DEVELOPMENT OF CO-CULTURE TECHNOLOGY OF GIANT TIGER PRAWN AND UNUTILIZED BENTHOS

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Isao Tsutsui holds a Doctorate degree in area studies from Kyoto University (in Japan) from his field work related to marine plants in Vietnam. His expertise is in the area of aquaculture and coastal environment. He has worked in the Federated States of Micronesia as a volunteer of Japan Overseas Cooperation Volunteers (JOCV), as a curator and field guide at Noto Marine Center, Japan, and as a visiting researcher at Kasetsart University, Thailand. Currently, he is investigating for benthos applicability to shrimp aquaculture.

ABSTRACT

Shrimp aquaculture is an important industry, which has become the second largest producer of farmed aquatic animals in the world (FAO 2010). Phytoplankton is generally encouraged to bloom in an intensive shrimp culture system, which is a major shrimp culture system worldwide, and is useful in the removal of surplus nutrients. However, phytoplankton is unstable and sensitive to changes in environmental conditions, such as salinity, sunlight, and water temperature. Thus, the phytoplankton is difficult to control and requires specialized techniques. Seaweeds are able to convert excess nutrients in the aquaculture systems into biomass, which also presents the possibility to generate additional revenue from the integrated multi-trophic aquaculture (IMTA) system. However, the consistent promotion or adoption of such systems has not been achieved (Troell, 2009). We suspect that the selection of seaweed species may not always have been appropriate to the specific environmental conditions particular to shrimp aquaculture ponds, especially their wide fluctuations of salinity and water temperature. Accordingly, it is required to apply new suitable species for use in co-culture with shrimp and prawn. *Chaetomorpha* sp. (a filamentous seaweed) and *Stenothyra* sp. (a micro snail) are not popular for IMTA because they have generally been considered nuisance, however, these organisms have characteristics of euryhaline and eurythermal. Our system is unique in that these unexploited benthoses are utilized to promote shrimp growth and quality and not to try to provide a supplemental income. In this presentation, the speaker introduces the basic concept for our shrimp co-culture system and some of the advantages of this co-culture system for sustainable shrimp culture with low cost and low carbon discharge for small scale shrimp aquaculturists in southeast Asian countries.

KEYWORDS

Chaetomorpha, color improvement, growth enhancement, shrimp co-culture, *Stenothyra*

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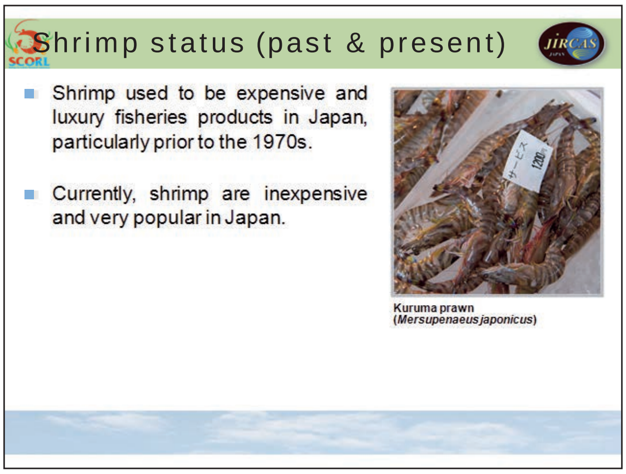
1


Shrimp status (past & present)
SCORL
JIRCAS
Shrimp used to be expensive and luxury fisheries products in Japan, particularly prior to the 1970s.
Currently, shrimp are inexpensive and very popular in Japan.
Kuruma prawn
(Mersupenaeus japonicus)

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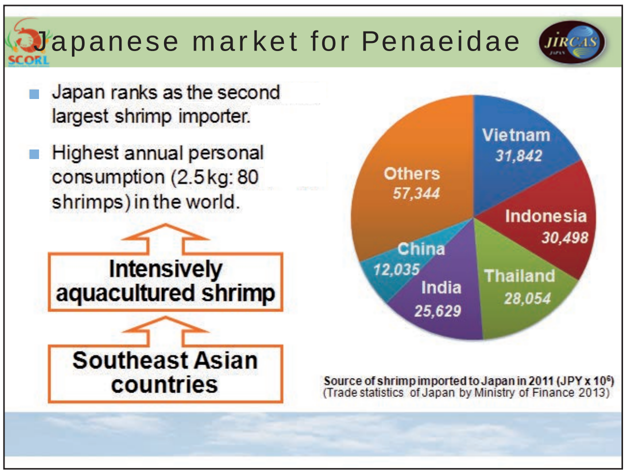
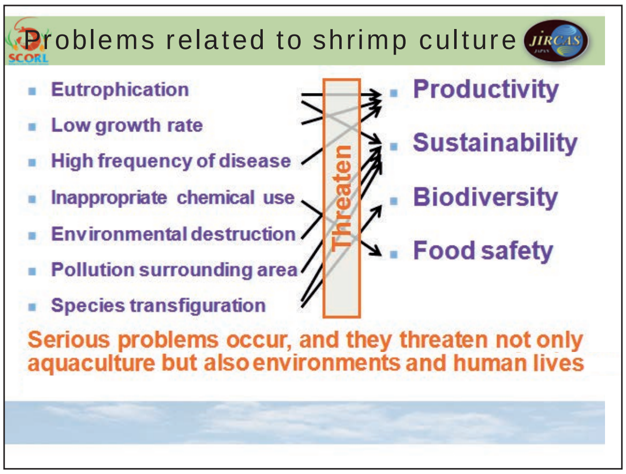
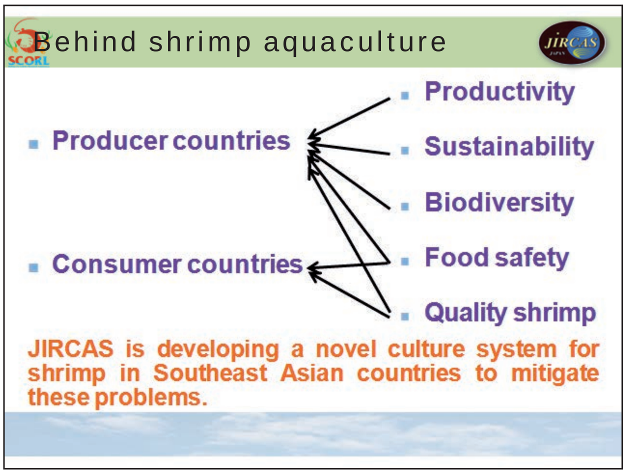

Japanese market for Penaeidae
SCORL
JIRCAS
Japan ranks as the second largest shrimp importer.
Highest annual personal consumption (2.5 kg: 80 shrimps) in the world.
Intensively aquacultured shrimp
Southeast Asian countries
Vietnam 31,842
Indonesia 30,498
Thailand 28,054
India 25,629
China 12,035
Others 57,344
Source of shrimp imported to Japan in 2011 (JPY x 10⁶)
(Trade statistics of Japan by Ministry of Finance 2013)

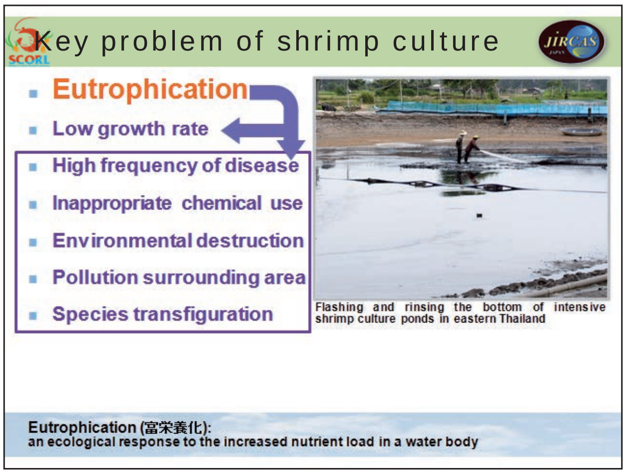
3


Problems related to shrimp culture
SCORL
JIRCAS
Eutrophication
Low growth rate
High frequency of disease
Inappropriate chemical use
Environmental destruction
Pollution surrounding area
Species transfiguration
Threaten
Productivity
Sustainability
Biodiversity
Food safety
Serious problems occur, and they threaten not only aquaculture but also environments and human lives

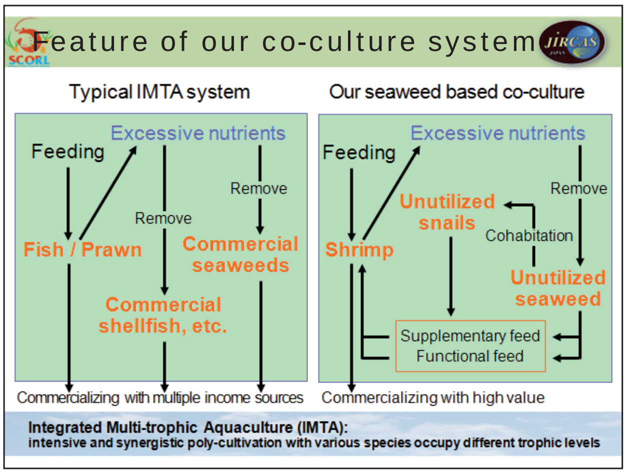
4


Behind shrimp aquaculture
SCORL
JIRCAS
Producer countries
Consumer countries
Productivity
Sustainability
Biodiversity
Food safety
Quality shrimp
JIRCAS is developing a novel culture system for shrimp in Southeast Asian countries to mitigate these problems.

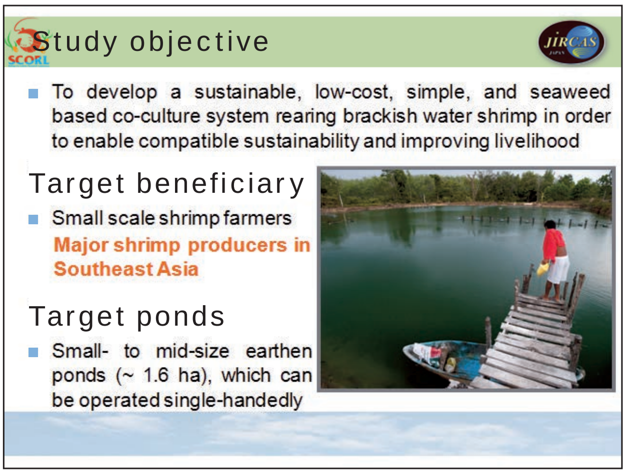
5


Key problem of shrimp culture
SCORL
JIRCAS
Eutrophication
Low growth rate
High frequency of disease
Inappropriate chemical use
Environmental destruction
Pollution surrounding area
Species transfiguration
Flashing and rinsing the bottom of intensive shrimp culture ponds in eastern Thailand
Eutrophication (富栄養化):
an ecological response to the increased nutrient load in a water body

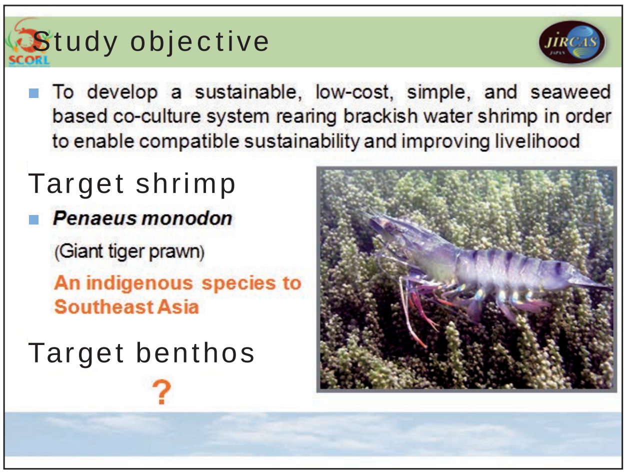
6


Feature of our co-culture system
Typical IMTA system
Our seaweed based co-culture
Excessive nutrients
Feeding
Remove
Remove
Fish / Prawn
Commercial seaweeds
Commercial shellfish, etc.
Commercializing with multiple income sources
Excessive nutrients
Feeding
Remove
Unutilized snails
Cohabitation
Shrimp
Unutilized seaweed
Supplementary feed
Functional feed
Commercializing with high value
Integrated Multi-trophic Aquaculture (IMTA):
intensive and synergistic poly-cultivation with various species occupy different trophic levels

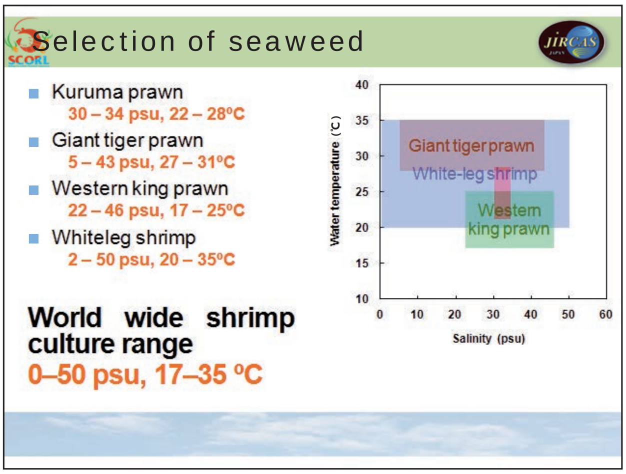
7


Study objective
To develop a sustainable, low-cost, simple, and seaweed based co-culture system rearing brackish water shrimp in order to enable compatible sustainability and improving livelihood
Target beneficiary
Small scale shrimp farmers
Major shrimp producers in Southeast Asia
Target ponds
Small- to mid-size earthen ponds (~ 1.6 ha), which can be operated single-handedly

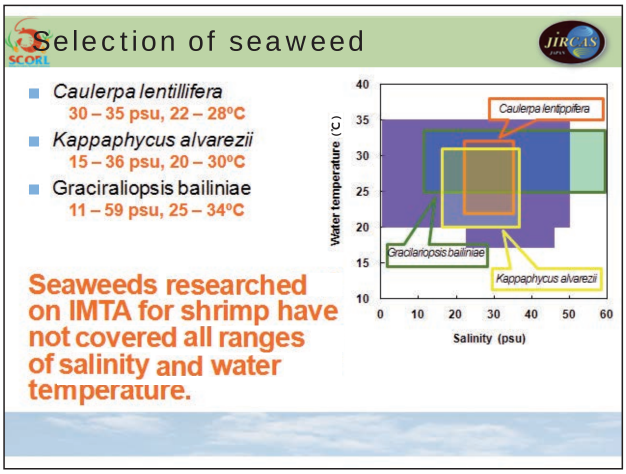
8


Study objective
To develop a sustainable, low-cost, simple, and seaweed based co-culture system rearing brackish water shrimp in order to enable compatible sustainability and improving livelihood
Target shrimp
Penaeus monodon
(Giant tiger prawn)
An indigenous species to Southeast Asia
Target benthos
?

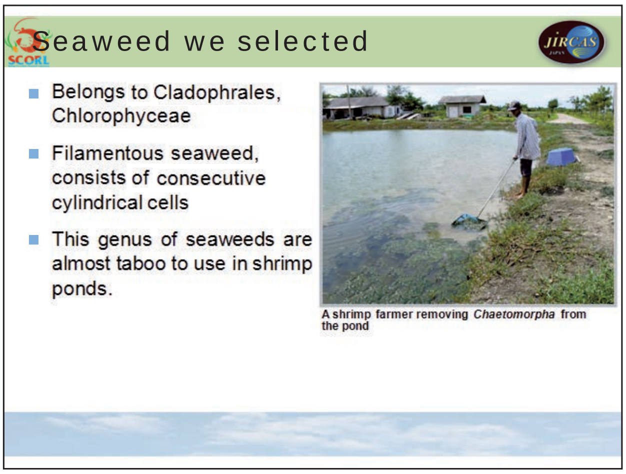
9


Selection of seaweed
Kuruma prawn
30 – 34 psu, 22 – 28°C
Giant tiger prawn
5 – 43 psu, 27 – 31°C
Western king prawn
22 – 46 psu, 17 – 25°C
Whiteleg shrimp
2 – 50 psu, 20 – 35°C
World wide shrimp culture range
0–50 psu, 17–35 °C
Giant tiger prawn
White-leg shrimp
Western king prawn
Water temperature (℃)
Salinity (psu)

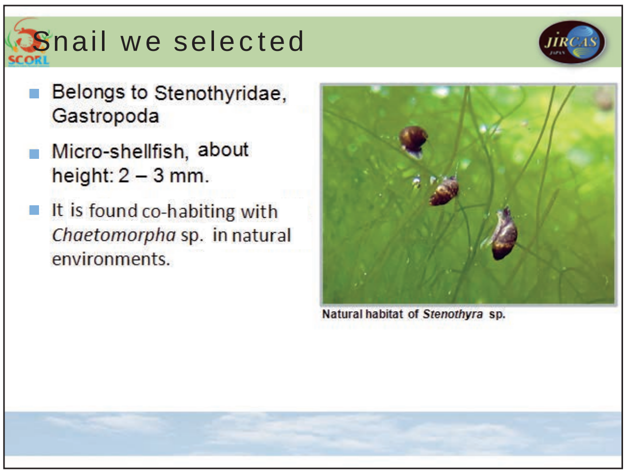
10


Selection of seaweed
Caulerpa lentillifera
30 – 35 psu, 22 – 28°C
Kappaphycus alvarezii
15 – 36 psu, 20 – 30°C
Graciraliopsis bailiniae
11 – 59 psu, 25 – 34°C
Seaweeds researched on IMTA for shrimp have not covered all ranges of salinity and water temperature.
Caulerpa lentippifera
Gracilariopsis bailiniae
Kappaphycus alvarezii
Water temperature (℃)
Salinity (psu)

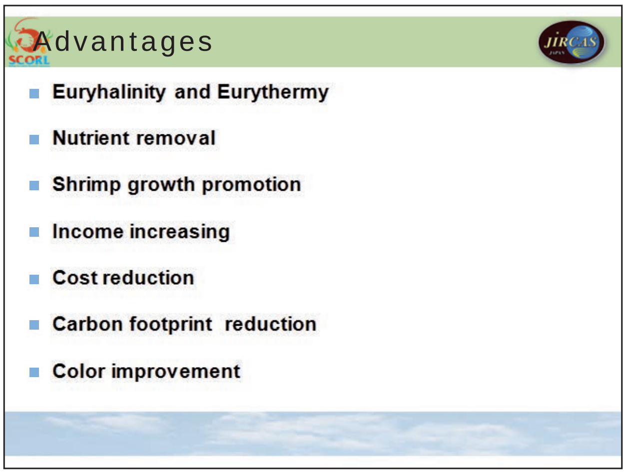
11


Seaweed we selected
Belongs to Cladophrales, Chlorophyceae
Filamentous seaweed, consists of consecutive cylindrical cells
This genus of seaweeds are almost taboo to use in shrimp ponds.
A shrimp farmer removing Chaetomorpha from the pond

12


Snail we selected
SCORL
JIRCAS
Belongs to Stenothyridae, Gastropoda
Micro-shellfish, about height: 2 – 3 mm.
It is found co-habiting with *Chaetomorpha* sp. in natural environments.
Natural habitat of *Stenothyra* sp.

13


Advantages
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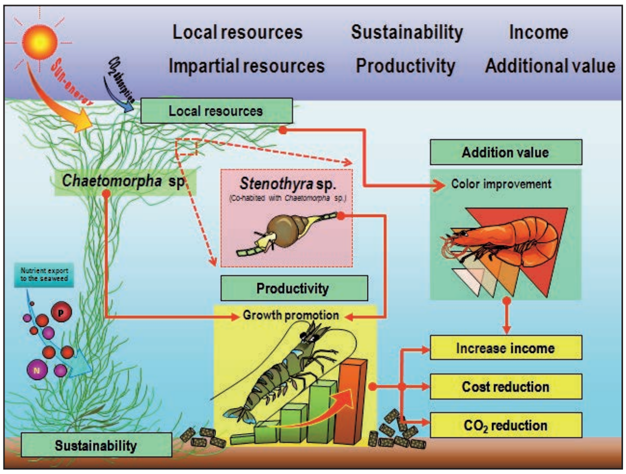
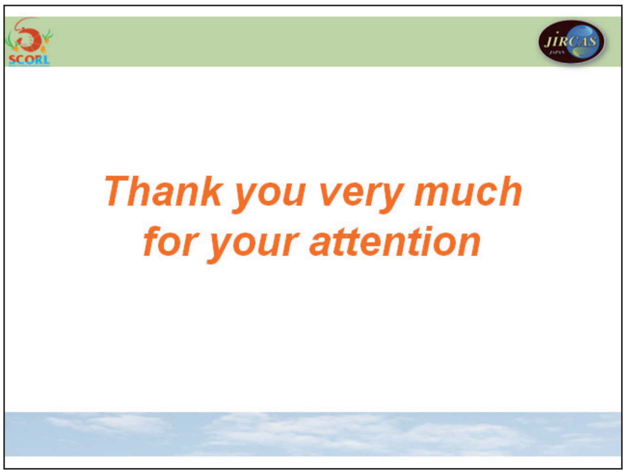
Euryhalinity and Eurythermy
Nutrient removal
Shrimp growth promotion
Income increasing
Cost reduction
Carbon footprint reduction
Color improvement

14


Local resources
Sustainability
Income
Impartial resources
Productivity
Additional value
Local resources
Addition value
Chaetomorpha sp.
Stenothyra sp.
Color improvement
Productivity
Growth promotion
Increase income
Cost reduction
CO_2 reduction
Sustainability

15


SCORL
JIRCAS
Thank you very much
for your attention

16

Chair Saito: Good morning, ladies and gentlemen. Now I would like to chair this session, "Sustainable Rural Income Sources." In this session we invited four presenters from the area of aquaculture, forestry, and biomass utilization. In this session we focus on sustainable rural income sources and we expect the information from each industry, the role of each industry, and the status of technology development in each area.

First, I'd like to invite Dr. Isao Tsutsui, JIRCAS researcher. His expertise is in the area of aquaculture and the coastal environment. Currently he is working in Thailand for benthos applicability to shrimp aquaculture, so Dr. Tsutsui, please.

Dr. Isao Tsutsui: Thank you very much, Dr. Saito, and good morning, everyone. It's my great pleasure to be here with you today. Before starting my presentation, I would like to define the terms of family *Penaeidae*. Shrimp and prawns are often used interchangeably. In this presentation I will use the term shrimp in the general discussion of *Penaeidae*. For the common name of each species I will use the FAO name.

I would like to start with the background of our studies.

Shrimp used to be expensive and luxury fisheries products in Japan, especially before the 1970s. However, now shrimp are inexpensive and a very popular item in Japan. Why has this happened?

This is because the present active shrimp consumption in Japan is supported by the imported shrimp, which accounts for more than 98 percent of the total consumption in Japan.

Globally, Japan ranks as the second-largest shrimp importer in the world. We eat about 2.5 kilograms of shrimp per year. This is the highest annual personal consumption in the world.

This imported shrimp is almost all intensively aquacultured shrimp that comes from Southeast Asian countries. Of course our active shrimp consumption stimulates the economic growth of producer countries. However, there are a lot of problems occurring related to shrimp ponds, shrimp aquaculture.

Eutrophication is an ecological response to increasing nutrients in the water. This occurs often in a closed aquaculture pond. A low growth rate, this is outbreaks always in aquaculture pond, especially shrimp culture. Chemicals are always overused. Environmental destruction, pollution of the surrounding area, species transfiguration.

So here I would like to emphasize that behind the active shrimp consumption, serious problems occur and these problems threaten not only aquaculture but also the environment and human lives.

So this is why I went overseas to research about shrimp aquaculture, as a Japanese scientist. This is also JIRCAS is developing a novel culture system for shrimp in Southeast Asian countries to mitigate these problems. We want to cut off these problems and regain better conditions for the producer countries.

I also would like to put one more thing. We will feed back to Japan, our country Japan, because our research fund is funded by Japanese taxpayers. Also, we can provide high quality shrimp to both producer countries and consumer countries.

Now I'll go through the outline of our system.

Within the problems of aquaculture, eutrophication is the key problem in a shrimp pond because eutrophication is directly affecting these problems.

Usually in intensive shrimp ponds, phytoplankton is used to reduce eutrophication. However, shrimp farmers always feel difficulty in managing the phytoplankton because biomass and species composition is easy to change. Therefore, we decided to use seaweed instead of phytoplankton.

Seaweed's biomass is more stable than that of phytoplankton and also it is easy to maintain.

This is a kind of integrated multi-trophic aquaculture system, so-called IMTA; however, our system is a little bit different from the typical IMTA system. In the IMTA system, all cultures, organisms, have commercial value. After starting the cultivation, excessive nutrients are absorbed by combined organisms, then all organisms are sold. In this system, multiple incomes are expected.

On the other hand, in our aquaculture system, we use the unutilized benthos with shrimp, and this unutilized benthos is used as the supplementary field and functional field for shrimp, then shrimp will be sold with a high value. Accordingly, the concept of our system is much different from the IMTA system.

The objective of our study is to develop a sustainable low-cost simple and seaweed-based aquaculture system having both sustainability and improving livelihood. The target beneficiary is small-scale shrimp farmers who are major shrimp producers in Southeast Asian countries. Target ponds are small- to middle-sized earthen ponds for small-scale shrimp farmers.

Target shrimp are of course giant tiger prawns and indigenous species to Southeast Asia. And benthos, actually the IMTA system for shrimp culture has not been at the practical level. This is because the salinity and water temperature range of commercial seaweed is very limited.

Shrimp are cultured in a wide range of salinity and water temperature in the world. On the other hand, seaweed, research on IMTA for shrimp, has not covered all ranges of salinity and water temperature. Therefore we started seeking the suitable seaweed. We tested more than 130 species, then finally we could find a suitable seaweed. The seaweed we chose is this one.

This seaweed grows in the stagnant water along the coast. In this environment, salinity and water temperature change widely depending on the seasons. Also, people always discarded their garbage to the stagnant water and then the environment is highly polluted in nutrients. When I saw this I recognized that this seaweed was likely to be tolerant to a wide range of environmental change, therefore I will try to use. This one is *Chaetomorpha* species.

However, this genus of seaweed is almost taboo to use in shrimp ponds because it looks very dirty and shrimp farmers believe that this kind of seaweed has a negative impact on shrimp growth, but the reality is not correct. I will explain later.

I also combined the microsnail, *Stenothyra* sp. This is a very small species up to 3 millimeters. This is often cohabiting with *Chaetomorpha* species in the natural environment. Also they use this seaweed as a spawning substrate.

Now I would like to briefly discuss the advantages of our aquaculture system.

Please recall from earlier, shrimp are cultured in a wide range of salinities and water temperatures. The figure on the left side shows the specific growth rate of *Chaetomorpha*. As the figure shows, the *Chaetomorpha* species can grow in a wide range of salinities and water temperatures. It covers all shrimp culture ranges in the world.

And this tendency is almost the same as *Stenothyra* also. So we can say that *Chaetomorpha* and *Stenothyra* are euryhaline and eurythermal species that can be easily introduced to shrimp aquaculture ponds all over the world.

The second advantage is nutrient removal of *Chaetomorpha* species. *Chaetomorpha* remarkably removes the ammonia and phosphate, so we can say that *Chaetomorpha* is effective in keeping the water quality in aquaculture ponds.

Actually, *Chaetomorpha* is preferably grazed by giant tiger prawns, even provide a high quality artificial shrimp feed to satiation and promote shrimp growth. And also, *Stenothyra* enhances the shrimp growth. The size is very suitable for giant tiger prawns.

Here I did a co-cultured experiment use a 100-liter plastic tank and the result shows that the shrimp growth was faster in a co-culture than that of a monoculture. And I estimate the shrimp growth up to harvest size of 15 grams.

Culture duration up to harvest size is estimated at 88 days in co-culture and 110 days in monoculture. Now there is an estimated 22-day reduction in the culture period under the co-culture system. Reducing the culture period is a very, very big advantage for shrimp farmers from the viewpoint of increasing income and reducing the shrimp disease risk.

And I applied this estimation to the small-scale shrimp pond of about one hectare. It resulted that 1.1 ton of shrimp feed can be reduced by crop. Therefore, shrimp farmers are saving about 66,000 Thai baht, which is about 2,000 US dollars per hectare per crop. And currently the carbon footprint is not so considered in aquaculture products; however, it will be important for merchandise in the future.

A reduction in shrimp feed is expected to reduce the carbon footprint too.

And finally I will illustrate one more advantage of the culture system. Seaweed has carotenoids and giant tiger prawns graze on the *Chaetomorpha* species. It becomes a much deeper red color when it’s steamed. The red color has significant appeal to the shrimp consumers.

As a conclusion, we use *Chaetomorpha* and *Stenothyra* for aquaculture of giant tiger prawns. These are local resources. Now *Chaetomorpha* and *Stenothyra* are a nuisance for human society; however, they have much potential in the aquaculture system. The sun and CO_2 are the additional inputs to our system. These are impartial resources, everyone can use these ones. These ones are free of charge. This is a very important point for small-scale shrimp farmers.

Artificial shrimp feed is applied to giant tiger prawns and produces nutrients; however, seaweed absorbs these nutrients. Giant tiger prawns graze on *Chaetomorpha* and *Stenothyra* and shrimp growth is enhanced. Promoted shrimp growth leads to increased income, cost reduction, CO_2 footprint reduction. Also, we can provide the shrimp color improvement.

Accordingly, our aquaculture system is simple and low-cost, sustainable, and has the potential to be used all over the world. Of course our aquaculture system is under development and it is still staying at the laboratory level. Also, there are a lot of things to be solved.

This is including not only aquaculture techniques, but also disease problems, environment problems, resources, processing by-products, also economy, management, business, and logistics, so I think therefore we will try to research and develop from the viewpoint of multidisciplinary work. So maybe it will take time; however, I would like to try it with many people in Thailand, my counterpart country. Thank you very much for your attention.

Chair Saito: Thank you very much, Dr. Tsutsui.