Large Scale Coastal and Offshore Integrated Multi-Trophic Aquaculture (IMTA)

FANG Jianguang, LIU Hui

Yellow Sea Fisheries Research Institute, CAFS. Qingdao, China

liuhui@ysfri.ac.cn

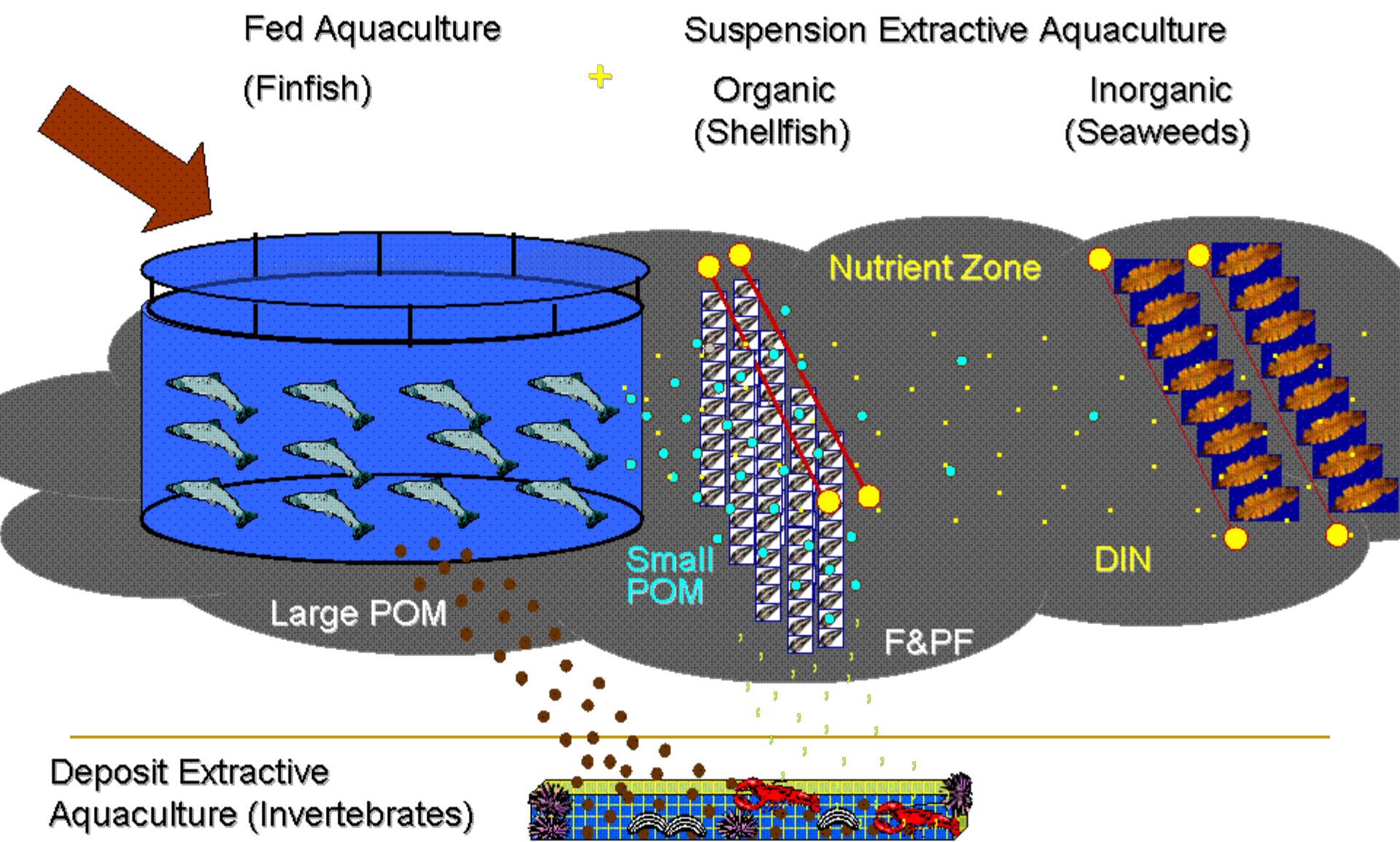
Concept

What is IMTA?

Integrated Multi-Trophic Aquaculture (IMTA) is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another. Fed aquaculture (e.g. fish, shrimp) is combined with inorganic extractive (e.g. seaweed) and organic extractive (e.g. shellfish) aquaculture to create balanced systems for environmental sustainability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

(cited from Wikipedia)

Concept of IMTA (Thierry Chopin, 2009)



Knowledge of IMTA

- 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.

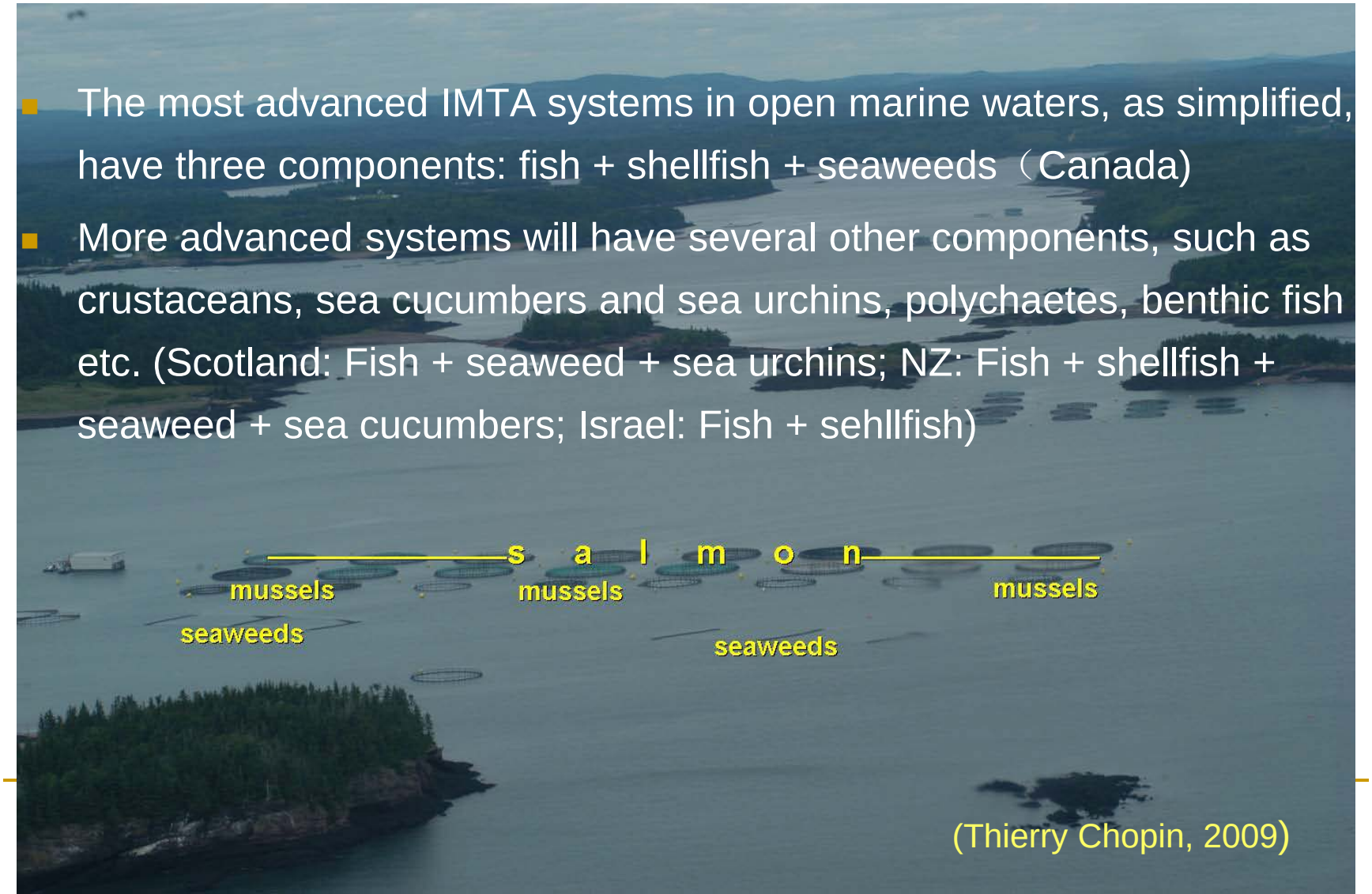
- IMTA is economically and environmentally positive.

Facts, Figures and Common practice of IMTA - A History

- IMTA started in China about 2000 years ago, and now there are commercial scale IMTA with a great variety of species combination, all along the China coast. However, most of the culture systems in China are still single species intensive culture.
- IMTA started in late 1980's in Chile, when the effluent water from a land-based intensive trout culture system was used subsequently for oyster and agar *Gracilaria* culture
- IMTA was first experimented in the US in 1996 as ways to treat wastewater from intensive shrimp farming
- IMTA has been on going in Canada since 2001 by integrating salmon, mussel and kelp
- IMTA started in European counties, though at a very small scale, during 1995 – 2006……

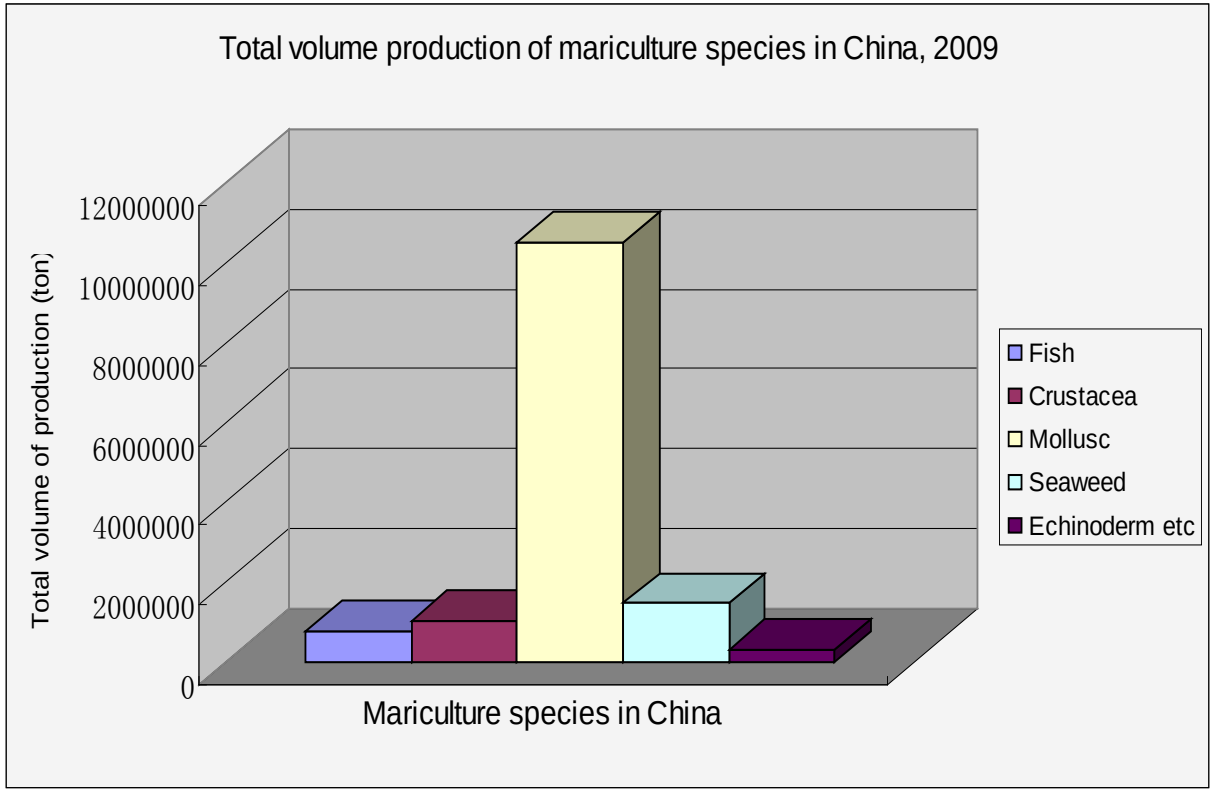
Facts, Figures and Common practice

- The most advanced IMTA systems in open marine waters, as simplified, have three components: fish + shellfish + seaweeds（Canada)
- More advanced systems will have several other components, such as crustaceans, sea cucumbers and sea urchins, polychaetes, benthic fish etc. (Scotland: Fish + seaweed + sea urchins; NZ: Fish + shellfish + seaweed + sea cucumbers; Israel: Fish + sehllfish)

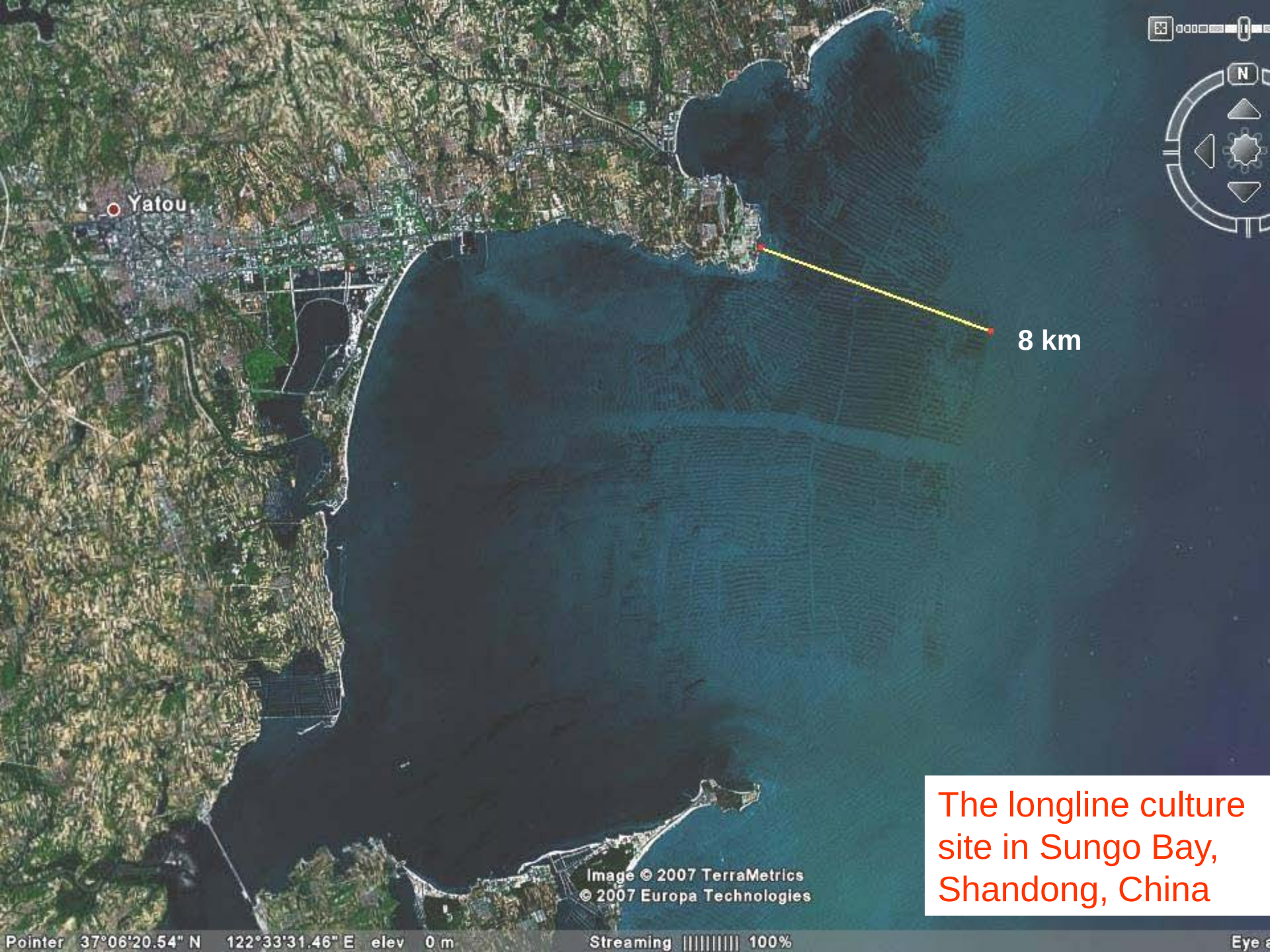


(Thierry Chopin, 2009)

Current status of mariculture in China



In 2009, mariculture production of fish, Crustacean, mollusc, seaweeds and echinoderm etc. were 0.77, 1.0, 10.5, 1.5 and 0.3 million tonnes, respectively; among which, 87.4% are extractive species (seaweeds, mollusc, and echinoderm)



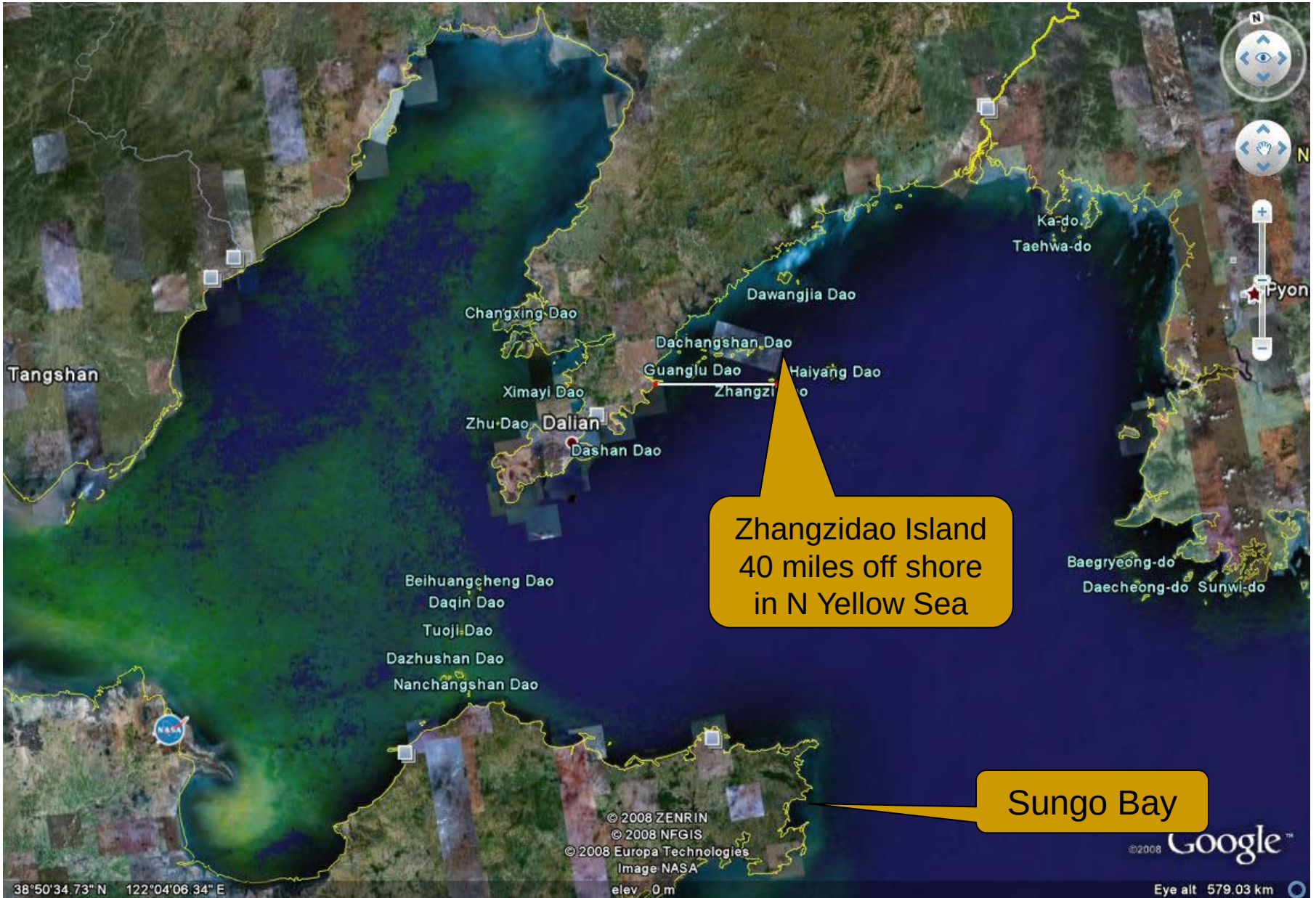
The longline culture site in Sungo Bay, Shandong, China

IMTA in Sungo Bay

Species	Culture area (ha)	Production (t)
Kelp	2 012	80 667
Scallop	164	7 457
Abalone	36	273
Oyster	719	5 3179
Clam	521	27 802
Razor clam		10 665
Shrimp	326	1 310
Finfish	10	535
Sea cucumber	387	1 311
Total	5 101	183 199

Yellow sea

Sea ranching in Zhangzidao Island, Dalian, Liaoning Province



IMTA for Sea ranching or sea bottom culture in subtidal zone in Zhangzidao Island, Dalian, Liaoning Province

Status of sea ranching in ZZD

Species	Sea ranching area (ha)	Annual yield (ton)
Scallop *Patinopecten yessoensis*	40,000	20,000
Abalone *Haliotis discus hannai*	1,000	100
Sea Cucumber *Apostichopus japonicus*	1,000	400
Sea urchin *Strongylocentrotus mudus*	1,000	300
Ark shell *Scapharca broughtonii*	3,000	500

Premise

IMTA should be implemented under the principle and framework of Ecosystem Approach for Aquaculture Management (EAA).

Definition of EAA -from FAO Mallorca workshop (May 2007)

"EAA is a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems".

(Picture courtesy of John Boreman, NOAA)

Premise -

The purpose of EAA

To plan, develop and manage the aquaculture sector in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by aquatic ecosystems.

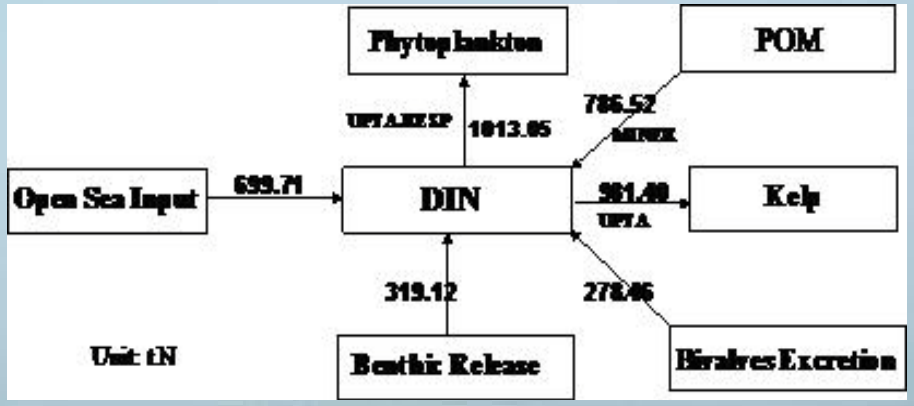
Main objectives of EAA

- Insuring human well-being;
- Insuring ecological well-being
- Facilitating the achievement of both, i.e. effective governance.

Research – Relationships between different species in an IMTA system

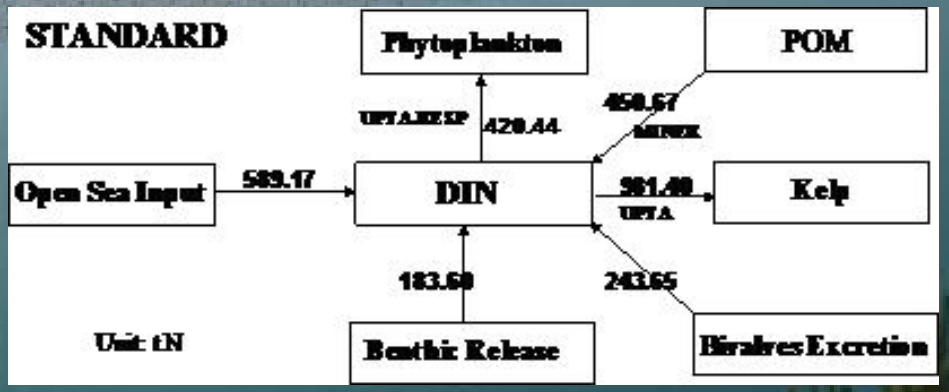
An IMTA system linked by energy and nutrient flow

Research – National Key Basic Research Project (973)



Nutrient Budget of Sungo Bay

Nutrient Budget of Cultured Laminaria



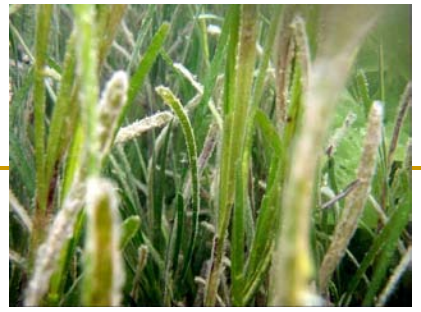
Pilot study of sea ranching - Chudao

Production and economic benefit of sea ranching

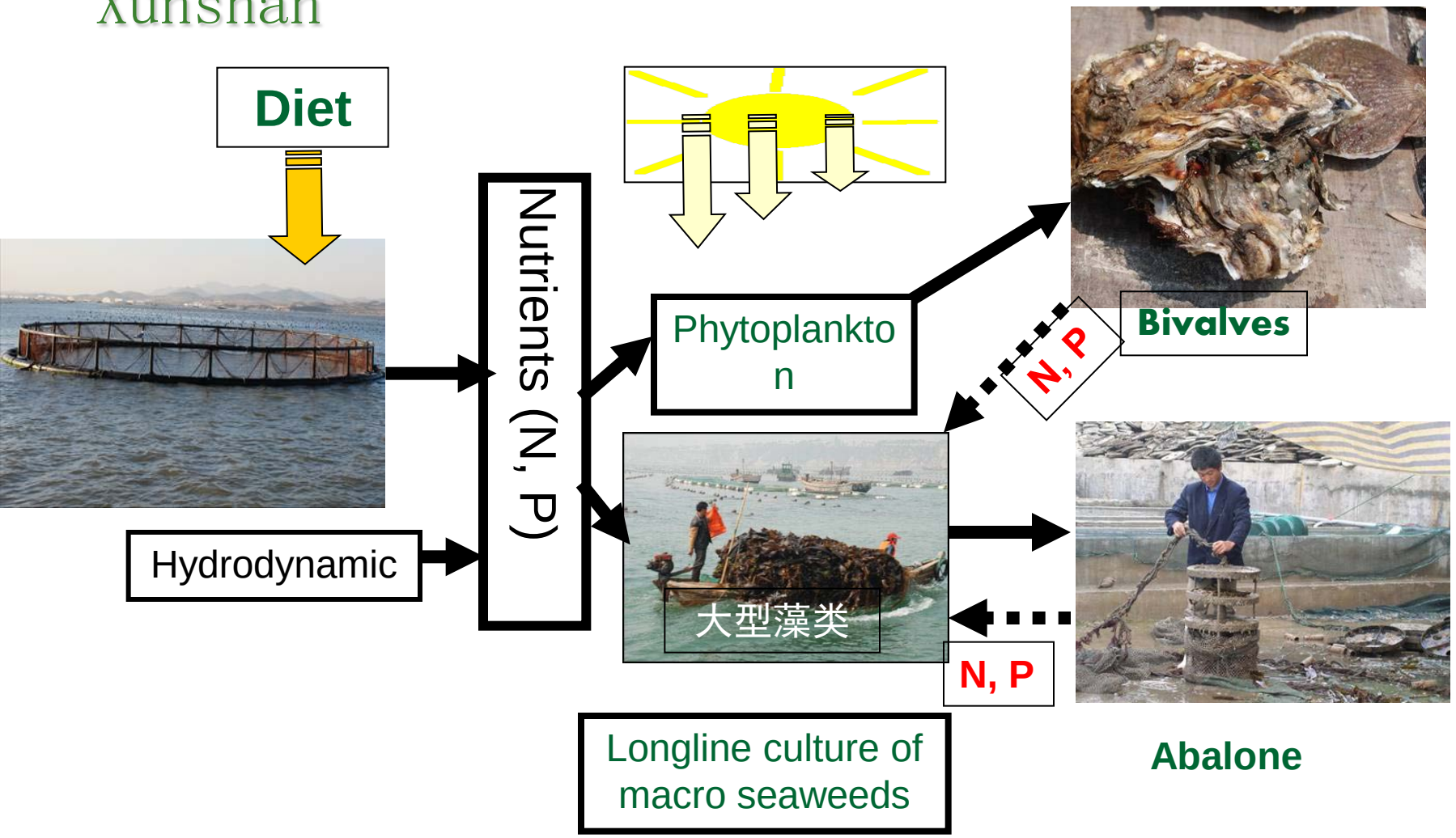
种类	年底播量（ind）	年产量 (kg)	单价 (元/kg)	合计 (万元)
刺参	500,000	20000	160	320
鲍	50,000	1500	600	90
海胆	自然苗	2500	56	14
菲律宾蛤仔	自然苗	200000	7	140
海螺	自然苗	20000	10	20
石花菜	自然苗	80000	6	48
牡蛎	自然苗	300000	0.5	15
紫石房蛤	自然苗	80000	6	48
合计	695万元			

海参底播面积100000亩，鲍增殖面积30000亩






Pilot study of longline culture - Xunshan



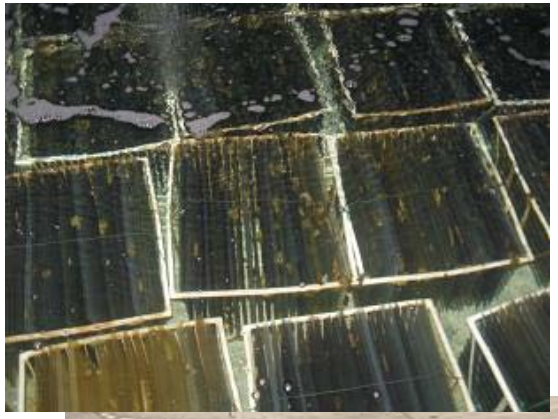
Long-line + net cage IMTA

A comparison of IMTA and finfish monoculture

In Sanggou Bay, The large scale mariculture history is almost 30 years, but the quality of benthos ecosystem is still kept in good status (measured by MOM-B)

In southern China, the history of some large scale finfish cage culture sites are more than 20 years, the accumulation of bio-deposit in the sea bed is almost 1m.

Better Technology – a number of other national research projects (支撑计划， 863 etc.)



Techniques for maintenance and handling cultured species

Marie Curie Actions
Human resources and mobility

Current international joint research project - EU FP7 project: IRC-IMTA

An International Research Consortium for promoting and developing Integrated Multi-Trophic Aquaculture (2009-2012)

The Objective of the programme is to establish an international research consortium for promoting and developing research into **Integrated Multi-Trophic Aquaculture (IMTA)** technologies that supports the sustainable development of aquaculture worldwide.

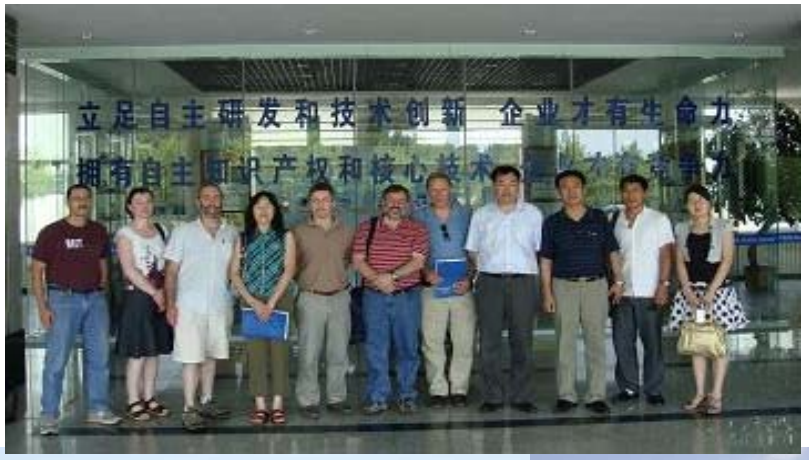
IRC-IMTA Project partner institutions

Name of partner	Institution	Country
Maeve Kelly	The Scottish Association for Marine Science	UK
Yannis Kotzamanis	Hellenic Centre for Marine Research	Greece
Celine Rebours	Norwegian Institute for Agricultural and Environmental Research	Norway
Dror Angel	The University of Haifa	Israel
Hui Liu	**Yellow Sea Fisheries Research Institute, CAFS**	**China**
Philip Heath	National Institute of Water & Atmospheric Research Ltd	New Zealand
Silas O. Hung	Department of Animal Science, University of California, Davis	US
Thierry Chopin	University of New Brunswick	Canada (supporting partner)
Shawn Robinson	Fisheries and Oceans Canada	Canada (supporting partner)

IRC-IMTA - *Impact and foreseeable result of this project:*

IMTA is broad based discipline, with key components such as husbandry, technology, sustainability, modeling, and marketing, which are important research areas for the partner institutions.

By combining their complementary skills the project partners will build a network of excellence in Integrated Multi-Trophic Aquaculture (IMTA) science and technologies



Conclusion and suggestions - Science

What do we know about IMTA?

Different from polyculture, "Multi-Trophic" refers to the incorporation, and at an optimized ratio, of species from different trophic or nutritional levels in the same aquaculture system.

We still need to define or decide:

- The carrying capacity of an aquaculture system
- The relationship between different trophic levels
- The energy and material flow in the culture system
- How to evaluate the success of an IMTA system?

Conclusion and suggestions - Technology

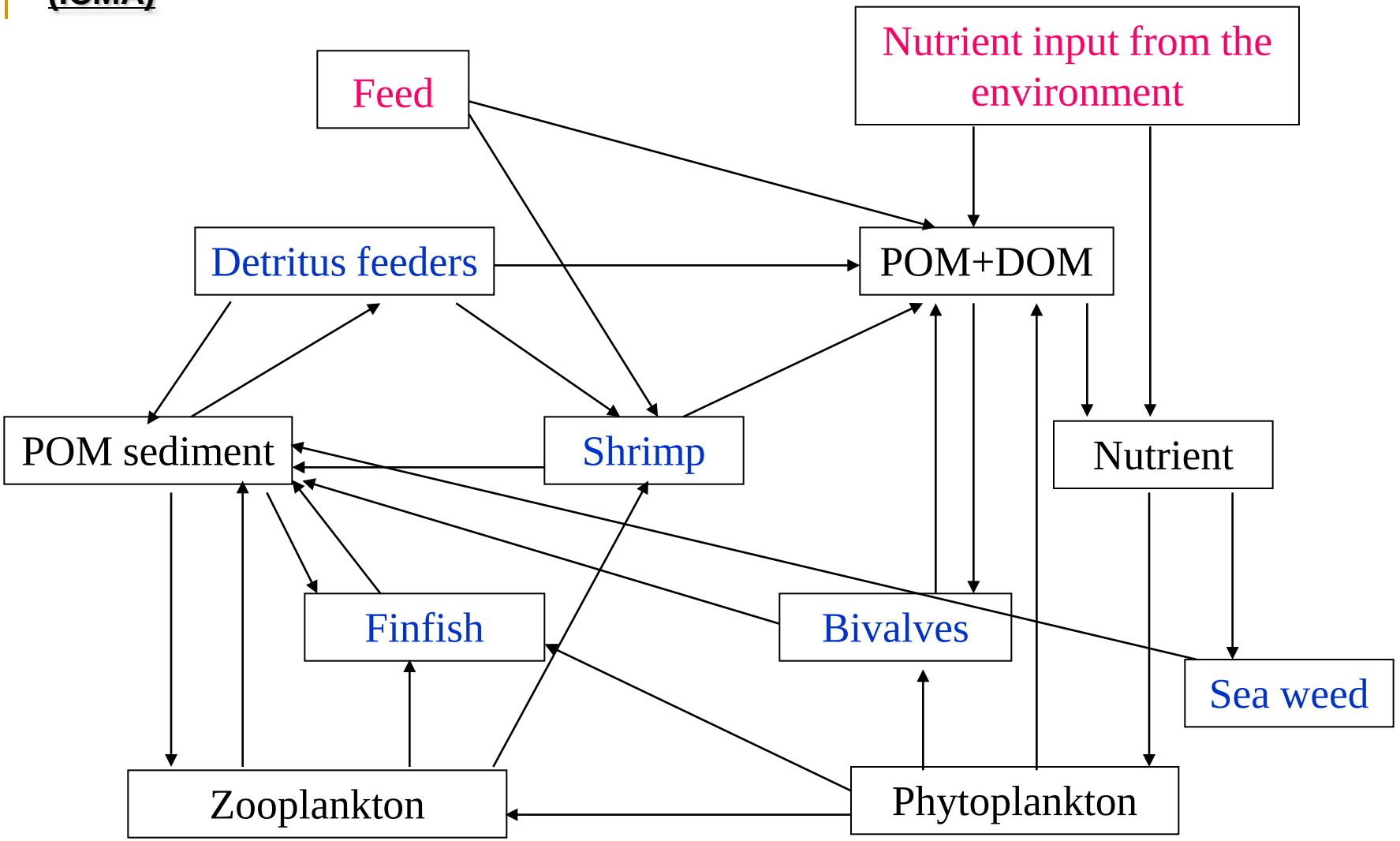
How do we implement IMTA?

For IMTA, we need to culture or maintain a hierarchy of species within an aquaculture system, healthily and relatively easy to transfer, feed and harvest.

Thus we need to develop:

- Thorough understanding of biological, biochemical, hydrographic and seasonal processes, etc. and their interactions with cultured species
- Engineering and operation methods
- Model estimation of economic and biological ratios between different species
- ……

Zero-pollution strategy: Integrated Complete-Cycle Multi-Trophic Aquaculture (ICMA)



Nutrient cycle in an IMTA system of five species

Conclusion and suggestions – other issues

- Policy support
  - Lack of approval and support of IMTA in some countries
  - Strong incentive for monoculture of high-valued species
- Governance
  - Fragmented management of aquaculture areas and farms, and lack of Ecosystem-based perspectives
- Social economy
  - Economically viability of the practice
  - IMTA can provide extra revenue and new jobs
- Public perception and stake holder support

Thank you!