

Application of the ASSETS eutrophication assessment methodology to four contrasting Chinese coastal systems



Sanggou Bay



Huangdun Bay

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China – General study area



ASSETS was applied to four very different coastal systems in China

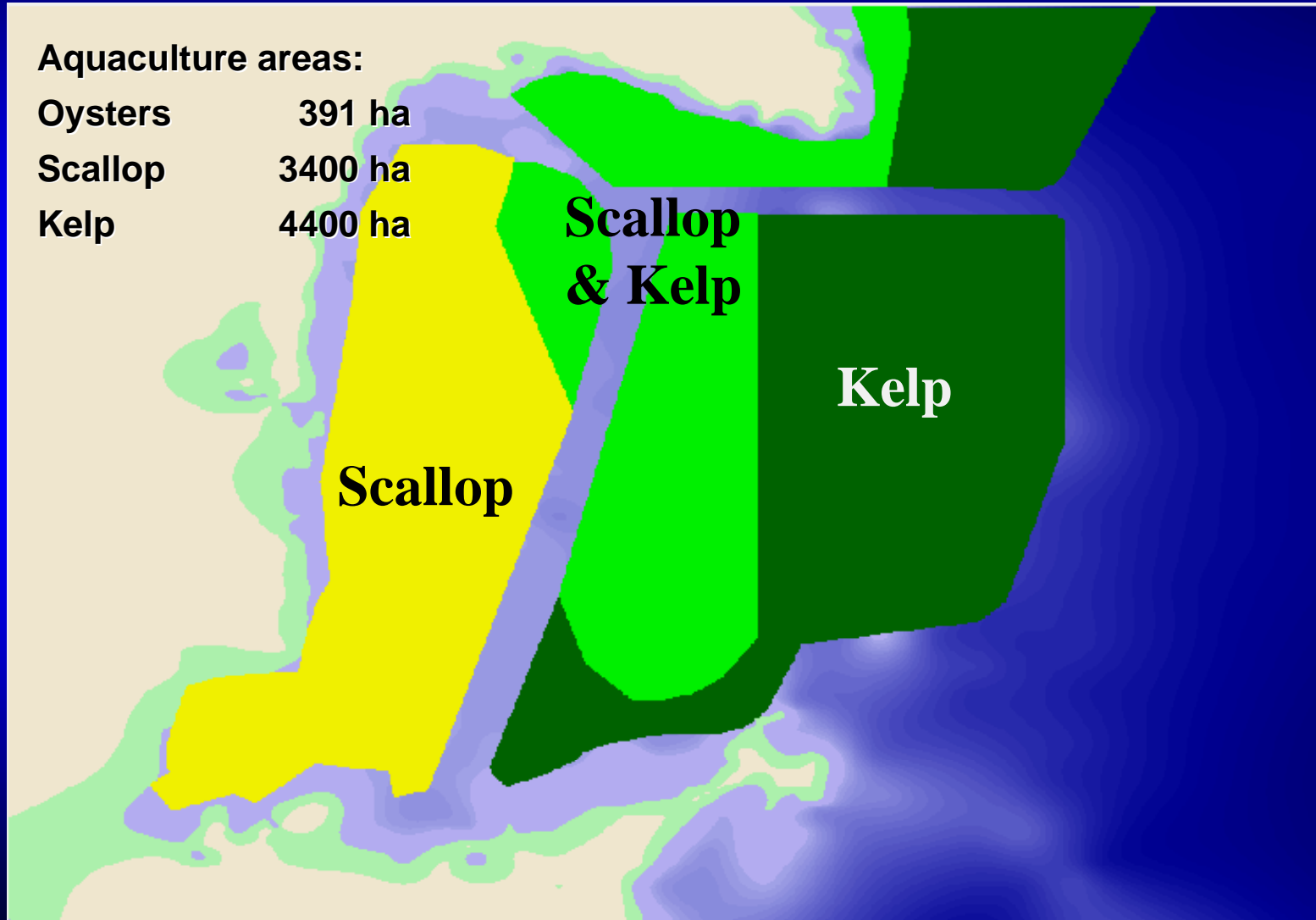
- Span 8 degrees of latitude (~900km);
- Include estuaries and coastal bays;
- Vary in size and human use;
- From sparsely populated to heavily populated.

Location of the four systems

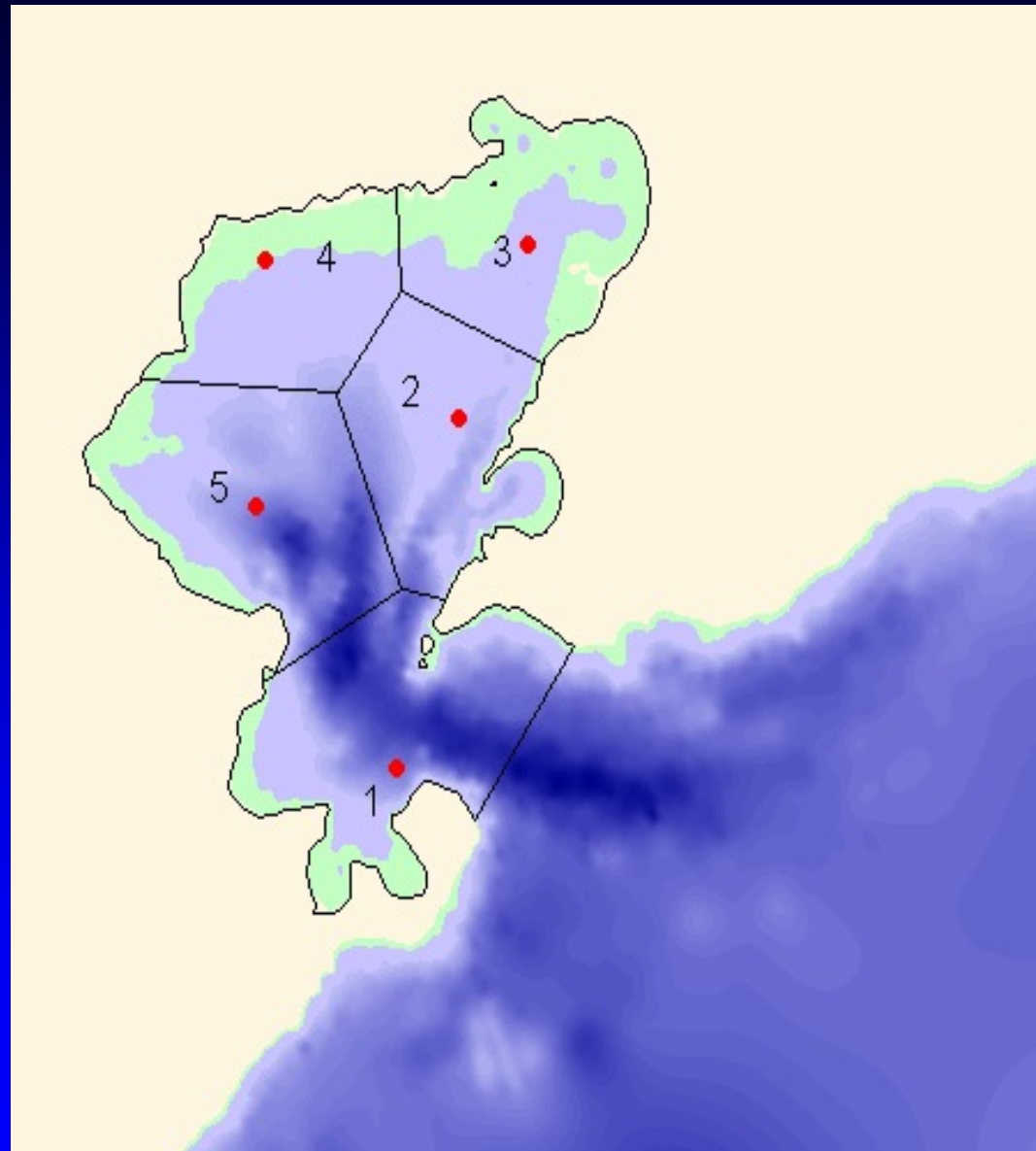
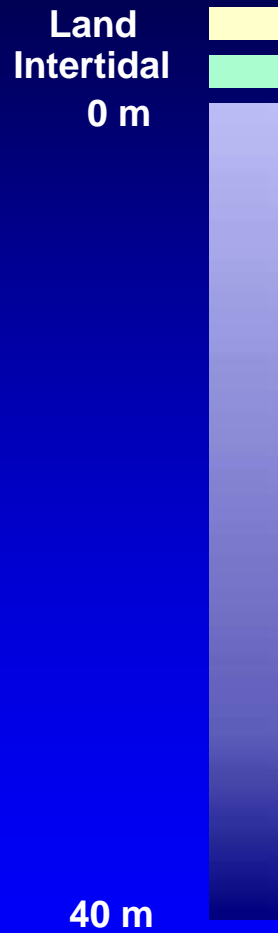


	Area (km ²)	Volume (10 ⁶ m ³)	Depth (m)	Type of system	Catchment population (X 10 ³)
Sanggou Wan	140	1,000	7.5	Coastal bay	200
Jiaozhou Wan	390	1,900	7	Coastal bay	4,900
Changjiang estuary	51,000	637,500	8	Estuary	400,000
Huangdun Wan	90	1,125	8	Estuary	500

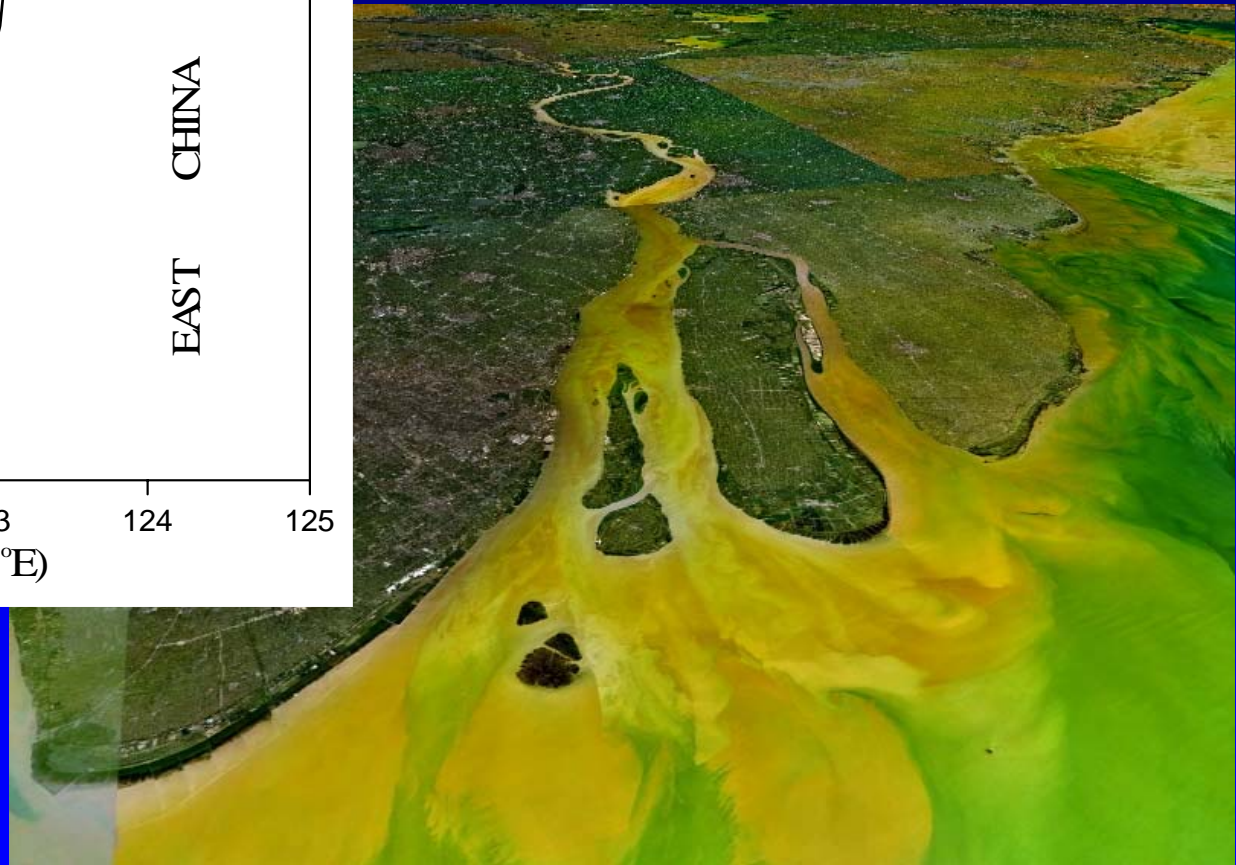
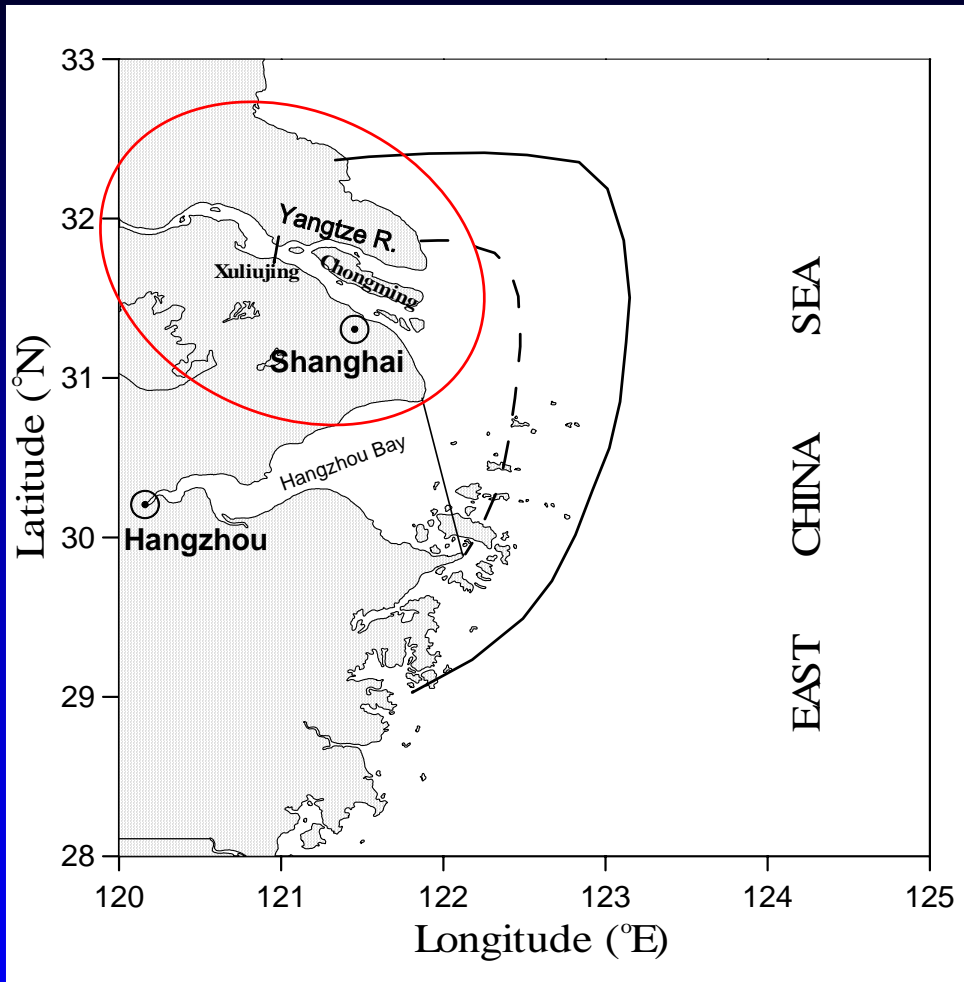
Sanggou Bay, showing aquaculture areas



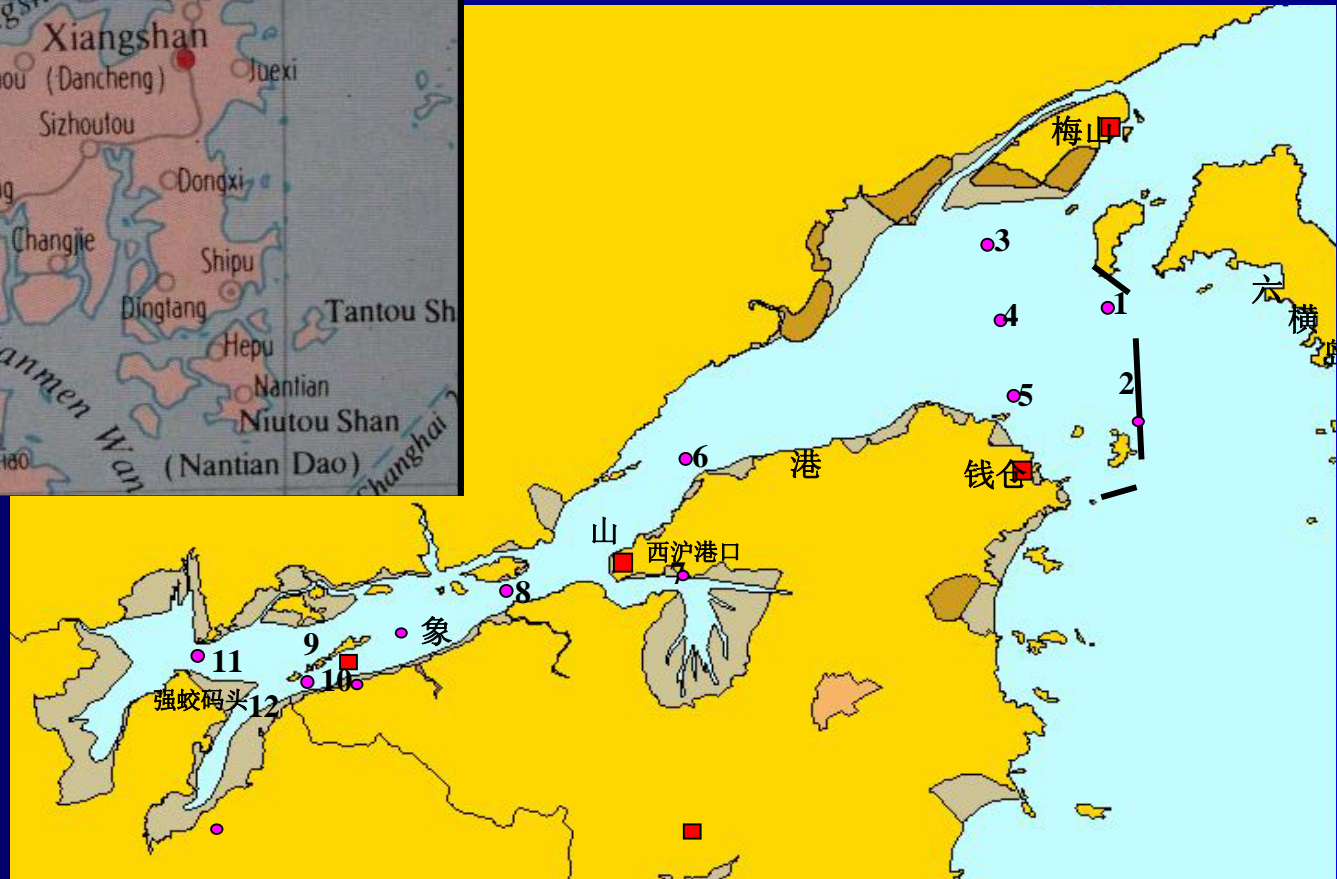
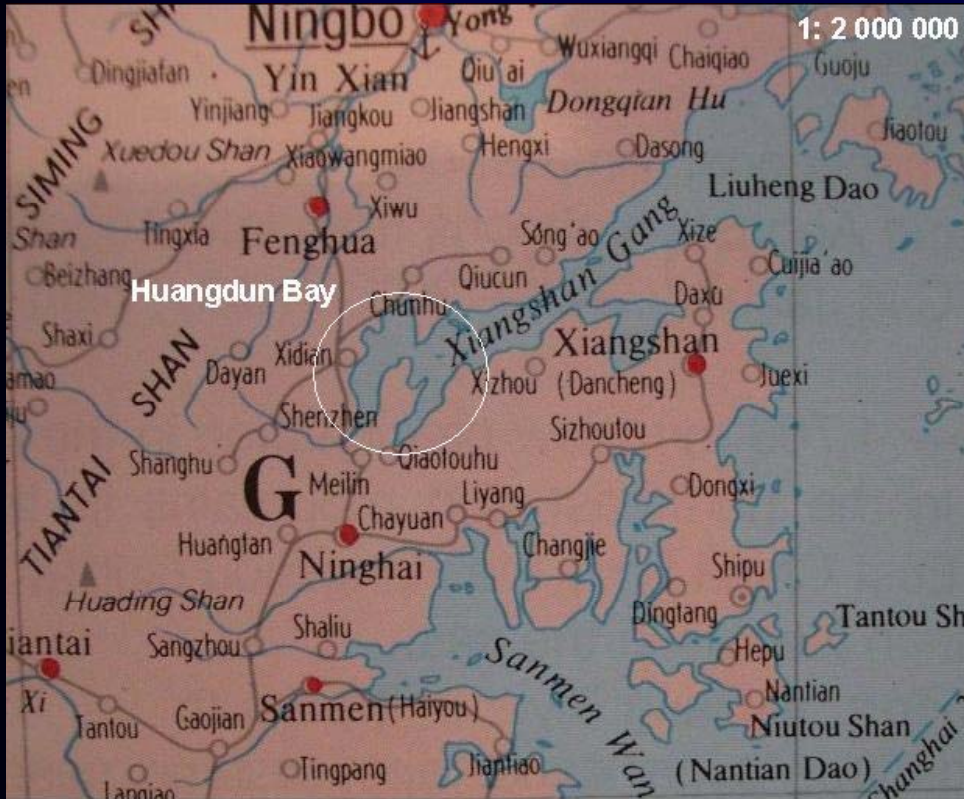
Jiaozhou Bay, showing bathymetry



Changjiang Estuary

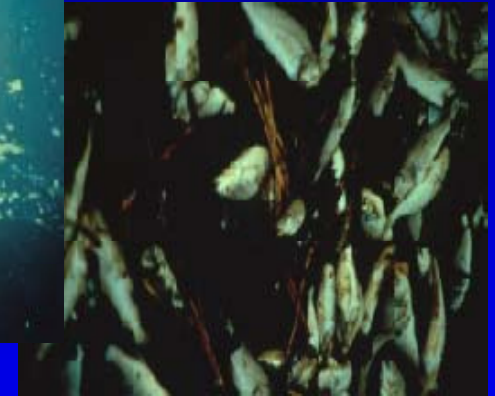
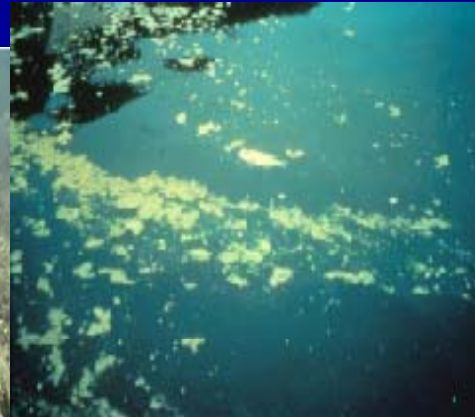
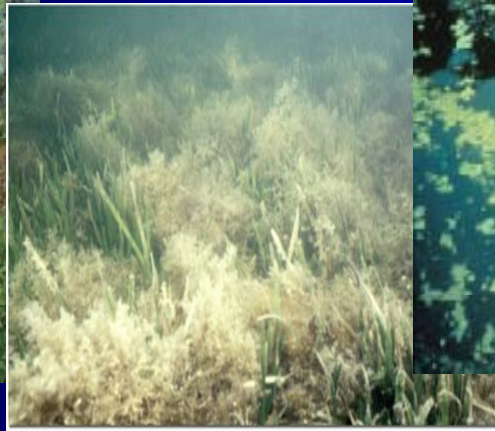
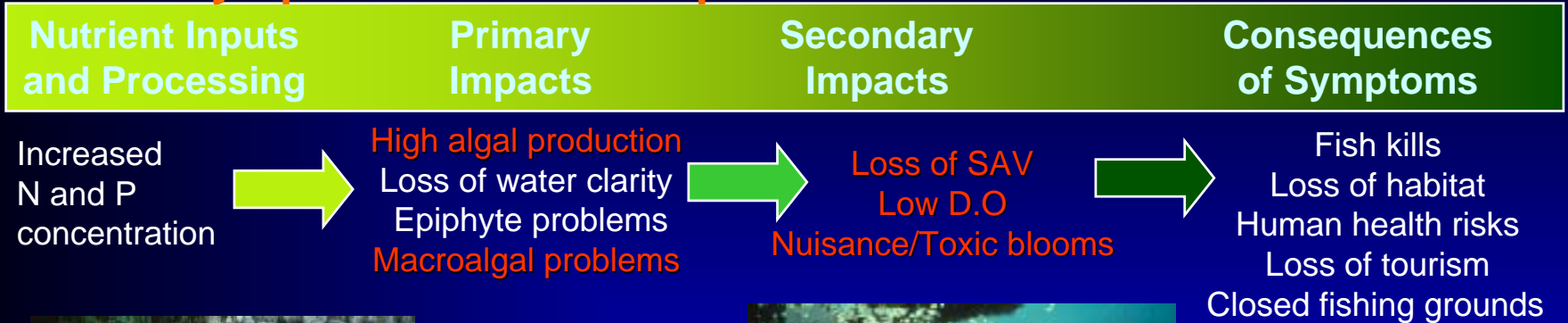


Huangdun Bay



The Problem – The Assessment Approach

Symptoms and Consequences of Nutrient Enrichment



ASSETS: Pressure - State - Response

P: Overall Human Influence (OHI) – Natural processing + Human Nutrient Load

S: Overall Eutrophic Condition (OEC) – Condition of waterbody

R: Determination of Future Outlook (DFO) – What will happen in the future?

Sanggou Bay – ASSETS Application



ASSETS: HIGH

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI) ASSETS: 5	Susceptibility	Dilution potential	High	Low susceptibility	LOW
		Flushing potential	Moderate		
	Nutrient inputs	Moderate			
Overall Eutrophic Condition (OEC) ASSETS: 5	Primary	Chlorophyll a	Low	Low	LOW
		Macroalgae	No Problem*		
	Secondary	Dissolved Oxygen	No Problem	Low	
		Submerged Aquatic Vegetation	No Problem		
		Nuisance and Toxic Blooms	No Problem		
Determination of Future Outlook (DFO) ASSETS: 3	Future nutrient pressures	Future nutrient pressures remain the same			NO CHANGE

Estuary Characteristics:

Population (X 10 ³)	200
Nutrient loading (tN y ⁻¹)	400
Mean depth (m)	7.5
Mean tidal range (m)	1.5
Water residence time (d)	20

Main issues and impacts:

Cultivation of scallops, oysters, kelp – high summer bivalve mortality from disease

Jiaozhou Bay – ASSETS Application



ASSETS: GOOD

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI)	Susceptibility	Dilution potential	Moderate	Moderate susceptibility	MODERATE
		Flushing potential	Moderate		
ASSETS: 3	Nutrient inputs	Moderate Low			
Overall Eutrophic Condition (OEC)	Primary	Chlorophyll a	Low	Low	LOW
		Macroalgae	No Problem*		
	Secondary	Dissolved Oxygen	Low	Low	
		Submerged Aquatic Vegetation	Low		
		Nuisance and Toxic Blooms	Low		
Determination of Future Outlook (DFO)	Future nutrient pressures	Future nutrient pressures decrease			Improve Low
ASSETS: 4					

Estuary Characteristics:

Population (X 10 ³)	4,940
Nutrient loading (tN y ⁻¹)	13,997
Mean depth (m)	7
Mean tidal range (m)	2.4
Water residence time (d)	52

Main issues and impacts:

Cultivation of clams, oysters and scallops, Redfield ratio changed from 10 to 24 in 40 years

Changjiang Estuary – ASSETS Application



ASSETS: BAD

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI)	Susceptibility	Dilution potential	Moderate	Moderate susceptibility	HIGH
		Flushing potential	Moderate		
ASSETS: 1	Nutrient inputs			High	
Overall Eutrophic Condition (OEC)	Primary	Chlorophyll a	Moderate	Moderate	HIGH
		Macroalgae	Unknown		
	Secondary	Dissolved Oxygen	Low	High	
		Submerged Aquatic Vegetation	Unknown		
		Nuisance and Toxic Blooms	High		
Determination of Future Outlook (DFO)	Future nutrient pressures	Future nutrient pressures increase			WORSEN HIGH
ASSETS: 1					

<u>Estuary Characteristics:</u>	Population (X 10 ³)	400,000
	Nutrient loading (tN y ⁻¹)	1,600,000
	Mean depth (m)	8
	Mean tidal range (m)	2.7
	Water residence time (d)	40

Main issues and impacts:
 400 million people, HABs increased 10X between 1990-2004, Three Gorges Dam to reduce flow, economic growth to increase load

Huangdun Bay – ASSETS Application



ASSETS: POOR

Indices	Methods	Parameters	Rating	Level of expression	Index
Overall Human Influence (OHI)	Susceptibility	Dilution potential	Moderate	Moderate susceptibility	HIGH
		Flushing potential	Moderate		
ASSETS: 1	Nutrient inputs		High		
Overall Eutrophic Condition (OEC)	Primary	Chlorophyll a	High	Moderate	MODERATE
		Macroalgae	No Problem*		
	Secondary	Dissolved Oxygen	No Problem	Moderate	
		Submerged Aquatic Vegetation	Unknown		
ASSETS: 3		Nuisance and Toxic Blooms	Moderate		
Determination of Future Outlook (DFO)	Future nutrient pressures	Future nutrient pressures increase			WORSEN HIGH
ASSETS: 1					

<u>Estuary Characteristics:</u>		
Population (X 10 ³)	500	
Nutrient loading (tN y ⁻¹)	463	
Mean depth (m)	8	
Mean tidal range (m)	3.9	
Water residence time (d)	30	

Main issues and impacts:
 Outer channel influenced by the Changjiang plume, aquaculture of finfish, oysters, *Enteromorpha*, and *Porphyra*

ASSETS: Four Chinese Systems

	Sanggou <u>ASSETS: HIGH</u>	Jiaozhou <u>ASSETS: GOOD</u>	Changjiang <u>ASSETS: BAD</u>	Huangdun <u>ASSETS: POOR</u>
Indices				
Overall Human Influence (OHI)	LOW	MODERATE	HIGH	HIGH
Overall Eutrophic Condition (OEC)	LOW	LOW	HIGH	MODERATE
Determination of Future Outlook (DFO)	NO CHANGE	IMPROVE LOW	WORSEN HIGH	WORSEN HIGH
Population (X 10 ³)	200	4,940	400,000	500
Loading (tN y ⁻¹)	400	13,997	1,600,000	463
Watershed characteristics	Rural	Urban	Heavily populated	Rural
Other influences	Aquaculture	Aquaculture, sewage, shipping, recreation	Sewage, industry, shipping	Aquaculture

Management: GEF/UNEP Yellow Sea Large Marine Ecosystem (www.yslme.org), China Blue Sea Action Plan, Total Load Control Plan (in development), particularly hotspots (e.g. Changjiang)

Concluding Remarks

- ASSETS has been successfully applied to four Chinese systems
- The Changjiang (Yangtze) is the most impacted and also the most populated watershed. Management plans include the GEF/UNEP Yellow Sea Large Marine Ecosystem, China Blue Sea Action Plan, and the Total Load Control Plan which addresses hotspots;
- Despite multiple uses, Jiaozhou Bay has a low impact and is expected to improve from sewage treatment implementation /upgrades. Shellfish aquaculture may play a pivotal role in reducing the concentration of particulate organic material;
- Opportunistic macroalgae are considered a problem in the US and EU - but in China, algae such as *Enteromorpha* are cultured for harvest, so the ASSETS criteria must be adapted to local considerations;
- HABs are a major problem both in parts of the Yellow Sea and in the East China Sea, and lower the ASSETS scores for some systems. As in other parts of the world, it is unclear what (if any) management measures may be taken to correct this.

