3RD YSLME
Science Conference
Qingdao, PR China

# Restoring coastal wetlands as nutrient sinks: case studies and regional strategies

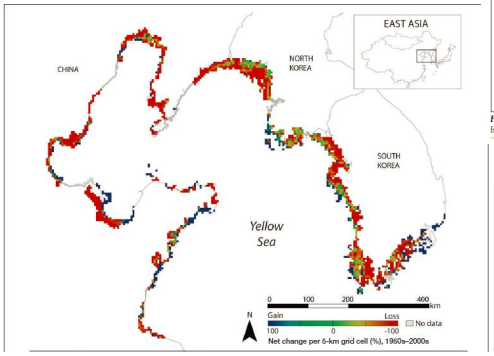
This work was funded by YSLME Project Phase II

**Guoxiang LIAO**
**National Marine Environmental Monitoring Center, China**
**July 19, 2019**

# PART 1 Status and changes of coastal wetlands inYellow Sea

## Status and changes

- According to historical topographic maps, tidal wetlands in the Yellow Sea occupied 1.12 and 0.55 million ha in the mid-1950s and 1980s, respectively,
- Only 0.39 million ha remained in 2000s (Murray et al., 2014).



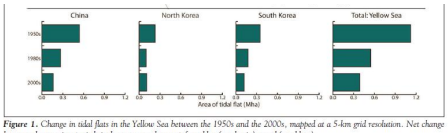




*Figure 1. Change in tidal flats in the Yellow Sea between the 1950s and the 2000s, mapped at a 5-km grid resolution. Net change between the two time periods is shown on a color ramp from blue (total gain) to red (total loss).*

| | Estimated area of tidal flat (ha) | | | % change | | | Continuous rate of change (% yr$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1950s | 1980s | 2000s | 1950s–1980s | 1980s–2000s | 1950s–2000s | 1950s–1980s | 1980s–2000s | 1950s–2000s |
| China | 539 794 | 267 751 | 161 066 | −50.4 | −39.8 | −70.2 | −2.7 | −1.8 | −2.2 |
| North Korea | 231 813 | 99 333 | 107 765 | −57.1 | 8.5 | −53.5 | −4.9 | 0.3 | −1.6 |
| South Korea | 350 331 | 177 729 | 120 472 | −49.3 | −32.2 | −65.6 | −2.4 | −1.6 | −2.0 |
| Yellow Sea | 1 121 938 | 544 812 | 389 303 | −51.4 | −28.0 | −65.3 | −3.0 | −1.2 | −2.0 |

**Notes:** Area estimates should be considered minima for the Yellow Sea, because 12.1% of the coastline could not be mapped owing to the presence of cloud or ice cover in satellite imagery obtained at suitable tide heights (Figure 1).

## New management policies

- China governments published *Announcement on Strengthening the Conservation of Coastal Wetlands and Strict Control of Reclamation* in 2018, the trend of reclamation of coastal wetland almost come to stop .


# Ecosystem services of coastal wetlands

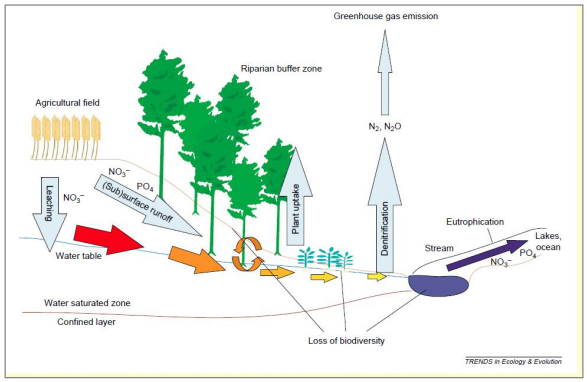
- **The Millennium Ecosystem Assessment summarized the ecosystem services that coastal wetlands can provide for human.**
  - Providing service
  - Regulating service
    - *Including pollution control and detoxification (retention,recovery,and removal of excess nutrients and pollutants)*
    - *Gernerally, estuary and marshes, mangroves could provide more services in nutrient and pollutant removal than other types of wetlands.*
  - Cultural service
  - Supporting service

Ecosystem services provided by coastal wetlands
Source: Millennium Ecosystem Assessment (Finlayson et al. 2005).

| Services | Comments and Examples | Estuaries and Marshes | Mangroves | Lagoons, Including Salt Ponds | Intertidal Flats, Beaches, and Dunes | Kelp | Rock and Shell Reefs | Seagrass Beds | Coral Reefs |
|---|---|---|---|---|---|---|---|---|---|
| **Coastal Wetlands** | | | | | | | | | |
| **Provisioning** | | | | | | | | | |
| Food | production of fish, algae, and invertebrates | ● | ● | • | ● | • | ● | • | ● |
| Fresh water | storage and retention of water; provision of water for irrigation and for drinking | • | | • | | | | | |
| Fiber, timber, fuel | production of timber, fuelwood, peat, fodder, aggregates | ● | ● | ● | | | | | |
| Biochemical products | extraction of materials from biota | • | • | | | • | | | • |
| Genetic materials | medicine; genes for resistance to plant pathogens, ornamental species, and so on | • | • | • | | ● | | | • |
| **Regulating** | | | | | | | | | |
| Climate regulation | regulation of greenhouse gases, temperature, precipitation, and other climatic processes; chemical composition of the atmosphere | ● | ● | ● | • | | • | • | ● |
| Biological regulation (C11.3) | resistance of species invasions; regulating interactions between different trophic levels; preserving functional diversity and interactions | ● | ● | ● | • | | • | | • |
| Hydrological regimes | groundwater recharge/discharge; storage of water for agriculture or industry | • | | • | | | | | |
| Pollution control and detoxification | retention, recovery, and removal of excess nutrients and pollutants | ● | ● | ● | | ? | • | • | • |
| Erosion protection | retention of soils | ● | ● | • | | | | • | • |
| Natural hazards | flood control; storm protection | ● | ● | • | • | • | ● | ● | ● |
| **Cultural** | | | | | | | | | |
| Spiritual and inspirational | personal feelings and well-being | ● | • | ● | ● | • | • | • | ● |
| Recreational | opportunities for tourism and recreational activities | ● | • | • | ● | • | | | ● |
| Aesthetic | appreciation of natural features | ● | • | ● | ● | | | | ● |
| Educational | opportunities for formal and informal education and training | • | • | • | • | | • | | • |
| **Supporting** | | | | | | | | | |
| Biodiversity | habitats for resident or transient species | ● | ● | • | ● | • | ● | • | ● |
| Soil formation | sediment retention and accumulation of organic matter | ● | ● | • | • | | | | |
| Nutrient cycling | storage, recycling, processing | | | | | | | | |

*Note: Scale is low ●, medium ●, to high ●; not known = ?; blank cells indicate that the service is not considered applicable to the wetland type. The information in the table represents expert opinion for a global average pattern for wetlands; there will be local and regional differences in relative magnitudes.*

# Basic mechanisms of using wetland as nutrient sinks




**Previous research proved that the nutrient load into the sea mainly including the load from river and the atmosphere.**

- Wetlands are being considered increasingly important for wastewater treatment because of the ability of many wetland plants to absorb large amounts of nutrient and a variety of toxic substances.

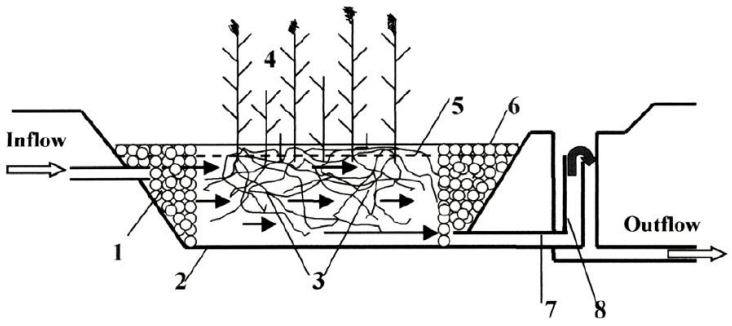



*Figure 5.3 Schematic layout of a constructed wetland with horizontal subsurface flow. 1 inflow distribution zone filled with large stones; 2 impermeable layer; 3 filtration material; 4 vegetation; 5 water level in the bed; 6 outflow collection zone; 7 drainage pipe; 8 outflow structure with water level adjustment (adapted from Vymazal et al., 2009).*

PART 2

# Case studies

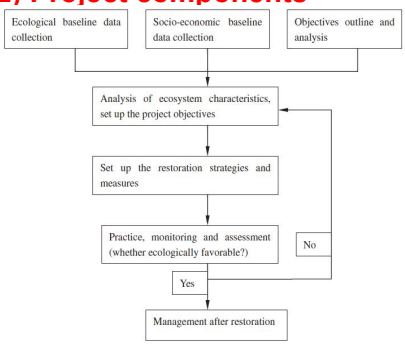
- **Four case studies detailing the design, implementation modalities, results and services of wetland and species in removing nutrients from the projects, and cost-benefits of such projects.**
  - 1) Coastal wetland restoration project on Wuyuan Bay,Xiamen, Fujian.
  - 2) Ningbo water and environment project, Zhejiang Province, China
  - ***3) Reed restoration for the salinized soil in Yellow River Delta, Shandong Province, China***
  - ***4) Use species and aquaculture to achieve the co-benefits of sustainable harvest and environmental performance in China***

# Case 1. Coastal wetland restoration project on Wuyuan Bay,Xiamen, Fujian Province, China

## 1)The objectives of the project

In order to restore the wetland and improve the sustainable development in coastal area around Wuyuan Bay, Xiamen.

## 2) Project components



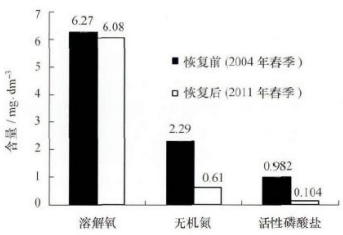
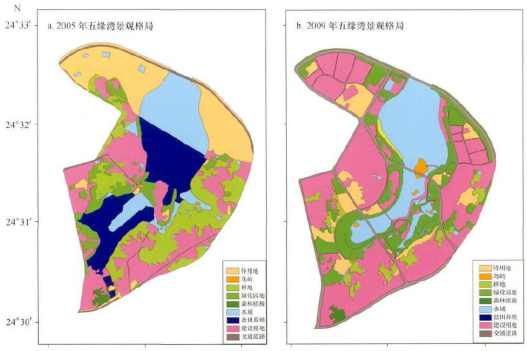




图2 五缘湾生态恢复前后水质变化

Fig. 2 Changes of seawater quality before and after Wuyuan Bay restoration




Changes of landscape before and after Wuyuan Bay restoration

| 时间 | 沉积物中各重金属的含量 | | | | |
|---|---|---|---|---|---|
| | 有机碳/% | 硫化物/mg·kg⁻¹ | 铜/mg·kg⁻¹ | 锌/mg·kg⁻¹ | 铅/mg·kg⁻¹ |
| 恢复前(2004 年春季) | 3.8 | 1 725.4 | 216.9 | 669.5 | 1.67 |
| 恢复后(2011 年春季) | 0.7 | 80.4 | 20.0 | 88.1 | 0.08 |

## 3) Results and service improvement

① The water in Wuyuan Bay after the restoration was generally of above Grade 2 water quality.

② Recreation of the ever-existed wetland has achieved a beautiful wetland park with high plant diversity and more birds.

③ At the same time, with the improvement in ecological quality, the value of the land near Wuyuan Bay has increased a lot.

The view of Wuyuan Bay in 2008 after restoration

# Case 2. Ningbo water and environment project, Zhejiang Province, China

## The objectives of the project

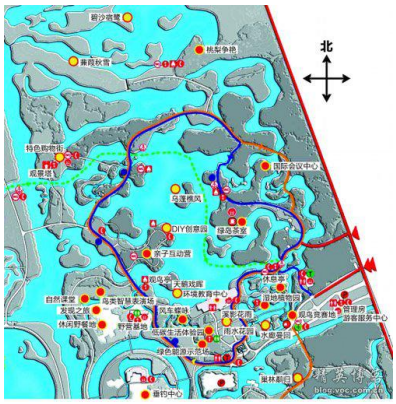
1) Restore, enhance and protect estuarine and freshwater habits;
2) Establish a center for promoting public education and scientific research;
3) Offer eco-tourism opportunities;
4) Control water pollution.

## Project components:

1) Constructed Wetland **(US$7.12 million)**
2) Establishment of a Wetland Center **(US$8.0 million)**
3) Design and Management Assistance **(US$2.0 million)**

## Results and service improve:

1) Reduce land-based pollution along the Cixi coast and the East China Sea,
2) promote the replication of innovative, simple and effective wastewater treatment techniques, and encourage coastal zone conservation.
3) Biological Oxygen Demand/Nitrogen, and Phosphorous had reduced largely.



**Project designs**

**The view of Cixi Wetland after restoration**

# Case 3. Reed restoration for the salinized soil in Yellow River Delta, Shandong Province, China

## The objectives of the project

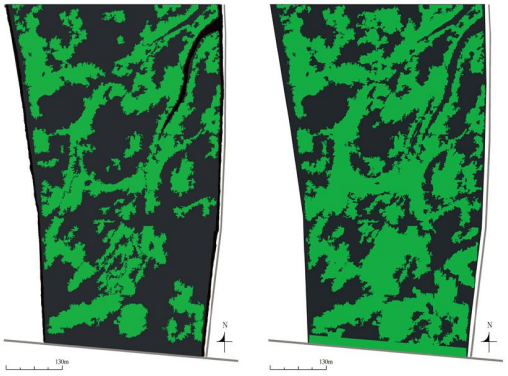
In order to restore the wetland and improve the ecosystem service and sustainable development in Yellow River Delta, especially for the salinized soil.

## Project components

1) Rapid desalination technology for soil in saline area (e.g. flushing freshwater, water management);
2) Natural restoration technology of reed wetland in saline mudflat (e.g. restore the hydraulic connection, and washing the sal);
3) Breeding and cultivation techniques of reed in saline area (including seedling transplanting, rhizome reproduction,reproduction by the adult plants).

## Results and service improve:

1) The restoration changed the vegetation community characteristics and the dominant species succession, and enhance the reed and river crab production;
2) Reed management can greatly enhance the carbon sequestration for coastal wetland.



盐地碱蓬—芦苇群落

光板地与盐地碱蓬群落

芦苇*Phragmites communis*

盐地碱蓬*Suaeda heteroptera*

# Case 4. Use species and aquaculture to achieve the co-benefits of sustainable harvest and environmental performance in China

## The objectives of the project

The recycling of aquaculture wastewater can not only reduce the pollution, but also achieve energy conservation and resource utilization.

**Design of aquaculture methods and selection of aquaculture species ( e.g. multi-culture mode)**

## Project components

1) Selection of salt-tolerant and anti-fouling organisms;
2) Construction of ecological farming model (muti-culture mode);
3) Regulating water quality using ecological floating beds;
4) Ecological restoration technology for aquaculture pollution, including restoration of shrimp pond bottom environment, Ecological restoration of coastal wetlands in aquaculture areas(e.g.Mangroves plantation,Large seaweed plantation)

**Regulating water quality using eclogical floating beds (aquatic plants)**

## Results and service improve:

1) Reduce pollution to the offshore;
2) Economic efficiency improvement;
3) Significant ecological benefits.

**Restoring aquaculture pond bottom environment by plantion of different plants**

PART 3

# Recommendations

## 1) Use of wetland in urban planning to increase the regulation services from wetlands

## 2) Designate marine parks to better conserve and wise use of coastal wetlands

- In China, the newly established State Forestry and Grassland Administration (SFGA) was authorized to unify the designation and management of all kinds of protected areas including the marine parks and wetland parks. It's believed that the development of marine parks in China will be faster and more efficient.
- RO Korea has also designated different types of marine protected areas to protect the coastal wetlands over the past decade. Nowadays, RO Korea has designated 23 RAMSAR sites to conserve the waterbirds and habitats.
- More and more marine parks were designated and manged along the coast of YSLME, the biodiversity and marine landscape were protected, as well as the scientific research, environmental education and the development of leisure entertainment.

# 3.3 Recommendations

- **3) Restore coastal wetland to enlarge the potential nutrient sink areas**
  - Potential priority areas to carry out restoration projects (China)
    - In 2016, Ministry of Finance (MOF) and SOA approved 18 projects of "Blue Bay", "South Mangroves and North Tamarix" and "Ecological Islands and Reefs" in different cities.
    - On April 2019, MNR and MOF approved that the restoration projects from 10 cities.

**Cities in Yellow Sea Region that implementing "Blue Bay" Projects**

| Provinces | No. of Cities | List of Cities (Year of being approved) |
|---|---|---|
| Liaoning | 4 | Dalian (2016); Panjin (2016); Jinzhou(2016); Dandong (2019) |
| Hebei | 1 | Qinghuangdao(2016) |
| Shandong | 4 | Yantai(2016); Weihai (2016,2019); Qingdao(2016, 2019); Rizhao(2016,2019); |
| Jiangsu | 1 | Lianyungang(2016) |
| Zhejiang | 3 | Ningbo(2016); Wenzhou(2016;2019); Taizhou(2019) |

# 3.3 Recommendations

- **3) Restore coastal wetland to enlarge the potential nutrient sink areas**
  - Potential priority areas to carry out restoration projects (RO Korea)
    - on 9th July 2018, Minister of the Ministry of Ocean and Fisheries of RO Korea announced the ‘Mid and Long-Term Ocean Restoration Plan for 2019 - 2023’ that will expand the target area for tidal flat restoration projects, the reinforcement of project management system and enlarge the incentive in restored area to revive the value of tidal flats.

| No. | Regional | Local | Site | Type | Commencement (predicted) |
|---|---|---|---|---|---|
| 1 | Incheon City (3) | Ongjin county (1) | Sido island and Modo island | seawater circulation (A) | Continued (2017~) |
| 2 | | Ghanghwa county (2) | Seon doo Ri | seawater circulation (B) | 2020 |
| 3 | | | Choji Ri | mudflat restoration | 2022 |
| 4 | Gyeonggi Province (1) | Hwasung city (1) | Baekmi Ri | seawater circulation (B) | 2021 |
| 5 | Chungnam Province (6) | Seosan city (2) | Gopa island | mudflat restoration | Continued (2017~) |
| 6 | | | Ungdo Ri | seawater circulation (A) | 2021 |
| 7 | | Seocheon county (1) | Yubu island | mudflat restoration | Continued (2017~) |
| 8 | | Taean county (2) | Dangsan4 Ri | mudflat restoration | 2020 |
| 9 | | | Nae Ri | mudflat restoration | 2022 |
| 10 | | Boryeong city (1) | Docksan Ri | seawater circulation (A) | 2019 |
| 11 | Jeollabukdo Province (2) | Gochang county (2) | Gojeon Ri | mudflat restoration | Continued (2017~) |
| 12 | | | Jaryoung Ri | seawater circulation (B) | 2023 |
| 13 | Jeollanamdo Province (11) | Sinan county (4) | Suchi island and Sangsuchi island | seawater circulation (A) | 2023 |
| 14 | | | Jonpo Ri | seawater circulation (A) | 2023 |
| 15 | | | Hwangma island and Maehwa island | seawater circulation (A) | 2021 |
| 16 | | | Goi isalnd | seawater circulation (B) | 2020 |
| 17 | | Muan county (2) | Yuwol Ri | seawater circulation (B) + mudflat restoration | 2019 |
| 18 | | | Seongnae Ri | seawater circulation (B) | 2023 |
| 19 | | Wando county (1) | Soan island | mudflat restoration | 2020 |
| 20 | | Gangjin county (1) | Beoljeong Ri | seawater circulation (B) | 2022 |
| 21 | | Boseong county (1) | Jeonil Ri | seawater circulation (B) | 2022 |
| 22 | | Suncheon city (2) | Guryong Ri | mudflat restoration | 2020 |
| 23 | | | Masan Ri | mudflat restoration | 2022 |

# 3.3 Recommendations

- **4) Enhance investment to strengthen the coastal wetland conservation and restoration**
  - Investment from governments (e.g. central or local governments)
  - Investment from governments (e.g. from private companies, agencies and organizations, or ecological compensation mechanisms)

- **5) Raise the public awareness to support the construction or restoration of wetlands**

*It's obvious that the costs for manmade wetland construction and coastal restoration projects are rather high. For example, in the case of Ningbo Water and Environment Project, the costs for constructed wetland, establishment of a wetland center, design and management assistance were estimated to US$7.12 million, US$8.0 million, US$2.0 million, respectively. Hence, it's very important to take the costs and benefits (including social, ecological and economic benefits) into account before planning or applying for the financial resources.*


THANKS