Y S F R I

Benefit Evaluation of IMTA Based on Ecosystem Service

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Qingdao, China

9-11September 2008

Our Knowledge on the IMTA …

Concepts based on ecosystem

1: IMTA (Integrated Multi-trophic Aquaculture) is an ecosystem based management approach that effectively mitigates the overabundance of nutrients introduced by fish farming. The lower trophic level organisms provide a biofiltration (filtering the water clean of small particles) service to cleanse the excess particulate matter (via shellfish) and nutrients (via seaweeds) from the environment and incorporate that material into their tissues (Folke et al. 1998, Neori et al. 2004, Whitmarsh et al. 2006).

2: IMTA is a form of marine farming that utilizes the ecosystem services provided by organisms of low trophic levels (e.g. shellfish and seaweed) raised in appropriate ratio to mitigate the effects of organisms of high trophic levels (e.g. fish)(White 2007, Troell et al.2003)

The Contribution of IMTA is to recycle food and energy for increased sustainability and profitability of the aquaculture industry.

The modes on the IMTA …

Fish+Kelp

from Fang

The modes on the IMTA …

Abalone+Kelp

from Fang

The modes on the IMTA …

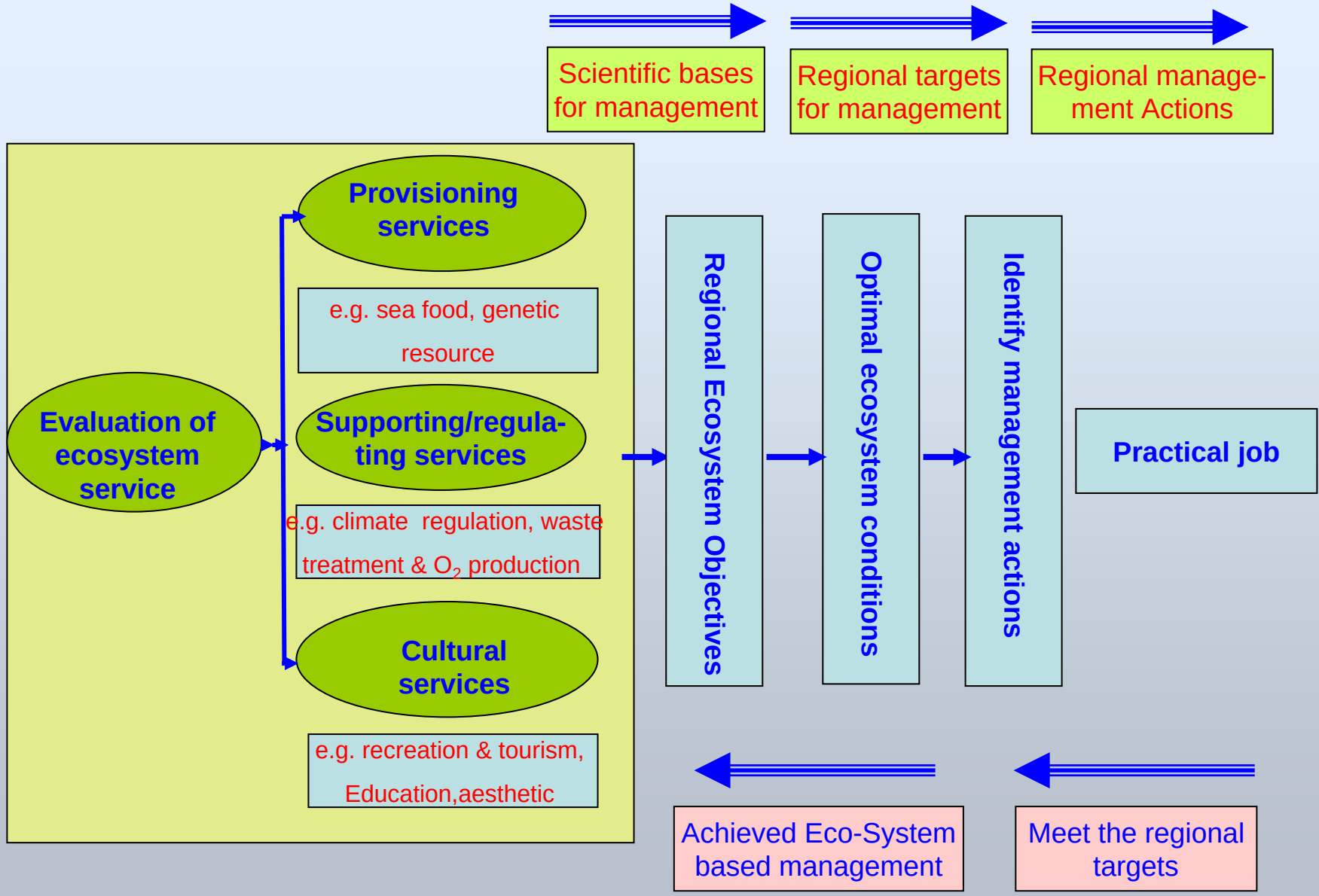
Kelp+Scallop

The modes on the IMTA …

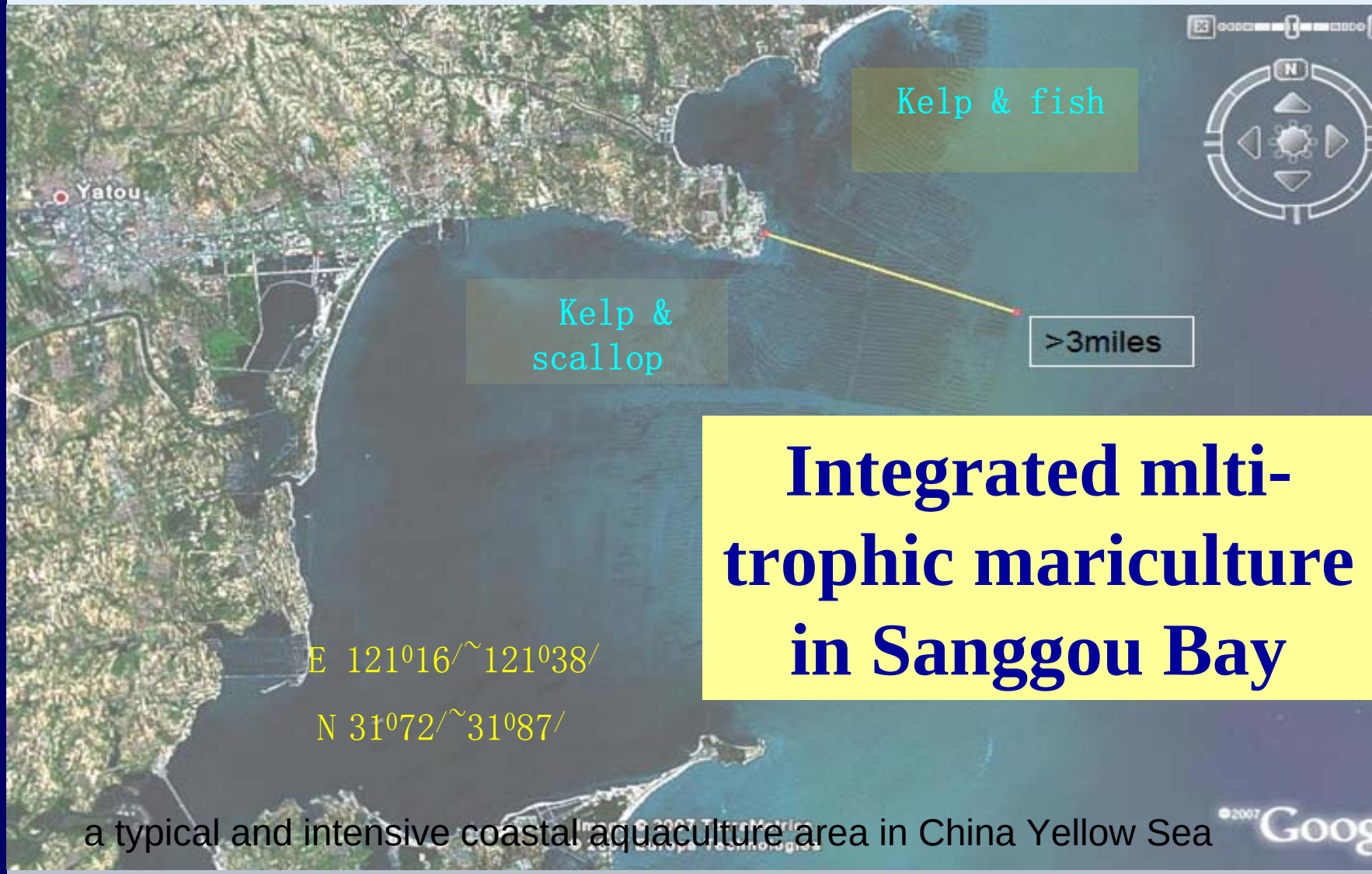
Kelp+Oyster

The modes on the IMTA …

What can we get? …



Case study …


Kelp & fish
Yatou
Kelp & scallop
>3miles
Integrated mlti-trophic mariculture in Sanggou Bay
E 121°16′~121°38′
N 31°72′~31°87′
a typical and intensive coastal aquaculture area in China Yellow Sea

Contents & methods

- ✓ Material production service (Market value approach)

$$V=\sum Bi \times Pi - Q$$

v=total value; Bi =production; Pi =production price; Q =cost

- ✓ Climate regulation service (Carbon tax & reforestation cost approach)

$$V = C \times Pc$$

v=total value; C =amount of fixed & released carbon; Pc = carbon tax;

- ✓ Oxygen production service (Shadow project approach)

$$V = O \times Po$$

v=total value; O =amount of produced oxygen; Po = Industrial oxygen cost

Contents & methods

- ✓ Waste treatment service (Shadow project approach)

$$E_t = \max\left\{\frac{T_j}{N_j\%}\right\} \times P_j$$

E_t =total value; P_j =wiped sewage cost; Tj =amount of removed N,P

- ✓ Nutrient cycle service (Market value approach)

Ef= $Ci \times Pi$ （i=N,P）

Ef = total value; *Ci* =pure content of N & P; *Pi* =price of N & P

Results of evaluation on Kelp & Scallop

Table 1.Value of food production service

Year	2007			
	Area(ha)	Yield(ton/a)	Price(CNY/kg)	Value ($\times 10^4$CNY• ha^{-1} • a^{-1})
Kelp	333.33	11000	6.5	21.45
Scallop		4800	4	5.76
Total				27.21

[a] Data (area, yield) from the statistical data of fishery in Sanggou Bay (Ocean and fishery bureau of Rongcheng city,2007)

[b] The price was from survey results of related company

Results of evaluation on K & S

Table 2. Quantity of fixed C and Value of climate regulation

Year	2007			
	Quantity of fixed C (ton/ha/a)	Reforestation cost (CNY•t^{-1}C)	Carbon tax ($•$t^{-1}$C)	Value (×10^4CNY• ha^{-1} • a^{-1})
Kelp	14.55	260	150	0.2609/1.0960
Scallop	1.555			4.4237/18.5790
	168			
Total(average)				12.56

a Fixed carbon by kelp was calculated by photosynthesis equation and yield

b Fixed carbon by scallop was calculated by coefficient of dry shell and wet body weight(Zhang,2005), and amount of predated phytoplankton (Zhang,2008)

c Value was calculated by the cost of foresting of Chian 260.9 CNY•t^{-1}C , and carbon tax of Sweden 150 $•$t^{-1}$C(1$=7.305CNY,Dec,2007)(Wang,2004), there, we got a average value.

Results of evaluation on K & S

Table 3. Quantity of produced O_2 and Value of oxygen production

Year	2007		
	Quantity of produced oxygen (ton/ha/a)	Price of industrial oxygen (CNY•t^{-1})	Value ($\times 10^4$CNY• ha^{-1} • a^{-1})
Kelp	39.6	400	1.58

[a] Production oxygen by kelp was calculated by photosynthesis equation and yield

[b] The price of industrial oxygen is 400 CNY•t^{-1}O(Wang,2004).

Results of evaluation on K & S

Table 4. Value of waste treatment service

Year	2007				
	Removed total N (t/ha/a)	Removed total P (t/ha/a)	Cost of sewage treatment for N(CNY•kg^{-1})	Cost of sewage treatment for P(CNY•kg^{-1})	Value($\times 10^4$CNY• ha^{-1} • a^{-1})
Kelp	1.5899	0.405	1.5	2.5	0.1807
Scallop	0.1062	0.027			0.0675
Total					0.2482

[a] Cost of waste treatment,1.5CNY•kg^{-1} for N, 2.5CNY•kg^{-1} for P (Zhao,2003);

[b] TN and TP of kelp were 4.818%and 0.322% respectively (Huang,2005)

[c] By harvest of scallop, 27kg of N and 1.8kg P were removed from ocean(Zhou,2002)

Results of evaluation on K & S

Table 5. Value of Nutrients cycling service

Year	2007			
	Amount of N flux (t/ha/a)	Amount of P flux (t/ha/a)	Average price of chemical fertilizer (CNY•t^{-1})	Value($\times 10^4$C NY• ha^{-1} • a^{-1})
Kelp+Scallop	0.1232	0.0249	2549	0.0378

[a] In the kelp and scallop polyculture area, during cultivation period, the exchange of sea water into the Sanggou Bay of inorganic nitrogen, the average concentration of 8.1705μmol/L, PO_4^{3-} -P, the average concentration of 0.7467μmol/L (Liu,2002);

[b] The average price of chemical fertilizer is 2549 CNY•t^{-1}(Ou Yang,2002).

Results of evaluation on K & S

Table 6 Value for ecosystem benefit of IMTA (kelp+Scallop)

Item		Value ($\times 10^4$CNY• ha^{-1} • a^{-1})
Provisioning services	Sea food production	27.21
Supporting/regulating services	climate regulation	12.56
	Oxygen production	1.58
	Waste treatment	0.25
	Nutrients cycling	0.038
Benefit	\	41.64
Cost	Purchasing Seedling	2.16
	Establishment &Management	8.25
Net Value		31.23

Results of evaluation on K & S

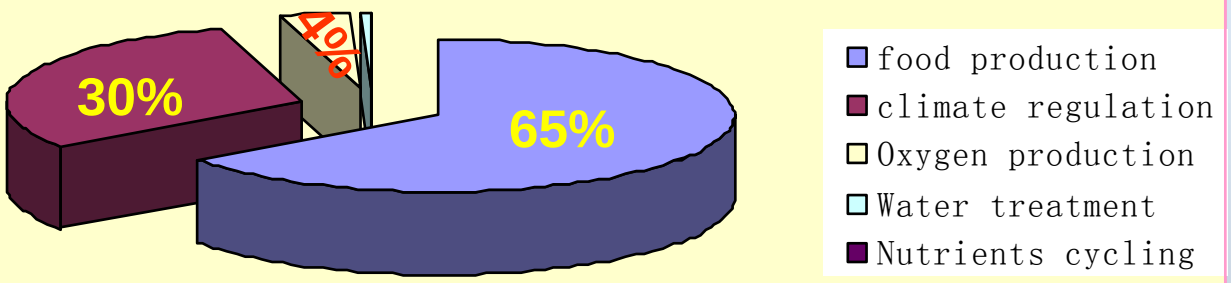


Fig3. The percentage of difference services in the total value

Among the five primary services valuated in IMTA of Kelp & Scallop ecosystem, food production service held the highest value (65%),followed by climate regulation service (30%) and oxygen production service (4%).

Results of evaluation

Table7. Value for ecosystem benefit of monoculture kelp

Item		Value ($\times 10^4$CNY• ha^{-1} • a^{-1})
Provisioning services	Sea food production	24.38
Supporting/regulating services	climate regulation	1.13
	Oxygen production	1.80
	Waste treatment	0.30
	Nutrients cycling	0.045
Benefit		
		19.41

Compared with the monoculture kelp ecosystem, the benefit per unit area of kelp & scallop ecosystem increased by 34% , and the net value per unit area increased by 38% .

Results of evaluation

Table8. Value for ecosystem service of monoculture scallop

Item		Value ($\times 10^4$CNY• ha^{-1} • a^{-1})
Provisioning services	Sea food production	5.76
Supporting/regulating services	climate regulation	11.57
	Oxygen production	0
	Waste treatment	0.068
	Nutrients cycling	0.045
Benefit	\	17.44
Cost	Purchasing Larva	

Compared with the monoculture scallop ecosystem, the benefit per unit area of kelp & scallop co-culture ecosystem increased by 58%, and the net value per unit area increased by 51% .

Results of evaluation on Kelp & Fish

Table 9.Value of food production service in Fish & Kelp co-culture ecosystem

Year	2007					
	Area(ha)	Yield(ton)	Price (CNY/kg)	Cost (CNY/kg)	Cost($\times 10^4$CNY • ha^{-1} • a^{-1})	Net Value($\times 10^4$CNY • ha^{-1} • a^{-1})
Fish	10.3	535	39.5	28.21	146.53	58.64
Kelp	9.7	305.55	6.5	2.7	8.51	11.97
Total					155.03	70.61

[a] Data (area, yield) from the statistical data of fishery in Sanggou Bay (Ocean and fishery bureau of Rongcheng city,2007)

[b] The price was from survey results of related company

Results of evaluation on K & F

Table 10. Quantity of produced O_2 and Value of oxygen production

Year	2007		
	Quantity of produced oxygen (ton/ha/a)	**Price of industial oxygen (CNY•t^{-1})**	**Value (×10^4CNY• ha^{-1} • a^{-1})**
Fish	−4.2508	**400**	**-0.126**
Kelp	**1.099**		

a Production oxygen by kelp was calculated by photosynthesis equation and yield

b Consumed oxygen by fish was 8.184% for the body weight (Ge,2006)

c "-" means deficit.

Results of evaluation on K & F

Table 11. Value of Nutrients cycling service

Year	2007				
	Amount of POM (t/ha/a)	Amount of TN (t/ha/a)	Amount of TP (t/ha/a)	Average price of chemical ferti-liz er(CNY•t^{-1})	Value ($\times 10^4$CNY • ha^{-1} • a^{-1})
Fish+Kelp	12.270	0.1093	0.2804	2549	3.227

[a] In the kelp and fish polyculture area, during cultivation period, the exchange of seawater into the Sanggou Bay of POM, the concentration of 419g.m^{-2}.d^{-1} , the concentration of TN is 3.91 g.m^{-2}.d^{-1} , the concentration of TP is 9.94 g.m^{-2}.d^{-1} (Ge,2006);

Results of evaluation

Table 12 Compare of different aquaculture mode

Aquaculture mode		Benefit($\times 10^4$CNY • ha^{-1} • a^{-1})	Cost($\times 10^4$CNY • ha^{-1} • a^{-1})	TV ($\times 10^4$CNY• ha^{-1} • a^{-1})
IMTA	Kelp+Scallop	41.64	10.41	31.23
	Kelp+Fish	73.963+/-…..	30.91	43.053+/-…..
Monoculture	Kelp	27.65	8.25	19.41
	Scallop	17.44	2.16	15.28
	Fish	…..	28.21	…..

The per unit service value of IMTA mode is much higher than the value of monoculture mode support .

The ellipsis means the results have not yet completed, and the next step of our work ...

Discussion

- Benefit evaluation provides decision-makers with idea of how the should optimize the ecosystem services , and achieves ecosystem based management finally.

- IMTA is a sustainable ecological aquaculture system approach, and introduction of IMTA has greater cont-ributions to the local social economy, environmental regulation and social culture.

Next step of our work …

- Evaluate the other aquaculture mode's service function
- Establish the evaluation index system of aquaculture
- Analysis the impact of aquaculture activities on the marine ecosystem services
- According to the regional objectives for management, optimize aquaculture modes


Thank you !