Nutrient budget in marine fish cage culture system and Integrated Multi-trophic Aquaculture scheme

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Outline

Part I. Introduction of marine cage culture and IMTA

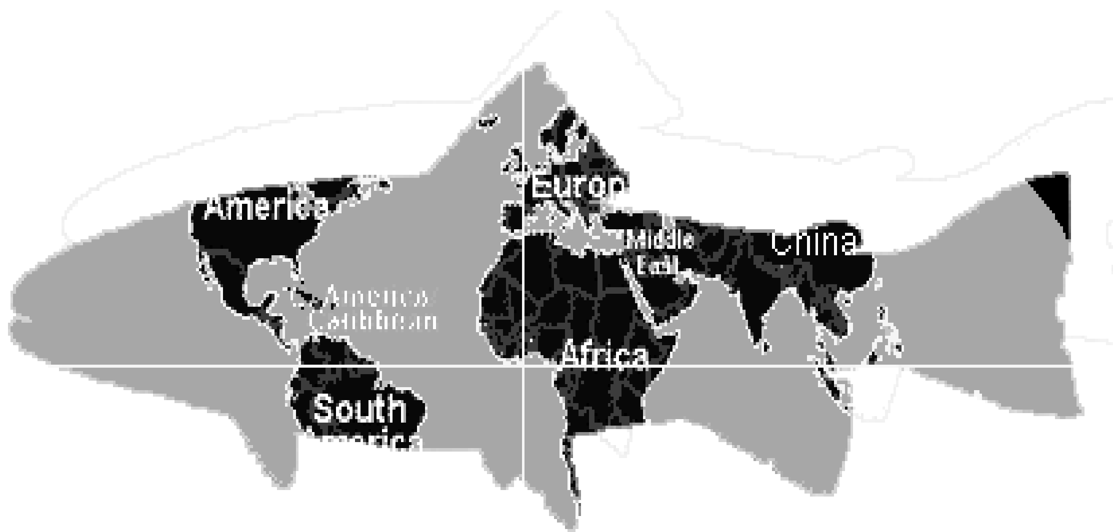
Part II. A case study

Part III. Discussion

Part I. General Introduction

Marine cage culture

- Almost half of the food fish supplies in the world are now from aquaculture
- Marine fish cage farming has proved to be a quite promising productive sector of industrial economy and has already been became the main fish culture method in coastal zone



Impacts

- One of the criticisms of intensive cage is environmental impacts from the nutrient load…that is “fish pooh and pee”

The thing about nutrient…

- When present in excess → Becomes a pollutant
- Appropriate concentrations → Essential for life

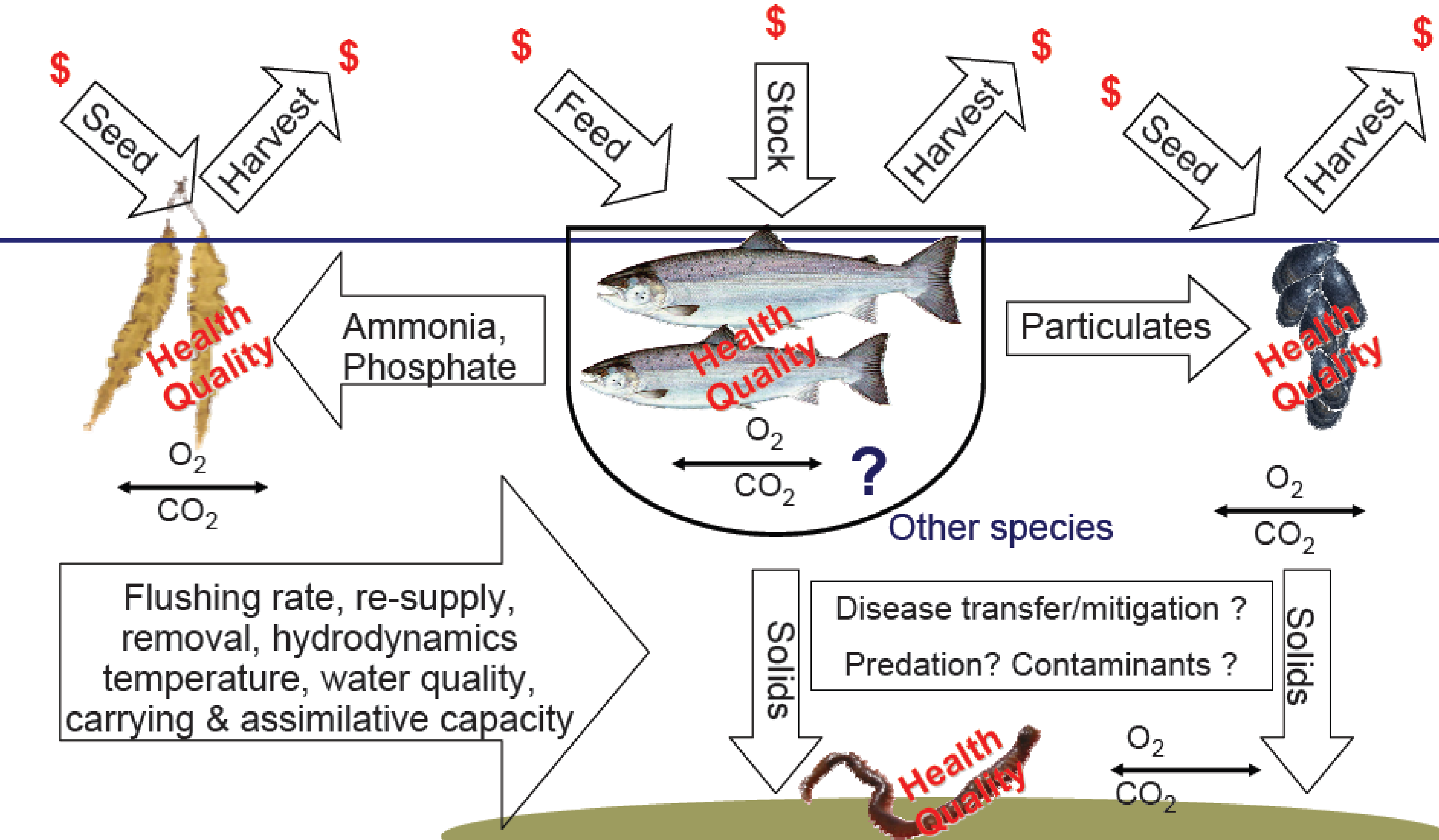
What can we do to minimize nutrient loading impacts?

- Ensure nutrient loading stays within the assimilative capacity of the localized ecosystem
- Recover some of the ‘lost nutrients’ in harvestable biomass

IMTA

- The by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another
- Fed aquaculture (e.g. fish) is combined with inorganic extractive (e.g. seaweed) and organic extractive (e.g. shellfish) aquaculture

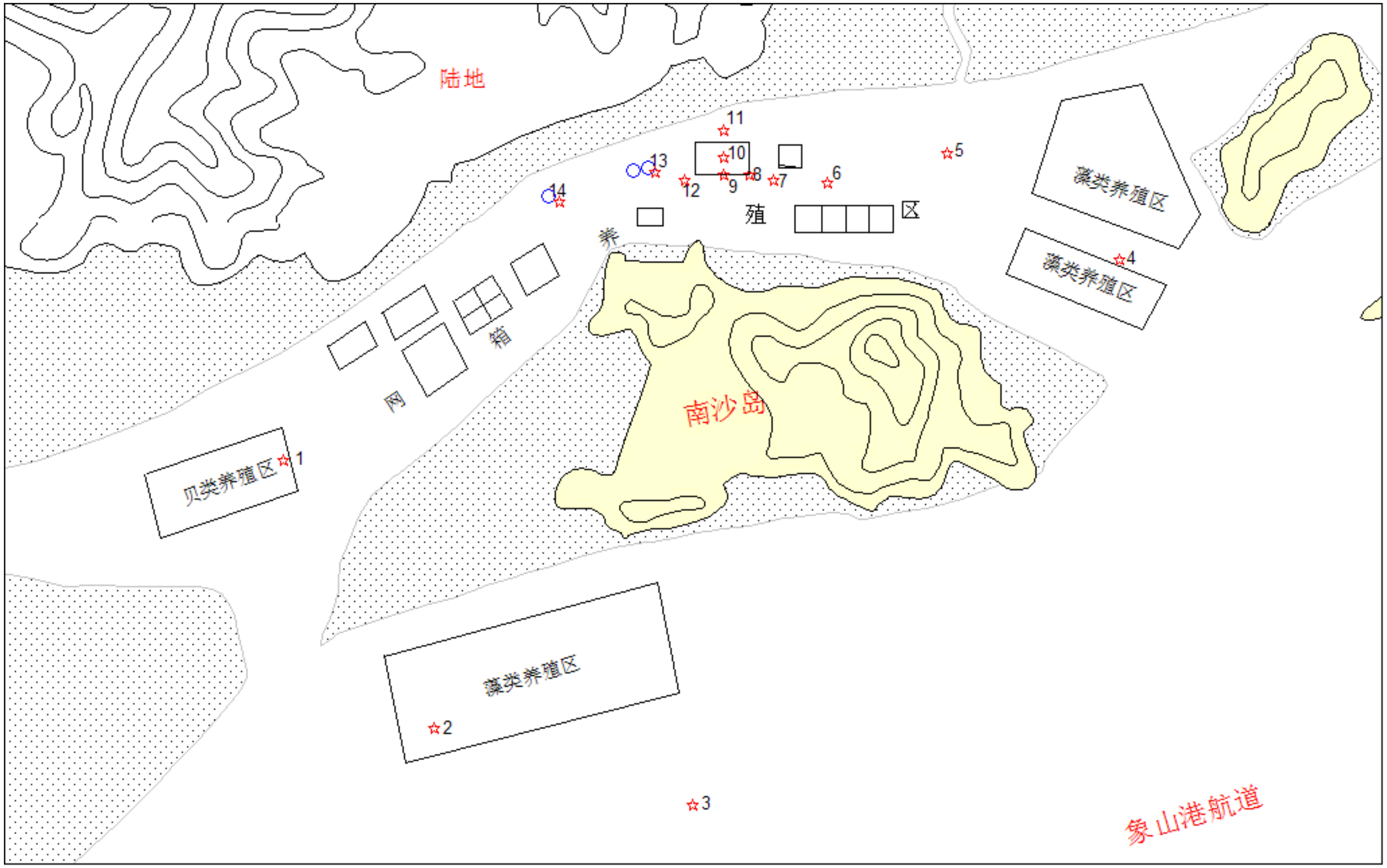
The overall IMTA model: Schematic overview



First…

- The nutritional mass-balance model in cage culture system

Part II. A case study



- Total 4000 polyethylene fish cages in use with dimensions 3m×3m×6m
- Sea bass *Lateolabrax Ljaponicus* and large yellow croaker *Pseudosciaena crocea* were the main culture species

Nutrient Mass Balance

- Feed+ Fry+ Hydrodynamic input + Release from sediment = Harvest of adult fish + Sedimention + Hydrodynamic output + Others

Amount and Composition of Feed

	Moisture	Protein	Lipid	Carbohydrate	Nitrogen	Phosphorus
蓝圆鲹 **Decapterus maruadsi**	**70.50**	**19.80**	**5.26**	**2.01**	**3.17**	**0.32**
日本金线鱼 **Nemipterus japonicus**	**63.08**	**17.72**	**13.73**	**3.22**	**2.84**	**0.41**
黄斑篮子鱼 **Siganus oramin**	**69.97**	**18.91**	**7.63**	**2.31**	**3.03**	**0.56**
中华青鳞鱼 **Harengula Zundsi**	**71.10**	**18.60**	**5.20**	**1.17**	**2.98**	**0.17**
Average	**68.66**	**18.76**	**7.96**	**2.18**	**3.01**	**0.37**

Amount and Composition of Fry

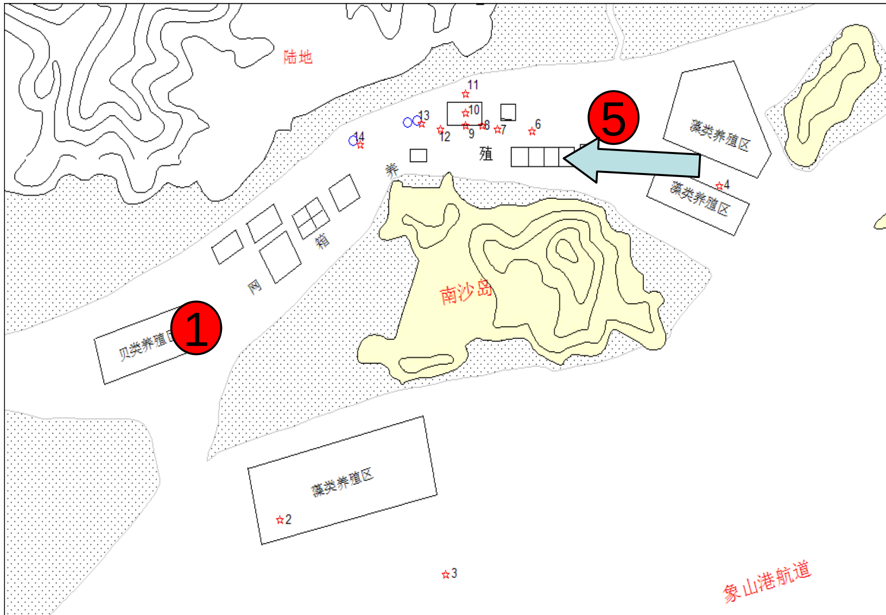
	Moisture	Protein	Lipid	Carbohydrate	Nitrogen	Phosphorus
鲈鱼 **Lateolabrax japonicus**	**70.14**	**18.12**	**14.89**	**0.00**	**2.90**	**0.19**
大黄鱼 **Pseudosciaena crocea**	**71.24**	**17.25**	**10.95**	**0.67**	**2.76**	**0.13**
美国红鱼 **Lutjanus sanguineus**	**70.23**	**16.68**	**4.03**	**2.02**	**2.67**	**0.21**
Average	**70.54**	**17.35**	**9.96**	**0.90**	**2.78**	**0.18**

Amount and Composition of adult fish

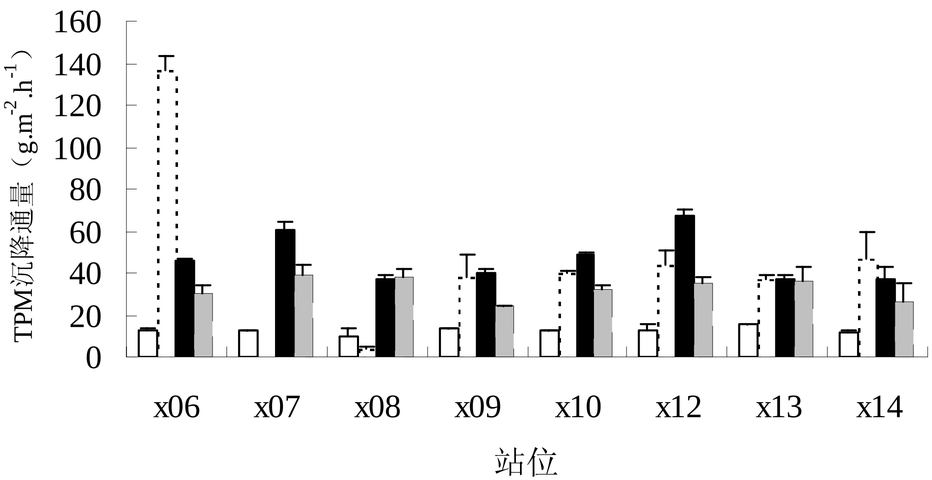
	Moisture	Protein	Lipid	Carbohydrate	Nitrogen	Phosphorus
鲈鱼 **Lateolabrax japonicus**	**76.5**	**18.6**	**3.4**	**0**	**2.98**	**0.24**
大黄鱼 **Pseudosciaena crocea**	**77.7**	**17.7**	**2.5**	**0.8**	**2.83**	**0.17**
美国红鱼 **Lutjanus sanguineus**	**76.6**	**17.12**	**0.92**	**2.4**	**2.74**	**0.27**
Average	**76.93**	**17.81**	**2.27**	**1.07**	**2.85**	**0.23**

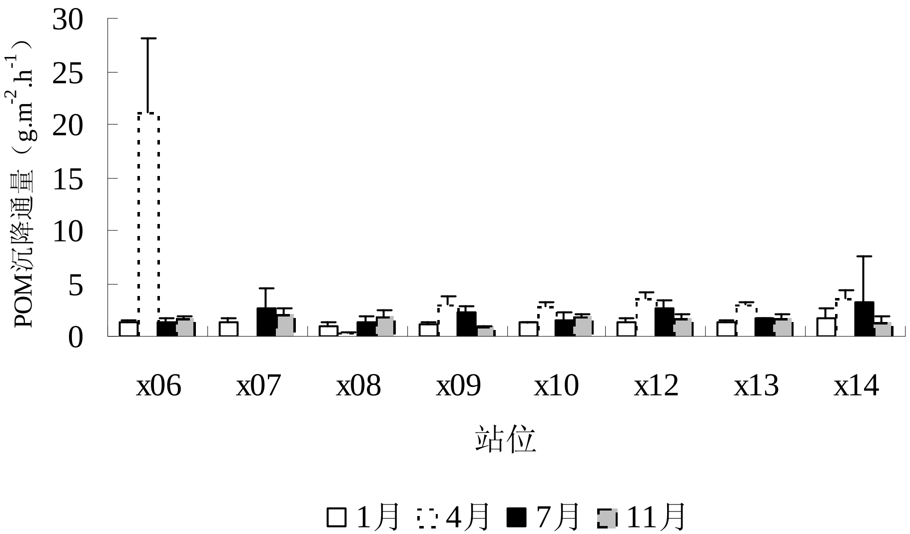
Hydrodynamic input and output

	5#（mg/L）		1#（mg/L）	
	DIN	PO_4	DIN	PO_4
2007-01	1.288	0.0781	0.914	0.0922
2007-04	0.955	0.045	1.159	0.049
2007-07	0.668	0.044	0.659	0.058
2007-11	0.960	0.071	1.192	0.071



Sedimention flux





- TPM：34.92 $g/m^2.h$
- POM：2.49 $g/m^2.h$

Diffusion flux--Fick first law

	NO_2^--N	NO_3^--N	NH_4^+-N	DIN	PO_4-P
2007-01	7.79	314.29	252.55	574.63	57.71
2007-04	21.50	520.63	505.59	1047.72	36.91
2007-07	-1.11	5123.88	1224.32	6347.09	34.76
2007-11	3.88	-313.10	486.06	176.85	37.39
Annual average	8.02	1411.43	617.13	**2036.57**	**41.69**

$\mu mol \cdot m^{-2} \cdot d^{-1}$

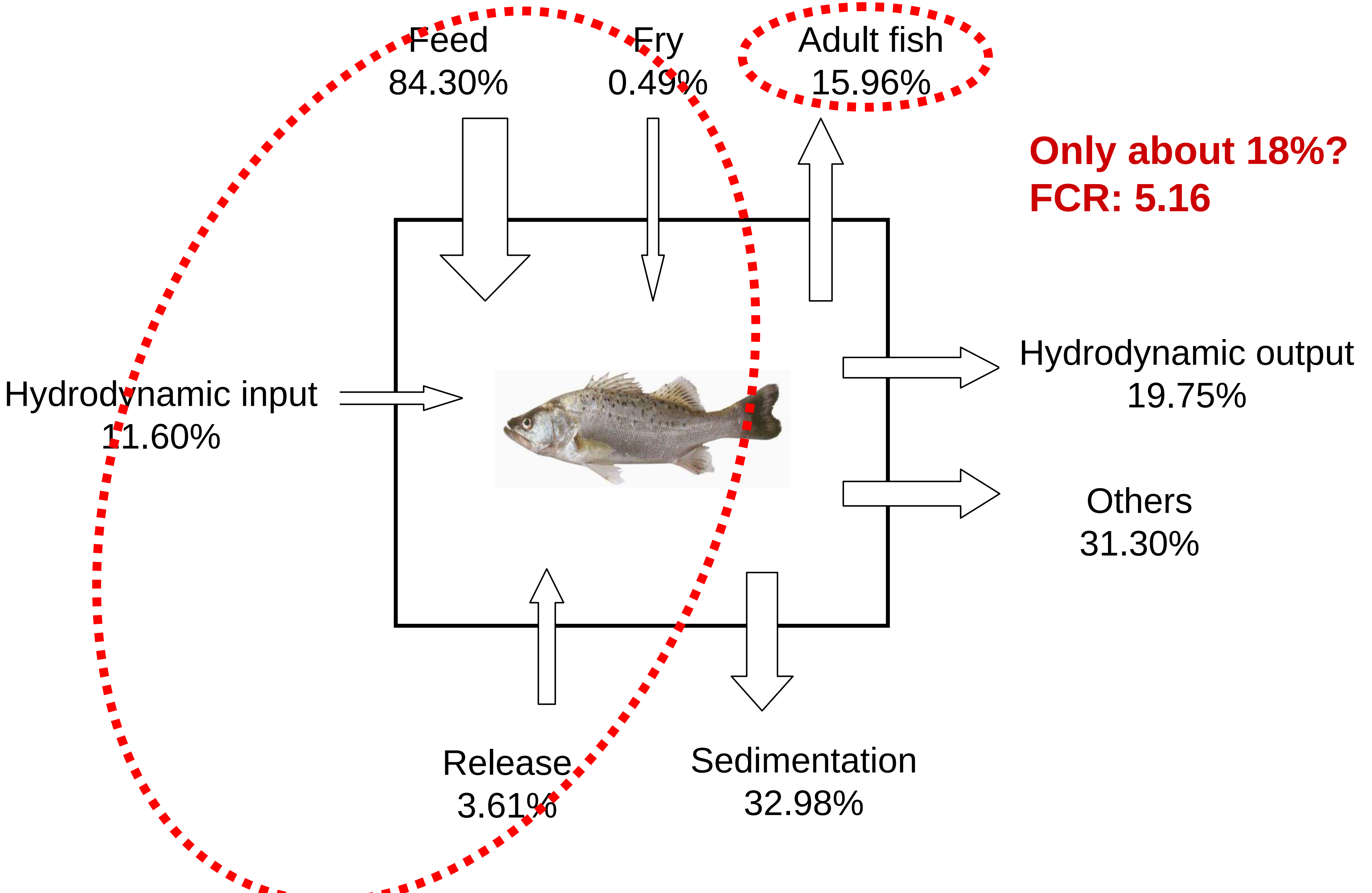


Fig.1 Nitrogen budget in marine fish cage culture system

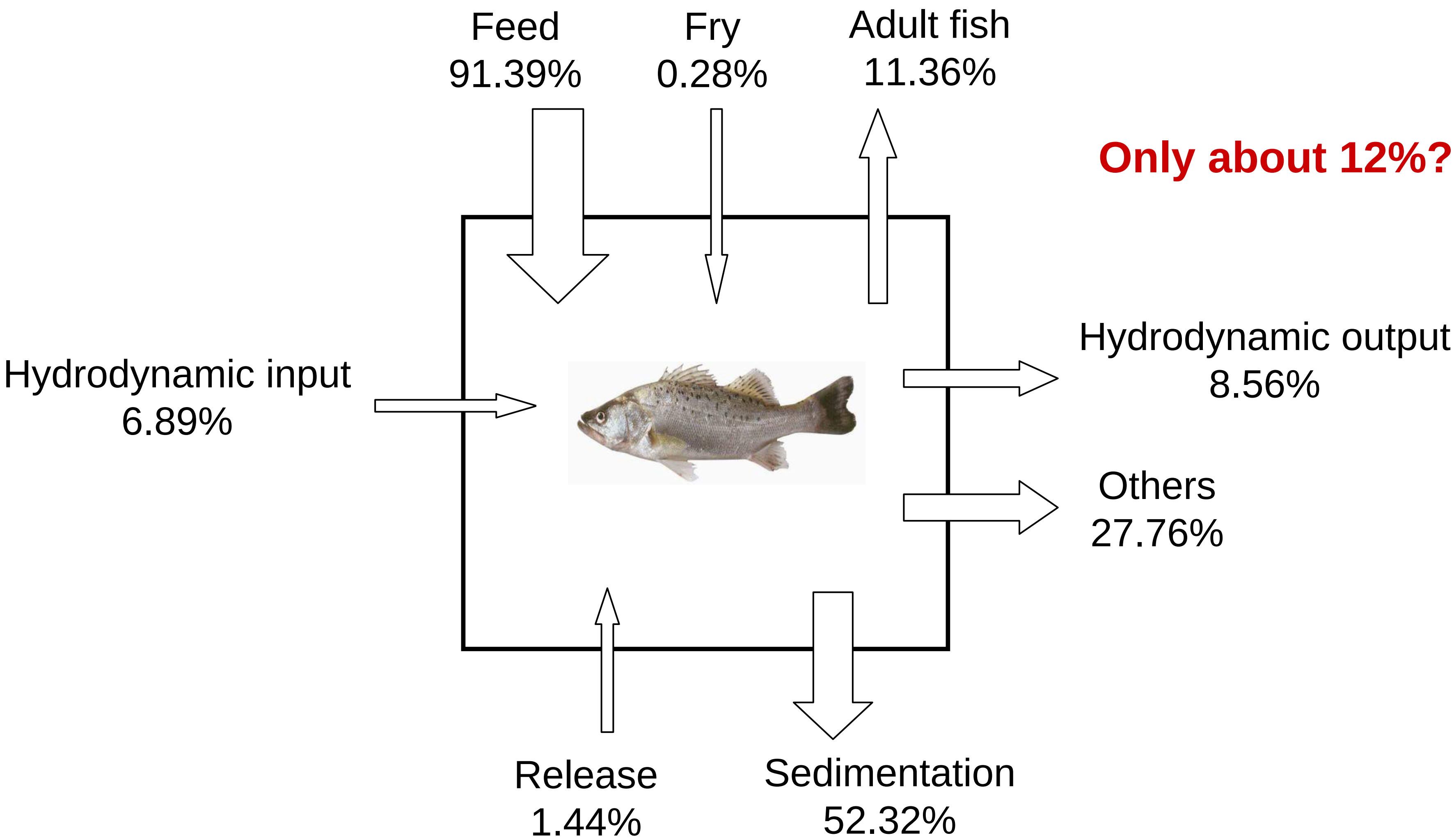
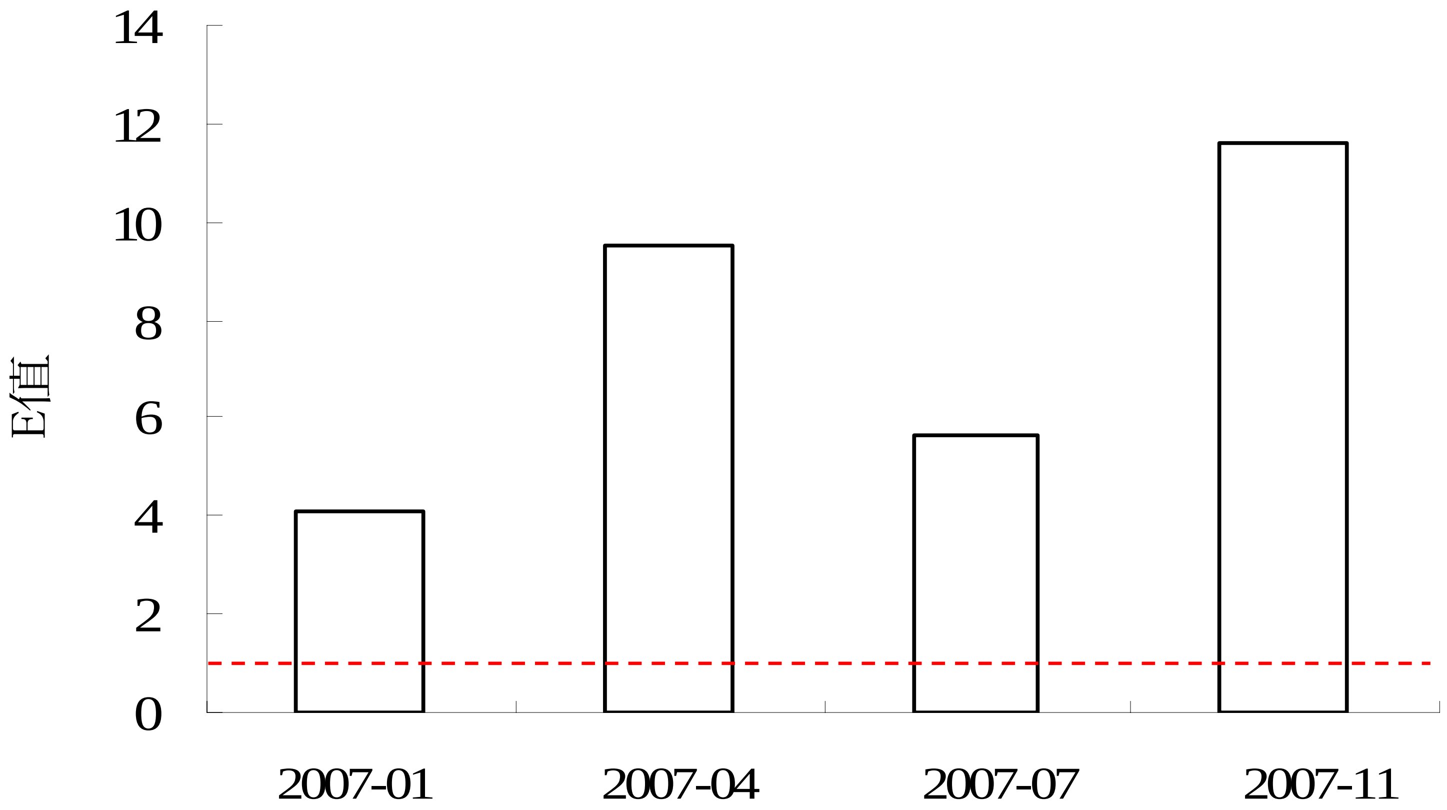


Fig.2 Phosphorus budget in marine fish cage culture system

- Cage area: 618800 m^2
- *Laminaria/Gracilaria* area: 747073.4 m^2
- *Ostrea plicatula:* 51390 m^2

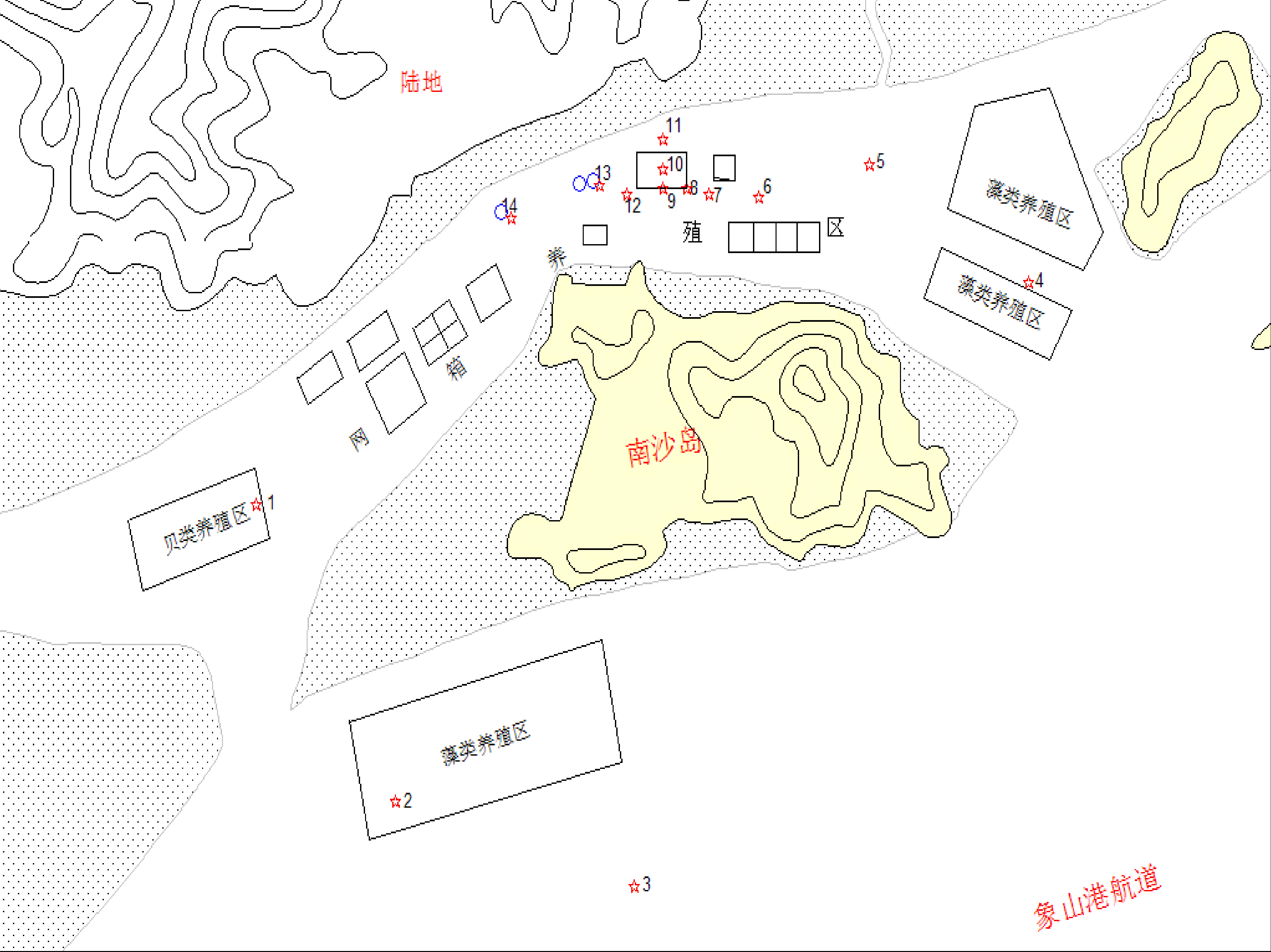
Nutrient content in water column (μmol/L)

Time	Area	NO_2-N	NO_3-N	NH_4-N	PO_4-P	N/P
2007-01	Cage	**0.89**	**65.43**	**3.23**	**2.43**	**28.62**
	Shellfish	**1.00**	**56.43**	**7.86**	**2.97**	**21.98**
	Macroalgae	**0.86**	**62.86**	**2.93**	**2.34**	**28.48**
	Control	**0.86**	**55.00**	**2.50**	**2.52**	**23.16**
	Average	**0.90**	**59.93**	**4.13**	**2.57**	**25.56**
2007-04	Cage	**0.99**	**68.71**	**2.54**	**1.51**	**47.84**
	Shellfish	**1.21**	**78.57**	**3.00**	**1.58**	**52.39**
	Macroalgae	**1.07**	**81.07**	**2.29**	**1.47**	**57.44**
	Control	**1.21**	**71.43**	**1.00**	**1.48**	**49.76**
	Average	**1.12**	**74.95**	**2.21**	**1.51**	**51.86**
2007-07	Cage	**3.29**	**40.93**	**1.43**	**1.57**	**29.08**
	Shellfish	**4.07**	**40.71**	**2.29**	**1.87**	**25.17**
	Macroalgae	**3.07**	**33.93**	**0.86**	**1.52**	**24.91**
	Control	**4.86**	**46.43**	**0.59**	**1.94**	**26.74**
	Average	**3.82**	**40.50**	**1.29**	**1.73**	**26.48**
2007-11	Cage	**0.48**	**63**	**3.19**	**2.64**	**25.25**
	Shellfish	**0.37**	**82.86**	**1.93**	**2.29**	**37.19**
	Macroalgae	**0.38**	**47.5**	**1.93**	**2.32**	**21.47**
	Control	**0.26**	**67.86**	**1**	**2.52**	**27.42**
	Average	**0.37**	**65.31**	**2.01**	**2.44**	**27.83**



- E=COD×DIN（mg/L）×DIP（mg/L）×10^6/4500
- *E* value much higher than 1
- Heavy eutrophication

What's wrong?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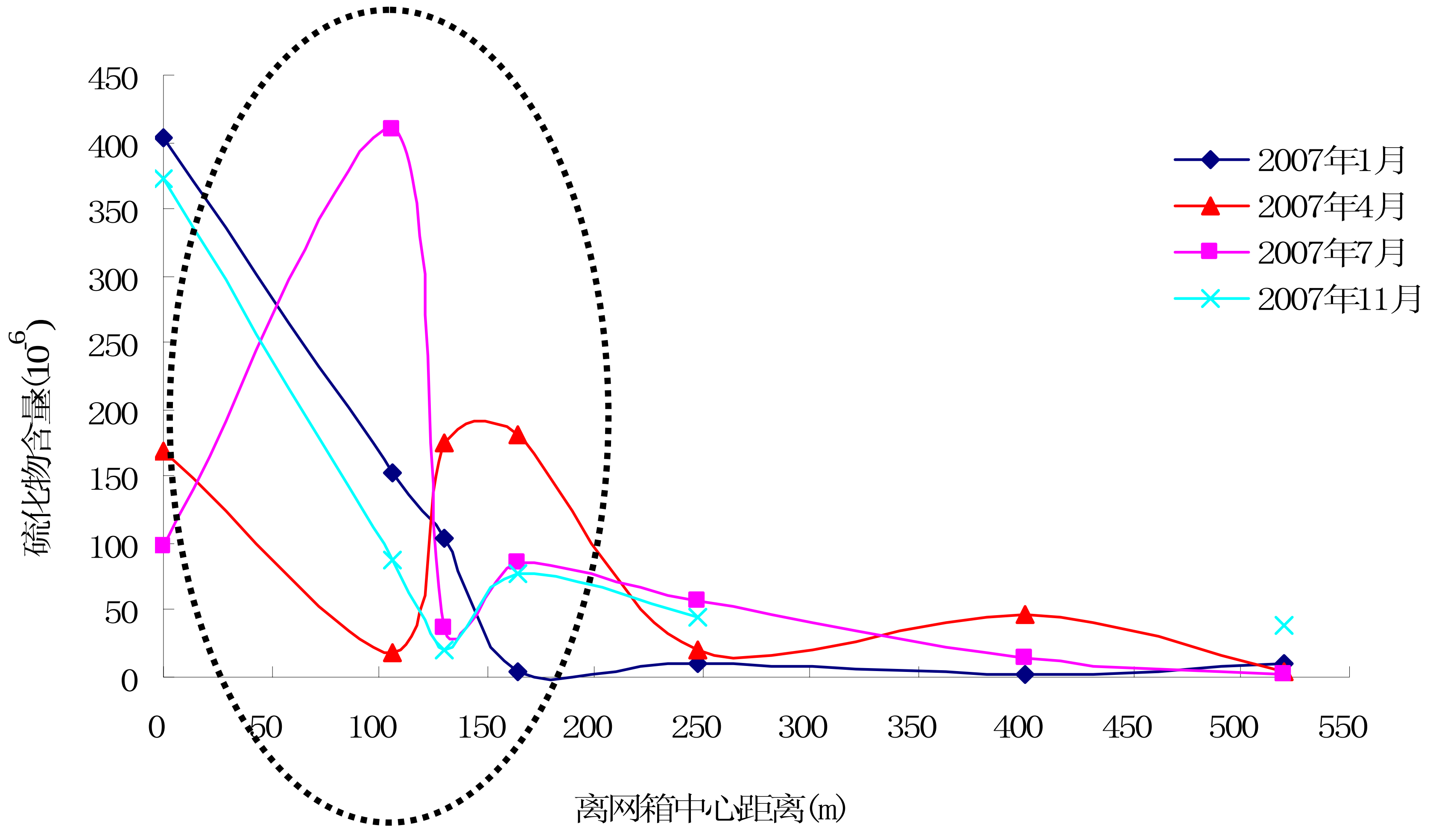
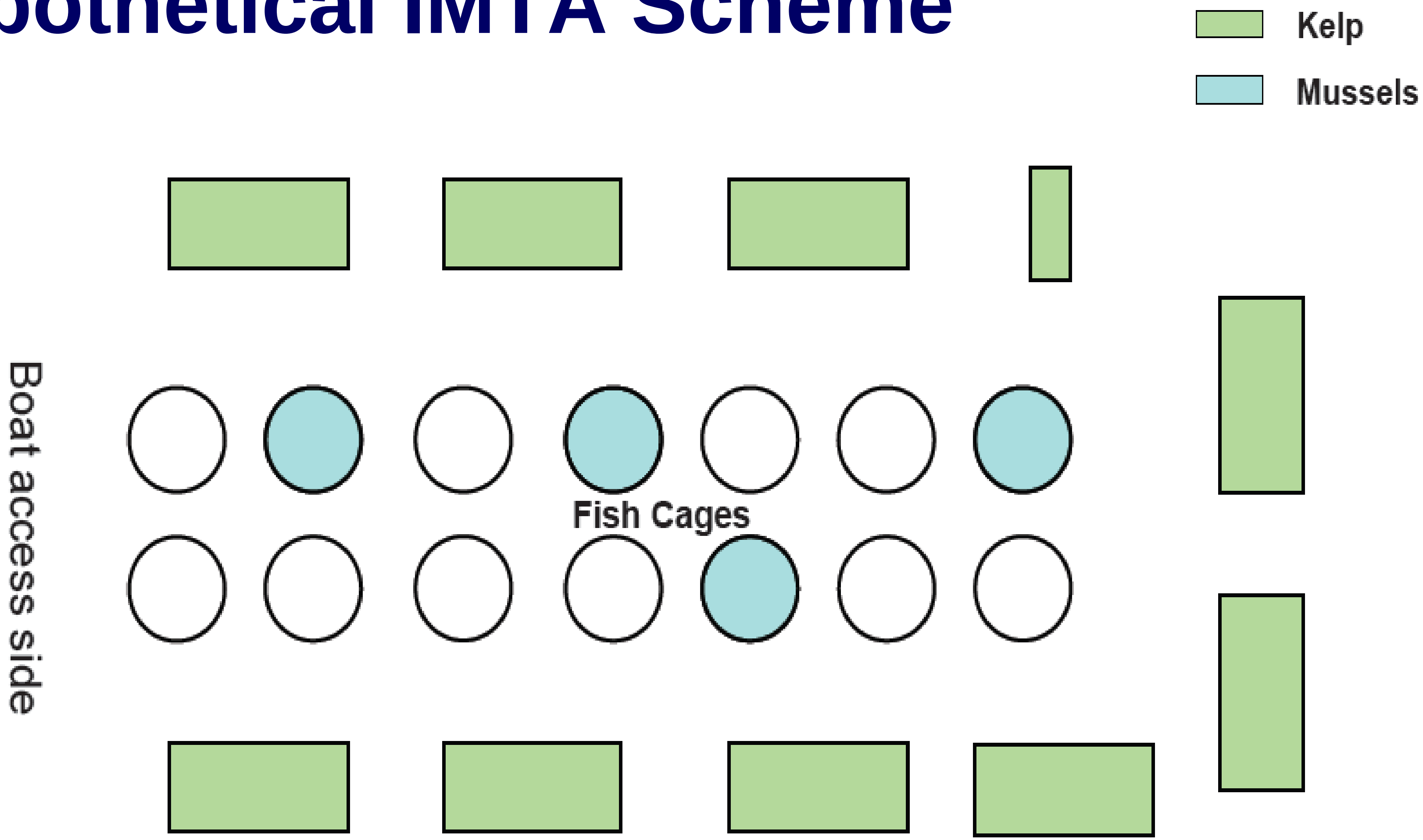
Sulfide content in sediment

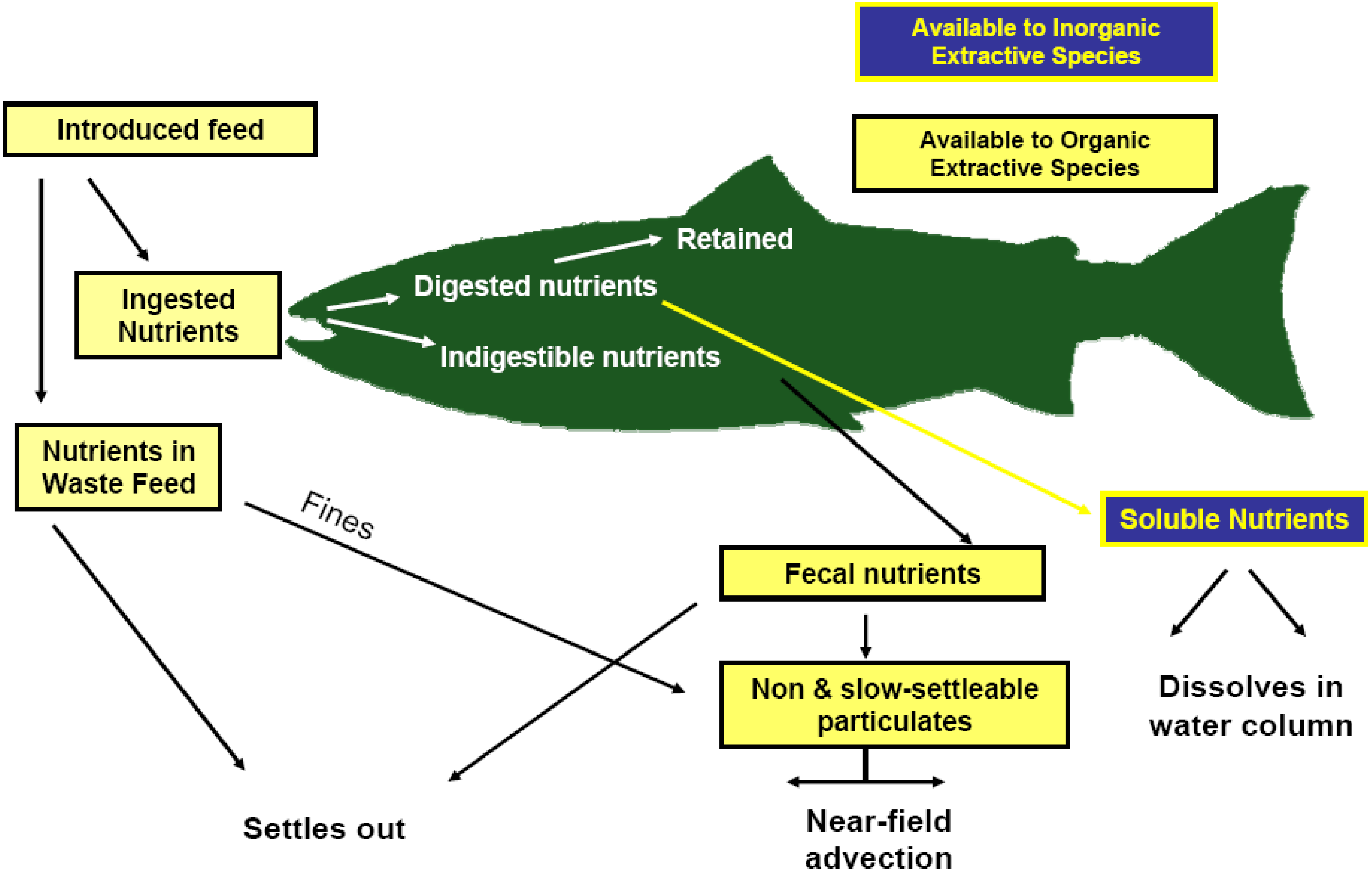


Hypothetical IMTA Scheme

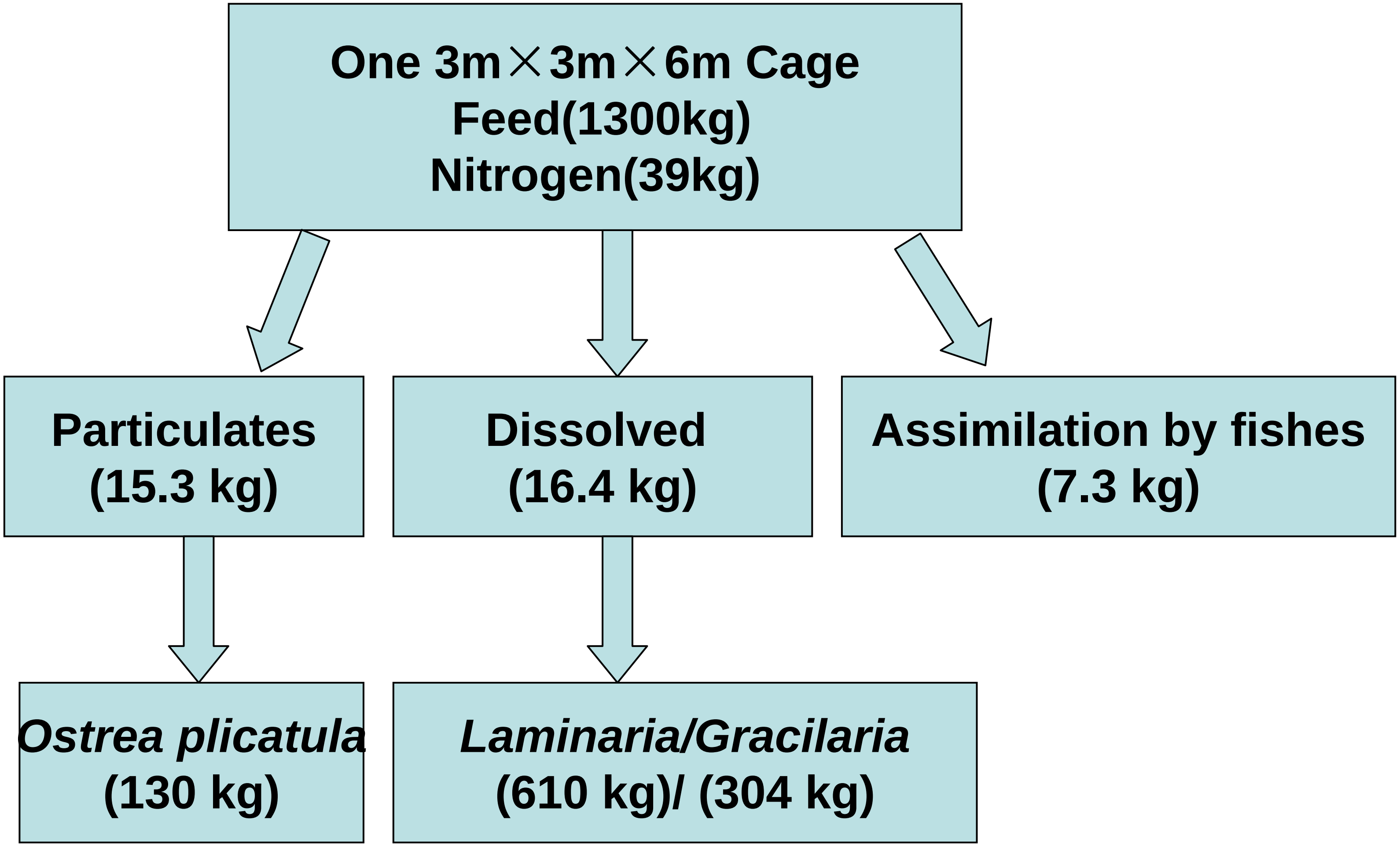


- **What is the optimal ratio?**

Nutrient flow chart



Calculation of nitrogen balance



Fish-Oyster-Seaweed (wet weight)

1 kg : 6.8 kg : 2.43 kg/ 1.21 kg

Part III. Discussion

- IMTA is not combined different species together simply
- Spatial arrangement
- Optimal ratio

Thanks for your attention