中国水产科学研究院南海水产研究所
South China Sea Fisheries Research Institute, CAFS

Bioremediation of mariculture environment

A case study in a marine cage fish farm in Daya Bay

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Outline

- Introduction
- Summary of the fish farm in Daya Bay
- Bioremediation scheme
- Results and discussion

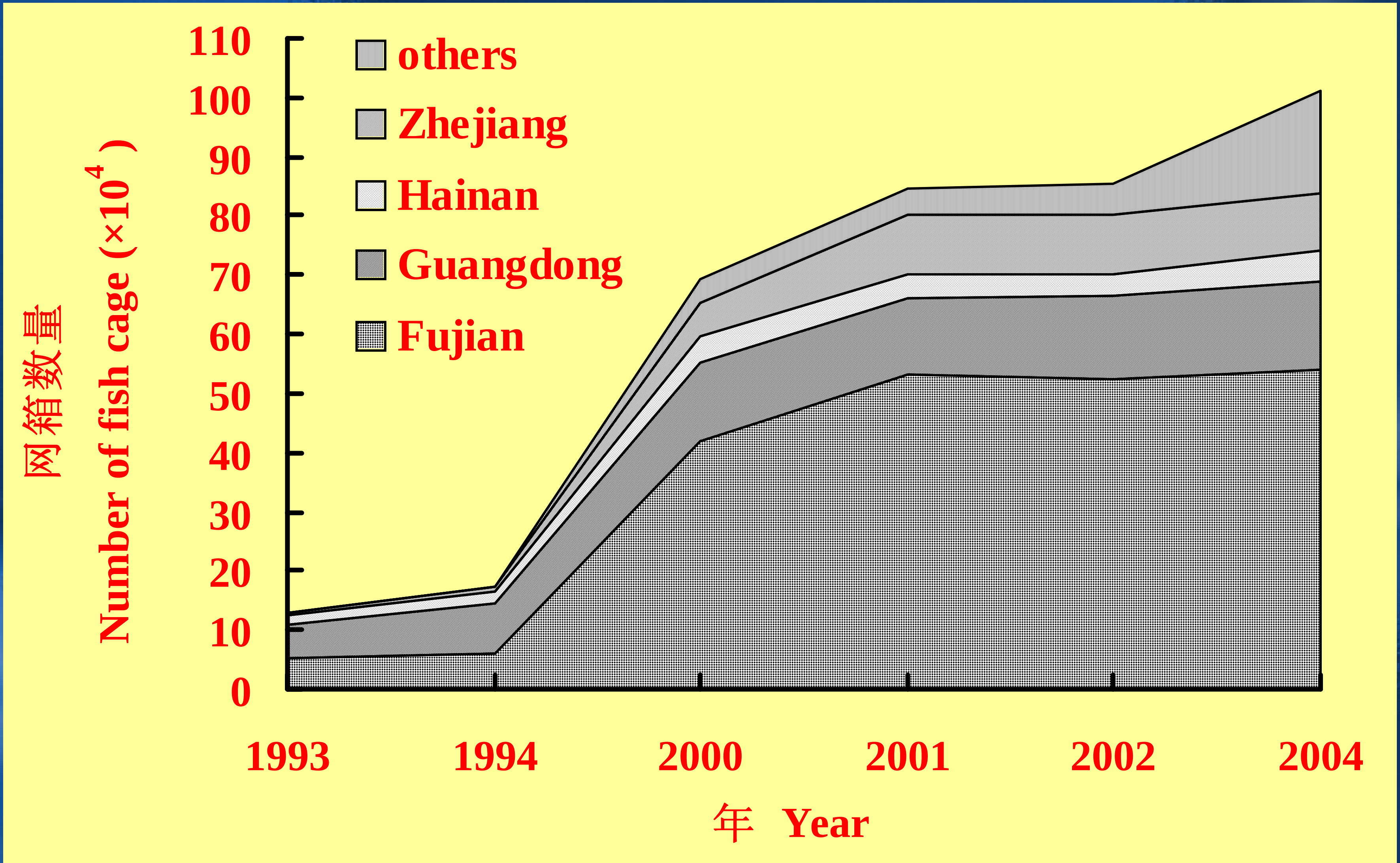
Ⅰ. Introduction

- **Developing of marine cage fish farming in coastal waters of China**

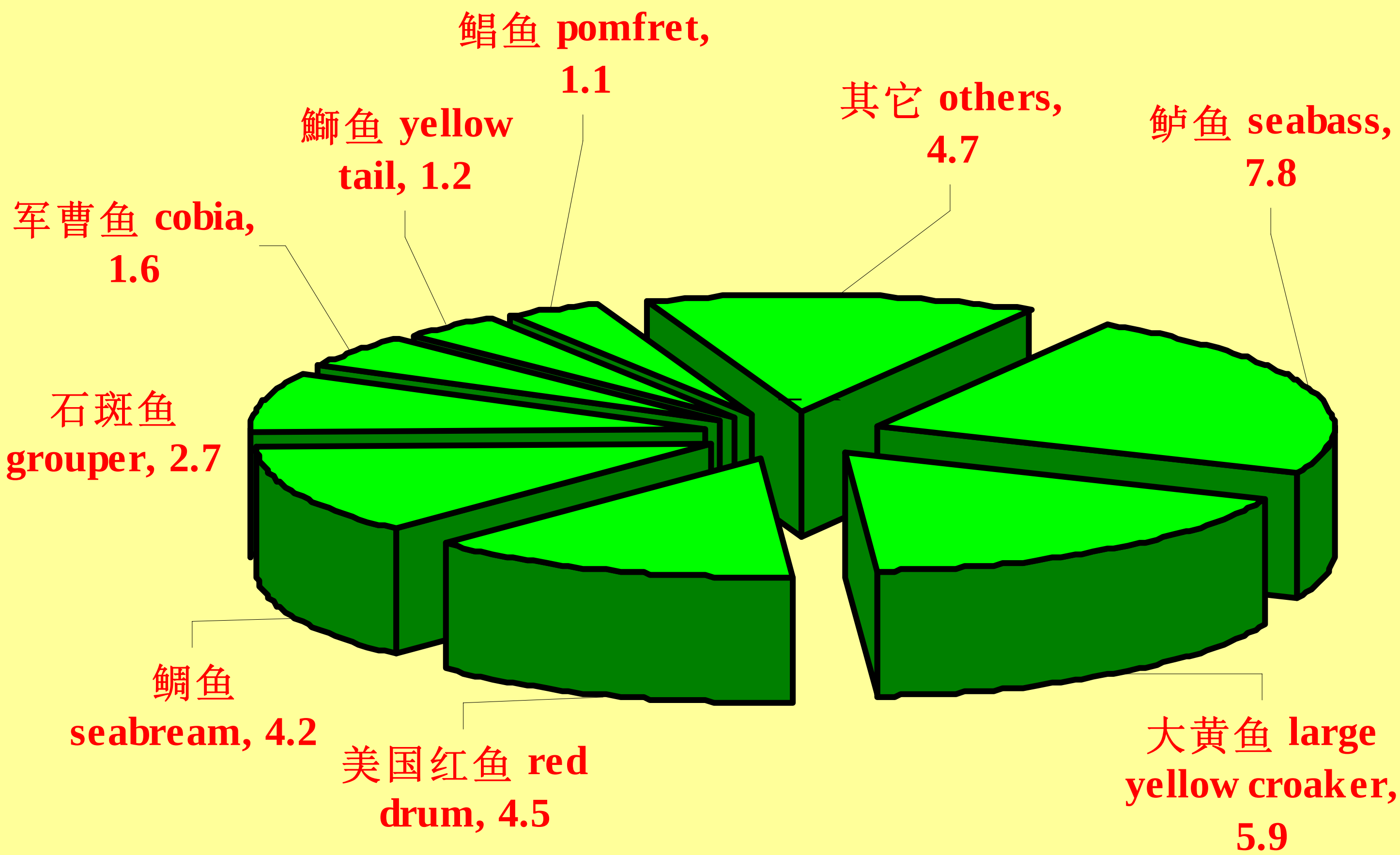
Marine cage fish farming first began in Guangdong coastal waters in China at the end of 1970s.

Number of traditional raft cage: Increased from about 130,000 cages in 1992 to 1,000,000 in 2004.

Annual yield: Increased from about 15,000t in 1992 to 337,000t in 2003.



Increasing trend of traditional marine fish farming raft cages in coastal region of China



Total yield of marine cage fish farming reached 33.7×10^4 t in China in 2003

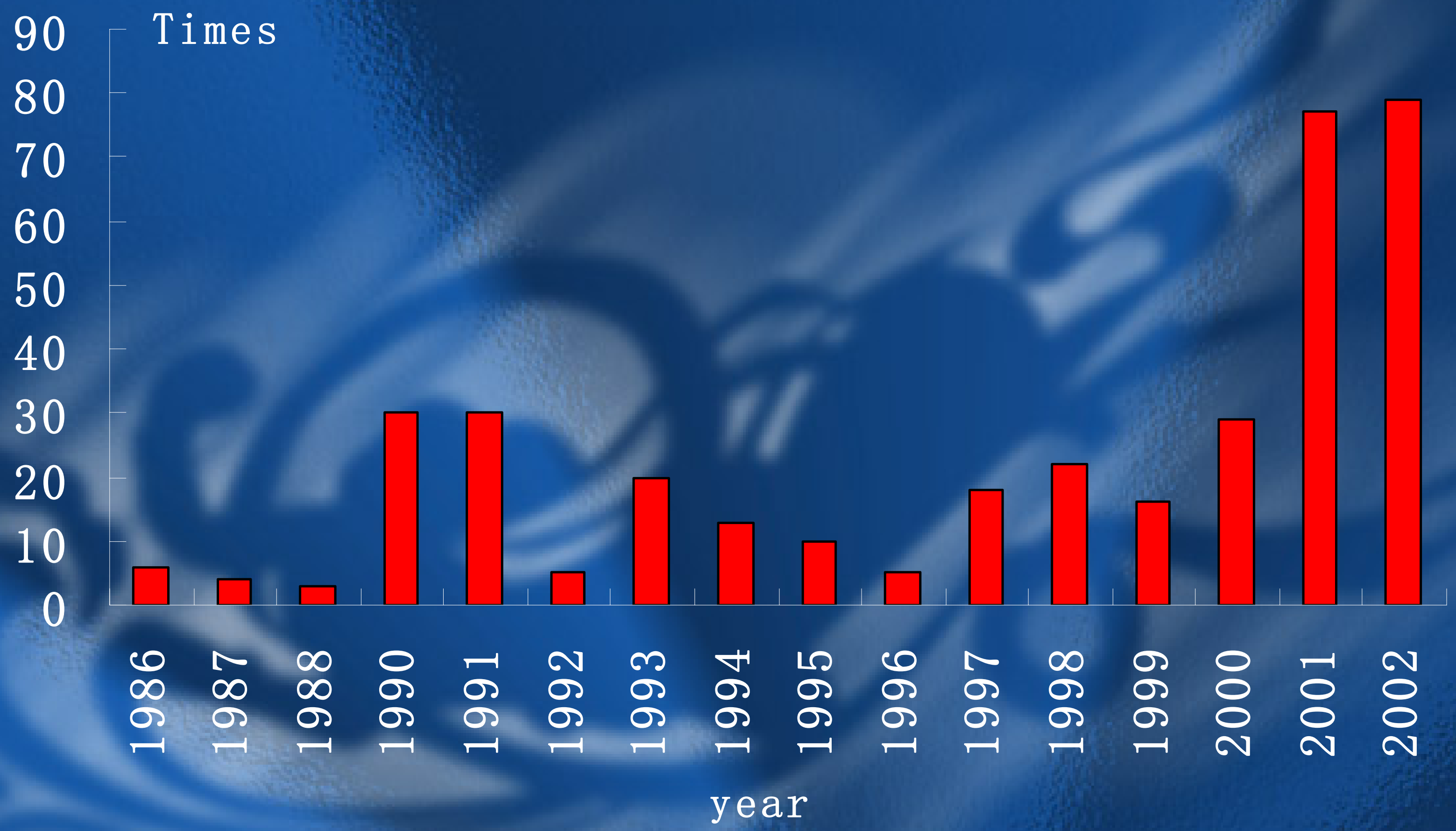
Data from FAO, 2004. Fishstat plus Solftware.

Issues caused by marine cage fish farming

- **Self-pollution:** eco-environment (water quality, sediment quality and biodiversity etc.) deteriorated in fish farm

- **Environmental impact in vicinity area:** coastal eutrophication, red tide and etc.

- **Disease:** decrease of fish production, antibiotics abuse, fish quality



Occurring times of red tide in the Chinese offshore area

（1986-2002）

History record of fishery production damage caused by red tide in Guandong coastal waters

Time	Occur place	Red tide organism	Damage
1980.5	Zhanjiang Harbor	*Guinardia flaccida*	Fish killed
1983.3	Daya Bay Dapeng Bay	*Rhizosolenia alata f.gracillima*	75 tonnes of fish dead
1986.2	Shengzhen Bay	*Noctiluca scintillans*	Fish dead
1987.7	Hongkong coastal waters	-	120 tonnes of fish dead, 24000 Ponds diret economic losses
1987.8	Tolo Harbor	*Skeletonema costatum*	3 million Hongkong Dollars diret economic losses
1988.12	Dapeng Bay	*Noctiluca scintillans*	Fish dead
1989.4	Shengzhen Bay	-	Fish dead
1991.3	Dapeng Bay	*Chattonella marina*	Fish dead
1997.11	Zhelin Bay	*Phaeocystis pouchetii*	60 million RMB diret economic losses
1998.3	Hongkong coastal waters	*Cochlodinium* sp.	1500 tonnes fish dead， 300 million Hongkong Dollars diret economic losses
1998.3	Dapeng Bay~Pearl River Estury	*Gymnodinium mikimoti, Dinophysis sp.*	300 tonnes fish dead， 40 million RMB diret economic losses
1998.4	Dongpin Harbor	-	5 million RMB diret economic losses
2000.8	Daya Bay	*Gyrodinium* sp., *Gonyaulaxovalis spinifera, Peridinium* sp.	5 million RMB diret economic losses

Dead fish caused by red tide

Ⅱ. Summary of the fish farm in Daya Bay

➢ Background of the farm

——The cage fish, setup in 1985 within Dapeng Ao Cove, a shallow semi-enclosed embayment located inside Daya Bay in the middle Guangdong coast of South China

——Marine fish farming activities are confined to about 30 ha within the inner part of the cove, with cage rafts occupying about 4 ha and annual fish yield of about 300~450 tones.

——The average fish stock density is about 5.1kg/m^3. Fish are fed mainly by using trash fish supplying an amount about 3-10% of the total biomass contained in the cage, and with a final food conversion coefficient of 5-10 (calculated as ratio of food input to fish production).

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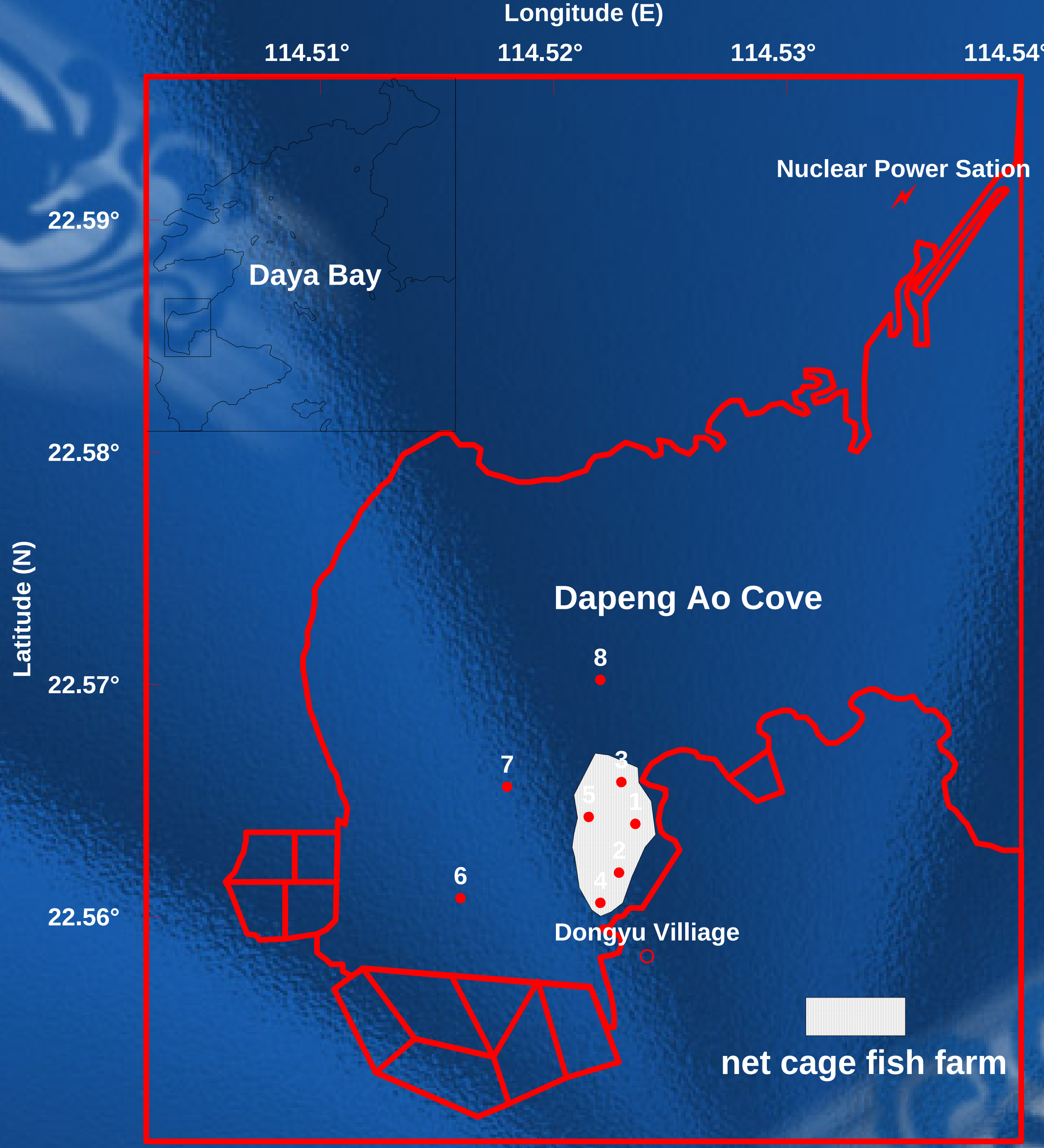
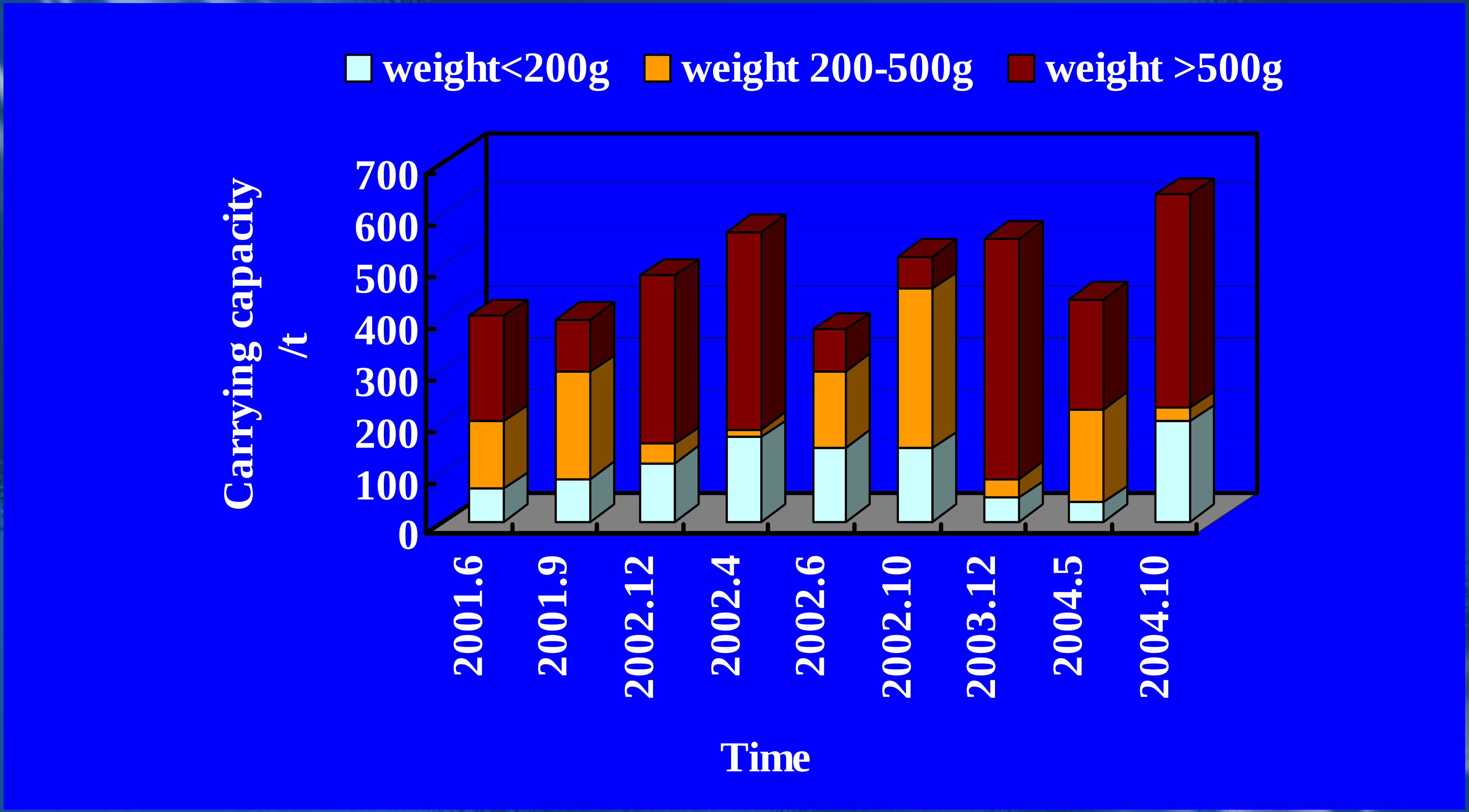
China
Guangdong Province
South China Sea
Huizhou
Daya Bay
Shenzhen
Marine cage fish farm



Location of sampling stations

Fish farming cages

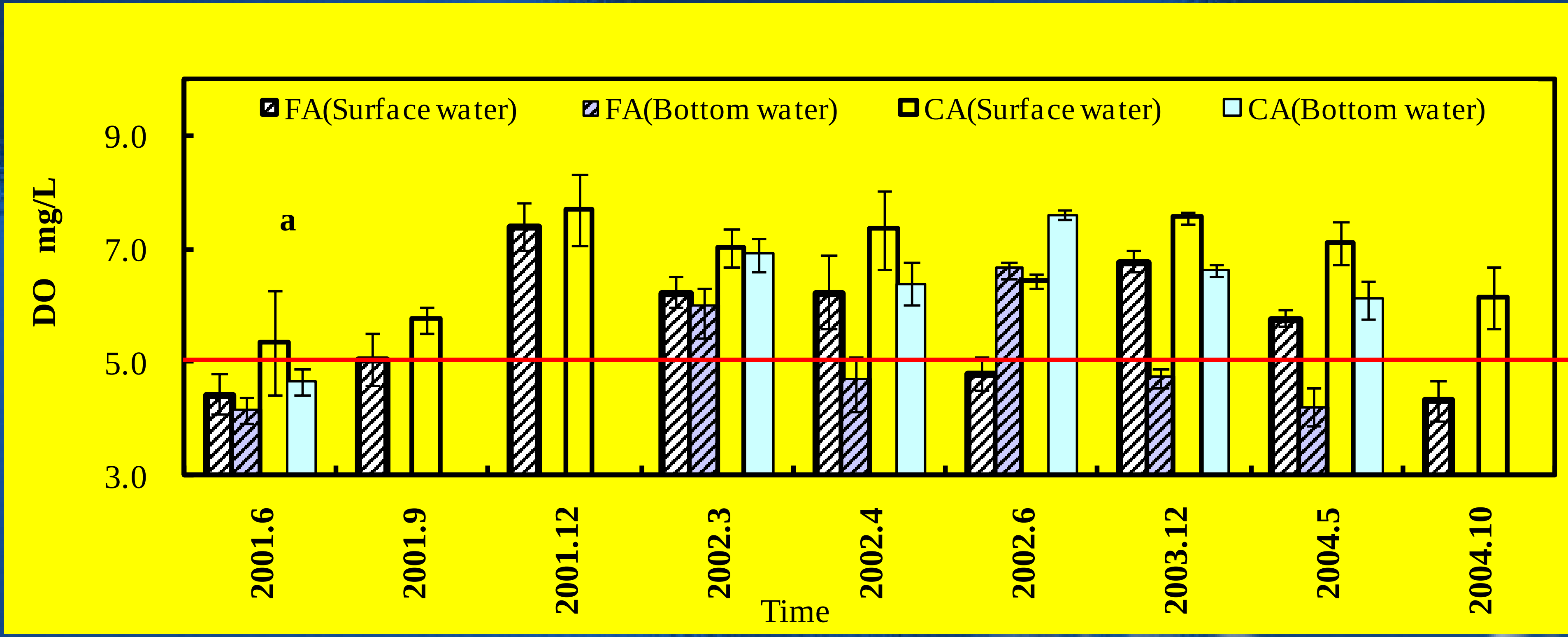


Seasonal changes of carrying capacity of different size of cage cultured fish

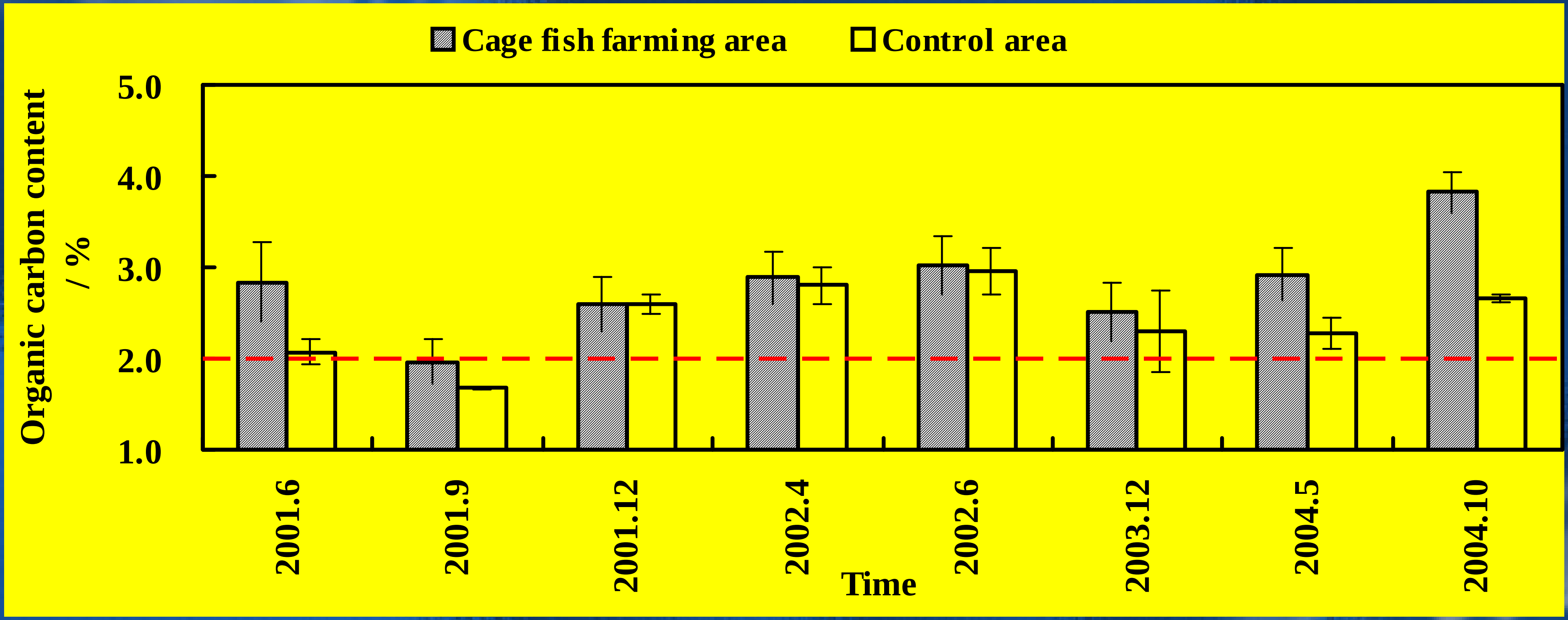
Ⅱ. Summary of the fish farm in Daya Bay

- **Major environmental issues**

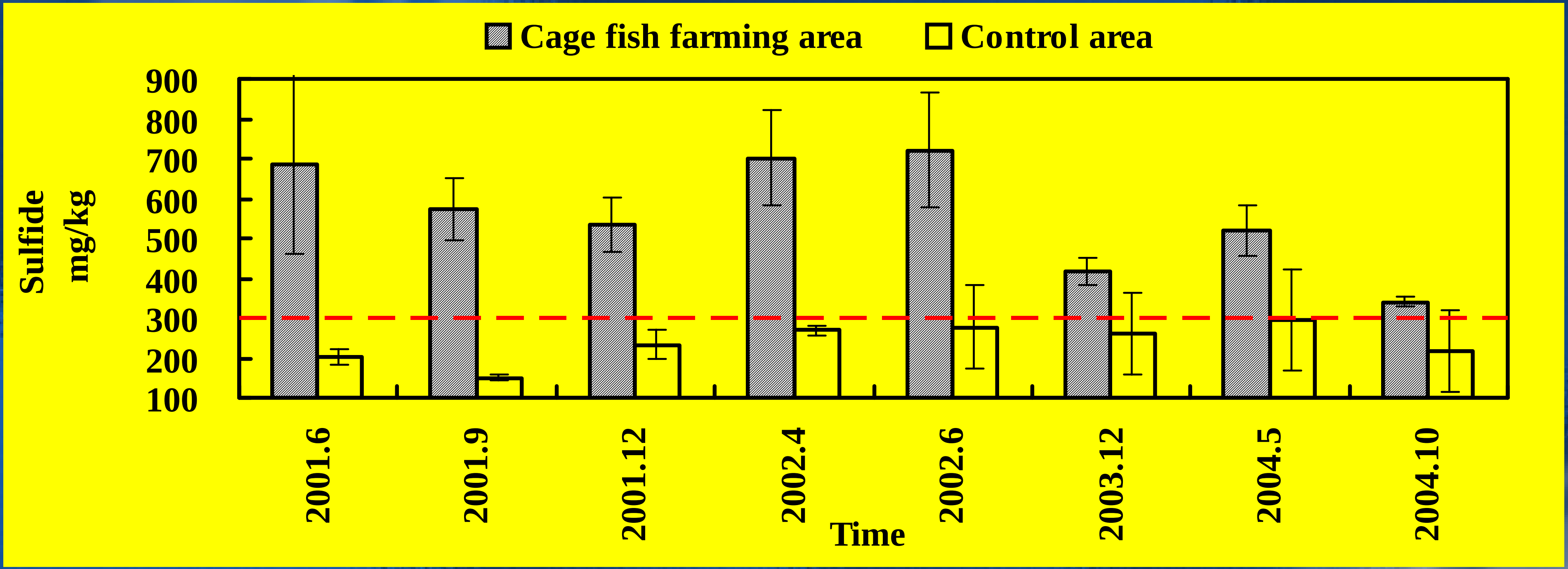
DO in water



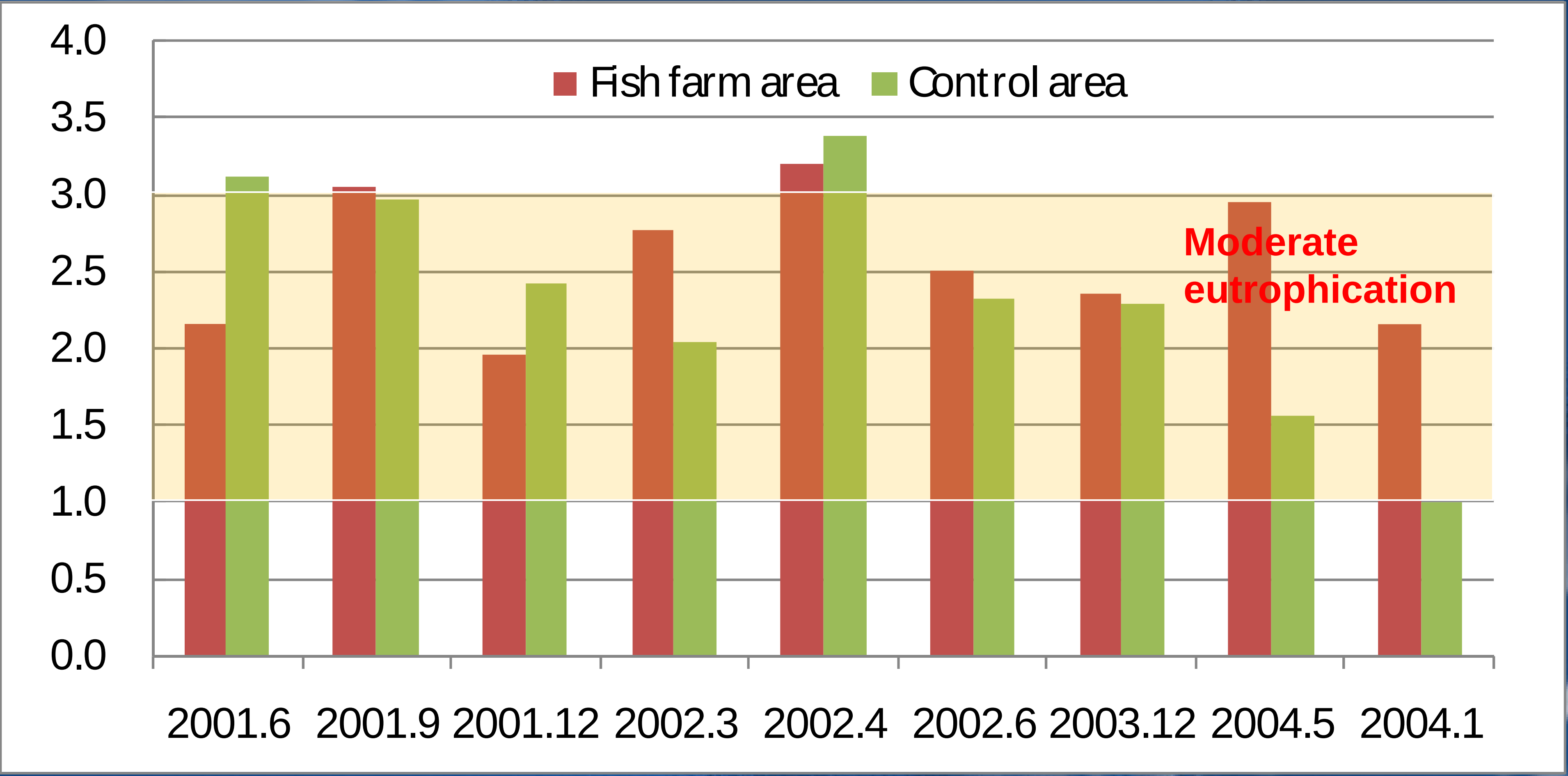
Sediment organic carbon content



Sediment sulfide content



Moderate eutrophication (NQI)



Ⅱ. Summary of the fish farm in Daya Bay

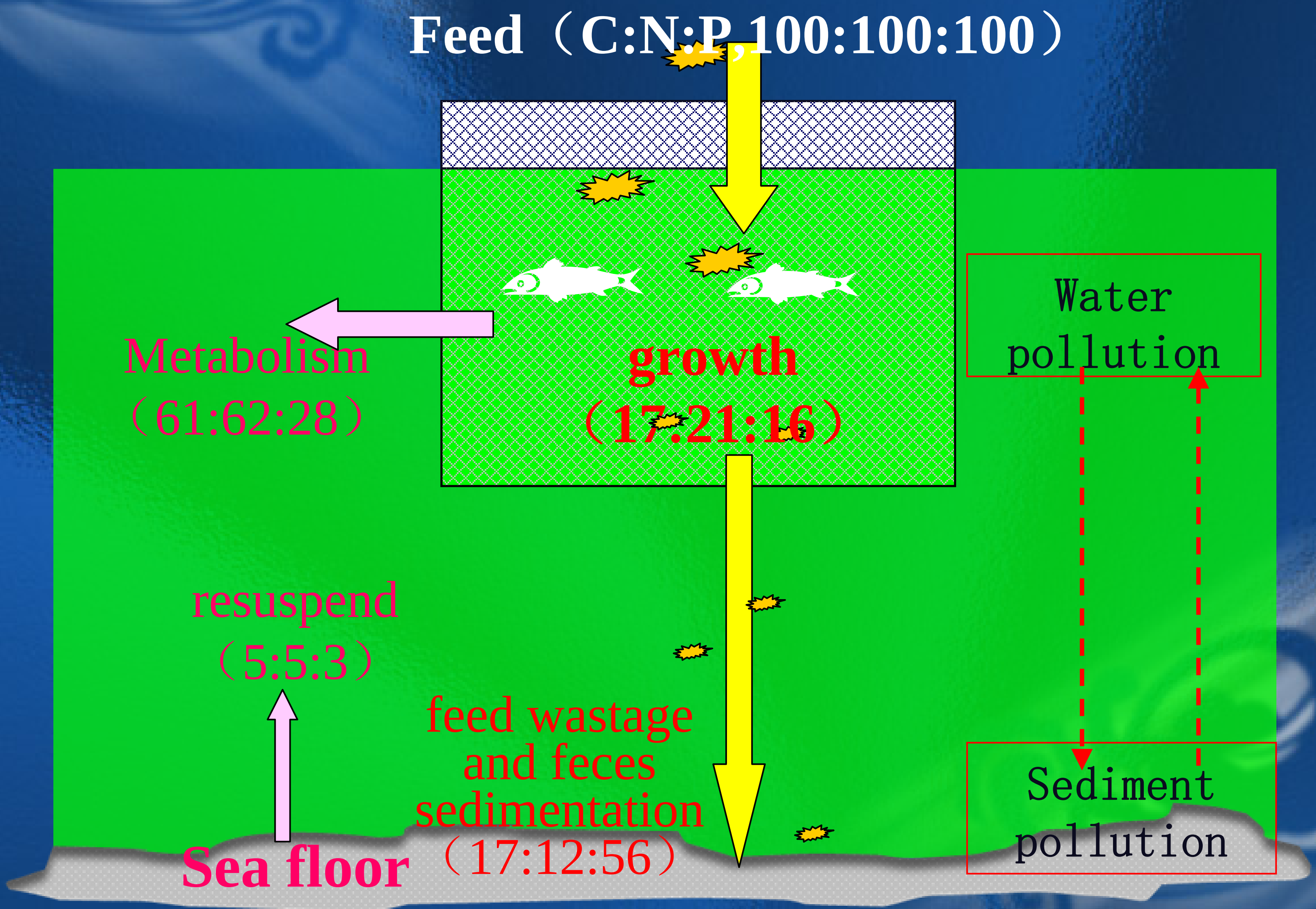
Sediment organic carbon, sulfide content and DO in water in cage fish farming area exceeded the standards of first class of Marine sediment quality and the second class of seawater quality for fisheries in China with exceeding rate of 90.9%, 100% and 62.5%, respectively; while those in control area were 76.2% and 14.3% and 20.0%, respectively. Sulfide content was about 2 times higher than that in control area.

Seawater was in moderate eutrophication.

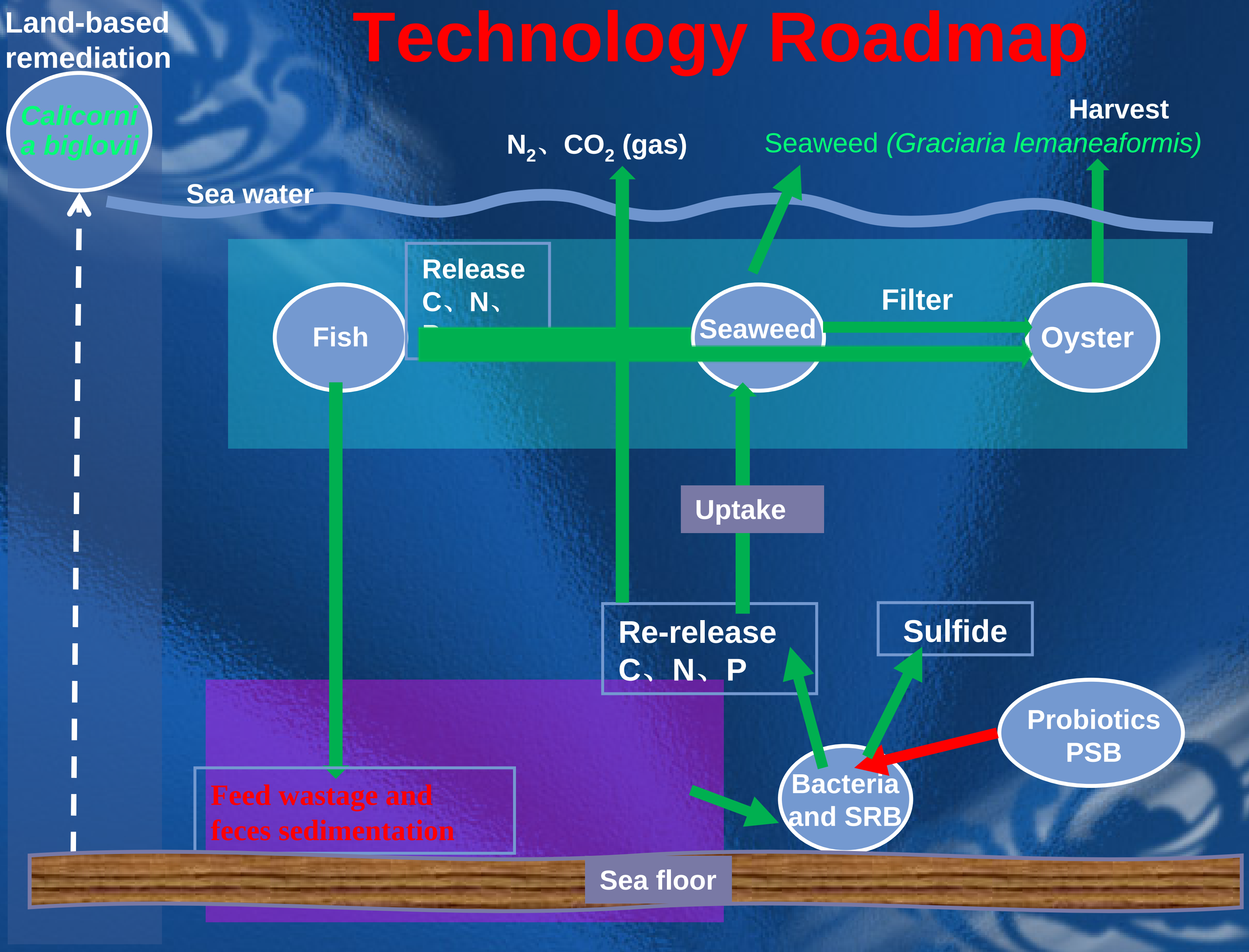
Suggested that sediment environment in the cage fish farm was polluted seriously, and seawater quality in the cove showed signs of deterioration in a certain extend due to the cage fish farming activities carried out for about thirty years.

Ⅲ. Bioremediation scheme

➢ **Nutrient budget in marine cage fish farming**



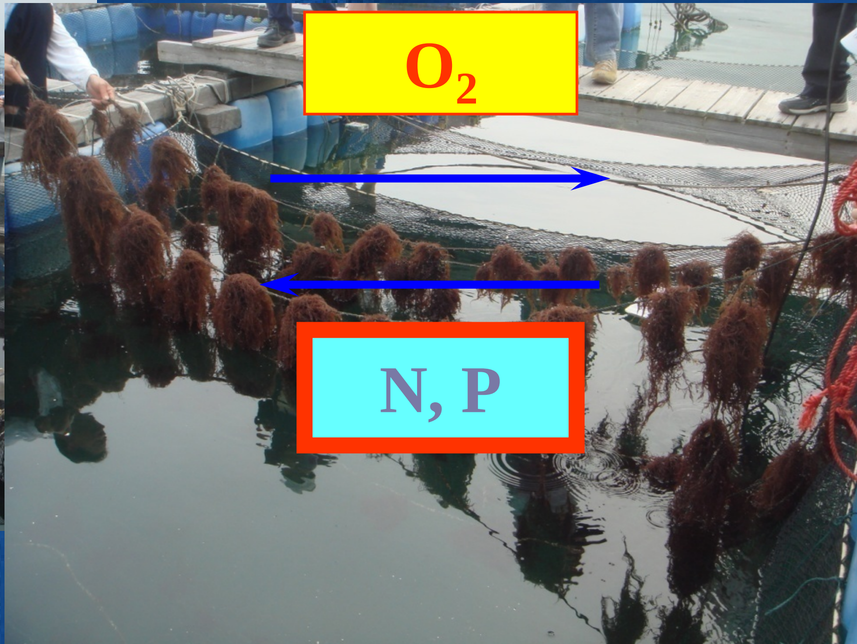
Technology Roadmap



Ⅲ. Bioremediation scheme

➢ **Bioremediation of IMTA on water environment**

Nutrient absorb — seaweed (*Graciaria lemaneaformis*)

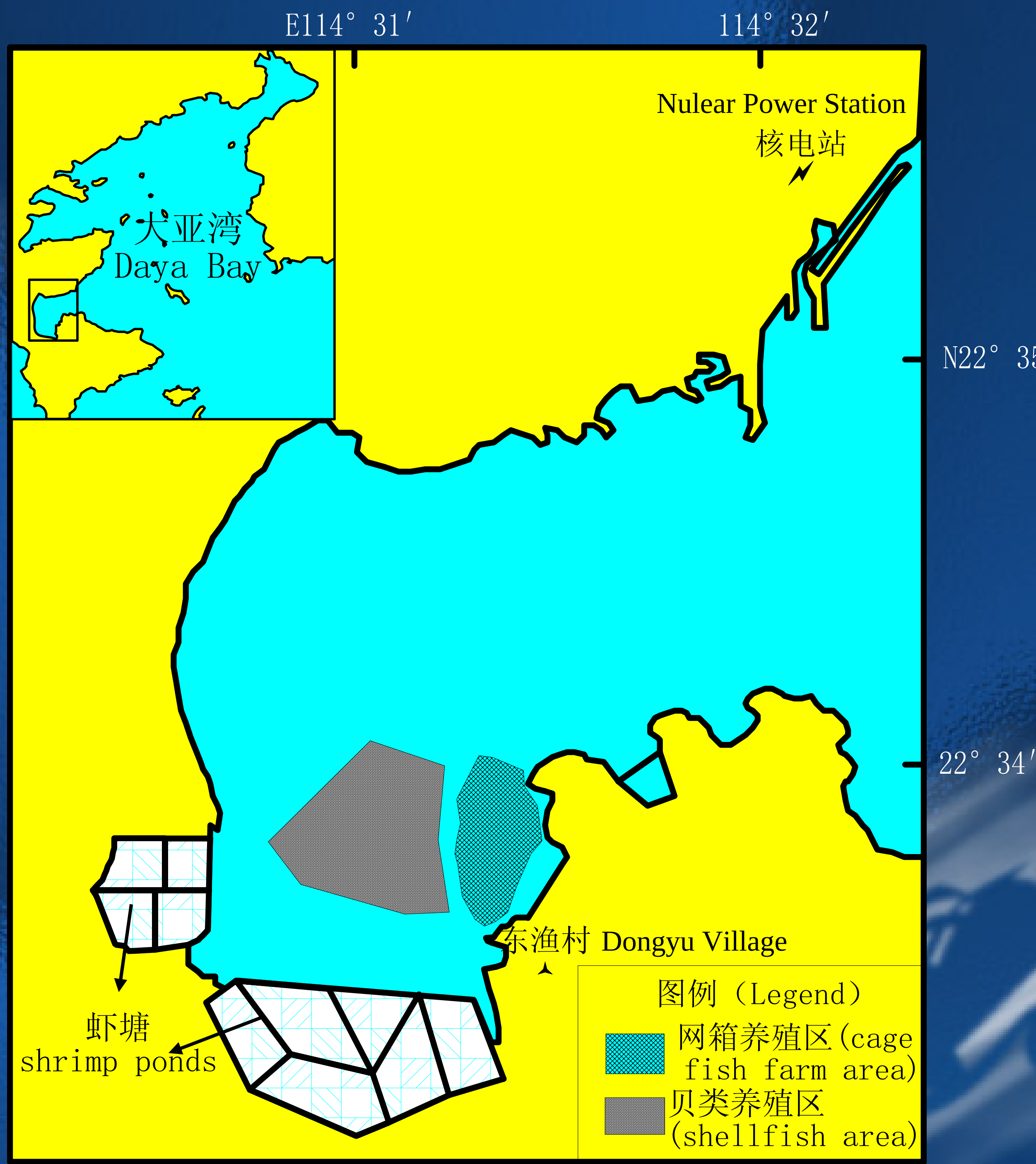


Ⅲ. Bioremediation scheme

➢ **Bioremediation of IMTA on water environment**

POM filter — pacific oyster

Demonstrate a IMTA model fish-shellfish-seaweed



Ⅲ. Bioremediation scheme

- **Land-based seawater-resistant vegetable (*Calicornia biglovii*) planting**

Ⅲ. Bioremediation scheme

Screen, purification and enrichment culture of local Sulfate Reducing Bacteria

50%

50%

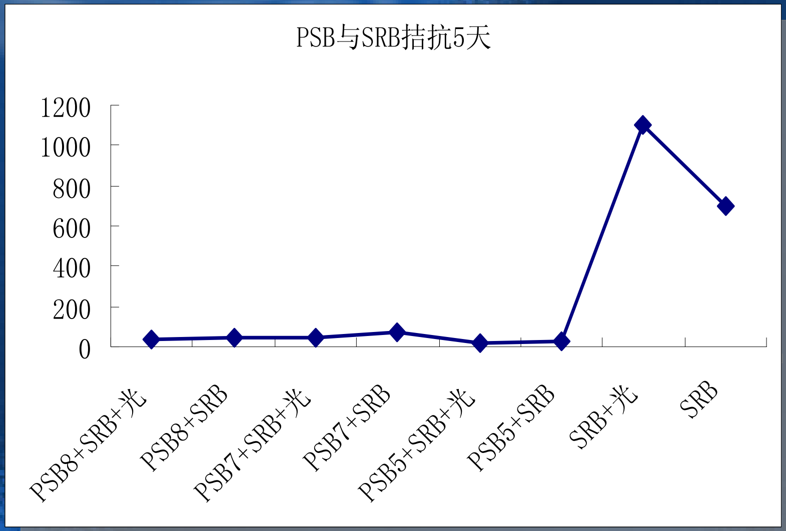
One week after inoculation sediment turn black, the adapter

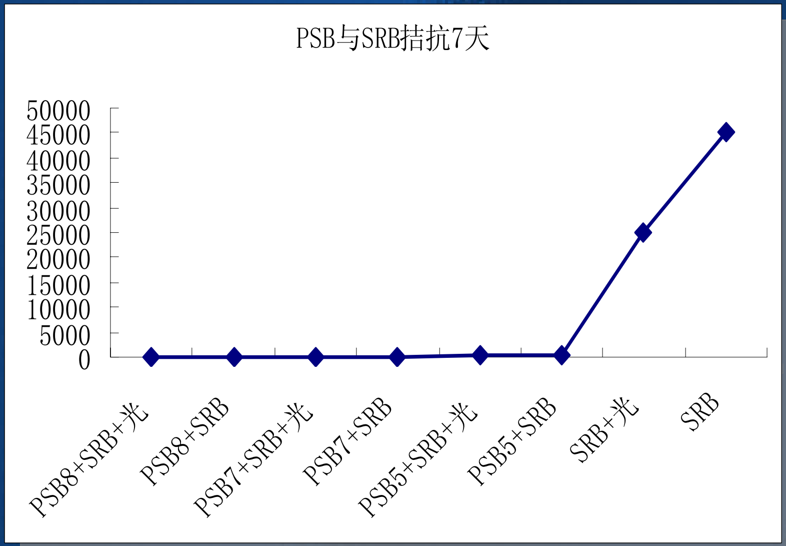
One week after inoculation sediment turn black, the adapter

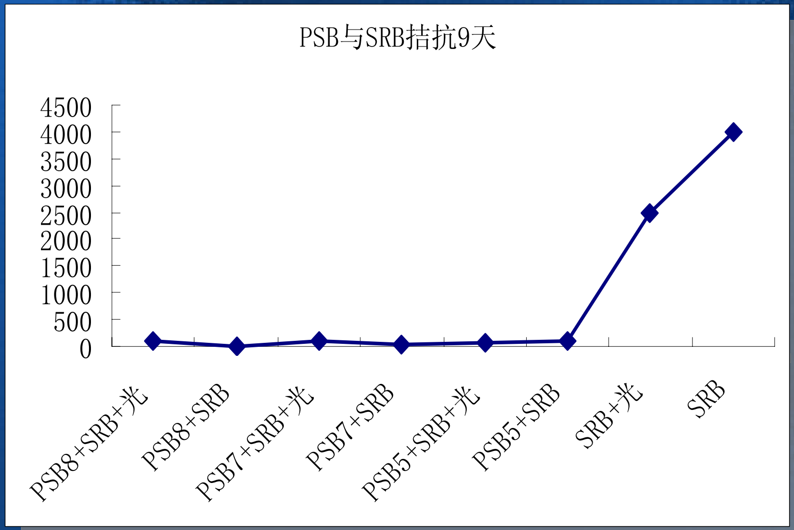
One week after inoculation sediment turn black, coated tablet

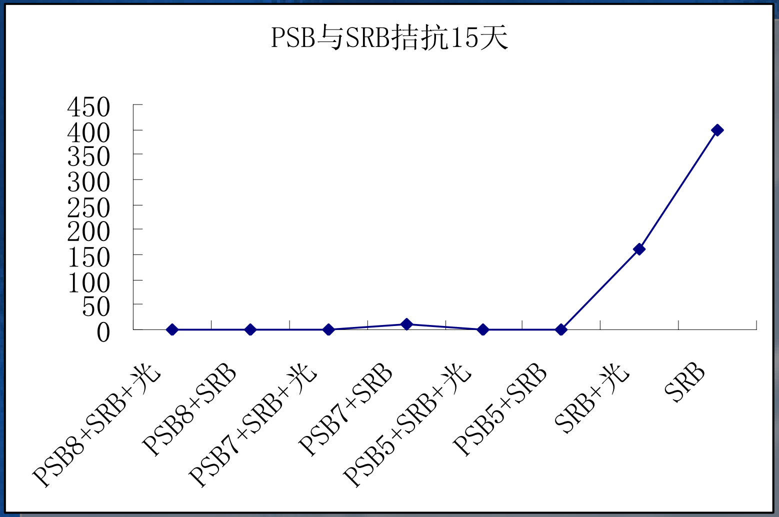
SRB

Photosynthetic bacteria and antagonism on Sulfate Reducing Bacteria







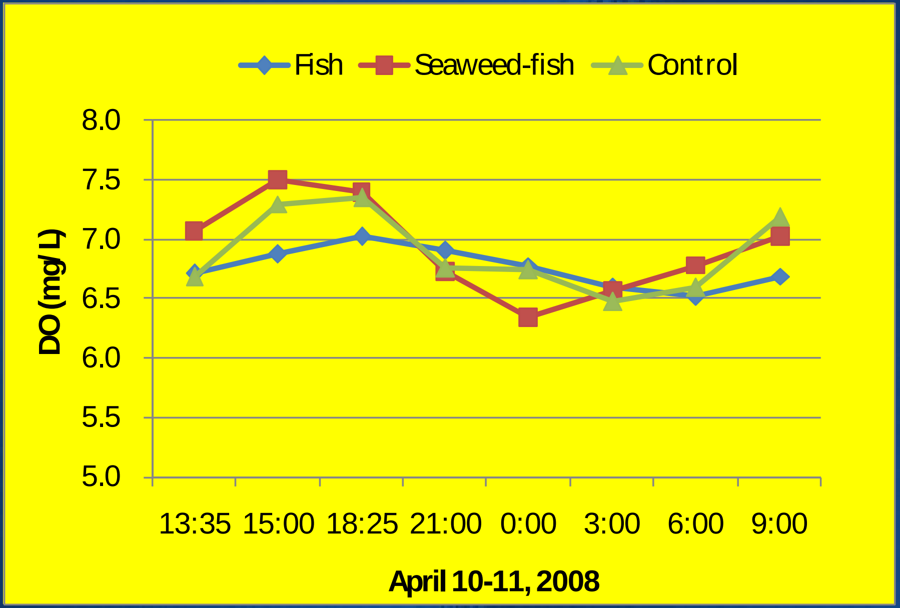


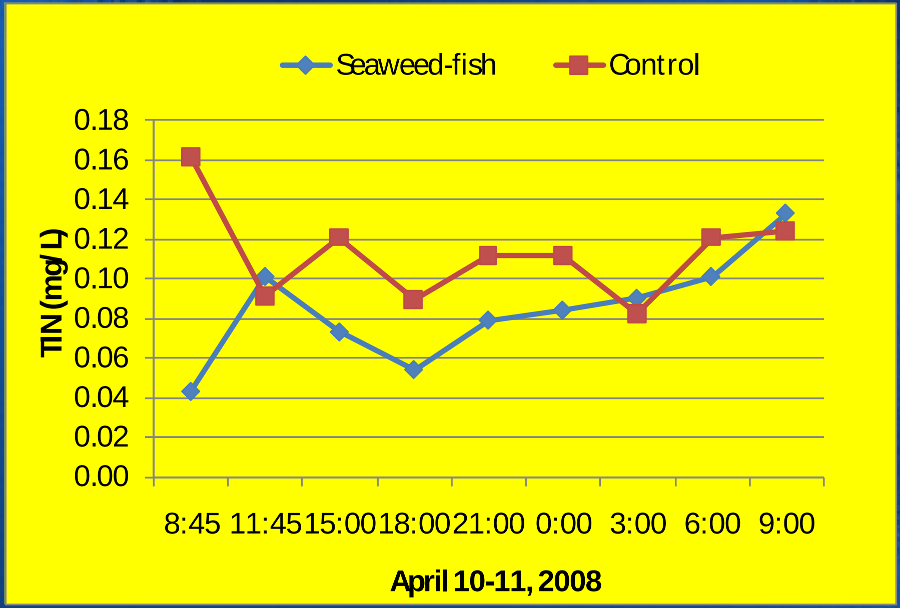
Ⅳ. Results discussion

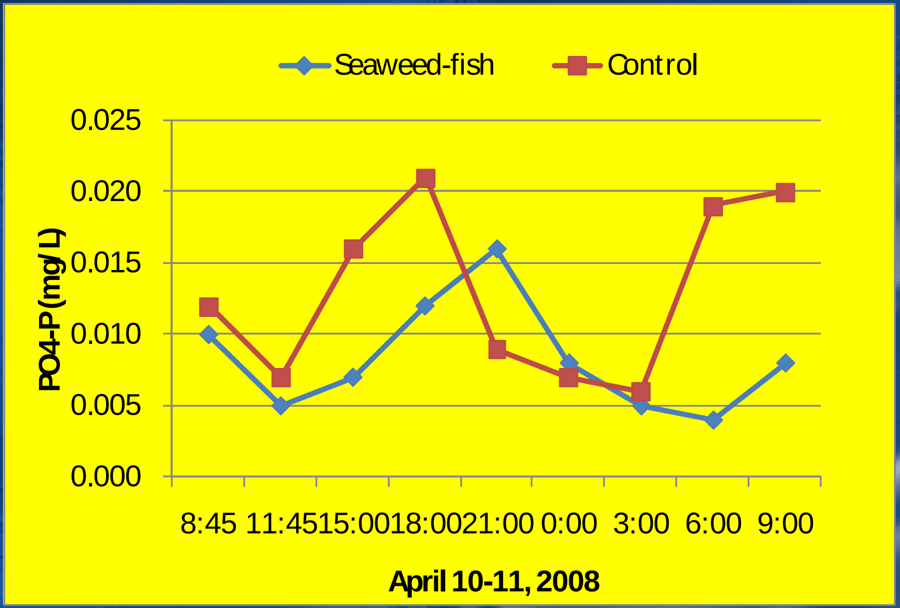
- **Mutual benefits to seaweed-fish co-culture**

DO production from seaweed.

Nutrient released from fish was absorbed by seaweed.







Calculation of nitrogen balance between discharge & uptake in fish cage

Seaweed-fish

$$FDN = IngN - ResN = \frac{(W_t - W_0) \times FCR \times FeCP}{CPN_{coe}} - (W_t \times FFtN - W_0 \times FItN) \times FiDM$$

$$SCA = \frac{TS_{wt}}{AWR \times AWC \times CR \times RM}$$

Yield of one 3m×3m×3m Cage: 200kg

Feed → Feed losses + Inorganic Release + Assimilation by fishes

8747 g N

↓

Assimilated by Cultivated Seaweeds

How Many?

↓

Gracilaria lemaneaformis (dry weight)

337 kg

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1 kg Fish need ***G*** **4.7 kg** ***Graciaria lemaneaformis*** (wet weight)

Calculation of nitrogen balance between discharge & uptake in fish cage

Oyster-fish

$$FDN = IngN - ResN = \frac{(W_t - W_0) \times FCR \times FeCP}{CPN_{coe}} - \left(W_t \times FFtN - W_0 \times FItN\right) \times FiDM$$

$$SCA = \frac{TS_{wt}}{AWR \times AWC \times CR \times RM}$$

Yield of one 3m×3m×3m Cage: 200kg

Feed → Feed losses + Inorganic Release + Assimilation by fishes

8747 g N

↓

Assimilated by Cultivated Seaweeds

How Many?

↓

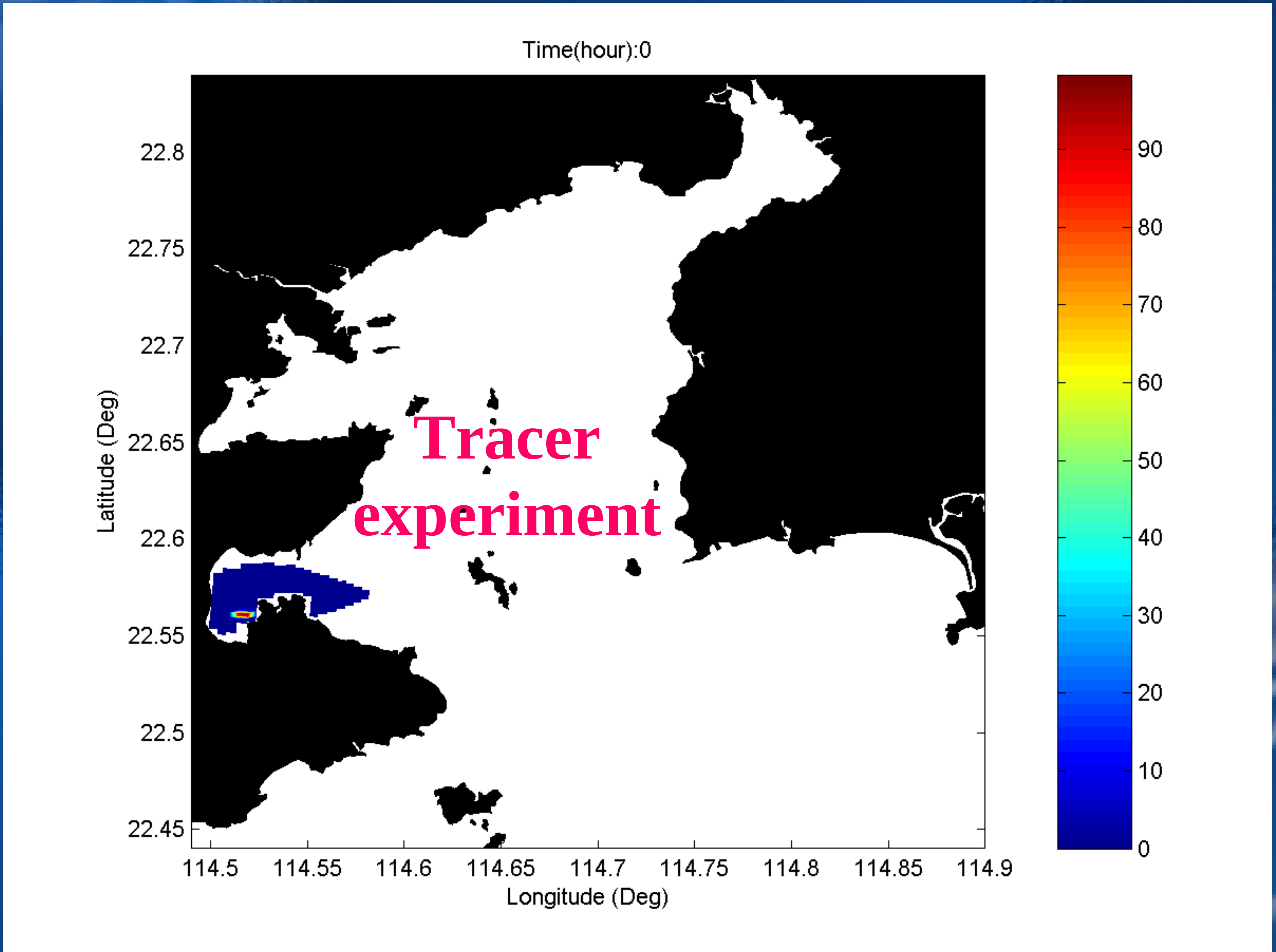
Pacific Oyster (dry weight)

77 kg

1 kg Fish need **G 5.1 kg** Pacific Oyster (wet weight)

Next study

Carrying capacity and IMTA model optimization based on hydro-ecological coupling simulation model



Thanks for your attention!