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South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

Overview of Aquaculture in China & case study of Ecological Intensification

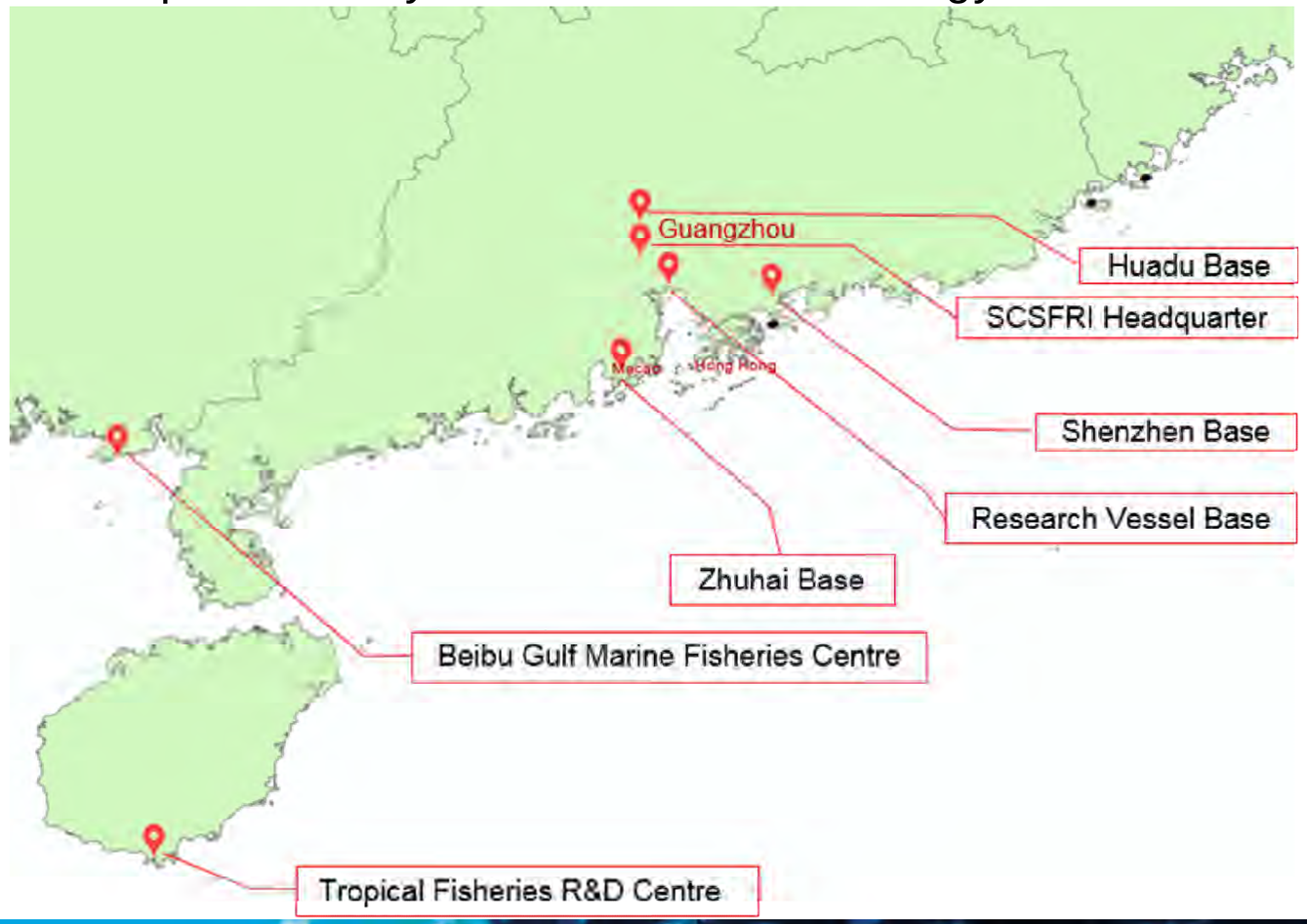
Changbo Zhu

This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773330 (GAIN)

About SCSFRI

South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences

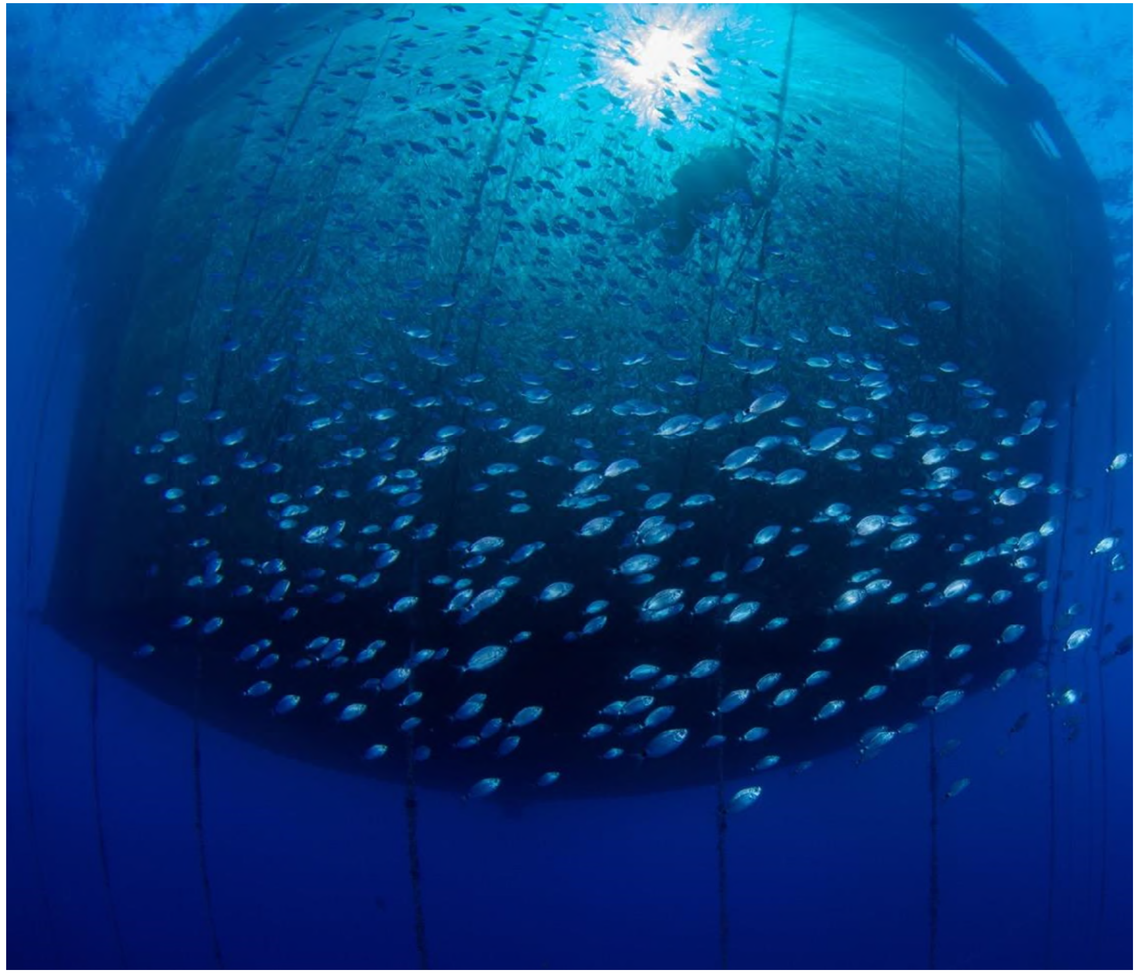
SCSFRI-South China Sea Fisheries Research Institute, CAFS (founded in 1953) is located in Guangzhou, China. It is a non-profit national scientific research agency focused on tropical & subtropical fishery sciences and technology.



Contents

- Overview of Aquaculture in China
- History, Production, Species, Mode, Area
- New technology and tendency

- Ecological Intensification case study
- An ex situ Shrimp-Rice aquaponic system
- Application in the inland saline-alkali areas

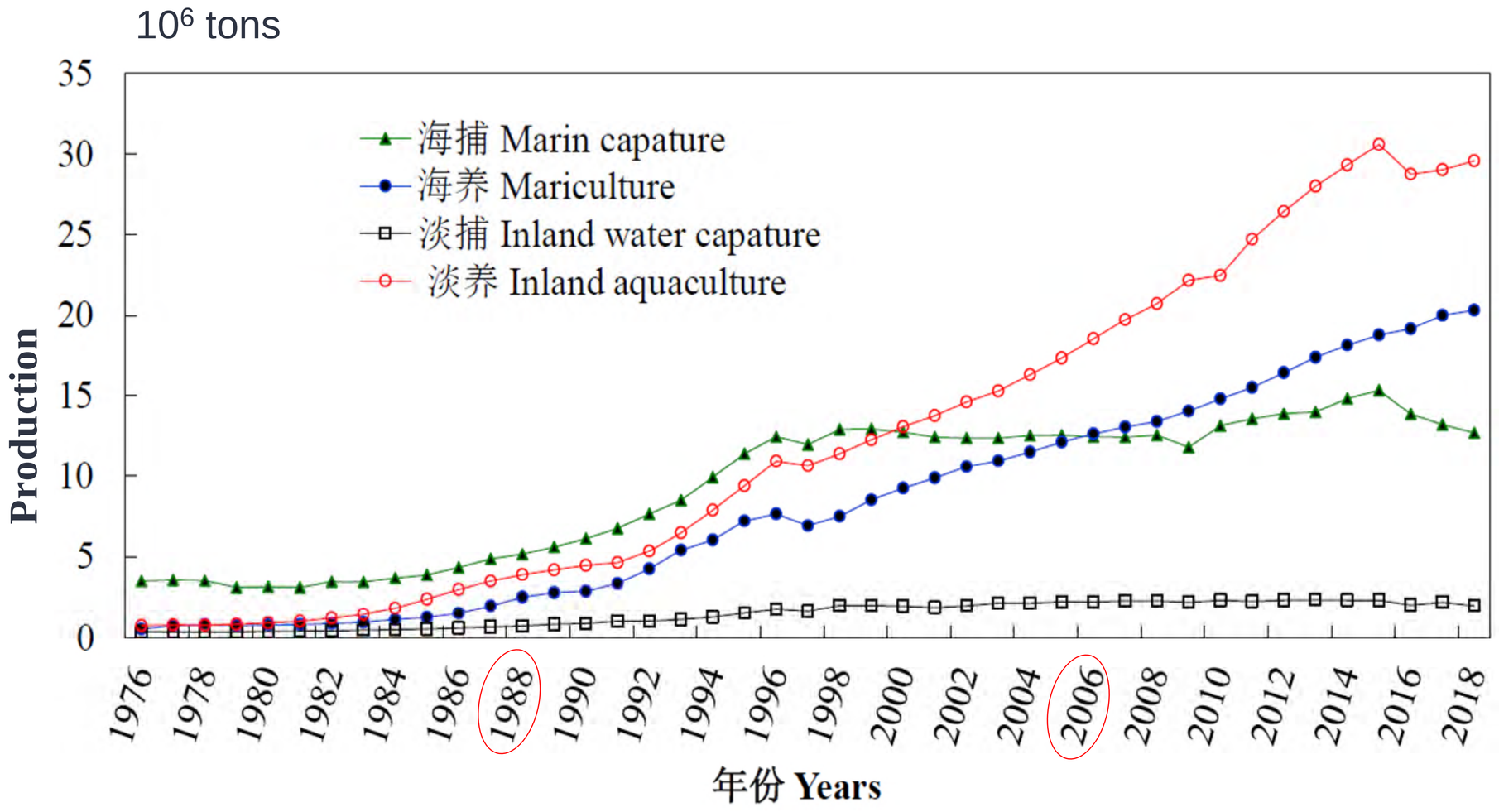


Brief history of Aquaculture development in China

460 BC, Fan Li wrote the world’s first monograph book on artificial fish farming.

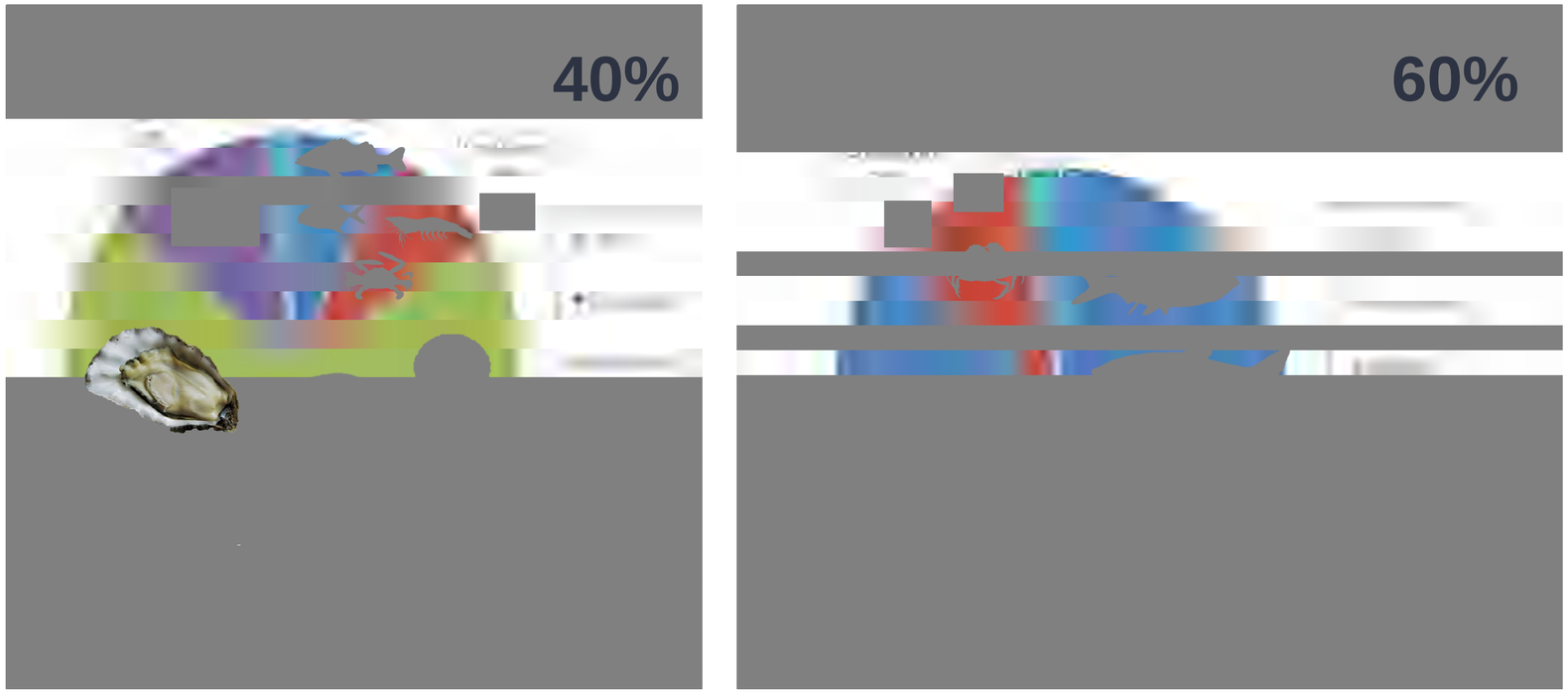
Video by Nutriera Ltd.

Fishery Production in China



- Fisheries provide 1/3 animal protein for 1.4 billion people.
- Aquaculture is the only source of fishery production increment for China market.

Composition of China’s aquaculture production (2019)

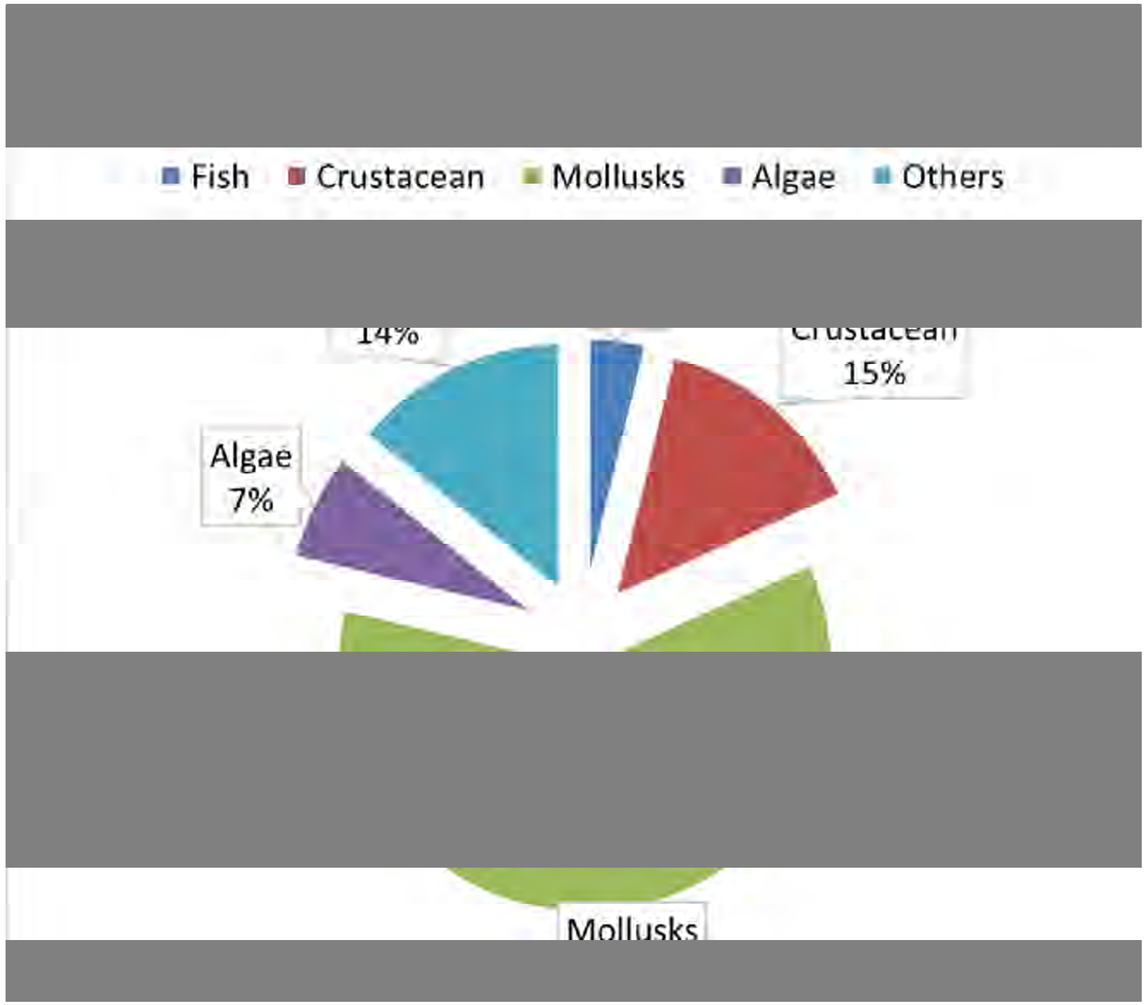


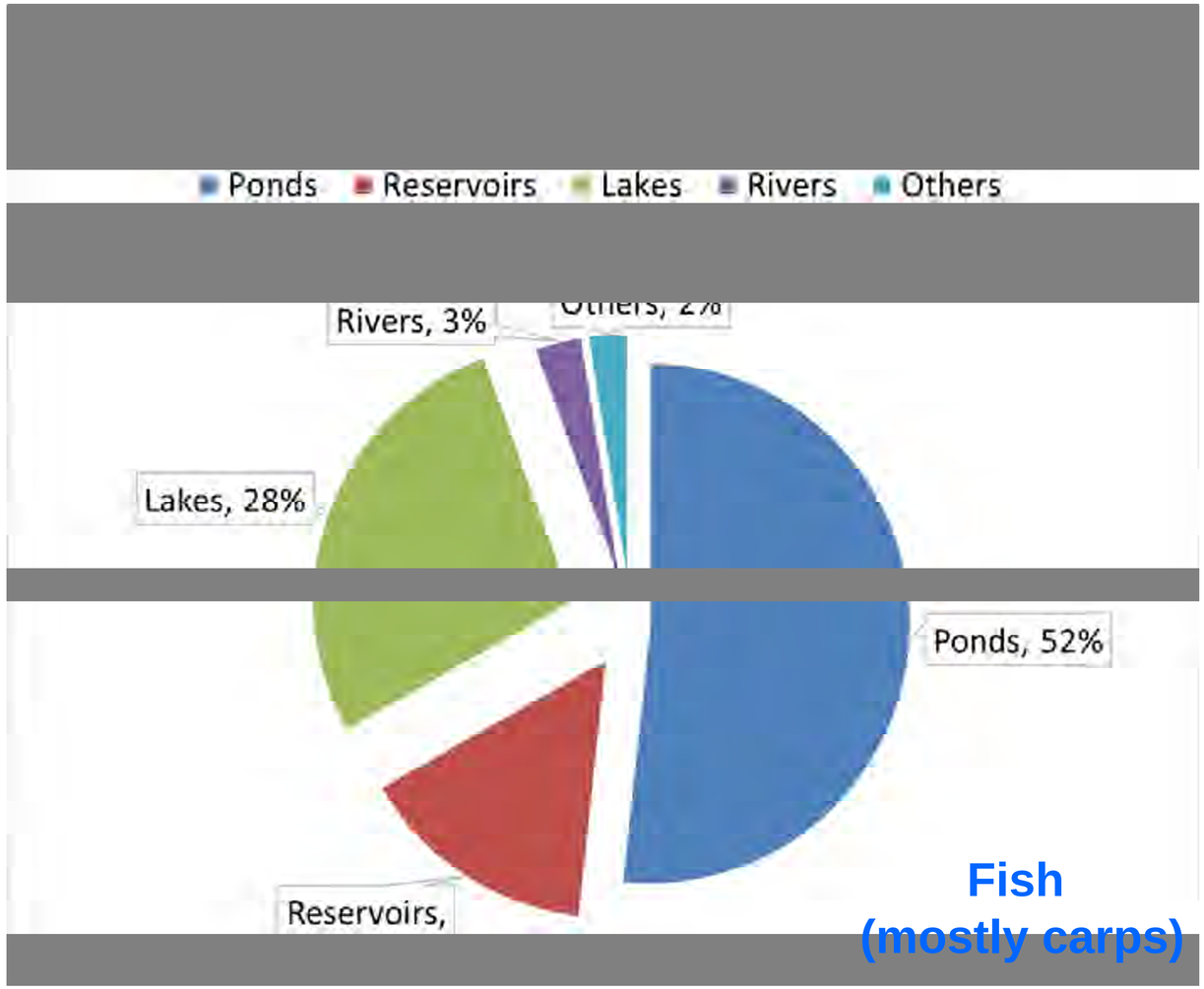
Aquaculture species

Local: > 280
Introduced: > 80
Artificial bred:~ 200
Total: **>550**

Large portion of low trophic level species, low feed cost.
Large carbon credit.

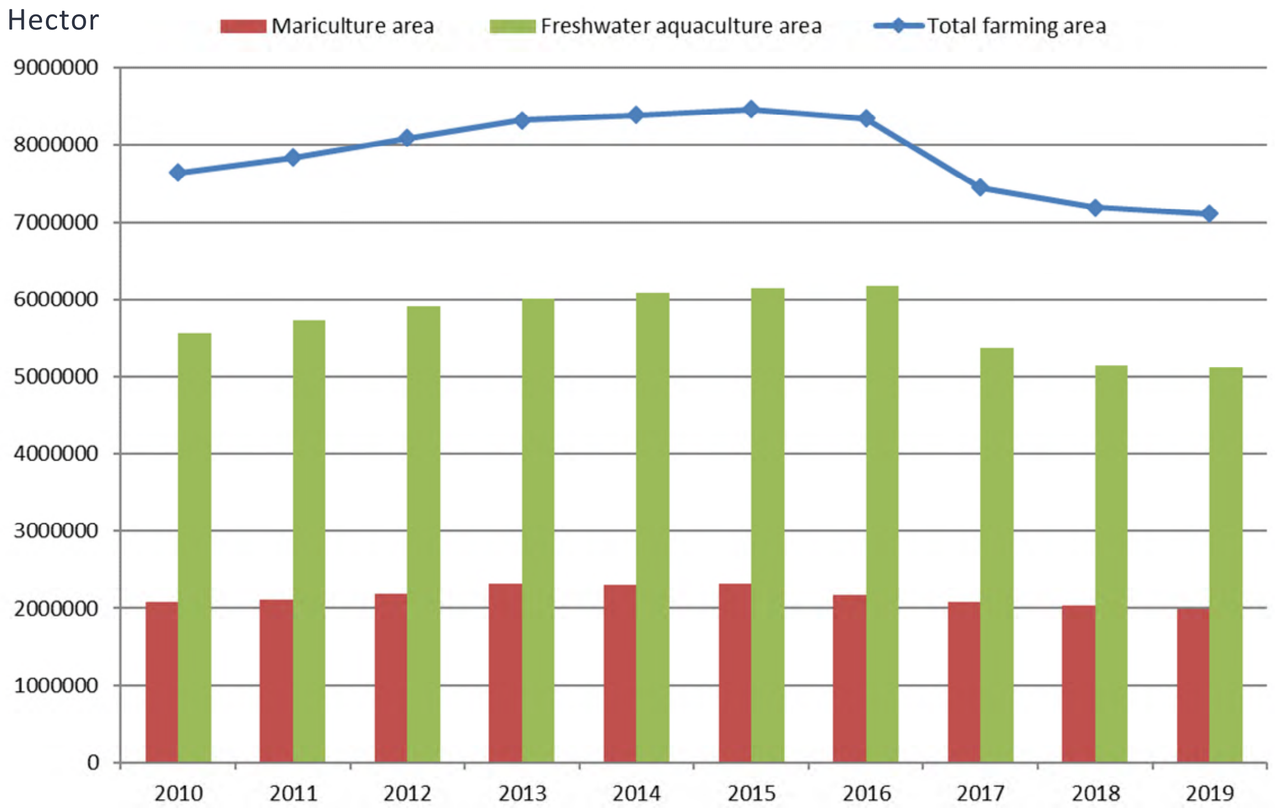
Aquaculture area distribution (2019)





Fish (mostly carps)

Aquaculture area of China



Total aquaculture area (Year 2019) ≈ 75, 000 km²

~Scotland, Czech

中华人民共和国农业农村部
Ministry of Agriculture and Rural Affairs of the People's Republic of China

2021-08-27

National plan for water areas of aquaculture (by 2030)

Water Type	**Area** (10^3 km^2)
Approved	233
Restricted	413
Prohibited	520

1. Reservoirs are no longer allowed for aquaculture.
2. Aquaculture waste water must be treated before discharge.

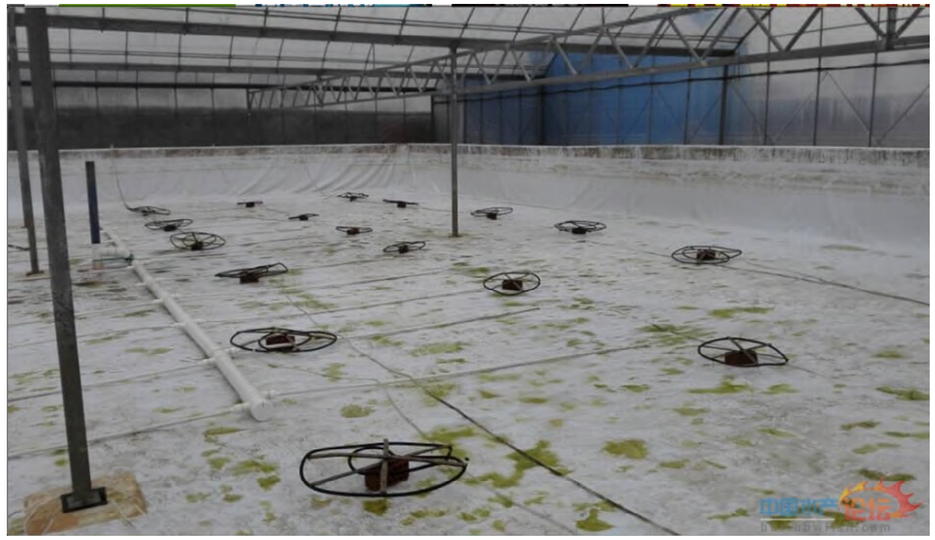
New aquaculture technology

- Biofloc system
- Far off-shore mariculture
- Inland saline-alkali waters farming

Developing tendency

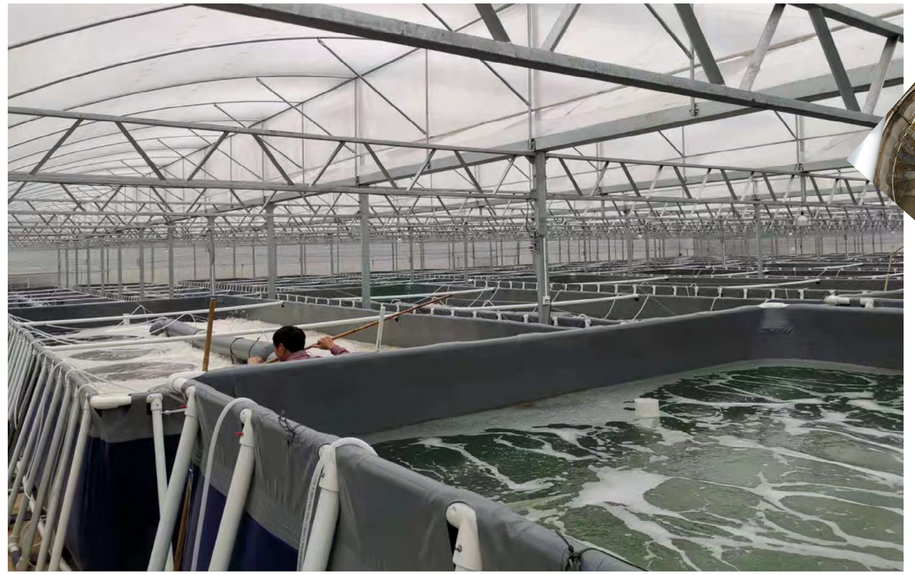
- Far off-shore
- Aqua-agriculture (aquaponics)
- Intensive IMTA (coastal)
- Filter-feeding aquaculture (lakes)
- RAS

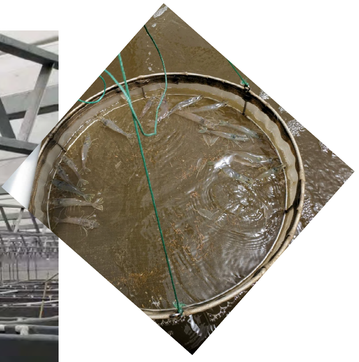
Bio-floc Technology，BFT



Nantong,Jiangsu

Yangjiang,
Guangdong





Aqua-agriculture systems (aquaponics)

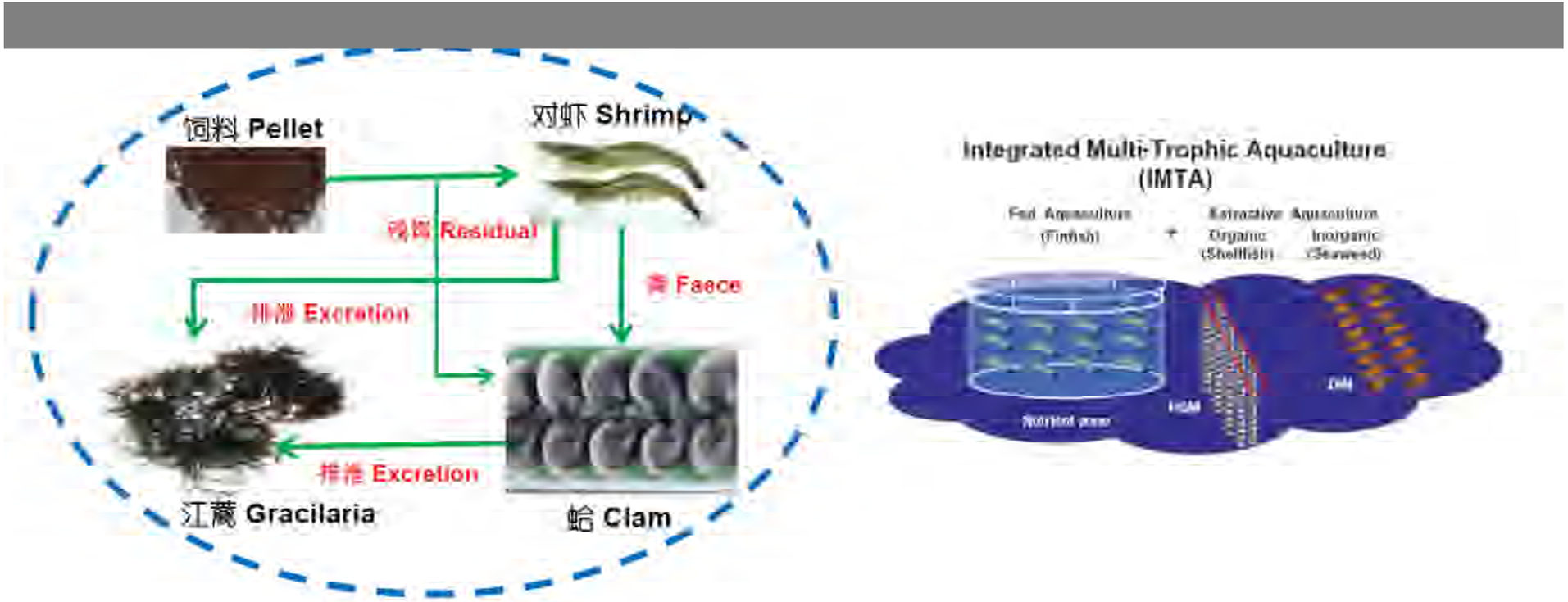
Traditional way with intensification

Rice field fish farming

Mulberry field - fish ponds system

Sugar cane field – fish ponds system

Intensive IMTA (ecological intensification)



将投饵养殖动物以一定的比例与非投饵养殖动物和植物混养，使一种养殖生物的副产出成为另一生物的输入物（肥料、食物、能量）。

In these systems the waste of one species is another's food or nutrition.

Blooming of offshore and far offshore mariculture in China

Deep Blue 1, Shandong, 2018

Zhenyu 1, Fujian, 2019

Dehai 1,Guangdong, 2018

Changjing 1, Shandong, 2019

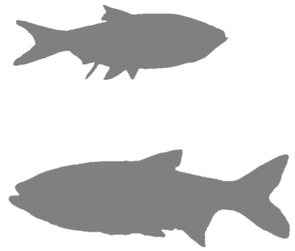
Genghai 1, Shandong, 2020

Penghu, Guangdong, 2019

Large scale filter-feeding aquaculture in lakes

Major species:

- Silver carp
- Big head carp



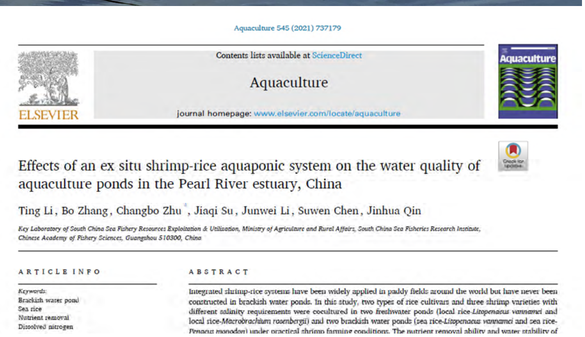
Advantages:

- Zero feed input
- Water quality improvement

Progress of an ex situ Shrimp-Rice aquaponic system

Case study of ecological intensification in land-based aquaculture

Ting Li, Bo Zhang, Changbo Zhu*, Jiaqi Su, Junwei Li, Suwen Chen, Jinhua Qin, 2021. Effects of an ex situ shrimp-rice aquaponic system on the water quality of aquaculture ponds in the Pearl River estuary, China. Aquaculture, 545 (2021) 737179. DOI: https://doi.org/10.1016/j.aquaculture.2021.737179



Aquaculture 545 (2021) 737179

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Effects of an ex situ shrimp-rice aquaponic system on the water quality of aquaculture ponds in the Pearl River estuary, China

Ting Li, Bo Zhang, Changbo Zhu*, Jiaqi Su, Junwei Li, Suwen Chen, Jinhua Qin

Key Laboratory of South China Sea Fishery Resources Exploitation & Utilization, Ministry of Agriculture and Rural Affairs, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China

ARTICLE INFO

Keywords:
Brackish water pond
Sea rice
Nutrient removal
Dissolved nitrogen

ABSTRACT

Integrated shrimp-rice systems have been widely applied in paddy fields around the world but have never been constructed in brackish water ponds. In this study, two types of rice cultivars and three shrimp varieties with different salinity requirements were cocultured in two freshwater ponds (local rice-*Litopenaeus vannamei* and local rice-*Macrobrachium rosenbergii*) and two brackish water ponds (sea rice-*Litopenaeus vannamei* and sea rice-*Penaeus monodon*) under practical shrimp farming conditions. The nutrient removal ability and water stability of

Intensive seabass aquaculture ponds in pearl river delta

Intensive shrimp farms on the coast of Guangxi

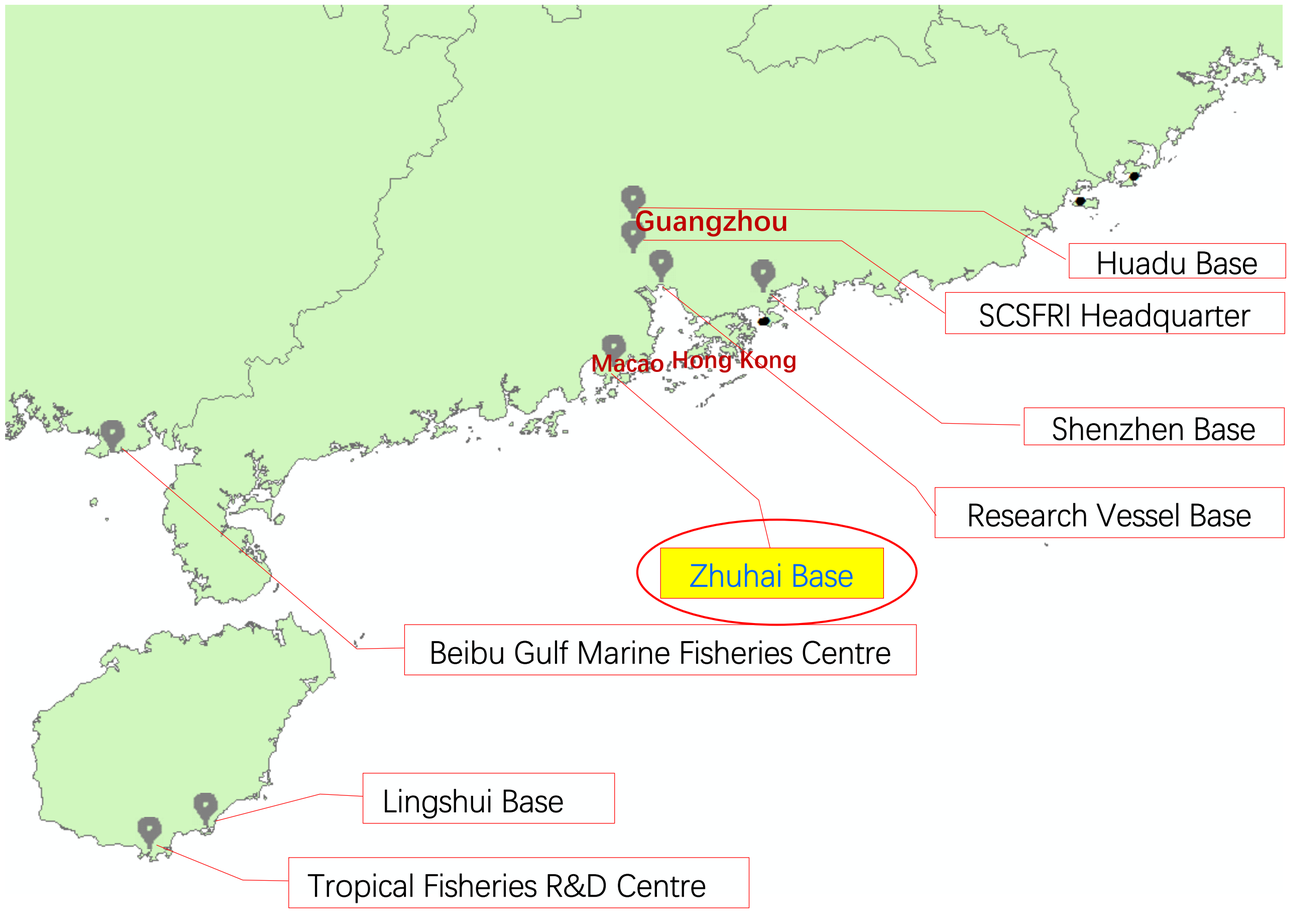
Shrimp pond-paddy field combined farming

Background:

Intensive monoculture is the dominant shrimp farming style in China and all over the world. It has three major **problems**:

- Eutrophication of pond water and effluent.
- Decreased survival and growth of shrimp.
- High risk of shrimp diseases outbreak.

Site of the pilot: Zhuhai Base



Scenario 1

Principle of pond-paddy co-culture

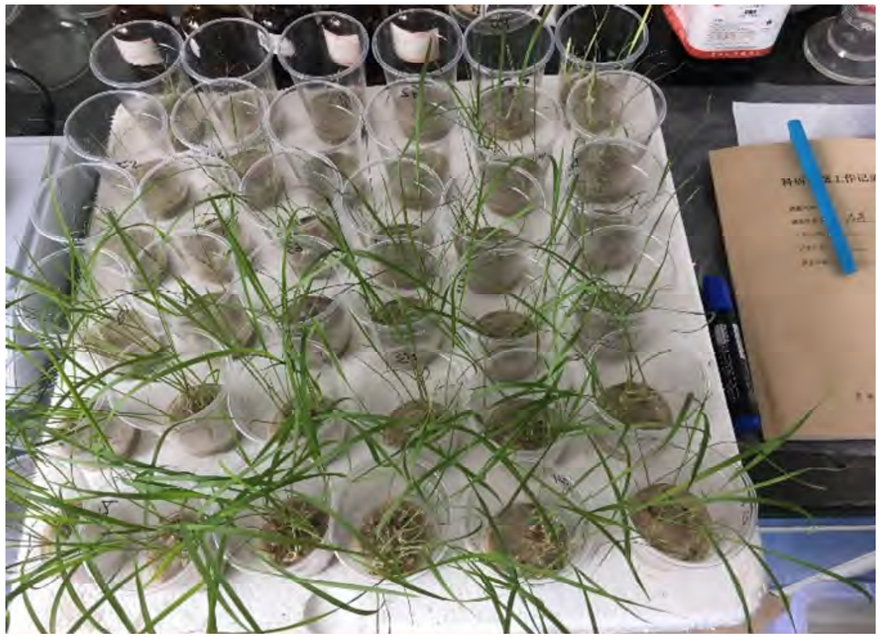
Benefits:

- Particle sediments (shrimp faeces and uneaten feed) from pond be pumped into paddy field as base fertilizer for rice seedling.
- Dissolved nutrients from pond be absorbed by rice, make sure good and stable water quality.
- Better survival and growth of shrimps.
- Double harvest: shrimp **+** rice.
- Zero discharge of wastes.
- …….

Brackish water

Choose the appropriate rice species

Common rice (< 3 ppt)

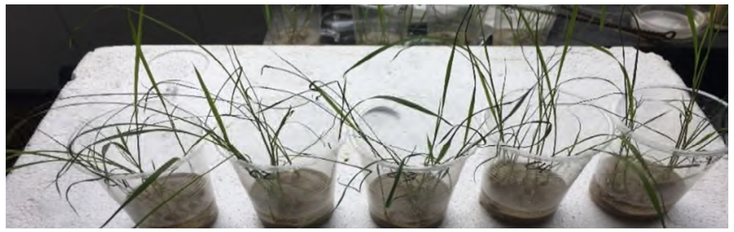


Saline rice (< 9 ppt)

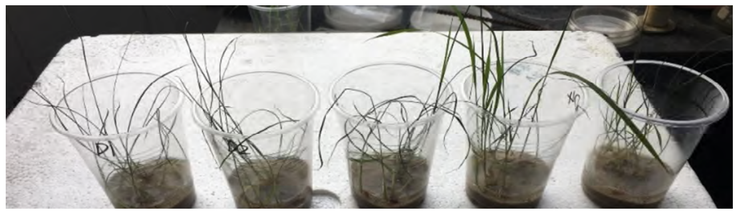
Growth test for saline rice at different salinities

T1：3‰

T2：6‰

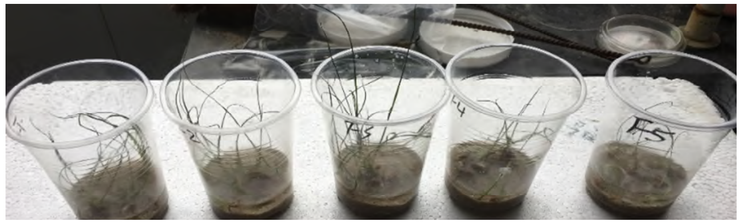


T3：9‰

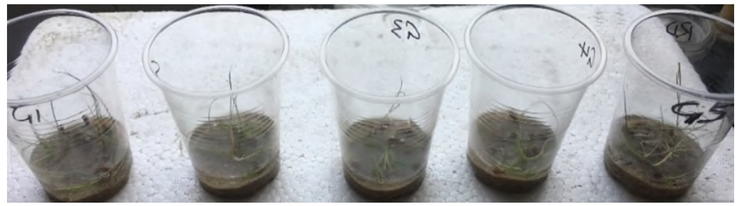


T4：12‰

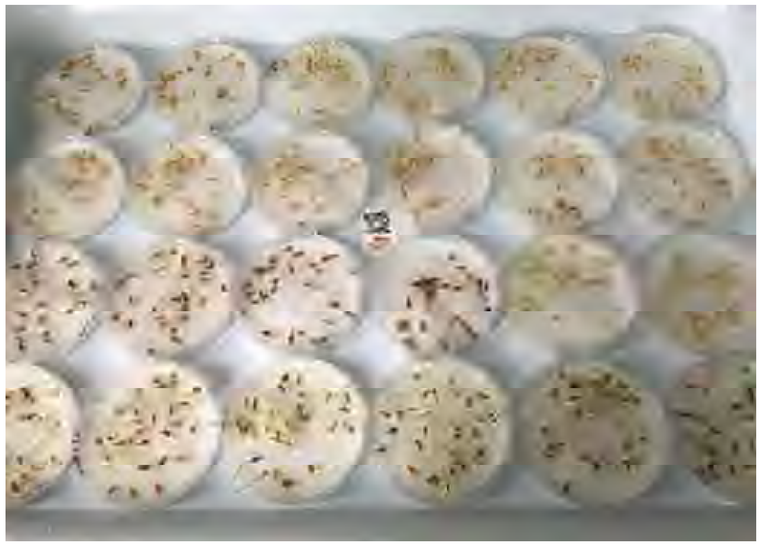
T5：15‰



T6：20‰



Salinity lower than **6‰** is suitable for saline rice, and it could endure short term salinity over 9.



Journal of Southern Agriculture

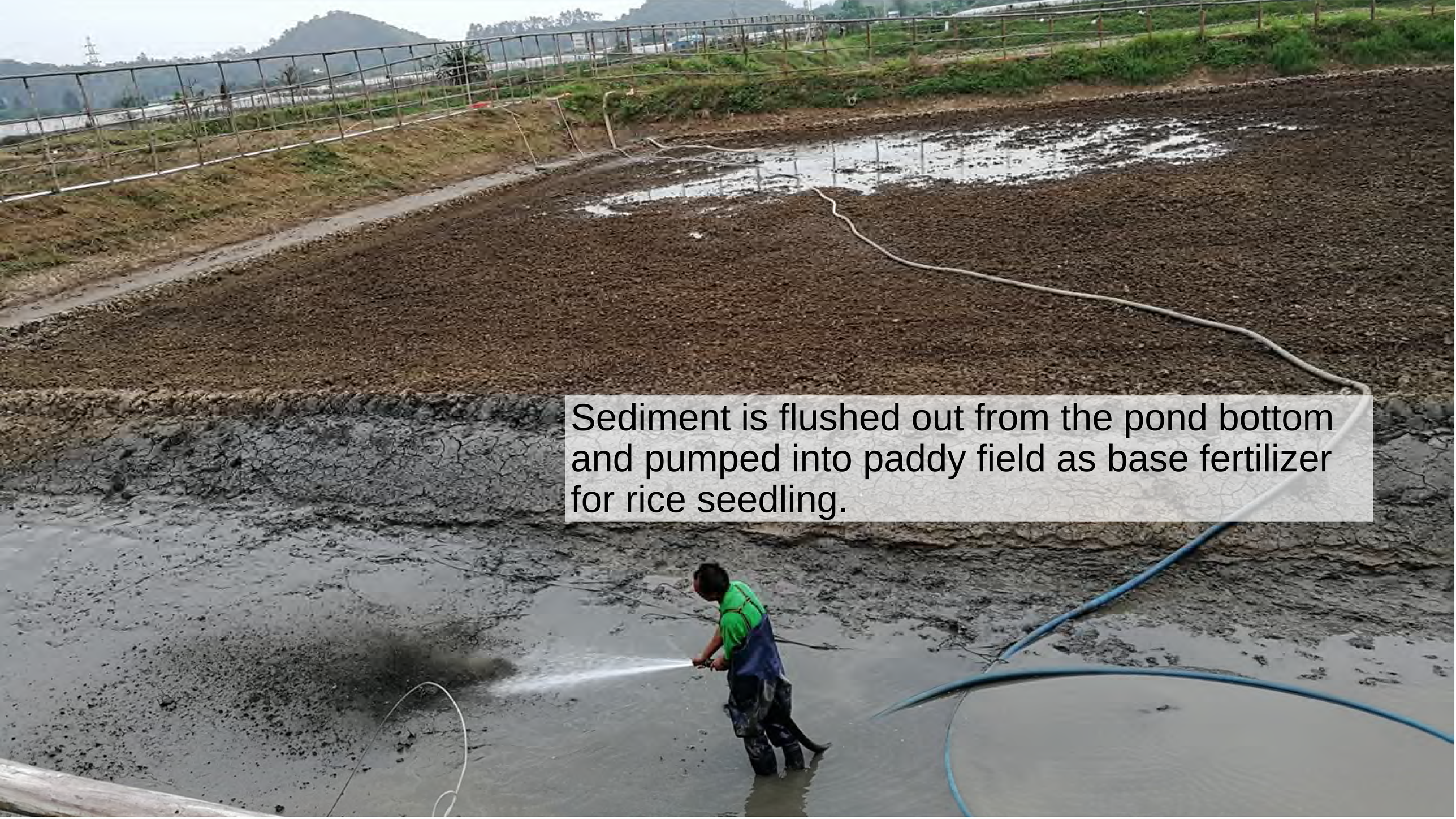
Effects of seawater stress on seed germination and seedling growth of Sea rice 86

LI Ting, ZHU Chang-bo*, LI Jun-wei, CHEN Su-wen, XIE Xiao-yong

(South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences/Key Laboratory of South China Sea Fishery Resources Exploitation & Utilization, Ministry of Agriculture and Rural Affairs, Guangzhou 510300, China)

Abstract:【Objective】The effects of salt stress on seedling growth of a new salt-tolerant rice variety (Sea rice 86) at seedling stage were explored, which provided scientific basis for the development and application of salt-tolerant rice and for the construction of fish-rice farming mode in low-salinity ponds. 【Method】Water culture experiment was conducted on Sea rice 86 during seed germination and seedling stages. Distilled water (0 salinity) was as control, and a series of seawater stress treatments (3‰, 6‰, 9‰, 12‰, 15‰ and 20‰) were simulated. Then the seed germination status (germination rate, germination potential, germination index and vigor index) and the morphological characters of seedlings (root length, stem length, leaf length and biomass allocation of plant organs) were investigated to analyze the response of sea rice to salt stress and its adaptation range to the salinity of seawater. 【Result】Seed activity of Sea rice 86 were promoted in low-salinity treatments but inhibited in high-salinity treatments. Seed germination rate, germination potential, germination index and vigor index reached its highest level in 3‰ treatments, then gradually declined as the salinity increased. With the increase of salinity in seawater nutrient solution, the seed germination and seedling growth of Sea rice 86 were adversely affected, growth indicators such as shoot length, seedling height, length of leaf and root, biomass, shoot to root ratio de-

Structure of the co-culture system


Sediment is flushed out from the pond bottom and pumped into paddy field as base fertilizer for rice seedling.

Rice seedling

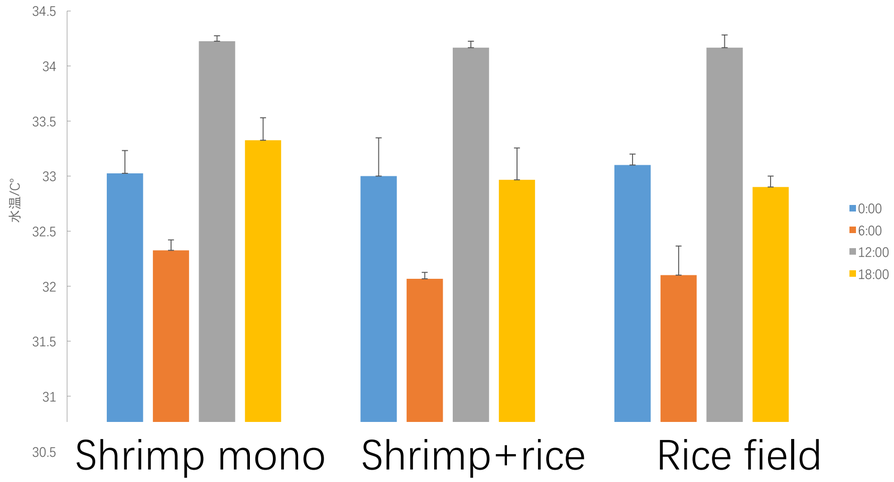
Shrimp seeding

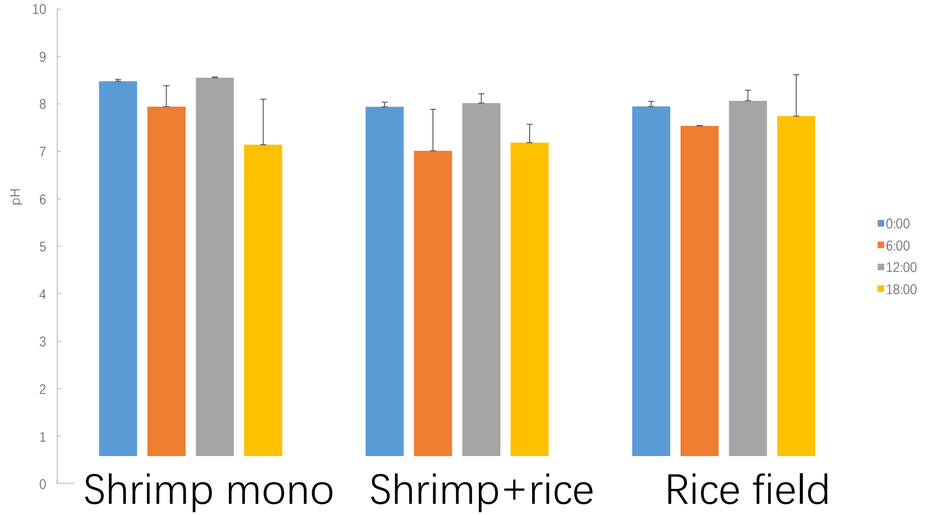
Feeding

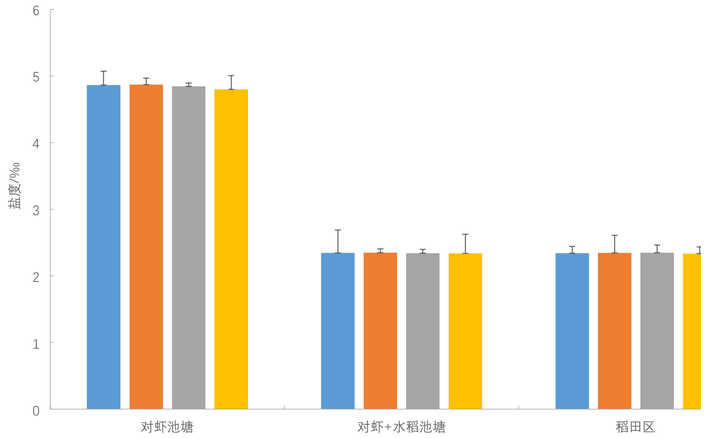
Heading of the saline rice

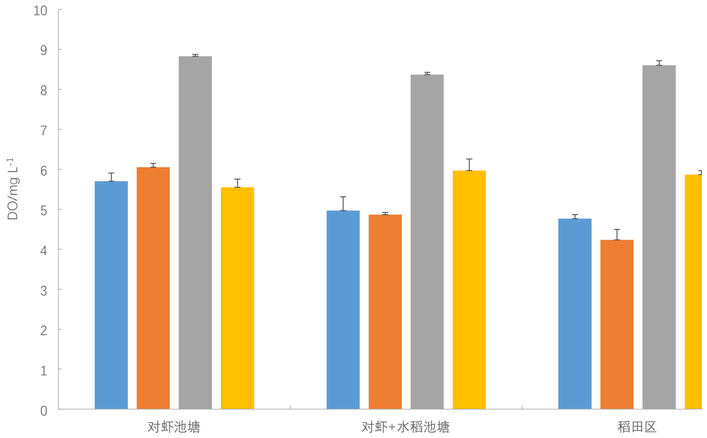
Good water quality for good survival and growth of shrimps.

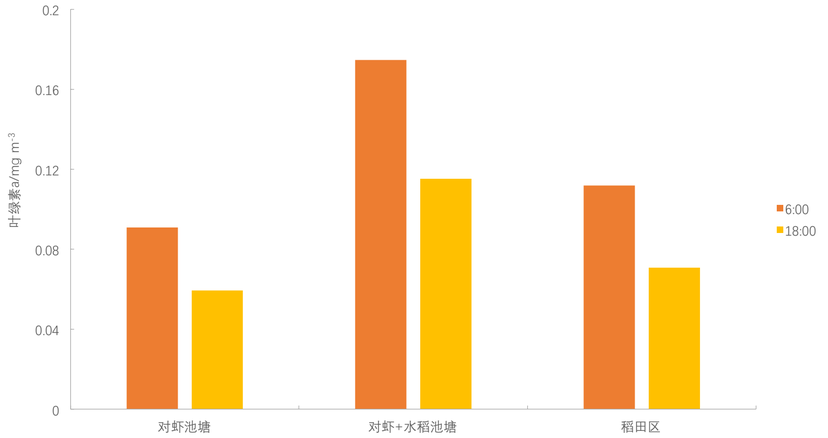
Apparent indexes: no significant difference





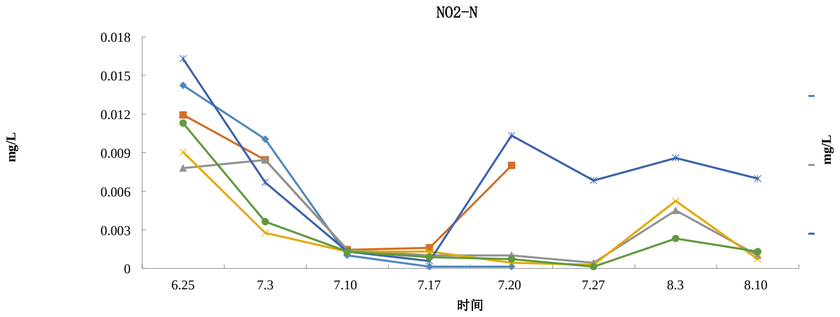


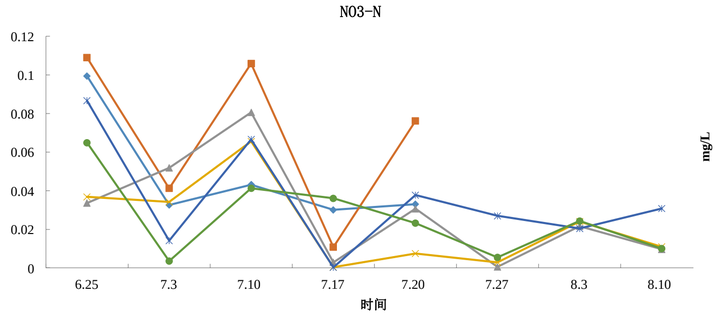


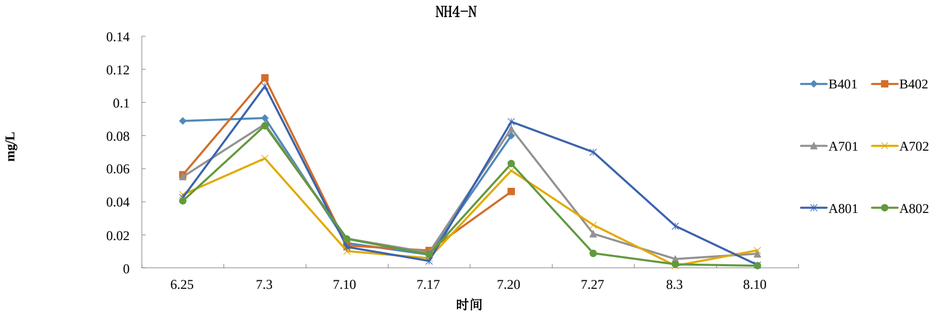


Nutrient content in pond water: big difference

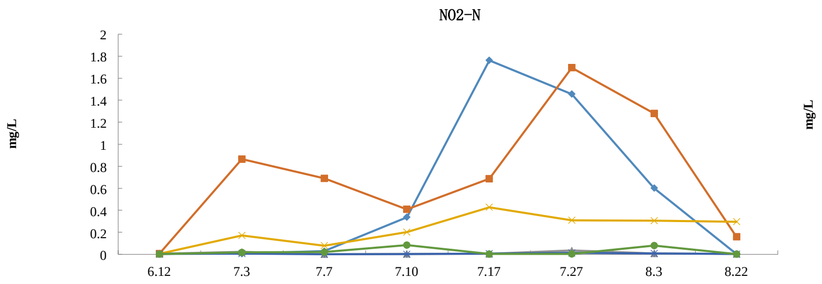
Co-culture

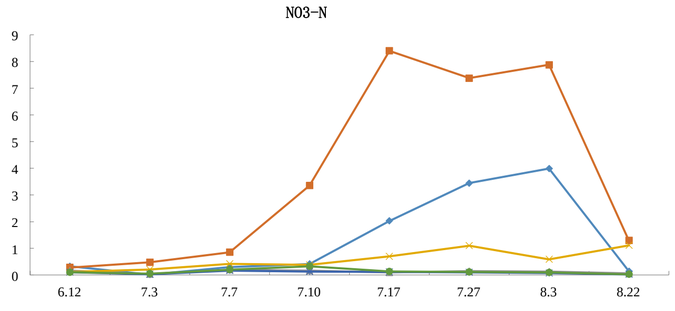


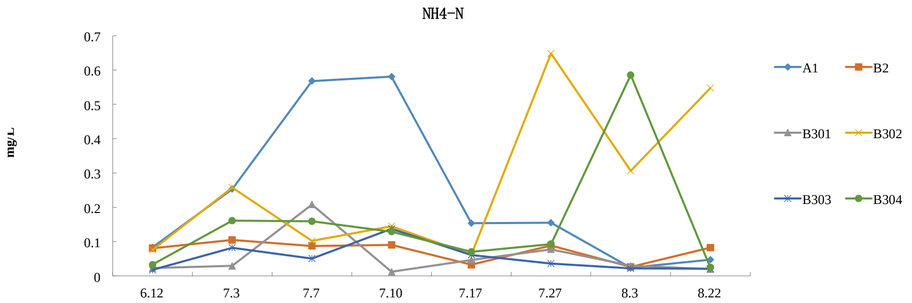




Shrimp monoculture

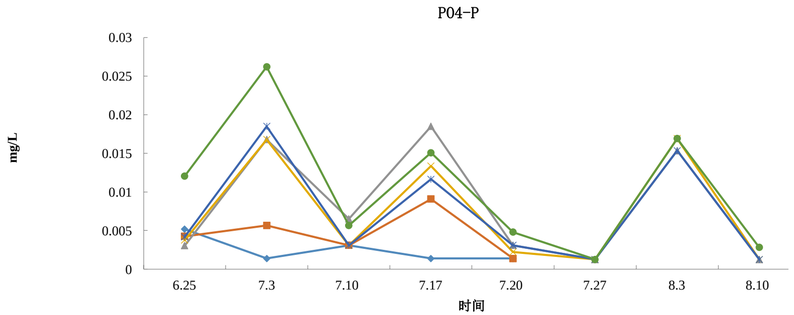


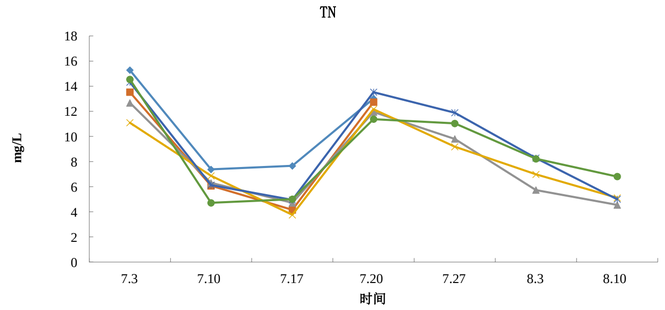


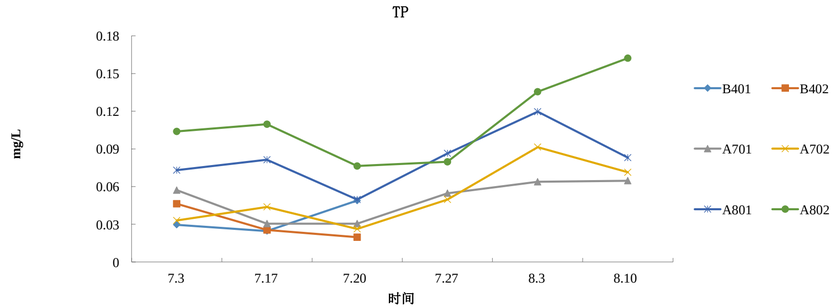


- Pacific white shrimp + Saline rice: Pond B401, B402, A701, A702, A801, A802
- Pacific white shrimp monoculture: Pond A1, B2
- Tiger shrimp monoculture: Pond B301, B302, B303, B304

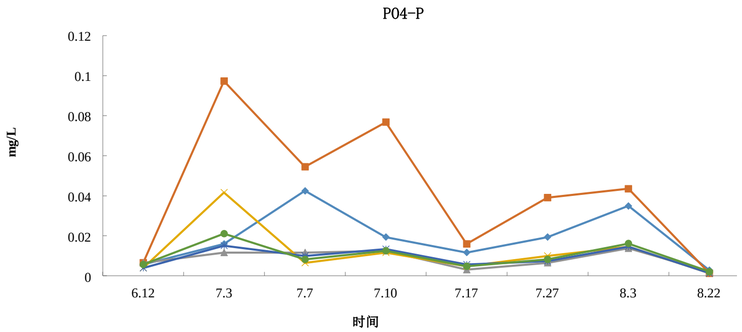
Co-culture

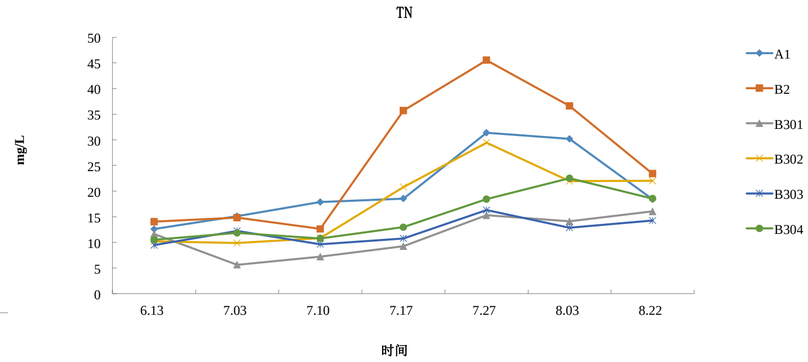


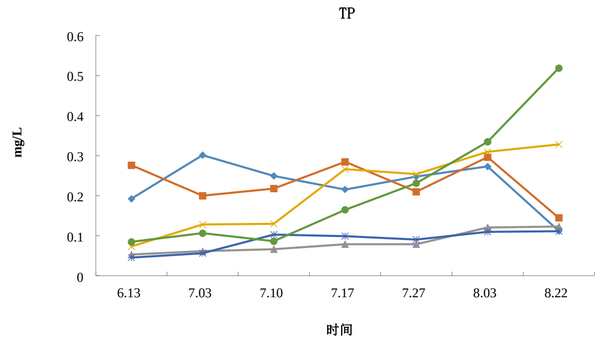




Shrimp monoculture







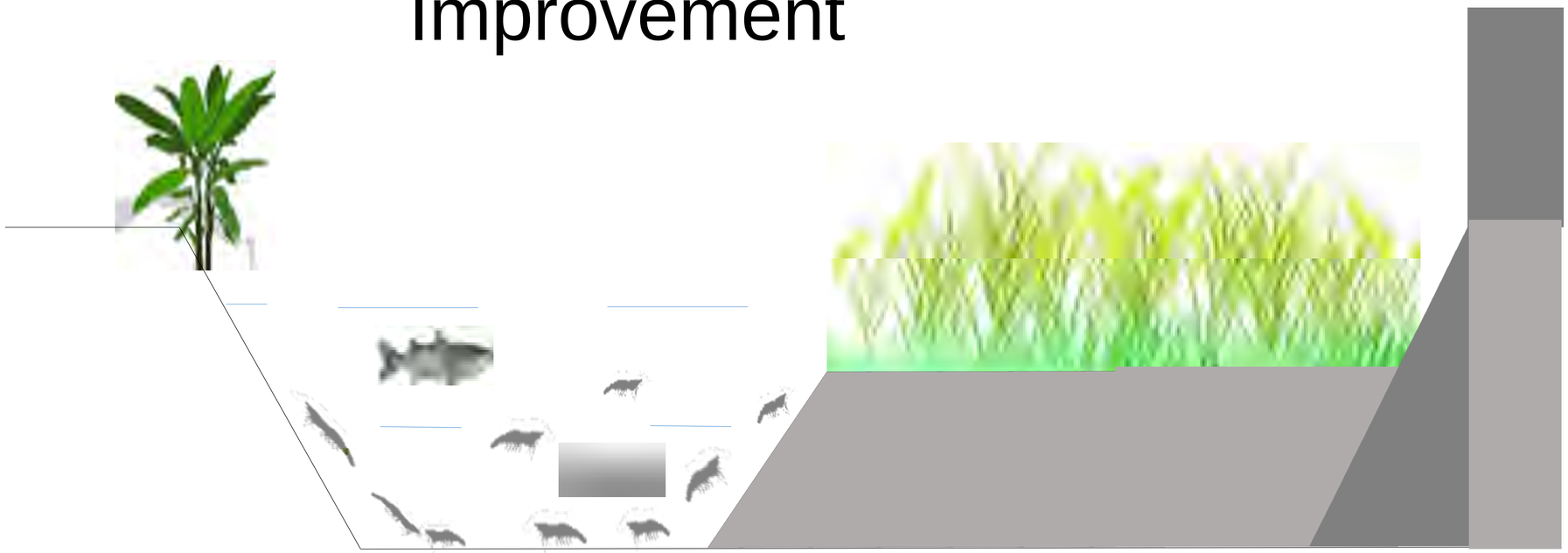
- **Pacific white shrimp + Saline rice: B401, B402, A701, A702, A801, A802**
- **Pacific white shrimp monoculture: A1, B2**
- **Tiger shrimp monoculture: B301, B302, B303, B304**

Rice harvest after typhoon attack

Shrimp harvest

Scenario 2

Improvement



- Easier for machinery operations in the paddy field, e.g. rice seedling, disease prevention and harvest.
- Easier for shrimp feeding and harvest in the pond.

Case 1: *Macrobrachium rosenbergii*- common rice combined farming

I. *M. rosenbergii* monoculture pond (MS) [Area: 0.4 ha, Seedling: 100 000 inds]

II. *M. rosenbergii* pond (50%) - early rice field (50%) combined farming (MR)

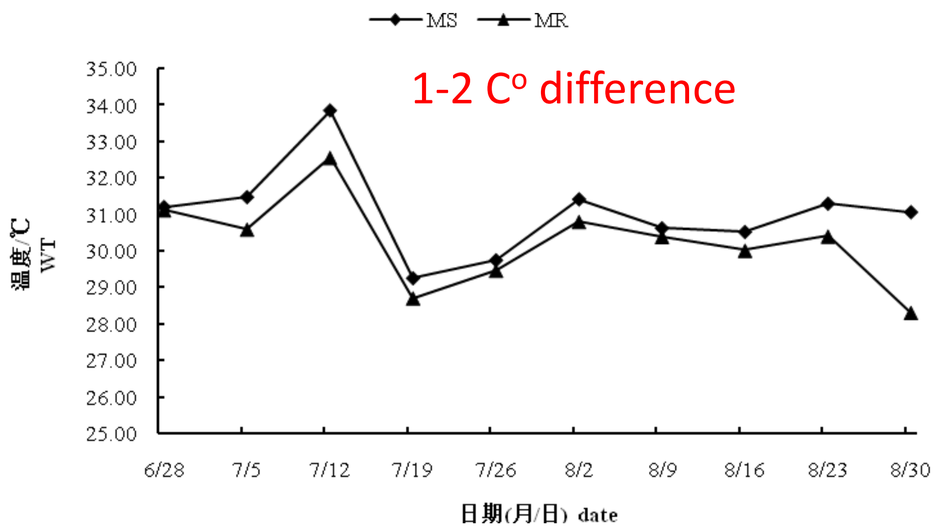
[Pond area:0.13 ha, Seedling: 60 000 inds] [Paddy area: 0.13 ha]

- Rice transplanting in paddy field: April 22; Rice harvest: Aug 9; Rice regeneration: Aug 16
- Shrimp seeding for both ponds: May 12
- Early stage of water body combination by pumping for MR: Jun 15 - Jul 15
- Middle stage of water body complete combination for MR: Jul 16 - Aug 9
- Late stage of water body combination for MR: Aug 9 – Sep. 7

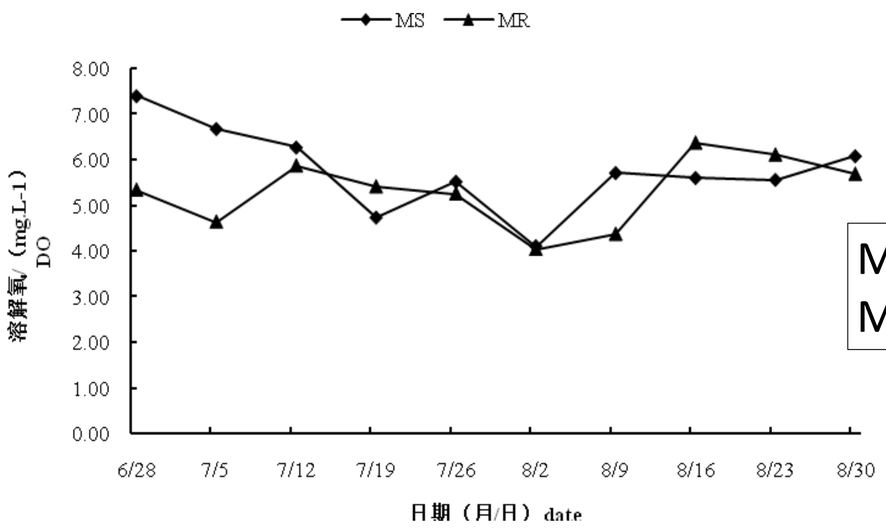
Salinity: 1-2

Results:

Water temperature

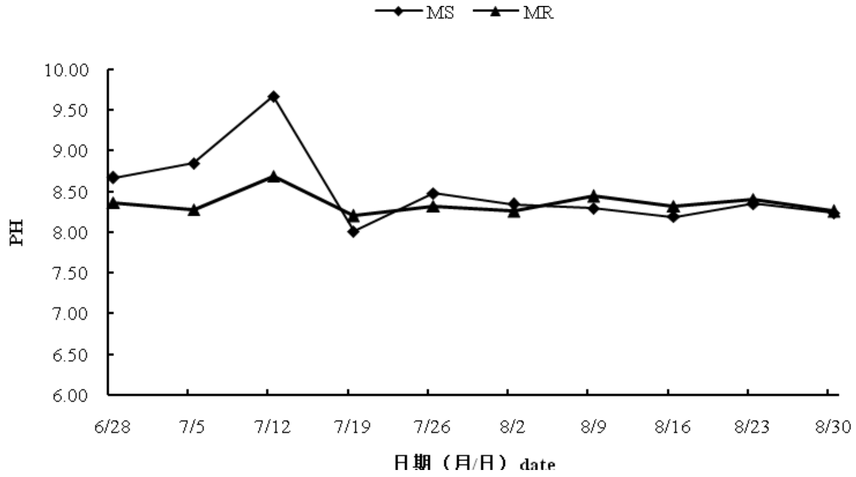


Dissolve oxygen

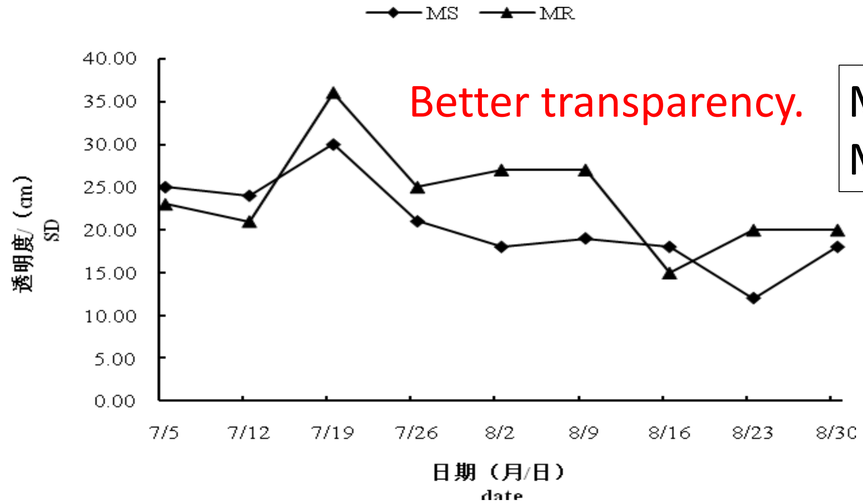


MS: shrimp monoculture
MR: shrimp-rice co-culture

PH



Secchi depth



MS: shrimp monoculture
MR: shrimp-rice co-culture

Tab 1 Water nutrient content during the trial

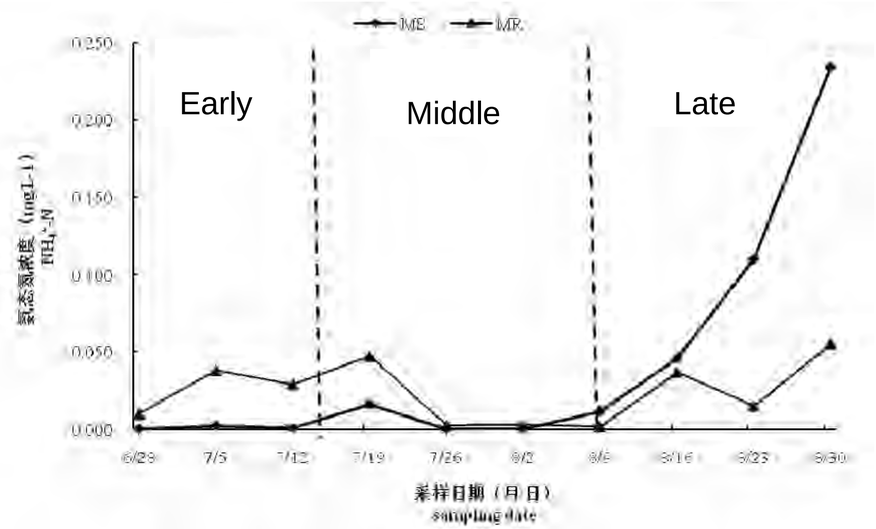
Water quality indexes	Ponds	average content	coefficient of variation
NH_4^+–N （mg·L−1）	MS	0.042±0.076a	1.803
	MR	0.024±0.020b	0.828
NO_3^-–N （mg·L−1）	MS	0.151±0.220	1.455
	MR	0.100±0.074	0.741
NO_2^-–N （mg·-1L）	MS	0.014±0.018	1.291
	MR	0.005±0.005	1.063
PO_4^{3-}–P （mg·L−1）	MS	0.006±0.004	0.797
	MR	0.002±0.002	0.759
COD (mg·L-1)	MS	3.796±0.459a	0.121
	MR	3.326±0.297b	0.089

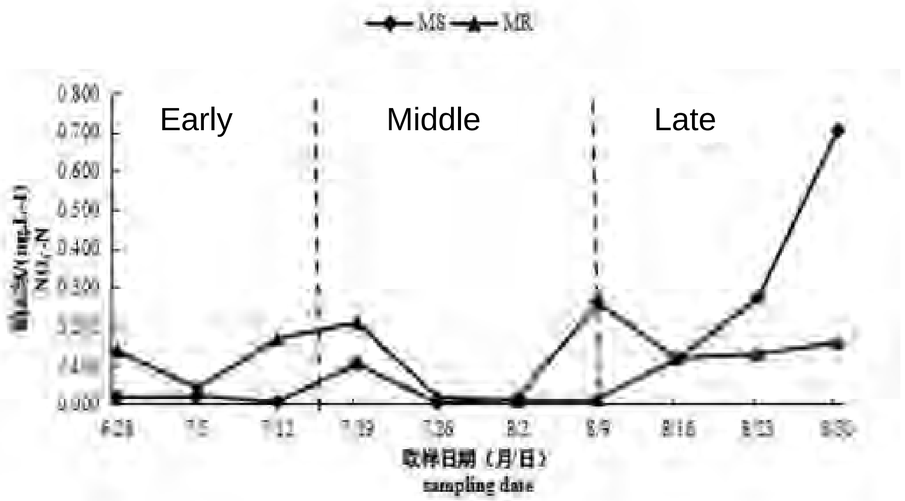
Much better water quality in MR co-culture system.

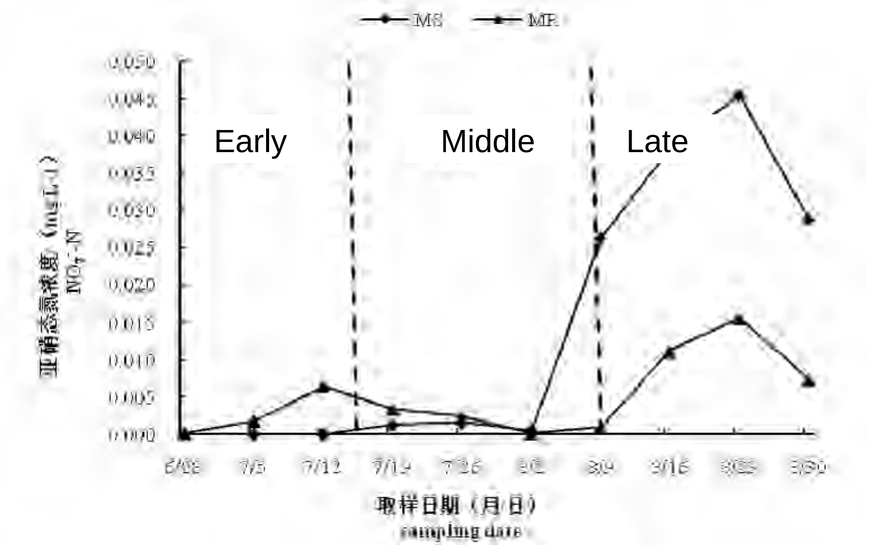
Rice harvest before typhoon

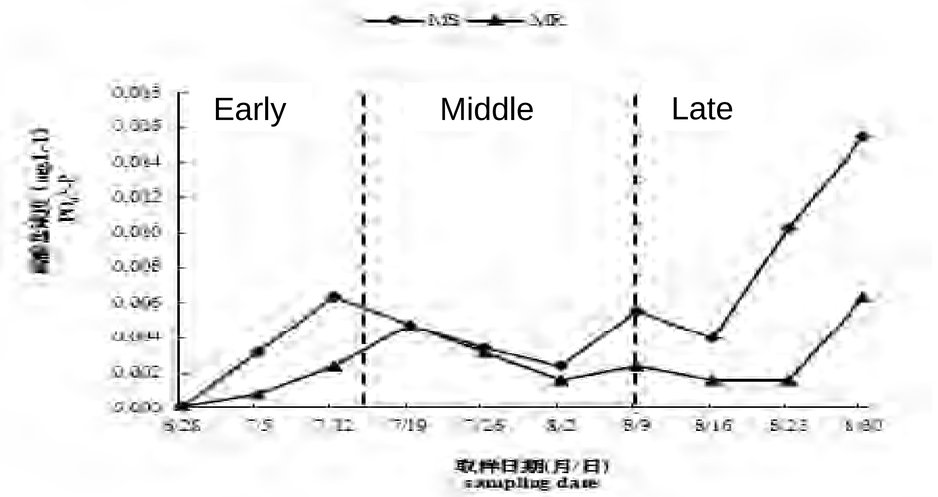
Rice regeneration after first harvest

Nutrients dynamics in pond water during the experiment



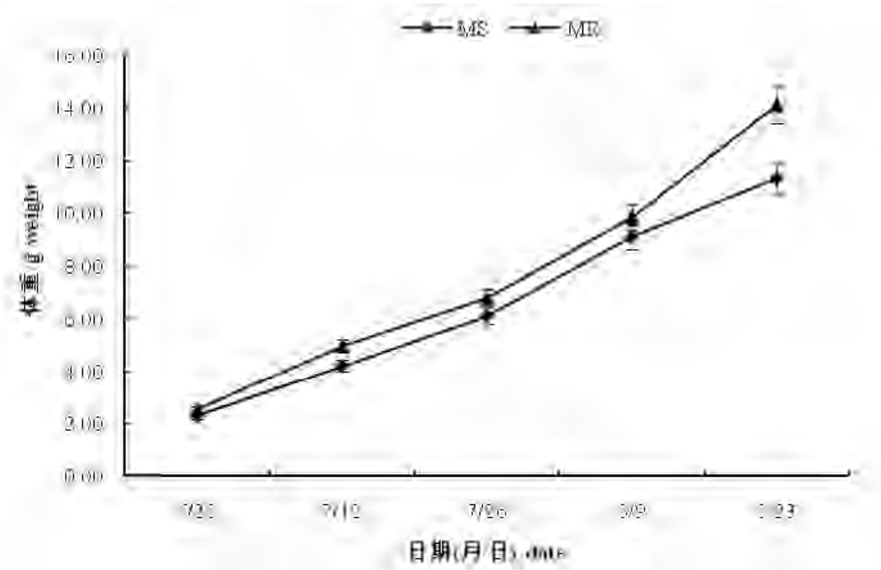






Shrimp growth

Body weight



Body length

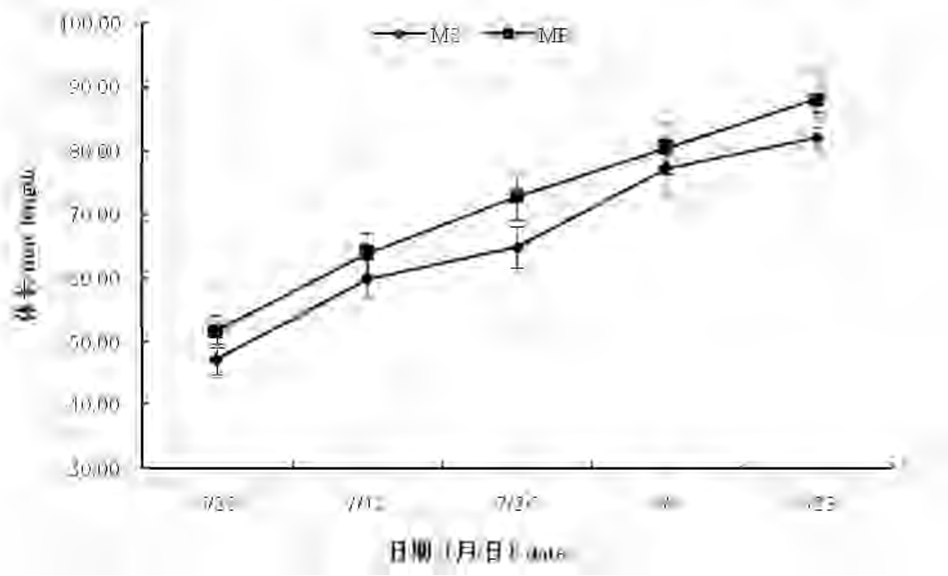


Table 2. Growth rates of *M. rosenbergii* during the experiment

Pond	Culturing days	weight gain	Specific growth rate
MS	56	397.44%	2.86
MR	56	459.40%	3.07

Case 2: Tiger shrimp pond-saline rice paddy field combined farming

Experiment details:

- Pond area: 0.13 ha
- Combined paddy area: 0.13 ha
- Rice transplanting in paddy field: April 12
- Tiger shrimp seeding: 120 000 inds, May 25, 2019
- Rice harvest: Jul 15
- Shrimp harvest: Jul 14, 2019
- Salinity: 2-5

Production: Tiger shrimp: 7620 kg/ ha
Saline rice: 5050 kg/ha

Application of Pond-Rice field aquaponics in the inland saline-alkali areas

Development of a shrimp-rice aquaponic system in Inner Mongolia

Before 2018, waste land

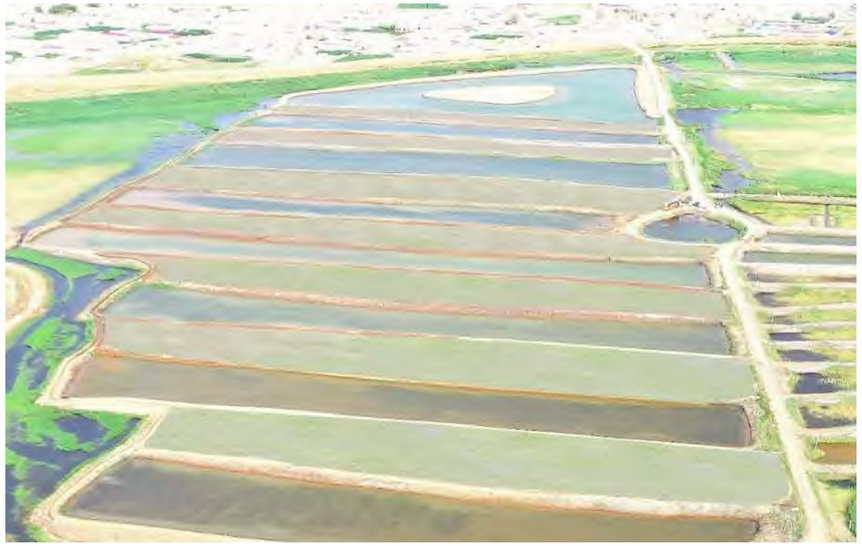
2019, construct pilot ponds

2020, construction of pond-rice field aquaponic system

Result: Saline-alkali waste land →Oasis with fish and rice

March 16, 2021

June 5, 2021



June 25, 2021

Benefits:

- **Restoration and reclamation of saline-alkali lands**
- **Development of rural economy with high value aqua-products**
- **Improve welfare and employment of rural community**

Thanks for your attention.

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