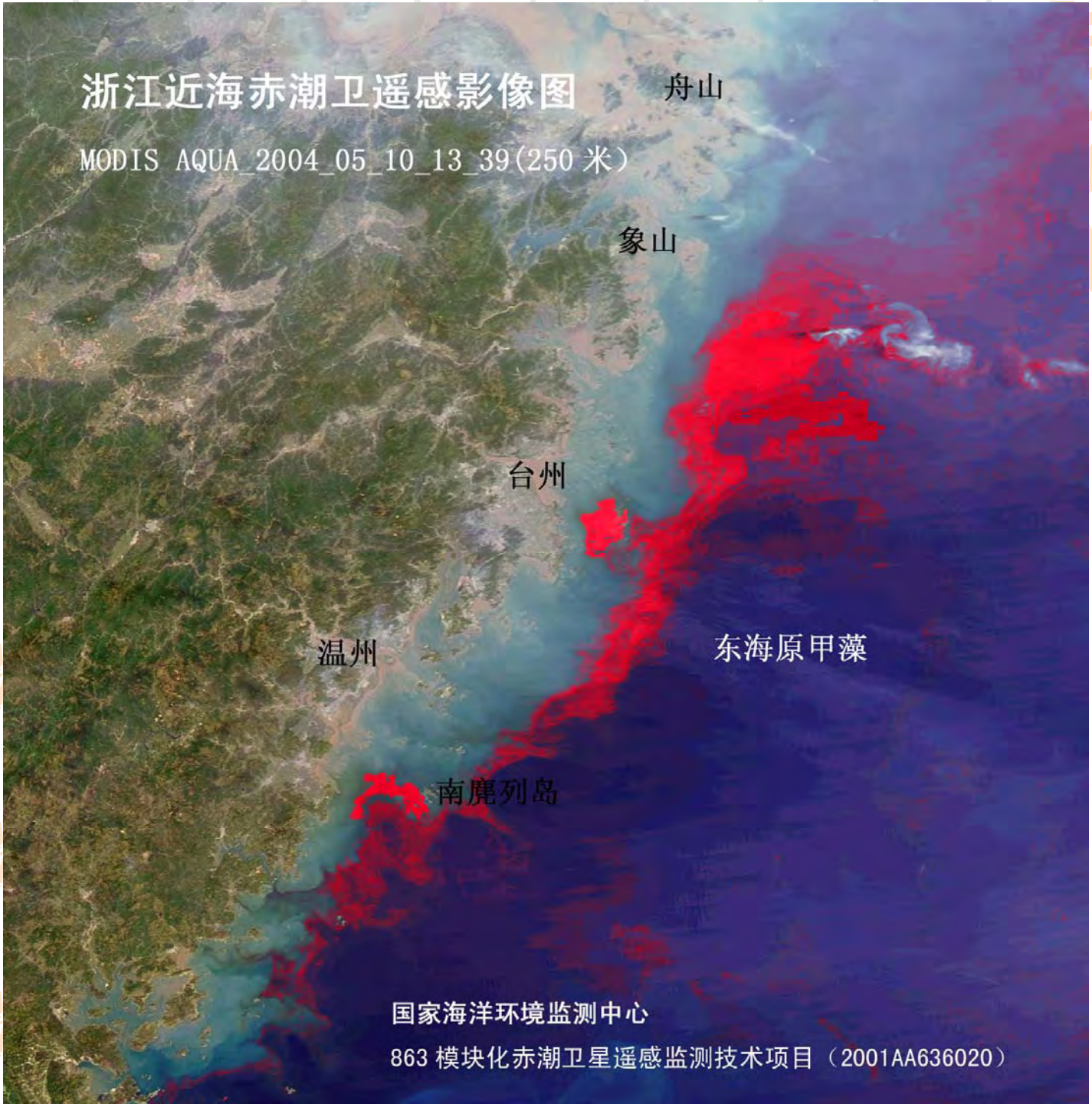




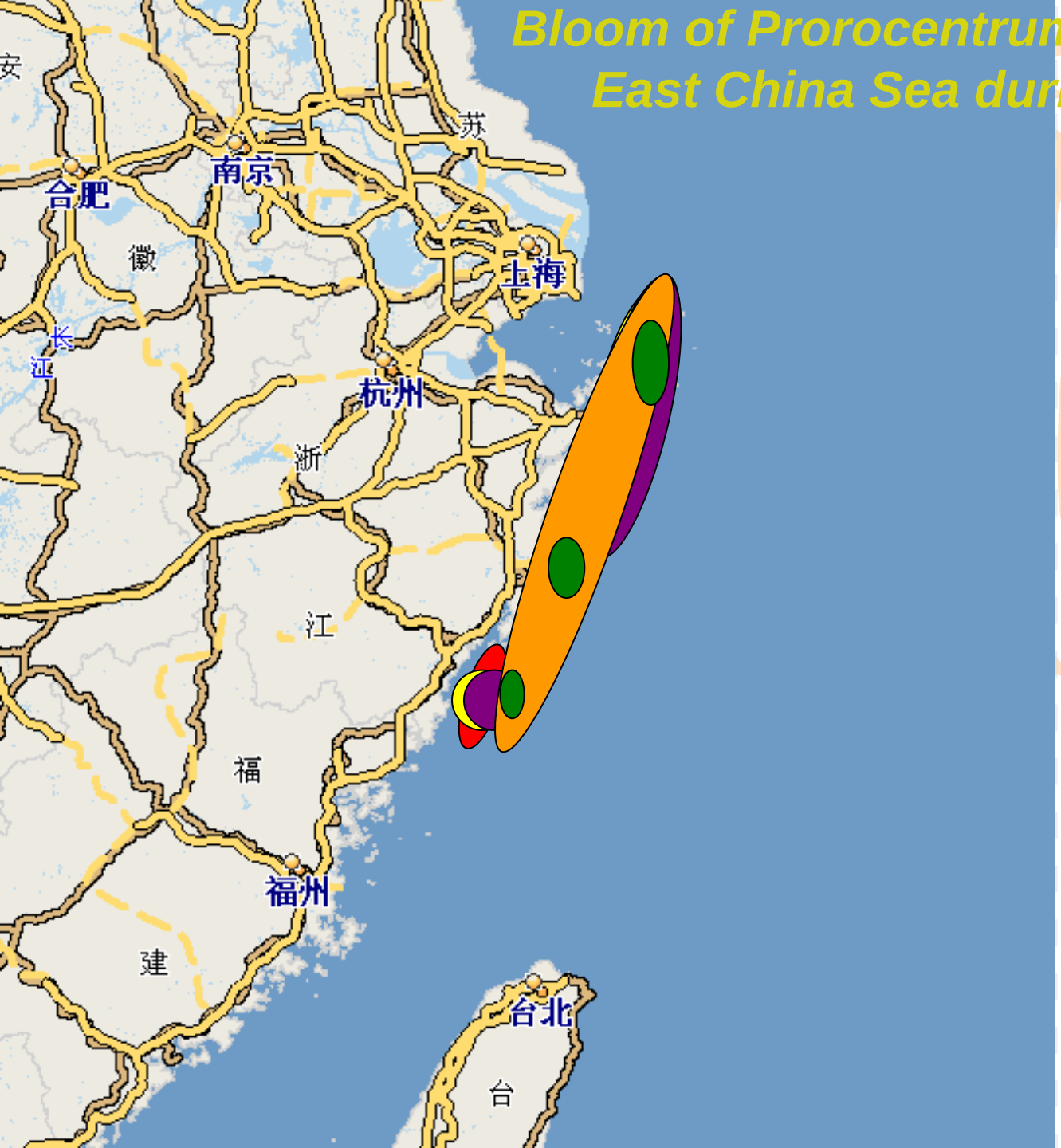


Prorocentrum donghaiense ***Karenia mikimotoi*** ***Alexandrium tamarense/catenatum***

Main dinoflagellates species for large scale HAB in East China Sea


浙江近海赤潮卫遥感影像图
MODIS AQUA_2004_05_10_13_39(250 米)
舟山
象山
台州
温州
东海原甲藻
南麂列岛
国家海洋环境监测中心
863 模块化赤潮卫星遥感监测技术项目（2001AA636020）

Bloom of Prorocentrum donghaiense in East China Sea during 2002-2006



2002年

2003年

2004年

2005年

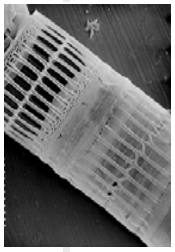
2006年

succession of HAB species:

"diatom→dinoflagellate→diatom"

Bloom of diatom → **Increase of Dino.** → **Bloom of dino.** → **diatom**

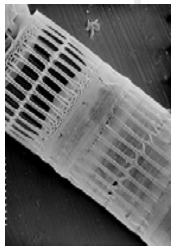
2002—2004:



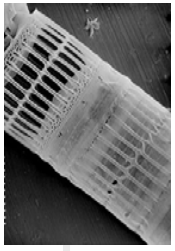
Early April

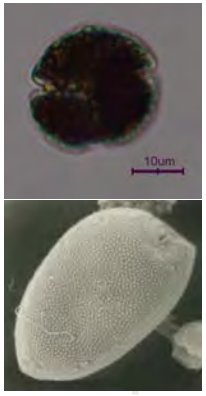
Large scale bloom of *Prorocentrum*

Early May-June

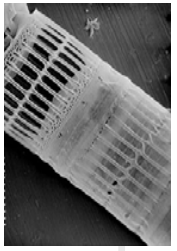


2005:





Large scale bloom of *Proro. & Karenia*

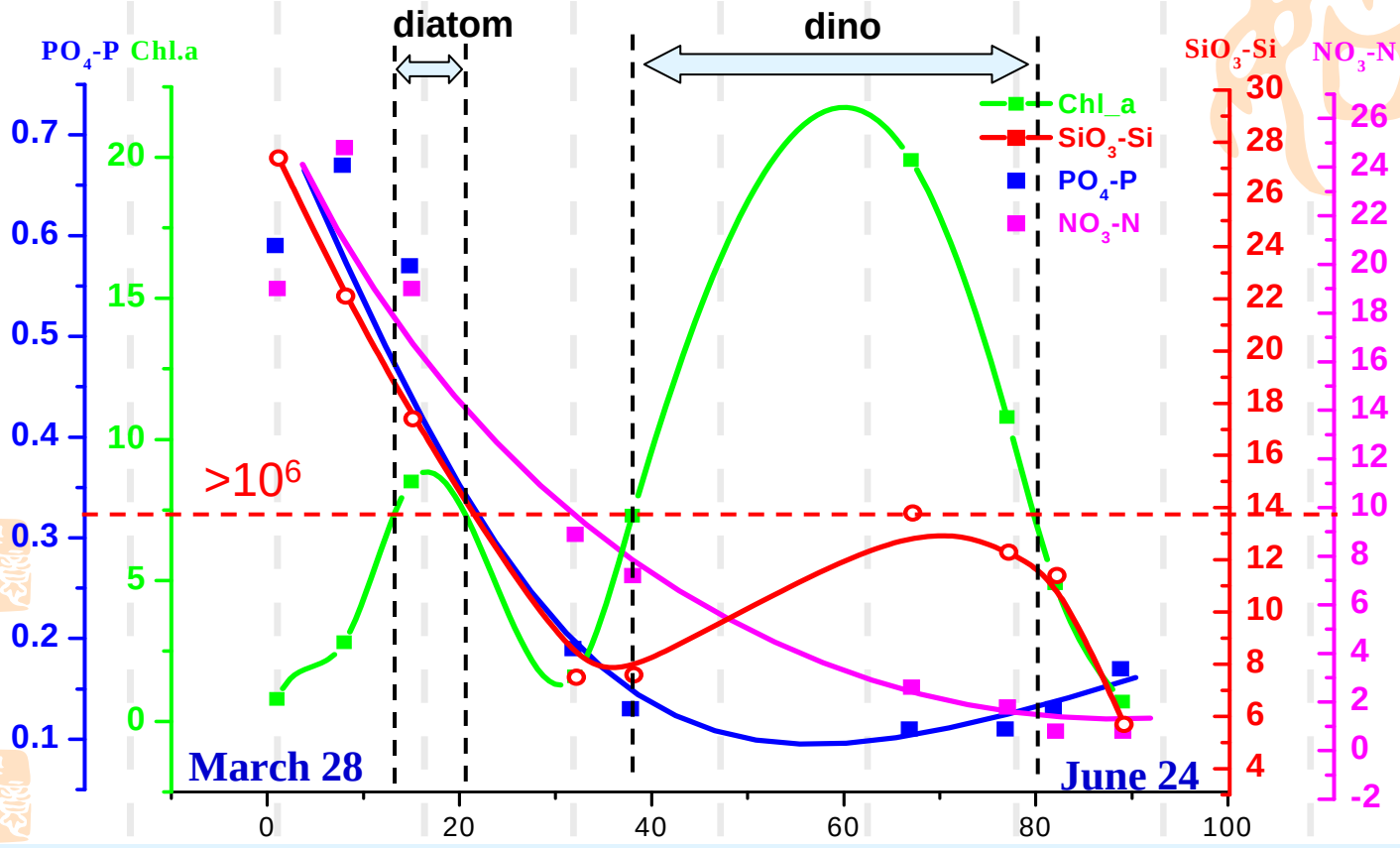


End of March early April

Early –middle of May

End of May to end of June

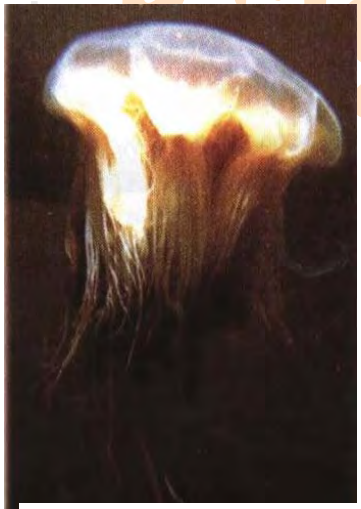
Change of nutrients during HAB process



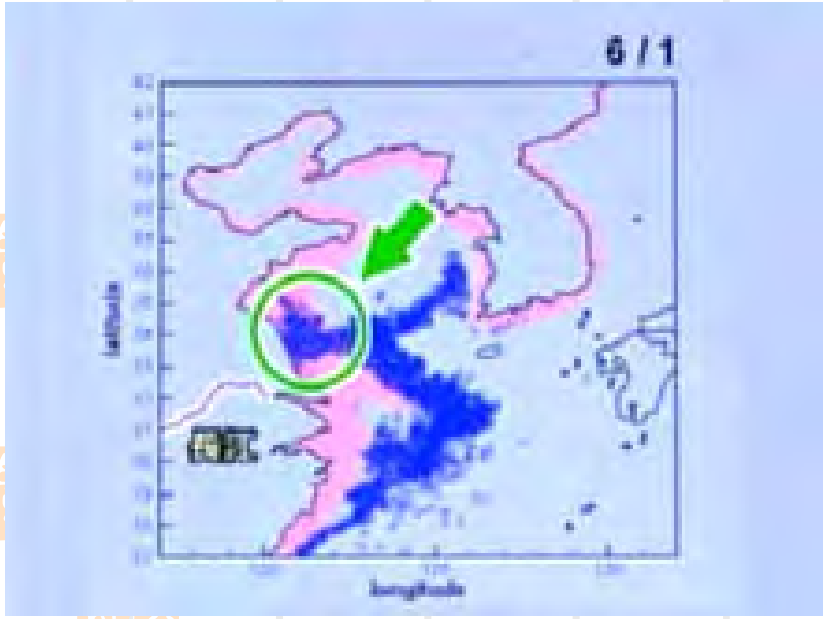
1. In March, Nutrients concentration are high, diatom bloom occurs ;
2. As decrease of nutrients, large scale dinoflagellate bloom occurs;
3. When NO_3-N concentration is lower than 1 μmol/L (some station lower than 0.1 μmol/L), HAB dispersed

Jellyfish Bloom

In recent years, bloom of *Cyanea nozakii* and *Stomolophus nomurai* occurred in Yellow Sea and East China Sea



Cyanea nozakii

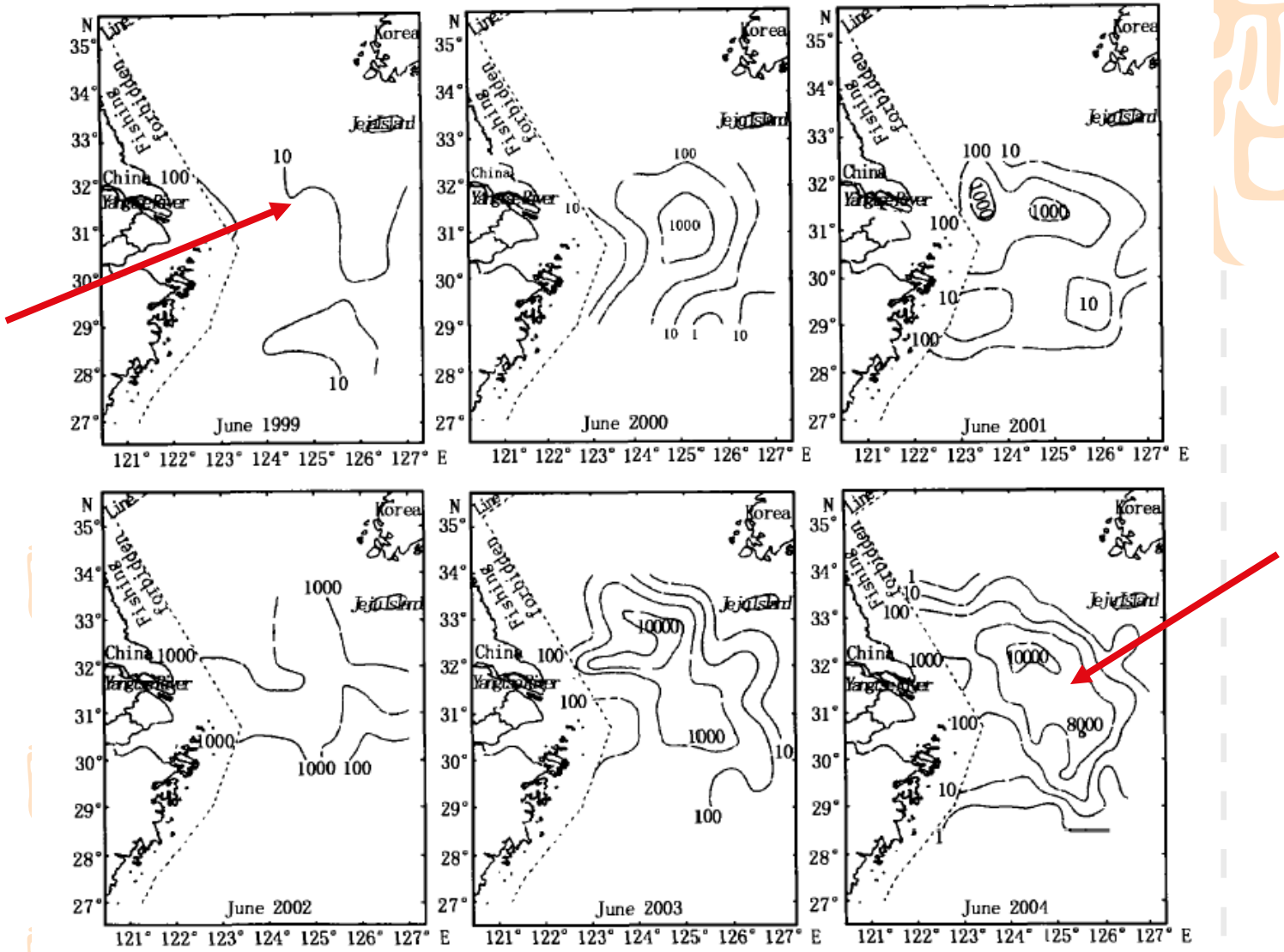


Stomolophus nomurai

Jellyfish bloom in coastal water of China

（From Song Sun）

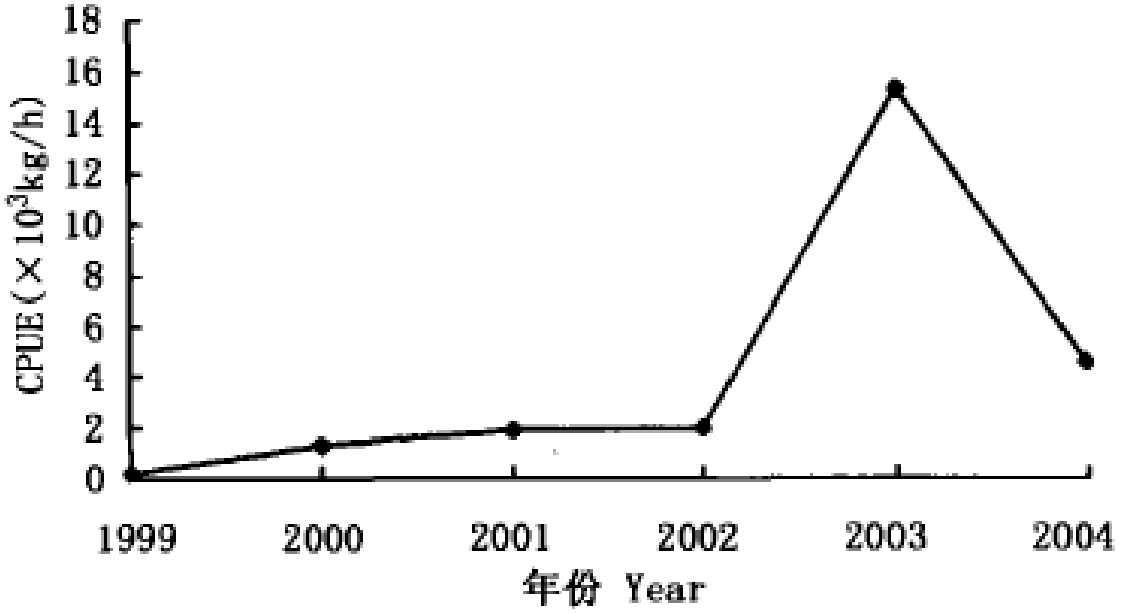
Jellyfish bloom in Yellow Sea and East China Sea in 2006



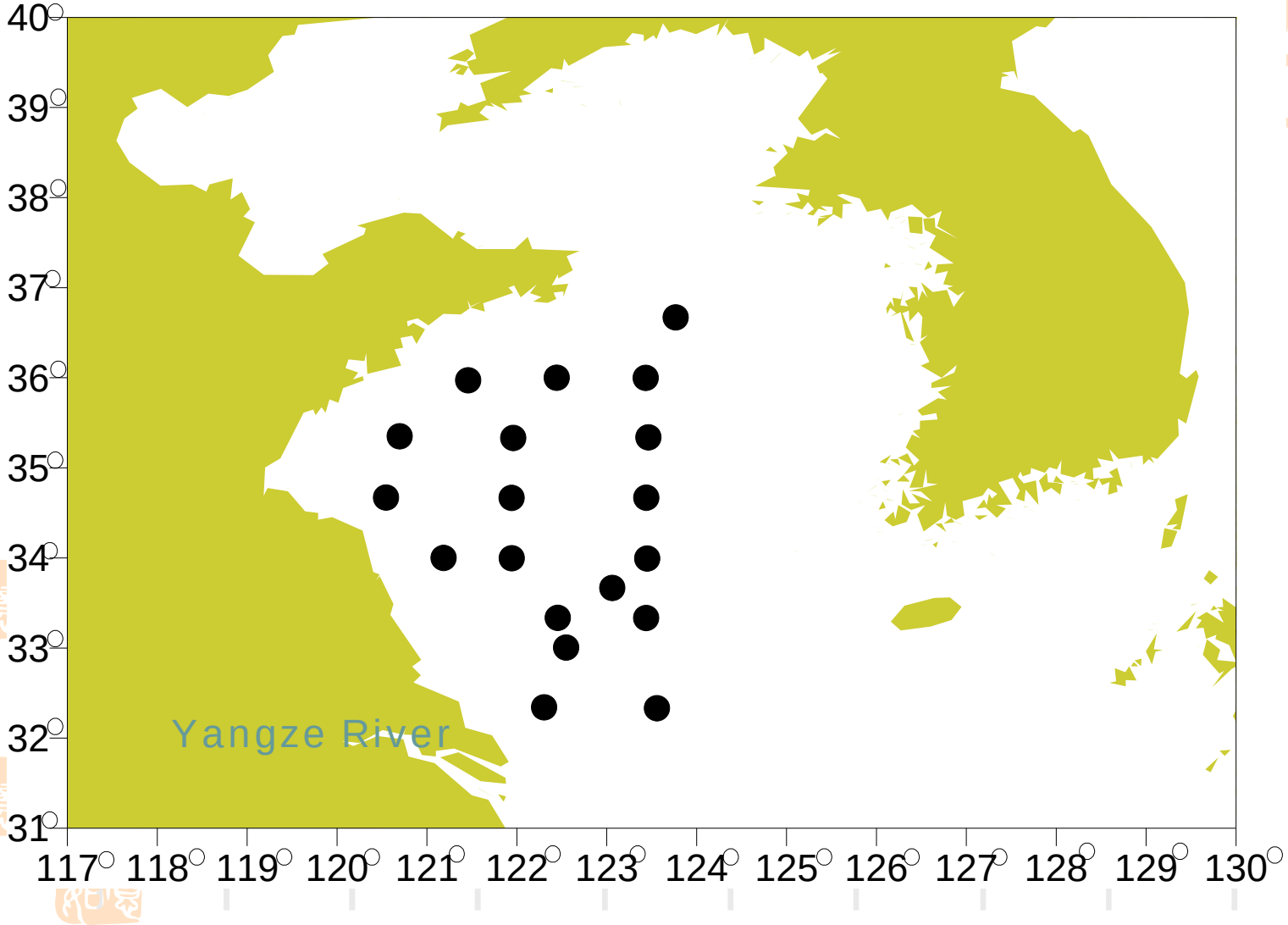
（F. Ding et al，2005）

Jellyfish abundance in Yellow Sea and East China Sea during 1999-2004

Dynamics of jellyfish biomass in the East China Sea



Changes of jellyfish biomass in the main jellyfish distribution area in summer

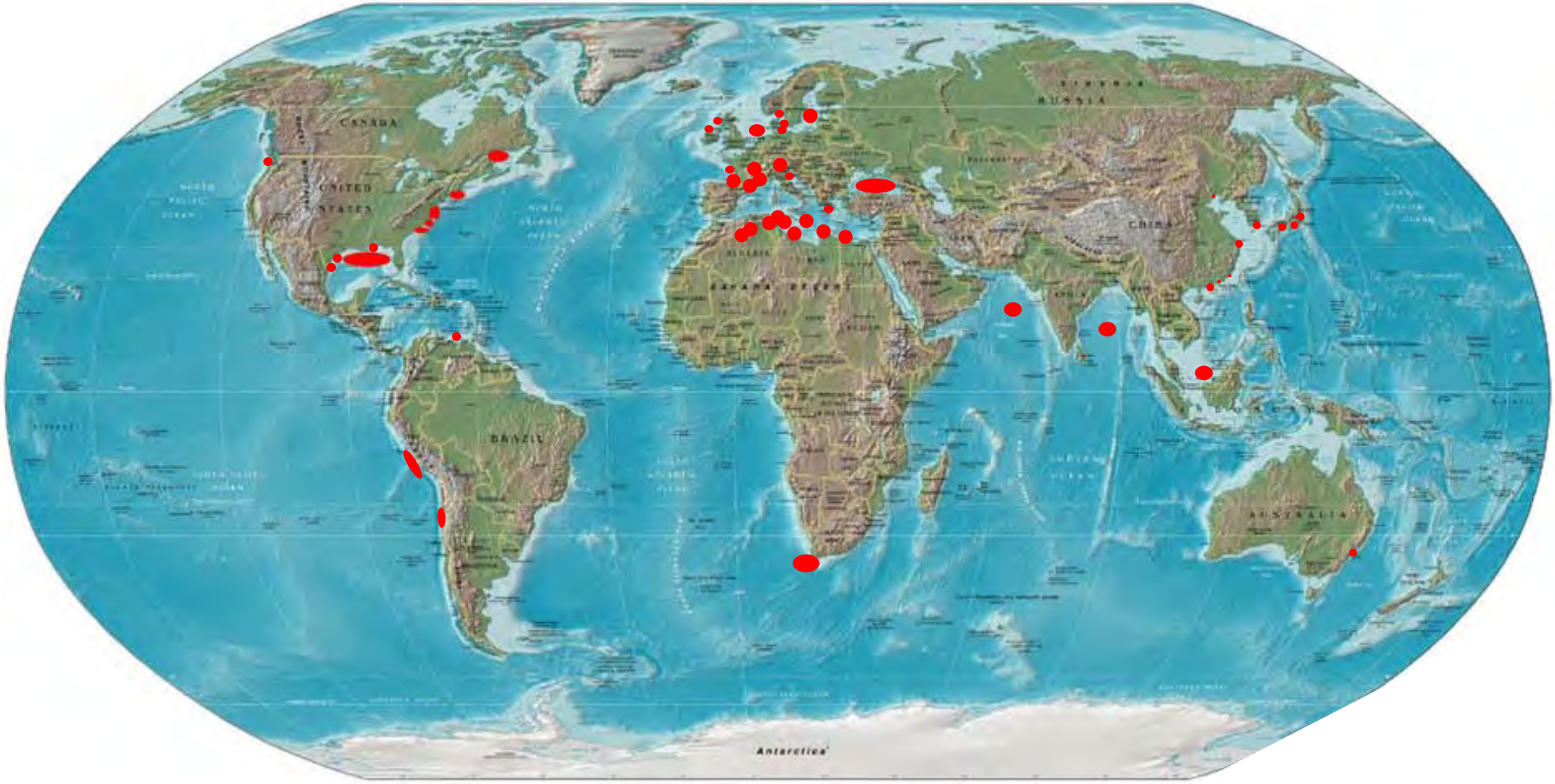


Stations jellyfish founded in summer of 2006

Biomass of jellyfish at summer cruise in2006

Total number of statins	0kg	<10kg	<100kg	<1000kg	>1000kg
23	2	2	3	5	11

Hypoxia



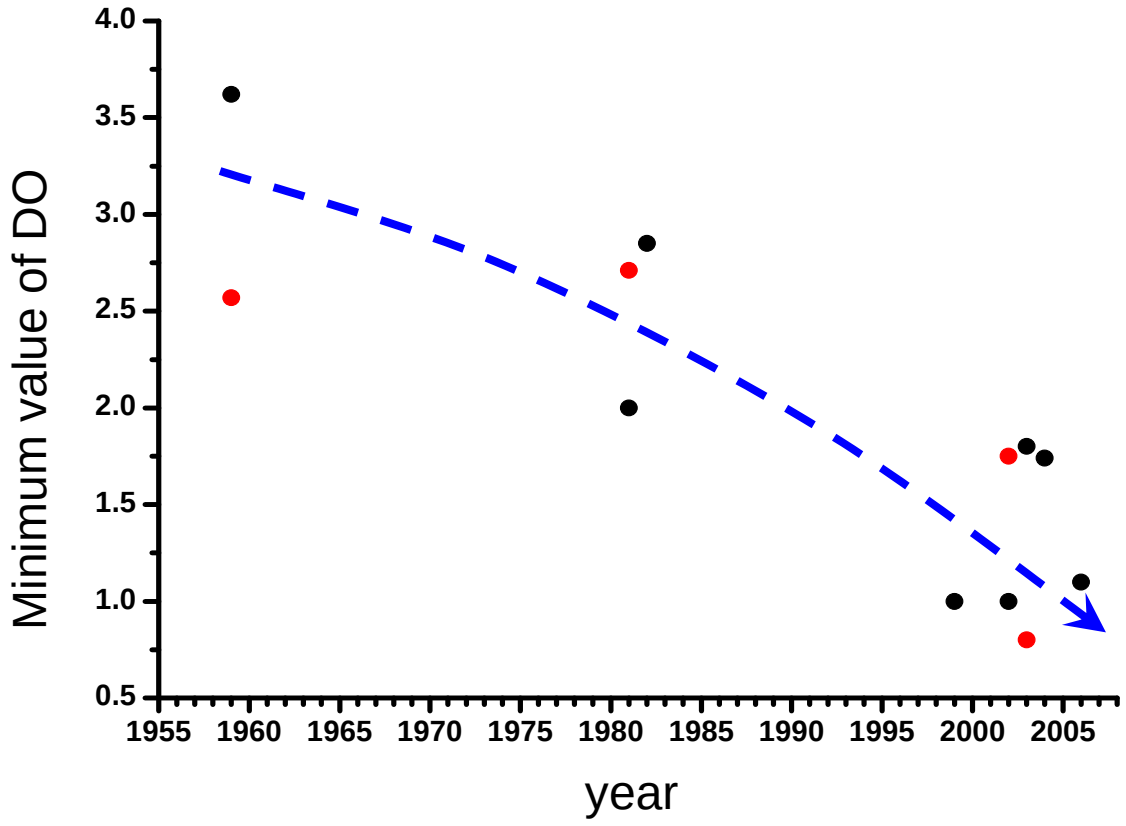
(From Z. Zhu)

Hypoxia area in the coastal water of the world

Figure 11 Hypoxy areas in the East China Sea.
(Source: Li & Zhang 2002)

Hypoxia in Estuary of Changjiang River

Variation of the minimum level of dissolved oxygen （DO） in the bottom layer in sea area off the Changjiang River Estuary



The Macroalgae Blooms in Yellow Sea in 2008

The green tides in the Yellow Sea

From end of May to August 2008, a large scale of green tides (macro algae blooms) broke out in the middle of Yellow Sea.

31 May, the first time of finding the green tides at the middle of Yellow Sea by flight monitoring.

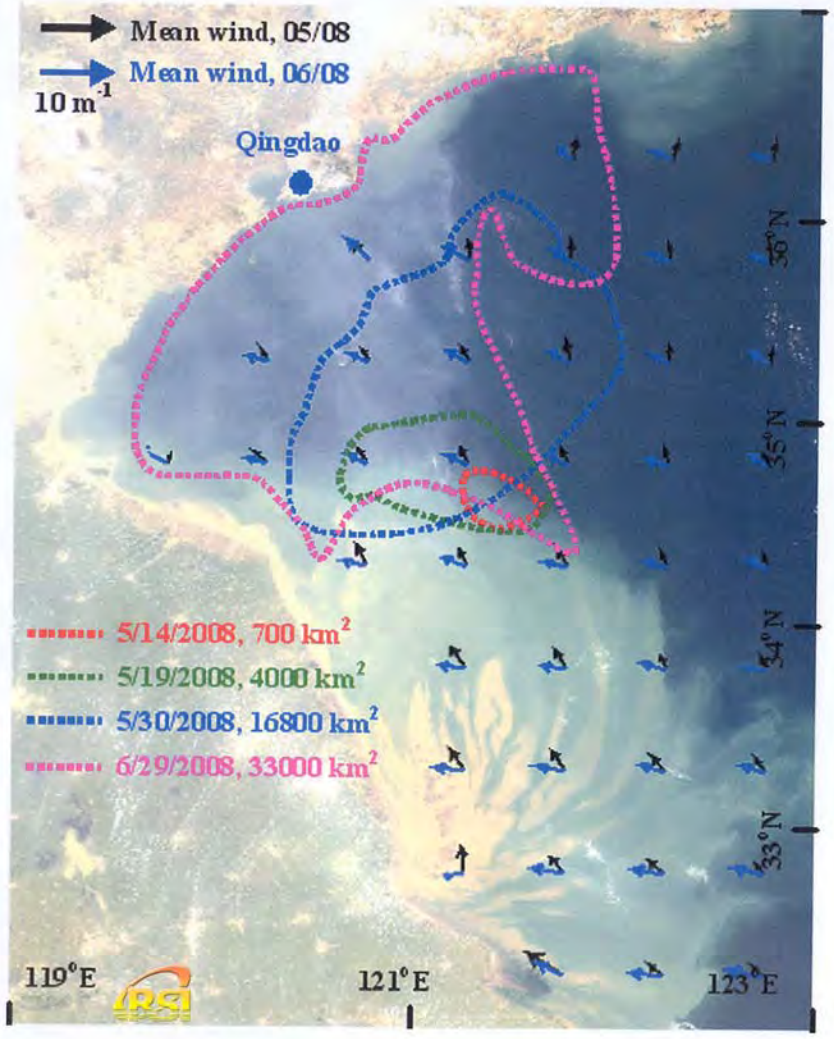
14 June, the green tides reached Qingdao coast and began to accumulate in seashore.

The affected area of the green tides is about 20,000km^2, with a covering area about 400 km^2.

Bloom in Coastal water of Qingdao City

From www.davegoblog.wordpress.com

The remote sensing results on development of green tide In Yellow Sea



The green tide in Qingdao coastal area is from south-west Yellow Sea , floated at sea surface, and accumulated in the coastal area of Qingdao.

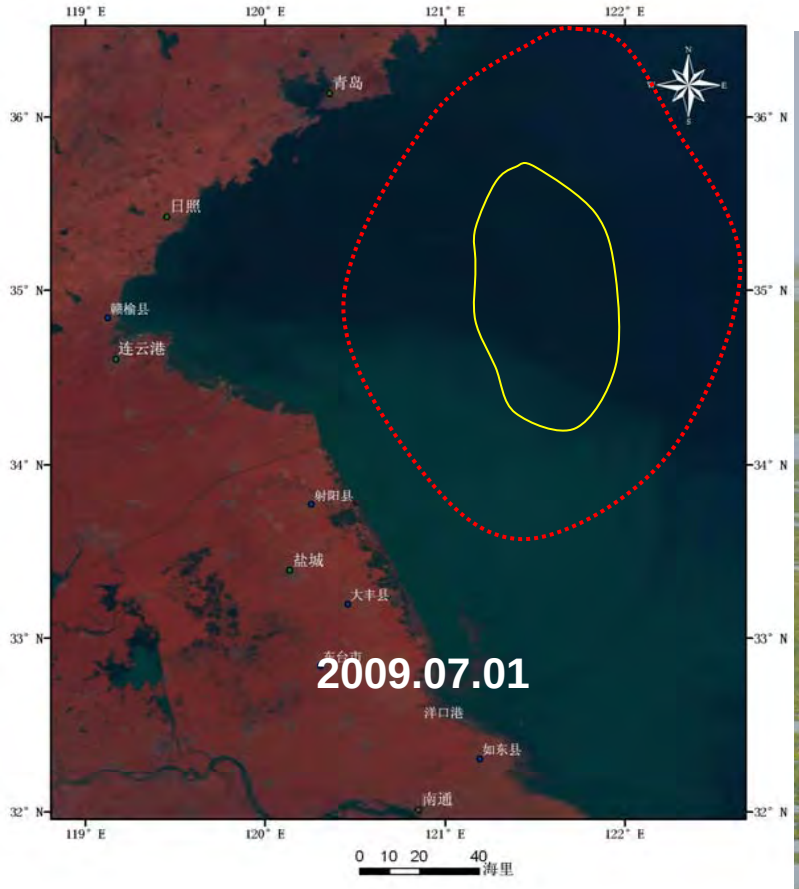
The left sketch map shows the development of the green tides based on remote sensing image.

The bloom species is *Enteromorpha prolifera*

Cultivated strain of Enteromorpha prolifera in lab

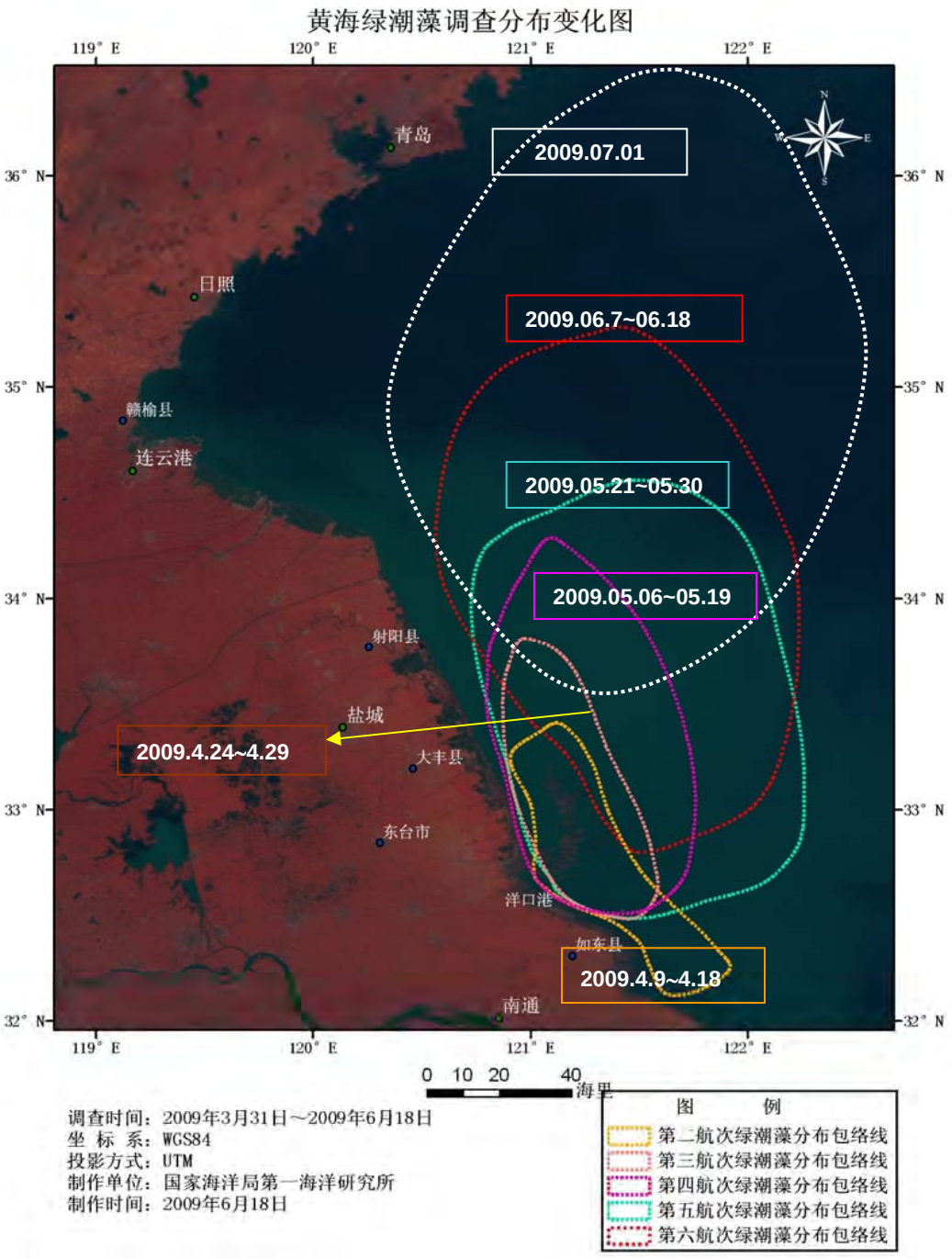
The bloom species is identified as *Enteromorpha prolifera*, but there are still some different opinions on taxonomy. Some people think that the dominant species should be *Enteromorpha linza*.

The development of green tide on July 1, 2009



漂浮藻生物量约 262000t

The development of green tide in 2009 during early April to early July



Sea Star

Sea Star Bloom

Empty shells of abalone and clam

Summary:

Multi-Stressors on Ecosystems of China Seas from both the climate change & anthropogenic activities are increasingly severe.

There are clear ecosystem changes, as evidenced in loss of biodiversity, decline in living marine resources, increasing HABs/Green Tides/Jellyfish blooms etc.

Further studies and management actions to reduce environment stresses are urgently needed.


Thank You