Ecosystem responses to anthropogenic activities and natural stressors in the East China and Yellow Seas

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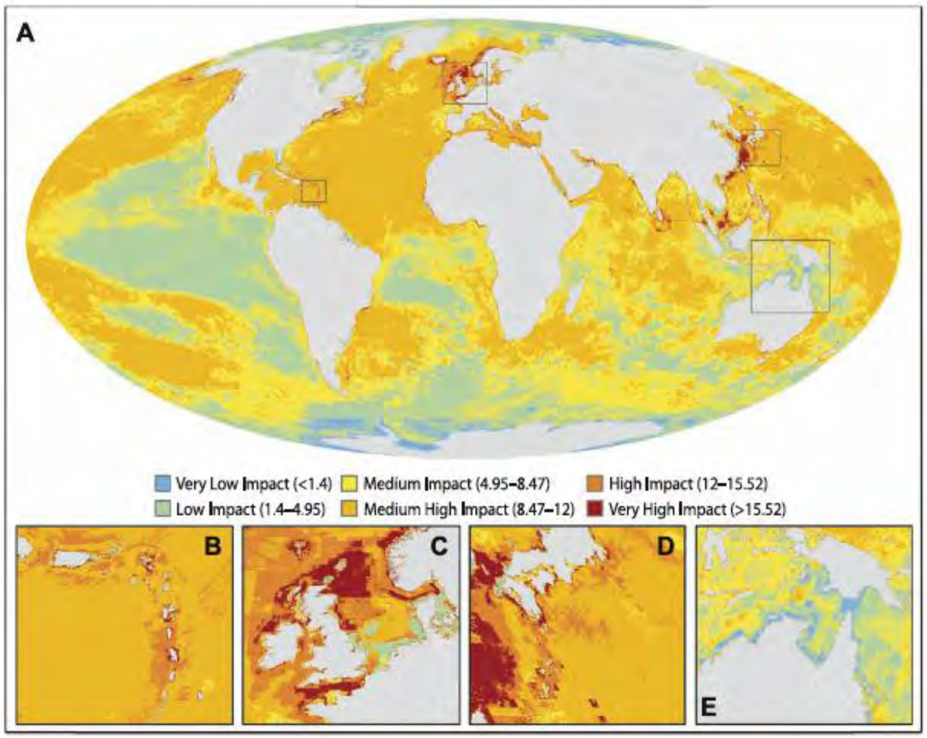
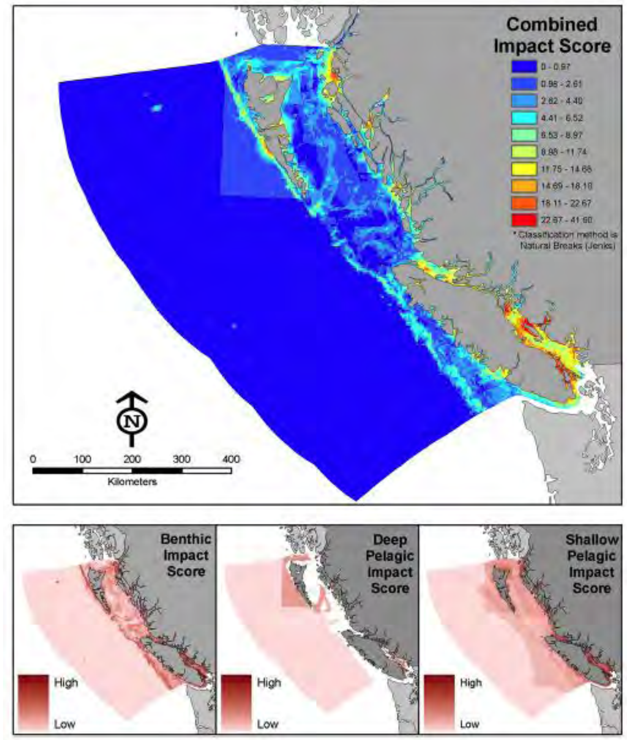
Background

Understanding cumulative impacts of multiple stressors is urgent issues for sustainable use of ecosystem serveices.



Halpern et al. (2008)

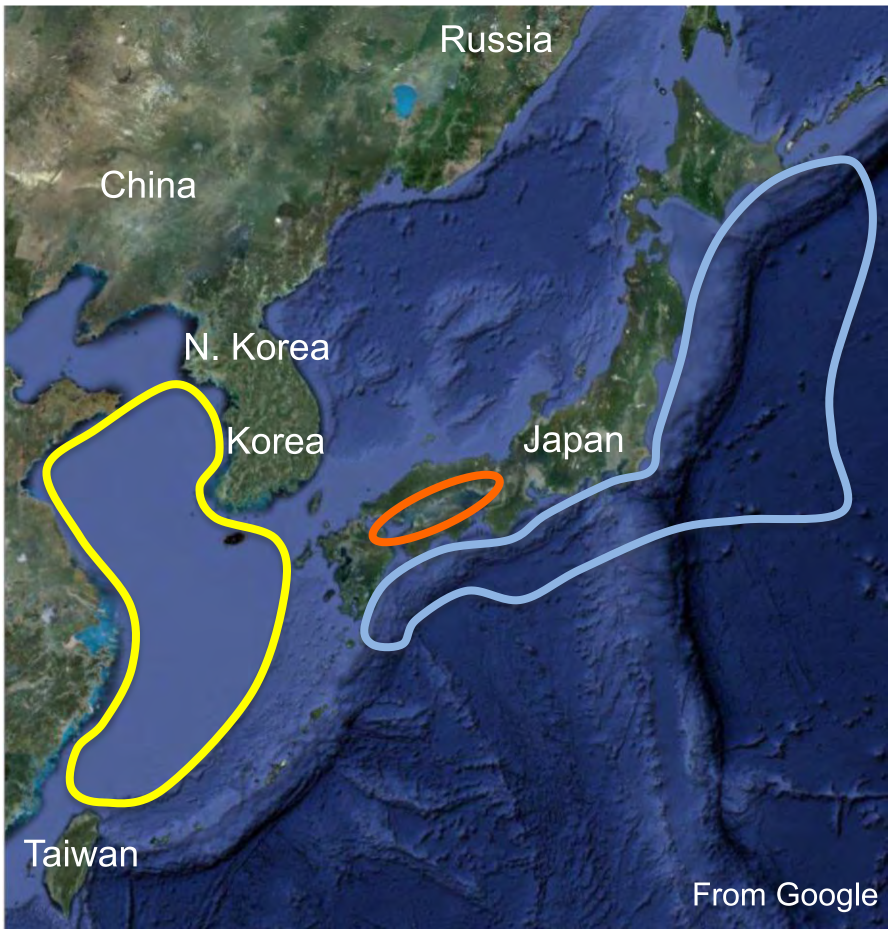


Ban et al. (2010)

PICES WG-28 has been trying to develop ecosystem indicators to characterize ecosystem responses to multiple stressors.

Comparative study on ecosystem responses to anthropogenic activities and natural stressors among inland, shelf and oceanic waters around Japan

Takahashi et al. (2012) at PICES S10



Shelf waters (4)
- East China Sea
- Yellow Sea

Inland waters (5)
- Seto Inland Sea

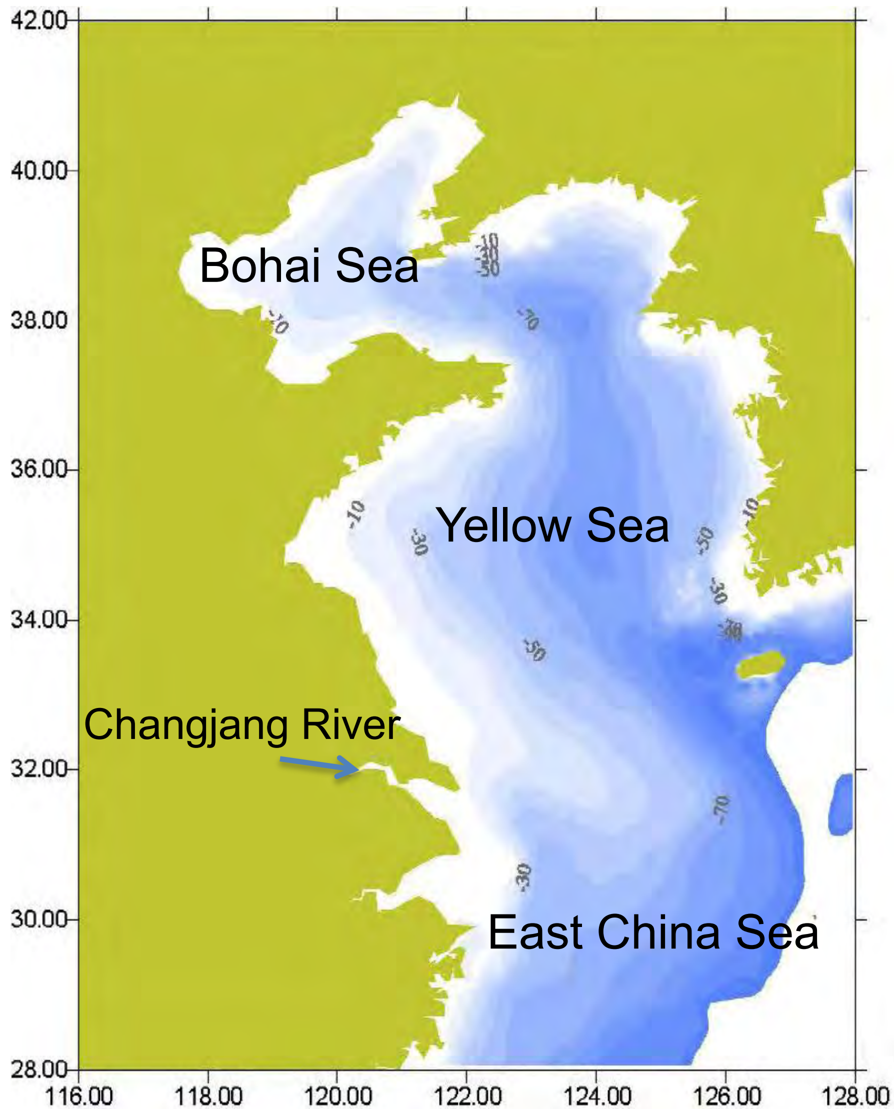
Oceanic waters (7)
- Kuroshio/Oyashio

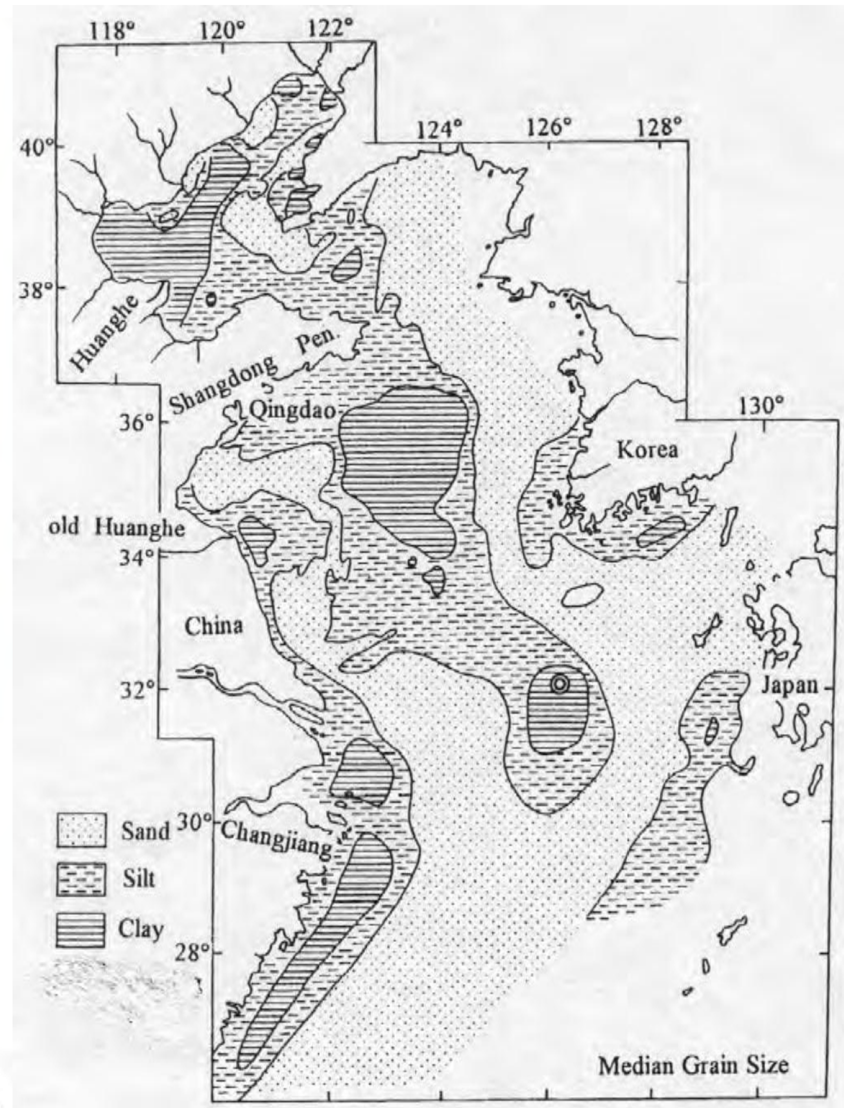
Ecosystem Changes under multi-stressors in the Yellow Sea

Mingyuan Zhu, Ruixiang Li and Zongling Wang
First Institute of Oceanography, State Oceanic Administration

Hiroshima, Oct. 19, 2012

Topography and sediments of the East China and Yellow Seas





Habitats-stressors matrix

Impacts of human activities and natural stressors were evaluated using the habitat-stressors matrix.

Human activities

Natural stressors

Activities/Stressors	**Intertidal**	**Coastal**	**Shelf**	**Oceanic**
1. Pollution from land	1. Rocky	1. Seagrass	1. Soft bottom	1. Soft bottom slope
2. Coastal engineering	2. Beach	2. Kelp forest	2. Hard bottom	2. Hard bottom slope
3. Coastal development	3. Mud	3. Rocky reef	3. Ice	3. Soft bottom benthic
4. Direct human impact	4. Salt marsh	4. Suspension feeder reef	4. Pelagic water column	4. Seamount
5. Ecotourism		5. Sub-tidal soft bottom		5. Vents
6. Commercial activity				6. Soft bottom canyon
7. Aquaculture				7. Hard bottom canyon
8. Fishing – demersal				8. Deep pelagic water column
9. Fishing – pelagic				9. Upper pelagic water column
10. Fishing – illegal				
11. Offshore development				
12. Pollution from ocean				
13. Freshwater input				
14. Sediment input				
15. Nutrient input				
16. HABs				
17. Hypoxia				
18. Species invasion				
19. Sea level change				
20. Sea temperature				

Modified from Halpern et al. (2007)

Scoring vulnerabilities

For each cell, vulnerabilities were scored as spatial scale, frequency, functional impact, resistance, recovery time.

Weak ⟺ Strong

Vulnerabilities	**1**	**2**	**3**	**4**
Spatial scale	< 10 km^2	10-100 km^2	100-1000 km^2	> 1000 km^2
Frequency	> 5 yrs	1-5 yrs	Seasonal	Continuous
Functional impact	Species	Single trophic	Multitrophic	Community
Resistance	Positive impact	High	Moderate	Low
Recovery time	< 1 yr	1-10 yrs	10-100 yrs	> 100 yrs

For each vulnerability, certainty was scored as 4 levels.

Unsure ⟺ Sure

	1	**2**	**3**	**4**
Certainty	< 15 %	15–50 %	50–85 %	> 85 %

How to treat scores

Impacts (*I*) of stressors were evaluated using the weighted mean vulnerability (*v*) with certainty (*c*).

$$I = \sum v \cdot c \,/\, C_{total}$$

Habitat	Sub-habitat	Activity/Stressor	Spatial scale		Frequency		Trophic impact		Resistance to change		Recovery time		Impact: *I*
			v	*c*	*v*	*c*	*v*	*c*	*v*	*c*	*v*	*c*	
INTERTIDAL	beach	Fishing - pelagic	2	2	3	2	2	2	2	2	2	2	**2.10**
COASTAL	sub-tidal soft bottom	Nutrient inputs	2	2	2	2	2	2	2	2	2	2	**2.00**
COASTAL	sub-tidal soft bottom	Coastal engineering	3	4	3	4	4	3	4	4	3	3	**3.11**
SHELF	soft bottom	Freshwater input	4	3	3	3	3	3	3	2	3	2	**3.00**
SHELF	soft bottom	Sediment input	3	3	4	3	3	2	2	2	2	2	**2.50**
SHELF	soft bottom	Nutrient inputs	3	3	4	3	3	3	2	3	3	2	**2.64**
SHELF	soft bottom	Polution from land	3	3	4	3	3	3	3	3	3	2	**2.86**
SHELF	soft bottom	Fishing - demersal	4	3	4	3	4	3	4	3	3	3	**3.47**
SHELF	soft bottom	Fishing - pelagic	3	3	4	3	2	3	3	3	3	3	**2.67**
SHELF	soft bottom	Sea temperature	4	4	4	4	4	4	3	3	3	3	**3.22**
SHELF	soft bottom	HABs	2	3	3	3	3	3	3	3	3	3	**2.60**
SHELF	soft bottom	Hypoxia	2	2	3	2	3	3	4	2	3	2	**2.91**
SHELF	soft bottom	Offshore development	1	3	2	2	3	3	3	2	2	2	**2.17**
OCEANIC	soft bottom slope	Sea temperature	4	4	4	4	4	4	3	3	3	3	**3.22**

Vulnerability scores

≦ 2.0 | 2.1-2.5 | 2.6-3.0 | 3.1-3.5

Activities/Stressors	Intertidal				Coastal				Shelf	
	Rocky	Mud	Salt marsh	Beach	Sea grass	Rocky reef	Suspention feeder reef	Sub-titdal soft bottom	Soft bottom	Pelagic water column
1. Pollution from land	2.8	2.8	2.5	2.5	2.5	2.8	2.5	2.8	2.9	2.9
2. Coastal engineering	3.5	3.5	3.3	3.3	3.3	3.5	3.3	3.3		
3. Coastal development	3.5	3.5	3.3	3.3	3.3	3.5	3.3	3.5		
8. Fishing - demersal									3.5	
9. Fishing - pelagic				2.1						3.1
11. Offshore development									2.1	
12. Pollution from ocean									3.1	3.1
13. Freshwater input	2.9	2.9	2.6	2.6	2.9	2.9	2.9	2.9	3.0	3.0
14. Sediment input									2.5	
15. Nutrient input	3.1	3.1	2.8	2.8	2.8	3.1	2.8	2.5	3.0	3.3
16. HABs									2.6	2.9
17. Hypoxia									3.2	
18. Species invasion	2.5	2.5	2.3	2.3	2.3	2.5	2.3	2.5		2.9
20. Sea temperature									3.2	3.2

1. Coastal development strongly affects to the intertidal and coastal waters.
2. Pollution from land and nutrient input impact through intertidal to shelf waters.
3. Fishing and increasing temperature affects strongly to the shelf waters.

Trends of pollutant contaminants in bivalves in the Yellow Sea during 1997-2006

Coastal Area	Oil	THg	Cd	Pb	As	DDT	PCBs
Water near Dalian	↘	↗	–	–	↗	–	
Water near Yantai	⇔	↘	⇔	-	↘	↘	–
Water near Qingdao	↘	–	↘	↘	↘	↗	–
Water in north Jiangsu	⇔	–	↘	↘	↘	⇔	–
Water near Nantong	⇔	–	↘	↘	↘	↘	⇔
Changjiang Estuary	↘	–	↘	↗	–	⇔	⇔

↗ significantly increasing; ↗ increasing; – slightly increasing; ⇔ no change

- slightly decreasing; ↘ decreasing; ↘ significantly decreasing; no enough data

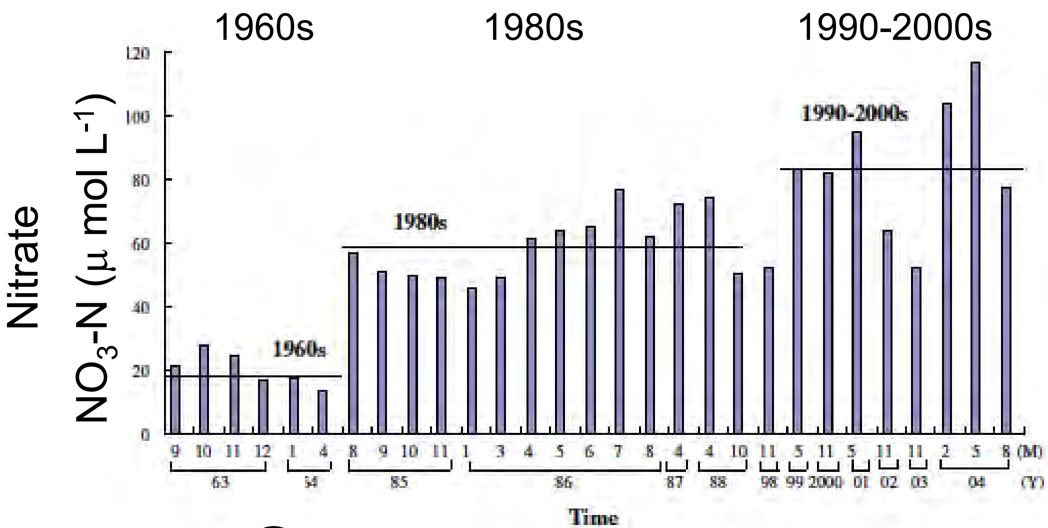
Contamination of mercury, cadmium, arsenic and DDT in bivalves increases along the coast line of Yellow Sea.

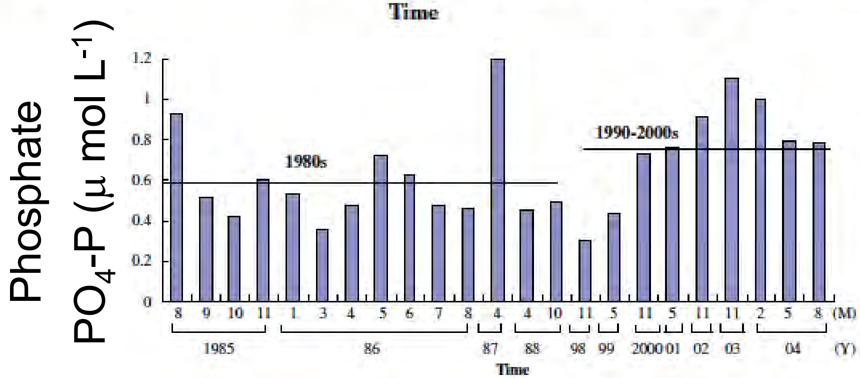
Reclamation in the Yellow Sea

Jiangsu Province

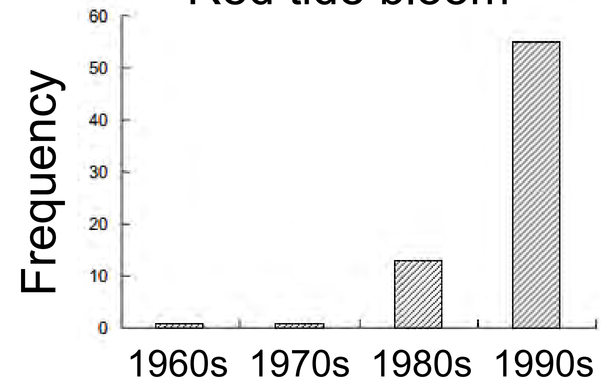
- Presently, over 5000 km^2 coastal wetlands, about one-fourth of China's total.
- Over 1300 km^2 coastal wetlands reclaimed over the past 15 years
- Plans to reclaim another 1800 km^2 by 2020

Nutrient increase and harmful algal bloom off the Changjang Estuary

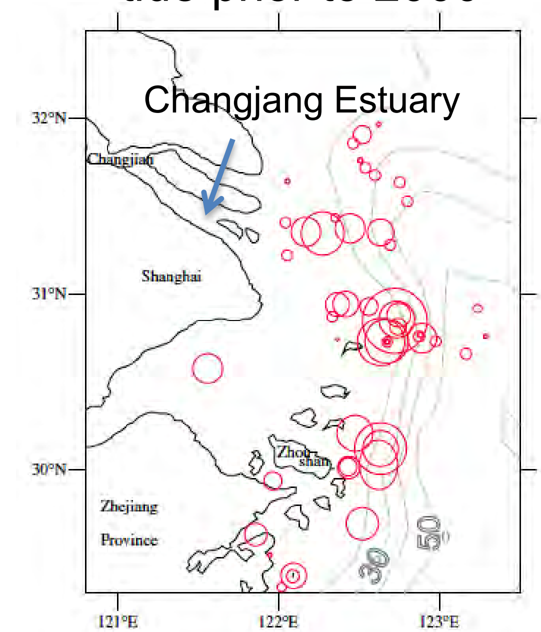




Red tide bloom



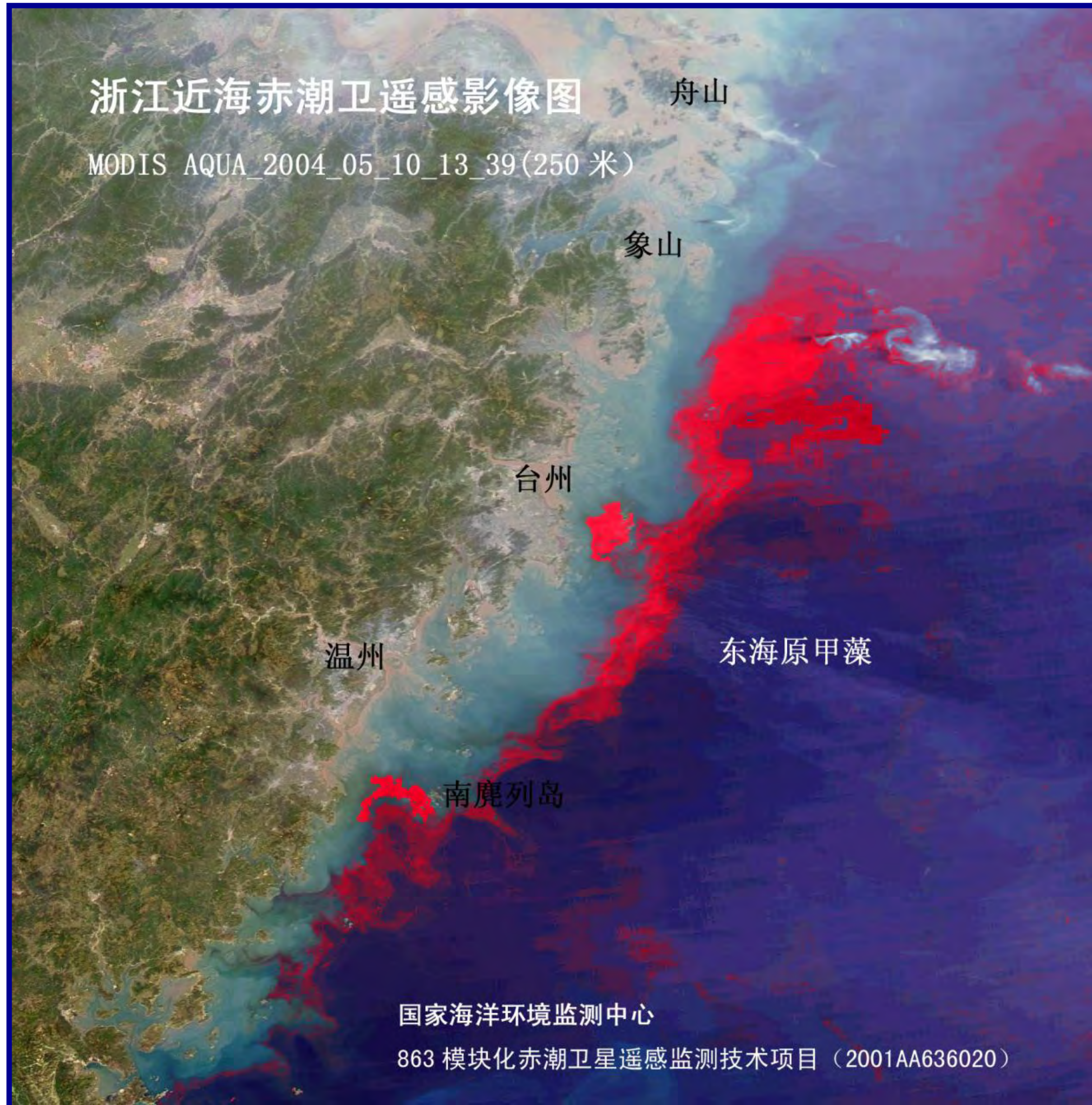
Occurrence of red tide prior to 2000



Frequency of red tide bloom increased with the increase in nutrient input after 1980s off the Changjang Estuary.

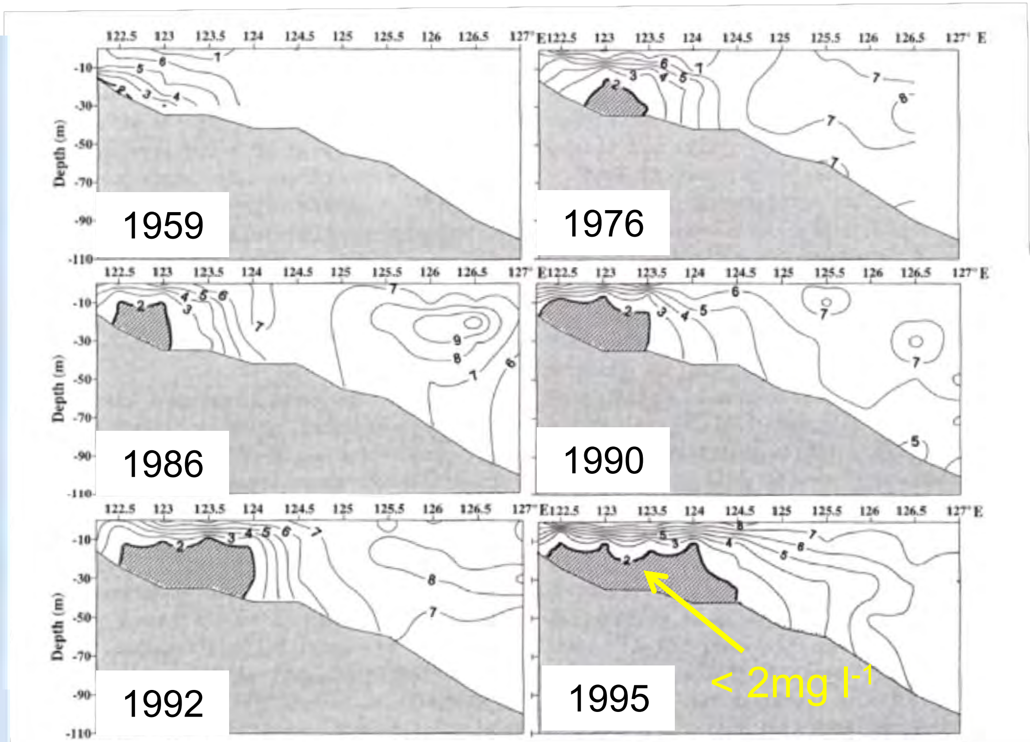
Zhou et al. (2008)

Satellite images of harmful algal bloom



Hypoxia: dissolved oxygen off the Changjang Estuary in summer

Li and Zhang (2002)

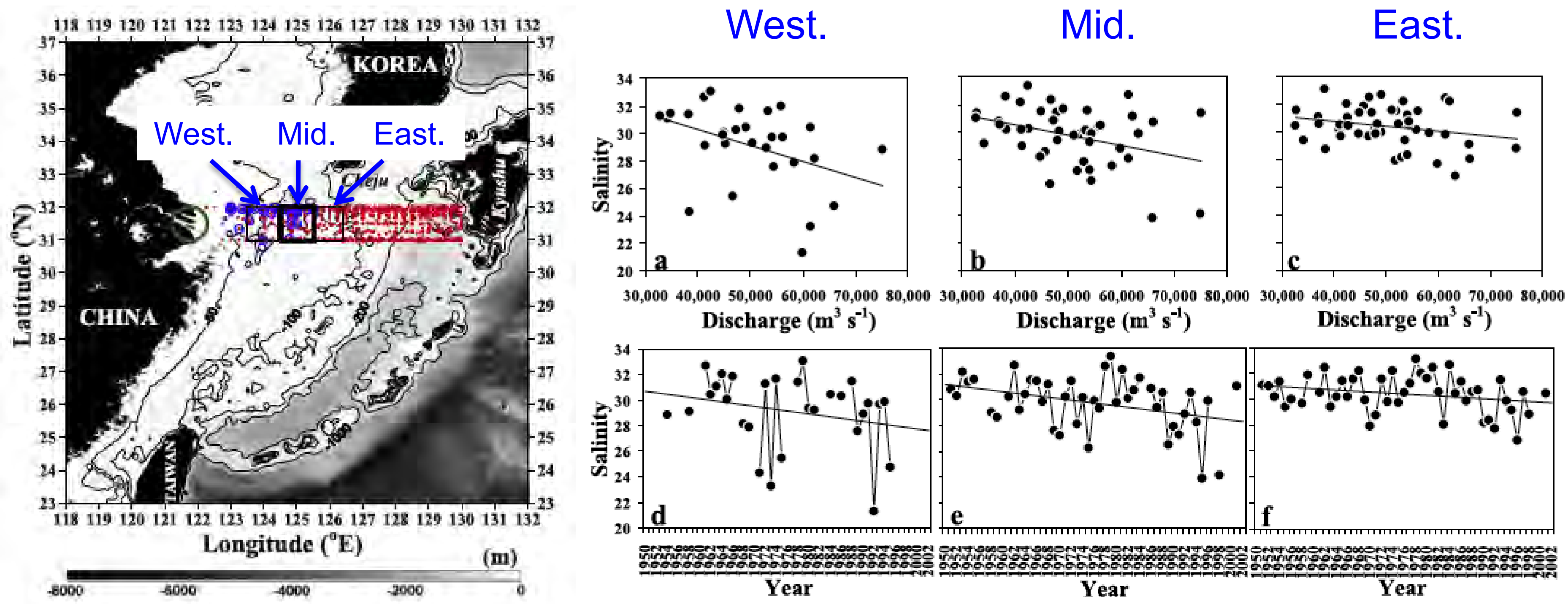


Ning et al. (2011)

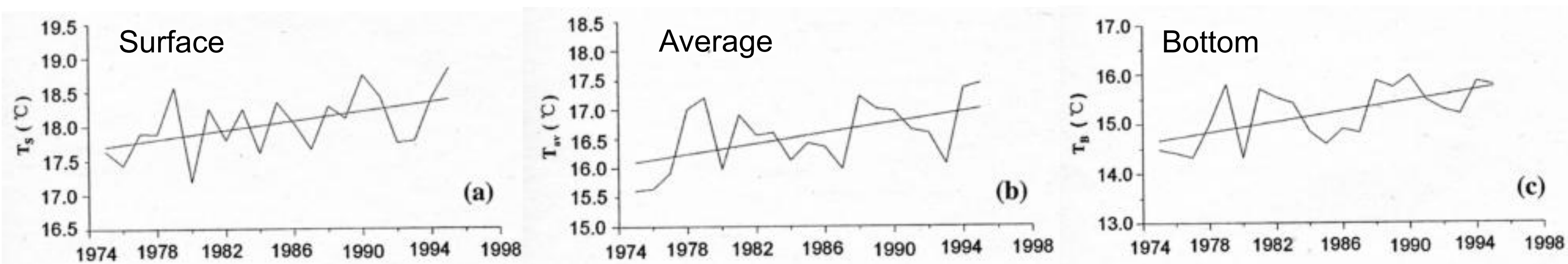
Potential causes –

- Strong stratification in summer
- Phytoplankton bloom
- Taiwan Warm Current

Warming and freshening in the East China Sea

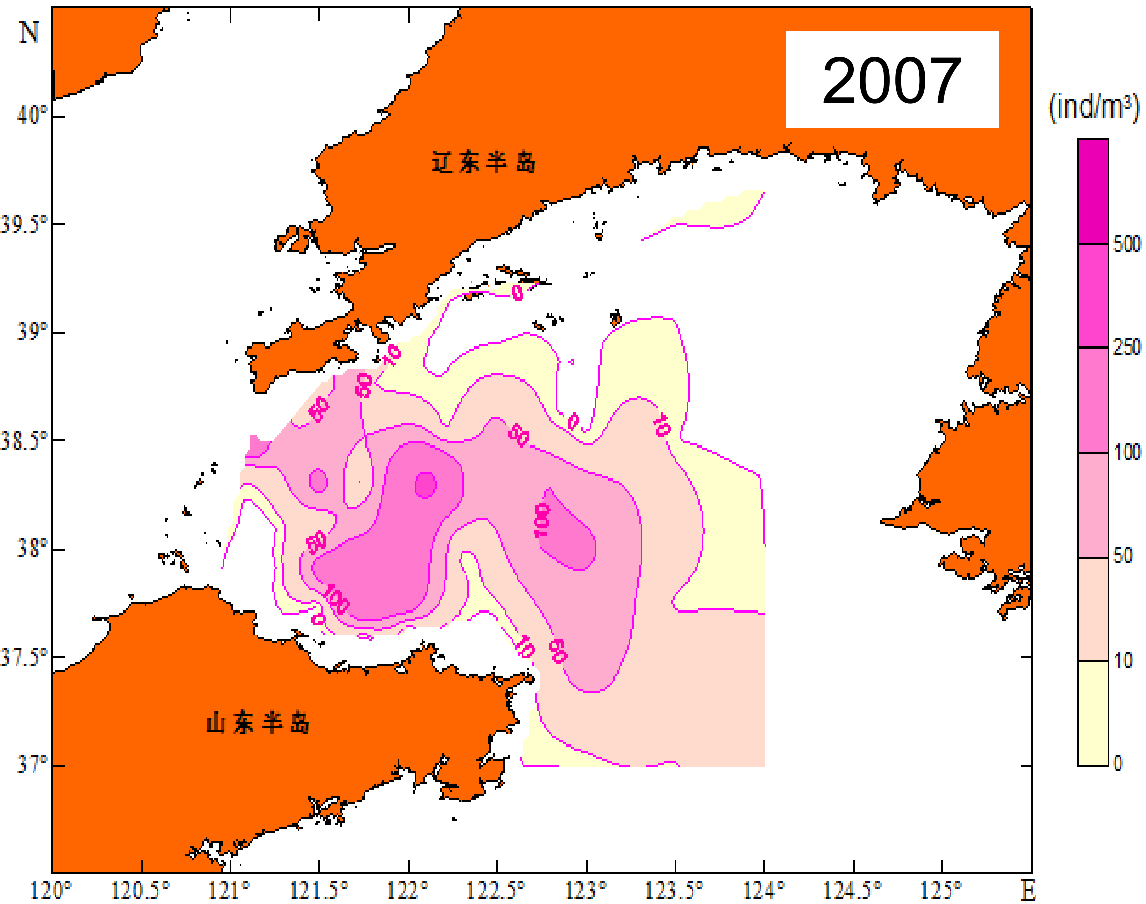


Surface salinity decreased during 1950 – 2002. Siswanto et al. (2008)

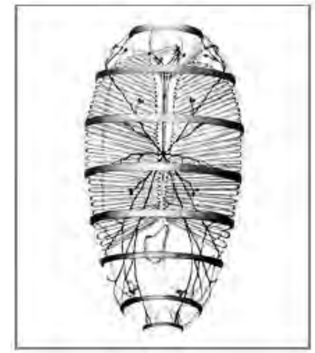


Temperature increased during 1975 – 1995. Ning et al. (2011)

Warm water tunicate moving north



- ***Doliolum denticulatum***

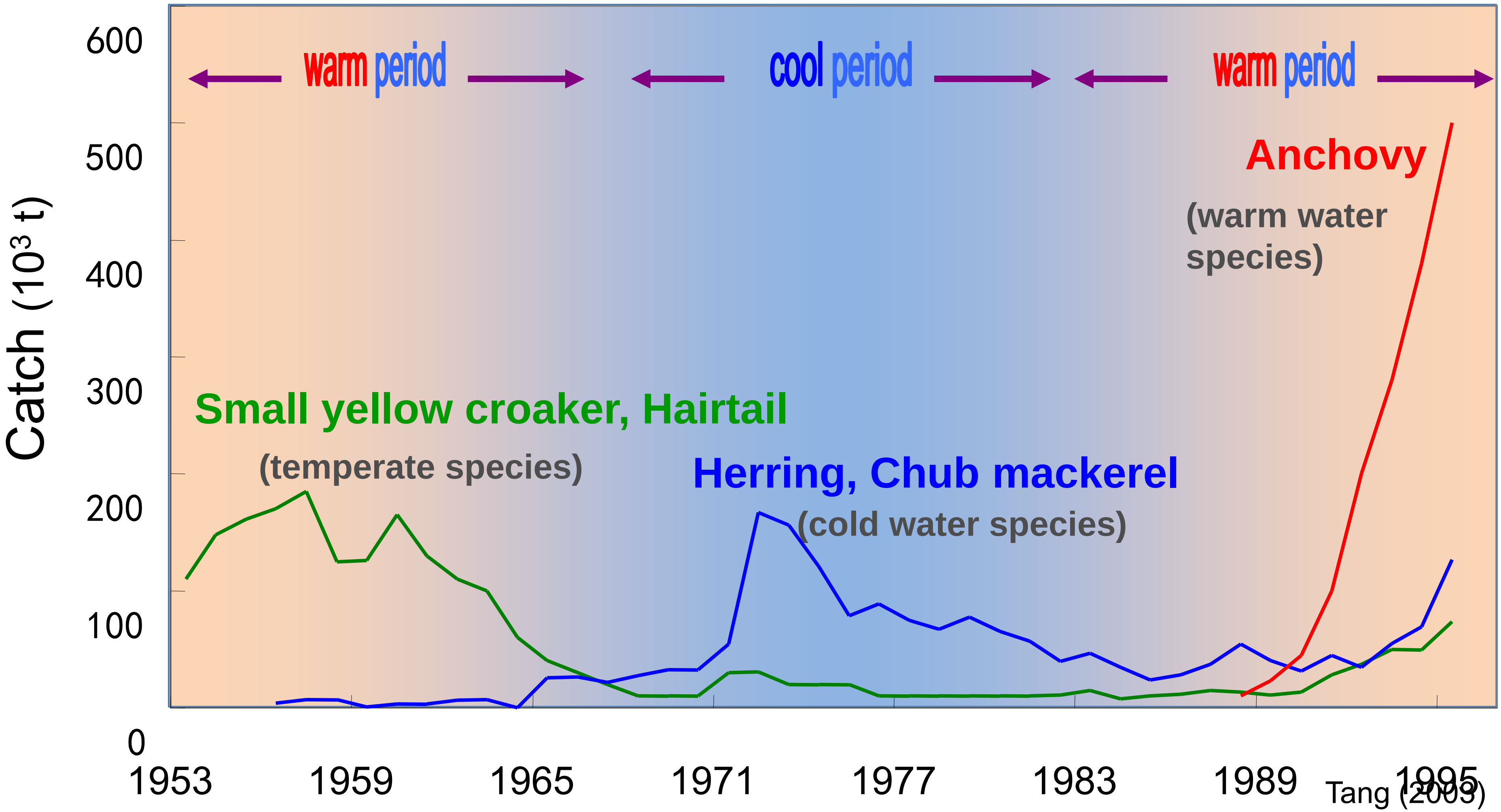


From Marine Species identification portal

a warm water species

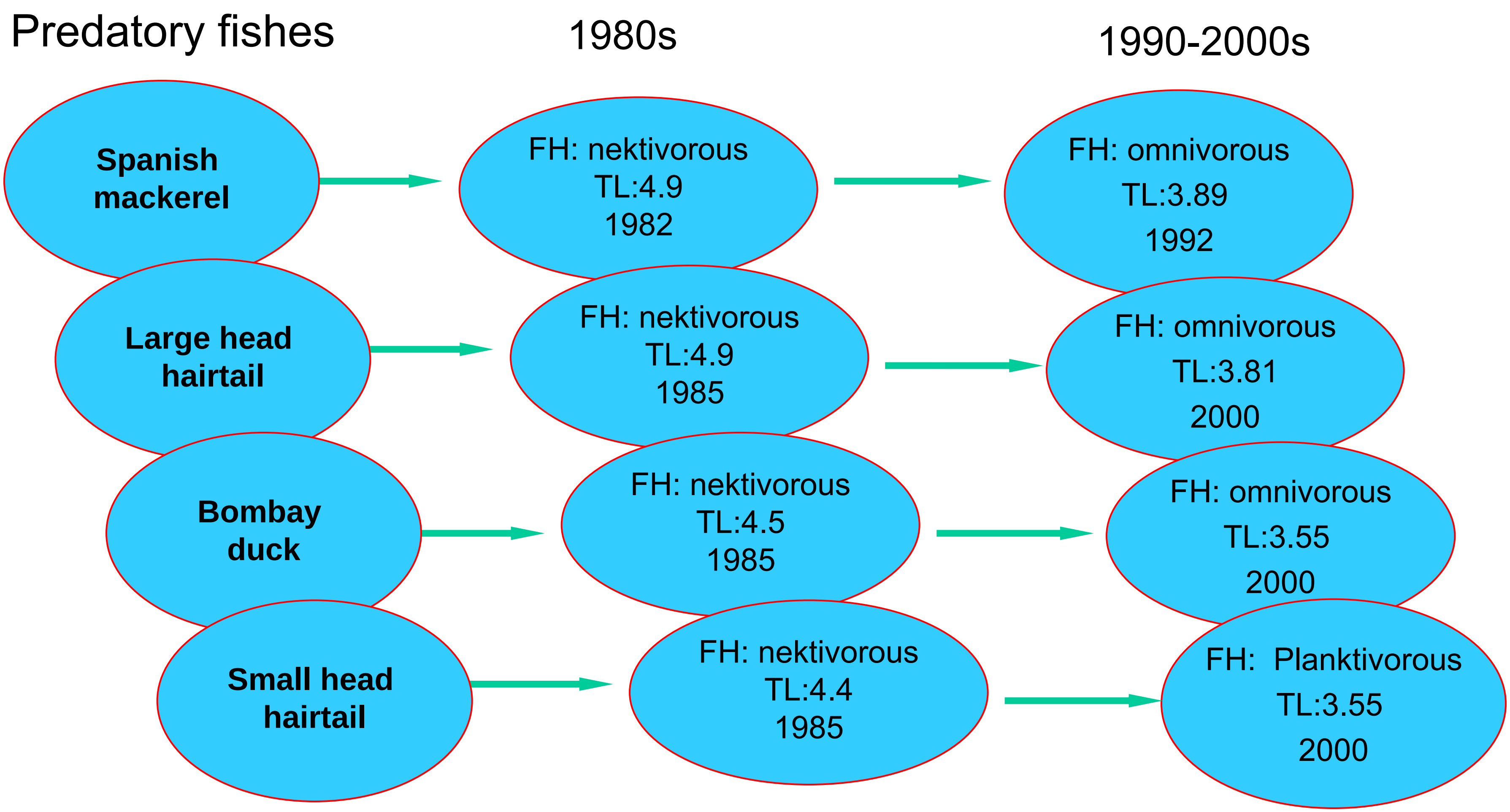
- **In 1958/59, distribution limited to 32˚N.**
- **In 2007, becoming the dominant species in the Northern Yellow Sea (38-39˚N).**

Shit of dominant fishes with climate change



Dominant fish species have been replaced among the cold, temperate and warm water species with temperature changes.

Feeding habits of predatory fish species in the Yellow Sea during 1980-2000



Potential causes –

(Zhen et al. 2007)

- Intensified fishing pressure (removal of high value & large fishes)
- Alteration of prey fish species with changing climate

Main stressors impacting ecosystems in the East China and Yellow Seas

Activities/Stressors	ECS/YS	SETO	K/O
1. Polution from land	2.7	2.1	
2. Coastal enginnering	3.4	2.6	
3. Coastal development	3.4	2.7	
4. Direct human impact		2.7	
5. Ecotourism		1.4	
6. Commertial activity			
7. Aquaculture		2.6	
8. Fishing - demersal	3.5	2.3	2.8
9. Fishing - pelagic	2.6	2.1	3.3
10. Fishing - illegal			
11. Offshore development	2.1		
12. Polution from ocean	3.1	3.2	
13. Freshwater input	2.9	2.4	
14. Sediment input	2.5	2.7	
15. Nutrient input	2.9	3.2	3.0
16. HABs	2.8	2.6	
17. Hypoxia	3.2	2.5	3.0
18. Species invasion	2.5	2.8	
19. Sea level change		3.0	3.2
20. Sea temperature	3.2	3.2	3.2

Coastal development and engineering have strong impacts to the ECS/YS and the SETO.

Demersal and pelagic fishing impact to the ECS/YS and the K/O, respectively.

Nutrient input has resulted in HABs and Hypoxia.

Increasing sea temperature affects to all 3 ecosystems.

Conclusions

- The habitats-stressors matrix was applied to the ECS/YS.
- Ecosystem responses to multiple stressors in the intertidal and coastal waters was gained.
- Coastal development, fishing, nutrient input and increasing temperature impact strongly to the ECS/YS.
- Need more responses for evaluation.