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Climate change: Adaptation and mitigation

"You can't walk away from climate change", Ian Macfarlane said last night, and I had to agree with him, although it seems that many people want to try. Even though the consensus now firmly favours the believers, and the sceptics are a dwindling minority, those that propose action to actually *address* climate change still face deeply entrenched opposition. Change is not easy, particularly when it's the majority that has to change and a large part of our economy along with it.

There's no doubt that we've gone too far down the road to avoid impacts now. The processes that have been put in train have a huge momentum, so the environmental changes we can observe now have probably got a long way left to run. Even if the world became 'greenhouse neutral' tomorrow, warming would continue until the new equilibrium is reached.

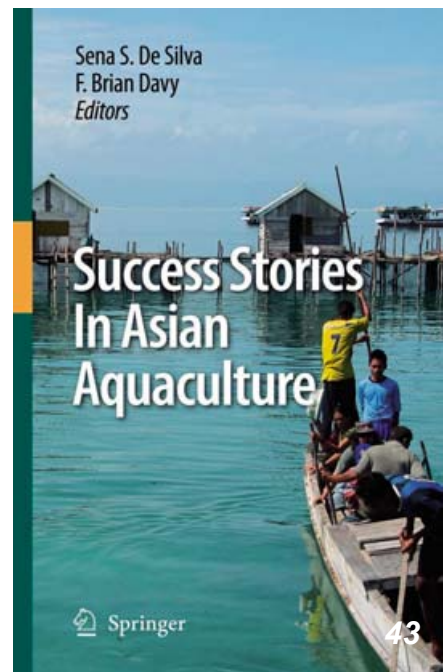
Responding to climate change isn't going to be cheap. A lot of our infrastructure and is going to have to be replaced and established practices are going to have to change. Agricultural industries will of course be amongst the most impacted due to their direct climatic linkage, though there may be winners and losers depending on what changes occur and where. In the long term, people living in the lowest lying areas such as the Mekong Delta and southern Bangladesh may be affected by saline intrusions into agricultural lands and ultimately displaced by even small rises in sea level. Quite clearly a lot of people are going to need new jobs, some industries will face considerable disruption and in the long term many people will also somewhere new to live as well.

We need to start thinking about how to cope with the coming changes. Just as the climate has a massive inertia, so does society. Getting people to change their behaviour will probably be a generational issue, so it is vital that we start now. There's some good news on that front, there's evidence that donors and the development community are beginning to put resources into projects concerning *adaptation* to climate change.

At the same time, we also need to think about how to avoid making the climate change problem worse. Unfortunately, we are not seeing the same amount of donor activity in climate change *mitigation*. Perhaps this is because adaptation is an issue where donor interventions directly affect and improve the livelihoods of the poor, whereas mitigation is not. At the end of the day we need both, but in the long term mitigation is the only choice we have. We cannot pursue an endless cycle of adaptation, climate change mitigation needs to be kept on the books as well.

Simon Wilkinson

AQUACULTURE ASIA



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Peter Edwards writes on

Rural Aquaculture

Changes in traditional inland aquaculture in West Java, Indonesia

West Java in Indonesia, which dominates inland production in the country, has a long history of various types of traditional small-scale aquaculture involving the integration of fish culture with various types of on-farm and locally available off-farm organic matter inputs. I witnessed this diversity on a study tour of the area in 1981, almost 30 years ago. I retraced my steps on a 10 day trip in late June and early July this year to see the changes that have taken place in aquaculture over the past three decades in West Java. I visited numerous farms and government facilities on a circuitous route in the Bogor, Sukabumi, Cianjur, Cirata, Bandung, Subang and Sukamandi areas. The trip was arranged and guided in part by two AIT

alumni: Dr Agus Somamihardja and Mr Widyatmoko, both employees of the Aquaculture Division of JAPFA, one of the largest agri-food companies in the country with a nation-wide network of aqua-feed salesmen, several of whom facilitated the visits to local farms. I was also guided to farms by Mr Reza Samsudin of the Department of Marine Affairs and Fisheries, Bogor, and Mr Jaka Trenggana of the Main Center for Freshwater Aquaculture Development, Sukabumi.

There has been a massive increase in national inland aquaculture production over the last three decades from about 120,000 tonnes in 1981, according to FAO statistics, to almost 750,000 tonnes in 2007, a six-fold increase.



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While the number of farmed species has increased from 10 to 16 (excluding the category 'freshwater fishes nei' for miscellaneous species), common carp (*Cyprinus carpio*) remains the major species with 36 % of the inland aquaculture total, closely followed by



Supplementary feeding a wastewater-fed nursing pond, Sukabumi.



Fish ponds are an integral part of villages in West Java, Sukabumi.



Feeding African catfish with dried marine trash fish, Bogor.

Nile tilapia (*Oreochromis niloticus*) at 28 %. These two species therefore comprise almost three quarters of national inland aquaculture production.

Because of the tremendous diversity of inland aquaculture practices and lessons learned for possible application elsewhere, I cover traditional aquaculture in this column. 'Modern' aquaculture which I'm defining here as

using agro-industrial pelleted feed rather than natural food produced by organic fertilisers and supplementary feeds as nutritional inputs, will be covered in my column in the next issue.

Traditional aquaculture overview

Traditional aquaculture as described in the earlier literature and as I witnessed three decades ago mainly comprised a polyculture with various combinations of common carp and tilapia (but Mozambique tilapia, *O. mossambicus* rather than Nile tilapia today), and kissing gourami (*Helostoma temmincki*), nilem carp (*Osteochilus hasseltii*), silver barb (*Barbodes gonionotus*) and giant gourami (*Osphronemus gouramy*). The typically small ponds were integrated with wastes or by-products from agriculture, local agro-industry such as soybean and rice processing, and sanitation (overhung latrines on ponds, diversion of fecally polluted water from rivers and streams into ponds as a fertiliser, and small wooden and bamboo cages sitting on the bottom of polluted rivers and streams stocked with common carp in monoculture which fed on benthic invertebrates). Traditional cage culture had already been reduced by 1981 as it had been banned by the government because the cages impeded water flow and contributed to flooding of urban areas. Significant nursing of fish was carried out in rice fields as well as in small ponds.

Most traditional practices continue to at least some extent today but they have either declined or have been modified and are now mostly overshadowed by 'modern' aquaculture.

Changing balance of species

Nile tilapia is increasing in popularity as a farmed species as it lacks bones in the muscle and koi herpes virus has been adversely affecting the farming of common carp since the early 90's. Production of the other traditional species remains relatively low and static by comparison. National production figures were in 1981 and 2007, respectively, for kissing gourami (4,000 and 6,000 tonnes), nilem carp (17,000 and 15,000 tonnes) and silver barb (17,000 and 15,000 tonnes). Nilem and silver barb were not reported to be cultured anymore in the areas I visited as they have too many bones although they are still popular in the eastern part of West Java, in the Ciamis and Tasikmalaya areas. However,



Fish ponds interspersed with rice fields, Sukabumi.

giant gourami remains popular with a major increase in production of 4,000 in 1981 to 36,000 tonnes in 2007, a nine-fold increase. This species is more expensive than common carp and tilapia as it is relatively slow growing even when fed mainly with pelleted feed and thus is a restaurant fish rather than contributing towards national food security.

Integration of crops and fish

I visited a small-scale farm in the Bogor area stocked with a polyculture of giant gourami, common carp and tilapia. The herbivorous giant gourami was being fed with leaves of banana, cassava and sweet potato grown on the pond dikes and in adjacent plots but pelleted feed was also being fed to the fish.

There are two systems of rice/fish nursing in West Java: nursing fry and growing rice together at the same time i.e. concurrently; and but nursing fry for one month between rice crops. The first system is now rarer than the second. A third type of integration with rice in which a crop of rice was rotated with a crop of grow-out fish never occurred in West Java and was reported to have ceased also in East Java where it used to be practiced.

Rice fields used to be a major source of fingerlings but the practice of rice field nursing has declined significantly. It is estimated that less than 10 % of fingerlings are now nursed in rice fields in Cianjur, a major nursing area. Thus, I was fortunate to be able to interview a farmer in Maleber, Cianjur, who is the only one still nursing in rice fields in the area. He was nursing fry concurrently with rice with trenches dug around and across the rice fields. He had stocked one liter of common carp fry (20,000

individuals) in a 2,000m² rice field and expected to harvest 40-50 kg of 14-15 g fingerlings in 40 days. This farmer was also nursing in ponds converted from rice fields which he reported is better, as the same amount of fry stocked in a nursery pond would produce double the harvest of fingerlings, 100kg, in the same 40 day period than in a rice field nursery.

Integration of livestock and fish

I saw far fewer examples of integration of livestock with fish than previously. Indonesia has developed a large-scale broiler chicken industry for domestic consumption as well as for export. Small-scale poultry production was said not to be profitable anymore. The government is also discouraging livestock/fish integration because of public health concerns of using manure and a desire to maintain a good image of aquaculture for exporting fish.



A common carp breeding system in a wastewater-fed pond, Sukabumi.

I saw a few relatively small broiler chicken houses over fish ponds. The chicken farmers rent the space above the ponds from fish farmers. The chicken bedding, manure and spilled feed are not allowed to fall into the pond but are collected for sale to fish farmers. I also visited a large-scale integrated system with 15 chicken coups each with 5,000 birds over a 20 ha lake stocked with airbreathing striped catfish (*Pangasianodon hypophthalmus*) for live export to Sumatra in plastic drums by truck and boat as the people in Java do not like to eat this species.

Raising goats in pens is a traditional practice in West Java and I saw both a small-scale and a relatively large-scale operation integrated with fish ponds. In both cases the manure was collected from beneath the goat pens constructed on the pond dikes. The larger-scale system had 110 goats, with manure placed in a hapa suspended in the pond to decompose, with release only of soluble nutrients into the pond to avoid deoxygenating the water from too high an organic matter loading rate.

Wastewater-fed seed production

Although the various types of traditional grow-out systems for wastewater-fed aquaculture have almost disappeared from West Java, wastewater is still used as a pond fertiliser but for seed production rather than grow-out of common carp and tilapia as I observed in Cianjur, Bandung and Sukabumi. Water from polluted streams and canals flowing from urban areas by gravity is diverted into fish ponds in peri-urban areas. Seed from these three areas comprises the major source of fingerlings to various grow-out systems,



Large-scale broiler chickens integrated with fish, Bogor.



Trench across the field in concurrent integrated rice fish culture, Cianjur.



Small-scale goat raising integrated with fish, Subang.



Close-up of goat fish integration, Cianjur.



On-farm crops provide feed for herbivorous giant gourami, Bogor.



Relatively small-scale broiler chickens integrated with fish, Sukabumi.



Harvesting common carp fingerlings from a wastewater-fed pond, Bandung.

and especially pellet-fed cage culture of common carp and tilapia in reservoirs which is reported to supply about 80 % of domestic fish supply in West Java.

Tilapia and common carp are bred and nursed in Cisaat, the fish farming area of Cianjur. Until the 1980s the tilapia species was *O. mossambicus* but the Chitralada strain of Nile tilapia was introduced from Thailand followed by the 3rd and 6th generations of GIFT from the Philippines, which were distributed to the farmers by the Main Center for Freshwater Aquaculture Development in Sukabumi.

Almost every house in Cisaat has 1-2 ponds and some have up to 5 ponds. Fish seed provides the main year-round household income. Good cash flow because of the short duration of nursing is no doubt an additional attractive aspect of seed production, as well as the free source of nutrients in the wastewater for these relatively small farming households. As Cisaat is a suburb of the city of Sukabumi, some families have additional livelihoods, including involvement in the seed transport business.

There are four groups of farmers involved in the various stages of tilapia seed production in Cisaat:

1. Male and female Nile tilapia broodstock are stocked at a ratio of 1:4 in small shallow ponds and fry are harvested every 15 days using nets to scoop them up from a harvesting pit after the water has been drained from the pond.
2. First stage nursers stock the fry at 200-250/m² and rear them to 2-3 cm fingerlings in 21 days with a mortality rate of less than 10 %.
3. Second stage nursers stock the 2-3 cm fingerlings at 150-200/m² and rear them to 3-5 cm in 21 days with a similar mortality rate.
4. Third stage nursers stock the 3-5 cm fingerlings at 75-100/m² and rear them for another 21 days with a mortality rate of about 20 % to 5-8 cm after which they are mostly transported from the area to be stocked in cages in reservoirs. A 1,000 m² pond of this type that I specifically enquired about had a depth of about 0.7-1.0 m when filled with water and produced about harvested about 250 kg of fingerlings.

Ponds are drained between cycles and limed. If the water is not fertile then chicken manure will be used to fertilise the pond. Rice bran and chicken broiler bedding (rice husks,

spilled chicken feed and manure) are used as supplementary feeds in the wastewater-fed ponds at a rate of about 300 kg/ha/day.

Common carp are bred in a similar ponds but the broodstock are placed in a hapa in the small shallow pond. The broodstock lay eggs overnight on 'kakabans', branches also placed in the hapas. About 24-36 hours after hatching, the fry swim into the pond through the mesh of the hapa and reach a size of 2-3 cm in 25 days. A few large broodstock are also stocked in the nursery pond to stir up the sediments which prevents the growth of emergent aquatic macrophytes.

During my earlier visit to Bandung, the major wastewater-fed aquaculture area was in Bojongloa but this former rural area is now well within the urban area of the city of Bandung. The former major wastewater-fed aquaculture suburb of Bogor, Muara, has similarly been swallowed up by urban development. However, wastewater-fed seed production still takes place in some of the more distant suburbs of Bandung. I visited Bojongsoang, the largest wastewater-fed seed production area in Bandung with more than 100 ha of ponds which started in 1983, presumably because of the demise of Bojongloa.



The rice field eel is cannibalistic, Bandung.

The wastewater-fed nursery ponds are large and shallow with a 60cm depth and are owned by well-to-do families, several families ponds being overseen by one manager. The farm I visited was 13 ha in size and at the time of my visit a 5 ha pond was being harvested, producing 1.8 tonnes (about 0.3-0.4 tonne/ha) of fingerlings of 10-12.5 g which were being placed in oxygen filled plastic bags for transportation by truck to Cirata reservoir. One week old common carp fry are stocked at a rate of 30 l of fry/ha and are harvested after 40 days. The fish consume natural food such as tubifex worms and no artificial feed is given. Up until about 5 years ago fish were nursed year round but now nursing alternates with rice cultivation as the soil quality, but not that of wastewater, was said to have declined. Fish nursing now runs from November until June with five harvests of fingerlings.

As the demand for fingerlings to stock cages in Cirata reservoir is large, there are also fish seed nurseries in Bandung using only artificial feed. The fry to stock the wastewater-fed ponds I visited in Bandung also come from a hatchery in Majalaya which does not use wastewater.

Recently developed systems

African catfish (*Clarias gariepinus*) is a relatively newly introduced species which the government is promoting as a third species for national food security alongside common carp and tilapia. As it is an air breathing species it can be raised at high density and marketed at a small size of 150-200 g, the preferred size for local consumption. The national production of African catfish has risen rapidly and in 2007 was over 90,000 tonnes. I visited a large-scale farm that was feeding dried marine trash fish, cooked chicken offal from a nearby slaughter house (a major by-product of industrial chicken farming that the farmer gets free but must remove it from the factory daily and provide the transportation) as well as pelleted feed.

I also witnessed harvesting the rice field eel (*Monopterus albus*), a relatively high-value species, in a farmer-managed trial using a technology developed by a local farmer and supported by the local government as an initiative to increase farmer income. Thirty kg of wild eel broodstock had been stocked in a 144m² rice field and fed with earthworms raised separately in a mixture of chopped rice straw, banana stems and other organic matter and composted goat and cattle manure. Large numbers of eels were observed being dug out of the rice field but production would be reduced by the cannibalistic nature of the species.



Common carp fingerlings are transported in oxygen filled plastic bags from Bandung to Cirata reservoir.



Harvesting sump in a newly constructed nursing pond in a former rice field, Cianjur.



Farm-based trial with rice field eel, Bandung.



A harvesting sump in a wastewater-fed tilapia nursing pond, Sukabumi.



Manure decomposes in a net to reduce the organic loading on the pond, Cianjur.

Mussel farming initiatives in north Kerala, India: a case of successful adoption of technology, leading to rural livelihood transformation

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The Malabar region, extending from Malappuram to Kasargode districts of Northern Kerala, is a well-known mussel fishery zone of India. Over 7,000 t (80%) of the total green mussel (*Perna viridis*) catch is exploited annually from this zone. The Central Marine Fisheries Research Institute (CMFRI) developed techniques for mussel culture in 1971 and subsequently field demonstrations in different areas with direct involvement of local rural folk were carried out¹. Demonstrations to popularise this technology have led to adoption of this simple farming method particularly in the Malabar region². The Malabar coast has extensive backwaters and estuaries, which are suitable for mussel farming during the post monsoon months (November to May) when higher saline conditions prevail. Farming activity during this period provides an opportunity for supplementary livelihood and additional income to the coastal rural population.

Mussel farming trials were initiated in 1995, by suspending four seeded ropes in Dharmadom Estuary, in Kannur District. This trial was successful and was the forerunner of mussel farming in estuaries in the Malabar region. Mussel farming demonstrations were carried out in the Dharmadom Estuary in 1996 and 2 t of mussels were harvested. Simultaneously, group farming by women was initiated in Padanne, Kasargode District. Women's groups in Kasargode District set up their own mussel farms with financial support extended by Development of Women and Children in Rural Areas (DWCRA) and the Training of Rural Youth in Self Employment (TRYSEM) programmes. The women repaid the loan within the stipulated period. Thus, the all women initiative was tremendously successful and mussel farming became a supplementary avocation for the coastal women of North Kerala³. Further field demonstrations were continued in new areas in different estuaries.

This article presents the technology transfer through community based interventions in the Malabar region, North Kerala, during the period 2001-2004, which ultimately resulted in widespread adoption of mussel farming as an alternate livelihood option among the coastal communities and rural empowerment.

The Malabar Coast has extensive estuaries and backwaters, which are suitable for farming the green mussel during the summer months, when higher salinity conducive for the growth prevails. The transfer of the mussel farming technology to the rural population was affected through a multi-stage dissemination process. The technology of mussel farming is simple, economically viable and eco friendly. The dissemination process involved four steps:



Malabar map.

1. Technology demonstrations through a participatory and co-management approach with the farmers and end users. The growth of mussels (specific growth rate) cultured in the demonstration farms were monitored.
2. Training by experts through hands on practice.
3. Technical assistance in site selection, setting up farms, seeding and management.
4. Information sharing and evaluations. Linkages were developed with the Kerala State Fisheries Department and their subsidiaries including the Brackish Water Fish Farmers Development Agencies (BFFDAs), Aquaculture Development Agency of Kerala (ADAK), NGOs and other national agencies.

Farming demonstrations

Open sea farming, raft culture, Thikkodi, October 2001

A demonstration raft (3 x 3 m) for mussel culture was launched in the mussel beds off Thikkodi, Kozhikode district, which has extensive mussel beds with excellent seed settlement. However, the mussel pickers discard the seed that is extracted along with the adult mussels. Over 25% of the seed is thus lost to the fishery, which can be effectively used for farming. In order to create awareness regarding this, the mussel farming demonstration was carried out with the help of two mussel pickers. 16 seeded ropes of 3 m each were suspended horizontally from the raft using the seed discarded by the mussel pickers. This experiment was successful in that, the mussel pickers started collecting the mussel from the next season onwards and sold them to interested persons, thereby gaining additional income besides preventing wastage of seed.

However, open sea farming, in spite of successful demonstrations has few takers due to the inherent management problems. The limiting factors are high investment, frequent monitoring which entails high cost in terms of hiring canoes, unpredictable environmental conditions, poaching etc. Although, there is increased consciousness of the effective utilisation of the mussel seed which would otherwise be wasted, the above stated factors impede the adoption process. Governmental support in this regard is essential in terms of financial assistance and security assurances.

Group farming initiative in Korapuzha estuary, Kozhikode District, 2002-2003

Korapuzha Estuary is a fairly large estuary suitable for mussel and oyster farming. The successful adoption of mussel farming in the adjacent districts of Kasargode and Kannur prompted the Aquaculture Development Agency of Kerala to initiate a group farming initiative in the Korapuzha estuary in December 2002. In collaboration with CMFRI, training was organised for a hundred farmers. Financial support was provided to each group of five members to set up one mussel-farming unit. Bamboo, nylon ropes and cotton net were provided to each group. The cost of procuring seed was also provided. Technical assistance was provided by

CMFRI. 41 farmers (groups), who started mussel farming in Korapuzha estuary with ADAK-CMFRI support, harvested their fully-grown mussels in June 2003. A total of 62 t shell-on mussels were harvested from the 41 units. The production per meter rope was 20 kg. The meat content was over 30%. These farmers have been harvesting mussels every year since then. Details of farming demonstrations in different estuaries are given in tables 1 and 2.

The farming demonstrations in different estuaries of Malabar region have effectively established the technological and economic viability of mussel farming besides identifying suitable sites for farming. The production and growth rates may vary depending on the salinity and productivity of the estuaries. It is evident that higher salinity promotes faster growth as observed in the Puduponnani, where the growth rate is higher compared to Purangara, Korapuzha. Meat content also is greater at higher salinities. However, mean production rates of 10-12 kg can be obtained in a period of 4 months in most of the estuaries. These demonstrations have conclusively shown that mussel farming can provide an excellent alternate livelihood option for the communities dependent on these water bodies.

Linkages

For effective dissemination of the mussel farming technology to the grass roots level and particularly to those whose livelihood is dependent on the backwaters and estuaries, it was essential to involve and connect all the stakeholders in the technology transfer and dissemination process. Linkages were developed between governmental, non-governmental organisations (NGOs) and enterprising individuals, mussel pickers and mussel farmers. In the transfer of the farming technology, technology demonstrations were carried out at suitable sites to establish the technical and economic viability. Training was the second step in the process to impart skill, technical knowhow and facilitate adoption. Technical support was also provided at each level of the adoption process. These were rendered through governmental and nongovernmental linkages. The state fisheries department was the important linkage at the provincial level. The Brackish Water Fish Farmers Development Agency (BFFDAs) and Aquaculture Development Agency of Kerala (ADAK), their two subsidiaries, were the instruments through which the transfer of technology was implemented. The BFFDAs and ADAK provided financial assistance and technical support,

Table 1: Technology demonstrations and their impact

Demonstration	Place	Group	Impact
Open sea mussel culture demonstration raft in (3 ft x 3 ft), 2001	Mussel bed, Thikkodi, Calicut	Mussel pickers	The effective utilisation of the mussel seed for farming, which the mussel pickers used to discard
Mussel culture demonstration farm, 2002	Purangara, Badagara	Women self help group	Viability of mussel farming technology
Mussel culture demonstration farm, 2002	Poorapuzha Estuary Parappangadi, Malappuram district	NGO (Unemployed youth)	Viability of mussel farming technology
Demonstration cum research farm for edible oyster culture 2002	Korapuzha estuary Kozhikode,	Local rural group	Viability of oyster farming technology
Integrated bivalve farm 2003, 2004, 2005	Moorad estuary, Kozhikode	Local rural group	Viability of mussel and edible oyster farming technology
Integrated bivalve farm 2004, 2005	Chaliyar estuary, Kozhikode	Local rural group	Viability of mussel and edible oyster farming technology

Table 2: Growth and production of cultured mussels in different estuaries

Estuary / year / site	SGR % month ⁻¹ (Length: mm)	SGR % month ⁻¹ (Weight: g)	SGR % month ⁻¹ (Meat: g)	Meat %	Salinity (ppt)	Production (T)
Moorad, 2002 Purangara	0.68	0.65	0.19	37.1	9-30	**
Korapuzha, 2003, Korapuzha	0.78	2.23	2.15	32.5	1-31	62
Elathur, 2003, Korapuzha	0.49	1.48	1.94	35.3	16-33	**
Korapuzha, 2003, Konganoor	0.29	0.76	0.32	33.7	15-32	**
Poorapuzha, 2003, Parapanangadi	1.07	2.89	2.42	33.0	2-35	0.042
Ponnani, 2002, Puduponnani	1.8	1.01	1.21	38.0	10-40	5
Moorad, 2004, Kottakal	0.65	1.79	2.06	27.0	23-35	**
Korapuzha, 2004, Korapuzha	0.53	2.02	1.28	39.5	10-31	40

**Not estimated due to rains / poaching

besides facilitating the dissemination process. A few enterprising mussel farmers served as models and proved to be catalysts in the technology adoption process. Shri Gul Mohamed was the first such mussel farmer who ushered in mussel farming into the Padanne village. He received the "Karshaka Shri" Award from ICAR in 2002. NGOs and self help groups also played a key role in the adoption process. The BFFDAs in Kannur and Kozhikode have developed into major catalysts in the technology adoption process. The BFFDA identifies prospective farmer groups in areas suitable for mussel farming. The groups are usually dependent on the water body for their livelihood and mussel farming serves as supplementary option. Training courses are arranged for the identified groups in collaboration with CMFRI. CMFRI provides necessary technical guidance besides hands on training. The financial support is provided by BFFDA to the farmer groups. The mussel culture activity is subsidised up to 25% of the total cost. 75% of the total cost input is by the farmers themselves. The BFFDAs of Calicut and Kannur have thus promoted mussel farming along the Malabar Coast.

The ADAK also provides financial support to prospective mussel farmers. Farmer groups are identified and provided training on mussel farming in collaboration with CMFRI. Each group is provided with materials for setting up one unit (bamboo, nylon rope, cotton netting, etc.) The cost of seed is also reimbursed to the farmers.

National Agricultural Technology Project (NATP) on mussel mariculture aided by the World Bank

As part of this national programme, two major initiatives in mussel farming were carried out in the Malabar region. With the increased interest and adoption of mussel farming in the Malabar zone, availability and abundance of the mussel seed for the farming sector was crucial. In order to address this issue, a focused survey of the distribution and abundance of mussel seed along the Malabar coast was carried out. Experiments were carried out to collect spat by setting artificial collectors in natural mussel beds.

Mussel seed production from wild

Spat collectors of different types were fabricated for collecting mussel spat from mussel beds. These were attached to a 3 x 3 x 3 GI frame. The frame was established in mussel bed area in Elathur in Kozhikode District. The frame was anchored using 200 kg concrete blocks. The following materials were used as spat collectors: Nylon net wall - old fish net was used to prepare a net wall suspended from a nylon rope and this was set over sides of the frame. Coir ropes of 1.25 and 2.5cm² thickness and 75 cm length were tied from one end to other of the frame. Nylon frilled ropes provided by M/s Garware ropes were also used as spat collector. They were attached to frame from one end to the other. Coir mats, bamboo baskets and tiles etc. were also used as collectors. The GI frame along with the spat collectors were set in September. However, the whole structure was destroyed and washed away in a heavy rains and turbulence developed due to the rough weather.

Mussel seed survey along the Malabar Coast

Mussel seed distribution and abundance was assessed along the Malabar Coast extending from Malappuram to Kasargod districts during 2001. The major mussel beds in Kozhikode district are South beach, Chaliyam, Elathur, Kollam, Moodadi, Thikodi and Chombala constituting about 435 ha. Mussel bed off Mahe constitutes nearly 20 ha. The major mussel beds in Kannur district are Thalassery, Thalai, Koduvally, Kadalai constituting 125 ha. In Kasargode district, the mussel beds of Kasargod are off Chembarika, Kottikulam, and Bekel constituting 40 ha. There is no significant mussel resource in Malappuram District. The total area of mussel beds along the Malabar Coast constitutes 620 ha in area. Spat settlement occurs on lateritic formations along South beach, Chaliyam, Elathur, Kollam, Moodadi and Thikodi. Granite rocks are observed in Chombala, Mahe, Thalassery, Thalai, Koduvally, Kadalai, Chembarika, Kottikulam and Bekel. Kozhikode had the highest seed biomass forming 68% of the total seed resource, followed by Kasargode (20.2%) and Kannur (9.8%) districts. The total seed biomass estimated for Malabar area as 8,221 tonnes. In Kozhikode district, Thikodi / Moodadi area contributes about 66% of the total seed. About 42% is distributed in Thalassery / Thalai areas of Kannur district.

Table 3: Trends in mussel farming adoption during 2000-2006

Year	Number of farmers	Estuary / place	Production (T)
Rack culture			
2000	250	Padanne, Kasargod district	250
2002-03	200	Korapuzha estuary, Kozhikode	62
2003-04	200	Korapuzha estuary, Kozhikode	40
2003-04	290	Kadalundi estuary, Malappuram district	380
2004-05	350	Kadalundi estuary, Malappuram district	420
2004-05	400	Padanne, Kasargod district	2500
2005-06	300	Moorad estuary	9
		Korapuzha estuary	77
2005-06	210	Kozhikode, Malappuram districts	
2005-06	414 individuals 180 societies	Padanne, Kasargod district	3086 4410
Bottom culture			
2004-05	14	Kannur	268
	10	Mahe estuary	
	50	Kahalundi estuary	
	75	Chaliyar estuary	
	20	Kokuvally (intertidal beds)	

Maximum spat settlement per unit area as observed in Kottikulam and Chembarika, where 4.6 and 3.8 kg m⁻² was recorded.

Training

Training for prospective mussel farmers were conducted in collaboration with the Trainers Training Centre (TTC) of CMFRI, BFFDAs of Kozhikode and Kannur Districts, State Fisheries Department, Kerala. The response was often overwhelming and technology adoption was enthusiastic especially among women self help groups. A total of 536 persons, comprising 235 women and 281 men were trained during this period.

Tangible impacts of the mussel farming initiatives

Over the past five years, the mussel farming initiatives have paid rich dividends in terms of increasing mussel production through farming besides increasing the social and economic benefits to the rural farmers both men and women who have taken to this method of farming (Table 3). Technology adoption, increased production through farming, women's empowerment, development of mussel seed trade and rope making and technology diversifications are the visible and tangible outcomes.

Technology adoption by women

In Padanne, Kasargode district "a silent, gentle transformation" is taking place, driving home a significant and poignant point that, given the opportunity, women can empower themselves. And that technologies are not inhibitive rather appropriate technologies are easily adopted. In Padanne, there is no significant mussel fishery in the region and mussels are not consumed locally; therefore introducing mussel farming as a supplementary livelihood option was constrained by several factors: acceptance and adoption of the technology, marketing and other social/religious considerations. Yet, mussel farming has found wide acceptance and high adoption rate in this region.

At present there are nearly 200 women mussel farmers' societies. Each societies comprises 15 -20 members. Besides this Kudumbasree groups aided by village Panchayats have also adopted mussel farming on a large scale. Each Kudumbasree also comprises 15-18 women. Several individual farmers and groups formed by men have also taken to mussel farming. These groups have availed loan from banks. The mussel production from farming has risen from 250 t to nearly 7,000 t in 2005-06.

Mussel seed trade

With increased adoption of mussel farming, demand for mussel seed increased tremendously as a result of which trade in seed has developed into an allied mussel farming activity generating additional income to mussel pickers. Active mussel seed trade occurs in South beach, Elathur, Kappad, Thikodi, Moodadi, Koduvally, Bekal and Kottikulam. About 100 kg seed costs Rs. 400-450.

Bottom culture of mussel

This has become widespread among farmers as well as mussel pickers in the Malabar region. The farmers themselves have resorted to this system as against the suspended method of culture. Here, the farmers collect seed from mussels beds and spread it near their homestead for harvest during lean season when fish is scarce. The mussel pickers also now relay the seed in inter tidal beds for harvesting later. They sometimes stock even the adult mussels. Bottom culture is being carried out by 14 farmers in Kannur, 10 pickers in Mahe estuary, over 50 farmers in Kadalundi, Kozhikode district, over 75 persons in Chaliyar. Over 20 mussel pickers in Koduvally, Kozhikode district relay mussels in the intertidal beds.

Technology modification

The technology of mussel farming extended by CMFRI was the vertical suspended rack/raft system. However, in shallow areas where depth is inadequate for suspending vertical ropes but which were otherwise suitable for mussel farming, farmers have resorted to suspending horizontally seeded ropes, thus adapting to the given conditions. Also

they use old nets and coir ropes for the seeding. Others have simply resorted to bottom culture to keep costs low. The people of this region have become more receptive to newer technologies such as seaweed farming, oyster farming etc.

In conclusion, the sustained mussel farming initiatives and interventions carried out by CMFRI has provided alternate livelihood options and livelihood diversification. It has led to increased fishing income, besides supporting complementary household activities particularly among womenfolk, rather than substituting one secure income source for another. Encouraging alternate livelihood options raises the opportunity income of fishing with potential conservation and economic benefits⁴. There is further scope for widening the horizons of these interventions by introducing other allied activities like small scale homestead processing units such as depuration, pickling, dried mussel and ready to eat processed products.

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Selective study on the availability of indigenous fish species having ornamental value in some districts of West Bengal

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The term ornamental fish needs no introduction. The global trade of the ornamental fish industry is increasing rapidly, at around 6% annually¹. In the aquaculture sector, ornamental fish breeding, culture and trade provide excellent opportunities as a non-food fishery activity for employment and income generation. It is environmental friendly, socially acceptable and involves low investment for adopting as a small scale enterprise with high return. The attractive coloration and quiet disposition of ornamental fish provide a source of joy and peace for people irrespective of age group. Increasingly, ornamental fish is becoming a fashionable activity with new fish varieties entering the market from time to time. By concentrating on such fish only, we may lose our indigenous fish biodiversity, some of which are edging towards extinction. Many indigenous ornamental fishes are very much useful for developing new strains to compete in world market. They are also used as a tool in biotechnological research in all over the world².

The history of culturing ornamental fishes in West Bengal is age old. A rich aquatic biodiversity, favourable condition, cheap labour and easy distribution make West Bengal as a pre-eminent hub for this promising industry³. Most of the indigenous and endemic fish species available in this state have significant potential for the purpose of ornamental

fish culture. However, severe depletion in the natural fish population of the state has largely been driven due by destruction of habitat, unsustainable modes of exploitation and other stresses. So with the present investigation, an attempt has been made to ascertain an overview of the availability of indigenous ornamental fishes in some districts of West Bengal.

A survey was carried out for 60 days (September-October, 2008) in four districts of West Bengal namely Howrah, Hooghly, and North and South 24 Parganas, because these districts are rich in different types of indigenous fish species which have got tremendous ornamental status in the international market. A considerable number of fish culture units have been concentrated in these four districts¹ (Table 1). The entire region under study is highly variable as far as topographic and climatic conditions are concerned. This region enjoys a tropical monsoonal climate, receiving an annual medium range of rainfall with high temperature in summer (30-39°C) and a sharp fall of temperature in winter (15-25°C).

Table 1. Selected areas of the districts where survey has been conducted

Districts	Name of the areas
Howrah	Pakuria, Domjur, Kadamtala, Amta, Ramrajatala
Hoogly	Dankuni, Chuchura, Srerampur, Mogra, Bandel, Saorafulli
North 24 pgs	Naihati, Amdanga, Barasat, Barrackpore, Khardah, Baranagar, Bonhooghly
South 24 pgs	Amtala, Mahestala, Falta, Bazbaz, Baruipur, Canning south, Dimond Harbour

Selection criteria for ornamental fishes

For the present study, small to medium (<20 cm) sized fish specimens (ideal for aquarium rearing) available in the aquatic habitats of the region were taken into consideration to assess their potentiality for aquarium purpose. Basic parameters considered for the assessment were i) adult size and hardness ii) attractiveness (coloration pattern, body morphology etc), iii) ability to thrive in a confined environment with supplementary food, iv) endemicity, v) behavioral and environmental compatibility with other species.

Identification of the indigenous fishes

The indigenous fish fauna having high potentiality as ornamental fishes that are available throughout the study areas of the selected districts were identified according to Nelson⁴ and Talwar and Jhingran⁵.

Result and Discussion

During the present investigation 30 species of indigenous fishes with potentiality as aquarium fishes belonging to 22 genera and 13 families have been recorded from the selected areas of the four districts (Table 2). Cyprinids were the most dominant family followed by Bagridae, Siluridae, Ambassidae, Notopteridae, Belontiidae, Belonidae, Chacidae, Mastacembelidae, Cobitidae, Nandidae, Anabantidae and Channidae.

Observation during the investigation

Throughout the survey we observed that the natural resources of the indigenous fish fauna are in declining trend. The condition may be due to increasing trend of aquatic pollution mainly by agricultural pesticides followed by discharge of pollutants along with industrial effluents from various sources.

The survey revealed that the habitats and breeding grounds of these valuable fishes are under threat due to the application of toxicants to prepare the water bodies for the sake of scientific composite fish culture or poly culture after eradicating the weed fishes, some of which are also potential indigenous ornamental fishes. The study further revealed that if such conditions are allowed to continue then a time will come when these valuable indigenous fish species will not be available to us. So now, the time has come to restore all such indigenous fishes and their captive culture is to be popularised. We urge the government departments, private agencies, other non government organisations to boost the culture of such fish species to save the progeny. In this respect it is essential to take immediate attention to popularise the captive culture as well as breeding of these indigenous fish species of Bengal.

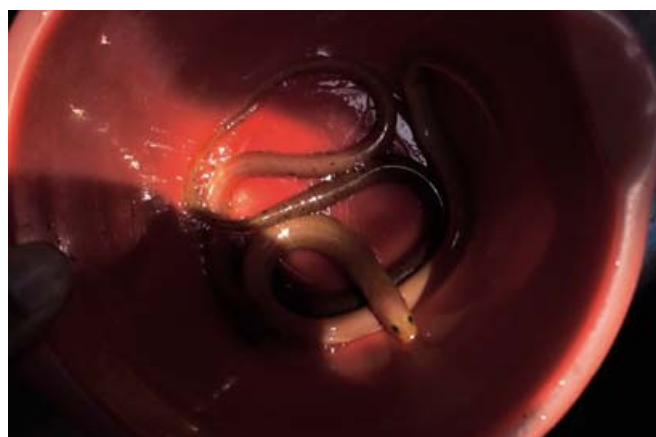
According to our study these resources are presently exploited in an unorganised way by some unscrupulous traders who operate this trade from outside the region. Their trade usually based on collection of certain target species which have high market value. This mode of exploitation would no doubt contribute largely to the depletion of natural stock of the said resources in the near future. A number of rural people, both men and women, are engaged in the wild collection and culture of the potential fish resources. But the fact is that the indigenous fishes produced in these areas or wildly collected are mostly to meet the demand of local markets and consumers. A lack of awareness and ignorance among rural masses, deficiencies of infrastructure and inadequate policies of the concerned authorities have been identified as major hurdles in the way of development of this highly promising sector of commercial fisheries.

Conclusions

Considering the tremendous prospects of these areas it is the prime time to make an integrated effort to promote this sector of fisheries in a sustainable way. Eradication of the ignorance and the enlightenment or awakening of awareness among the rural masses is the essential criteria to restore those valuable fishes.

The following measures are suggested for the sustainable utilisation of these potential aquatic resources to enhance the fisheries sector to earn more foreign exchange:

- Abundant and systematic development of a comprehensive database including feeding, breeding and environmental requirements of each potential indigenous fishes.
- To evolve sustainable farming technologies for commercially important native ornamental fishes.
- Provision of better extension support in the form of technology, finance and marketing to needy fishermen, particularly with regards to the unemployed to motivate them to adopt ornamental fish production as a business.



Albino eel.

Table 2. List of fishes frequently available in the selected areas

Local name	Common name	Scientific name	Family
Pholui	Black knife fish	<i>Notopterus notopterus</i> (Hamilton-Buchanan)	Notopteridae
Chital	Humped feather back	<i>Notopterus chitala</i> (Hamilton-Buchanan)	Notopteridae
Kalbasu	All black shark	<i>Labeo kalbasu</i> (Hamilton-Buchanan)	Cyprinidae
Kanchan pungti	Rosy barb	<i>Puntius conchoni</i> (Hamilton-Buchanan)	Cyprinidae
Gilli pungti	Golden barb	<i>Puntius gelius</i> (Hamilton-Buchanan)	Cyprinidae
Pothia pungti	Two spot barb	<i>Puntius ticto</i> (Hamilton-Buchanan)	Cyprinidae
Sophore pungti	Spot fin swamp barb	<i>Puntius sophore</i> (Hamilton-Buchanan)	Cyprinidae
Maurala	Mola carplet	<i>Amblypharyngodon mola</i> (Hamilton-Buchanan)	Cyprinidae
Anju	Zebra danio	<i>Brachydanio rerio</i> (Hamilton-Buchanan)	Cyprinidae
Dangila danio	Dangila danio	<i>Danio dangila</i> (Hamilton-Buchanan)	Cyprinidae
Bashpata	Devario danio	<i>Danio devario</i> (Hamilton-Buchanan)	Cyprinidae
Rasbora	Gangetic scissor tail	<i>Rasbora rasbora</i> (Hamilton-Buchanan)	Cyprinidae
Gunte	Guntea loach	<i>Lepidocephalus guntea</i> (Hamilton)	Cobitidae
Tengara	Golden cat fish	<i>Mystus tengara</i> (Hamilton-Buchanan)	Bagridae
Tengara	Striped dwarf cat fish	<i>Mystus vittatus</i> (Bloch)	Bagridae
Aar	Long whiskered cat fish	<i>Aorichthys aor</i> (Hamilton-Buchanan)	Bagridae
Ritha	Rita	<i>Rita rita</i> (Hamilton-Buchanan)	Bagridae
Pabdah	Gulper cat fish	<i>Ompok pabda</i> (Hamilton)	Siluridae
Pungas	Indian tiger shark	<i>Pungasius pungasius</i> (Hamilton-Buchanan)	Siluridae
Chacca	Indian chaca	<i>Chaca chaca</i> (Hamilton-Buchanan)	Chacidae
Kankley	Long nosed Needle fish	<i>Xenontodon cancila</i> (Hamilton-Buchanan)	Belontiidae
Nama chanda	Elongated glass perchlet	<i>Chanda nama</i> (Hamilton-Buchanan)	Ambassidae
Ranga chanda	Indian glass fish	<i>Pseudoambassis ranga</i> (Hamilton-Buchanan)	Ambassidae
Nadosh	Leaf fish	<i>Nandus nandus</i> (Hamilton-Buchanan)	Nandidae
Koi	Climbing perch	<i>Anabus testudineus</i> (Bloch)	Anabantidae
Khalisa	Stripped gourami	<i>Colisa fasciata</i> (Schneider)	Belontiidae
Khalisa	Dwarf gourami	<i>Colisa lalia</i> (Hamilton-Buchanan)	Belontiidae
Chuna khalisa	Sunset gourami	<i>Colisa sota</i> (Hamilton-Buchanan)	Belontiidae
Pankal	Spiny Green eel	<i>Mastacembalus punctatus</i> (Hamilton-Buchanan)	Mastacembelidae
Lata	Spotted snake head	<i>Channa punctatus</i> (Bloch)	Channidae

- Development of captive culture fisheries in 'beels', reservoirs and wetlands on a co-operative basis with some other culture.
- Establishment of periodic monitoring of the health of the aquatic fauna as well as water quality parameters.
- Enforcement of fisheries and environmental laws and acts in the maintenance of resource sustainability and to check unauthorised wild collection of targeted species.

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Peacock eel.

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Aquaculture Livelihoods Service Centres in Aceh, Indonesia: A novel approach to improving the livelihoods of small scale fish farmers

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The world community responded rapidly to the devastating effects of the tsunami in December 2004 in Aceh and elsewhere. The Asian Development Bank (ADB) was quick to initiate a multi-sector project, the "Earthquake and Tsunami Emergency Support Project (ETESP)", with a major component on fisheries and aquaculture (ETESP-Fisheries) in Aceh, to rebuild the livelihoods of the coastal communities that were most affected. This ADB financed project was executed by the Badan (BRR) established by the Government of Indonesia in April 2005 to lead the reconstruction of Aceh and Nias.

Many social, technical and economic difficulties confront rural producers trying to rebuild their livelihoods after being devastated by natural calamities, despite the generosity of donors and concerns of the government. Governments, more often than not, express rehabilitation in terms of the repair or building of state infrastructure but this has limited impact unless the effected populations are assisted through their difficulties to become productive and socially organised and become "real" partners in the process from inception, design and implementation when it comes to reconstruction at village/ community level - a strategy adopted by the ETESP-Fisheries program.

To realise the full potential to improve livelihoods and reduce rural poverty through rebuilding the coastal fisheries and aquaculture in Aceh is a gigantic task. The potential lies in the formation of producer associations which could be trained with business organisational skills. Such associations have the potential to help mitigate low productivity, to form networks for dissemination of better management practices, to negotiate better deals on inputs, to arrange credit from banks, to assist coordinated cropping and marketing of larger quantities, to provide

a legal entity and status required for investment, and to provide traceable sources for consignments of shrimp.

- There are many challenges to overcome in attaining the above. These include:
- The need to develop a vision and a guiding policy from government which has difficulty in moving from a "control" mode to a "service delivery" mode.
- The development of functional services available through government and private sector.
- The development of a legal framework that promotes the formation of "producer associations" as legal entities.
- An increase in reliable productivity from traditional ponds.

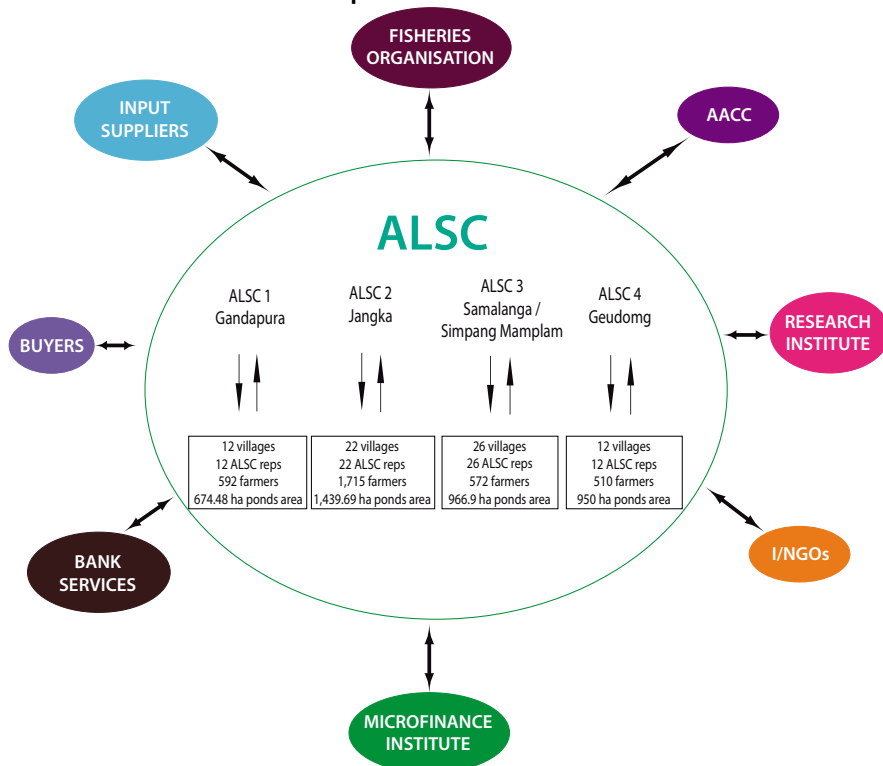
- Facilitation, awareness and acceptance of concepts such as better management practices (BMPs) and adoption thereof to improve yields and product quality, food safety, and reduce disease risk.
- Awareness of the increasingly stringent consumer demands of international markets in relation to food quality, traceability and sustainability.
- Ability to produce the quantities and qualities demanded by buyers thereby gaining valuable income potential.
- Wider access to, and capacity of, technical, market and financial services.

In this paper we discuss the form and function of aquaculture livelihood centres, which aim to help address



NACA DG visiting farmers and local officials at Samalanga ALSC.

General operational model of ALSCS



some of these issues. These are centres of the people, for the people, managed by the people, to address their problems and develop practical solutions, in this instance of small scale fish farmers. As this is a novel approach to facilitate sustainable growth of small scale aquaculture that would have application elsewhere, we felt it was appropriate to bring the concept to the public domain, primarily to bring about dialogue to improve its form and function, and to investigate its adaptability to comparable situations.

Aquaculture Livelihood Service Centres

The concept

Responding to the potential for coastal shrimp farming in Aceh to restore and improve livelihoods through the development of a premium export industry for large *Penaeus monodon* shrimp requires careful and progressive technical, social and economic facilitation over a period of time. It is in this context that the concept of livelihoods clusters has been proposed to meet some of these demands.

The livelihoods approach has advanced through two inter-related and innovative activities implemented through the

fisheries component of ETESP. Following the rehabilitation of 3,000 ha of shrimp ponds (tambaks) over three years through the application of a livelihoods approach and community contracts, four "Aquaculture Livelihood Service Centres" (ALSC's) in Bireuen and Aceh Utara districts were set up by the farmers to address some of the daily problems that they encounter, with the assistance of the project.

In the absence of government or private sector extension services, a specialised "Aceh Aquaculture Communication Centre" (AACC) was set up in Balai Budidaya Air Payau centre (BBAP), Ujung Batee, Aceh to provide advice and information services using websites and voice over internet (VOIP) to facilitate communication. This centre services the needs of the ALSCs, which are owned and managed by the local farmer groups, through modern communication channels.

ALSC based farmer groups at sub district and district level implement and manage the aquaculture activities through participatory approaches in order to accomplish their common goal of reducing risk and the maximising profit while meeting the expected market demand through sustainable aquaculture operations. The ALSC are expected to become fully self sustaining business and technical centres for

the fish/shrimp farmer associations through payment of services fees by the members.

The associations and centres are free to obtain services from the private sector e.g. feed and fertiliser suppliers, hatcheries, shrimp exporters, private laboratories and banking services. The members of the associations can achieve benefits by collectively purchasing inputs and marketing produce and thereby taking advantages of economies of scale and increased market power, maximising their profits and minimising cost of production.

Location

ALS Cs have been established by shrimp and milkfish farmers in four sub districts (Samalanga, Jangka, Gandapura and Samudera) in the East coast of Nanggroe Aceh Darussalam (NAD), North Sumatra, Indonesia. All ALS C centres are located strategically near the centres of each sub district with good access to main roads, and nearby aquaculture pond areas many of which were rehabilitated by ETESP Fisheries.

Composition of ALS Cs

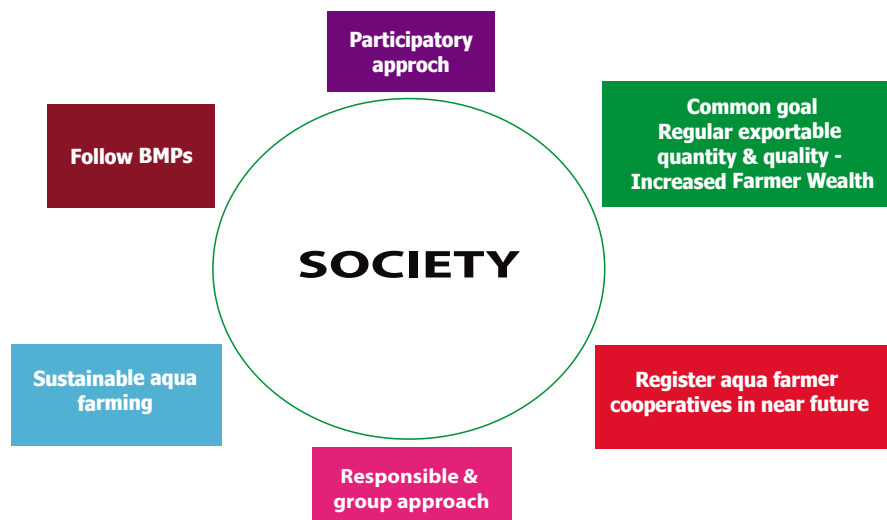
ALS Cs are the centres at which rural producer associations, in this case fish farmers, begin to operate their own services in the absence of government or other private sector extension services. All ALS C committee members are drawn from the fish farming communities of the respective sub-districts. The members elect from amongst themselves a Chairperson, Vice-Chairperson, Secretary, Treasurer, and an Executive Committee (lead farmers from each village engaged in aquaculture as a main source of livelihood), and these personnel together are responsible for operational procedures. A schematic representation of the composition and organisational set up of farmer owned and managed ALS Cs is shown below.

The activities of ALS Cs are also technically supported and advised by various government agencies' staff such as the DKP- Dinas Perikanan dan Kelautan (Marine and Fisheries Affairs Agency). The activities are coordinated by ETESP Fisheries, FAO and OISCA field facilitators and lead farmers. The engagement of the different agencies through the ALS C is mediated to collate the perceptible differences in approach. Most farmers in the respective

sub-districts are active members of ALSCs. The registered members abide by the rules and regulations of ALSCs decided by the community (e.g. prohibition of the use of pesticides and antibiotics, crop planning, and a group approach to finding solutions for the various aquaculture related issues). The committee members/lead farmers and children of the farmer communities are well trained in the basics of computer operations and who in turn continue to train the farmer community/ groups at the village level. Leaders of villages in the sub-districts are also executive members of ALSC committee and it enables the ALSC to operate within the established social structure of the villages and contributes to the effective decision making. The matter of “elite capture” is ever present but countered through frequent meetings at which the farmers of all levels have democratic voice.

The committee members and lead farmers of the four ALSCs form the leadership for a producer association at the district level for furthering business developments in collaboration with various associated service providers such as hatchery operators, inputs suppliers, processors and exporters.

Organisation of small-scale aqua-farmers through ALSC



Community involvement

Capture fishers LSC's are based on existing fisher organisations referred to as “Panglima Laot” which is a traditional organisation with a feudal past. An equivalent organisation is lacking within the aquaculture sub-sector and the ALSCs are therefore focusing on the development of the aquaculture producer association, capturing interest by providing valued technical services.

In the formation of the LSCs, the farmer communities first underwent a process of socialisation for inculcation of the ALSC and AACC concepts and operation system through a large number of participatory farmer meetings at the village and sub district levels for periods up to six months. All the committee members were elected by the communities at the sub-district level, before establishment of the ALSCs. ALSC based farmer groups at sub-district and district level implement and manage the aquaculture activities through a participatory approach in order to accomplish their common goals of reducing risks and maximising profits while meeting the expected market demand through sustainable aquaculture operations.

In the future, it is expected that the ALSCs would depend on government and external agencies only for advice and information on technological advances and possibly extra services if available and/or needed. Further financial support will not be required.

Functions and operation

- 1. Group approach and linkage to stakeholders:** ALSC operations bring together aquaculture farmers and organisations from different backgrounds to work in partnership, a process that requires partners to pool their commitment of human, financial and natural resources to achieve sustainable growth of the aquaculture sector and also thereby increase aquaculture farmer wealth in Aceh Province, Indonesia.



Observing a shrimp grown in a pond supported by ALSC.

The diagram illustrates the connection between ALSC and various service providers such as input suppliers, banking services and shrimp buyers and exporters. The principal role of the ALSC is to provide technical and the business expertise and to sustain useful information flows. Progressively, it is intended to introduce banking services, micro-finance facilities, and create communication networks through the ALSC and to begin to create awareness of finance, credit, savings, small-scale business, and investment. The private sector will provide regular ongoing inputs on market needs and pricing strategies.

ALSCs will run as networks of service centres, conforming with a “cluster approach”, as operational information, extension, micro-finance and trading centres, with the purpose of improving the livelihoods of aquaculture farmers and their families through increasing their human and social capital, and know how on simple but effective business management.

2. Promoting sustainable aquaculture: ALSC based farmer groups at the sub district and districts levels implement and manage the aquaculture activities through a participatory approach in order to accomplish their common goal of reducing risks and maximising profits while meeting the expected market demands through sustainable aquaculture operations. Aquaculture in small-scale farmer owned ALSC is developed through implementation of responsible BMPs to minimize the risk of disease out breaks and increase profit. The ALSC group has an internal control system to ensure compliance with the BMPs by all members.

3. Planning activities: ALSC centres support farmer communities for decision making in crop planning including harmonised stocking and harvesting in collaboration with various stake holders to minimise the risk of disease outbreaks during farming and increase the overall simultaneous harvest to levels of interest to larger buyers, both of which are the major challenge for the farmers in Aceh.

4. Providing Services: The ALSCs also provide technical services such as application and adoption of BMPs, disease diagnosis,

information, training and planned financial services for the well being of individual farmers as well as farming communities.

5. Legal entities: There are ongoing efforts by the ALSC committees to register producer associations as legally recognised entities for furthering business developments and mutual benefits to the stakeholders thereby improving the livelihoods of the aqua-farmer communities. The legal status would facilitate farmer community access to banking and micro finance services.

6. Traceability and marketing: At present, most Aceh shrimp are grown extensively using low densities that are capable of producing superior quality shrimp. There exists a strong potential for branding Aceh shrimp. However, certain practices have to be put in place through the ALSCs system to achieve this goal; these include implementing BMPs, maintaining consistent quality and quantity, establishing partnership with processing plants/exporters, assuring food safety standards through record keeping and traceability systems.

This concept has been introduced by ETESP to ALSCs members, and will be further supported by FAO, OISCA and processors with the objective of achieving successful market access.

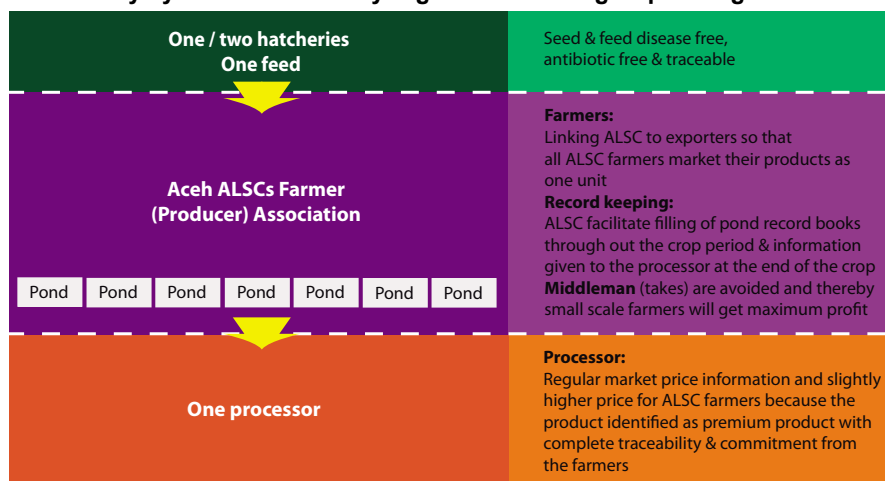
The challenges for the exporters are to organise group harvests at sub-district and district levels. This can be easily facilitated through farmer owned and managed ALSCs by focussing on:

- Sourcing of post larvae and feed through selected suppliers via ALSCs.
- Traceability back to shrimp farms and the hatcheries through record keeping at all levels.
- Selling produce as one unit coordinated by ALSCs to one processor/exporter.
- Better management practices monitored by ALSC committee members to control the hygiene and safety of shrimp produced associated farmers.
- Screening of all inputs for banned antibiotics.

Aceh Aquaculture Communications Centre Location

Aceh Aquaculture Communication Centre (AACC) is located at Brackishwater Aquaculture Centre (BBAP/Balai Budidaya Air Payau) at Ujung Bate, Aceh Besar district, NAD, North Sumatra, Indonesia. AACC was established in January 2009 with the approval of the Indonesian government, funded through ADB ETESP and technically advised by ETESP NACA. It provides information and communication services related to aquaculture direct to farmers and their associations through the ALSCs.

Traceability system facilitated by organised farmer group through ALSCs



Composition

Formal agreement between ETESP Fisheries and BBAP to delegate 8 part-time staff for efficient operation of AACC was reached on 29 April 2009. The job responsibilities for AACC staff are well described and necessary training is being provided. For further strengthening and consultation of the AACC-ALSCs operational system, there are current plans to conduct regular visits to each ALSC to establish full time permanent position for AACC operations.

The organisational set up of the AACC consist of a Manager, Vice Managers for Diseases Diagnosis Services, Information Services, Technical Services, Training Services, Website management, and Translation and Quality Control.

Community involvement

The AACC works with aqua-farmer associations primarily through the ALSC system, however services can also be provided to farmers outside the established ALSCs areas on a needs basis. The communities' technical and information needs will be fulfilled through services provided.

Functions and operations

The principles of AACC are to: 1) facilitate communication between farmers and other stakeholders/partners; 2) provide free source of information to ALSC and farmers through website, printed materials and other communication tools; and 3) facilitate ALSC and farmers in Aceh to access services provided by BBAP (information, technical, disease diagnosis, and training). At this stage, AACC provides four major services including:



Farmers conversing with AACC expert via Skype.

1. Information services

Providing information on market access; product prices, suppliers (hatchery, feed, agro input supplies), the latest articles and information related to sea food business internally and externally. Regular dissemination of updated news and practical information about aquaculture has been initiated.

This information can be accessed through the AACC website, brochures, posters and newsletters. The interactive website, "Jaringan Petambak Aceh" (Network of Aquaculture Farmers in Aceh; <http://petambakaceh.org>) will provide practical information and materials for aquaculture farmers, covering market information, extension materials, business directories and others developed based on the needs identified by participation of the farmers themselves. AACC provide online consultation and communication with ALSCs via Skype (voice chat over the internet) for immediate feedback and technical advice.

2. Technical information services

This service provides all technical aspect on aquaculture; information and technical consultation. Normally ALSC committee members provide the required services if within their capacity and experience. However, requests beyond their capacity are forwarded to AACC or another appropriate institution for technical assistance. Regular information on new technologies is also disseminated to ALSCs to keep the farmers updated on the recent development in sustainable aquaculture practices.

The information service is underutilised at present being newly established but records are kept and these show a growing trend in the number of enquiries. The AACC must prove its capability to the farmers in order that the demand for the services grows.

The type of services sought by farmers and provided to farmers through the system								
ALSC	Month	Technical advice sought				Laboratory services	Farmer meetings	Computer training
		Shrimp	Milkfish	Tilapia	Grouper			
Samalanga	April	10	5	0	2	2	15	0
	May	15	7	0	5	3	12	16
Jangka	April	25	60	18	11	3	30	0
	May	32	74	23	17	5	50	16
Gandapura	April	10	15	0	7	33	15	0
	May	60	22	0	11	42	45	16
Samudera	April	25	5	0	0	10	16	0
	May	40	10	0	0	14	30	16

3. Disease diagnosis service

AACC facilitates the farmers access laboratory facilities at BBAP centre for disease diagnosis via the ASLCs. The diagnoses, results and recommendations are sent back to ALSC rapidly to be effective and applicable.

Established protocols and standard operation procedures for sample collection for water quality and disease diagnosis are provided to farmers. Fine tuning of protocols and SOP for aquaculture practices in Aceh will be further improved as development progresses.

In case of serious disease outbreaks, AACC staff will visit and provide practical field level solutions to farmers through meetings and this information will be disseminated to other areas for prevention of further spread of disease.

4. Training services

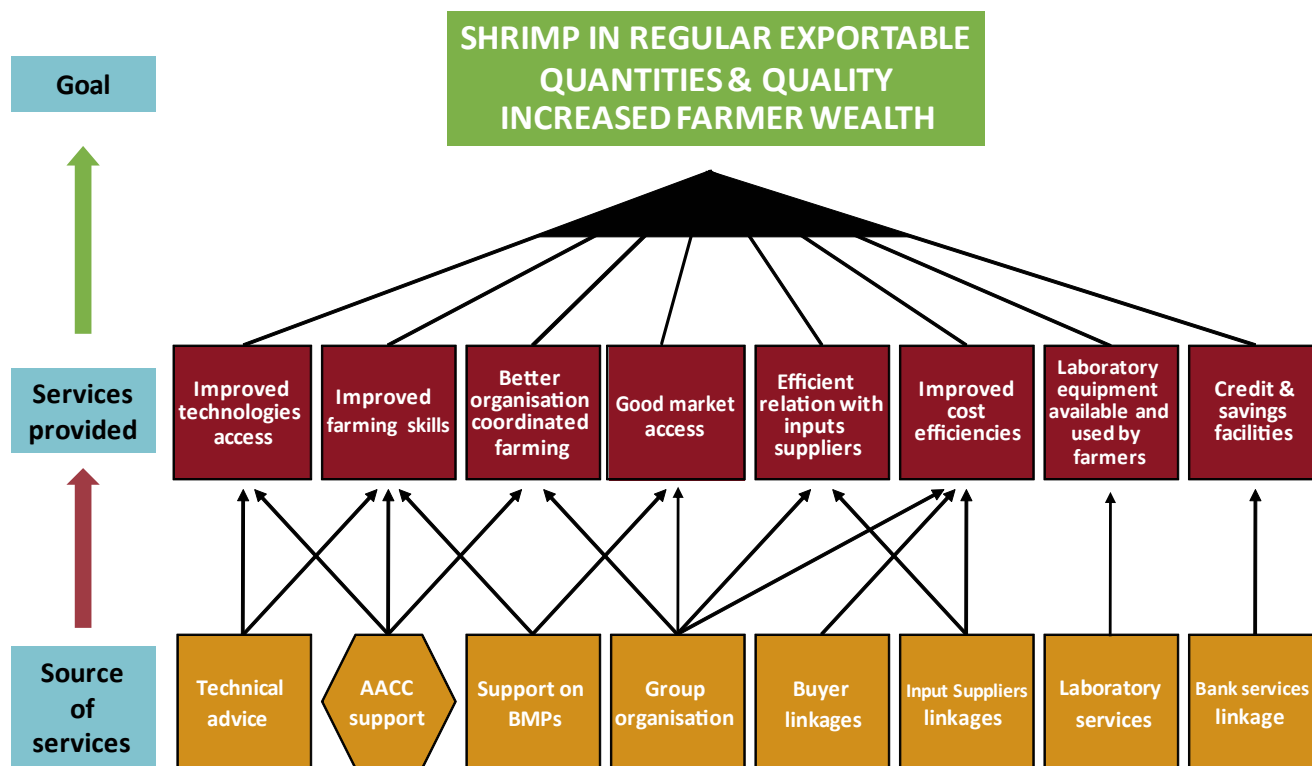
AACC conducts training based on identified needs of Aceh farmer communities through ALSCs or when new technologies become available and are ready for dissemination. The training may focus on technical aspects, business management, and other capacity building topics through lectures and/or hands-on training.

For deliberation of services, AACC cooperate with training providers, such as extension unit of BBAP or other government institutes, as well as the other parts of the private sector.

Effectiveness of the ALSC-AACC model

- There is growing close coordination and collaboration between farmers at the sub-district and district levels. Considering the history of the area this itself is a breakthrough. After establishment of ALSC, farmers have improved crop planning, sharing experiences and resources through regular farmer meetings organised by ALSCs with the objective of overcoming the various issues and challenges in their practices.
- Information on disease outbreaks at village, sub-district and district level are quickly transmitted across boundaries, are well discussed and shared with other ALSCs for control of disease through a group approach.
- The farmer owned website facilitates effective communication between farmer communities and stakeholders. The website provides a platform for improving business and collaboration among stakeholders.
- Effective communication between farmer communities and government agencies, research organisations and laboratory services established. Communication gaps between farmer communities and stakeholders have been reduced through ALSC-AACC operational system.
- ALSC-AACC operational systems are well explained to stakeholders through meetings/discussion groups and it helps to plan their activities based on the community needs e.g. banks, micro finance units).
- ETESP Fisheries facilitated service provider meetings with input suppliers of quality materials and at discounted prices. Service providers welcome such arrangements through the ALSC system (e.g. Gold Coin feeds, Medan). To date a few exporters and processors have visited ALSC sites and started preliminarily discussions for group harvests and on processes leading to the introduction of a traceability information system (need further supports during harvest periods July-September 2009).
- Effective dissemination of BMPs was achieved through ALSC-AACC system in four sub-districts. As a result harmonised stocking and crop planning are in place, communities

Schematic representation of the services provided by ALSC and its goals



are enthused in harmonised harvesting and traceability for minimising risks and maximising profits through high level coordination with stakeholders.

- The table above indicates the types of services sought and provided to farmers in the current system. It is evident, although the data are available only for two months, that the use of the system of communications to address farmer problems and concerns are on the rise, indicating that the system is operating to expectations.

Expectations for the Future

It is expected that the ALSCs will become self sustaining units, with business acumen and technical centres for fish/shrimp farmer associations. In the future these would depend on government and external agencies only for advice and information on technological advances and possibly services if available but not financial support. The associations and centres are free to obtain services from the private sector e.g. feed and fertiliser suppliers, hatcheries, shrimp exporters and banking services. The members of the associations would achieve benefits in group purchasing of inputs and marketing produce and thereby maximising their profits and minimising costs of production.

Progress facilitated by NACA

The work on the development of better management practices (BMPs) on the shrimp culture commenced with the organisation of small scale aquaculture farmer groups at one or two villages, grouping of farmers at the sub district level (IFC NACA Shrimp project during the year 2007-08), drawing on common resources, and experiences drawn from comparable practices in Andhra Pradesh, India, and inducing the farmer to act in groups rather than individually for the betterment of all. The three years collaborative project of IFC/NACA and ADB/BRR/NACA from 2007-09 provided the basis and a strong foundation for the establishment of farmer owned Aquaculture Livelihoods Service Centre in Aceh and thereby improving the livelihoods of the small scale aquaculture farmer community in Aceh.



Farmers accessing computer to obtain information at ALSC.

Acknowledgments

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Regular farmer meeting.

e-Sagu Aqua: An innovative information and communication technology model for transfer of technology for aquaculture

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Fisheries and aquaculture extension services respond to knowledge needs of farmers and rural people with a view to improving fish production, livelihoods, welfare and management of natural resources. Ideally, fisheries extension should facilitate the flow of information and technology from R&D to farming communities and return feedback on field requirements to researchers. In the past in India, extension was seen primarily as a public service, organised, managed and institutionalised by national government. Today, government and public extension institutions must adopt diverse strategies to build dialogue and collaboration among a variety of public, private and non-governmental and community based institutions.

Various models of extension such as the 'transfer of technology model'¹; the 'integrated rural approach'², 'training and visit' system³, 'farmer field schools'⁴ and 'decentralised extension' models have been tried over the years in many developing countries. These models have achieved considerable success in aiding the food self sufficiency in many countries but still extension systems are left with many constraints to overcome and challenges to be met. These challenges of extension have opened the door to examine new approaches such as how information and communication technology (ICT) can be cost-effectively and practically employed to facilitate knowledge sharing among farmers, extension agents and other stakeholders⁵.

In the past few years, the power of the internet as a communication medium has captured the imagination of developmental organisations around the world. A number of projects have been undertaken in various parts of the world attempting to provide sustainable digital access to rural communities. ICT driven models currently dominate in Indian fisheries are Aqua-Choupal, Village Knowledge Centres/Rural Knowledge Centres, web kiosks, help lines, Kisan Call Centres and e-Sagu Aqua. The e-Sagu Aqua is an innovative and unique model of information exchange which has been implemented in freshwater in Andhra Pradesh State of India. This article deals with the profile, technology transfer modalities, model components, information and communication system and strength and limitations of the e-Sagu Aqua model.

Approach

We investigated the e-Sagu Aqua model in West Godavari district of Andhra Pradesh where it was in operation. We interviewed 47 participating farmers using a structured interview schedule on the model profile, technology transfer modalities, components of the model, the information and communication system and its data base. The benefits

accrued, the strengths and the limitations of the model were also studied. Farmers were asked to rank 15 strengths and nine limitations of the system.

Findings

Profile of the model – key players

The primary centre of e-Sagu Aqua was housed at the International Institute of Information Technology (IIIT) in Hyderabad, manned by a team of fishery experts. The fisheries information system comprised animal and farm databases, weather and other agro-ecological data. This project was sponsored and managed by Media Lab Asia, Department of Information Technology (DoIT), Government of India (GoI) as a not-for-profit research organisation. The project design was done by Media Lab Asia and IIIT Hyderabad together.

Technology transfer modalities

A team of fishery experts worked at the Central e-Sagu Aqua system lab supported by aquaculture/fisheries information system located in state headquarters. One small computer centre (a few computers and one computer operator) were linked through a dial-up internet connection that had been established for a group of five to six villages. An appropriate numbers of coordinators were selected from the villages. Depending on the crop, each coordinator was allotted a fixed number of farms. The coordinator collected the details of the farms they were responsible for surveying including soil data, water resources and capital availability and sent the information to the main e-Sagu Aqua system. Every day, the coordinator visited a fixed number of farms and took four to five photographs of samples and pond conditions in each farm. The photographs and other information are recorded in a CD-ROM and sent to the main lab through a regular parcel service. Aquaculture experts with diverse expertise (soil, water, production and health) at the central e-Sagu lab analysed the crop situation with respect to soil, weather and other pond management practices and prepared farm specific advice for transmission back to the farmers. This advice was downloaded at the village e-Sagu centres. The coordinator delivered the advice to the concerned farmer. Thus each farm received required advice at regular intervals, starting from stocking operations to harvest precautions.

Components

The system essentially comprised four components ie. farmers, coordinators, fishery experts and an information and communication system.

i) Farmers

The farmers are usually engaged in their day-to-day farm operations and hardly find time to visit either reliable source of information like scientists of aquaculture/fisheries research stations nearby or officers of department of fisheries / any NGO operating in that area to find solutions for their farm related problems.

ii) Coordinators

The coordinators were either educated progressive farmers or qualified rural youth who possessed adequate fish farming knowledge and were generally selected from the same village. Soon after selection, they were trained rigorously by the fishery experts on aspects like soil sample collection for soil testing, water sampling, water testing, improved farm practices, pond management practices, identification of various disease, symptoms of damage, methods of field investigation, symptoms of diagnosis different diseases, disorders, deficiencies, allied aspects and basic photographic techniques.

iii) Fishery experts

A fishery expert with a Masters degree in fisheries/ aquaculture has been recruited. He is directed to collect information and update his knowledge in relation to the fish culture from sources such standard text books, journals, popular articles, bulletins released by Department of Fisheries and Regional Fisheries Research Stations, special publications from reputed national and international research institutes and also information available on the internet. Linkages with other fishery scientists of reputed research institutes and aquaculture information centres were also made.

Information and communication system

The system contained the following information in its database: Farm history, crop details, soil details, weather data, farmer details, case sheets, photo bank and a library.

Strengths and limitations of e-Sagu Aqua model

Strengths

Fish farmers in the West Godavari district faced enduring problems in freshwater fish culture. Experts of e-Sagu Aqua system hold the key to the transformation of fishery technologies and made it responsive to the urge of aqua farmers and it served the purpose of transfer of technology (TOT) very effectively like reduction of lag period from lab to land. The major species covered were rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus cirrhosus*). Moreover, the experts were proactive and took all possible precautions to avert problematic situations by reminding the farmer about the operations to be taken up immediately on weekly basis. Therefore, this system had more penetration and helped the scientific community to reach all the farmers in remote villages besides developing credibility. To create more awareness among the farming community and to disseminate fishery technologies there was a rapid exchange

of information among the stake holders. During the time of emergency such as disease outbreaks in the fish farms, accurate and effective of advice were delivered by the expert team to the farmers. The farmers felt that there is an in-built accountability in this system as the agro-advisory developed by each expert is archived and delivered in the form of printed matter. Hence, the experts were more watchful, paid maximum attention and took most care while developing and submitting the advice. Quick deployment of services during the time of crisis (100%), accountable advice (100%), significant reduction of lag period from lab to land (96%), cost effective methods (94%), vehicle to reach the remote places (43%), rapid exchange of information among the major stakeholders (40.42 %) were the strengths of the e-Sagu model as perceived by the respondents. One of the major constraints in fishery technology transfer is the lack of access to information. Viewed in this context the commencement of the project has improved the information reach significantly where the project staff have gone to the field every week to provide appropriate advice based on the crop status. However, this reliance was more in the case of small farmers as compared to medium and large farmers. On the contrary access to fishery scientists was more among large farms as compared medium and small farms.

Limitations

Limited financial resources and limited coverage of subjects were the major weaknesses of the model felt by 100 and 56% of the respondents respectively. e-Sagu Aqua was funded by Media Lab Asia for two years to implement in Mahbubabad mandal of Warangal and Mudigonda mandal of Khammam districts of Andhra Pradesh related to agricultural crops. The same project was then implemented in West Godavari district of Andhra Pradesh for fresh water fish culture in August 2006. The Media Lab Asia, with a vision of leveraging information and communication technologies and other advanced technologies for the benefit of the fish farmers' development, focuses on ICT application for healthcare, education, livelihood generation and empowerment of the disabled and providing rural connectivity. Since the Media Lab financial support for the project ended, the model has been modified as a new ICT application or 'virtual' model by one of the collaborators. A constraint is that ICT-enabled models need to grow to the stage where they can attract institutional investors, as computer penetration is still poor in rural locations and support is required to establish the necessary facilities. The present project concentrated on technology transfer and support of fresh water fish farming alone. If content and technical expertise was built up for other subjects such as horticulture, poultry, animal husbandry and agriculture it would be beneficial for the farmers.

Conclusion

Recent developments in information and communications technology (ICT) offer a great opportunity to facilitate the flow of information and technology services delivery to farmers. In this paper, by integrating freshwater aquaculture and information technologies, a framework for ICT based aquaculture information extension and dissemination is proposed. By exploiting progress in information technology, extension aims to provide fresh and expert advice to the needy farmers in a timely and personalised manner to improve freshwater aquaculture productivity and also to

increase the profitability of the farmer by increasing the efficiency of aquaculture inputs and reducing the cost of production. The real benefits lie not in the provision of technology per se, but rather in its application to create powerful social and economic networks by dramatically improving communication and the exchange of information. 'e sagu Aqua' is a successful case of ICT being used in highly effective manner to directly address development goals.


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Freshwater pearl crop: an emerging enterprise in the Indian subcontinent

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Pearls one of the most ancient of gems, are esteemed around the globe because of their cool and soft emergence, pastel hue and recognition to diverse disposition as compared to the other jewels. Previously Japan, China, Australia and French Polynesia have had exclusive authority on pearl culture techniques. During the early period of the last century Japan dominated in the frontier of pearl cultivation, later joined by the Australians in 1950's and French Polynesians a decade later, both through technical exchange from Japan, which gradually lost its monopoly on technical grafting skills.

The grafting process is the crux to success in any pearl culture operation, and in the early stages of the industry the techniques were closely guarded secrets by Japanese technicians, who were often brought in to conduct the grafting work in other countries. Currently, Australian, Chinese, Tahitians, American and Indian technicians are engaged in the grafting process. Earlier in the marine segment three oysters fundamentally ruled the pearl world. The Japanese and Indians employed *Pinctada fucata* for akoya pearls ranging from 4mm to 8mm. Australians employed their indigenous species *P. maxima*, the gold lipped pearl oyster, for production of 12 to 18 mm sized pearls and in French Polynesia *P. margaritifera* to produce a wide range of black, grey or greenish tinge pearls were produced of 10 to 14 mm size range.

Pearl culture is a billion dollar business and one of the world's largest aquaculture activities in terms of value. Until recently, opportunities for investing in this specific area have been limited. The hatchery and indoor production of juveniles have created an avenue for taking up this venture even in regions where pearl mussel resources are depleted, as established in Indonesia. India is in the process of establishing its own 'niche market' employing indigenous mussel fauna.

Freshwater pearl farming opportunities in India

In the early 1990s another dimension to pearl culture was added with the emergence of Chinese freshwater pearl crops. China has stood as a major contender for Japan as far as quantity of pearl product is concerned, although the value of marine pearls is generally much higher, and freshwater pearls are considerably different in character and do not necessarily occupy the same market niche.

The Indian subcontinent is bestowed with a rich and diverse group of mussel fauna. The genus *Lamellidens* is represented by nine species and two sub-species, while the genus *Parreysia* is represented by 35 species and six sub-species under two sub-genera¹. The most popular wealth of mussels are *Lamellidens marginalis*, *L. corrianus*, *L. consobrinus* and *Parreysia corrugata*. Their worth has been elevated of late because of their role in indigenous production of freshwater

pearls². Most other species also possesses nacre, but their potential for culture pearl production are yet to be realised. Every mussel has the ability to produce a pearl of some sort, however only those possessing a lustrous mother of pearl layer can form a gem quality pearl. Hence, though two thirds of the available species possess magnificent inner nacreous deposit, their success in pearl production through surgical practice is yet to be under taken.

Natural pearl formation is instigated when a foreign particle such as a piece of sand, shell piece or parasite make its way into particular region of mollusc and cannot be expelled. As a defense device, the animal secretes a calcium carbonate material known as nacre to coat the foreign body. Layer upon layer of this coating is deposited on the irritant, resulting in a shimmering and iridescent creation of a pearl. Cultured pearls are formed essentially by the same process, except that the irritant, otherwise called a nucleus, of desired shape and size is surgically implanted into the body of bivalve mollusc where it is difficult to be expelled. The animal does the rest, creating this prized biological gem. Thus, the nature's hand has not been completely eliminated; in fact it is the animal that determines the character of the pearl produced. According to the size and colour of pearl desired the appropriate mussel species is selected. *Lamellidens marginalis* and *L. corrianus* produce a maximum of 6mm sized pearl with a pinkish hue in former and silvery in latter. In *Parreysia corrugata* 3mm sized pearls can be retrieved with a golden yellow tone.

Freshwater pearl culture practices

Collection of mussels

Mussels are handpicked and collected from the wild in buckets, baskets or crates with water for short distance transportation. The collected mussels are preferably transported during the cooler early morning hours, where possible.

Pre-operative conditioning

The indigenous pearl mussel species are collected from freshwater bodies and are subjected to pre-operative conditioning for two days. They are kept in ferro-cement tanks (200 litre capacity) with aged tap water at a stocking density of one mussel per litre of water. Pre-operative conditioning ensures proper relaxation of adductor muscles in preparation for surgery. This aspect is important in view of limited application of narcotising procedures as followed in marine pearl culture operation.

Surgical implantation

Surgical implantations are of three types, made in three different regions of the mussel depending on the pearl type targeted. Individual mussels are taken up for a particular

type of implantation. The mantle cavity insertion method is a simple technique. Prior to surgery, mussels of required shell length and weight are collected. They are carefully opened by means of a speculum, 0.5 cm wide, without causing injury to the adductor muscle and soft parts of the mussels. A small area of the mantle from the anterior side is carefully detached from the upper shell valve and a nucleus of the desired size and shape (up to 1 cm in size for designed pearl) is inserted slowly into the mantle cavity and is further pushed in deep to avoid rejection. Both the valves of a single mussel can be implanted with the preferred foreign body.

In the mantle tissue method the mussels surgery are segregated into two groups before surgery, the mussels to be operated upon (the recipient mussels) and those to be sacrificed (the donor mussels). The live donor mussels are sacrificed and the pallial mantle ribbon extracted and cut into appropriate sized graft pieces and implanted alone or along with a small nucleus (2 mm diameter) into the mantle tissue of the recipient mussel. Such grafting is done on both the side of the mantle lobes. The number of implantations can vary between 2-8 depending upon the size and mantle thickness of the recipient mussel.

In the gonadal method of implantation once the live graft pieces are ready, the recipient mussels are carefully opened with the shell opener to about 0.5cm. A small measured incision is made by means of a special knife placed at the other end of the graft needle, under the outer membrane of the gonad. Care is to be taken not to cut deep into the gonadal tissue to avoid damage to the coils of the intestine. One implantation is made per animal.

Post-operative care

Post-operative care is an important step in freshwater pearl culture operation that is required for the implanted mussels to recover. The implanted mussels are placed at the rate of two mussels per bag in a ventral side up position for a period of 10 days. Sufficient care is taken to allow free opening and closing of the shell valves for respiration. The units are daily examined; dead mussels and those that reject the nucleus are removed.

The food requirements of most of the bivalves are still poorly understood. Most of the commercially important species of bivalves are plankton feeders. However the examination of the gut content does not give any precise idea of their feeding habit. It contains organic materials, colloidal substances, particles of organic detritus and living organic particles (bacteria, planktons, eukaryotic cells). The size of the particles plays an important role as well as their concentration on the rate of retention. *Chlorella*, *Chlorococcum*, *Kirchneriella* and *Spirulina* are considered to be their preferred diet³.

Pond culture of implanted mussels

Ponds are generally 2.5 metres deep with a clayey soil base and slightly alkaline waters. A rectangular shaped pond with proper inlets and outlets is ideal for implanted pearl mussel rearing. Ponds without aquatic macrophytes and algal blooms such as *Microcystis* and *Euglena* are suitable for pearl culture operations. The ponds are provided with P.V.C tubing (5 cm diameter) platforms (16 x 8 m) as rafts for hanging the pearl mussel culture units. The implanted mussels are placed

in nylon bags (1.0 cm mesh, 12 x 14 cm) at two mussels per bag and reared. The physico-chemical parameters and water level of the ponds are monitored throughout the culture period. The optimum temperature regime lies between 20° to 30°C.

Harvest of pearls

India being a tropical country, the culture period of pearl is narrow compared to other temperate countries. The pond culture of operated mussels varies from twelve months or more depending upon the size and number of nuclei implanted, the health of the mussels and the condition of the pond environment. In the case of mantle tissue and gonadal implantation methods the colour of the pearls varies from silvery white to golden yellow and deep pink depending upon the mother mussel and the nature of the donor mantle grafts employed⁴. At the end of the culture period (12 to 14 months), harvesting is done. The mussels are either individually sacrificed, or individually pearls are taken out from the pearl sac of the live mussels without sacrificing. Some freshwater mussels are capable of producing gem quality pearls. As the pearls are produced through a natural process they show a wide range of variation in their appearance and quality. To maintain uniformity in coloration and quality, pearls after harvest are subjected to value addition through surface cleaning or bleaching and dyeing or both cleaning and bleaching which may enhance their value.

Concerns

The biological parameters that need to be checked before initiation of pearl culture include water quality, water source, water depth, substratum type, nutrient load, temperature and superior quality of recipient as well as donor mussels. Site selection has to be convenient for operational activities. Mussels collected from the wild are ideal, however pathological parameters of the indoor produced animals need attention prior to selection. Pearl culture demands various ancillary activities that require appropriate attentions viz. mussel collection, implantation, nucleus preparation, culture unit fabrication, farm management and harvesting. The product should have a steady market avenue for better remuneration.

Acknowledgements

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Preliminary risk assessment of Pacific whiteleg shrimp (*P. vannamei*) introduced to Thailand for aquaculture

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Marine shrimp (*Penaeus* spp.) are important commodities for several Asian countries, including Thailand (Briggs *et al.*, 2005). Thailand had been one of the largest exporters of Black tiger shrimp (*P. monodon*) for decades until the outbreaks of viral diseases (white spot syndrome virus, WSSV; and yellow head virus, YHV) in the early 1990s. In response, low salinity shrimp farming techniques were developed and quickly applied in agricultural areas, especially rice fields (Szuster, 2001; Tiensoongrussmee, 2000). Further disease outbreaks, poor growth performance and declining prices for *P. monodon* led to the introduction of Pacific whiteleg shrimp (*P. vannamei*) to Thailand in 1998 (Briggs *et al.*, 2005). *P. vannamei*, a species native to the Pacific coasts of Central and South America (Perez Farfante and Kensley, 1997), is known for its tolerance to a wide salinity range and its fast growth rate in brackish water (Holthuis, 1980).

Aquaculture of *P. vannamei* has rapidly expanded because of the species' fast growth, low incidence of native diseases and availability of domesticated strains. The annual production of *P. vannamei* in Thailand has surpassed *P. monodon* every year since 2004. In 2007, an estimated 441,450 tons of *P. vannamei* were produced, representing more than 99% of the total marine shrimp production in Thailand (DOF, 1999-2005). This rapid expansion has facilitated the release of farmed *P. vannamei* into natural environments (Senanan *et al.*, 2007).



Figure 1. Sampling sites in the Bangpakong River (1 = Bangklah, 69 km from the river mouth; 2 = Muang, 45.8 km from the river mouth; 3 = Bangpakong 1, 10.5 km from the river mouth, 4 = Bangpakong 2, 6.5 km from the river mouth and 5 = the Bangpakong river mouth).

While aquaculture promises economic and social benefits, aquaculture escapees can pose ecological risks to the receiving aquatic environments (e.g., De Silva 1989; Naylor *et al.* 2001; Miller *et al.* 2004; De Silva *et al.* 2006). Some ecological impacts, such as reducing aquatic biodiversity or spreading alien pathogens, may undermine the sustainability of aquaculture and small-scale fisheries. By incorporating science-driven ecological risk assessment prior to new introductions and integrating a risk monitoring program, we may prevent such undesirable outcomes. This paper presents



Figure 2. *P. vannamei* captured from the east coast area of Thailand (Trat province).

data relevant to ecological risk assessment of *P. vannamei* culture in Thailand, generated by studies conducted during 2005-2007 by our research team. This three-year research program, funded by the National Research Council of Thailand, used a case study of *P. vannamei* introductions to the Bangpakong River and along the east coast of Thailand. The research focused on the following aspects: (1) the quantity of escapes from farms located in the Bangpakong River watershed, (2) the ability of escapees to survive natural conditions, (3) the reproductive capacity of escapees, (4) the spread of Taura Syndrome Virus (TSV), an alien pathogen carried by *P. vannamei*, and (5) the ability of *P. vannamei* to compete for food with local species.

The research questions followed the risk assessment framework, consisting of the following steps: (1) identification of hazards (i.e., events leading to undesirable consequences), (2) assessment and prediction of the likelihood and severity of the harms (frequency/exposure analysis and harm/effect analysis), and (3) characterisation of risk (i.e., combined probability of the likelihood of hazard realisation and severity of harms). Our research program focused on step (1) and the beginning of step (2). In our context, hazards include (1) the escape of *P. vannamei* from farms to natural ecosystem; (2) the survival of escaped *P. vannamei*; and (3) the reproduction of escaped *P. vannamei*. We attempted to address two types of impacts, the spread of TSV and food competition. Senanan *et al.* (in press) provided detailed description of the framework and illustrated its use for the case of *P. vannamei* in Thailand.

We chose the Bangpakong River, one of the largest and most important estuary ecosystems in eastern Thailand, as a case study because (1) its watershed harbours the largest area of shrimp farming in eastern Thailand (8,900 hectares

of Chacheangsao province in 2004, DOF 1999-2004), (2) its estuarine conditions provide viable habitat for escaped *P. vannamei*, and (3) already installed stationary stow nets within the main channel are quite effective in capturing wild shrimp, enabling us to obtain escaped *P. vannamei* from the wild.

Our research program has generated the first set of quantitative data that feeds into preliminary risk analysis of the releases of *P. vannamei*. These data answered the following questions: how many *P. vannamei* have escaped? Can escapees survive in the natural environment? Can escapees establish a natural population? What is the extent of geographic spread of the alien pathogen, Taura Syndrome Virus (TSV)? Can *P. vannamei* potentially compete with native shrimp species?

How many *P. vannamei* have escaped?

Results from Manthachitra *et al.* (2008), Senanan *et al.* (2007) and Senanan *et al.* (in press) indicated that *P. vannamei* has escaped from farms to the Bangpakong River and the numbers of *P. vannamei* sampled in the river positively correlated with the location and area of shrimp ponds. Mantachitr *et al.* (2008) used remote sensing and a geographic information system (GIS) to estimate location and total area of shrimp ponds (active, inactive, and abandoned ponds) in the Bangpakong River watershed and found that most ponds were located within 5 km of the river. During 2005-2007, the authors' estimates of active pond area ranged from 88.72 km² in 2007 to 116.81 km² in 2005. The highest concentration of shrimp ponds were found in the middle section of the Bangpakong River, including three districts of Chachoengsao province (Bang Khla, Mueang Chachoengsao and Ban Pho). Survey of marine shrimp populations in the Bangpakong River during the same period (Senanan *et al.*, 2007, in press) confirmed the presence of *P. vannamei* in the river (Figure 1). Mean proportion of *P. vannamei* relative to all penaeid shrimp per net per year (all stations combined) ranged from 0.005 (June 2005) to 0.16 (January 2006), with the highest abundance detected in 2006. The presence of *P. vannamei* in the river may be a consequence of pond water releases during the intense farming activities of 2005. In addition, Barnette *et al.* (2008) and Senanan *et al.* (in press) detected high occurrence of TSV in sub-adult *P. vannamei* caught from the river. Their results might indicate the intentional release of diseased individuals into the river.

Our studies were not designed to address the issue of escapes of larval life stages from hatcheries, and the magnitude of this source remains unknown. However, hatcheries are highly concentrated in the Bangpakong watershed. The issue of larval escapes from hatcheries remains an important concern that will require additional research and monitoring.

Can escapees survive the natural environmental conditions?

Results from Panutrakul *et al.* (in press) and Chavanich *et al.* (2008) indicated that *P. vannamei* escapees can likely survive the environmental conditions of the Bangpakong River and its river mouth. Panutrakul *et al.* (in press) conducted toxicological experiments to evaluate the physiological limits of larvae and juvenile of *P. vannamei* and *P. monodon* to extreme salinity and pH changes. The authors found that

both species can tolerate a wide range of salinity and pH. For both life stages, *P. vannamei* could tolerate a wider range and more extreme changes of salinity and pH than *P. monodon* (Figure 2). The data suggested that both life stages of *P. vannamei* could adapt to estuarine conditions of the Bangpakong River where water quality, especially salinity, can fluctuate dramatically. During the dry season (December to May), the salinity in the Bangpakong River is within the tolerance limits of *P. vannamei*. Although the salinity in the river may approach zero at most sites during the wet season (June to November), *P. vannamei* would be able to migrate to the river mouth. Panutrakul *et al.* (in press) detected an increase in abundance and size over time of *P. vannamei* captured in the river and near the river mouth.

Chavanich *et al.* (2008) analysed stomach contents of wild-caught *P. vannamei* and local shrimp species. They found that *P. vannamei* consumed the same diet types in similar proportions as local shrimp species. The diet types included phytoplankton, appendages of crustaceans, remains of sea grass leaves, macrophytes, and small mollusc shells and unidentified detrital material (Figure 3). Stomach content analysis indicated that *P. vannamei* can utilise food resources available in the Bangpakong River and these resources were shared between *P. vannamei* and local shrimp species.

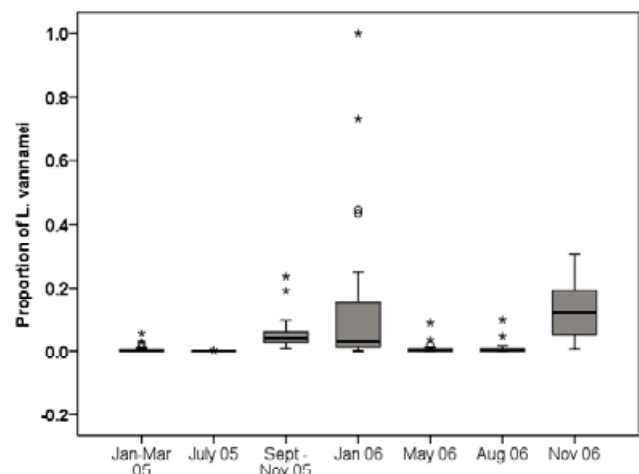


Figure 3. *P. vannamei* abundance relative to the total number of Penaeid shrimp species (proportion of *P. vannamei* per net) in the Bangpakong River during January 2005 – November 2006. * and O indicate extreme values and outliers, respectively. (Data reported in Senanan *et al.* (2007) and Panutrakul *et al.* (in press)).

Can escapees establish a natural population?

The maturity of *P. vannamei* escaped from farms to natural environments is another important factor determining their ability to establish a feral population. Senanan *et al.* (2008) compared the histology of gonads of wild-caught *P. vannamei* and captive *P. vannamei* of known ages. Captive individuals could develop mature gonads at 11 months after post larvae 15 (ovaries contained 50% mature oocytes; testes contained 80% mature sperm cells). They did not find sexually mature individuals in the wild although some wild-caught males larger than 19 g contained a small percentage of mature sperm cells. We still cannot conclude that escapees can establish a feral population. However, this study might have under-sampled sexually mature individuals due to inappropriate sampling sites and timing. This issue remains important for

further investigation. A monitoring program in off-shore areas may provide opportunities for us to obtain sexually mature individuals.

What is the extent of geographic spread of the alien pathogen, TSV?

Using PCR and immunological analyses, Barnette et al. (2008) examined the occurrence of TSV and two local viruses (WSSV and YHV) in populations of *P. monodon* adults in the Gulf of Thailand, populations of local shrimp species and *P. vannamei* in the Bangpakong River. The data suggested that TSV has already spread into the Bangpakong River and the Gulf of Thailand. The authors detected the presence of TSV in *P. monodon* adults, local shrimp species of the Bangpakong River (ten species, namely *Penaeus monodon*, *P. semisucatus*, *P. merguensis*, *Metapenaeus brevicornis*, *M. affinis*, *M. tenuipes*, *Parapenopsis hungerfordi*, *Macrobrachium rosenbergii*, and two other species belonging to the Family Caridae), and wild-caught *P. vannamei* (Figure 4). The authors also detected TSV in green mussel (*Perna viridis*), blue swimming crab (*Portunus pelagicus*) and Asian seabass (*Lates calcarifer*). TSV appeared to be more widespread in dry seasons compared to wet seasons. In addition, Barnette et al. (2008) showed that all three viruses can be horizontally transmitted among shrimp species (*P. vannamei*, *P. monodon* and *Macrobrachium rosenbergii*).

Can *P. vannamei* potentially compete with native shrimp species?

Chavanich et al. (2008) conducted food competition experiments pairing *P. vannamei* with one of two local shrimp species (*P. merguensis* and *Macrobrachium* sp.) or blue swimming crab (*Portunus pelagicus*) (see also in Panutrakul et al., in press). The authors concluded that *P. vannamei* could potentially compete for food with both local shrimp

species. In aquaria, *P. vannamei* often approached food items faster than the local species. Although this study may not represent a natural situation, as only two individuals were paired in each aquarium, the findings raise important issues about food competition and may serve as a starting point for further ecological studies that address crucial ecological interactions between an alien species and the receiving biotic communities.

Although our research has both retrospective and predictive elements of risk assessment as *P. vannamei* is already present in Thailand, the approach used and the data generated from our research can provide guidance for many countries that plan to introduce *P. vannamei* or other alien aquatic species for aquaculture. Furthermore, the data raise some important management issues for countries that have already introduced this species for aquaculture. Some recommendations based on these data include the following:

1. Implement preventative measures to reduce the numbers of escapes from shrimp farms and hatcheries. In addition, releasing pond water containing diseased shrimp should be prohibited.
2. Sanitise ponds containing diseased individuals before releasing pond water into natural systems. This strategy will reduce the input of both pathogens and escapees into natural ecosystems.
3. Strengthen the screening requirements for pathogens in broodstock. Tighter import regulations may also help reduce the spread of pathogens from aquaculture facility to natural ecosystems.
4. Discourage polyculture of *P. vannamei* with local shrimp species because pathogens can transfer among them. This may lead to enhanced virulence of TSV in local shrimp species.

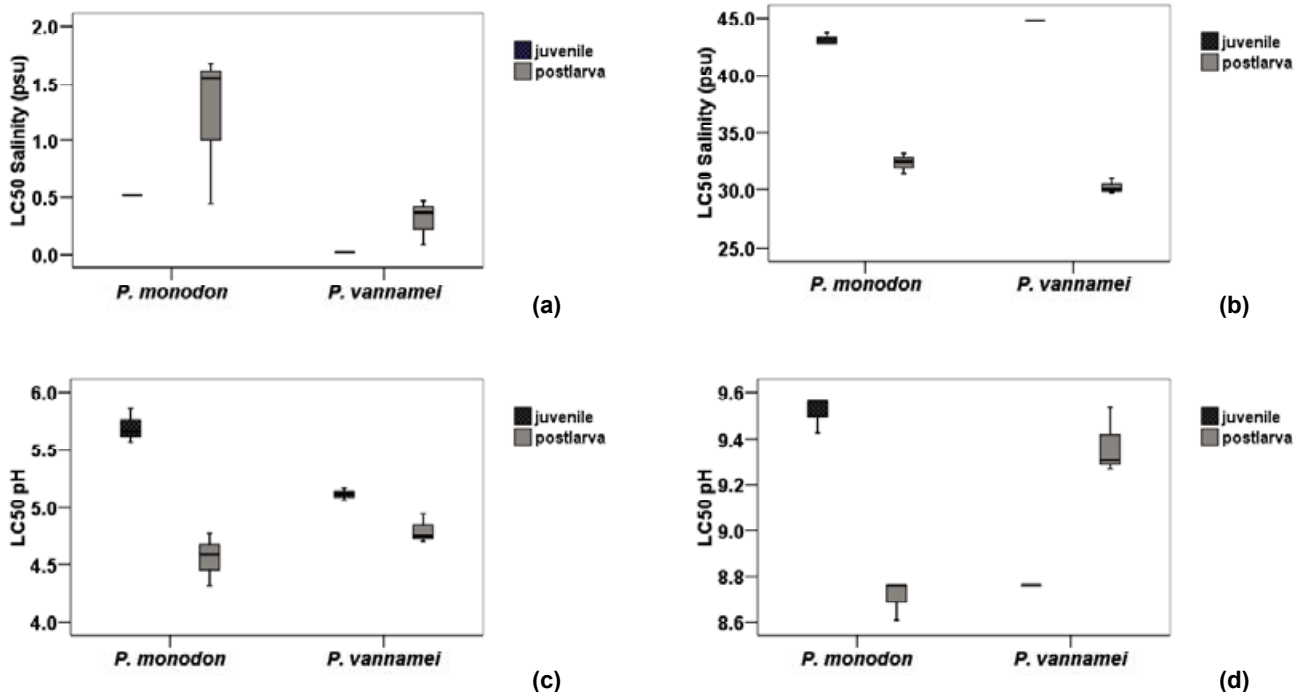


Figure 4. Boxplots of 96-hour LC50 of postlarvae and juveniles of *P. vannamei* and *P. monodon* at (a) low salinity (0-20‰), (b) high salinity (30-40‰), (c) low pH (4.5-6) and (d) high pH (8.6-9.6).



Figure 5. Diet types found in gut content of *P. vannamei* and local shrimp species of the Bangpakong River.

5. Establish a monitoring program for the presence of *P. vannamei* and TSV in the wild, especially the off-shore areas. Such a program will allow for the detection of the geographic spread of escapees and some of their impacts.
6. Communicate the risks associated with alien species to shrimp farmers, fishermen and other relevant parties to help prevent future escapes. These parties may also take part in a network to monitor realised impacts of *P. vannamei*.
7. Continue to support relevant research, including long-term monitoring of population establishment and realised impacts of *P. vannamei*, the development of risk decision-making tools, and the development of risk reduction/mitigation strategies.

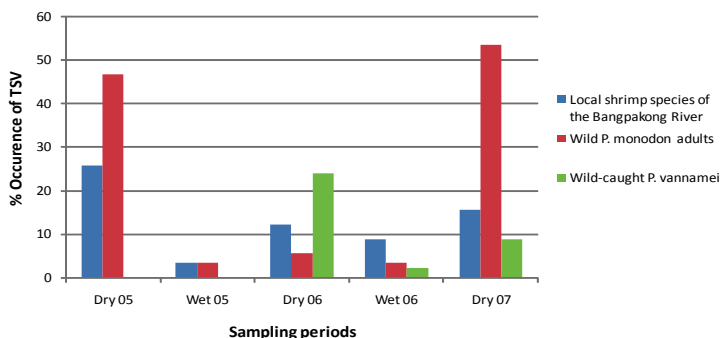


Figure 6. Percentage occurrence of Taura Syndrome Virus (TSV) in shrimp species local to the Bangpakong River, wild *P. monodon* adults and wild-caught *P. vannamei* during the dry and wet seasons of 2005-2007.

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Endurance or opportunity: Recognition is the key to success; the story of a catfish farmer of the Mekong Delta

From a humble beginning to the top of the league of the catfish farming sector

It was one of the most intriguing encounters when the extremely shy, self-made catfish farmer Trang Hung, the President of the HungCa Co Ltd. from Dong Thap province in the Mekong Delta, agreed to enlighten us with his most incredible life story which over a 35 year period has made him one of the major players in the catfish farming sector in the Mekong Delta.

Mr Hung is the fourth of six siblings of a fisher family of the Mekong Delta. He was educated up to the 5th grade when he decided to continue the traditional family livelihood of fishing. Around 1974 as an 18 year old he decided to catch catfish fingerlings in the flood period plains, and rear them in a wooden cage of 6 x 12 m with stainless copper mesh on the sides. He continued to feed the stock with a mixture of rice bran, morning glory and broken rice, depending on availability and affordability at the time, when the fish reached about 1.2 kg in 11 months. He sold the produce at local markets in VinLong, CanTho and other nearby places. Through this practice, over the subsequent years his production annual production increased to about 15 t.

Mr Hung was inquisitive and was always on the look out to improve his farming practice. He began to notice that if the cage bottom touched the soil, the stock grew better and was less prone to disease, and the flesh was also white. This simple observation made him believe that tra catfish would perform better in earthen ponds than in cages, and that was the beginning of pond farming of catfish in the Mekong Delta!

By 1984, within a decade, Mr. Hung had expanded his practice to 2 ponds (10 x 10m) and 3 cages, and a production of 20 tonnes per year. By 1990 he had 10 cages and 3 ponds, each of 1 ha, obtained through a lease from the government - areas not suitable for rice cultivation - and achieved a production of 150 tonnes per year. Up to this stage Mr Hung would procure wild caught fingerlings from the wild in Cambodian waters, himself using his fishing skills, and his farmed produce was sold for around 3,200 to 3,400 VND/ kg (\$US 0.31 – 0.32), fetching approximately 4,000 VND/ kg (US\$ 0.38) in Ho Chi Min City.

During the period 1991-95 he improved the practice to obtain three crops per 24 months, and a production to 5,000 tonnes per year, and proceeded on to improve further and further when by 2000 he was able to produce 10,000 tonnes in 5 ponds and 10 cages. In 1993, as the catfish exports began to occur Mr Hung commenced selling his produce to processing plants. Mr. Hung began to further expand his farming activity and by 2005-06 he was able to produce nearly 60,000 tonnes per year, with a concurrent expansion of culture pond area to 200 ha, through land leases, and thus became one of the most important players in the catfish farming sector in the Mekong Delta.

Mr. Hung's endeavours did not stop at achieving this incredible level of production of 60,000 tonnes per year. He decided to venture into the processing sector, where he established a processing plant, which currently is



Mr Hung in a happy mood revealing his life story

capable of handling 100 tonnes of raw material per day. The plant employs 1,900 people of which 90% are women, empowering rural households and communities. Mr Hung plans to have a second processing plant functioning by February 2010, and he continues to forge ahead.

The simple lesson learnt is that human endeavour, an open mind, hard work, determination and the ability to recognize emerging opportunities enables one to reach great heights, bringing reward to the individual, but even more importantly bringing wealth and prosperity to the community - empowering the poor and the needy. Mr. Hung's personal wealth is secondary to the wealth, empowerment and happiness he has brought to the community!!!

Based on the translation of an interview with Mr Hung October 2009 in Dong Thap, Vietnam.

Asian fish health experts visit Australia

Olsen, L. and Ingram, B. (Fisheries Victoria)

Fisheries Victoria, a Division of the Victorian Department of Primary Industries in Australia, recently hosted two fish health scientists from Asia for a two week visit. The visit was an initiative of the Victorian government as part of its Aquaculture Futures Initiative (AFI) and Visiting Fellows Program to build fish health and biosecurity capability within the state and to enhance international engagement and collaboration. It was a great honour to host the two fish health experts from the Network of Aquaculture Centres in the Asia-Pacific (NACA), Dr. C.V. Mohan, now the Manager of Research and Development for NACA (previously the Regional Animal Health Expert), and Dr. Suppalak Lewis on secondment to NACA from the Thai Department of Fisheries.

The two week visit was conducted in February 2009 and the visitors were able to see Murray cod (*Maccullochella peelii*) farming in both recirculating aquaculture systems (RAS) and open-water production systems utilising existing irrigation reservoirs for cage culture in the state's north-west, hatchery and raceway growout operations of trout in the cooler mountainous region of Victoria; the state mussel hatchery at Queenscliff, and an

abalone farm in the south of the state. They also visited the Australian Animal Health Laboratory (AAHL) at Geelong, run by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Murray cod

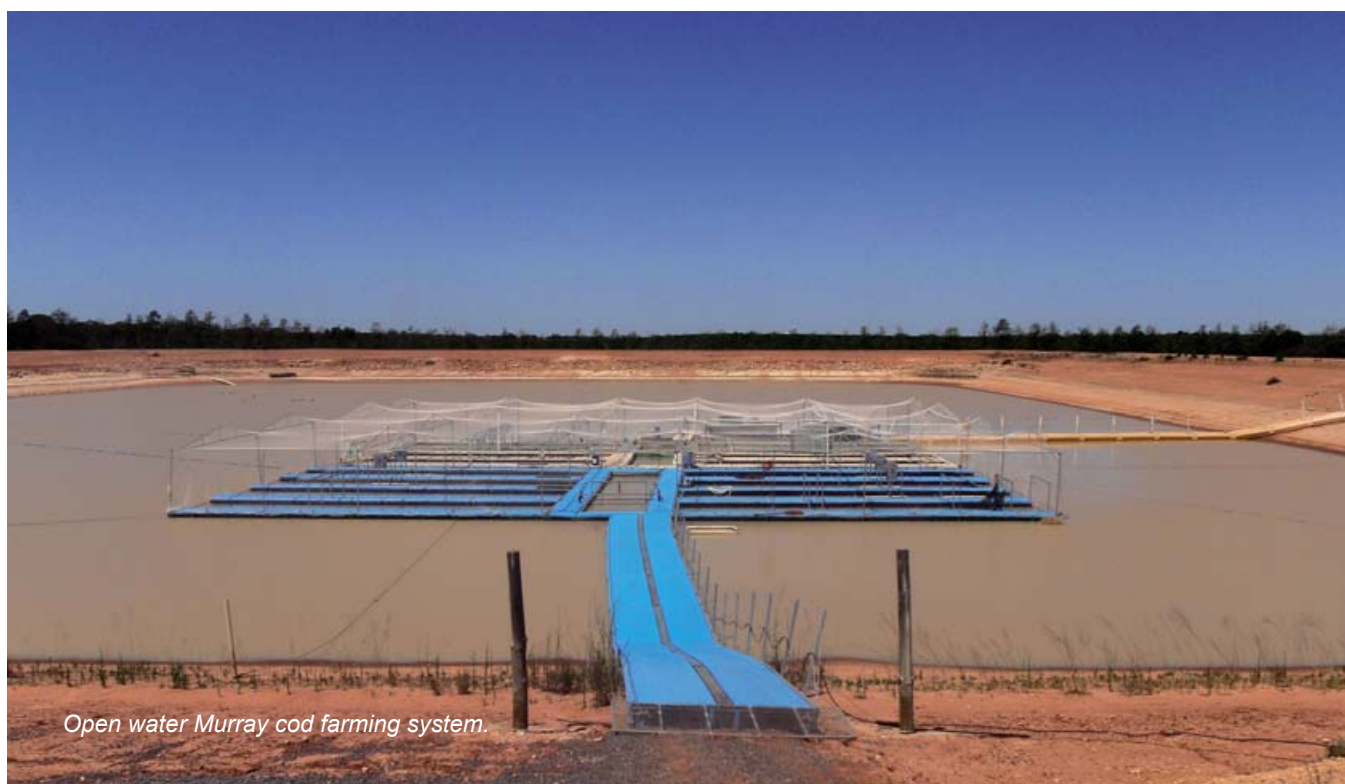
The Murray cod farming industry in Victoria produced 18 tonnes in 2006/07 valued at over \$300,000². The emphasis of the visit was on the open-water production of Murray cod in large horticultural irrigation reservoirs. This system uses the irrigation water as the base for farming the Australian native fish in floating net pens. The farmers growing the fish are primarily horticulturists looking to diversify their operations. As this industry is in its early days of development, there is still a need to work out the carrying capacity and water management regime for the fish farming operations. This is a major focus of the current research being done by Fisheries Victoria on behalf of the emerging open-water Murray cod farming industry. Other issues such as system design, feed and chemical management and health and biosecurity protocols are also being addressed in the current research.



Dr Mohan and Dr Lewis demonstrating fish health examinations to Murray cod farmers in Victoria.



*Open water farmed Murray cod (*Maccullochella peelii*).*



Open water Murray cod farming system.

Salmonids

The salmonid farming industry in Victoria is the largest and most developed aquaculture industry in the state with production of 1,361 tonnes in 2006/07 valued at \$7 million². Dr Mohan and Dr Lewis noted the challenges of climate change for the industry. Drought over the past 5 years coupled with increasing temperatures mean the Victorian salmonid industry will have increasing incidences of temperature related stress and disease issues.

Mussels

The mussel farming industry of Victoria, valued at \$2.3 million in 2006/07 with production of 824 tonnes², is situated in Port Phillip Bay and Western Port. To support the growing industry, the Victorian government, together with the mussel farming industry, has constructed a shellfish hatchery to aid the industry development. The industry has been challenged in the recent years due to the variability and unreliability of the wild spat fall of mussels in Port Phillip Bay. The new shellfish hatchery is considered to be a very important part of the mussel industry's development and longevity.

Abalone

The Victorian abalone industry is beginning to get back on its feet after a devastating virus decimated a large portion of the industry. The virus, abalone ganglioneuritis, is a herpes-like virus that is suspected of entering the farms from wild stock. The 2006/07 farmed abalone production was 121 tonnes with a farm gate value of \$4.3 million². The visitors were able to tour the largest abalone farm in the state (unaffected by the virus) and take note of the outstanding biosecurity program in place. Not having been on an abalone farm before, both the visitors were most impressed.

Seminars and workshops

Two seminars were held during the visit in which Dr. Mohan and Dr. Lewis gave presentations on fish health perspectives from Asia. The first one was a "Fish health and biosecurity seminar" in the Melbourne area. This was presented to an audience of national, state and interstate government representatives, local farmers and Victorian aquaculture industry consultants. Dr Mohan



Newly settled mussel spat on a culture rope produced in the new shellfish hatchery at Queenscliff, Victoria.

gave a presentation on NACA and aquatic animal disease management in the Asia-Pacific. Dr Lewis gave a presentation on diseases encountered in SE Asian aquaculture as well as an outline of how the fish health system works in Thailand.

Another workshop titled "Fish health and biosecurity workshop for Murray cod fish farmers" was held in the state's northwest. It was attended by most of the open-water Murray cod aquaculture industry. After the presentations on Murray cod farming, biosecurity, chemical use in aquaculture and disease and health management of aquaculture species in Asia, a hands-on workshop on fish health monitoring was held. Demonstrations on monitoring, dissections and sample preparations were done by Dr Mohan and Dr Lewis.

Several recommendations to Fisheries Victoria and the Victorian Aquaculture Industry were made by Dr Mohan and Dr Lewis. They were:

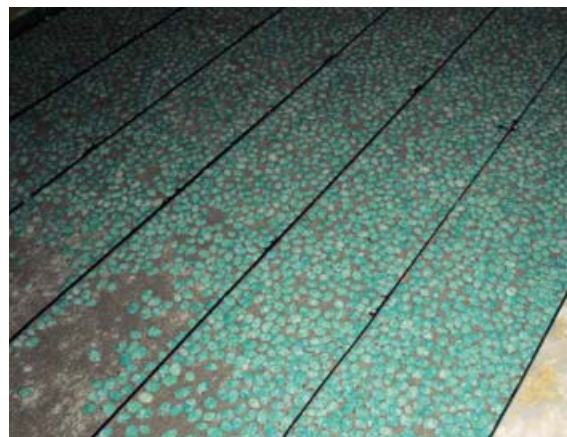
- Continued R&D for the open water Murray cod aquaculture system along with increased technological transfer to industry.
- A longitudinal population based epidemiological study to identify risk factors for poor production and disease issues.
- Development, implementation and validation of Better Management Practices (BMPs) for Murray cod farming.

- Further collaboration between NACA, Fisheries Victoria, Biosecurity Victoria, CSIRO and others in the area of fish health management.
- Improved networking between farmers and specialists.

Fisheries Victoria is in the process of implementing all of the recommendations made.

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Juvenile abalone at a Victorian abalone farm.

Black gill disease of cage-cultured ornate rock lobster *Panulirus ornatus* in central Vietnam caused by *Fusarium* species

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In Vietnam, cage-culture of ornate rock lobster *Panulirus ornatus* has been practiced for several decades in the central coastal region, especially in Phu Yen and Khanh Hoa provinces. In recent years the lobster industry has been contributing significantly to national commercial sector, yielding approximately US \$ 100 million annually^{15,17}. During 2003 – 2005, a research group from Research Institute for Aquaculture No. 3 investigated 272 lobster cages in Phu Yen, Khanh Hoa provinces and found that moribund and dying lobsters showed some gross clinical signs such as red body, blistered gills and black gills. Of these, black gills appeared to have caused mortality in 69.5% of cages out of the 272 cages studied. Mortalities were found mainly at the grow-out stages, thereby causing great losses for the industry¹⁶. Black gill disease was first reported in 1975 from American spiny lobster *Homarus americanus*¹¹. In general, black gill condition in shrimp caused by *Fusarium* species initially produces generalized “gill discoloration” which gradually develops to “blackened gill” condition and eventually leading to death of affected individuals⁶. Other situations such as exposure to nitrite, ascorbic acid deficiency and infection by infectious hypodermal and haematopoietic necrosis virus, *Flexibacter* or fungus *Haliphthorus* are also known to produce black gill conditions in lobsters³. Previously, the disease has never been reported in lobster cultured in Vietnam, although it was known to occur in black tiger shrimp *Penaeus monodon*⁹. This paper describes black gill disease of ornate rock lobster, morphology of the fungus isolated and the pathological aspects of infected animals.

Materials and methods

Isolation and identification

Ornate rock lobster *P. ornatus* (30 to 220 g in body weight) showing gill discoloration from pale brown to black and/or wounded were collected from cages for examination. Small pieces of the gills were removed from these animals for observation under a light microscope.

Small pieces of the gill from a total of 97 diseased lobsters were washed in sterile sea water and each sample was inoculated onto a potatoes dextrose agar (PDA) petri disc with 2% NaCl and 1 g/L Streptomycin sulfate and 1 g/L ampicillin to avoiding bacterial contamination. To obtain a pure culture, a single spore culture was made 4 days after incubation at 30°C. The fungal isolate was inoculated onto PDA and incubated at 30°C for 4-10 days in the dark. Thirty conidia were selected randomly from the isolate and their sizes were measured to be calculated for the average size with standard deviations (SD). The fungus was identified according to Nelson *et al.*, 1983¹⁴.



Figure 1: Ornate rock lobster *Panulirus ornatus* with black gill disease collected from a farm of Khanh Hoa province, Vietnam in 2004.

Pathogenicity challenge

One strain NHT 01 recovered from a diseased lobster cultured at a farm in Van Ninh district, Khanh Hoa province in 2004 was selected from the isolates for an artificial experiment. Ten day old colonies of the fungal strain NTH 01 were used to harvest conidial suspension by adding 10 mL sterile seawater into each culture plate, and collecting the suspension. The fungal conidial suspension was calculated using haemocytometer, and adjusted to three concentrations of 8×10^3 , 8×10^4 and 8×10^5 conidia/mL.

Healthy lobsters with average weight of 40.2 ± 3.3 g/ were collected and kept in 180 L running seawater tanks for 7 days. Each tank contained 8 lobsters. Seawater was treated with 30 ppm chlorine and maintained at 28°C and pH 8.2. Five experimental tanks were set up for the purpose of experimental infection. Lobsters were injected intramuscularly at the second segment with 0.1 mL of conidial suspension. The control group was injected with 0.1 mL seawater into each lobster. Another group was kept in the same condition but without any injection. Tanks were aerated during the course of experiment. Moribund and fresh dead animals were sampled for observation and re-isolation of fungal elements. Mortality and abnormal behaviours of the experiment lobsters were also recorded.



Figure 2: Fungal hyphae and conidia of an ornate rock lobster naturally infected *Fusarium solani* (cotton blue stain).

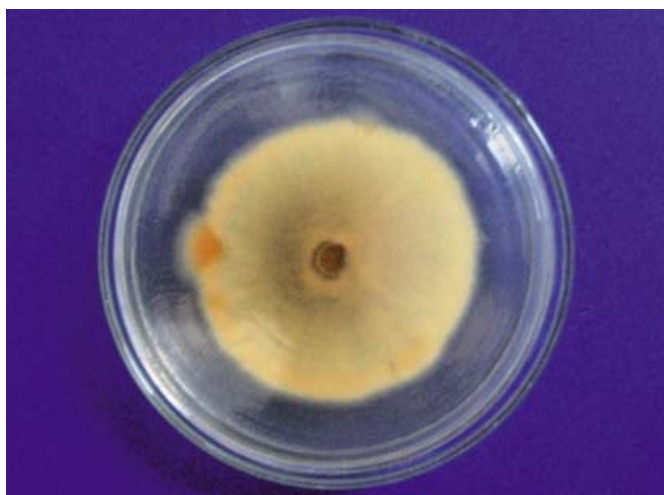


Figure 3: Surface of a 7 d-colony of *Fusarium solani* NHT 01 on PDA at 30°C in the dark.



Figure 4: Conidia of *Fusarium solani* NHT 01 on PDA at 30°C in the dark showing 1-4 septates (cotton blue stain).

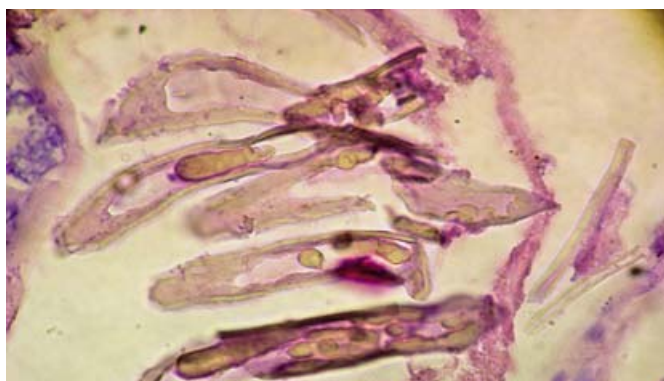


Figure 5: Fungal elements in the degenerative gills (H&E stain) of an artificially infected ornate rock lobster.

Histopathology

Gill samples from all of the 97 diseased lobsters with black gills were collected carefully and fixed in the Davidson solution for 12-36 h, then restored in 70% ethanol. Sampled tissues were embedded with paraffin, sectioned at 5 μm , and stained with haematoxylin and eosin. Slides were observed under a light microscope (OLYMPUS CX31).

Results

Incidences

Based on field observation, lobsters with black gills became weak, lethargic, pale, had difficulty in respiration and were usually observed swimming near the water surface. In some cases, fouling by *Balanus* sp. and juvenile *Pteria* sp. were also observed on the shell. Gills became red brown to black. The lesions appeared to eventually destroy the gill filaments in the advanced stage of infection and spread out off the gills. Black spots due to formation of melanotic pigment were always observed in the gills of the infected lobsters (figure 1). Wet mounts of gill lesions showed the presence of invasive fungal mycelia and conidia (figure 2) in all diseased animals.

Septate mycelia of NTH 01 extending from the gill filaments and their conidia were clearly observed under a microscope. Ninety seven fungal isolates were recovered from total 97 infected lobsters (100%) with black gills.

Fungal isolation and identification

All the fungal strains recovered from the 97 diseased lobsters had similar character of conidial shapes and colony. Therefore, a strain NTH 01 was selected for further morphological observation in order to identify into species. The microscopic characteristics of the strain NTH 01 was described as follows:

Colonies on PDA at 30°C were white to olive yellow or pale yellow to brownish yellow in aged cultures, 73.1 \pm 0.8 mm after 7 days of inoculation (figure 3). Hyphae were septate and hyaline, 2.42 \pm 0.41 μm in diameter. Conidiophores were elongated and monophialides forming microconidia in the aerial surface. Conidiophores were simple (non-branched) or branched monophialides. Microconidia were abundant, oval or ellipsoid, usually with one-cell, (11.6 \pm 2.07 μm) x (3.8 \pm 0.8 μm). Macroconidia were produced after 7 days of inoculation, usually abundant, subcylindric or slightly curved, 2 – 4 septates, predominantly 3-septate (24.7 \pm 1.9) μm x (5.0 \pm 0.6) μm (figure 4). Chlamydoconidia were formed on terminally lateral branches or intercalary and occasionally in chains or in pair. The fungus was identified as *Fusarium solani*.

Pathogenicity challenge

Ornate rock lobsters artificially infected with NTH 01 showed similar clinical signs to naturally infected animals. Cumulative mortality after 14 days were 57.1%, 72.4% and 77.1% in the 3 groups inoculated with conidial concentrations of 8×10^3 , 8×10^4 and 8×10^5 conidia/mL, respectively. Control groups remained healthy, showed no mortality and no fungal elements in the gills during the course of experiment. Re-isolated fungus was morphologically similar to NTH 01.

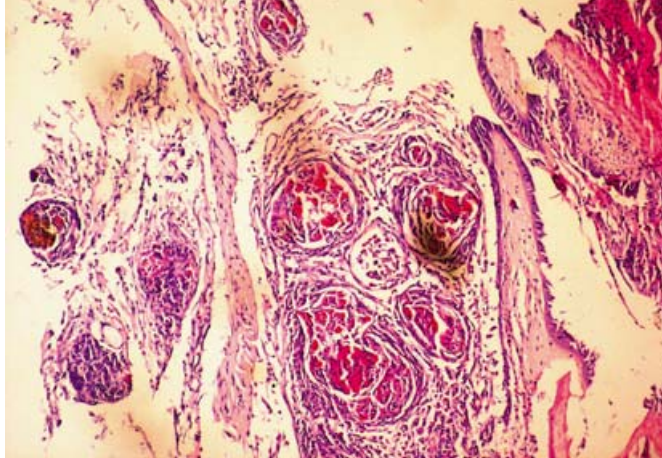


Figure 6: Fungal hyphae encapsulated by multiple layers of fusiform haematocytes (H&E stain) in the gill tissue of an artificially infected lobster.

Histological changes

Gill lesions of the artificial infected lobsters showed fungal mycelia inside the cuticle. Fungal elements in the degenerative gills were observed as threads in haematoxylin and eosin stained sections (Figure 5). Cross sections of the gill lesions showed that the fungal hyphae were encapsulated with multiple layers of fusiform haematocytes (figure 6).

Discussion

This study reported a first case of *F. solani* causing black gill disease in cage-cultured *Panulirus ornatus* in Vietnam. Attempts have made to recover 97 fungal strains from 97 ornate rock lobsters cultured in cages with black gill condition. The fungus was identified as *Fusarium solani* which is similar to a fungus reported from American lobster *Homarus americanus*.¹¹ *F. solani* is frequently isolated from American lobsters *Homarus americanus*¹¹, shrimp such as *Penaeus japonicus*² and *P. californiensis*⁵, and sharks^{1,12}. In Vietnam, several researchers have reported *Fusarium sp.* from *Panulirus sp.*⁴ and shrimp⁷, however, species identification had never been described until a study on black gill disease of *P. monodon* was made during 2001-2005⁶. Of which *F. incarnatum* was reported as a causative agent⁹.

Pathogenesis and pathogenicity of *Fusarium* species to crustaceans have been known amongst fish pathologists for some time. In this study, *Fusarium solani* NTH 01 also showed high pathogenicity to healthy lobsters indicating that this is an important pathogen.

In addition, milky haemolymph syndrome was also known as the most problematic for spiny lobsters *Panulirus sp.* cultured in Vietnam with possible causative agent by Rickettsia-like bacteria¹⁰. Poor quality of water environment is usually accompanied with high mortality¹³.

Finally, although lobsters are generally well equipped for the natural environment¹⁸, unfavourable conditions such as polluted water, high density and overfeeding may lead to some disease problems. Good farm practices and better planning are highly recommended for successful lobster aquaculture.

Acknowledgements

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Marine Finfish Aquaculture Network

Effects of the partial substitution fish oil by soybean oil in the diets on muscle fatty acid composition of juvenile cobia (*Rachycentron canadum*)

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The cobia (*Rachycentron canadum*) is a carnivorous fish. It can grow with good feed conversion efficiency in offshore net cage systems from fingerling to marketable size (4 – 6 kg) in 1 year. Cobia are provided with high-energy feeds. At present, commercial feeds for cobia contain lipid levels around 15 – 24%^{1,2}.

Aquaculture feeds depend heavily on animal ingredients³ and fish oil is the main lipid source used in such feeds, especially in those formulated for carnivorous species. The demand for marine fish oil (MFO) in aquafeeds is continually increasing and may exceed 75% of the global supply by the year 2010⁴. In order to maintain the rapid growth of the global aquaculture industry, it has been becoming increasingly crucial for the aquaculture feed industry to evaluate alternatives to fish oils for coming decades⁵.

Soybean oil is the world's largest source of vegetable oil and contains higher levels of poly-unsaturated fatty acids than others, such as rapeseed oil or palm oil, but lacks eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), with linoleic acid (18: 2n-6) dominating at approximately 51–64% (NRC, 1993). A number of studies has shown that soybean oil can partially replace fish oils^{6,7}, without reducing growth and feed efficiency. However soybean oil

does not cover the essential fatty acid requirements of many marine fishes. It changes the final balance of dietary fatty acids in the feed and changes the fatty acid composition of fillet⁸, thereby reducing flesh quality⁷.

The objective of this study was to determine the effects of substituting soybean oil for fish oil in diets on muscle fatty acid composition of juvenile cobia.

Materials and methods

Six isonitrogenous experimental diets (45 % crude protein; 20 % lipid) were formulated to produce diets in which 0% (D0), 20% (D20), 40% (D40), 60% (D60), 80% (D80) and 100% (D100) of fish oil was replaced by soybean oil. All the dry ingredients were mixed until homogenous in a mixer, and then water and lipid were added and mixed. 2.0 mm and 3.0 mm diameter pellets were wet- extruded for cobia different growth stage, air-dried to about 100 g kg⁻¹ moisture and sealed in vacuum-packed bags and frozen stored (-20°C) until feeding. Samples of all diets were subjected to proximate composition and fatty acids analysis; the results are presented in Tables 1 and 2.

Table 1: Experiment diets composition (g kg⁻¹ diet)

Ingredients	Diets					
	D0	D20	D40	D60	D80	D100
Fish meal ^a	450	450	450	450	450	450
Shrimp head meal	260	260	260	260	260	260
Wheat meal	30	30	30	30	30	30
Gluten	120	120	120	120	120	120
Fish oil ^b	100	80	60	40	20	0
Soybean oil ^c	0	20	40	60	80	100
Vitamin C	10	10	10	10	10	10
Vitamin Premix	20	20	20	20	20	20
Mineral	10	10	10	10	10	10
Proximate composition						
Crude protein	45.89	45.06	44.81	45.70	44.55	42.75
Lipid	20.28	20.12	20.25	20.14	20.67	19.95
Ash	6.16	4.75	5.01	5.34	5.16	4.94
Moisture	9.54	9.72	10.81	10.65	11.92	11.40

a: Vietnam fish meal: Crude protein = 600 g kg⁻¹, b: Vietnam fish oil; c: Soybean oil from Tuong An company (Vietnam).

Table 2: Main fatty acid composition of diets (% total fatty acids)

Fatty acid	Diets					
	D0	D20	D40	D60	D80	D100
18:2n-6	0.66	1.60	2.29	3.40	3.39	6.29
18:3n-3	0.14	0.06	0.06	0.07	0.07	0.11
20:4n-3	0.05	0.05	0.00	0.05	0.04	0.05
20:5n-3	0.56	0.49	0.36	0.35	0.32	0.24
22:6n-3	1.85	1.64	1.21	1.19	1.10	0.86
∑SFA	8.72	8.30	7.66	8.11	7.72	8.70
∑MUFA	1.79	1.52	1.31	1.39	1.28	1.44
∑n-3	2.89	2.50	1.81	1.84	1.69	1.40
∑n-6	0.71	1.64	2.29	3.44	3.43	6.33
n-3/n-6	4.07	1.52	0.79	0.53	0.49	0.22
∑HUFA	2.47	2.19	1.57	1.59	1.46	1.16
EPA/DHA	0.30	0.30	0.30	0.30	0.29	0.28

Fish rearing

Juvenile cobia (*Rachycentron canadum*) was obtained from a farm in Nha Trang (Khanh Hoa, Vietnam). Fish were acclimated and fed with a commercial diet (45 % crude protein, 20 % lipid) for 2 weeks before starting of the trial, and then fish (initial mean weight 12.69 g) were randomly distributed to each of 18 tanks with 15 fish per tank. Fish were fed to satiation in 30 min, twice daily at 08:00 h and 16:00 h. The feeding trial lasted for 8 weeks. Temperature and salinity in tanks were monitored daily, while pH and ammonia and oxygen were monitored once per three days. Animals were kept under natural photoperiod conditions. During the experimental period, temperature was 28 - 32°C, salinity was 26 – 30 ‰, pH: 7.8 - 8.5, ammonia was lower than 1 mg L⁻¹ and dissolved oxygen was not less than 4.5 mg L⁻¹.

Sample collection and analysis methods

At the end of the 8-week feeding trial, fish in each tank were individually weighed and sampled for muscle analysis 24 hours after the last feeding. Three fish from each tank were randomly sampled and frozen at -30°C for muscle fatty acid analysis.

Fatty acid composition was determined in diets and muscle of fish. Lipid extraction was according to Folch et al., 1957 and fatty acids were transformed to methyl esters. Fatty acids were separated by gas chromatography (GC 6890A, Agilent, USA) using equipped with a FID detector, and using a HP-FFAP (0.25 mm x 25 m) capillary column with nitrogen as the carrier gas. The injector and detector temperatures were both kept at 250°C. The column temperature was programmed initially at 120°C for 1 min, 12°C/min to 150°C, 10°C/min to 180°C, 0.5°C/min to 184°C, 4°C/min to 190°C and to a final temperature of 210°C. Fatty acid methyl esters were identified by comparison to external standards (SIGMA).

Results were expressed as mean ± standard of deviation (SD) and group mean difference were compared using one – way ANOVA. When there were differences, the group means were further compared with Duncan's multiple range test. All computations were performed with SPSS 12.0. A significant level of P < 0.05 was employed at all cases.

Results

All feeds were readily accepted, fish survival rates over 93 % were recorded in all treatments. The muscle fatty acid composition clearly reflected that of the dietary lipids. Table 3 shows the muscle fatty acid profiles. There were no significant differences on SFA in muscle of cobia. Levels of n-3 HUFA in muscle were reduced significantly from 3.41 % to 1.73 % and levels of MUFA increased significantly from 3.77 % to 10.19 % while replacement of fish oil by soybean oil increased from 0 % to 100 %. The EPA/DHA was not significantly affected by replacing levels.

Discussion

Inclusion of vegetable oils in fish diet modifies the body fatty acid profiles, and this effect that is more evident in marine fish species because of their limited ability to convert 18C fatty acid to longer polyunsaturated fatty acid⁹. In this present study, there was a notable increase in muscle levels of both 18:2n-6 and 18:3n-3 as the soybean oil in the diets was increased. Similar results have been reported for other species such as seabream *Sparus aurata*^{7,10} sharpsnout seabream *Diplodus puntazzo*¹¹. These authors also reported a strong dependence of muscle fatty acid composition on the experiment diet that fish has received. In addition, replacement of dietary fish oil by soybean oil had resulted in lower levels of n-3 PUFA especially EPA and DHA in fish muscle. Fish oil replacement by soybean oil in diet reduced n-3 PUFA fatty acids and increased the n-6 PUFA fatty acids in cobia muscle. Content of essential fatty acids such as EPA, DHA in diets reduced the as the soybean oil in the diets was increased and influential right up to the concentration of EPA, DHA in the muscle of the fish. This suggests that these are fatty acids necessary for cobia, a similar composition to that obtained on several marine fish species such as seabream^{7,8,10}, humpback grouper *Cromileptes altivelis*¹³. n-3/n-6 ratio in the muscle of the fish is strongly affected by n-3/n-6 ratio in feeds. According to Sargent *et al.*¹⁴, n-3 and n-6 series fatty acids play a role as substrates for some enzymes related to lipid metabolism in the body of fish, so the balance of the n-3/n-6 is very important for the growth of fish. In present experiments, the n-3/n-6 ratio in the fish muscle decreased rapidly from 11.43 to 1.80, while this ratio in the feed decreased from 4.07 to 0.22. This may be the cause of changes in the biochemical composition of the fish muscle. Saturated fatty acids are a major muscle component, which may be the reason why they increased in fish muscle. These

Table 3: Fatty acid composition of muscle from cobia fed different diets (% total fatty acids)

Fatty acid	Diets					
	D0	D20	D40	D60	D80	D100
14:0	0.67 ^c	0.57 ^b	0.55 ^b	0.52 ^b	0.43 ^a	0.37 ^a
16:0	4.59	4.31	4.44	4.69	4.41	4.51
18:0	6.62 ^a	6.63 ^a	7.03 ^{ab}	7.71 ^{bc}	7.69 ^{bc}	8.38 ^c
20:0	0.57 ^b	0.52 ^{ab}	0.47 ^a	0.54 ^{ab}	0.48 ^{ab}	0.45 ^a
22:0	0.17 ^c	0.17 ^{bc}	0.14 ^{ab}	0.16 ^{bc}	0.13 ^a	0.13 ^a
24:0	0.26 ^e	0.23 ^d	0.22 ^{cd}	0.20 ^c	0.16 ^b	0.13 ^a
14:1n-5	0.18 ^c	0.16 ^b	0.15 ^b	0.15 ^b	0.13 ^a	0.12 ^a
16:1n-7	1.68 ^c	1.46 ^b	1.41 ^b	1.34 ^b	1.14 ^a	1.01 ^a
18:1n-9	1.55 ^a	2.92 ^b	3.98 ^b	5.65 ^c	6.90 ^d	8.90 ^e
24:1n-9	0.37 ^e	0.32 ^d	0.30 ^{cd}	0.26 ^c	0.21 ^b	0.16 ^a
18:2n-6	0.27 ^a	0.42 ^b	0.55 ^b	0.74 ^c	0.86 ^c	1.08 ^d
18:3n-3	0.08 ^a	0.09 ^{ab}	0.11 ^{bc}	0.12 ^c	0.13 ^c	0.15 ^d
20:2n-6	0.07	0.07	0.07	0.08	0.08	0.08
20:3n-3	0.33 ^{bc}	0.30 ^{abc}	0.37 ^c	0.28 ^{abc}	0.24 ^{ab}	0.20 ^a
20:4n-3	0.08	0.07	0.07	0.06	0.06	0.05
20:5n-3	0.75 ^d	0.64 ^c	0.59 ^c	0.57 ^c	0.46 ^b	0.38 ^a
22:6n-3	2.58 ^e	2.25 ^d	2.11 ^{cd}	1.93 ^c	1.61 ^b	1.30 ^a
SFA	12.89	12.43	12.85	13.81	13.30	13.95
MUFA	3.77 ^a	4.86 ^{ab}	5.84 ^{bc}	7.41 ^{cd}	8.32 ^{de}	10.19 ^e
n-3	3.77 ^d	3.35 ^c	3.24 ^c	2.97 ^c	2.50 ^b	2.08 ^a
n-6	0.34 ^a	0.50 ^b	0.61 ^b	0.82 ^c	0.94 ^c	1.17 ^d
HUFA	3.41 ^e	2.96 ^d	2.76 ^{cd}	2.56 ^c	2.13 ^b	1.73 ^a
n-3/n-6	11.43 ^e	6.95 ^d	5.28 ^c	3.78 ^b	2.72 ^{ab}	1.80 ^a
EPA/DHA	0.29	0.29	0.28	0.30	0.29	0.29

Data in the same row with different superscripts differ at $P < 0.05$

fatty acids is well presented in both the diets and the muscle, it would appear that the muscle can make good use of it, mainly as an energy source.

This study shows that soybean oil replacement modified the fish muscle fatty acid profile, reducing the levels of EPA, DHA and increasing the levels of LA, LNA. It would be interesting to analyse the effects of replacement fish oil by soybean oil in cobia diets for longer period of time.

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Growth response of cobia *Rachycentron canadum* (Pisces: Rachycentridae) under the hypersaline conditions of the Emirate of Abu Dhabi

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Cobia (*Rachycentron canadum*) are a migratory pelagic species and are present in the Arabian Gulf, Red Sea, South Africa to the southern Japan, all tropical and subtropical oceans and seasonally in temperate waters^{1,2,3,4}. Cobia are reported to withstand a wide range of water temperatures and salinities¹. In the United Arab Emirates (UAE) cobia, known locally as sikel, is a common fish in the local markets and usually attains high prices. UAE is listed as one of the top five producers of wild caught cobia in the world⁵. Due to their high growth rates and adaptability to different culture facilities and conditions, cobia aquaculture operations are expanding throughout the world^{4,6,7,8,9}. The global aquaculture production of cobia has increased from 3 tons in 1995 to 25,373 tons in 2006¹⁰.

Salinity tolerance of cobia is another interesting characteristic. In nature the fish is found at salinities ranging from 8 to 44 ppt. Under culture conditions, the juvenile fish were reported to adapt well when taken from waters of 22 to 44 ppt salinity to water as low as 5 ppt with good FCRs and growth rates^{5,10}.

Encouraged by the worldwide successful practices of cobia, it was decided to consider adopting this species for aquaculture at the Aquaculture Center, Abu Al Abyad Island (ACAAB), Emirate of Abu Dhabi, UAE. Accordingly, in June 2005 juvenile cobia, averaging 2.28 g body weight and 8.92 cm body length, were introduced from Taiwan and grown at ACAAB.

Abu Al Abyad Island, where the Center is located, is the major island of Abu Dhabi Emirate and it is known for its harsh environmental conditions where water temperature and salinity during summer time reach as high as 36°C and 58 ppt, respectively¹¹. The results of rearing this species under the hypersaline conditions of Abu Al Abyad Island (50-55 ppt) are presented in this article.



A one-year cobia.

Acclimation of the fish

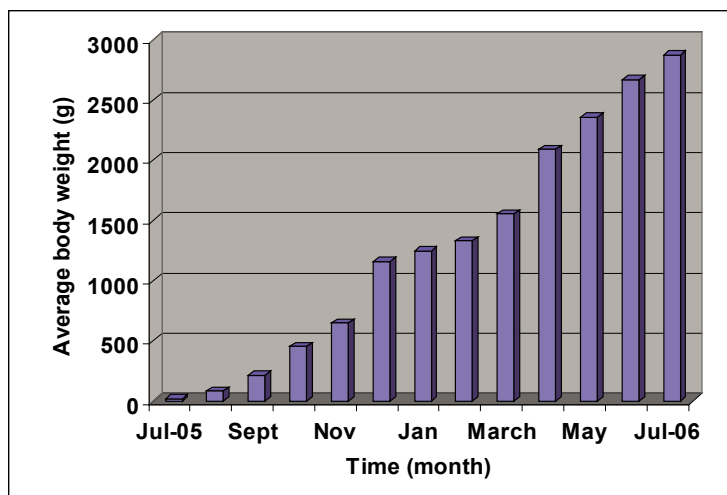
Upon arrival at the ACAAB, the fish were placed in a 30-t rectangular concrete indoor tank with water salinity of 24 ppt similar to that of the origin. Fish feeding started 24 hours post-arrival and were fed to satiation with 2 mm marine fish feed (45% protein and 10% lipid), three times/day. After two weeks of rearing the fish under 24 ppt, the water salinity was gradually increased by 2 ppt/day until the fish were completely acclimatized to the natural seawater salinity of Abu Al Abyad Island (55 ppt) over a period of 15 days. During this acclimation period, the fish mortality mounted to 7%.

Grow-out

Following the acclimation period, 87 % of fish were tagged and released into the sea with the purpose of replenishing the wild habitat around the Island. The remaining cobia fingerlings averaging 19.68 ± 0.89 g body weight and 16.43 ± 1.12 cm body length were transferred for grow-out to four 5 x 5 x 2.5 m³ (55 m³ water volume) floating net cages placed near the shore of an artificially dredged channel. All cages were shaded from direct sun light with green shading materials. The fish were stocked at a rate of 4 fish / m³. Floating pellet feed (54% crude protein, 10% crude fat) were used during the grow-out period at a feeding rate 0.5 – 1% BW. Fish were fed twice a day, 6 days a week. At monthly intervals 25 fish from each cage net were individually weighed and measured and the daily feed allowance was adjusted accordingly.

Within a growth period of 12 months the average body weight attained was 2.87 kg, ranging in size from 1.78 to 3.86 kg. The feed conversion ratio attained was about 2.0. No diseases issues were observed during the grow-out period and the average survival rate was 80%.

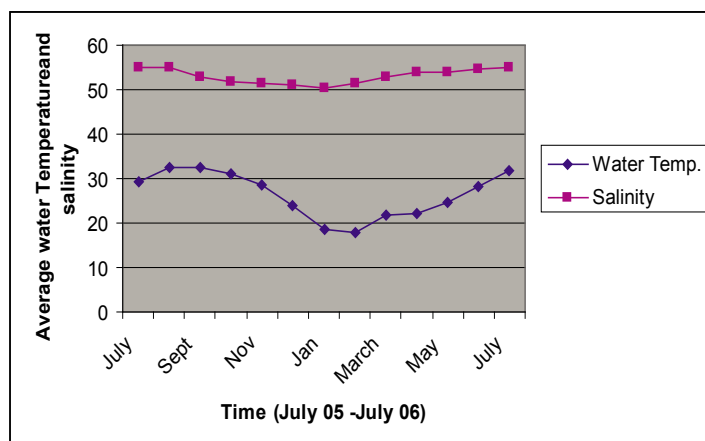




Growth performance of cobia *Rachycentron canadum* under hypersaline conditions.

During the grow-out trials the salinity ranged between 53 and 57 ppt (54.99 ± 1.1 ppt) while the water temperature ranged from 17°C to 34°C.

The growth rates obtained may be low when compared to 6 kg/year obtained in other parts of the world (e.g. Taiwan). However, they compare well with the results reported by Benetti *et al.*⁸. The authors indicated that cobia grown in tanks in Miami, USA at densities of 2 -3 kg/m³, reached about 2 kg in 12 months and this low growth performance was attributed to the high stocking densities applied. During the present trial, a very low stocking density (4 fish/m³) was applied but still the growth rates achieved remained much below the expected high rates. The reason behind this slow growth rates in the present study could be attributed mainly to the high salinity levels prevailing in the area all year round.



Water temperature and salinity recorded during the grow-out period.

Conclusion

The growth results obtained at ACAAB are not consistent with the impressive growth rates reported elsewhere and that was due to the depressive effect of the high salinity levels prevailing in the area. Nevertheless, when comparing the growth performance of cobia with that of other marine fish species cultured in the Center¹², it is obvious that cobia is very much the most promising candidate for a viable aquaculture in the area. To evade the depressive effects of high salinity and temperature and make cobia aquaculture more promising in the area, it could be recommended that future trials should consider the indoor rearing of cobia during summer time, in particular during July and August, before transferring them to cages or even pond systems.

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Success Stories in Asian Aquaculture

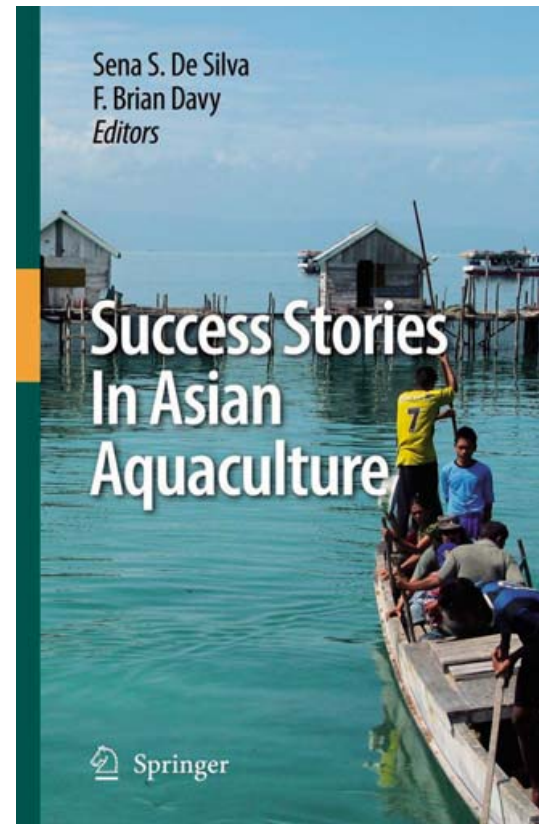
NACA is pleased to announce the release of a new flagship publication, *Success Stories in Asian Aquaculture*. The stories in this book reflect the unique nature of Asian aquaculture, providing first-time insight into how and why it has become so successful. Overall, the book demonstrates how the resiliency, adaptability, and innovation of small-scale aquaculture farmers have been crucial to this success. It also places aquaculture development in Asia into a wider global context, and describes its relationship to natural systems, social conditions, and economics. The book is unique in its in-depth presentation of primary research on Asian aquaculture, and in demonstrating how aquaculture can have a lasting positive impact on livelihoods, food security, and sustainable development.

This book will appeal to a wide range of readers. The introduction and conclusion give an excellent general overview of Asian aquaculture, and

the individual case studies provide a wealth of new information for specialist readers. Researchers, development workers, and decision-makers, in particular, will be interested in how the Asian experience might be used to strengthen aquaculture development more generally and in other parts of the developing tropics of Latin America and Africa.

Success stories in Asian Aquaculture is edited by by Sena S. De Silva, Director General of the Network of Aquaculture Centres in Asia-Pacific, and F. Brian Davy, Senior Fellow at the International Institute for Sustainable Development in Canada.

A PDF version of the book will shortly be made available for free download from the NACA website. You can order hard copies of the book online from the Springer website at the link below: <http://www.springer.com/environment/aquatic+sciences/book/978-90-481-3085-6>



Twelfth Regular Session of the Commission on Genetic Resources for Food and Agriculture

Aquatic genetic resources were included in the portfolio of the Commission on Genetic Resources for Food and Agriculture (CGRFA) only in 2007, at its 11th regular session held in June 2007. NACA is pleased that it was involved in the immediate follow-up activities that principally involved the coordination of the preparation of the document, *The Use and Exchange of Aquatic Genetic Resources in Aquaculture: A Synthesis*. This synthesis will facilitate the Commission's consideration of access and benefit sharing of genetic resources for food and agriculture, which will be a major issue that will be deliberated at its Twelfth Regular Session in Rome, October 2009, and is also available on the web site of the CGRAF (Background Study Paper No 45).

The synthesis on aquatic genetic resources is based on reviews on seven species/ species groups of aquaculture importance which were presented and discussed at a consultation in Chonburi, Thailand in April 2009. These were:

- Common carp *Cyprinus carpio* (Jeney, Z. and Zhu, J.).
- Pacific salmon *Oncorhynchus* spp, and Atlantic salmon *Salmo salar* (Solar, I.).
- Nile tilapia *Oreochromis niloticus* (Eknath, A. and Hulata, G.).
- Tropical catfish *Clarias* spp (Na-Nakorn, U. and Brummett, R.) and striped catfish, *Pangasianodon hypophthalmus* (Nguyen, T.T.T.).
- Marine shrimp (Benzie, J.).
- Selected molluscs, (Guo, X.).
- Emerging aquaculture species with food, ornamental and ecotouristic value (Nguyen, T.T.T., Rimmer, M.J., Davy, F.B., De Silva, S.S.).

The synthesis document is available for download from: <ftp://ftp.fao.org/docrep/fao/meeting/017/ak527e.pdf>

Training of trainers programme will strengthen small scale farmer competitiveness in ASEAN



Participants of 'Training of trainers' programme from five Asian countries.

NACA is presently implementing a project on *Strengthening capacity of small holder ASEAN aquaculture farmers for competitive and sustainable aquaculture*, supported by the ASEAN Foundation. The project aims to improve the competitiveness and sustainability of farmers through the development and adoption of better management practices. The project is working with five countries and five commodities, ie. Cambodia (snakehead culture), Indonesia (grouper and seabass culture), Philippines (seaweed culture), Thailand (cage culture of tilapia) and Vietnam (shrimp culture).

The national teams in each country have conducted training needs assessments to identify production issues associated with each commodity practical measures that farmers could adopt to increase their efficiency and sustainability. The next objective of the project is to spread the message and to assist small scale farmers to adopt these 'better management practices' (BMPs).

Accordingly, the project conducted a 'Training of Trainers' programme from 3-7 August 2009 at the NACA Secretariat in Bangkok. The course was opened by Ms Ivy Adan, Head of Programmes for the ASEAN Foundation. The 17 trainees, including the national teams, participated in

24 lecture and discussion sessions. The training covered a wide range of social, technical and extension issues, practical experiences in adoption of BMPs amongst small scale farmer groups in the region and the findings of the national teams. Participants also discussed approaches to facilitate the dissemination and adoption of BMPs with reference to the target commodities. Dr. Filemon A. Uriarte, Jr., Executive Director of the ASEAN Foundation presided over the closing ceremony for the Training of Trainers programme.

The next steps for the project will include the development of practical manuals and other extension materials, which will be used to support forthcoming training of small scale farmers in the five target countries towards the end of 2009. This will be followed by a regional workshop in early 2010 to allow farmers to share experiences and to introduce the BMPs developed under the project to other countries in the region.

NACA would like to express its sincere gratitude to the ASEAN Foundation and its staff for their support and assistance to make this project possible. For more information, please visit the project webpage at: http://www.enaca.org/modules/bmpprojects/index.php?content_id=13.



Executive Director of the ASEAN Foundation, Dr Uriarte, awarding certificates to participants in the training.

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Workshops on development of better management practices for catfish farming in the Mekong Delta organised in Vietnam

The two workshops on the *Development of better management practices for catfish farming in the Mekong Delta organised in Vietnam* were organised at the Dong Thap Department of Agriculture and Rural Development, Cao Lanh district, Dong Thap Province and the Can Tho University, Can Tho City on 5-6 and 8-9 October 2009, respectively.

The two meetings brought together catfish farmers, district and provincial officials, representatives from the Ministry of the Agriculture and Rural Development (MARD), processors and other stakeholders associated with the sector from the nearby provinces. At the meeting, draft better management practices (BMPs) for three sub-sectors, ie. catfish growth-out, hatchery and nursery operations, were presented and discussed in detail and the responses of the stakeholders obtained. The draft BMPs had been prepared based on an extensive survey of industry practices under the project *Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta*, funded by AusAID.

At both meetings there was a very intense stakeholder participation and there was consensus that adoption of BMPs by sector is an obvious way forward to attain sustainability and meeting the modern certification requirements. The Vietnamese stakeholders were impressed by the achievements gained through formation of collaborative clusters of small scale shrimp farmers in India. It was appreciated that adoption of suitable BMPs and a cluster-based approach enables small scale farmers not only to make better profit but also act responsibly to minimise environmental impacts, attain sustainability and meet certification requirements.

The Vietnamese farmers volunteered to adopt BMPs on a trial basis and in some cases such farms would act as demonstration farms. The draft BMPs will be now be revised based on the stakeholder responses and will be ready for implementation of BMP trials in four provinces by January 2010. The draft BMP guidelines will be supplemented with suitably prepared brochures (growth-out, seed production and nursing) for easier comprehension by farmers.

On the completion of the BMP trials, a national stakeholder workshop including representation of MARD will be held in October 2010 when the final adoption of BMPs for wider dissemination and strategies for implementation of cluster approach will be decided upon.

For more information, please view the project webpage at the link below:
http://www.enaca.org/modules/inlandprojects/index.php?content_id=1

The draft BMP document is also available for download from:
<http://library.enaca.org/inland/projects/draft-catfish-bmps-09.pdf>



Participants of the meeting in Dong Thap.



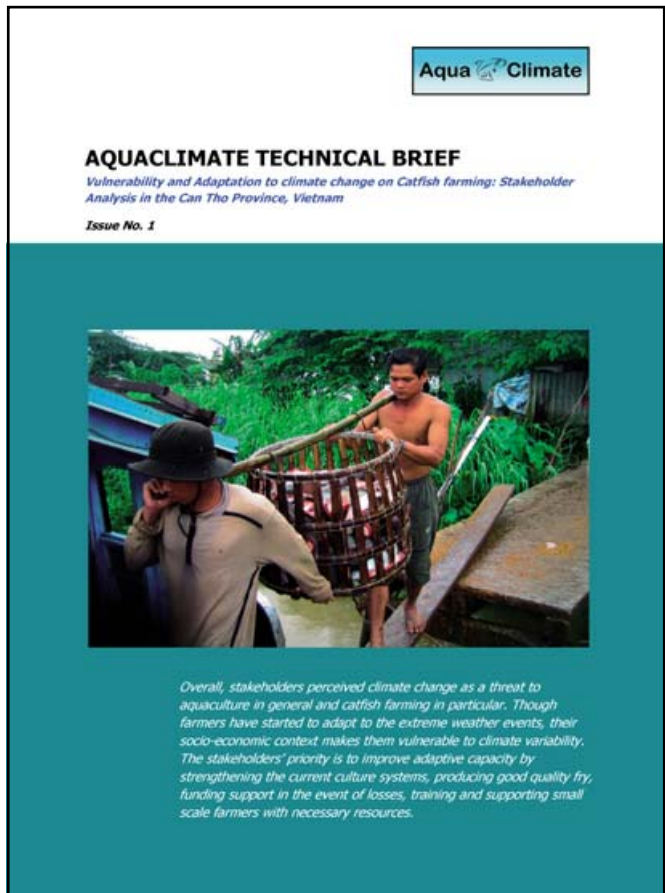
A participant making comments on the draft BMPs.

Vulnerability & adaption to climate change impacts on catfish farming - case study Can Tho, Vietnam

The Mekong Delta is the 'food basket' of Vietnam, and is of significance both from a production (volume and economic) and livelihood view points. Vietnam is prone to extreme weather events. Cyclones regularly impact Vietnam raising sea levels and sending saline storm surges up estuaries. Flooding is also a common occurrence. Vietnam, particularly the Mekong delta is highly vulnerable to climate change especially extreme weather events.

Catfish farming on the Mekong Delta is one of the world's fastest growing aquaculture sectors and is Vietnam's largest aquaculture sector by both volume and value. Catfish (*Pangasianodon hypophthalmus*) is a freshwater fish native to the Mekong river system (including Vietnam) that is cultured almost entirely in deep earthen ponds at very high density. The catfish farming industry and associated industries contributes significantly to the livelihoods of the local population.

On 21 June 2009 the AquaClimate team held a vulnerability and adaption to climate change on catfish farming stakeholder workshop and focus group meeting in Can Tho, Vietnam. Stakeholders including catfish farmers in general expressed that climate change is a serious threat and needs to be addressed in an integrated manner. The main changes they observed were: shift in weather patterns, higher temperatures, early rains, floods, saline water intrusion and frequent typhoons. Suggestions from farmers to address extreme weather events included, producing good quality fry, developing new culture systems, building dykes, livelihood diversification, training and awareness workshops and financial support to farmers. Sustaining catfish production in the Can Tho Province is crucial for the large number of farmers who are dependent on it for their livelihoods. Stakeholders are willing to co-operate to address future threats from climate change. The intention to co-operate may be strengthened by improving the existing institutional and policy frameworks.



More information is given in the Technical Brief Vulnerability and Adaptation to climate change on Catfish farming: Stakeholder Analysis in the Can Tho Province, Vietnam, available for free download from:

<http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=210&lid=986>



NACA welcomes Dr Nigel Abery, Coordinator of the Adaption of aquaculture to climate change project

NACA is pleased to welcome Dr Nigel W. Abery, who joined NACA on 5 August 2009 to take up a post coordinating the project on Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture and aquatic resources-dependent sectors in the south and south east Asian region. Dr Abery has previously worked in fisheries and aquaculture policy development and administration, fisheries resource management planning and fisheries and

aquaculture research and development for the Fisheries Victoria Division of the Department of Primary Industries in Victoria, Australia. Fisheries Victoria is co-investing in Dr Abery's post at NACA through the Aquaculture Futures Initiative, a component of the Victorian Government's Future Farming Strategy.

Dr Abery can be contacted through nigel.abery@enaca.org.

EU supports better management practices for responsible aquaculture

The demand for quality, responsibly produced and certified aquaculture products is predicted to increase substantially in coming years and the most practical, economical and acceptable way to achieve these goals is for small scale farmers to adopt better management practices (BMPs), collectively as a cluster, in a given locality. BMPs in the aquaculture context outline norms for responsible farming of aquatic animals. BMP's are management practices, and implementation is generally voluntary; they are not a standard for certification. However, implementation of BMPs will help to achieve compliance with standards set by international agencies, certification bodies and trading partners.

NACA's experience with the promotion of BMPs in India, Indonesia, Thailand and Vietnam clearly indicates that they improve the quantity, safety and quality of products taking into consideration animal health and welfare, food safety, environmental and socio-economical sustainability. They also assist farmers to improve their income through better crop outcomes and cost reductions achieved through more efficient use of resources.

The European Commission, under the 7th Framework Programme (FP7) Cooperation Theme 2: Food, Agriculture, Fisheries and Biotechnologies, has approved funding (Euro 0.97 million) for the project "ASEM Aquaculture Platform", coordinated by Ghent University, under the leadership of Professor Patrick Sorgeloos. The project involves nine participating European and Asian institutions.

Better management practices

The project's major aim is to develop a strong 'Community of Practice' to reconcile ecosystem and economic system demands to promote and consolidate sustainability in aquaculture development in both regions. Specific actions include; 1) validation of first round recommendation; 2) translating key themes into concrete actions; 3) facilitating industry interaction; 4) building and exchanging knowledge and its application. The project will be conducted through well defined ten work packages.

NACA plays a crucial role in the project's planned initiatives and will lead the work packages on, "Development and validation of commodity-specific Better Management Practices (BMPs) for smallholder farmers in the Asia-Pacific region", and on "Communication". The objectives of these two work packages are, respectively:

1. To promote wider adoption of BMPs for key aquaculture commodities in NACA member countries, thereby ensuring sustainability of this important food production sector and improving the livelihoods of the stakeholders. This package will have two facets:

Commodities for which BMPs are already developed and being implemented (e.g. shrimp) where the focus will be to assess the impacts of BMP implementation and developing strategies for scaling up at the national and regional levels.

Commodities for which BMPs are presently being developed (e.g. striped catfish) where the focus will be on validation and implementation of BMPs.

2. The objective of the work package is to increase the understanding of each others' sectoral characteristics by improving the flow and impact of information between EU and Asia and from ASEM platform to major stakeholders including society at large.

The above grant enables NACA to continue its work on the development, adoption and improvement of BMPs on commodities and farming systems that it commenced nearly a decade ago. In this regard NACA will continue to cooperate with national governments, regional and international organizations. The project is expected to further facilitate and consolidate the position that adoption of BMPs is the most useful gateway to achieving sustainability, food quality and food safety in aquaculture, and most of all ensuring that small scale, farmer and family owned, operated and managed aquaculture systems are able to remain competitive in the modern market place.

Global Conference on Aquaculture 2010

9-12 June, Bangkok, Thailand

In 1976, FAO held the first ever global conference on aquaculture, the Kyoto Conference, which explored opportunities for aquaculture development and triggered the recognition of aquaculture as a significant food production sector. Ten years after the millennium conference, with aquaculture now providing nearly 50% of global food fish supplies, FAO in partnership with NACA and the Thai Department of Fisheries, are organising the Global Conference on Aquaculture 2010, to evaluate where the sector stands today and face the challenges and opportunities ahead.

Plenary lectures together with six regional reviews and one global synthesis will set the scene for six thematic sessions and associated expert panel discussions on key aspects of aquaculture development and management in the coming decades. The conference will provide a global forum to build consensus to advance sustainable aquaculture development and contribute to the Millennium Development Goals. Have your say on the future of aquaculture development: Join us in Bangkok from 9-12 June 2010. For more information, visit:

<http://www.aqua-conference2010.org>

Myanmar delegation visits CIFA to study aquaculture

After recent visits from Sri Lanka and Bangladesh, a Myanmar farmers' delegation has travelled to the Central Institute of Freshwater Aquaculture, Bhubaneswar to study aquaculture. A 15-member delegation led by U Than Lwin arrived at Bhubaneswar on 14 July 2009 on an eight day visit to CIFA and Kolleru Lake, Andhra Pradesh, to study the remarkable aquaculture development in India, the second highest aquaculture producer in the world, next to China. The team included 11 members of the Myanmar Fish Farmers Association, 2 members each from Myanmar Fisheries Federation and Aquaculture Division of Myanmar Fisheries Department. Welcoming the delegation at CIFA, Director of the Institute, Dr A.E. Eknath said that both Myanmar and India have many things in common and a long history of cooperation. He expressed happiness that such a large delegation has sought CIFA's technology to help boost its fish production. Giving a comprehensive and informative account of institute's overall growth, Dr. Eknath pinpointed the remarkable achievement of CIFA in development of Jayanti rohu through selective breeding techniques. The team evinced keen interest in this improved variety of rohu, which gives 17% higher yield per generation than normal rohu. 'Our main objective in coming here is to learn the best carp (Jayanti) technology available here to increase fish production in our own country', said Mr U Than Lwin, the president of Myanmar Fish Farmers Association. 'Our endeavour would be to increase both quality and quantity of fish without destabilising our environment', he added.

The members of delegation interacted with all the heads of division and other nodal officers of CIFA. Mr U Hla Win, a retired Deputy Director General of Myanmar Department of Fisheries, who is presently the adviser of Myanmar Fisheries Federation made a presentation narrating the overall fisheries activities in Myanmar. 'Myanmar has invaluable and appreciable fishery resources with diversity in marine and freshwater fish species which need to be effectively exploited for raising production capacity', said Mr Win while underlining the importance of high technologies in building a modern, developed and economically strong nation. Dr Kuldeep Kumar, senior scientist took the delegation on a guided tour of different culture and production facilities in CIFA farm. Aquaculture specialists stationed at different places explained to the guests about the advanced technologies and ongoing research activities and took pleasure in answering their queries. The sprawling freshwater aquaculture farm of CIFA, the largest in the world provided an excellent backdrop for the field programme.

The delegation later visited a number of aquaculture farms and hatcheries in Kolleru lake area of Andhra Pradesh, the carp pocket of India. They had series of interactions with the progressive fish farmers, entrepreneurs and hatchery owners in the area. The delegation studied the whole process of fish production and marketing chain in Kolleru operating through forward linkages of improved post-harvest services like packaging, processing, storage, transport, marketing and backward linkages of providing inputs like seeds, fertilisers, chemicals, feed and aquaculture machineries; which has scripted the success story of



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aquaculture in the region. 'We are here to learn modern methods and techniques from this part of the world', opined Ms Thuza Maung, a delegation member. The delegation had some more interactions with members of trade bodies with an aim to gain understanding of the whole production and marketing process. Before leaving for Myanmar on 21 July, the delegation expressed hope for transfer of knowledge, better linkages and cooperation, capacity building through training and exchange programs, and strengthen bilateral ties through participation in various programs.

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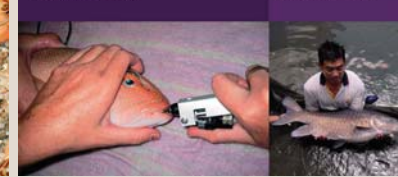
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Aquaculture Asia and IFACA, linking our condolences to the recovery of aquaculture leaders by the earthquake and tsunami of 26 December 2004. We are pleased and honoured by the event and will work to assist people to rebuild their lives and livelihoods, in collaboration with our partners throughout the region. Consensus of interested organizations has been formed to collaborate in the medium and long term recovery of farmers, fishes and coastal governments. More inside.

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Enquiries and further information

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