



Restoration of Coastal wetlands in China: Chances and Challenges

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Outline

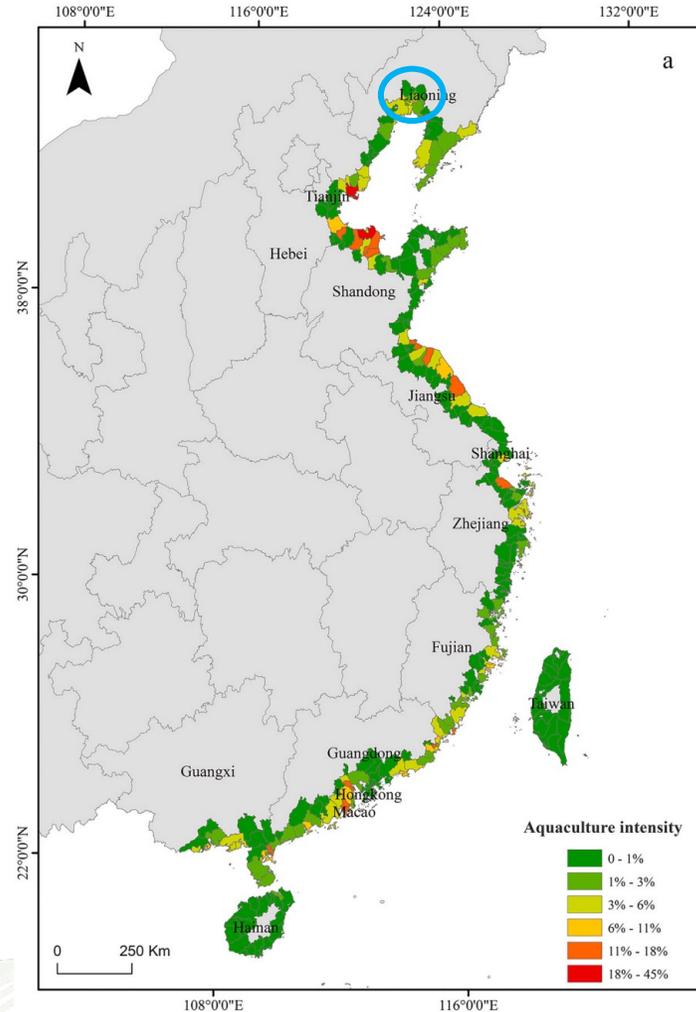
- 01 / **About aquaculture ponds**
- 02 / *About *Spartina alterniflora**
- 03 / *About the use of dredging sediments*



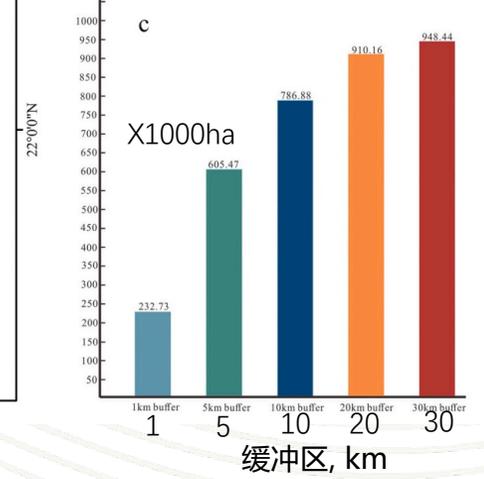
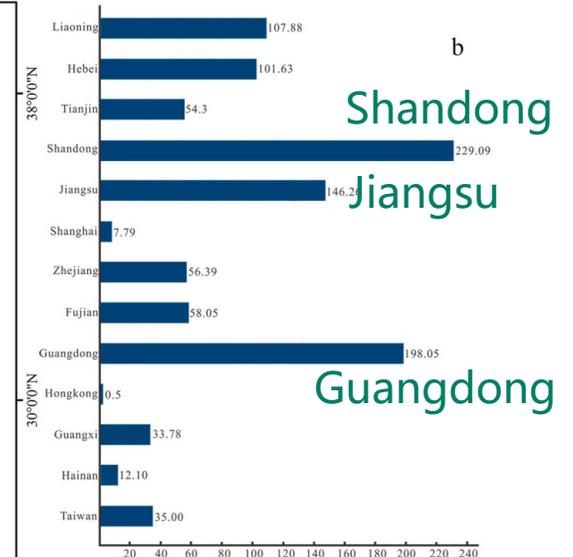
About aquaculture ponds

- China has over 1 million ha of aquaculture ponds along the coastal zone
- More than half is within 5 km from the coast line
- This does not include the fish net and floating raft farming on the sea

Most of the area is transformed from coastal wetlands



Aquaculture area by province



Aquaculture ponds within and out of Nature Reserves



Restoration from aquaculture ponds at the Liahe Estuary Nature Reserve

3 years after levees are flattened



Many breeding birds



Levees partly destroyed to promote hydro connection



Levees remain



Suggestions

- **Recovery works best with all the levees removed, but highly cost**
- Levees can be partly reserved to promote habitat diversity, with tidal creeks restored
- Trees and shrubs can be planted along levees to increase vegetation diversity
- Increase biodiversity and carbon sequestration with relatively low cost



Aquaculture ponds out of Nature Reserves

- About 2/3 of fish products are from aquaculture, 40% is from mariculture
- 80% of the seafoods are shellfish (10M tons/yr), others are algae, shrimps, crabs and sea cucumber, fish is only a small fraction
- **If aquaculture ponds are restored to wetlands, how to keep the income and jobs of the local community?**
- **How to maintain the productivity to provide enough seafood for the consumers?**



How about restore half of the aquaculture ponds?

- Keep at least half of the area as tidal wetlands
- Aquaculture ponds can provide food for some birds
- Tidal wetlands or floating mats can absorb excessive nutrients and provide habitats for birds
- Fishing tourism can partly compensate the loss of aquaculture ponds



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Floating mat of
*Sesuvium
portulacastrum*

Best practice at the Hong Kong Mai-po Wetland

- Tourists, farmers, and birds can co-exist harmoniously
- Aquaculture ponds are dredged in turn, and tourists are limited with appointment in winter



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补固碳能力



About *Spartina alterniflora*

Benefits

- Coastal protection
- Land accretion
- **Carbon sequestration**
- Water purification
- Food for benthic species and fish

Negative effects

- Dense and tall, hard for birds to hide or predate
- Occupy the niche for native plant species
- Block tidal creeks



Spartina Control Action Plan (2022—2025)

By 2025, 90% of *Spartina* in each province/city should be eradicated



The screenshot shows the official website of the National Forestry and Grassland Administration (NFCA) and National Park Administration. The header features the agency's name in Chinese and English, along with a navigation menu. The main content area displays a notice titled "Notice of the National Forestry and Grassland Administration, Ministry of Natural Resources, Ministry of Ecology and Environment, Ministry of Water Resources, and Ministry of Agriculture and Rural Affairs on Issuing the 'Spartina Control Action Plan (2022-2025)'" in Chinese. The notice is dated 2023-03-10 and includes options for font size and printing.

A big challenge to remove
>700 Km² of *Spartina* !

More challenge afterwards:

- What if the native species cannot survive?
- How to deal with erosion?
- CO₂ emission due to disturbance
- High cost for eradication, restoration and maintenance!

Limitations of the *Spartina* control project

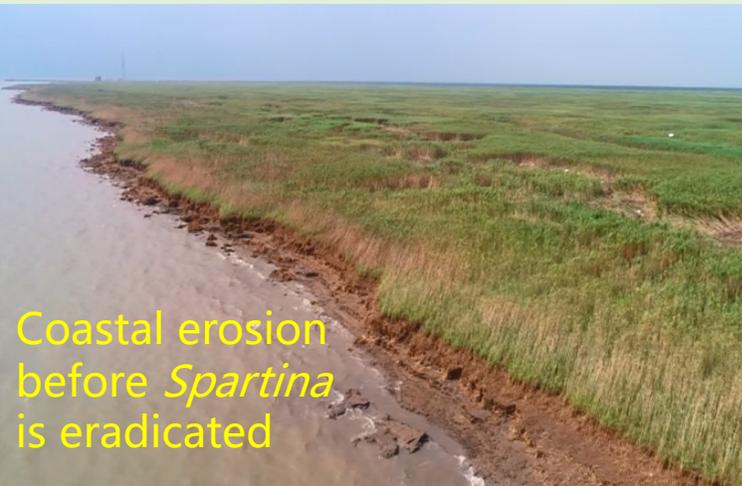
- **High cost:** ~50M CNY/km². If the same amount is used for management, it can be more cost effective, with other functions of *Spartina* remain
- **High maintenance cost afterwards:** Sedimentation of tidal gauges, algae blooming in the enclosure, decreased salinity, reed expansion, frequent re-invasion of *Spartina*
- Disturbance of the habitat during eradication, and the restored wetland has no or limited natural tidal influence



Enhanced risk of coastal erosion and blue carbon loss



Shanghai coast after *Spartina* eradication



Coastal erosion before *Spartina* is eradicated

Tidal flats prone to erosion are more endangered, especially at sections with high sediment salinity



Qingdao coast after *Spartina* eradication

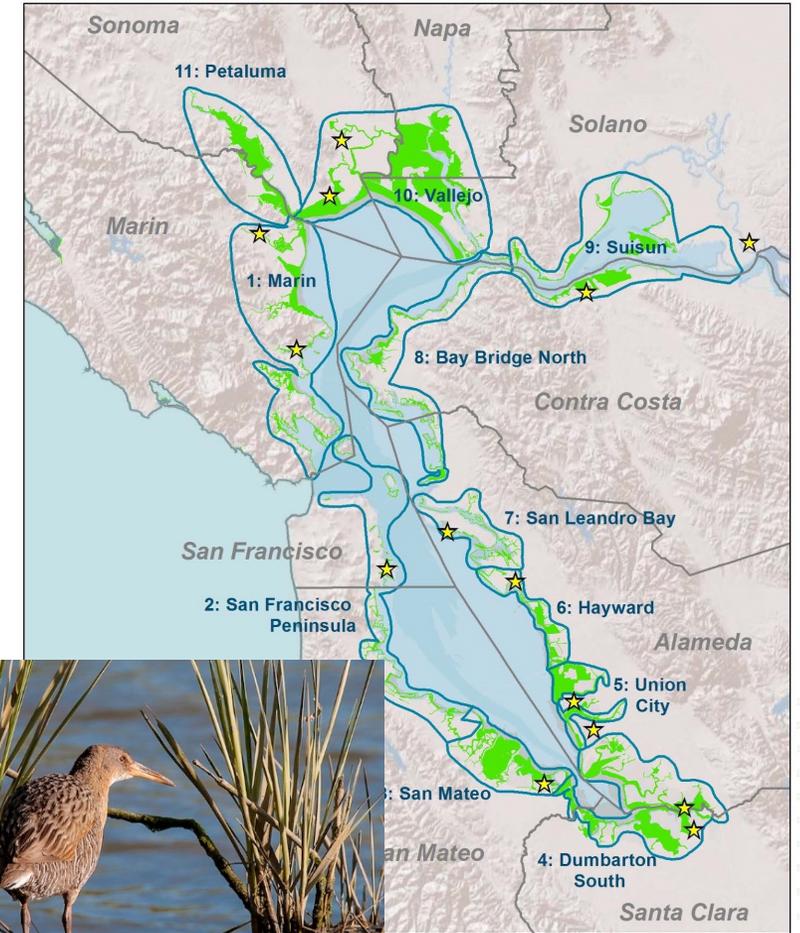


Re-invasion of *Spartina* after removal



Scattered *Spartina* patches can provide bird habitat

- San Francisco Bay started eradication of *Spartina* in 2000, when it was only about 3 km². Till now they still spray herbicides every year.
- *Spartina* has to be partly reserved since one of the endangered species, Ridgway's rail, use it as habitat, which shows it also contributes to nature conservation at invaded sites.
- **Scattered *Spartina* patches provide habitats for thousands of birds at the east headland of Shanghai**



里氏秧鸡(Ridgway's Rail)

Native species are difficult to survive in some places

Shanghai coast along the Hangzhou Bay

Spartina coast is **46 km**, about **63%** of the total length, and **86%** of the vegetated area, 30-80m wide



- This is an erosion coast, especially dangerous under frequent storm surges if coincided with high tides
- The average water salinity is $>15\text{‰}$, hard for the survival of native plant species
- *Spartina* is the only species that can easily survive; tidal flat needs to be much further elevated for the establishment of *Phragmites*, which will result in new hard structures
- *Spartina* can provide important protection for the southern coast of Shanghai. Complete removal may cause strong erosion and hazard.



Spartina as bio-resources

Philosophy:

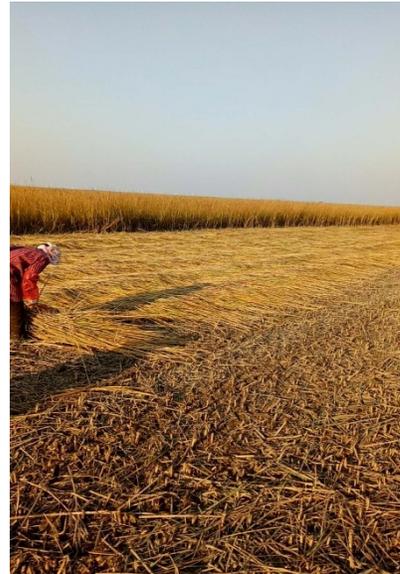
- Mitigate storm surges in Summer
- Harvest for use in Autumn
- Bird habitat in Winter and Spring

Within ~13ha of harvested area:

- About 8000 birds from 25 families, 44 species were recorded
- **January** has the highest number of wintering species observed

Abstraction of bio-liquids and salt:

- Products for gout (reduce blood uric acid), healthy beverages
- Feeding stuffs for animals and organic fertilizers



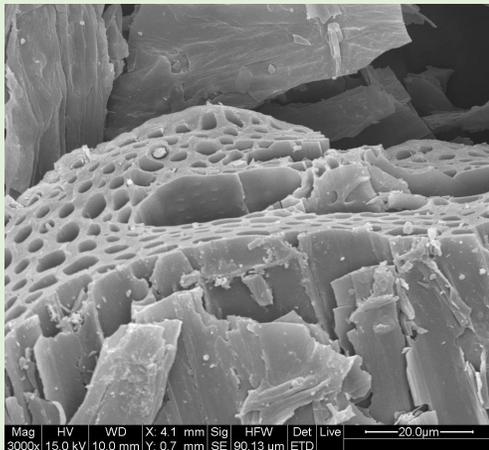
Bioliquid extracted from *Spartina*



Products anti-gout



Movable charcoal
maker with self energy
maintenance



Pore structure
of biochar

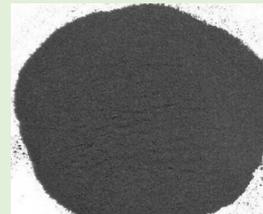
Mag 3000x HV 15.0 kV WD 10.0 mm X 4.1 mm Sig SE HFW 90.13 µm Det ETD Live

Biochar from Spartina:

- High surface area ratio (20-250 m²/g), rich oxygenated functional groups, and high rate of inorganic minerals in ash
- Useful for agriculture, chemical plants, and many other aspects



Biochar



Ash



Coke tar

Big Potential as Silage Fodder

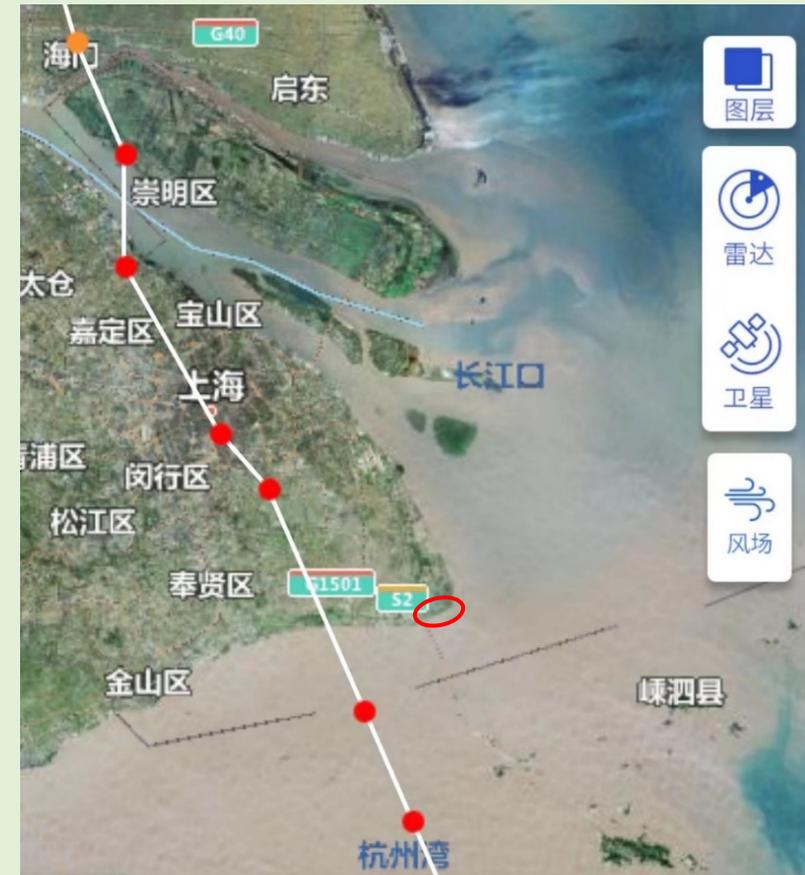
- **Coarse protein in *Spartina* is >8%**, higher than regular crop stems
- **No need to remove salt from the hay**, palatable for cattle
- **1-2 years of storage**, easy for transportation
- Best harvest in July and October, **avoiding seeds, while protect the coast during Typhoon season**, and provide habitat for migrating birds in winter and spring
- Highest benefits for carbon sequestration, coastal protection and bio-conservation
- **Low cost and sustainable**
- **Needs: Crawler-type harvesting, smashing, and packaging machine**



Coast protection after *Spartina* harvesting

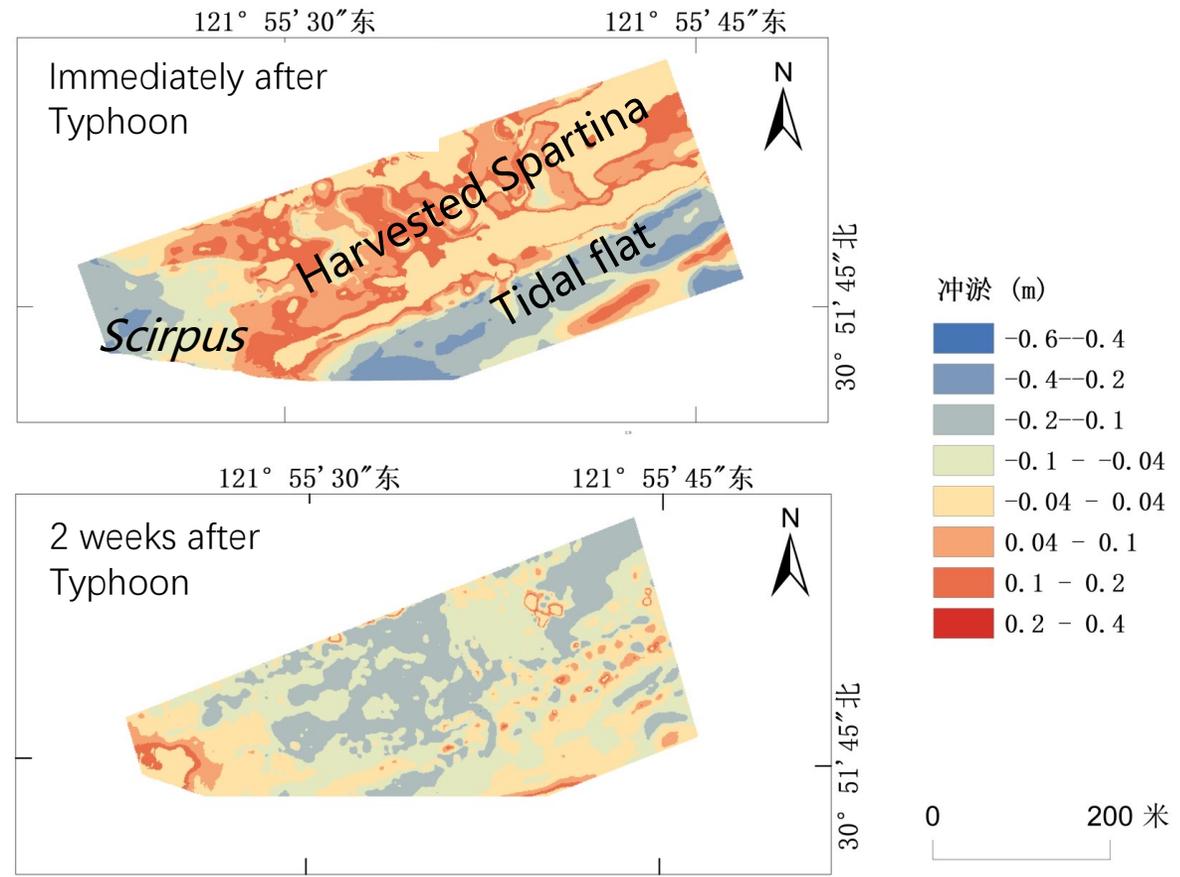
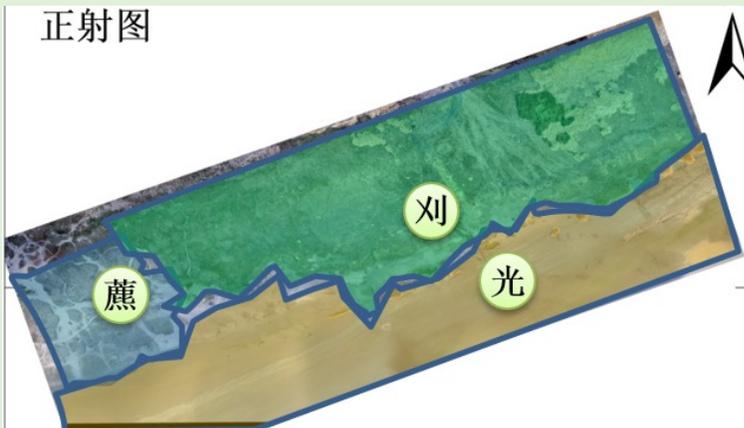


Sept. 15, 2022, Typhoon Muifa landed at Shanghai with central wind speed 35 m/s



Coast protection after *Spartina* harvesting

- After Typhoon, sediment accretion happened in harvested *Spartina* zone, while *Scirpus* and tidal flat zones were eroded
- Adjustment occurred within 2 weeks after Typhoon



Harvested *Spartina* zone as habitat for water birds



Nature based *Spartina* management strategies

- Dig canals as tidal creeks, and harvest in early summer and autumn, to provide habitat corridors and patches for birds
- **Grazing with Milu or water buffalos**, to keep low vegetation height or even bare flat patches through trapping and browsing
- **Harvested biomass can be used in many ways with economic benefits, while the harvested area can provide habitat for birds, protect the coast and sequester carbon**

Much lower cost in the long term!



Other use of *Spartina* zone

Aquaculture at high tidal zone

- Low disturbance with simple levee, and protected by *Spartina* outside
- Sea water can enter the ponds during spring tides
- High quality mariculture products
- *Spartina* in the ponds needs to be removed often

More guidance is needed for this type of use



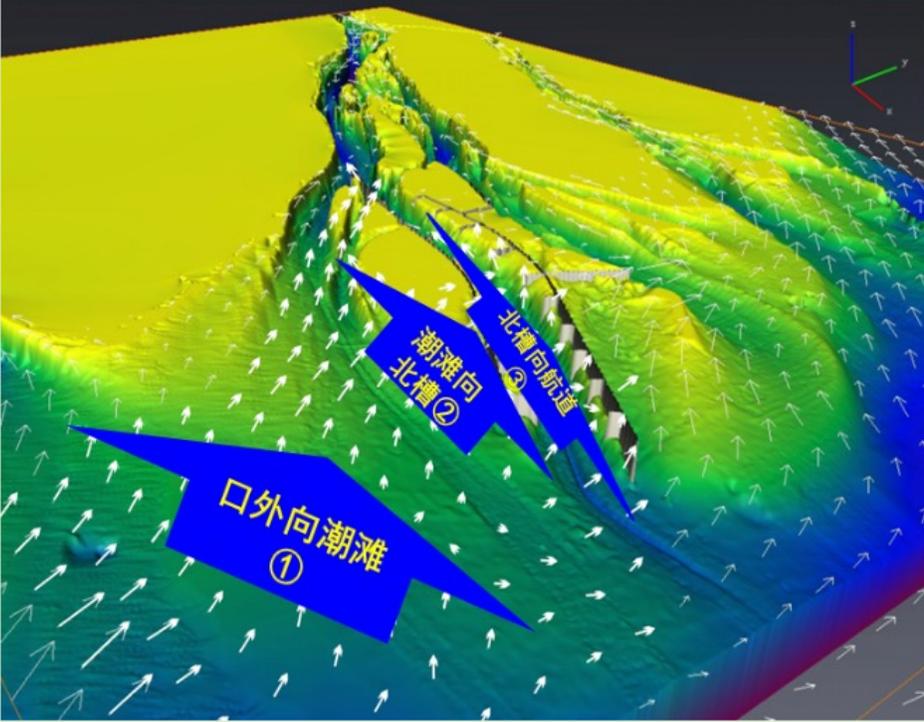
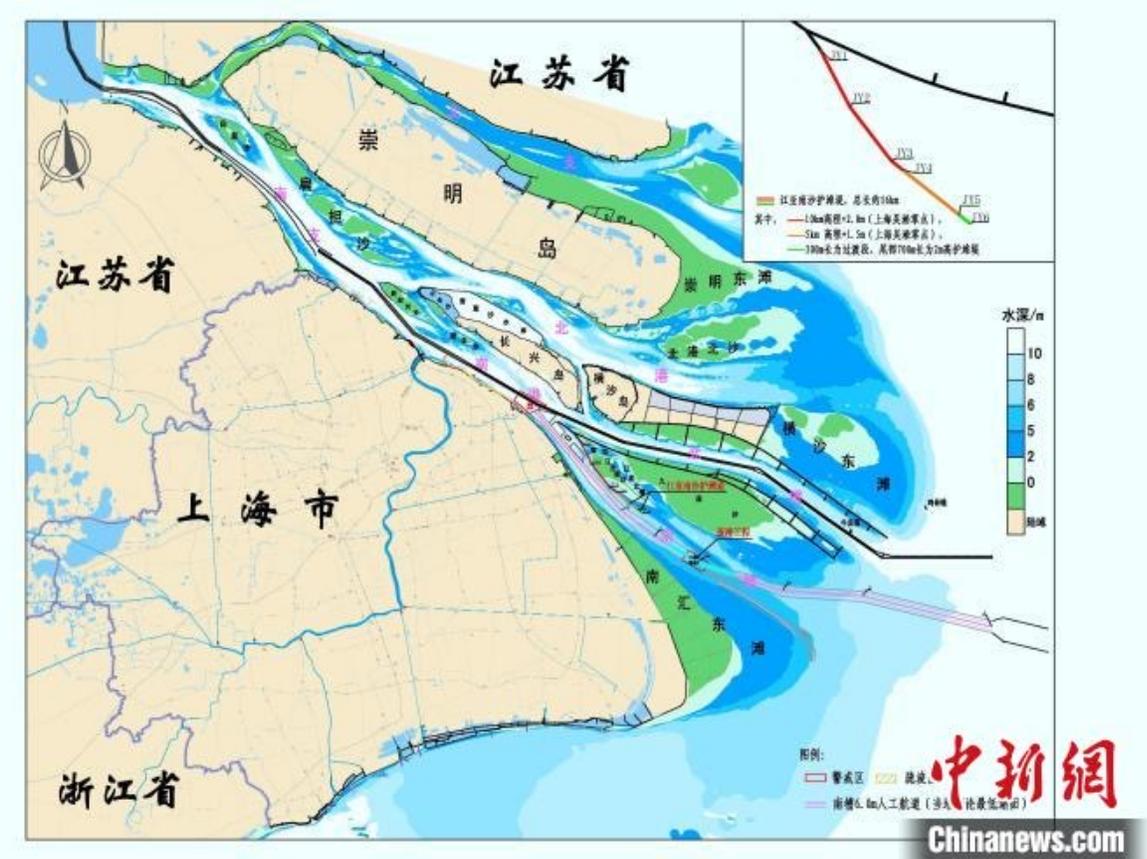
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Dredged sediments from the navigation channel: > 50 M m³/Year

- 2010-2020, 106 km² of land was created
- Since 2020, dredged sediments are poured to the sea, which will flow back to the navigation channel again with tide



Mud bank near the estuary and sediment transportation path

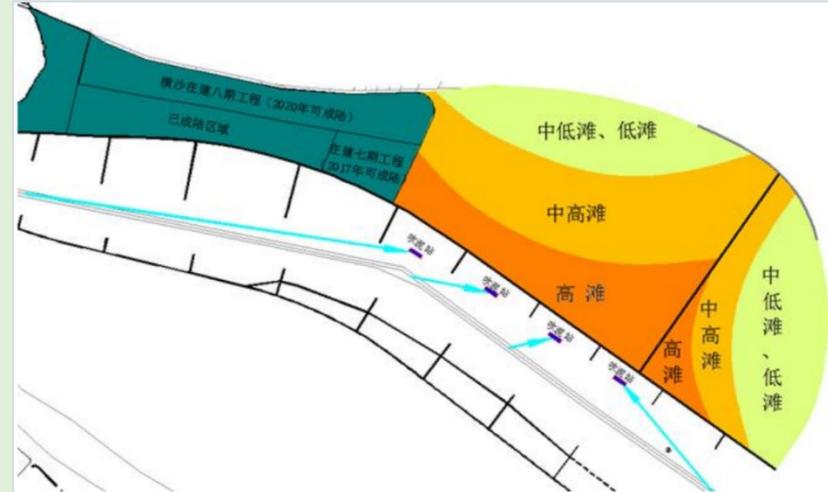
About the dredging sediments

- Reclamation
- Decreased sediment input
- More frequent and stronger storm surges

Sediment relocation need for dredged sediments

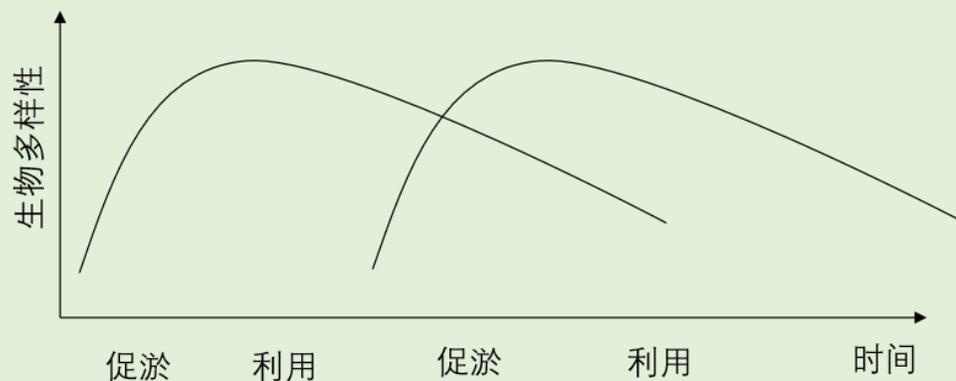
Semi-artificial wetland creation with dredged sediments

Coastal protection	Biodiversity conservation	Carbon sequestration
Raw materials	Land resources	Water purification

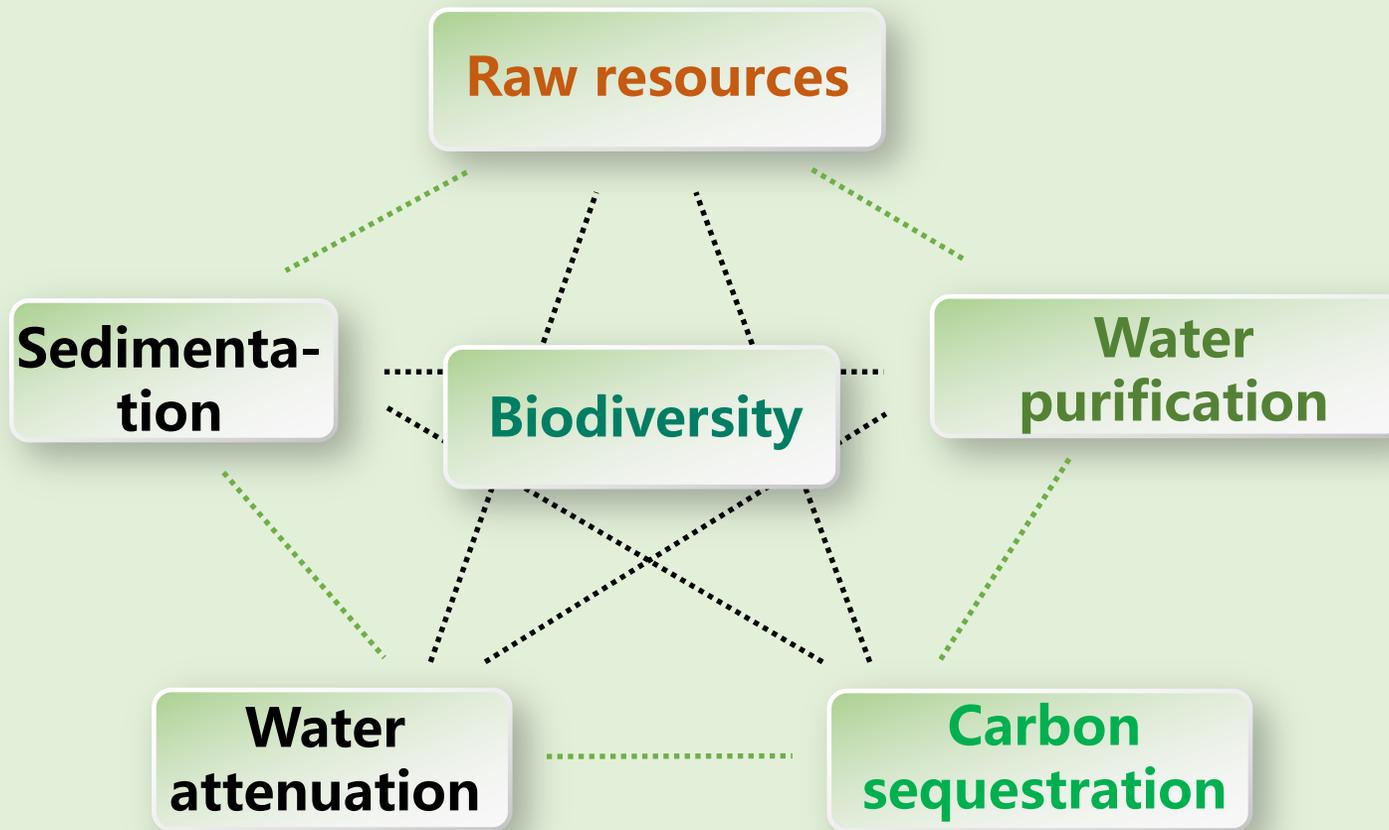


Combination of dredged sediment use and land creation

Long term win-win for ecological, economical and social benefits



Compromise of multi-functions in coastal restoration



Coastal sustainable development



Cost-benefit ratio
Eco-tourism
Balance between ecological and economical benefits
Land-sea统筹



Questions?



Natural wetland



致谢：国家自然科学基金42141016, 42176164
Artificial wetland/farmland