ISSN 0859-600X
Volume XIII No. 2 April-June 2008

AQUACULTURE ASIA

Vietnamese catfish

Culture-based fisheries in Lao

Changing face of carp culture

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NACA
An intergovernmental organization that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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Printed by

Scand-Media Co., Ltd.

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Volume XIII No. 2 **ISSN 0859-600X**
April-June 2008

Standards for catfish aquaculture

The development of aquaculture standards is back in fashion. At the centre of attention is the Vietnamese catfish industry, which has emerged from the 'catfish war' with the US stronger than ever, now producing more than one million tonnes per year and exporting all over the world.

The meteoric rise of the catfish industry has prompted a mad scramble for the establishment of 'standards' for catfish production. Standards have been proposed or are in development by EurepGAP, GTZ, WWF (the Pangasius Aquaculture Dialogue) and Naturland (Naturland Standards for Organic Aquaculture). These groups have different goals and priorities and so for the most part these standards are being developed as separate entities, and may not be mutually compatible or complementary.

There are a few things that trouble me about this situation. Firstly, the word 'standard' implies a norm that has broad-based acceptance. A proliferation of standards is a headache for both farmers and consumers, and the resulting fragmentation of effort reduces the chance of a broadly accepted standard (ie. a *real* standard!) emerging. The organizations propounding various standards need to get together with stakeholders from throughout the value chain and start talking about developing a common approach. This issue was raised by NACA at a recent meeting of the Pangasius Aquaculture Dialogue. It has also been raised in more general terms at a series of international consultations on the development of guidelines for aquaculture certification over the past year.

Secondly, the standards are for the most part being developed, funded and promoted by US and European interests and consultants and not by local industry. Given the still recent 'catfish trade war' and resistance of domestic industry in many countries to the importation of Vietnamese catfish, there are legitimate concerns that some of these standards could serve as non-tariff trade barriers in future, ie. that they are potentially a wolf in sheep's clothing.

Lastly, Vietnamese interests, particularly those of farmers, are not necessarily well represented on the various committees that have been established in the name of consultation. There is a substantial gap that exists between the people that are promoting standards and Vietnamese producers. Some of this gap is cultural: posting thick English-language documents on the internet and engaging in vigorous debate at public meetings may be accepted forms of consultation for international experts but they aren't necessarily an appropriate form of consultation in the local context; some of the gap would also appear to be due to lip service to consultation by people who are more concerned about putting a report on a shelf than establishing a standard that key stakeholders, that is to say the farmers, accept and can follow. It is one thing to put a group of technical experts in a room and have them devise a technically excellent, cutting edge standard, but is it *appropriate* for small scale catfish producers to implement? Has it been field tested? Is any guidance is offered to small scale farmers on how they can achieve the performance measures required by the standard? If standards are going to be adopted in reality, we should not forget that farmers need to be one of the primary beneficiaries.

Simon Wilkinson

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Peter Edwards writes on

Rural Aquaculture

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From integrated carp polyculture to intensive monoculture in the Pearl River Delta, South China

Dramatic changes have taken place over the last 20 years in inland Chinese aquaculture with a decline in traditional integrated Chinese carp polyculture. I was fortunate to witness the peak development of the former as a consultant for UNDP/FAO at the Integrated Fish Farming Center, Freshwater Fisheries Research Center, Wuxi, in 1981, which included field visits and interviews of farmers of the dike-pond system (DPS) in the Pearl River (Zhujiang) Delta. On a visit to southern China last November I spent a day revisiting fish farms around Quangzhou and in Shunde County (now a district), Quangdong Province and saw at first hand these remarkable changes.

Traditional dike-pond system

The integrated agriculture-aquaculture DPS system dates back to the 14th century (Lo, 1990). Wetlands in the Pearl River Delta were reclaimed by digging ponds and using the excavated soil to raise elevated dikes on which fruit and vegetables were raised, including mulberry bushes to provide leaves to feed silk worms which supported the silk industry of southern China. It was also characterized by integration with other local human activity systems besides plant crops and used inputs, both on- and off-farm, from animal husbandry, sanitation and cottage-level industries such as silk and soybean processing wastes. It used the well known Chinese practice of carp polyculture which consists of a polyculture of up to 8-9 species of fish, with various feeding and spatial niches leading to efficient utilization of nutritional and spatial niches or resources in the pond. The major species in the dike-pond system were the herbivorous grass carp, the filter feeding bighead and silver carps, the detritus feeding mud carp, and the omnivorous common and crucian carps. It reached its most complex stage of development in the 1980s during the era of collective ownership of agriculture.

Watering vegetables with fish pond water. Shunde District, 2007.

Cultivation of mulberry (foreground) adjacent to a fish pond. Le Liu People's Commine, Shunde County, 1981.

Watering vegetables with pond water, foreground, sugar cane background. Shajiao People's Commune, Shunde County, 1981.

The most comprehensive description of the system is the book by Ruddle and Zhong (1988).

Demise of the dike-pond system

As I witnessed late last year, the dike-pond system has changed beyond recognition since the Government introduced a market-driven economy in the mid 1980s. The Pearl River Delta now has the most expensive land in southern China as it has been the powerhouse of Guangdong's economic reform of the last 25 years (Jin, 2007). Guangdong Province took the lead in China in setting up special economic zones (SEZs) starting in 1979. Township enterprises are booming in the former rural area. By the early 1990s, Shunde County at the centre of the former DPS had already become one of the four richest counties in China. It is the largest productive base of electric appliances in China; it is the "capital of home appliances of the world" and it hosts annually China's International Fair of Home Appliances. The largest bicycle production base and the largest producer of microwave ovens in the world are also located in Shunde District as well as factories for manufacture of air conditioners, refrigerators, electronics, telecommunication appliances, garments and animal feed.

The cultivation of mulberry was one of the defining features of the pond-dike system but it has disappeared from most of Shunde District. Polyculture of Chinese carps has been mostly replaced by monoculture of high-value species such as eel, freshwater prawn and soft-shell turtle over the past decade (Yee, 1999). The farmer I interviewed during my recent visit, was culturing channel catfish in 100 mu (6.7 ha) area of ponds in Xin Long village in Longjiang, Shunde District. The village had 1,000 mu (67 ha) of privately owned ponds in which many species were being cultured, including tilapia. Although the fish farming village was surrounded by urban/industrial development, it was not going to be converted into factories as it was a special area for aquaculture as decided by the village fish farmers according to the farmer I interviewed.

Most fish ponds have aerators. Shunde District, 2007.

Feeding channel catfish with pellets. Shunde District, 2007.

While considerable areas of land and ponds occupied previously by dike-pond systems have been converted into urban and industrial development, there may be a larger pond area today than in the 1980s as previously reported by Yee (1999). Many farmers continue to be involved in aquaculture although mainly intensive culture of high-value species with off-farm feed within aerated ponds. There is a ready market for fish in the relatively affluent area and intensive fish culture is more profitable for farmers than the traditional DPS dominated by lower value filter feeding species. Dikes are now much narrower to maximize pond surface area as aquaculture is more profitable than dike cropping and many are in poor shape through neglect as well as erosion by aerated pond water. Crops are still being cultivated on the dikes of some ponds but are mainly integrated with aquaculture through use of the pond for watering crops. I saw no livestock in Shunde District as manuring of ponds is no longer required; today the major concern is pond eutrophication from residual fertilizer effects of uneaten fish feed and faeces rather than use of livestock and human manures to fertilize the pond as in the past.

Cultivating vegetables on a fish pond dike. Shunde District, 2007.

Nutrient relationships of the dike-pond system

A widely held misconception is that the dike-pond system was a more or less closed system in terms of nutrient flows. Ruddle and Zhong (1988) in their detailed study of the traditional dike-pond system claimed that it was a relatively closed ecological cycle "based almost entirely on the tightly managed recycling of materials" and the "bulk of the inputs have always been generated from the within the system itself". Similar claims were often repeated: "the Chinese dyke-pond system…is unique in integrating agriculture and aquaculture within a single self-contained system…requiring minimal input of energy and materials" (Zhong, 1989); "without any external input of fuel, fertilizer or feed in an ecologically-balanced system" (Chan, 1993); and, "the DPS itself supplied most of the nutrients for effective functioning of the system" (Yee, 1999).

However, it was difficult to reconcile the production and export of large amounts of nutrients in commercial crops such as fish, pigs, silk, sugar and vegetables with a "relatively closed ecological cycle" (Edwards, 1993). It was estimated that the mean yield of fish alone would require an absolute minimum of 180 kg of consumable nitrogen/ha/year, most of which could not have been regenerated within the system. Data from household surveys presented by Ruddle and Zhong (1988) showed that most of the total inputs to the fish ponds were manures, mainly pig manure but also human manure or nightsoil. With an extremely high local population density in the dike-pond area of 1,700 persons/square km and only 12% of the agricultural land under rice, a considerable amount of pig feed and human food must have been imported into the system. It was also claimed that the feed requirements of the pigs were met by a "diet of greens, particularly water hyacinth, sugar cane tops and vegetable waste". Feeding greens to pigs is a traditional Chinese practice but pigs are monogastrics and require additional, more digestible sources of feed for adequate growth. While the ponds effectively treated human and pig manure and the nutrients were recycled in the dike-pond system, it was characterized by considerable nutrient flows from outside the system rather than being a closed system.

An example for sustainable development

Another myth in view of the demise of the dike-pond system is that it provided a model for sustainable aquaculture elsewhere. According to Chan (1993), the dike-pond system "should serve as a model for economic as well as ecological development for the rest of China and many other parts of the world"; and "many countries in the region would benefit from adaptation of the Chinese DFS model" (Korn, 1996).

This page: Fish ponds are interspersed with urban and industrial developments. Shunde District, 2007.

Integrated duck-fish culture. Sanshui District, 2007.

The dike-pond system provided benefits for centuries but could not compete with industry in terms of social development or sustainability even though it may have been environmentally sustainable. There has been widespread delinking of crops and livestock from fish ponds in the major fish farming areas of China. According to Zhou En Hua, my interpreter as well as teacher in China over 25 years ago, who now runs feeding demonstrations in various provinces of the country, "it is really difficult to locate any large-scale fish farms with integrated farming practice as we saw in the early 80s in most of the aquaculture production areas of China". However, I did see large numbers of integrated duck/fish farms on the outskirts of Guangzhou, simplified two component feedlot livestock/fish systems, presumably because fish culture is still a profitable way to treat and reuse duck manure where there is high market demand for ducks as in southern China.

Towards sustainable intensive aquaculture

The intensification of inland aquaculture is causing environmental concerns in China because of pond eutrophication and the absence to date of treatment of pond effluents. A farmer of a large pellet-fed tilapia farm I visited in Hua Du District told me that his major problem is very green water from excess residual nutrients. Zhou En Hua recently told me that he never recommends monoculture in pellet-fed ponds to farmers as pond water readily becomes eutrophic which stresses the fish. He recommends an 80:20 system of stocking fish with 80% of the biomass at harvest comprising the target species, and the remaining 20% of the biomass, "service fish" such as silver carp to feed on the phytoplankton produced by fish metabolic wastes. Although silver carp has a relatively low value compared to target fish such as crucian carp and tilapia, the improvement in water quality leads to a better food conversion ratio, less disease, reduction or elimination of the need for chemicals and drugs, safer fish and therefore a higher economic return for the farmer. Thus, some of the principles of traditional Chinese aquaculture practice are being introduced to help to make pellet-fed monoculture environmentally as well as socially sustainable.

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Better management practices for Vietnamese catfish

Simon Wilkinson, NACA

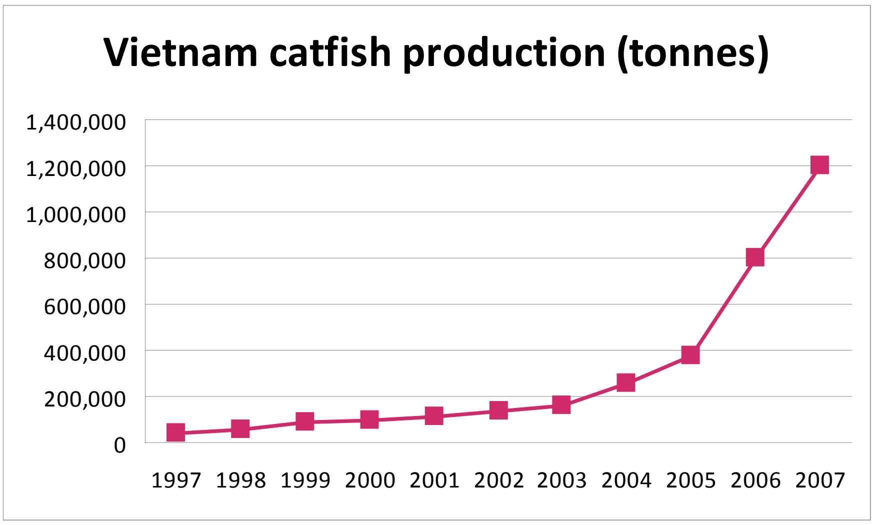
Feeding time in a growout pond.

The phenomenal growth of the catfish farming industry in Vietnam is attracting the attention of the world, and with good reason. In 2007 the industry is estimated to have produced at least 1.2 million tonnes of catfish, a staggering increase considering that in 2000 the industry was only producing 100,000 tonnes. The spectacular success of the industry is due to a unique combination of factors that include market opportunity, the robust nature of the catfish, the abundance of high quality water resources available in the Mekong Delta, and the sheer determination and entrepreneurial nature of Vietnamese farmers.

In January we were privileged to travel to Vietnam to discuss implementation of a new project on Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta, funded by AusAID's Collaborative Agriculture Research and Development Programme. The project team consists of a collaborative partnership between the Research Institute for Aquaculture No. 2, Can Tho University, the Victorian Department of Primary Industries (Australia) and NACA, with DPI and RIA2 taking the lead roles in the respective partner countries. The purpose of the project is to help the industry improve its environmental performance and profitability through more efficient use of resources and improved farming practices. During our visit we had the opportunity to get out into the delta to discuss emerging issues with small and medium-scale catfish farmers and some of the major processing/export companies.

Development of the industry

Catfish farming has been farmed in the Mekong Delta of Vietnam for more than 50 years. However, the export of basa and tra catfish began in the mid-1980s primarily as fillet to Australia (Tuan 2003). Increasing interest from Asian markets fueled development of



the industry from 1990 onwards, with exports later expanding to European markets and the United States.

It wasn't long before the success of catfish as an export commodity began to attract the ire of producers in importing countries. In 2001 the Catfish Farmers of America and related interests formed a lobby to campaign for a ban on the import of catfish products from Vietnam. This culminated in the filing of an antidumping complaint with the US International Trade Commission. Faced with the reality of lower labour and input costs in Vietnam, the commission was forced to declare Vietnam a 'non-market economy' in order to apply penalty tariffs on imported Vietnamese catfish products, a move that was widely seen as trade protectionism on the part of the US government.

Although attempts to block the import of catfish into the US were frustrating for Vietnam at the time, they may actually have been a blessing in disguise. Exporters were forced to look for other markets and they found one: The rest of the world. Catfish once destined for the US started to find its way into other countries where it quickly found a niche as a cheap, white, tasty fish suitable for staple consumption. With wild catch fisheries no longer able to service the growing demand for fish, this niche quickly grew into a gaping chasm, one that even 1.2 million tonnes of catfish has not yet filled.

This farm has constructed their own pellet machine which dumps food directly onto a conveyor belt for express delivery to the pond.

Culture practices and emerging issues

The catfish aquaculture industry in Vietnam presently consists of about 60% small-scale producers, typically with ponds in the range of 2,000 square metres to several hectares. Catfish are typically grown in ponds around 4.5 metres deep with a high level of water exchange on the order of 20-30% per day required to maintain the health of the stock and keep the flesh colour white; if exchange is insufficient the flesh takes on a yellow cast which is regarded as undesirable by processors.

Tra is an extraordinarily robust fish with air breathing capability and a wide tolerance of environmental conditions, enabling it to be cultured at extremely high densities. Farmers in the delta are commonly harvesting 300-400 tonnes/ha per crop, with some reports of yields of up to 700 tonnes/ha. Tra grows rapidly, reaching a marketable size of 1 kg within six months, allowing farms in the delta to produce two crops or an incredible 600+ tonnes/ha production per year. Even though the profit margin is small – typically around US$ 0.1 - 0.15/kg – the total return to the farmer (US$ 60,000 – 90,000+ per hectare) is massively superior to any other crop, and represents a huge improvement to the standard of living of farmers, many of whom were formerly growing rice.

Like other growth industries before it, catfish farming is beginning to experience some growing pains as

View of a catfish pond, a boom to confine floating feed pellets is visible to either side of the feeding shed.

Raceway inlet for water from the river.

Catfish processing facilities enforce strict hygiene standards to comply with the requirements of export markets.

The growth of the catfish industry is fueling expansion of feed manufacturing plants.

farmers explore the limits of the system and importing countries start raising requirements for products to access their markets:

- Seed quality is the number one issue of concern to farmers as there has been a marked deterioration. Seed supply is currently insufficient to meet demand and there are suggestions that private hatcheries may have resorted to forced spawning of broodstock that are not in good condition or fully ripe. Losses in the nursery stage of culture are very high.

- Not surprisingly, health at all stages of production was also an issue of significant concern. Mortality rates, although widely variable from farm to farm, are generally felt to be on the increase, possibly due to seed quality and to increasingly high stocking densities.

- Feed costs are a major issue and there is currently no auditing system in place to ensure that feed manufacturers are meeting the advertised specifications of their feeds. Some farms are manufacturing their own feeds in order to gain control and flexibility over feed composition, in addition to reducing costs.

- Farmers are also concerned with the balance between stocking density, water exchange and flesh colour, seeking to minimise losses due to disease and pumping costs while achieving a high yield and quality necessary to get a good price from processors.

- Short production chains are an unusual feature of the industry. There are no middlemen; farmers sell their crops directly to large processing/export companies. Prior to purchase, processors collect samples of the crop to assess flesh quality and conduct laboratory tests for chemical residues. If the product passes inspection the farmer is offered a price based on its quality; if the farmer accepts the price a contract is signed and the crop harvested. Processors meet the cost of laboratory testing and transportation, farmers pay their own labour costs for the harvest.

Fillet quality is a major issue for processing plants, although preferences vary according to market, with fillet colour more important in Western European markets while Eastern Europe is mainly concerned with price. Trimming fillets of red muscle and fat is a major component of processing operations, with end products carefully sorted and graded before being frozen individually by blast or in blocks.

It was apparent during our visit that feed manufacturers and processing plants are also undergoing a dramatic expansion of the delta, with new facilities being constructed and existing facilities adding capacity to cater to growing international trade in catfish. This is generating significant employment opportunities; one processing plant

Processors are experimenting with value-added products such as this smoked catfish sausage.

From rice farming to riches: Catfish farming has dramatically improved the quality of life for many farmers. The pond with the feed conveyor belt is in the back yard!

we visited (Vin Hoan Corp.) employes around 3,500 workers alone. The labour requirements are such that the company is presently constructing accommodation facilities to house its workforce.

Proliferation of 'standards': A headache for farmers

The rapid growth of the catfish farming has not gone unnoticed by environmental NGOs. Several have or are attempting to establish various certification 'standards' for catfish aquaculture, including Eurepgap, GTZ, WWF (Pangasius Aquaculture Dialogue) and Naturland (Naturland Standards for Organic Aquaculture).

During our discussions with farmers and processors it was apparent that they are only too keen to improve the performance of their farms and the quality of their products. Due to the high intensity of catfish farming small improvements can deliver big gains to producers, and processors are very much concerned to ensure their products meet the requirements of importing nations. It was clear that the industry will gladly accept guidance that helps them to address such issues but the proliferation of standards is a source of concern. As one farmer said at our planning meeting: "Producers are being caught amongst a proliferation of standards. I just want one standard I can't follow them all". Similarly, major retail buyers have made it clear that the proliferation of standards is also a source of confusion to consumers.

Ironically, even though proliferation is recognized as an issue, proliferation continues. It seems that the proponents of different standards find it difficult to bridge the ideological and political gaps that exist between them. Everyone wants 'their' standard adopted as 'the' standard; and this fragmentation is in turn a barrier to any particular 'standard-in-principle' gaining the widespread acceptance that is required for it to become a standard in fact.

Towards better management practices

The goal of the BMP project is not to develop certification standards per se. Instead, the project aims to improve management practices, simultaneously delivering increased profitability to the farmer and improved environmental performance through more efficient use of resources. As BMPs are implemented voluntarily, the incentive to adopt them is provided simply by their direct economic benefit to the farmer.

In our discussions farmers emphasized that BMPs should focus on simple, practical measures that they can easily implement. Some certification standards, for example, were considered difficult or impossible for farmers to follow. They emphasized the need to start the process of developing BMPs by working with them to see what changes were required and also what changes were feasible for them to make, in a 'bottom up' approach. Demonstrating the practical value of BMPs to farmers was also seen as a critical issue for their adoption. The development of standards by foreign consultants with token input by farmers was not greeted with much enthusiasm; such 'paper standards' were at best viewed as being 'impractical', or as one participant exclaimed 'Just theory!'.

As a starting point, the Vietnamese project partners (RIA 2 and Can Tho University) will conduct a detailed survey of catfish hatcheries, production and processing in the delta in the first half of 2008, which will identify key issues where the development of better management practices may benefit the industry. The project will run for two years, and further updates will be published in Aquaculture Asia, the NACA Newsletter and on the NACA website, where a dedicated page has been established to track the progress of the project, please visit the link below:

http://www.enaca.org/modules/inland_projects/index.php?content_id=1

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Project team after enjoying the hospitality at a catfish farm.

Ipomoea aquatica – an aquaculture friendly macrophyte

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Water spinach or 'morning glory', *Ipomoea aquatica* (Forssk) is a common emergent aquatic plant that can grow freely over the water surface or over marshy ground. Named for its beautiful flowers, a single stem can grow up to 20 meters in length with profuse branching, and its apical shoot may advance 10cm per day under suitable conditions. Morning glory is basically a vine, which may form dense masses of tangled vegetation, thus developing impenetrable canopies over the water surface, restricting light penetration into the depths. It is found growing wildly in tropical and subtropical countries and is cultivated widely in China, Indonesia, Thailand, Vietnam, Myanmar, Philippines, Bangladesh, and in India (Naskar, 1990). Morning glory has probably been cultivated for more than 2000 years. It is sold in tightly packed bunches in Asian markets and considered as one of the most cheap as well as delicious leafy vegetables preferred by all groups of consumers – rich and poor.

Morning glory is widely consumed throughout the region.

Morning glory – an ideal substratum for periphyton growth

Morning glory can play a significant role in providing a natural substratum for periphyton, which is an ideal food for many species of fish. Investigations have shown that a number of periphyton species, mostly filamentous algae, grow around the periphery of the stem. Older stems develop a thick mat of periphyton upon which fish graze. The roots developing from each node, also harbour periphyton. In our local investigations, we have periphyton to be principally composed of species from two distinct families viz., Cyanophyceae and Chlorophyceae, along with a variety of zooplankton including *Brachionus* sp. All the algae listed below are filamentous and some of them have holdfasts, a characteristic feature of periphyton.

List of periphyton categorized by family:

Cyanophyceae

- *Phormidium sp.*
- *Oscillatoria sp.*
- *Rivularia sp.*

Cholorophyceae

- *Ulothrix sp.*
- *Oedogonium sp.*
- *Characium sp.*
- *Microspora sp.*
- *Cladophora sp.*
- *Amphithrix sp.*
- *Chaetophora sp.*

Morning glory - a support for organic farming

Periphyton-based organic farming is now widely recognised as a source of contaminant-free products in tune with social aspirations and consumer preference. Organic aquafarming is being promoted widely as a safer alternative to the use of chemicals in aquaculture (van Dam, 2002, Azim, 2003). In this connection, morning glory-based substratum may be developed to increase natural productivity of water bodies by producing a large amount of periphyton. The present study has determined that an older stem usually provides a periphyton-covered surface area of about 28 cm^2. In organic farming systems, morning glory may act as a suitable substratum to allow the growing of autotrophs around which heterotrophs congregate. This practice gradually helps to enhance the natural productivity of water body by producing a considerable amount of natural food organisms essential for fish culture and production with minimum exogenous input.

Morning glory – a nutritious aquatic plant

Morning glory has long been cultivated in order to harvest its leaves and stems as leafy vegetables, which are one of the most preferred foods found in the major meal of rural India, particularly in Bengal during the summer months. Nutrients analysis of *I. aquatica* has shown that it contains a remarkably high amount of crude protein and organic matter, along with low of crude fibre, making it potentially suitable as a fish feed component. A critical analysis carried out to investigate the nutritional qualities of *I. aquatica* determined its composition to be 32.2% crude protein, 10.8% crude fiber, 6% crude lipid, 6.0% and 30.0% ash. The total carbohydrate (NFE +crude fibre), was 31.8%. Micronutrient content (per g): vitamin B1 (thiamin), 87μg; nicotinic acid, 0.6 mg; riboflavin, 120 μg; vitamin C (ascorbic acid), 1.37 mg; along with substantial carotenoids: β–carotene, xanthophylls and taraxanthin. Mineral content included K, 41.4 mg; Mg, 31.0 mg; Zn, 1.7 mg; Cu, 0.1 mg; Ca, 2.0 mg; Na, 5.0 mg; P, 1.0 mg; along with gross energy content, 337.9 kcal per 100g; and protein/energy value was 95.3 mg protein/ kcal.

When formulated feed prepared using *I. aquatica* was given for 60 days to the fingerlings of three carp species viz., *Labeo rohita*, *Catla catla*, and *Cyprinus mrigala* to evaluate its efficacy as a fish feed, feed conversion efficiency (FCR) ranged from 1.8 – 2.5, gain in body weight ranged from 18.2 – 33.3g, protein efficiency ratio ranged from 0.7 – 1.0, and protein retention and specific growth rate were in the range 0.7– 1.0% per day.

Significantly, *I. aquatica* has been found to contain a very low amount of antinutrients as trypsin inhibitor, calcium oxalate, tannin, and phytate, compared to other leafy vegetables. A critical biochemical analysis of fish tissues (liver, muscle + blood) in the post-feeding efficacy of formulated diet containing *I. aquatica* plant has also supported it as a potential fish feed and have been able to enhance in maintaining the fish growth up to optimum level.

Fish food and fodder

This species can play a significant role directly as a food for fish, especially for grass carp, Ctenopharyngodon idella, a voracious grass eater, which can consume every day an amount of grass equal to its body weight. In such condition, morning glory vegetation may be put and maintained in the periphery of water bodies where grass carp are cultured. In view of nutrient conversion efficiency, maintenance of morning glory vegetation in any water body may also fetch two benefits at a time: Morning glory eating grass carp are to be treated as an organic product that will have more consumer preference, and thus may generate profitable revenue. 2. Morning glory eating grass carp indirectly benefits the health of consumers, as it is a source of rich nutrients that ultimately reach to grass carp eaters. Grass carp along with other fish like rohu (*Labeo rohita*) may be cultured in the same water bodies for organic farming as a part of integration: the former eat morning glory vegetation, while later graze over periphyton assembled around the morning glory stem. It is also used as a fodder given to cattle, pig and goats, which prefer to relish it. Chopped and boiled, it is given to the pregnant cow to improve the health of the young.

Cultivation

Pre-cultivation practice

Morning glory grows easily in marshy places or even in full course water bodies. It is propagated by seeds, or by stem cuttings. Packed viable seeds are now available in market. These seeds are sown over marshy places during peak winter period. Farmers collect stem fragments by chopping them into several pieces, each of which must have at least single node from which roots initiate. In case of full course water bodies, long stems can be put at the edge of the ponds, and then fixed in place with bamboo poles.

Land preparation and plantation

The ground where seeds/ stem cuttings are to be sown/planted should be hydric soil or saturated. There is no need to take any special care to prepare the ground before sowing/planting of seeds/stem cuttings unlike other conventional crops. Seeds are simply sown over the ground, taking one month to reach a harvestable stage.

Harvest and production

The first harvest may take place one month after seed sowing and then can be done at weekly intervals. During the first harvest, stem cuttings can be prepared for transplantation elsewhere and once established cuttings may be made at any time. It has been estimated that about 60 kg can be harvested per 100 m^2 during first cutting, which then induces crop to sprout a number of branches which increase the biomass production even more. Consequently the second harvest may be double that of the first, gradually increasing to four times before beginning to decline.

Economy

One bundle of morning glory typically weighing around 200 g costs about Rupees 1.50 (1US$=Rs. 45.00). Market surveys have shown that harvesting costs increase up to the fifth harvest and then gradually decline, while the production increases.

Conclusion

Morning glory cultivation may bring several advantages at a time in the scenario of south Asian perspective. There are vast areas of low lying lands in the region, which remain inundated during post monsoon period and remain exposed as marshy ground till late winter. As morning glory has characteristics of both seasonal crops and perennial vegetation, it may be utilized as circumstance permits: In seasonal wetlands it can be cultivated by sowing seeds in late winter, and yields may be harvested till the early summer when farms can no longer sustain the crop. In full course water bodies, it may be kept and maintained around the periphery of the ponds. In such case, harvesting may be difficult, but it may be used for fish feed, especially for grass carp. In organic farming the young shoots may be harvested for leafy vegetables; simultaneously older stems may continue to provide a periphyton support system for grazing fish like carp. When it is found covering the pond prolifically, it must be thinned out periodically to maintain a suitable density and permit light to penetrate the water. Through these practices low lying inundated areas and wetlands to be used cultivating morning glory to serve the dual purposes – one as a delicious leafy vegetables of high nutritive value and the other as an ideal substratum for carp culture in particular.

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A status overview of fisheries and aquaculture development in Pakistan with context to other Asian countries

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The fisheries sector plays an important role in the alleviation of poverty and the achievement of food security in many parts of the world. In many economies, fisheries exports generate more foreign exchange than the revenues earned from any other traded food commodity such as rice, cocoa, coffee or tea (FAO 2004). According to the Economic Survey of Pakistan 2006-2007 (ESP 2006-2007), fisheries are the principal source of livelihoods for many rural communities inhabiting the long coastline of Sindh and Balochistan, as well as inland along the major rivers, and in the vicinity of lakes and dams. In 2006 the total fish production was 604,900 metric tons (Table 1). The fisheries sector is estimated to provide direct employment to about 379,000 fishermen and 400,000 people in ancillary industries (State Bank of Pakistan).

In Pakistan the domestic consumption of fish at 1.9 kg per capita is amongst the lowest in the world. However, fish are also an important source of nutrition for many people, particularly in rural areas, containing 15-20% protein with high levels of vitamin A, phosphorous and many other useful dietary supplements, in addition to low cholesterol content (Mazid 2002).

During 2006-2007 the fisheries sector witnessed a growth of 4.2 percent (ESP 2006-2007). Although the fisheries sector represents only a small amount of Pakistan's total GDP it contributes substantially to the national income through export earnings. Figures from the Trade Development Authority of Pakistan (TDAP) 2007 indicate that fish and fish preparations are among the top 16 export items and second among primary commodity category exports after rice (Figure 1). During 2006-07, a total of 123,615 metric tons of fish and fisheries products were exported, earning US$ 188 million (TDAP 2007). The top 10 countries to which fish were exported fish include China, U.A.E, Thailand, Belgium, Malaysia, Korea, Hong Kong, Saudi Arabia, Japan and Sri Lanka (TDAP 2007). The bulk of the captured fisheries from the marine areas go into low value usages (ESP 2006-07).

Pakistan has a considerable extent of resources i.e. 0.29 million sq km of marine (National Institute of Oceanography, 2007) with 1120 km long coastline and approximately 8.6 million ha of inland waters with details as mentioned in table 2 below.

Although aquaculture has been growing at a good pace in Pakistan, an in-depth analysis clearly indicates that it utilises only around 1% of the available water resources while others such as waterlogged areas (56%) and flood water areas (18%) return a haphazard fisheries production (Figure 2). Of the millions of hectares of waterlogged areas created due to massive irrigation systems, practically no attempt has been made to use these water bodies for fish culture (FAO 2003a). Careful planning is needed for judicious use of these underutilized areas for productive fish farming.

The situation is further aggravated by the fact that the average growth of aquaculture area and production are divergent to each other as far as the Sindh province (which hosts around two thirds of fisheries resources) is concerned (Figure 3).

Another impediment to the sector is its data deficiency. Either the data is lacking or its reliability is questionable. This can be gauged from the fact that the data of fish farms and the fish production both seem on lower side because there may be hundreds of fish farms which are not reported or could not be surveyed by the fisheries departments due to their meager manpower resources, non availability of sufficient operational funds, vehicles and other difficulties including the law and order situation. This can be supported by the fact that only in one district i.e. Shikarpur a difference of more than 500% was found in data available (1994) and the survey conducted in 1996. According to the survey 8008 acres were recorded as compared to 1436 previously recorded in District Fisheries Office. The difference is plotted in Figure 3.

Keeping in view the above, up to 40% of fish ponds seem to be missing from the record. This situation demands extensive surveys to be carried out in the country, especially in far flung inland areas, to bring out the actual figures. The matter is similarly true for the data pertaining to the fish production in the country specifically of the inland areas because the fish catches that culminate at small inland markets and subsistence fish catches also need to be accounted for a complete picture of fish production in the country.

Pakistan's commercially important marine fish fauna comprise of some 250 demersal fish, 50 small pelagic, 15 medium-sized pelagic and 20 large pelagic fish. In addition, there are 15 commercial species of shrimp, 12 of squid/cuttlefish/octopus, and five of lobster. The freshwater fauna comprises more than 200 fish species and 35 of shellfish including prawns and crabs. Around 20 fish species are commercially important.

According to various partial surveys carried out in the continental shelf area to explore fisheries resources, Pakistani waters provide a fishing potential of up to 1.0 million tonnes per annum from marine sources alone (Table 3) which can be increased through sea ranching and conservation measures such

Table 1: Total fisheries production in Pakistan 2006

Fish Production (2006)	Quantity ('000' tons)
Marine	425.0
Inland	179.9
Total	604.9
Source: MINFAL	

Table 2: Pakistan's water resources

Resources	Area
Marine (sq km)	
Continental Shelf	50,270
Exclusive Economic Zone	240,000
Total Marine	290,270
Freshwater (ha)	
Rivers/ streams	3,102,408
Canals, Drains & Abandoned canals	346,803
Lakes	127,109
Dams/ reservoirs	195,670
Waterlogged areas	3,031,600
Deltaic Area	700,000
Flood Water Area	1,000,000
Fish farms	60,230
Total Freshwater	8,563,820
Source: DOF Sindh Province 2004, * WWF Pakistan.	

Table 3: Fisheries resources potential

	Makran Coast	Sonmiani Bay/ Sindh Coast	Total ('000 tonnes)
Small pelagic	140-240	320-520	450-750
Demersal	120-200	170-290	300-500
Total	260-440	490-810	750-1250
Source: Surveys of Pakistan Fishery Resources, September 1983 to June 1984 - Summary of Findings Dr. Fridtjof Nansen (UNDP/FAO Programme GLO/82/001).			

as declaring marine protected areas and alternate fishing zones to sustain yields. Whereas the Extensive Riverine Irrigation System which is one of the world's largest contiguous irrigation systems, covering around 63,000+km (FAO 2003a) provide a wide network of canals, lakes, ponds, marshes, waterlogged areas, natural depressions, dams etc; covering more than 8 million hectares; has an immense potential to produce high stocks of fish.

FAO's "State of World Fisheries and Aquaculture 2004" (FAO 2004) states that in 12 of the 16 FAO statistical regions at least 70 percent of stocks are already fully exploited or overexploited, suggesting that that the maximum fishing potential has been reached and that more cautious and restrictive management measures are needed. The report further indicates that "…world marine fish production from capture was 87 million tonnes in 2000, which decreased to about 84 million tonnes in 2001 and was constant in 2002". The next issue of the same publication, SOFIA 2006 (FAO 2007), concludes that the "marine capture fisheries – when summed together worldwide – seem to have reached a ceiling". The same situation seems to be prevailing in Pakistan too, the fish production from marine as well as inland capture fishery has been decreasing or is stagnant except for a little rise during 1999 (Figure 4).

Table 4: Fisheries and aquaculture production of selected Asian countries

Country	Freshwater area (ha)	Aquaculture production (tonnes)	Aquaculture growth rate	Per capita fish consumption (kg)	Total (culture+capture) production (tonnes)	Exports (value in '000' US$)
India	5700000	2 837 751	6.3	5.0	6 318 887	1591851
Bangladesh	4,560,900	882 091	7.8	15.0	2 215 957	359472
Sri Lanka	n.a.	1 724	n.a.	25.0	163 684	3137
Indonesia	1165000	1 197 109	6.9	23.6	5 578 369	1802961
Malaysia	n.a.	175 834	7.8	60.0	1 390 017	634370
Philippine	n.a.	557 251	-0.4	n.a.	2 803 603	347830
Viet Nam	1700000	1 437 300	30.6	30.0	3 367 200	2741127
Myanmar	n.a.	474 510	45.1	n.a.	2 217 466	460057
Nepal	n.a.	22 480	n.a.	1.6	42 463	15
Iran	n.a.	117 354	16.5	6.1	527 912	34,107
Thailand	8,563,820	1 144 011	10.8	32.0	3 743 398	4465767
Pakistan	n.a.	80 622	4.2	2.2	515 095	194

Table 5: Comparison of water resources and production in Pakistan and Bangladesh

	Area		Production ('000 tonnes)			
	Marine (km^2) ***	Freshwater (ha)	Marine	Freshwater	Total	In million tonnes
Pakistan* (2006)	290,270	8,563820	425.0	179.9	604.9	0.60
Bangladesh** (2003-2004)	207,163	4,560,900	455,207	1,646,819	2,102,026	2.1
Source: *MINFAL PK **Fishery Statistical Yearbook of Bangladesh 2003-2004, ***FAO						

According to FAO statistics, the contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals continues to grow, increasing from 3.9 percent of total production by weight in 1970 to 27.1 percent in 2000 and 32.4 percent in 2004. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.8 percent per year since 1970, compared with only 1.2 percent for capture fisheries and 2.8 percent for terrestrial farmed meat production systems over the same period. Production from aquaculture has greatly outpaced population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.1 kg in 2004, representing an average global annual growth rate of 7.1 percent. In 2004, countries in Asia and Pacific accounted for 91.5 percent of the production quantity and 80.5 percent of the value in the world aquaculture production, with China, India, Viet Nam, Thailand, Indonesia and Bangladesh among the top 10 producers in aquaculture production. Further, the majority of aquaculture production of fish, crustaceans and molluscs continues to derive from the freshwater environment (56.6 percent by quantity and 50.1 percent by value). Mariculture contributes 36.0 percent of production quantity and 33.6 percent of the total value (FAO 2007).

Figure 1: Source: Economic Survey of Pakistan 2002-2003

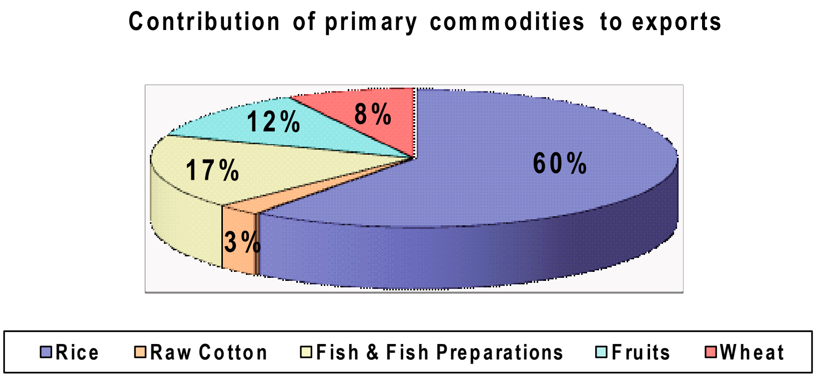
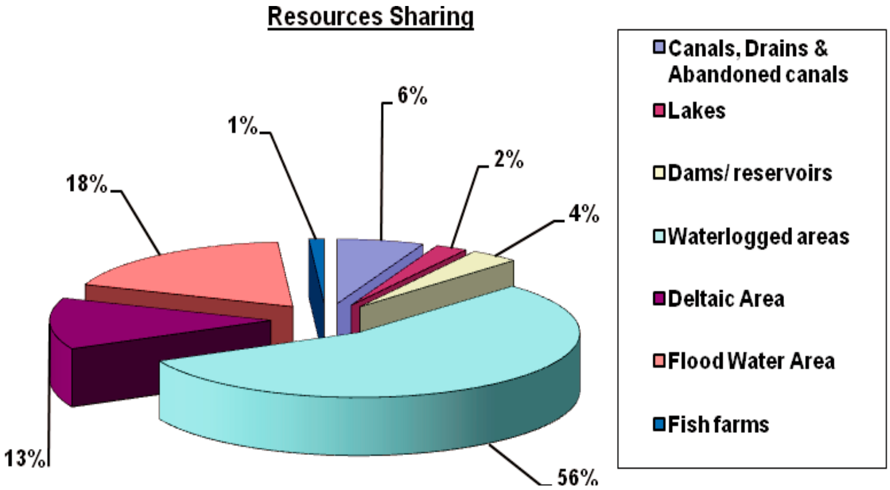


Figure 2: Source: DOF Sindh Province



This situation requires taking necessary steps to enhance fish production from the existing resources on one hand and to explore new ways to get additional production through aquaculture, on the other. Although Pakistan has better growth in fisheries sector, an eye on some selected Asian countries (table 4) will help to compare ourselves in an overall scenario (data correspond to the year 2005 except where indicated).

Viet Nam and Thailand are the highest foreign exchange earners in the region mainly as a result of the export oriented growth in their aquaculture production (FAO 2007). On the other hand, Bangladesh which seems to be a natural role model in fisheries sector for Pakistan due to many aspects including similarity in fish fauna, climatic conditions, socio-economic behaviour, socio-demographic characteristics of farmers etc, has almost half the Inland fisheries resources to Pakistan but 7-8 times more production, only from inland sector, 53 % of which comes from aquaculture (Mazid 2002). According to FAO, Bangladesh was the sixth top country in aquaculture production with 914,752 tonnes and third top in inland capture fisheries with a catch of 732,000 tones (FAO 2006). The obvious reason behind this extraordinary performance being the higher development investments from government as well as donor sides. In Bangladesh, 54% of all the investments in the fisheries sector have been spent on aquaculture development (Mazid 2002). A comparison of Pakistan and Bangladesh has been given in table 5 to readily assess the above situation.

The fisheries sector needs prompt attention with regards to planning vigorous efforts to enhance production from all resources including marine, brackish and freshwater, which have tremendous potential for fish and shellfish production especially through aquaculture development. While planning, it is necessary to consider global trends which clearly show that more than 60% (28.9 million tonnes) of aquaculture production comes from inland areas. In the local scenario inland areas offer considerable opportunity for aquaculture growth owing to the extensive irrigation system and water logged areas that could be made available to aquaculture with little modification. In contrast, the coastal areas are sparsely populated and would require relatively huge investments most probably by corporate culture. As such the inland aquaculture sector needs to be addressed on priority basis.

It is essential to divert the aquaculture sector towards export orientation by changing culture practices and adopting species suitable for export markets. This will also boost the rural economy and play in poverty alleviation among farming communities. Overall, aquaculture development can boost the economy of the country through export earnings. It is thought that the fisheries have the potential to bring in US$ 1 billion annually (EC Prep report June 2005).

Recommendations

In this context following recommendations are put forth for the steady growth of fisheries and aquaculture sector in Pakistan. These measures include:

- Shrimp are an important source of export earnings and as such shrimp culture needs due consideration, but this should not ignore the environmental impacts and should adhere to the International Principles for Responsible Shrimp Farming 2006 and FAO's "Code of Conduct for Responsible Fisheries".
- There is potential for enhancing fish production from irrigation and multipurpose reservoirs through stocking and conservation programs.
- Pen and cage culture need to be developed on priority basis in irrigation canals, lakes/ reservoirs and coastal areas to improve fish production from these huge resources which at present are underexploited.
- Pond culture needs to be improved on intensive lines; more importantly catfish and tilapia culture need immediate attention.
- As indicated by the global trends, new vistas in aquaculture may be explored which include prawn and crab culture, oyster culture, seaweeds culture etc.
- Integrated Fish Farming (IFF) is an area that has a tremendous potential for producing additional fish if promoted. Poultry farming and cattle raising is well developed and can be integrated with fish culture; rice-fish culture has a high potential.
- Improvements in post harvest technology and value additions for better export earnings need to be taken into consideration.
- It is essential to divert culture trends towards export markets by changing the culture practices and selecting species of demand in export markets.
- Food safety measures must be ensured as per the principles of HACCP, SPS and CODEX in order to capture higher portion of foreign markets and enter the competitive environment under WTO. These need implementation at all levels from production to consumption and capture to culture.
- Soft small and medium loans (microfinance programmes) with easy accessibility to aquaculturists and fishermen need to be made available.
- Cluster development of aquaculture along the coast with provision of all the basic amenities can bring about a major breakthrough in coastal aquaculture production. Allotment of land in these clusters should be made only to solid investors with time-bound terms of reference.

Figure 3: Growth of aquaculture

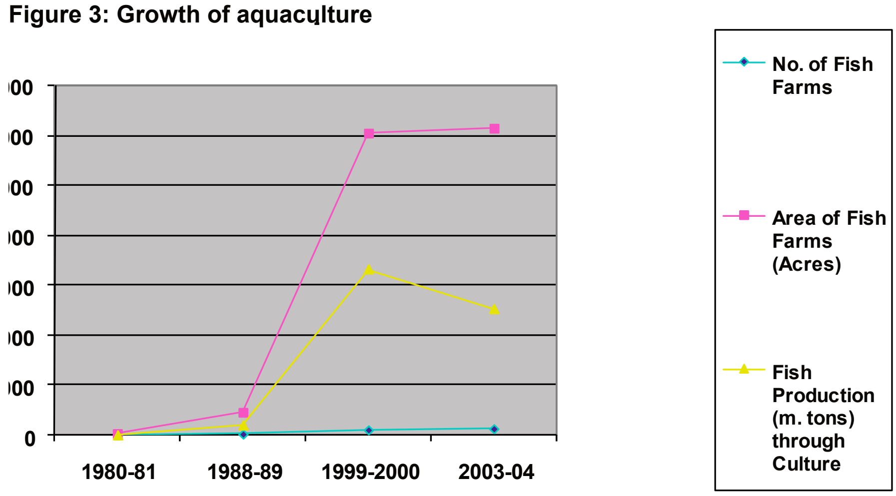


Figure 4. Source: Jarwar AMA, 2004

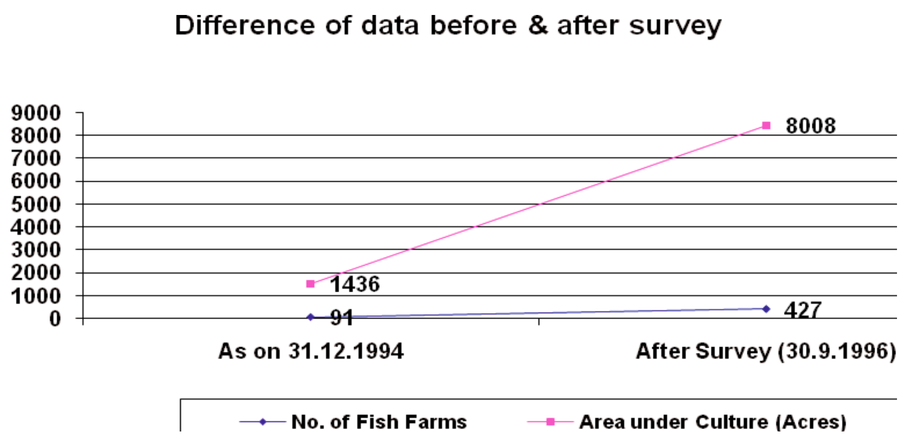
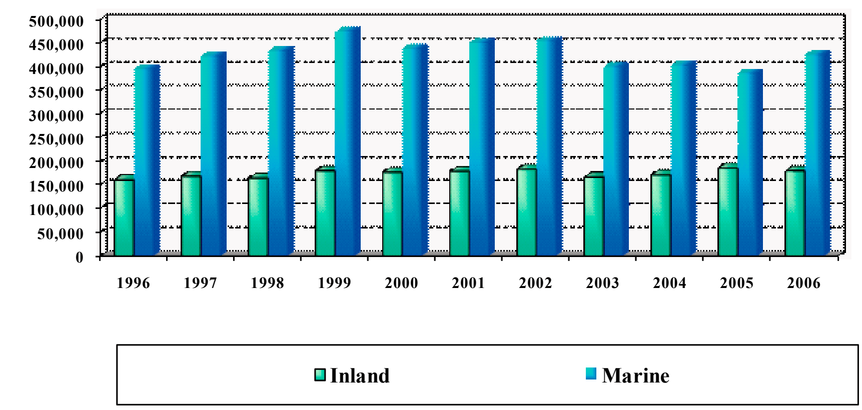


Figure 5. Source: MINFAL



- Tax holiday for aquaculture industry and processing zones is a must for rapid growth of sector including duty free imports of latest machinery.

- Effective extension services are needed to be established with quality assurance for steady growth of the sector. The private sector may also be involved in this area.

- Fisheries and Aquaculture should be brought under a "code of practice" to be devised in line with FAO's "Code of Conduct for Responsible Fisheries".

- Protected areas (PAs) should be declared and enforced and alternate fishing zones may be introduced to provide relief to fish and shellfish stocks.

- Sea ranching should be investigated as a means to reduce pressure on natural stocks.

- Fine mesh nets used for trapping fish meal species catch significant amounts of juvenile fish of larger species and small edible fishes as well as endangered, associated or dependent species, without any consideration of target or non-target species. These need to be strictly stopped from such practices and such nets removed from creeks areas to protect the fisheries resources.

- Community Based Fisheries Management should be encouraged for sustainable management of fisheries resources.

- The annual fishing-ban be implemented in its nature and spirit and alternate means of livelihood should be provided, along with incentives, to the fishing communities to sustain traditional fishing grounds.

- All this cannot be achieved without capacity building of concerned institutions for which following steps can be taken:

- The organizational structure of fisheries institutions needs to be strengthened and widened and the nature of posts/skill staff adjusted to allow specialized work to be conducted.

- A better remuneration packages for employees needs to be adopted to assist in recruitment and retention of specialist staff, improve productivity and eradicate corruption.

- The R and D wings in the fisheries departments are not commensurate with the needs of the sector therefore they need to be upgraded and streamlined.

- There are many organizations involved in research on fisheries and aquaculture on federal and provincial level. These efforts need to be monitored and coordinated as well as streamlined as per the applied requirements of the sector.

- Infrastructure development is required to make available sufficient hatcheries, nurseries, soil and water testing and disease diagnostic laboratories, extension/support centers and vehicles for extension staff to support the industry.

- To cater the post harvest improvements small jetties and processing plants need to be established along the coast, rivers and inland lakes along with allied facilities of cold storage, fish carrying boxes, insulated transportation vehicles etc.

- Intensive training programmes should launched for human resource development in the sector for which overseas trainings need to be arranged for fisheries managers and trainers. The fisheries training facilities must be functionalized to the maximum capacity and multifaceted working for training of farmers and fishermen.

- Aquaculture development authorities may be established with clear mandate to develop inland and coastal areas and full support should be extended to these bodies. Such authorities should be equipped with effective extension tools and a committed team with chalked out targets and strategy to achieve the set targets in stipulated time frame.

- As the nature of fisheries resources and the problems of the fisheries sector are different from livestock or agriculture, it is necessary to separate and strengthen the fisheries administration at both federal and provincial levels.

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The changing face of post-grad education in aquaculture: contributing to soaring production and sustainable practices

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The range and type of post-graduate education and training available in Asia and further afield continues to develop and increase to meet the needs of the sector. As the production and value of aquaculture has soared over the last two decades new opportunities to gain the right qualification has become ever more important to open the right door and, in time, the career of choice. Typical profiles and expectations of students have changed significantly over this period as has the range of study options. Twenty years ago the overwhelming proportion of MSc students enrolled on programmes at AIT, Stirling or Auburn, who were major established providers at the time, were government officers typically supported by overseas development assistance. Increasingly, applicants work for non-government and the commercial sector or have aspirations to do so. The growing diversity of employment also means that the type of skills required in graduates is changing. Many employers now require new recruits to have a broad range of problem solving skills in addition to technical knowledge including capacities for management, information handling and communication. Understanding of how institutions function and the social and economic implications of aquatic resource management are now considered mainstream skills. On the other hand specialised skills are also increasingly required in fish health, genetics, environmental management and nutrition as production systems become more technology driven.

The old adage that the qualification allows the learning to begin 'on the job' is less acceptable as employers seek to recruit those best prepared for specific roles and this has led to increasing demand for graduates with employment experience. Rapid changes in aquaculture practice have also led to an urgent need for upgrading/retraining of those already within the sector and related sectors.

These trends occur at a time when the separation of study and employment is becoming less practical due mainly to the high costs of full-time dedicated study. Not only are programmes increasingly expensive but loss of earnings and career opportunities need to be considered, quite apart from consequences for family life.

Engagement in a work situation in parallel to study can also make learning more effective as the application of knowledge within work situations can help to deepen the learning process. There are several approaches to this including making post-graduate education more flexible and managed around work as short intensive modules, using internships as part of full-time study options and part-time distance learning whilst remaining in employment.

Flexible study options are becoming increasingly popular with employers who may wish to support staff development without losing key employees for long periods of time. 'Sandwich' courses are not new but there is a trend towards modularising programmes, thus making them more flexible, among aquaculture programme providers such as the Asian Institute of Technology[1] and University of Stirling[2]. This flexibility can be particularly important to employers with limited numbers of employees; loss of a key member of staff for prolonged periods of time to overseas study can have significant costs and extended periods of time spent away tend to mean longer periods for readjustment and return to normality on their return. Ideally, shorter periods of study are less disruptive to work and family life.

Credit sharing is also a trend that should allow greater mobility of students but is dependent on harmonisation of programme structures and assessment. Universities such as Ghent and Wageningen have long shared credit but now a larger range of institutions are involved through various EU programmes encouraging such trends. Patrick Sorgeloos[3] from Ghent is working to extend these arrangements to Vietnam and allowing more flexible study between Belgium and Vietnam to the benefit of students registered for study in both countries. The rapid growth of aquaculture in Asia has encouraged interest among Europeans in studying in the region. Ad hoc placement for research projects and study tours have become established features of European programmes but these are now developing into more formalised internship arrangements such as that supported under the EC-funded Asia Link programme[4] between AIT, Universities in Vietnam, Cambodia and Nepal and Stirling, UK and Alveiro in Portugal. This programme includes opportunities for both Asian and European students to engage in placements with private and public sector partners. Ideally such internships provide benefits to both parties, with the student or new graduate gaining work experience and opportunities for mentoring from professionals and the employer gets the enthusiasm, energy and fresh ideas of working with an individual beginning their career. Other benefits include those associated with cultural exchange and friendships that form with such short-term but intensive internships. Mutual benefit is the key feature of internships and their design and the management of participants and local mentors is taking various forms to ensure this. Nick Innes-Taylor[5] of Wetland Alliance, a SIDA-funded programme working in SE Asia, insists that potential interns develop work programmes based on problems identified by the local host organisations. A short accessible report of the intern's key findings is a required output before leaving the site.

An innovative approach to combining postgraduate training and employment is on-going in Bangladesh where Stirling and the Bangladesh Agricultural University are delivering a blended distance learning programme in Aquatic Resource Development to over 60 students living and working throughout the country. Funded by the Common-wealth Scholarships Commission, the programme allows people to study while working, primarily targeting students for whom a conventional face-to-face course, locally or overseas, is not an option. Studying at distance has its own challenges and students need high levels of motivation to complete the certificate (yr 1), diploma (yr 2) and full masters (yr 3). The programme is designed around successive modules over the first two years followed by a project year based on a part-time commitment of 10-15 hours/week. Regular contact with local tutors by mobile phone and with UK-based tutors through the internet helps to support students self-learning. Continuous assessment of participation in discussion boards and electronically submitted assignments are key features of the programme. The relationship with the workplace is critical; potential participants require letters of support from their employers and the project year is designed around an issue identified by the student and his/her employer.

The education and training session of the WAS meeting at Busan, Korea will be reflecting on the changing face of education with representatives from Asia, Australia and Europe. Flexible learning, the role of internships and combining work with study through Distance Learning will be featured.

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Hatchery management in Bangladesh

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To meet the increasing demand for animal protein in Bangladesh, adoption of intensive and extensive culture practices on certain selective species of fishes is very important. Induced spawning has opened the door of new era in the production of fish throughout the world.

For intensive and extensive fish culture it is necessary to ensure the supply of suitable sized good quality fish seed in sufficient quantities. The main source fish seeds in Bangladesh are spawn produced in government and private hatcheries, and some collected from rivers.

The seed collected from natural breeding grounds have many problems such as the inclusion of seed of predatory fishes or disease. Wild seed is collected and handled in crude and unscientific methods that can potentially lead to large scale mortality during transportation from collection centres to nursery ponds and also in the nursery ponds after release. Therefore, emphasis should be placed on expansion of hatchery facilities to supply high-quality fish seed required to support aquaculture development.

For proper planning, management and sustainable development of hatcheries it is necessary to identify the specific problems and requirements of an area. We conducted a survey to collect information on hatchery management that we hope will be helpful to fish culturists, farm managers, production specialists, policy makers and extension workers. The results of the present study will also provide valuable information to researchers who are interested to conduct similar type of study in future.

Materials and methods

Production season of fish seed generally starts in March and ends by late August every year. However the survey for collection of data was conducted during March to September. The study area was Kotwali Thana under Jessor district. Data was collected by direct interviews with individual respondents. Questions were asked systematically in a very simple manner with explanation wherever it was felt necessary and the information recorded.

Results and observations

Establishment of hatcheries

The establishment year of the surveyed hatcheries ranged from 1981 to 1985. The maximum hatcheries in the surveyed area were established in 986-91. Table 1 shows the year of establishment of the hatcheries in the studied areas.

Occupation of the hatchery owners

On the basis of occupation the hatchery owners have been divided into two types. The first type is hatchery business only and the other type is hatchery business and others. Among the surveyed 21 hatcheries owners, nine earn their livelihood from only the hatchery business and 12 had other business interests such as service, agriculture etc.

Educational status

The educational status of hatchery owners of the surveyed areas are presented in table 3. Out of 21 private hatcheries owners 9.52% were illiterate but had the ability of signature. About 14.29% and 23.81% of hatchery owners had primary and high school education respectively. 23.81% and 19.02% hatchery owners had SSC and HSC level education respectively. Only 9.52% owners had graduation level education.

Training status of hatchery owners

The training status of the private hatchery owners are presented in the table 4. Out of 21 private hatchery owners 14.29% had no training while 19.05% had received short term training from the District Fisheries Office. 55% owners received training from others owners / farm managers. The rest gained their knowledge on hatchery operation through personal contact with the Upazilla Fisheries Office.

Source of funds for hatchery operation

About 47.62% of owners had funds for seed production from their own sources. About 33.33% and 14.29% of owners got their funds as a loan from relatives and friends and from banks respectively. Only 4.76% hatchery owners got their loan from NGOs. It was observed during investigation that there was less contribution of NGOs and there was no contribution of the money lenders (mohazon) in the survey areas.

Transportation facilities

During investigation it was observed that the hatchery owners had no transportation facilities of their own. The buyers hired truck or pick up vans even manually operated vans for hatchlings transportation.

Communication facilities of hatcheries

The communication facilities of surveyed fish hatcheries are shown in table 6. About 52.38% owners mentioned the facility as excellent i.e. they are satisfied for existing communication facility while 37.08% and 9.52% owners mentioned the facility as good and not good respectively.

Status of employees of hatcheries

Status of the staff of hatcheries is presented in table 7. From the table it is found that the surveyed hatchery had no specialist but they employed skilled

Table 1: Year of establishment of the hatcheries in the region under investigation

Year of establishment	No. of hatcheries	Percentage
1980-85	7	33.33
1986-91	11	52.38
1992-97	211	14.29

Table 2: Occupation status of the hatchery owners of surveyed area

Type of occupation	No.	Percentage
Only hatchery business	9	42.86
Hatchery+service	5	23.81
Hatchery+agriculture	6	28.57
Hatchery+others	1	4.76

Table 3: Educational status of the hatchery owners of the studied area

Educational status	No. of hatcheries	Percentage
Illiterate but having ability signature	2	9.52%
Primary education	3	14.29%
High School Education	5	23.81%
S.S.C Education	5	23.81%
H.S.C Education	4	19.02%
Graduate Education	2	9.52%

Table 4: Showing the training status of hatchery owners

Source of training in fish seed production	No. of hatcheries	Percentage of hatcheries with trained personnel
No training	3	14.29
Short term training	4	19.05
Consulting with UFO	14	66.67
Others	1	0

Table 5: Funding source of the hatchery owners of the surveyed area

Source of funds	No. of hatcheries	Percentage
Self	10	47.62
Self + relatives + friends	7	33.33
Bank	3	14.29
Self + NGOs	1	4.76
Mohazons	0	0

Table 6: Communication facilities of the hatcheries

Type of communication facilities	No. of hatcheries	Percentage
Excellent	11	52.38
Good	8	37.08
Not good	2	9.52

Table 7: Status of staff of fish hatcheries in the surveyed area.

Type of employee	Temporary employee	Permanent employee	Mean monthly salary	Mean daily salary
Officer	0	0	0	
Specialist	0	0	0	
Skilled	12	9	3895.24±332.38	87.14±3.73
Unskilled (labours)	119			

and unskilled labourers. Labourers work as permanent and temporary basis. The ean monthly salary of skilled labourers was Tk. 3895.24 ± 332.38 and mean daily salary of unskilled labours was Tk, 87.14 ± 3.73.

Area of hatcheries

It was observed that the maximum area of hatcheries in the surveyed area was 24.75 decimals and minimum was 5.78 decimal with an average of 11.12 ± 5.19 decimal. Hatchery sizes of the study area are shown in table 8.

Number of ponds in hatcheries

The present investigation deals with the only fish seed producing hatcheries. This type of hatchery cannot rear fry or fingerlings as they do not have nursery or rearing ponds, only producing spawn. They had only stocking ponds for brood stock management. The maximum number of stocking ponds was six and the minimum was two with an average 4±1.05. During investigation it was observed that every fish hatchery owner had their own brood stock pond. As regard to ownership it was observed that the ponds were their own or leased.

Water and soil quality of ponds

Table 10 shows the water and soil quality conditions of the ponds. Answering the question about water and soil quality about 80.95% and 19.05% owners claimed that water qualities of their hatcheries were satisfactory and moderately satisfactory.

In terms of soil quality of the ponds about 90.40% and 9.52% owners of the hatchery mentioned as satisfactory and as moderately satisfactory respectively.

Occurrence of fish disease in hatcheries

About 95.24% owners reported that there were no fish disease problems in their farms, while the rest of the owners reported that there were occasional attack of fish disease. It was a remark-

Table 8: Area of hatchery in the surveyed area

Area (ac)	No. of hatcheries	Percentage
0.05-0.110	13	61.90
0.1-0.15	3	14.29
0.15-0.2	3	14.29
0.2-0.25	2	9.52

Table 9: Shows the number of ponds in the hatcheries

Number of ponds	No. of hatcheries	Percentage
2	2	9.52
3	4	19.05
4	8	38.10
5	6	28.57
6	1	4.76

Table 10: Water and soil quality of the surveyed fish hatcheries

Characteristic	% of hatchery		
	Satisfactory	Moderate	Unsatisfactory
Water quality	80.95	19.05	0
Soil quality	90.48	9.92	0

Table 11: Occurrence of fish disease in private hatcheries

Category of occurrence of fish disease	No. of hatcheries	Percentage of occurrence
No disease	20	95.24
Seldom attack	1	4.76
Every year attack	0	0

Table 12: Category of land ownership of surveyed hatchery

Category of land	No. of hatcheries	Percentage
Own	7	33.33
Own + leased	11	52.38
Only leased	3	14.29

Table 13: Data showing the supplementary feeding used in different hatcheries

Name of feeds	Minimum	Maximum	Mean ± SD
Fish meal	10%	25%	18.14 ± 5.33
Oilcake	15%	38%	25.10 ± 5.39
Rice bran	20%	50%	38.9 ± 11.93
Wheat bran	6%	22%	12.67 ± 4.74
Flour	2%	6%	4.38 ± 1.16

Table 14: Showing the use of fertilizers in different hatcheries

Name of fertilizer	Minimum	Maximum	Mean±SD
Urea	4%	12%	7.43±2.45
TSP	3%	10%	6.12±3.14
MP	1%	3%	2.1±1.32
Cow dung	10%	15%	7.8±2.15

able observation that in no farms was there any serious fish disease problem in the survey period.

Category of land ownership

61.90% owners reported that the land used for hatchery purposes was their own land and the rest 38.10% reported having both leased and own land. But no owner had only leased land for hatchery purposes. Table-12 shows the category of land ownership percent distribution.

Supplementary feeds used for brood fishes

During the present investigation it was found that the use of feed for brood fish was comparatively common. These type of feeds were used for better growth of brood fish. Both inorganic and organic fertilizers were used to increase the pond vegetation and productivity. The types of feed, fertilizer, lime used by the private hatcheries are shown in table 13.

Fertilizer

The types of fertilizers used in private hatcheries in this region are urea, TSP, MP and cowdung:

- Urea: Fertilizer urea used in these hatcheries ranged from 4% to 12%. TSP: Fertilizer TSP used in these hatcheries ranged from 3 to 10%.
- MP: Fertilizer MP used in these hatcheries ranged from 1% to 3% with an average 2.1 ± 1.32%.
- Cowdung: The use of cowdung in these hatcheries ranged from 10% to 15%.

Problems and constraints faced by private fish hatchery owners

The problems and constraints faced by the private fish hatchery owners in the study area have been categorized under four general types, such as technical, economic, social and natural. Fish seed farm owners responded to these problems regarding operation of their farms are presented in table 15. About 28.57% and 9.52% owners claimed that the production of farms hampered due to lack of technical knowledge and insufficient water in the dry season. Among economic problems it was reported that the lack of credit and lack of marketing system were crucial constraints. Among social problems the theft of fish and toll collection by terrorists were main constraints then the problems related to leasing. Only 23.81% of hatchery owners faced the problem of flood.

Table 15: Problems of the owners of private fish hatcheries in the surveyed area

Kinds of problems	No. of hatcheries	Percentage of total farms
A. Technical		
1. Lack of technical knowledge	6	28.57
2. Lack of chemicals and fertilizers	0	0
3. Non availability of food	0	0
4. Insufficient water in dry season	2	9.52
5. Diseases	1	4.76
B. Economic		
1. Lack of credit	6	28.57
2. Lack of marketing facility	2	9.52
C. Social		
1. Theft of fish	5	23.81
2. Poisoning in pond as enmity	2	9.52
3. Toll collection by terrorist	5	23.81
4. Joint partnership	3	14.29
5. Problem of taking lease of pond	4	19.05
D. Natural calamity		
1. Flood (caused by heavy rain)	5	23.81
2. Other natural calamity	0	0

Recommendations

The following policy and recommendations are suggested depending on the findings of the present study:

- Credit for fisheries is not easily available or institutionalized. An appropriate system to provide credit with low interest rate from institutional sources should be established.
- For overcoming the problems of inbreeding as suggested by hatchery owners (i) government hatcheries should have "brood banks" to supply quality broodstock to the private hatchery owners, (ii) collecting wild, non domesticated fish species from rivers or natural habitats, (iii) purchase cultivated, genetically improved species from other fish farms or hatcheries with well known origin.
- Government should take positive steps to train up interested people on modern methods of hatchery management.
- For induced breeding, supply of various types of inputs should be ensured at low cost and government should control and check the quality of inputs.
- For better seed production appropriate dosage for hormone should be administered.
- The problem of poor quality fish seeds due to inbreeding depression in the private hatcheries must be addressed.

Conclusion

Apart from some adverse socio-economic and other impacts, fish farms present in this region contribute a remarkable amount to inland fish production in Bangladesh. As the fisheries sector plays a vital role in the socioeconomic development, opportunity for employment, poverty alleviation of large number of population, we have to reduce all the adverse impacts of aquaculture for sustainable growth in the future. The NGOs and government

Production of *Cirrhinus molitorella* and *Labeo chrysophekadion* for culture based fisheries development in Lao PDR Part I: Captive spawning

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Project team inspecting one of the project study sites in Bolikhamxay Province.

The Government of Lao PDR is targeting an increase in fish consumption to 23 kg caput/year by the year 2020, almost a doubling of the current level of consumption. In view of the unlikely increase in capture fisheries, the envisaged increase in per caput consumption can only be realized through increasing aquaculture related production. A substantial increase in fish production could be obtained through effective and optimal utilisation of seasonal water bodies, such as flood plain depressions and reservoir coves for culture-based fisheries (CBF), a practice that requires little or no capital inputs and harnesses natural productivity of these water bodies for augmenting fish production (De Silva et al. 2006). The practice also is environmentally non-perturbing, compared to conventional aquaculture. Through village community participation, CBF augment current food fish availability, particularly in the lean period of the traditional wild capture fisheries (March to August), and raise the income of village communities.

The Australian Centre for International Agricultural Research (ACIAR) has recently instigated a project, Culture-Based Fisheries Development in Lao PDR (Project No. FIS/2005/078), which aims to develop best practice approaches and production models for CBF in Lao PDR that will improve the yields and economic benefits to village communities (Figure 1). This project involves collaboration amongst six institutions, two each in Australia (Deakin University and DPI, Victoria), two in Lao PDR (Department of Livestock and Fisheries - DoLF and Living Aquatic Resources Research Center - LARReC) and Thailand (Network of Aquaculture Centers in Asia-Pacific - NACA and Fisheries Faculty, Kasetsart University).

An important aspect of CBF is the production and provision of sufficient numbers of juvenile fish of selected species for stocking purposes. However, in Lao PDR fry/ fingerling production is low even though demand for stocking into both pond and rice-fish systems is high. Most fry produced in Lao PDR originate from the Provincial government hatcheries that have an overall production level of less than 15 million (Meenakarn and Funge-Smith 1998), which is insufficient to meet the needs of CBF.

The emphasis on aquaculture and CBF development calls for an increase in the quantity and quality of seedstock of a variety of species suitable for different forms of aquaculture practices. The Culture-Based Fisheries Development in Lao PDR project has identified two popular indigenous fish species, Cirrhinus molitorella (mud carp, “Pa Keng”) and *Labeo* (syn *Morulius*) *chrysophekadion* (black sharkminnow, “Pa Phia”) for use in CBF, based on their popularity and existing on-going culture. Their selection was also in accordance with the increasing trend in the region to lay emphasis on the culture of indigenous species in preference to exotics and or alien species.

This article is the first part of a two part series that aim to review current, readily available, information on these two indigenous species which will be used to improve and refine artificial propagation and culture techniques to support CBF development in Lao PDR. In particular, the review focuses on information within Lao PDR, as well information from the Mekong Fish Database (MRC 2003). See the next edition of Aquaculture Asia for Part 2 of this series.

Cirrhinus molitorella and *Labeo chrysophekadion*

Cirrhinus molitorella is a freshwater cyprinid native to Asia that inhabits lakes, rivers and reservoirs from the Mekong (Thailand, Cambodia and Vietnam) and Chao Phraya (Thailand) basins, to the Pearl River deltas (China) (MRC 2003, FishBase 2007) *C. molitorella*, which has fine meat texture, good meat quality and high nutritional value, is mainly sold live or fresh locally (Figure 2), but some is also canned, dried and salted, or minced to form a fish cakes or dumplings (FAO 2007a). *C. molitorella* has a long history in aquaculture being first undertaken in the Pearl River region of southern China during the Tang Dynasty (618-904 A.D.), and today is a well-established aquaculture species particularly in this region (FAO 2007b). Between 1990 and 2001, aquaculture production of *C. molitorella* was between 80,000 and 220,000 tonnes per year, the vast majority (>99%) was produced in China (FAO 2007b). *C. molitorella* is a popular aquaculture species in the Luang Probang Province of Lao PDR where it has been propagated and farmed since 1991 (Pinthip et al. 2001, Souksavath 2001, Somboon et al. 2003). In 2005 the Lao PDR produced just 3,100 tonnes (FAO 2007b).

Labeo chrysophekadion is one of the larger Asian cyprinids that is widely distributed throughout the Mekong (Thailand, Cambodia and Vietnam) and Chao Phraya (Thailand) basins, as well as the Malay Peninsula, Sumatra, Java and Borneo (Malaysia and Indonesia) (FishBase 2007). *L. chrysophekadion* is a very important commercial species in the Mekong River basin and in southern Lao PDR is one of the more expensive fish at the market (Singhanouvong and Phouthavong 2002). The species is caught with small to large scale fishing gear and sold in markets fresh (Figure 2), dried and salted, used widely in the aquarium trade, and has very good potential for aquaculture (Rainboth 1996, MRC 2003). However, capture fishery and aquaculture production statistics for this species are not readily available (FAO 2007a). Captive breeding and rearing of *L. chrysophekadion* has been described in both

This article is the first part of a two part series that aims to review current, readily available, information on two indigenous species *Cirrhinus molitorella* (mud carp, "Pa Keng") and *Labeo* (syn *Morulius*) *chrysophekadion* (black sharkminnow, "Pa Phia") for use in Culture Based Fisheries (CBF) development in Lao PDR. These two species are consumer preferred and are currently cultured to some extent. In this part the existing knowledge on the artificial propagation of these two species is reviewed, and these will be further improved and refined to ensure supplies of good quality seed stock to support CBF development in Lao PDR.

Fresh Cirrhinus molitorella (left) and L. chrysophekadion (right) at a provincial fish market in Lao PDR.

Thailand and Lao PDR (Pennapaporn 1970, Thavonnan and Udomkananat 1979, Thienchareon et al. 1989, Thienchareon et al. 1990, Tienchareon and Oonsrisong 1990, Unsrisong et al. 1990, Leelapatra et al. 2000, Thi et al. 2003).

Spawning seasonality

Most freshwater tropical fish species spawn during the monsoon season, and this is also the case for *C. molitorella* and *L. chrysophekadion* (1), thought to be primarily because rainfall increases the available habitats and nutrients for the hatchlings. The water quality of many water bodies usually improves, with increased oxygen and cooler temperatures. Hardness and pH of the water also change with the inputs of rainwater runoff (Meenakarn and Funge-Smith 1998).

Table 1. Spawning seasons of *C. molitorella* and *L. chrysophekadion*

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Country	Habitat	Source
C. molitorella														
				■	■	■	■					Lao PDR	Pond	Nuanthavong and Vilayphone 2005
					■	■						Lao PDR	Pond	Gorda 2001
					■	■	■					Lao PDR	River	Singhanouvong *et al.* 1996
L. chrysophekadion														
				■	onwards							Thailand	Pond	Laoobuth *et al.* 1993
					■	■						Cambodia	River	Bardach 1959, Sokheng *et al.* 1999
					■	■						Cambodia	River	Bardach 1959, Sokheng *et al.* 1999
						■	■					Thailand	River	Boonmon and Kantejit 1977
						■	■					Lao PDR	River	Baird *et al.* 1999
						■	■	■	■			Thailand	Reservoir	Boonmon and Kantejit 1977, Chabjinda *et al.* 1992
				■	■	■	■	■	■	■		Thailand	Ponds	Thienchareon *et al.* 1989, Tienchareon and Oonsrisong 1990

Table 2. Summary of hormone treatments for induction of spawning in *C. molitorella* and *L. chrysophekadion*

Species	Treatment	First injection	Second injection	Hours between injections	Source
C. molitorella	Suprefact® (ml/kg) + Motilium® (tablet)	♀ 0.2+one ♂ 0.1+?	Nil		Gorda 2001
	Suprefact® (µg/kg) + Motilium® (mg/kg)	♀ 15-18+10 ♂ 7-9+5	Nil		Nuanthavong and Vilayphone 2005
L. chrysophekadion	PG1 ("dose")	♀ 0.5-0.7	♀ 1.5-2.0	6	Thienchareon *et al.* 1989, Tienchareon and Oonsrisong 1990
	PG1 (mg/kg) + HCG (IU/kg)	♀ 2.3+500 ♂ 1.2+800	♀ 3.5+2,000 ♂ Nil	6-8	Thi *et al.* 2003
	PG1 (mg/kg) + LHRHa (µg/kg) + DOM2 (mg/kg)	♀ 2.0+0+0	♀ 4.0+150+15		Trinh Quoc Trong *et al.* 2005
	Suprefact® (µg/kg) + Motilium® (mg/kg)	♀ 5-8+5-10 ♂ 3-4+3-5	♀ 10-15+5-10 ♂ Nil	6	Tienchareon and Oonsrisong 1990, Leelapatra *et al.* 2000

1. PG = pituitary gland of either common carp or mrigal.
2. DOM = Domperidone

Injecting a L. chrysophekadion broodstock with a hormone to induce spawning.

Both *C. molitorella* and *L. chrysophekadion* are semi-migratory species that undergo upstream migrations to spawn. *C. molitorella* migrate upstream from December to March to spawn in the floodplains of large rivers during the rainy season, before returning downstream from June to August (MRC 2003, Nuanthavong and Vilayphone 2005). Riverine *L. chrysophekadion* migrate upstream from March to spawn early in the monsoonal flood season (June-July) (Boonmon and Kantejit 1977, Baird et al. 1999), whereas fish in reservoirs tend to spawn later and over a longer period (July-October) (Boonmon and Kantejit 1977, Chabjinda et al. 1992) (Table 1).

Captive spawning

The first hormone to be widely and successfully used for induction of fish spawning was carp pituitary gland (PG) extract. But in Lao PDR this method is not suitable due to the shortage of large sized cyprinid broodstock for extracting pituitary glands (Meenakarn and Funge-Smith 1998). Human Chorionic Gonadotropin (HCG) has also been successfully used to induce fish spawning and this can be obtained commercially as a "ready-to-use" dry hormone. This is more convenient to use than CPG and dosages for fish can be applied more accurately (De Silva et al. 2007). Luteinizing Hormone Releasing Hormone analogues (LHRHa) are highly effective (and affordable) in stimulating gonadotropin secretion and inducing ovulation in freshwater fish. One LHRHa in particular, Buserelin Acetate, is widely used to induce spawning in *C. molitorella* and *L. chrysophekadion*. Buserelin Acetate is readily available in commercial form, such as Suprefact® (Sanofi-Aventis) which is used primarily to treat humans with hormone-dependent advanced carcinoma of the prostate gland. The effectiveness of LHRHa is further enhanced when used in combination with a dopamine antagonist. Suprefact® is often combined with the domperidone Motilium® (Janssen-Cilag), an antiematic medicine used to relieve nausea and vomiting, and discomfort caused by gastroparesis in humans (Table 2).

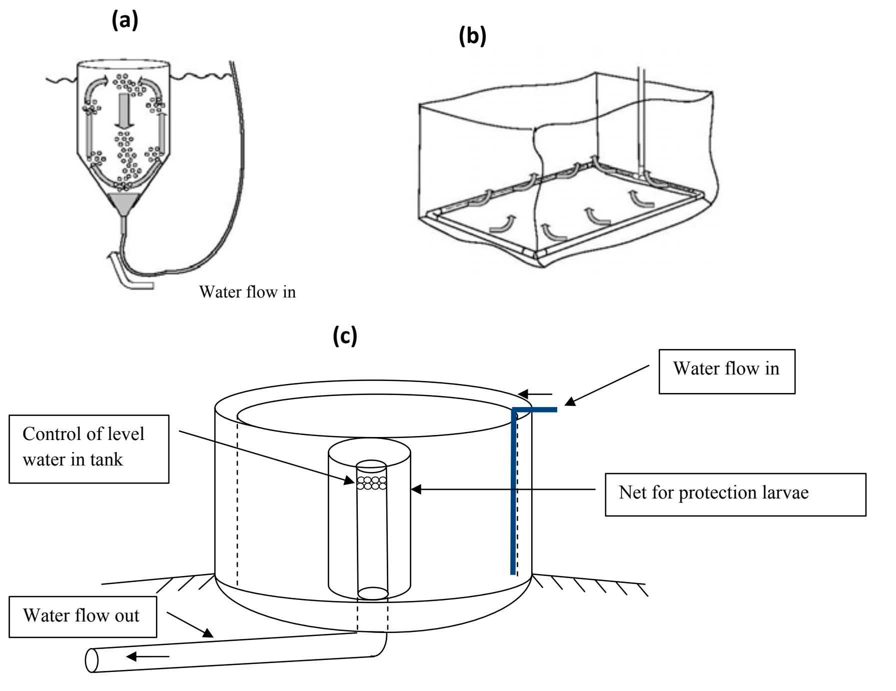
C. molitorella

C. molitorella production has been limited by dependence on use of wild-caught seed, until success in induced breeding technology for captive broodstock significantly promoted its farming (FAO 2007a). At present artificial propagation is the major source of *C. molitorella* seedstock, though seedstock may still be collected from the wild and used for grow-out and maintenance of genetic quality of broodstock (FAO 2007a). In Lao PDR, propagation of *C. molitorella* was initially achieved by collecting mature breeders from the wild, but since 1996 propagation of captive reared broodstock has occurred at the Naluang Station, and two private farms in the Luang Prabang Province (Nuanthavong and Vilayphone 2005).

In captivity *C. molitorella* reach sexual maturity from 300-500 g weight after 2-3 years (Gorda 2001), but will not spawn unless induced by hormone injection and environmental stimuli, such as flowing water (FAO 2007a). Female *C. molitorella* are induced to spawn with a single injection of Suprefact® (15-18 µg/kg) combined with the Motilium® (10 mg/kg), while a half dose is applied to males (Nuanthavong and Vilayphone 2005) (Table 2). Gorda (2001) injected females with 0.2ml/kg Suprefact® and one Motilium® tablet to induce ovulation, and males with 0.1 ml/kg Suprefact® and Motilium® to promote spermiation. Following injection, one female and two males are placed together in one tank and allowed to spawn naturally (Gorda 2001, Nuanthavong and Vilayphone 2005). Injections are given at 6:00 hours and spawning occurs 6 hours later at 26-27ºC (Nuanthavong and Vilayphone 2005), or at 21-22ºC, (Gorda 2001). *C. molitorella* often make a low mating call 'ku ku', with many bubbles coming up to the surface of water (FAO 2007a). Gorda (2001) reported fertilisation rates of 70-80% following spawning. The fecundity of C. molitorella is 80,000-100,000 eggs/kg (Gorda 2001, Nuanthavong and Vilayphone 2005). There is no information on the sperm of *C. molitorella*, though Gorda (2001) estimated there were 8-10 million spermatozoa per mL of milt.

L. chrysophekadion

In captivity *L. chrysophekadion* will reach sexual maturity within a year at a body weight of 600 g weight when cultured in earthen ponds



Egg incubators used for L. chrysophekadion and C. molitorella. (a) Jar for hatching eggs (source: Meenakarn and Funge-Smith 1998). (b) Hapa for hatching eggs (source: Meenakarn and Funge-Smith 1998). (c) Circular tank (Chinese model).

(Thienchareon et al. 1989), and can be induced to spawn from 800 g (Leelapatra et al. 2000) (Figure 3). *L. chrysophekadion* have been induced to spawn by hypophysation using PG from either common carp (*Cyprinus carpio*) or mrigal (*Cirrhinus cirrhosus*) (Table 2). Thienchareon et al. (1989) and Tienchareon and Oonsrisong (1990) found that two injections of 0.5-0.75 "dose" and 1.5-2.0 "dose" (actual concentration of "dose", ie active ingredient per kg fish, unknown) given 6 hours apart resulted in spawning 4-5 hours after injection. Thi et al. (2003) induced spawning in *L. chrysophekadion* with PG in combination with HCG; females were initially injected with 2.3 mg/kg PG and 500 IU/kg HCG, then re-injected with 3.5 mg/kg PG and 2,000 IU/kg HCG 6-8 hours later. Males required a single injection with 1.2 mg/kg PG with 800 IU HCG applied at the same time as the second injection of females (Table 2). Tienchareon and Oonsrisong (1990) and Leelapatra et al. (2000) induced spawning in female *L. chrysophekadion* with two injections of Suprefact® in combination with Motilium®; 5-8 µg/kg Suprefact® with 5-10 mg/kg Motilium® and 10-15 µg/kg Suprefact® with 5-10 mg/kg Motilium® 6 hours later. These fish spawned 4-5 hours after the second injection. The gametes are hand-stripped from the broodstock and combined using a dry fertilisation method (Tienchareon and

Small hapas used to incubate the eggs of C. molitorella.

C. molitorella eggs.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Oonsrisong 1990). Male fish require a single injection equivalent to half that of females, or are not injected (Thienchareon et al. 1989).

The fecundity *L. chrysophekadion* ranges from 10,000 to 300,000 eggs (Boonmon and Kantejit 1977) to 1.09 million eggs (in a 49 cm fish) (Kamonrat et al. 1972). L. chrysophekadion maintained in 600 m^2 have been reported to spawn twice within two months in the one spawning season (Thienchareon et al. 1990). In contrast, female *C. molitorella* apparently spawn once per season.

Egg incubation

Several methods have been used to incubate pelagic or semi-buoyant eggs of fish such as those of *C. molitorella* and *L. chrysophekadion* in Lao PDR. First, fertilised eggs can be incubated in hatching jars (up to 1million eggs/m^3) supplied with a constant flow of water and aerated (Figure 4a). Second, eggs can be incubated in an aerated hapa (Figure 4b) made from plankton netting that is suspended in a tank or pond (Figure 5). Alternatively, large numbers of eggs may be incubated in circular concrete or fiberglass tanks (eg. Chinese model) that are aerated and provided with a constant flow of water (Figure 4c) (Meenakarn and Funge-Smith 1998). One disadvantage of this latter technique is that a large quantity of fresh, filtered, water is required.

The eggs of *C. molitorella* (Figure 6) swell rapidly after fertilisation and placing in freshwater (Gorda 2001). In Naluang Station (Lao PDR), large circular tanks (Chinese model) are mainly used for incubating *C. motitorella* eggs. Nuanthavong and Vilayphone (2005) incubated eggs in hapas (100,000-150,000 eggs/hapa) held in a small concrete tank. The incubation period is temperature dependent; eggs hatch 12-14 hours after fertilisation at a water temperature of 23-24ºC (Gorda 2001), to 16-17 hours at 26-28ºC (Nuanthavong and Vilayphone 2005). Hatch rates are 60-90% (Gorda 2001, Nuanthavong and Vilayphone 2005).

The semi-buoyant eggs of *L. chrysophekadion* hatch 14-16 hours after fertilisation at 28ºC (Watanadirokul et al. 1983, Leelapatra et al. 2000), 18-22 hours at 20-30ºC (Tienchareon and Oonsrisong 1990) and approximately 12 hrs at 29-30ºC (Thi et al. 2003). Newly hatched *L. chrysophekadion* larvae are 6-7 mm in length (Watanadirokul et al. 1983). The fertilisation and hatching rates of *L. chrysophekadion* were 35-88% and 35-77%, respectively (Thi et al. 2003).

Acknowledgements

This review has been undertaken as part of the Australian Centre for International Agricultural Research (ACIAR) Project, Culture-Based Fisheries Development in Lao PDR (Project No. FIS/2005/078). The authors wish to thank the project leader, Prof. Sena S De Silva (Network of Aquaculture Centres in Asia-Pacific (NACA), Bangkok, Thailand), as well as Dr. Thuy Nguyen (NACA, Bangkok, Thailand), Mr Lieng Khamsyvilay (Director, Living Aquatic Resources Research Center (LARReC), Vientiane, Lao PDR), Mr Roger Khamphet (Deputy Director, LARReC, Vientiane, Lao PDR) and Mr Bouthong Saphakdy (Department of Livestock and Fisheries, Ministry of Agriculture and Forestry, Lao PDR) for support and advice during the preparation of this review.

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Application of ipil-ipil leaf meal as feed Ingredient for monosex tilapia fry (*Oreochronis niloticus*) in terms of growth and economics

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Background

By production volume, tilapia (*Oreochronis niioticus*) culture is one of the largest freshwater aquaculture species worldwide and is mostly produced using semi-intensive systems in developing countries (FAO, 2000). Tilapia was introduced first in Bangladesh in 1954 from Thailand (Ahmed, 1956). Legumes such as Ipil-ipil (*Leucaena leucocephala*) are potentially a valuable feed resource for aquaculture in the tropics because of their widespread distribution in those areas. Most varieties have not been evaluated as feed for fish. Ipil-ipil and leaf material of *Leucaena* compares favourably with lucerne in terms of crude protein (CP), calcium (Ca) and phosphorus (P), and it is also a good source of b-carotene. Under optimum growing conditions, *Leucaena* can yield large amounts of high quality forage (NAP 1984). Legumes provide high-quality protein and energy, the nutritive value and digestibility of tropical legumes is higher than that of tropical grasses and the quality of herbage from grasses rapidly declines with increasing maturity.

Methodology

As in most fish culture systems, balanced feed is one the most significant inputs in tilapia culture, and accounts for 30 to 60% of production costs (El-Sayed, 1990; Goddard, 1996; Tudor et al., 1996). Tilapia, however, are also able to feed on vegetables, grains, algae, zooplankton, etc., which has been proven in a number of nutrition studies (Belal and Al-Jasser, 1997). Substitution of fish meal in balanced feed has been vital to reducing feed costs, and overall tilapia production costs. The ipil-ipil tree was cultivated in the dyke and roadside of the research conducted in the Allahwala

Hatchery and fisheries project of Cox's Bazar, Bangladesh. The recently collected fleshy leaves were selected for processing into ipil-ipil leaf meal. The process involves drying the fresh leaves, grinding and screening to produce the final meal product.

Four ingredients ie. fish meal, soybean meal, ipil-ipil leaf meal and rice bran were used to formulate four experimental diets as per table 1. The control diet (1) contained no ipil-ipil leaf meal.

The experiment was carried out for a period of 21 days from the 21 May to 11 June 2006, in four 3 x 1.5m hapa, installed in a nursery pond with a bamboo frame. Each hapa contained three identical chambers for replication to study the growth of monosex tilapia fry under different experimental diets. Each diet was trialed in a one hapa to allow comparison of their effect on growth. 600 fry graded for approximately uniform size were stocked into each hapa, with each chamber containing 200 fry.

The monosex tilapia fry were conditioned to feed at the surface. Experimental diets were fed as a powder spread on centre of each chamber by a small plate to avoid feeding competition with exterior fish. The amount of feed supplied to reared fry was 25 % of the total biomass per day for first 10 days and 20% of total biomass per day for the following 11 days. The growth and survival of the reared specimens in each hapa with three replicates were recorded on three occasions at seven day intervals. Samples were collected from a number of sites within each chamber. 10% of the fry (20 individuals) were sampled from each chamber with total length recorded. The economic feasibility of the experimental diets was studied by analyzing the unit cost and total costs of all ingredients were used in the experiments.

Results of the experiment

At the end of the third week the mean body weight and body length was recorded as per table 2. The length increment of this present study was lower than previous results. Generally the length increment depends on size at stocking with the larger specimens obtain greater length. So, the present experimental results were significant.

Table 1. Experimental feed formulations

Feed component	Diet 1 (control)	Diet 2	Diet 3	Diet 4
Fish meal	33	30	30	35
Soybean meal	35	33	30	25
Rice bran	32	17	15	25
Ipil-ipil leaf meal	0	20	25	15

Table 2. Mean body weight and length of tilapia on different diets after 21 days

	Diet 1 (control)	Diet 2	Diet 3	Diet 4
Mean body weight	2.167±0.35g	2.183±0.34g	2.267±0.35g	2.5±0.38 g
Mean body length	5.17±0.30 cm	5.187±0.31cm	5.19±0.31 cm	5.30±0.32 cm

Table 3. Tilapia performance on the four experimental diets

	Diet 1 (control)	Diet 2	Diet 3	Diet 4
Absolute growth	919.26g	929.26g	979.26g	119.26g
Average daily growth rate	11.50	11.62	12.25	14
Specific growth rate	5.86%	5.90%	6.05%	6.52%
Feed conversion ratio	2.74	2.73	2.78	2.42
Feed conversion efficiency	36.43%	36.67%	35.99%	41.23%
Protein efficiency ratio	1.04	1.047	1.028	1.178

Table 4. Crude composition and cost of the experimental diets

	Diet 1 (control)	Diet 2	Diet 3	Diet 4
Moisture	13.31%	13.47%	13.55%	13.6%
Fibre	16.79%	15%	14.8%	16%
Fat	7.63%	7.41%	7.4%	7.5%
Ash	9.31%	9.24%	9.25%	9.3%
NFE	18%	19.38%	19.7%	18.65%
Preparation cost/kg (Tk)	20.82	18.33	17.85	19.15
Unit cost/kg (Tk)	45.6	35.46	35.71	34.65

The performance of the different diets were assessed in terms of absolute growth, average daily growth rate, specific growth rate, feed conversion ratio, feed conversion efficiency and protein efficient ratio as per the table 3. Survival was100% in all experimental diets. Overall, a better growth of the reared tilapia was obtained using diet 4 which contained mixed protein of plant and animal origin. The present experiment demonstrated that tilapia show very poor growth when *Leauceana* constitutes 25% or more of the dietary protein. During the course of the experiment water temperature ranged from 30 to 32°C, water pH ranged from 7.2 to 7.4, and dissolved oxygen from 5.8 to 6.2 mg/L which are well within acceptable limits for tilapia culture.

A protein level of 35% was maintained for all diets, while the basic composition and cost of each diet was as follows:

The lowest production cost indicates economic viability of the feed. Ekramullah (1989) found preparation cost of pelleted feed ranged from Taka 11.87 to taka 26.14 per kg. In the experimental study the preparation cost of per kg feed 20.82, 18.33, 17.85 and 19.15 are in the agreement with the report of the researcher. In fish, partial replacement of fish meal or marine animal protein and soybean meal by ipil ipil leaf meal resulted in better growth performance, indicating an economical profit.

Discussion

The achievement of the present study was that 24% feed cost were reduced by using experimental diet 4 which contained 15% ipil-ipil leaf meal (a non-conventional feed ingredient) in the diet. Thus from over all discussion of the experimental results, it has been established that ipil-ipil leaf meal at 15%level used in the diets has good nutritive values and has a significant effect on the growth, FCR, FCE, and all of the performance measure of *O. niloticus*.

From the overall discussion of the present experimental results it has established that better growth and minimum feed cost of reared species may also be obtained using the feed with mixed protein of plant and animal origin. To achieve a balance nutritional composition in fish feed, a more diverse choice should be made in selecting feed ingredients. Products derived from ipil ipil have been shown to be important ingredients for practical feed of tilapia fish. The findings in the present study shown that ipil ipil leaf meal could be used as protein substitute up to 25% and optimum level 15% in the diet of growing tilapia. However, further studies are needed to justify the long term effect and benefit of ipil ipil leaf for fish health and fish production.

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Fermented feed ingredients as fish meal replacer in aquafeed production

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Feed is the most significant input for most aquaculture systems. Among feed ingredients, fish meal is a major component of feed costs. This has stimulated the evaluation of a variety of alternative dietary protein sources for partially or totally replacing fish meal protein in aquaculture feeds. Use of cheap animal protein ingredients like shrimp head meal waste as such is limited by the presence of exoskeletal chitin and ash content though it contains high levels of protein with an excellent amino acid profile. Similarly use of plant based ingredients in fish feed formulations have certain limitations viz., amino acid imbalance, low protein content and anti-nutritional factors. Utilization of seaweeds and other aquatic plants is also limited due to the presence of high crude fiber and low protein content.

Fermentation is a unique process which will improve the nutritional value of feed ingredients. Fermentation reduces the presence of exoskeletal chitin in shrimp head meal, anti-nutritional factors and fibre in plant based feed ingredients thus improves their nutritive value. Further bacterial fermentation hold promise for growth enhancement and immunostimulants in aquaculture. Fermentation also increases the availability of certain vitamins viz., riboflavin, cyanogobalamine, thiamine, niacin, B6, B12 and folic acid levels in some feed ingredients.

Fermented shrimp head meal

Fermentation is an important tool to reduce the chitin and ash content in shrimp head meal. Fermentation increases the total available protein, calcium and phosphorus. Lactic acid bacterial fermentation has been used successfully in fish insolation (Hall and Silva, 1994). *Lactobacillus plantarum* is used for fermentation of shrimp head meal. The amino acid profile of fermented shrimp head meal is relatively high except for histidine and tryptophan. Biologically ensiled shrimp head silage meal can effectively replace fish meal up to 30% in the diet of African catfish *Clarias gariepinus* fingerlings (Nwanna, 2003). Chitinoclastic and proteolytic bacterial strains could also be used to ferment prawn shell waste in order to improve the nutrient content; an increase in nutrient content was noted in terms of protein, lipid and total sugar in fermented product. Fermented shell waste has been used in both hatchery and grow out diets of *Penaeus indicus* (Amar, et al., 2006)

Nutritive value of fermented sesame seed meal, linseed meal, black gram seed meal and grass pea meal

Anti-nutritional factors such as phytic acid, tannin and crude fiber from raw seed meal viz., sesame seed meal, linseed meal, black gram meal can be reduced by fermentation with lactic acid bacteria. Soaking of raw seed meal in water at 28-30°C for 30 minutes followed by fermentation results in an increase in protein and lipid content and elimination of phytic acid and tannin. Fermented sesame seed meal incorporated at 400g kg-1 in diets of rohu resulted in good growth (Mukhopadhyay, et al., 1999). Inclusion of fermented linseed meal in the rohu diet up to 30-40% was recorded (Mukhopadhyay, et al., 2001). Fermented black gram can also partially or totally replace the fish meal in diet of tilapia. Fermentation of black gram can reduce the level of anti-nutritional factors and it has been included in the diet of carps viz, catla, rohu and mrigal (Ramachandran, et al., 2007). Fermentation of grass pea with *Bacillus* sp. reduces the crude fiber (Ramachandran, et al., 2005).

Fermented barley, wheat gluten as an alternative protein source

Diet palatability and amino acid profile were increased by fermentation of barley and wheat gluten. Fermented grain and wheat gluten act as an alternative protein rich ingredient in diet for *Penaeus vannamei* (Poveda and Emoroles, 2004).

Nutritive value of fermented seaweeds

Seaweeds contain high quantity of protein, minerals such as potassium, phosphorum, calcium and salt. Seaweeds are the cheapest protein sources available but their utilization is limited by the presence of crude fiber, which can be eliminated by fermentation. Single cell detritus prepared by fermentation of seaweeds is used as a hatchery diet (Uchida, et al., 1997). *Lactobacillus brevis* is suitable for fermentation of seaweeds. Lactic acid fermentation can be performed on seaweeds such as *Gracilaria* sp., *Ulva* sp., *Laminaria* sp, *Undaria pinnatifida*, Hypnea sp, *Chondrocanthus*, *Gelidium* sp. to improve their nutritive values and reduce the crude fibre content.

Nutritive value of fermented aquatic weeds

Aquatic plants contain substantial amount of protein and minerals. The presence of anti-nutritional factors restricts their use in animal feeds. Fermentation reduces the tannin, phytate, mimosine level in *Lemna polyrhiza*, *Leucaena leucocephala* (Bairagi, et al., 2004). Inclusion of fermented *Lemna* at 30% in the diet resulted in the best growth performance in Rohu fingerlings. Water hyacinth (*Eichornia crassipes*) is a freshwater macrophyte which forms dense vegetation in ponds. Water hyacinth has low protein and high fiber content which has been used as animal feed. Fermentation may reduce its fiber contents and improve its nutritive value for fish feed. Molasses fermented water hyacinth was efficiently utilized than raw water hyacinth in Nile tilapia (Elsayed, 2003).

Conclusion

Fermentation is an environmentally friendly process consumes less energy and produces less waste. It is a typical example of biodiversity put in to efficient usage that can be applied to a variety of different products. The fermentation process significantly improves nutritive value, acceptability, digestibility and eliminates anti-nutritional factors in plant based ingredients. This provides a promising future for sustainable aquaculture. Fermentation will help feed manufacturers to replace fish meal to certain levels and help in reducing the feed cost and thereby increasing the profitability of aquaculture systems.

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Aquaculture and fishing management in coastal zone demarcation: the case of Thailand

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Policies on fisheries management

The Department of Fisheries (DOF) of Thailand proclaimed the fisheries area nationwide into three management zones legalized under the National Fisheries Law of 1947. Zone 1 covers the coastal areas from the shoreline to a distance of 3 km. Zone 2 includes the inshore areas covering the distance from 3 km to 12 km of offshore. Zone 3 is the exclusive economic zone covering 200 nautical miles from the inshore line. Such fisheries management zones however, have not effectively reduced the conflict between commercial and small-scale fishers who compete to exploit the fisheries resources in specifically in Zone 1. Recognizing this problem, the DOF promoted the concept of territorial use rights in fisheries and a fishing rights system to strengthen the defined coastal zone management boundaries.

Theoretically, the fishers and stakeholders take their role as resource managers seriously. They participate in decision-making processes on coastal resource management in their own areas of responsibility. They make use of accessible infrastructure to develop their respective fishing community's economies. Such actions have led to the improvement of the fishers' and stakeholders' livelihoods and security while also empowering them to participate in the esponsible and exploitation of the marine resources.

The fishing rights pilot project implementation

The DOF formulated the Fishing Rights Pilot Project under the Eighth National Social and Economic Development Plan to address conflicts between commercial and small-scale fisheries in Prachuabkirikhan Province, Thailand. This pilot project was broadly based on the concept of Territorial Use Rights in Fisheries (TURFs) and the fishing rights system of Japan. In practice, the concepts of both systems are similar, clearly defining coastal zone management boundaries with exclusive use rights for fisheries. In Japan, the fishing rights system belongs to the Fisheries Cooperative Associations (FCA), of which Japanese fishers should be members in order to gain the right to access fisheries.

The Fishing Rights Pilot Project was implemented in the coastal zone at Bang Saphan Noi and Bang Saphan Districts, Prachuabkirikhan Province in 1997. The coastal areas of these two districts, covering a distance of up to 5 km from the shoreline, were demarcated. Small-scale fishers are free to fish inside the designated zone, however irresponsible fishing gears and particular trawls and light luring purse seines using mesh size smaller than 2.5cm are legally prohibited inside the zone (Yamao and Suanrattanachai 2002).

Coastal zone demarcation in Chumphon Province

A locally-based coastal resource management project was implemented in Pathew District in Chumphon Province, Thailand (LBCRM-PD) as a collaborative project of the DOF and SEAFDEC Training Department (TD). Comprising a number of activities, Activity 2 which included zone demarcation, was encouraged and extended in the district under the LBCRM-PD (Yamao and Suanrattanachai 2002). The zone demarcation activity made use of the experience from the zone demarcation in Bang Saphan and Bang Saphan Noi Districts, but covered a distance of only 3 km of coastal areas as defined in the National Fisheries Law, 1947. The zone demarcation was aimed at alleviating the conflict between small-scale fishers and commercial fishing boats that operate such gear as trawls and push nets.

The fishers and stakeholders' participation in the coastal resource management was guided by the legal framework of the Constitution of the Kingdom of Thailand, 1997. The constitution defined that these stakeholders have the right to participate in decision-making processes on local resource management. The Chumphon Provincial Office of Fisheries officials took a leading role in conducting public hearings on the zone demarcation at Pakklong Sub-district, after which the fishers and stakeholders of the Sub-district agreed on the marked position and areas of the zone demarcation.

The Pakklong Sub-district Administrative Organization (Ao Bo To) submitted the community's consensus on the zone demarcation to higher authorities of the government agencies. After the Cabinet approved the zone demarcation, Chumphon Province made a proclamation on the zone demarcation on October 4, 2002, which was made effective one month later on November 4, 2002. The zone demarcation consisted of two areas. Area I covers forty-six km^2 from Bang Bird Mt. to Khao Lamyai Mt. while Area II is 70 km^2 from Khao Lamyai Mountain to Khao Bang Jak Mountain. (Auimrod et al. 2003). Since Area I and Area II are not defined as an exclusive use rights area, both local and non-local small-scale fishers conventionally utilize its fisheries resources. The zone demarcation was an outcome of the local fishers' and stakeholders' participation in hearings that achieved a community consensus on coastal zone management.

Zone management for fishing and aquaculture

The local fishers, fish farmers and other stakeholders benefit from the utilization of the coastal area in the demarcated zone, through fishing, boat cruises and engaging in fish cage and shellfish culture (Suanrattanachai et al. 2003), particularly in Area II. However, while the Area II conflict between small-scale fishers and commercial fishing boats was alleviated, new conflicts between the fishers and fish farmers also became a serious problem. Fish farmers including the newcomers tried to expand their fish cage culture areas. The newcomers marked certain areas and reserved these areas for their own use for fish cage culture. Some of these marked areas encroached into the conventional cruising lane of fishing boats. Additionally, some of these marked areas have been used as safe anchorage for fishing boats during the monsoon season to avoid disasters from strong winds.

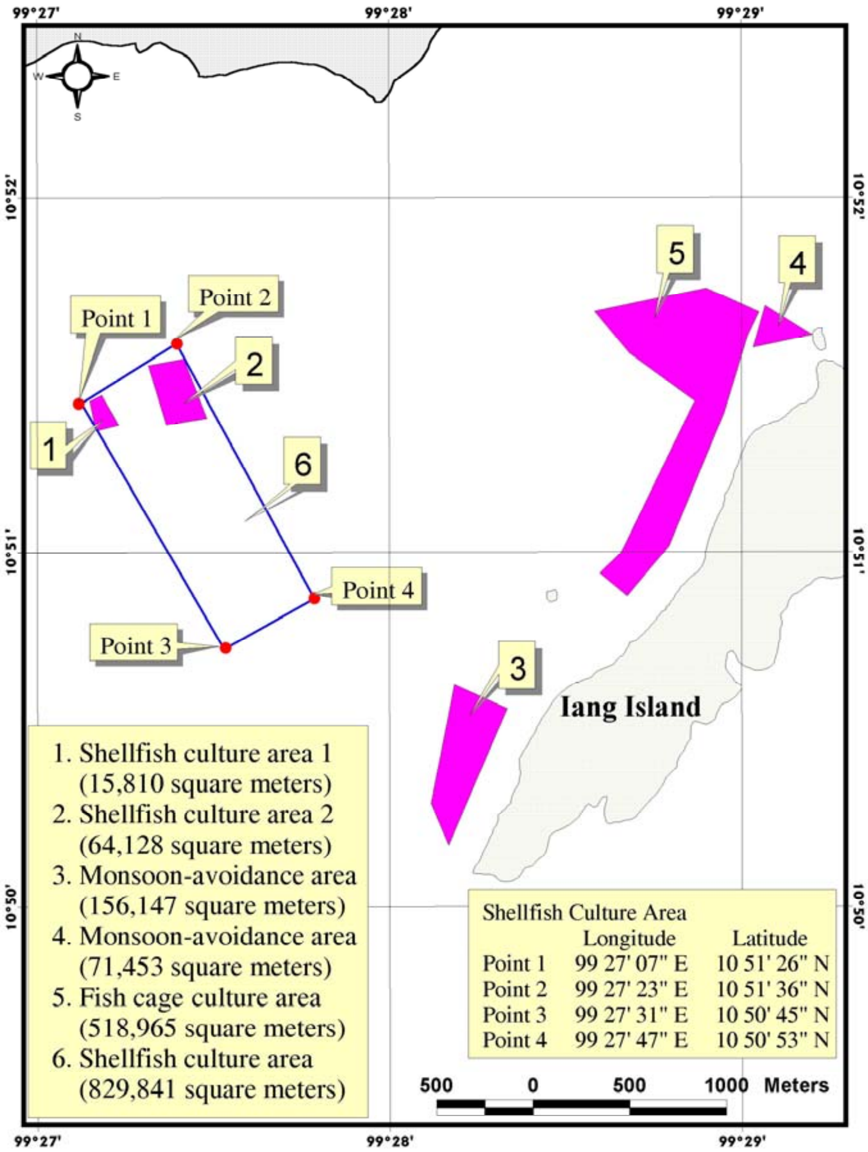
To alleviate the conflict between the fishers and fish farmers, the Chumphon Provincial Office of Fisheries and the LBCRM project staff proposed to implement the concept of zone management for fish and shellfish culture. The main objective was to reduce the conflict between the fishers and fish farmers in utilizing the fishing grounds in Thungmaha Bay, Pakklong Sub-district, and to control the number of fish farmers and fish cages and farming area. After stakeholders adopted this concept, the Provincial Office held the first pre-consensus meetings with all seven villages of Pakklong Sub-district. The elected representatives of each village joined the Provincial Office and the project staff to conduct site selection using a global position system (GPS). The elected representatives fully supported the move to mark the site selected based on their local knowledge and customary life in the fishing grounds.

The marked site selected was divided into three areas corresponding to their main usage. One area intended for fish cage culture covering Area No. 3 and No. 5, is 300 rais (48 hectares); the second area for shellfish culture covers Area No. 6, which is 600 rais (96 hectares); and the third area (Area No. 4) is reserved as a monsoon anchorage place to provide a safe place for the fishers.

In 2004, the Provincial Office tried to formally propose the zone management for aquaculture under the Seafood Bank Program. However, this program was stopped after the Thailand political crisis in September 2006.

In practice, all stakeholders particularly the fishers and fish farmers respected the rules and complied with the provisions of the zone management for aquaculture. Thus, the newcomers

Fig. 2. Final draft of the designated zone management for fishing and aquaculture, Pakklong Sub-district



Arranged by Sukchai Arnupapboon and Siriporn Pangsone, Research Division
Southeast Asian Fisheries Development Center, Training Department. February, 2003.

Provided by Sukchai Arnuphapboon and Siriporn Pangsone, Capture Fisheries Technology Division, SEAFDEC/TD.

stopped expanding and reserving the coastal areas for their own use for fish cage culture. The fishers conveniently cruise their boats for their fishing operations in the area surrounding the Thungmaha Bay. The zone management for fishing and aquaculture does not exclude outsiders, but they have to obey and comply with the community's rules on zone management especially on where to fish and where to operate their fish culture cages.

The implications of the zone management

Major conflict

A major conflict between crab trap fishers and the fish farmers using push nets for collecting fish bait (trash fish) became a serious problem of the zone management in Pakklong Sub-District. Crab trap fishers claimed that they lost their crab traps due to the push net operations for fish bait. Thus, the fish farmers, operating push nets for fish bait, had to pay certain compensation to the crab trap fishers for the traps destroyed.

Push net and crab trap fishing are actually illegal fishing operations. In practice, fish farmers still continue to operate the push net to catch fish bait because they claimed that the fish caught helped them reduce the cost of feed for their fish cage culture ventures. The price of fish bait sold in frozen fish plants are not affordable due to their high price. Meanwhile, the crab trap fishers also continue to trap the crab resources whole year round except from October to December as regulated under the National Fisheries Act, 1947, Section 32, which prohibits taking of gravid crabs such as *Scylla serrata*, 2) Portunus pelagicus, and 3) *Charybdis ferriatus* during that period (Bureau Office of Fisheries Administration and Management 2007).

Conflict resolution

The stakeholders particularly the crab trap fishers from village no. 7 and the fish farmers using push nets for catching fish bait from village nos. 1 and 6 of Pakklong Sub-district convened a meeting to solve their respective conflicts. The rationale of the meeting was to end the problems of fishing gear loss and destruction of both push net and crab traps on one hand, and the alleviation of the expected declining coastal resource on the other hand. The head of village no. 7 was the chairperson of the meeting. Crab trap fishers and fish farmers living in all the villages participated in the meeting.

During the meeting, the fish farmers proposed that they would continue to engage in push net operation in the boundary of 200 m only, which surrounds their respective fish culture areas. Such agreed limited area for push net operation fully supported the reduction of crab trap destruction. The fish farmers also proposed to assign certain fishing days for each group, so that crab trap fishers could have their fishing days during odd number calendar dates while the fish farmers could have fishing days on even number dates. The fish farmers also offered to allow the crab trap fishers to set their traps inside the 200 m boundary of their fish culture areas on odd dates (Chart 1), and agreed that push net operators that did not follow this arrangement and caused destruction of crab traps would have to pay compensation to crab fishers. Stakeholders agreed on these arrangements as rules. However, these rules could be cancelled whenever government agencies consider such rules as not applicable. Since the social endorsement of the community rules on fishing operational management has been fully respected by the stakeholders concerned, non-local stakeholders who come to fish around the zone management area also obey these rules. Such rules have been put in effect and practice from May 2003 until the present.

This is a traditional practice of self-governance in fisheries by the local stakeholders in Pakklong Sub-district, which has become part of the LBCRM project implementation. The local stakeholders initially solve their conflicts in fishing in the same area using their own ways, making use of the regulations on zone management for fishing and aquaculture to alleviate the conflict. Thus, they applied a form of "sharing the fisheries" by assigning particular fishing day or fishing time for their respective fishing operations.

However, the Pakklong Ao Bo To Council and the higher authorities of the government agencies have not officially approved the community rules on fishing operational management. At the same time, the stakeholders concerned also recognized the vulnerability of such community rules, but they appreciate the rules just the same to help them control and manage the stakeholders' utilization of the fishing ground.

Opportunity and linkage to traditional-and-legal practices

The stakeholders have taken advantage of the geographic boundary of the fishing zone management to settle their conflicts and share resources. As demonstrated, this initiative strongly supports the concept of community-based fisheries management (CBFM) with clearly defined boundaries (Petch-kamnerd et al. 2003). However, as demonstrated through the CBFM project in Pakklong Sub-district, uncertain implications became obvious as some stakeholders continue to irresponsibly operate push net and crab traps. These types of fishing gear operations are not legally recognized and defined by the Thai National Fisheries Law, 1947, Section (7) and (32) to operate in a restricted fishing ground and fishing season.

The Pakklong Sub-district Administrative Organization Council has the full authority and function to manage and control the use of the coastal resources in its own boundary. This authority and function is defined in the Ao Bo To Act, 1994 (Ratchagool and Tambol). The Council has not submitted the community agreement to higher authorities such as the District Office and Provincial Office of Fisheries for approval. This is because such means of fishing operation by the concerned stakeholders are also not legitimized. Therefore, the community's compliance with the agreed rules may not be sustainable. For such reasons, the gap between traditional and legal practices certainly remains wide, leading to less opportunity of combining and institutionalizing both stakeholders to have jurisdiction with any community agreement under a community-based organization or entity.

The institution of community-based organization or body should come first. Then, the community-based organization will be delegated the right to fish including (World Humanity Action Trust 2007):

Table 1. Number of respondents by type of engagement in fisheries sector

Type of respondents	Village No. 1	Village No. 6	Village No. 7	Total
Engaged in fishing only	0	0	22	22
Engaged in both fishing and aquaculture	3	1	1	5
Total	3	1	23	27

Table 2. Households engaged in coastal aquaculture and their capacities

Village	No. of farming household	Experience on average (years)	Grouper		Sea bass	
			No. of cage (cages)	No. of fish (tails)	No. of cage (cages)	No. of fish (tails)
No. 1	3	10	9	233	10	317
No. 6	1	9	3	450	2	350
No. 7	1	0.5	1	300	1	200

Table 3. National Fisheries Act, 1947 legally controlled push net and crab fisheries resources

Item	Ministerial Notification	Provincial Notification
Push net [7],[8]	Section 32 (2) and (4): prohibits push net fishing gear operated by powered boat having length longer than 14 m, from fishing operations in territorial waters of Prachuabkirikhan Province, Chumphon Province and Surattani Province (Annex II)	MOA 0528/10491 on September 18, 2002: prohibits all kinds of push net fishing gear from fishing operation in the demarcated coastal zone of Chumphon Province (Annex IV)
Fertilized crab fisheries resource [7]	Section 32 (7): prohibits anybody from fishing gravid crab species, namely: 1) Scylla serrata, 2) *Portunus pelagicus*, 3) *Charybdis ferriatus* from October to December annually, but allowed governmental officials to fish the fertilized crab fisheries resources for experimental purposes (Annexes I and III).	
Crab trap [9]	The crab trap fishing gear was not defined in Section 4 (13), (Annexes I and III)	
Fish farmer[9]	Section 5, Ministerial regulation No. 5 (1947): culture of fishes in allowable areas (Annex V)	

- The right of exclusion, ie. the right to limit access to a territory.
- The right to determine the amount and the nature of the use right in a territory.
- The right to extract benefits from using the resources within a territory.
- The right to the future returns from the use of the territory.

These rights are anticipated to bring security, exclusivity and permanence to community-based organization to manage the coastal resource in a certain defined boundary [18]. The practice of CBFM in Pakklong Sub-district without doubt showed that both stakeholders have not received the right to fish as suggested.

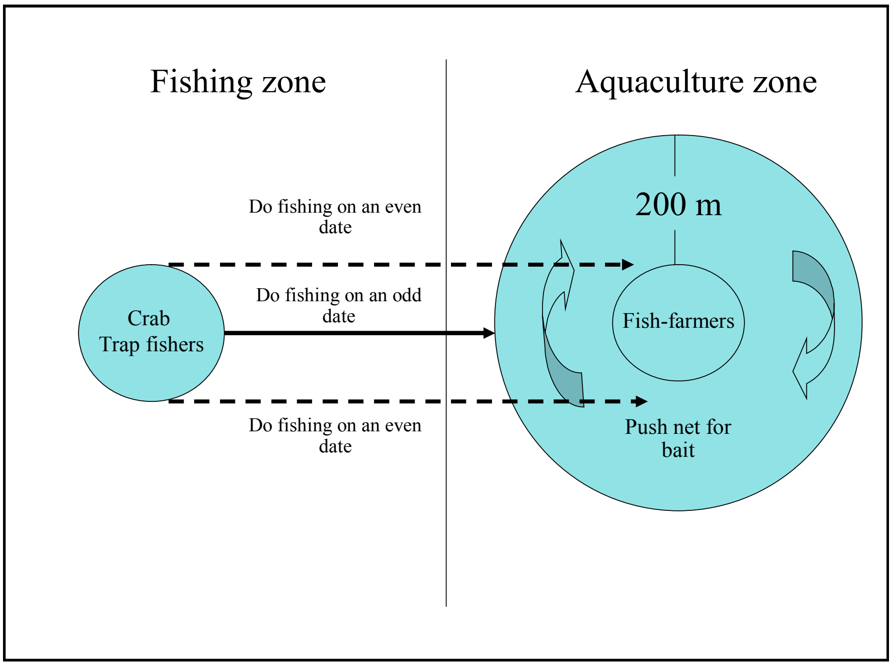
Practice and awareness to sustain resource use

Both fish farmers and crab trap fishers recognized that their means of fishing operation may have contributed to the vulnerability of the sustainable resources. Each user has his way of sustaining the use of the fisheries resources to secure their livelihood and employment. The fish farmers have tried buying fish bait more frequently than doing push net operation. Now, they operate the push net in the surrounding area within 200 m distance from their cage culture establishments.

Crab trap fishers have also their own means of strengthening the manner of sustainable resource use. Actually, the crab trap fishers organized themselves into a fishers' group using crab trap, as suggested by a local Thai non-governmental organization, the Thai Environmental Institute. The constitution of the group received technical support from the Chumphon Marine Fisheries Development Center (CMDEC) and SEAFDEC/TD. The main activity of this group is to operate the crab bank. Thus, every member of this group has been requested to donate and put gravid crabs in the crab bank cage. Moreover, every member has to use crab trap with 2.5 inches mesh size of the bottom net.

The releasing of gravid crabs into the cages is meant to enhance the crab resources. In return, this activity gives a good experience to crab trap fishers who are members as well as non-members of the crab trap fishers' group. They cited that releasing gravid crabs into the cage is effective in enriching the recruitment of the crab resources. They get more yields now compared with the pre-conducting crab bank activity. To strongly contribute to the group activity, SEAFDEC/TD extended assistance to the chairperson of the fishers' group using crab trap to enable him to visit the crab resource enhancement activity in Japan. Now many members of the fishers' group using crab trap release gravid crabs voluntarily in their own crab cage. Such action shows that the members are aware of the sustainable use of the crab resources.

Chart 1. The designated boundary of fishing zone with clearly defined fishing days practiced in Pakklong Sub-district



Conclusion

The clear defined division of coastal area in Thailand has been undertaken to reduce conflicts between small-scale fishers and commercial-scale fishers. Community-based fisheries management (CBFM) is an appropriate approach to encourage stakeholder's participation in managing the coastal areas and can help reduce social conflicts in the fisheries sector.

The practice of coastal zone demarcation in Chumphon Province is an outcome of the locally-based coastal resource management project. The coastal zone demarcation was originally based on the consensus of the stakeholders' democratic participation in zone management of a designated coastal area under the legal framework of the Thai National Fisheries Law, 1947. The coastal zone demarcation of Pakklong Sub-district, Pathew District, Chumphon Province became a legal legislative by notification to the Chumphon Provincial Office since on 4 November 2002.

Within the boundary of the coastal zone demarcation of Pakklong Sub-district, a fishing zone management for fishing and aquaculture has been implemented. The zone management is a mechanism to control the number of newcomers and their capacity on fish cage culture that is friendly to coastal environment. The local stakeholders conventionally operate in the territory of the recognized zone management areas reserved for coastal aquaculture establishment and as cruising lane for fishing boats.

The community agreement could secure the efforts of the fish farmers to do push net operations for fish bait within the 200 m boundary of their fish cage culture areas on even calendar dates. Similarly, crab trap fishers are safe to do crab trap fishing on odd dates of the calendar without any destruction from any push net operation. However, the community agreement may not be effective much longer because it has no legislative framework especially that push net operation for fish bait is not legally recognized. Therefore, both stakeholders may not be legitimized to establish community-based organization to take the function of managing the coastal resources.

Fortunately, the fish farmers and crab trap fishers still have the sensible awareness of the sustainable use of the coastal resources. Fish farmers try to buy fish bait more often for fish cage culture to replace their catch from push net. Crab trap fishers release gravid crabs into crab cages to enhance the stock of the crab resources.

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Reservoir fisheries of freshwater prawn – success story of an emerging culture-based giant freshwater prawn fishery at Malampuzha Dam in Kerala, India

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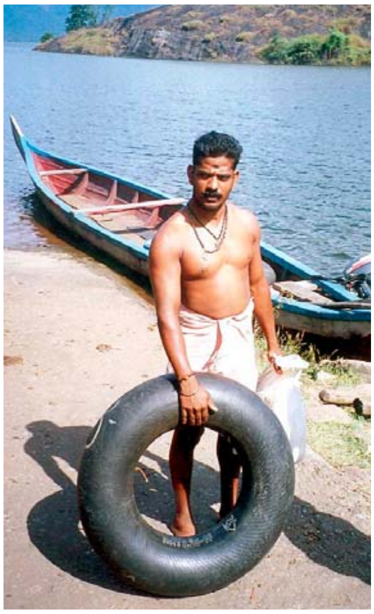
The Department of Fisheries of Kerala State in India stocked 600,000 post larvae of the giant freshwater prawn, *Macrobrachium rosenbergii* (also known as 'scampi' in India) in Malampuzha Dam in Palakkad District during September–November 2005 and began harvesting medium and large sized prawns in April 2006. The fishing operations are being done by newly formed fishers Self Help Groups (SHG). The fishers harvest 30-50 kg daily, the large sized prawns sold at about Rs. 300/kg to an exporter at farm gate. This fishery has brought considerably higher income to the 122 tribal and settler fisher families, including 47 SC/ST families (underprivileged communities protected by legislation), in the hill tracts.

M. rosenbergii is not endemic to the Malampuzha - Bharathapuzha river system, though it occurs in southern Kerala. In the past where Vembanad Lake connected to the Arabian Sea there was a flourishing fishery, now dwindling due to barrage construction, pollution and other anthropogenic factors.

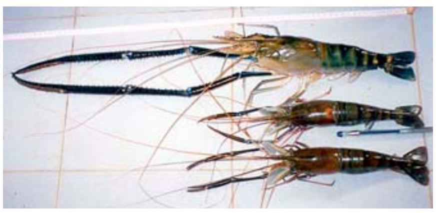
Prior to the formation of the SHGs the tribal people and settlers around the dam were engaged in fishing in the 2,320 ha reservoir (the main objectives of damming the Malampuzha river in 1952 were for irrigation and potable water), but the landings were poor due mainly to poaching and lack of motivation and participation of local fishers. The newly organized SHGs were motivated and cooperative with the participatory approach adopted by the DoF, allowing the 'poachers' to join as SHG members, which had a healthy effect on management and fish yield.

A survey of the reservoir catches conducted on 16/06/2006 showed that until about 10 am 719 kg of finfish (stocked Indian major carps, common carp and naturally recruited wild fishes, mainly minor cyprinids and catfishes) and stocked prawns were landed and sold at the DoF fish sales counter, of which 41.8 kg (fetching Rs 10,450) were from the prawns. *M. rosenbergii* males and females (all berried) caught ranged from 200 to 350 g and 25-30 cm, and about 100-150 g and 20-24.5 cm, respectively.

A total of 53.53 tonnes of fish and prawns amounting to Rs. 14.75 x105 were caught during the year 2005-2006. The average annual production from Malampuzha reservoir for the past 15 years was 3.76 kg/ha, the highest being 9.4 and the lowest 0.07 kg/ha. The production for the year 2005-2006 was 23.14 kg/ha, showing a 20 kg/ha



SHG fisherman using a tire tube as a float to sit on while fishing for prawn/ laying gill nets. Both fish and prawn are caught with the monofilament net of mesh size 12, 15 &20 cm.



M. rosenbergii from Malampuzha Dam.

Table 1. Small water bodies/multi-purpose ponds used for aquaculture in Kerala with reference to Palakkad District[1, 2]

Type of water body/pond	Kerala No. & (Area in Acres)	Palakkad No. & (Area in Acres)	Mean size (Acres)		% Total in Palakkad No. (Area in Acres)
			Kerala	Palakkad	
Panchayath (local govt.)	6820 (3,661.73)	633 (401.34)	0.54	0.63	9.3 (11.0)
Temple	2524 (1,039.58)	314 (302.03)	0.41	0.96	12.4 (29,1)
Irrigation	838 (5,022.76)	61 (1,895.49)	5.99	31.07	7.3 (37.8)
Private	36461 (51,539.64)	3070 (2,142.20)	1.41	0.70	8.4 (5.8)
Quarry	904 (818.64)	134 (129.04)	0.91	096	14.8 (15.8)
Total	47547 (62,077.02)	4212 (4,870.10)	1.31	1.16	8.9 (7.8)

1. Source: DoF, 2001. Panfish Book - Palakkad District, District Fisheries Data Book, Janakeeya Mathsya Krishi Cell, Department of Fisheries, Kerala, Trivandrum, 382 p.; DoF, 2002. Kerala Fisheries - Facts and Figures. Statistical Wing of the Department of Fisheries, Trivandrum, 212 p.
2. The area units are indicated as given in the source/s (One hectare = 2.44 acre).

Table 2. Reservoirs and irrigation tanks and paddy fields with high potential for freshwater prawn stocking/integration in Palakkad District, Kerala[1].

Water bodies	Number	Area (ha)
Reservoirs/dams:	9	6,683
Malampuzha:		2,313
Mangam:		393
Meenkara:		259
Chuliyar:		159
Pothundy:		363
Walayar:		259
Parambikulam:		2,092
Thunakadavu:		283
Kanjirapuzha:		512
Irrigation reservoirs (not dams):	89	1947
Paddy fields (potential integration - for paddy-cum-prawn culture):[2]		124, 000
Padasekarams (collective paddy farming) under seasonal fish culture:		1,235 ha

1. Source: Same as for Table 1.
2. Traditional rice fields in Palakkad (often referred to as granary of Kerala) are now unprofitable and high price prawn integration in the system would improve the socio-economics of the area.

increase over the average production for the last 15 years. The revenue from prawn/fish catch for a single year (2005-2006) was Rs. 1,475,000, which is only 500,000 less than the total revenue of the previous 15 years, clearly indicating the profit margin achieved through prawn stocking and improved participatory exploitation of the reservoir fishery resources.

As on September 2006, i.e. 10 months after stocking, a total of 6,374 kg of prawns were harvested, earning a return of more than Rs. 16,00,000. The total fish catch from April to September 2006 was 26.8 mt, valued at Rs. 693,000.

A return of Rs. 1,600,000 from the stocked freshwater prawns within a10-month period by spending Rs. 250,000 on stocked prawn seeds, is a remarkable achievement. Adding about Rs. 50,000 as harvesting and other expenses, the total input cost for scampi culture was only Rs. 300,000, resulting in a cost-benefit ratio of 1:5.3, indicative of a high performance of the reservoir stocking.

The stocked prawns showed exceptional growth, attaining a maximum individual size of 632 g. The large sized prawns caught within 10 - 12 months since the PL stocking, is indicative of healthy conditions for prawn growth in the reservoir during this virgin stocking.

As per DoF/SFG regulations 75% of the total earning from the reservoir catches is distributed to fisher families of Malampuzha, within eight SHGs, and the remaining 25% is deposited in a revolving fund, utilized for stocking of fish /prawn seed and fisher welfare. One Kudumbasree (SHG exclusively of women members) unit consist of five women, is also among the beneficiaries in the DoF project.

One of the major causes of failure of reservoir fisheries and fish culture in Kerala is poaching, which was very prevalent in Malampuzha reservoir as well., Since most of the so called ‘poachers’ have been included in the SFGs in the scheme, poaching has been controlled, which is a landmark achievement through participatory approach.

Stocking *M. rosenbergii* post larvae in Malampuzha reservoir has yielded significant results. It appears that the new culture-based prawn fishery will be continued, judging also from the earlier smaller trials in smaller Meenkara Dam nearby (see Table 1), where a continuing minor culture-based fishery was established as a project to rehabilitate underprivileged fishers organized into SHGs around its vicinity. There is considerable scope for further development of regular culture based fishery and integrated farming of freshwater prawn in the neighborhood of Malampuzha reservoir in Palakkad District and other parts of Kerala (see Tables 1 & 2), There are 54 reservoirs in Kerala (2 - >5000ha, 13 - 1,000-5,000ha, & 39 - <1,000ha). It must however, be noted that qualitative and quantitative changes in the fish fauna and associated ecosystems in these man-made impoundments and water bodies where such stocking is/will be done, should be reviewed periodically , especially from the point of view of biodiversity changes and sustainability. This calls for development of adequate skilled manpower, especially competent fishery professionals, infrastructure and other facilities by the Government and the private sector with possible assistance from global/regional fisheries/aquaculture development agencies.

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SKRETTING

Determining and locating sea cage production area for sustainable tropical aquaculture

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"How many fish can be grown without causing damage to the surrounding environment?" and "where is the area that will give the highest production?" are questions that may be asked by a profit-driven but environmentally-minded sea cage farmer. More specifically, given a set of environmental conditions, feeding regimes and sea cages arrangements, what monthly maximum production of fish can be sustained and where to find such a site in a particular coastal area? Answers to these questions are provided by a model called MOM developed by Stigebrand et al. (2004) and its implementation using a GIS tool. The original version of the model was intended to calculate holding capacity of fish species from temperate areas, such as salmon. More recently, the model has been expanded to include other tropical species such as grouper, rabbit fish and barramundi.

In this article, we report a result from simulations using the MOM model to answer the above questions. The aim is to select a set of key input parameters that will enable a sea cage farmer to determine his/her production based on certain selected inputs. The selected parameters from a particular coastal area are then imported to a GIS tool to generate a map showing areas with different production categories.

The sea cage at Awarange Bay during our Summer-trip in June 2007.

Maximum holding capacity

The inputs to MOM model are presented in Table 1 and the output is the monthly maximum production. The output generated from 100 simulations of these inputs ranges from 0 to 217 tonnes. We then classify the production into 3 (three) classes based on percentiles : low (0 to 5 tonnes – less than 33% percentiles), medium (6 to 31 tonnes – 34 to 67% percentiles) and high (32 to 217 tonnes – above 67% percentiles). Classifying parameters into several classes is commonly used for site selection exercises (Salam et al., 2005).

A stepwise discriminant analysis is used to select the pertinent input variables from 28 input variables in Table 1, with an additional variable RCW - the ratio of cage depth to water depth, associated with the three output classes. The selection is based on the F value criteria, ie. the F-value of 3.84 and 2.71 is used to keep and remove a variable, respectively. The selected variables are: sigma, SIG, (standard deviation of water flow), ammonium concentration

Functions:

1. F1 = 0.03 SIG – 7.30 AMO + 0.11 CD + 0.12 SC - 0.87 OXC + 2.59 RCW + 0.62
2. F2 = 0.17 SIG – 3.32 AMO + 0.06 CD – 0.05 SC + 0.50 OXC – 1.45 RCW - 2.8

in a cage (AMO), water current at the surface (SC), cage depth (CD), critical oxygen level in the cage (OXC), and the ratio of cage depth to water depth (RCW). The resulting canonical discriminant functions for the selected inputs are F1 and F2 and are presented in (1) and (2). Fig. 1 presents the three classes of production. Almost 77 % of the group cases are correctly classified.

Fig 1 implies that in order to have a high production, irrespective of F2, F1 in (1) has to be positive. This can be achieved by large sigma and strong surface current for waste dispersion, low ammonium and critical oxygen concentrations in a cage for maintaining healthy fish, deep cages and a large ratio of cage depth to water depth for reducing waste accumulation. The mean values for these parameters for each production group are presented in Fig 2.

Figure 1. Territorial map for three production classes: low (1): 0-5 tonnes/month; medium (2): 6-31 tonnes/month; high (3): 32-217 tonnes/month.

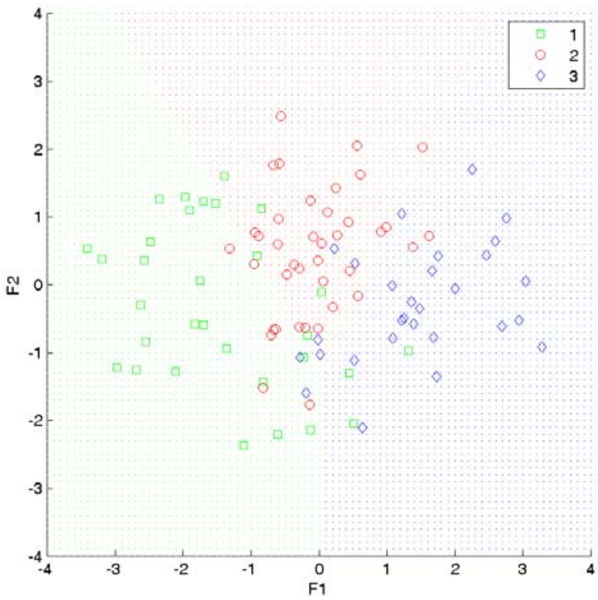
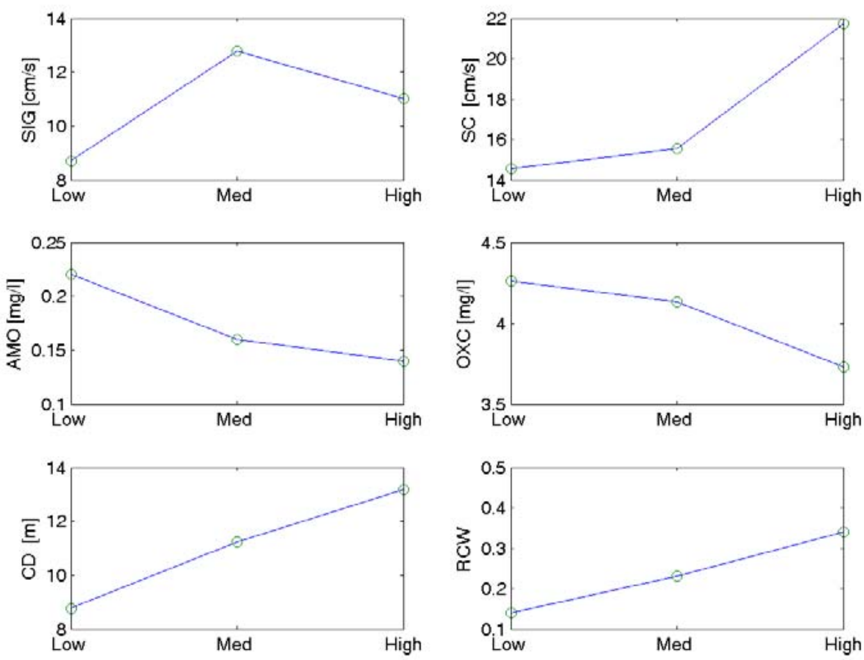


Figure 2. Mean value of the selected input parameters associated with low, medium and high production.



Production map

Spatial values of each of these selected parameters are generated and put into layers using GIS tool. These values are obtained either from measurements or resulting from hydrodynamic modelling. Mathematical relations (1) and (2) are then applied to spatially determine production categories based on these layers. Fig 3 demonstrates the mapping of potential sea cage areas from Awarange Bay in South Sulawesi, Indonesia. The map also shows the location of a sea cage operated by a government institution RICA (Research Institute of Coastal Aquaculture). A picture taken of this sea cage unit is shown in Fig 4.

The development of the MOM model and its application to the aquaculture of tropical finfish is part of our ACIAR project FIS/2003/027 Planning tools for environmentally sustainable finfish cage culture in Indonesia and northern Australia. The main study sites for this project are located in Indonesia, but we envisage the main project outputs will be applicable anywhere in the region.

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Figure 3. Sea cage production map for Awarange bay in South Sulawesi. A sea cage plotted in 'x' is also shown.

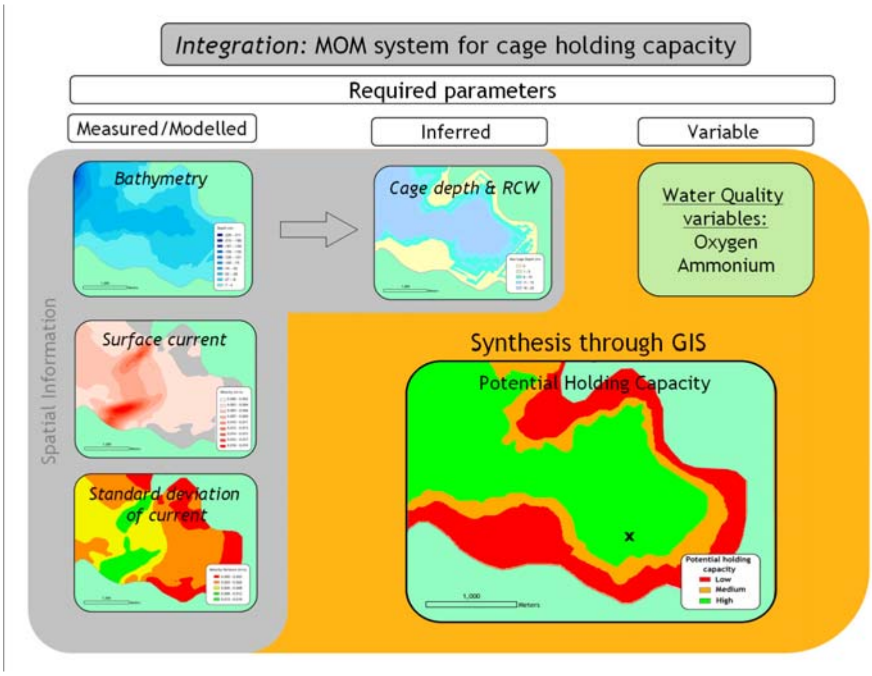


Table 1. Input parameters used in 100 simulation for computing maximum holding capacity for tropical fish species (grouper, rabbit fish and barramundi). Six parameters, denoted by asterix, are selected by a stepwise discriminant analysis in classifying production into low, medium and high holding capacity.

Input Parameters	Range
Temperature (°C)	28-32
Water depth (m)	21-100
Sigma* (cm/s) [SIG]	2-20
Salinity (ppt)	29-33
Bottom oxygen (mg/l)	1-6
Ammonium* (mg/l) [AMO]	0.01-0.38
Surface current* (cm/s) [SC]	1-30
Bottom current (cm/s)	1-29
Number of cage rows	1-3
Cage area (m^2)	36-100
Cage length (m)	6-100
Cage depth* (m) [CD]	1-20
Distance between cage rows (m)	0-2
Reduction factor	0.7-0.8
Critical oxygen in cage (mg/l)	3-5
Critical ammonium in cage (mg/l)	0.12-0.50
Critical oxygen at the bottom* (mg/l) [OXC]	1-3
FCR (food conversion ratio)	1-3
Protein content of feed (%)	43-80
Fat content of feed (%)	15-53
Carbohydrate content of feed (%)	2-10
Ash content of feed (%)	10-15
Sinking velocity of feed (cm/s)	5.68-13.88
Fish initial weight (g)	30-40
Fish final weight (g)	122-398
Protein content of fish carcass (%)	10-20
Fat content of fish carcass (%)	5-10
Sinking velocity of fish faeces (cm/s)	1-9.07

SPC Pacific-Asia marine fish mariculture technical workshop: "Farming Marine Fishes for our Future"

Antoine Teitelbaum & Ben Ponia

Advances in marine finfish aquaculture are being made at a rapid pace. Traditionally this has been led by large commercial interests such as the European salmon farming industry. More recently the strong market demand for the live reef fish trade (LRFT) in Asia has also led to a rapid increase in localised production. The quantity of farmed marine finfish production in the world is 900 thousand metric tonnes in Asia and 1.5 million metric tonnes for the rest of the world (FAO 2004). These well developed industries pose relevant lessons for the Pacific region to learn from.

There has been considerable interest within the Pacific Islands to investigate the options of marine finfish aquaculture to supply domestic or international markets for food and ornamental species. Several countries have achieved commercial production of high value species and there is an increasing list of public and private sectors organisations involved in the industry.

At the 2nd SPC Regional Aquaculture Meeting held in November 2006 the SPC member countries identified marine finfish as an important commodity for development. Subsequently the SPC has become more involved in this field. One recent example is a three week course for Pacific Islanders marine finfish hatchery training held in Thailand in May 2007. The SPC approach is also to advise countries by utilizing its links with Pacific, Asian and Australian counterparts.

As a result of this, the SPC decided to organise a consultative forum among technical persons to enable a face-to-face exchange of ideas and discussion of issues. Whilst the local situation differs from country to country in the region (and between regions) there are some strategic issues of common concern where the sharing of technical information could be of mutual benefit.

In December 2007, the SPC aquaculture section hosted the Pacific-Asia Marine Fish Technical Workshop, held in Noumea. Selected countries with prospects towards developing a marine finfish aquaculture industry were invited to attend the workshop, together with a regional group of experts on this topic.

French Polynesia, New Caledonia, Marshall Islands, Palau, Papua New Guinea and Solomon Islands were invited to participate at the workshop. The following regional organisations, from Australia, the Pacific and Asia (IFREMER, Network of Aquaculture Centres in Asia-Pacific, University of the South Pacific, Queensland Department of Primary Industry - Northern Fisheries Center, The WorldFish Center and the Australian Government Department of Agriculture, Fisheries and Forestry), also attended. Private sector investors for the region were also represented with Good Fortune Bay Fisheries (from Australia and the Marshall Islands) and Aqualagon (from New Caledonia). A total of 25 participants from Pacific, Australia and Asia attended the workshop.

This workshop was a technical consultation between marine finfish aquaculture experts and SPC member countries that are active in marine finfish aquaculture. Its goal was to provide SPC with advice on the most feasible options for marine finfish aquaculture and identify a regional framework for collaboration to address priority research and development needs in the Pacific.

The workshop objectives were to:

- Provide an update on status of marine fish farming within selected Pacific Islands.
- Assess global trends of the industry in terms of production and markets.
- Consider niche opportunities for the Pacific region, for example in terms of export and domestic markets and alleviation of food security.
- Identify priorities for research, development and training requirements.
- Establish programs for further regional and inter-regional collaboration.

NACA presented its regional aquaculture program and related activities and emphasis was made on the Asia-Pacific Marine Finfish Aquaculture Network, a strong potential link for the SPC and its members. The Coordinator of the Marine Finfish Aquaculture Program (NACA), Dr Sih Yang Sim provided a very detailed presentation on the status and trends of marine finfish aquaculture in Asia, including the markets, the economics of the industry, the farming practices used in the different countries and also a scope for future development. Asia is often used as a model for Pacific islands which can learn from mistakes and successes of this region.

At the workshop participants are divided into small groups and worked on the following subjects:

- Development of linkages with the Asia Pacific region, three groups (simulating Asia, Australia and The pacific) analysed the strength, weaknesses, opportunities and strength of those three regions towards providing guidance the Pacific.
- Design of a regional strategic plan for marine finfish development in the Region (establishing objectives, strategies, action and indicators).
- Development project concepts to address bottlenecks in this industry in the Pacific Region.

An interactive CD, compiling all the PowerPoint presentations as well as the group work's result was published at the end of the workshop and is available on request from the SPC aquaculture section (marieangeh@spc.int).

A marine finfish aquaculture development strategic plan will also be developed during 2008, compiling the different experiences of the Pacific and using the results of the group work. It will be posted on line on the aquaculture portal www.spc.int/aquaculture.

Developing Better Management Practices for Marine Finfish Aquaculture

A workshop on the 'Development of Better Management Practices for Marine Finfish Aquaculture in the Asia-Pacific region' was held in Lampung, Indonesia, 7–10 November 2007. The workshop was held to begin the process of developing Better Management Practices (BMPs) for the marine finfish aquaculture sector, which is growing rapidly in Asia. The rapid expansion of marine finfish aquaculture, and concerns regarding its environmental sustainability, has led to the development of several accreditation / certification schemes, and the proposed development of others. NACA and ACIAR are concerned to ensure the participation of small-scales farmers, who provide the bulk of production in Asia, in certification and market access schemes. The development of a BMPs-based approach is intended to allow small-scale farmers to adopt practices that will better support their participation in more formal accreditation / certification schemes in the future, and facilitate market access by small-scale farmers in the face of increasing consumer demands for environmental and social responsibility in aquaculture. The 4-day workshop was undertaken as part of the ACIAR-funded project 'Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region' (FIS/2002/077). The workshop was attended by 60 participants from Australia, Cambodia, China, France, India, Indonesia, Myanmar, Norway, Philippines, Thailand and Vietnam, involving participants from government, research, NGO and the private sector. There was a strong participation in the workshop by the private sector, with about half the participants coming from private industry, including representatives of farmer organizations and feed companies. Industry participants were supportive of the need to develop BMPs for marine finfish aquaculture as a way to enhance the sustainability of their industry.
The workshop was also attended by representatives of environmental and other NGOs. The full report from the workshop will be available in early 2008. The workshop was organized by NACA and the Directorate General of Aquaculture (DGA) of Indonesia in conjunction with the Australia Centre for International Agricultural Research.

Breeding and seed production of silver pompano (*Trachinotus blochii*, Lacepede) at the Mariculture Development Center of Batam

Nur Muflich Juniyanto, Syamsul Akbar and Zakimin

The Indonesian marine finfish aquaculture sector has a new potential species, silver pompano (*Trachinotus blochii*, Lacepede). Silver pompano is a pelagic and active species that is easy to domesticate and culture in tropical marine waters.

The Silver pompano belongs to the Carangidae (trevally and jacks) and lives in the coral reef areas of less than 7 meters depth (Paton, et.al., 1989). According to Borut Forlan (2004), Silver pompano live in the open sea and are found in the Atlantic, Indian and Pacific oceans. Juvenile silver pompano are commonly found in sandy areas or near sandy-clay estuary water. At the juvenile stage they tend to group together, becoming solitary as adults (Bianchi, G., 1985). Sand molluscs and other invertebrates are the main natural food of this fish (Bianchi, G., 1985).

Silver pompano was introduced from Taiwan, China because it is the most popular species cultured in Taiwan, but it is also found in Indonesian waters. It takes 3 years for the fish to mature as broodstock (Anonymous, 2007). As the fish grow fast and fetch a good market price it has a good potential for aquaculture in the Asia-Pacific.

At present the Mariculture Development Centre of Batam has been successful in breeding and producing the seed of silver pompano so that the fingerlings can be produced locally for grow out and reduce reliance on importated fingerlings from overseas sources.

The price of silver pompano is around Rp. 60.000/kg or about US$ 6/kg, almost the same as the price for grouper. However, the silver pompano is easier to farm, faster growing so shortening the grow out period, has a high survival rate, is more disease resistant and can be stocked in floating cages at around 3 cm size.

Silver pompano (Trachinotus blochii, Lacepede).

Broodstock management

Broodstocks management, larval rearing, nursery and post harvest are key areas for the success of seed production. Broodstock are recruited from cultured stock at the floating net cages. The fish that are selected for broodstock should be at around 1 kg body weight, have no abnormalities and the body should be propotionally balanced. Broodstock are fed trash fish, pellets, vitamins and multivitamins mixed at about 3-5% of the total body weight. Water quality management is vital in order to succeed in production. The water exchange is about 400% in 24 hours, and water quality parameters are maintained at pH 7.4-7.8, DO 4-6 ppm, water temperature 29-31°C and salinity at 30-32 ppt.

Spawning technique

The capacity of the broodstock spawning tank is 10 m³ and 10 fishes at 1:1 male to female ratio are kept in the spawning tank. Male broodstock are smaller than the females. The spawning patten of silver pompano does not follow monthly lunar cycles. Spawning is stimulated by hormonal treatment and no natural spawning takes place at present. The HCG is administered by injection to mature broodstock at 250 IU/Kg dosage and fibrogen at 50 IU/Kg dosage. The injection has to be done twice across a two day period. The eggs are usually released on the third day with 60-70% fecundity and are about 800-850 microns in size.

Larval rearing

The capacity of the larvae rearing tanks is 6 m³. The stocking density is maintained at 200,000 eggs/tank or 20 eggs/liter. The hatching rate of silver pompano eggs is about 65-75%.

A flow-through system is used for larval rearing maintained at three liters/minute increasing to ten liters/minute at the end of the larval rearing period. Phytoplankton *Nannochloropsis* sp is given during the first 14 days at 200 liters in the morning and afternoon. Tank bottom cleaning by siphoning

Table 1. Feeding programs for silver pompano broodstock.

Day	Feed Compositions	Remarks
Monday	Squids + pellets mixed + Biovit aquatic	Pellet mixed (yellow eggs + pellets + squid oil)
Tuesday	Trashfish + pellets mixed + Biovit aquatic	
Wednesday	Trashfish + pellets mixed + Biovit aquatic	
Thursday	Squids + pellets mixed + Biovit aquatic + vitamin C	
Friday	Trashfish + pellets mixed + Biovit aquatic	
Saturday	Trashfish + pellets mixed + Biovit aquatic + vitamin E	
Sunday	-	Day off

should commence at day ten in order to maintain the water quality, and it should be done every two days.

The larvae are fed with live feed (the rotifer *Brachionus plicatilis* and *Artemia*) and artificial feed. Rotifers are given from day three to day fourteen 5-15 individuals/ml and given three times a day (morning, afternoon and evening). At day ten pellets are given in addition to rotifer and the pellet is around 250-300 micron in size. *Artemia* are given at day fourteen at 0.25 individual/ml. At day fifteen rotifers should be stopped and the quantity of pellets increased every 1-2 hours. At day eighteen the quantity of Artemia also should be increased to 0.5 individual/ml and should be stopped at day 22.

The harvesting of larvae is conducted at day 21 using a 500 microns scope net. After harvesting to the larvae are graded and survival rate (SR) estimated. Normally the survival rate is around 20-25%.

Nursery

The stocking density of seed in the nursery is maintained at 20 individuals/liter. In the nursery unit water exchange is maintained at 200%. Siphoning should be done twice a day in the morning and evening to clean wastes from the bottom of the tank.

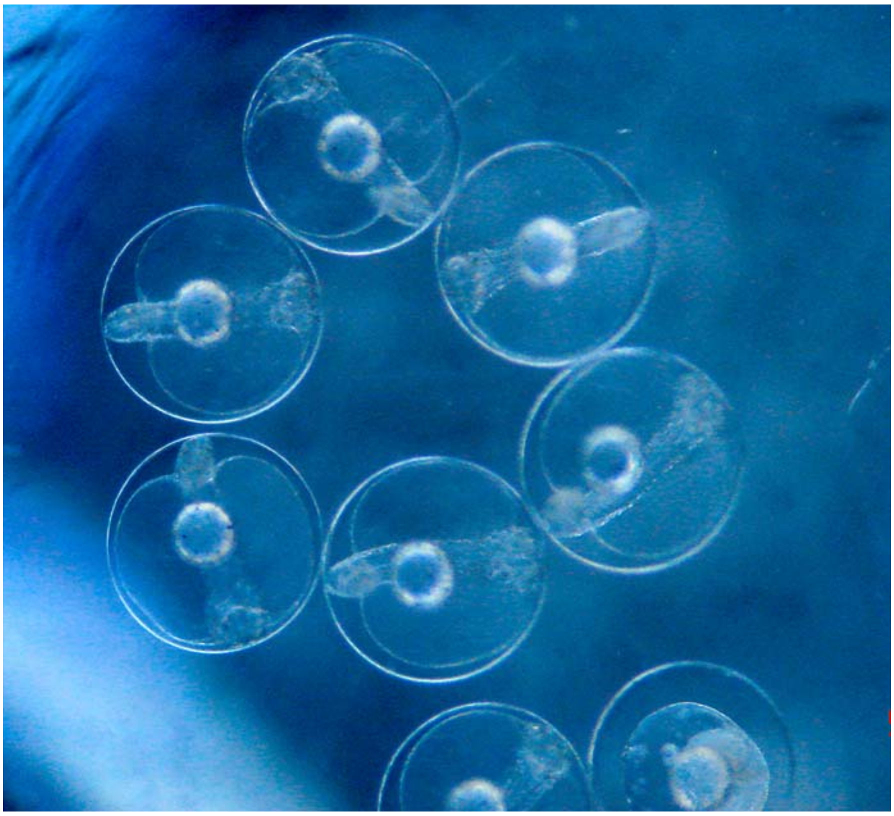
Pellet feeds are used at nursery stage and the size of the pellets is depending on the mouth size of the fish. The total consumption of pellets could reach 1 kg/day especially on day 30. Grading should be done depending on the growth rate but should be at least every 3 to 4 days.

Silver pompano is a suitable candidate for marine finfish aquaculture in Indonesia because it is more tolerate to water quality problems, easy to adopt to pellet feeds and grow fast. The growth rate of the larvae can reach 1 mm/day.

The table and graphic show the growth of silver pompano fingerlings. At day 35 the larvae reached 3.4 cm in length and were ready to be sold or to be cultured in floating cages.

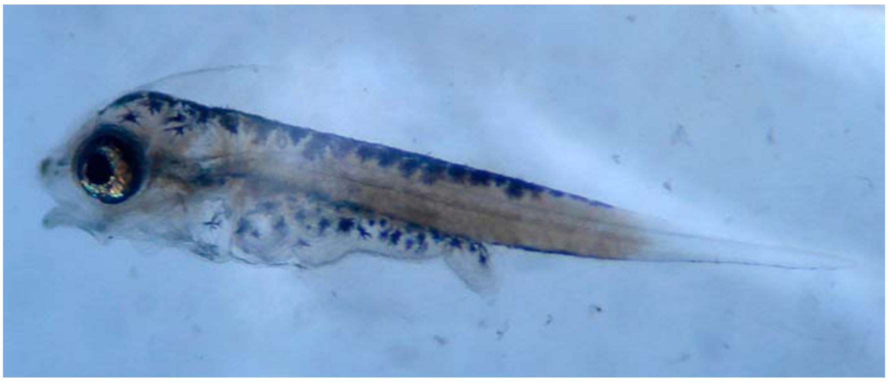
At the end of rearing period the seeds density was 0.5 individuals/liter which is about 21% survival rate. So from stocking of 200,000 eggs 42,000 fingerlings are harvested at the end of the hatchery/nursery cycle. However, similar to other marine finfish species such as grouper and golden trevally, deformities are also a problem, for silver pompano a 5% deformity rate is common.

Before distributing to the farmers feeding should be stopped for one day so that the fingerlings are fasted and metabolic rate can be reduced during the transportation to minimize losses. The temperature of the water



Fertilised eggs.

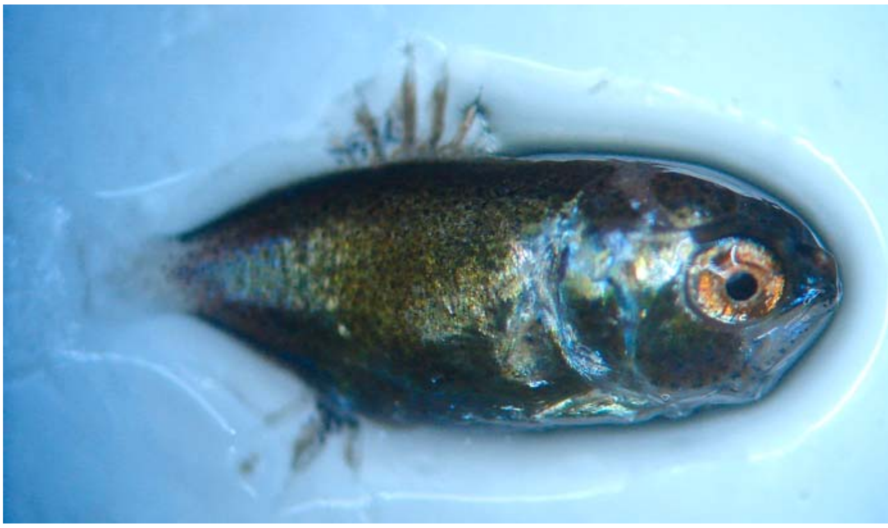
Above/below: Larval development.



for packing should be maintained at 25°C-27°C and the ratio of water and oxygen is 1:3 at 200 fingerlings/bag.

Production constraints of silver pompano

Although silver pompano is a good candidate for aquaculture in Indonesia it is not without problems. At seed production stage, stocking density plays an important role. As silver pompano is a very active and fast swimming species so stocking density should be carefully considered so that it allows plenty of space for the fingerlings to move around to reduce stress. The same applies to transportation of fingerlings, they should be packed at lower densities otherwise mortality rate is high. When the water quality is not maintained at an optimum level, disease may occur. So water quality management is vital for success of fingerling production and to minimize disease problems.

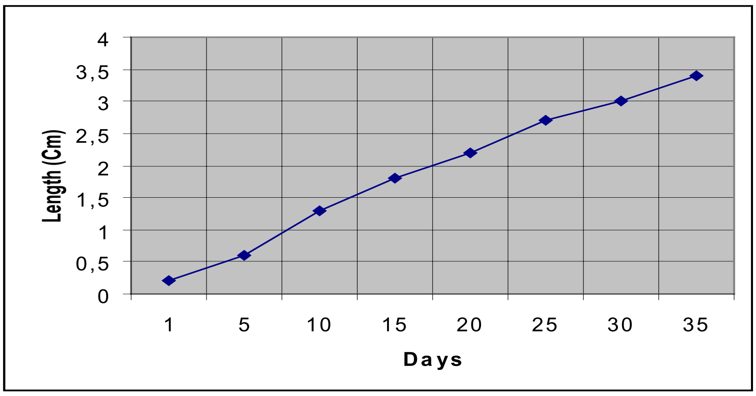


Early juvenile.

Table 2. Development of seed.

Days	Length average (cm)	Growth (cm)
1	0.2	0
5	0.6	0.4
10	1.3	0.7
15	1.8	0.5
20	2.2	0.4
25	2.7	0.5
30	3.0	0.3
35	3.4	0.4

Data on the growth of silver pompano.



Conclusion

Silver pompano is not a new commodity in Indonesia, it is a well known wild caught species in fishing communities. It is a suitable marine finfish aquaculture species because of its fast growth rate, easy weaning to pellet feeds and wide tolerance of water quality. Silver pompano fetch a relatively high market price in Indonesia with good market demand. It has a good quality flesh that is suitable for various cuisines and is accepted by consumers in Indonesia and in the region. Now that the technology for seed production is available it is anticipated that the grow out industry will take off in the near future, at least in Indonesia.

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Potential of silver pomfret (*Pampus argenteus*) as a new candidate species for aquaculture

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Research on developing the culture technology for the silver pomfret Pampus argenteus Euphrasen was initiated for the first time during 1998 by the Mariculture and Fisheries Department (MFD) of Kuwait Institute for Scientific Research (KISR) and succeeded in larval rearing of this species with the eggs collected from the wild (Almatar et al., 2000). Since then several investigations have been carried out at MFD, Kuwait, relevant to hatchery larval rearing (Al-Abdul-Elah 2001), feed requirement and growth under tank culture conditions (Cruz et al., 2000; Almatar and James 2007), breeding under domesticated culture conditions (James and Almatar 2007) and health management (Azad et al., 2007) of this species. In more recent years, during 2005, East China Sea Fisheries Research Institute and Shanghai Fisheries University in China have initiated research on the culture of silver pomfret and has succeeded in the larval rearing of this species based on the eggs collected from the wild (personal communication, Huang Xu-xiong, Shanghai Fisheries University, China). Other countries in Asia are also showing interest in developing the culture technology for this species because of its depleting wild stock, market demand and high price.

Silver pomfret fingerlings produced in the hatchery.

Hatchery and larval rearing

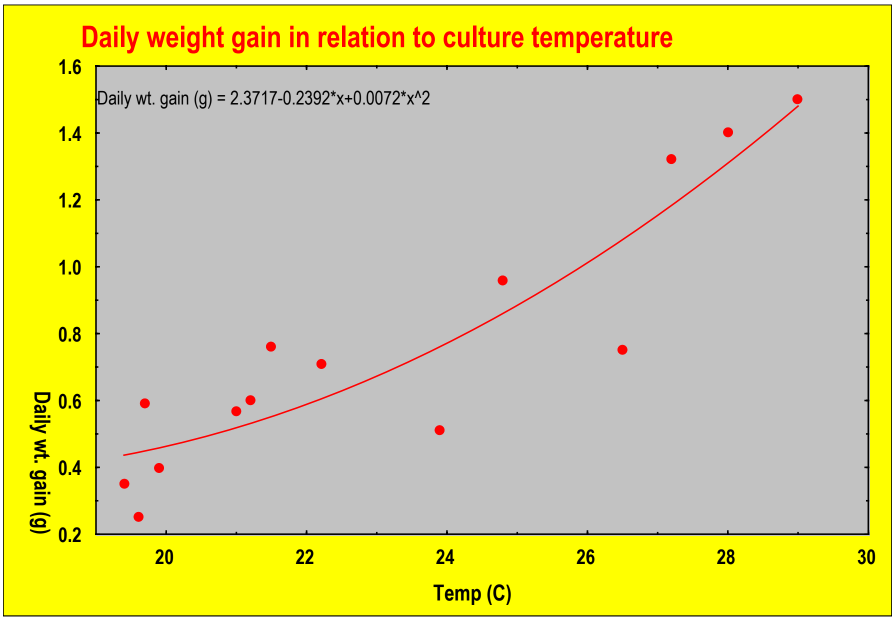
The hatchery performance of silver pomfret shows that it is possible to produce about 3.5 g size fingerlings for grow-out stocking within 50 days after hatching from the egg. Another advantage is that the larvae readily accept inert feed after a brief exposure to Artemia nauplii. This makes it easy to wean them to formulated feeds, enabling reduction in usage of costly live feed such as Artemia nauplii during the larval rearing period. Furthermore, unlike other carnivorous marine fish species, there is no cannibalism during the larval rearing period, making this species easier to handle. Research efforts have improved the survival rate of larvae from less than 1% during 1998 and 1999 to about 4% as of 2000 due to the improvements made in the administration of live feed in the hatchery. It is anticipated that further research will continue to improve larval survival and facilitate commercial ventures.

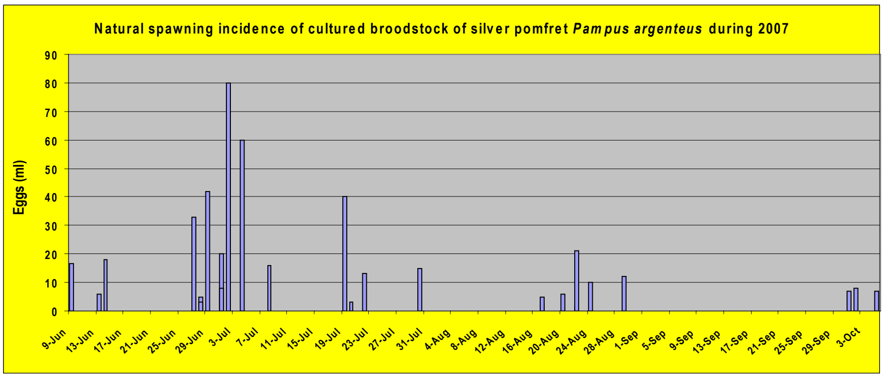
Growth performance

To understand the optimum growth of silver pomfret, species specific formulated feed is required but it has not yet been developed. However, investigations carried out at MFD, Kuwait with an objective of screening the commercially available formulated feeds for this species have observed the suitability of salmon feed for the grow-out culture of silver pomfret. Research carried out at MFD during 2004 enhanced the growth rate of this species by using feed additives along with salmon feed and achieved growth rates of up to 1.5 g/fish/day. Recent investigations carried out on the growth performance of silver pomfret under tank culture conditions, using tank capacities varying from 4m^3 to 125m^3, show that the growth is fast in the initial period before winter under Kuwait's climatic conditions. Under ambient seawater culture conditions the average body weight increased from 3.7g to 81.9g within three months of culture. The growth rate is significantly higher during summer and early winter when the ambient seawater temperature is above 26°C. In general, the growth rate of fish in relation to the tank culture water temperature shows a linear relation in which the fish growth rate increases with temperature up to 30°C. After 14 months of grow-out the combined male and female size ranged from 74-315 g (mean size 182.7±50.5 g). Wide size variation occurred in the population due to the smaller size of males compared to that of females. Furthermore, the males dominate in the population constituting 60-70% during the culture trials.

The grow-out studies under tank culture conditions show that it is possible to obtain marketable size fish of over 250 g size after 20 months (1.8 years) culture period. This growth rate is considerably higher than the estimated

Silver pomfret eggs from the cultured brood-stock and hatching out of larvae.





age of 2.86 years requirement for the wild stocks of silver pomfret to reach about 300 g size (males and females combined) under Kuwait's climatic conditions. The results obtained till now are very encouraging to identify silver pomfret as a potential new candidate species for aquaculture.

Broodstock development and spawning

The present cultured brood-stocks of silver pomfret at MFD/KISR originated from the wild eggs collected during 2004. Spawning of cultured silver pomfret under captive culture conditions was a challenging issue and remained elusive over the years untill 2006. Overcoming some of the technical constraints the MFD/KISR made a breakthrough for the first time during 2006 in achieving natural spawning of two-year old cultured brood stocks kept in 125 m3 capacity tanks. Although matured males were present in the population, the eggs were not fertilized during 2006. However, during 2007 fertilized eggs were obtained through natural spawning in the brood-stock holding facility as well as through hormone induction. This has enabled us to produce hatchery reared progeny of this species for the first time and showed the possibility of breeding the fish for commercial applications. Furthermore, breeding the fish under culture conditions will enable commercial hatchery production and farming of this species to meet market demand. Aquaculture of silver pomfret will alleviate the pressure on capture fishery and thereby allow for the recovery of its rapidly depleting wild stocks.

Prospects

The temperature dependent growth of silver pomfret shows the possibility to achieve increased growth under tropical climatic conditions (26-30°C) thereby shortening the grow-out culture period. This will be a considerable economic advantage for commercial farming since this species is widely distributed in the tropical waters and fetches a very high market price. Further research requirements augment for refinements to enhance the egg quality and spawning of domesticated broodstock, hatchery larval survival and grow-out production assessments using earthen ponds and sea-cages.

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NACA Newsletter

Published by the Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

ISSN 0115-8503

Volume XXIII, No. 2
April-June 2008

19th Governing Council meeting held in Kathmandu, Nepal

The Government of Nepal hosted the 19th NACA Governing Council Meeting in Kathmandu from 5-8 March. Delegates from NACA's 17 member governments and FAO's Assistant Director General, Mr Ichiro Nomura, were welcomed by the Honorable Mr Chhabi Lal Bishwokarma, Minister for Agriculture and Cooperatives. The meeting was opened by Mr Nagendra P. Chaudhary, State Minister for Agriculture and Cooperatives, with opening remarks delivered by Mr Bharat Prasad Upadhyay, Director General, Department of Agriculture.

Collectively, NACA members represent around 90% of global aquaculture production by volume. The Governing Council is NACA's peak policy body, which meets on an annual basis to review the work plan and determine the direction of the organization.

The Governing Council has slated a number of new activities for 2008. Chief among these was a request to develop a programme on aquaculture of indigenous highland/coldwater species, in collaboration with FAO, as a measure to combat the disproportionately high levels of poverty affecting rural communities in mountainous areas.

Other new initiatives to commence in 2008 include an increased emphasis on production and marketing of 'not so high value' fish species, which are economically important to many rural communities; a desk study on the feasibility of culture and marketability of alternative marine finish species to identify priorities for aquaculture research and development; inclusion of traceability as an issue in 'better management practice' and aquaculture certification projects; and establishment of an 'on the job' training and staff exchange programme among members, to build capacity of local personnel.

Speaking at the meeting, Mr Ichiro Nomura, FAO, highlighted the huge increase in aquatic food production that will be required to feed a growing world population. By 2030, it is projected that the world will need to produce an additional 37 million tonnes just to sustain current per capita consumption levels, the increased demand fueled simply by population growth. With most fisheries resources now fully exploited or depleted, the bulk of this will need to be farmed. Aquaculture is likely to make an increasingly important contribution to local food security and livelihoods, particularly in many remote and resource-poor rural areas.

The Hon. Chhabi Lal Bishwokama, Minister for Agriculture and Cooperatives.

Lighting of the ceremonial lamp by the Hon. Minister.

"The challenge is to develop approaches to increase the contribution of aquaculture, which are realistic and achievable, within the context of current social, economic, environmental and political circumstances", Mr Nomura said. "Such approaches should not focus only on increasing production; they should also focus on producing a product that is affordable, acceptable and accessible to all sectors of the society".

Mr Nomura went on to highlight the need to promote regional networking and cooperation for aquaculture development, noting that the FAO Committee on Fisheries and its Sub Committee on Aquaculture had suggested that NACA-like mechanisms be established in the Americas, Africa and the Pacific Islands. Significant progress had been made over the past few years with the establishment of the Network of Aquaculture Centres in Central-Eastern Europe in 2004, and the Aquaculture Network for Africa in 2007, which would provide a platform for both intra- and inter-regional collaboration.

NACA would like to thank the Government of Nepal for the excellent arrangements and warm hospitality offered to all delegations. The Report of the Director General to GC 19 is available for download, including information on NACA's activities for the previous year, from:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=199&lid=923.

OIE/NACA Regional Workshop on Aquatic Animal Health

The OIE/NACA Regional Workshop on Aquatic Animal Health organised by the World Organisation for Animal Health (OIE) and the Network of Aquaculture Centres in Asia-Pacific (NACA), was opened on 25 March 2008 in Maruay Garden Hotel, Bangkok, Thailand by Dr Sakchai Sriboonsue, Director General of Department of Livestock Development, Royal Government of Thailand.

Dr Sriboonsue, Director General of the Department of Livestock Development, Thailand (left); Dr Teruhide Fujita, OIE Regional Representative for Asia and the Pacific (right).

The objectives of the 4 day (25-28 March 2008) workshop were:

1. To recognise the importance of control and prevention of aquatic animal diseases, of their negative impacts and of responsibilities of government authorities;
2. To provide updated information on Emerging Aquatic Animal Diseases in the Region;
3. To train National Focal points on OIE Aquatic Animal Disease Standards (OIE Code and Manual) and on OIE World Animal Health Information System (WAHIS) (using computers) for the purpose of 1 above; and
4. To strengthen regional collaboration on aquatic animal disease control and prevention.

Dr Fujita, OIE Regional Representative for Asia and the Pacific, in his address stressed the importance of control and prevention of aquatic animal diseases and noted that the workshop would provide an opportunity for focal points to share updated information on emerging aquatic animal diseases in the region, and to strengthen international collaboration in the development of OIE aquatic animal health standards including the Aquatic Animal Health Code and the Manual of Diagnostic Tests for Aquatic Animal Diseases.

Professor Sena De Silva, Director General of NACA, highlighted the importance of aquaculture to the region and emphasized the commitment of NACA to promoting responsible aquatic animal health management in the region. He thanked the Royal Government of Thailand for hosting the meeting. He also noted and thanked Dr Sakchai Sriboonsue, Director General of the Department of Livestock Development, and Dr Somying Piamsomboon, Director General of the Department of Fisheries, for their ongoing support to regional aquatic animal health management in the region.

The DG of the DOF in her message congratulated OIE and NACA for coordinating the workshop and highlighted the need to strengthening surveillance and reporting in the region. The DG of DLD emphasized the need for rapid sharing of disease information in order to minimize the spread of pathogens associated with international trade. He urged the participants to make best use of the workshop and contribute to improved reporting from the region.

OIE aquatic focal points nominated by OIE delegates from 19 countries in the region are participating in the workshop. Resource experts from the OIE Aquatic Animal Health Standards Commission, OIE Information Department (Paris), OIE Regional Representation for Asia and the Pacific, FAO, Thailand Department of Fisheries, Mahidol University in Bangkok, SEAFDEC AQD and NACA are providing technical presentations and hands on practical training in WAHIS online reporting.

A new initiative to establish and operationalise a WAHIS OIE-NACA 'Regional Core' database on aquatic animal diseases that will accommodate OIE listed and non-OIE listed diseases of regional concern is also being discussed. The QAAD (Quarterly aquatic animal disease) reporting system will continue until the WAHIS OIE-NACA regional core becomes functional. The NACA Asia Regional Advisory Group on Aquatic Animal Health (AG) will support the WAHIS OIE-NACA Regional Core and assist in revising the list of diseases to be included in the Regional Core on an annual basis. The Regional Core is intended to increase the speed and accuracy of international aquatic animal disease reporting and to provide a valuable resource for the formulation of international trade and quarantine policy. The Regional Core will be based on the same software as WAHIS, which allows member governments to submit disease reports directly to the OIE Central Bureau in Paris via a web-based interface, and contains an automated warning system that alerts members via email when one member submits an urgent disease notification. The envisaged Regional Core will provide access to both current and historical records on the aquatic animal health status in member countries and can generate customized health/disease status reports on demand. The outputs of the Regional Core will be hosted on NACA and OIE Regional Representation for Asia and the Pacific websites.

The report and recommendations from the workshop will be available for download on the NACA website in due course.

Vietnam catfish BMP project kicks off

The project Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta kicked off with its first planning meeting held at Can Tho University on 29 January, followed by several days in the field visiting farms and processing plants.

The catfish farming industry in Vietnam is growing at a phenomenal rate. In 2007 the industry is estimated to have produced at least 1.2 million tonnes of catfish, already exceeding the government's 2010 development target and delivering a massive US$ 1 billion economic boost to farmers and rural communities.

As the industry is still in a phase of rapid expansion considerable interest has arisen in issues of sustainability, with several NGO groups vying to develop certification 'standards' for catfish production. However, previous experience has shown that such standards can be difficult for small scale farmers to follow, particularly when high targets are set without any practical guidance to farmers on how to meet them.

The philosophy of the catfish 'better management practices' (BMP) project is different. The aim of the project is to help farmers improve their management practices, delivering increased profitability and environmental performance by making more efficient use of resources. BMPs are implemented voluntarily and the incentive to adopt them is provided simply by their direct economic benefit to the farmer. BMPs are not certification standards, but they can help build the capacity of farmers to meet them.

Participants in the catfish BMP project planning meeting.

The visit provided a good first opportunity for project partners to begin scoping out the issues facing the industry with farmers and processors, and to develop a corresponding workplan and priorities for developing BMPs.

During discussions it quickly became apparent that seed quality is the number one issue of concern to farmers, as there is a shortage of supply and a marked deterioration in quality has occurred, leading to increasing losses in nursery and grow out. Health issues are also becoming more prevalent as the industry intensifies. Flesh quality, particularly colour which is affected by water quality and exchange rates within ponds, is an important issue for processors and exporters as it strongly affects price in some markets.

Catfish aquaculture is extraordinarily intensive with yields of 300-400 tonnes/ha not uncommon. It is likely that small improvements in feed quality, feeding efficiency and power usage could also translate into large economic and environmental gains for producers.

As a starting point for the development of better management practices, the Vietnamese project partners (RIA 2 and Can Tho University) will conduct a detailed survey of catfish hatcheries, production and processing in the delta in the first half of 2008, which will identify key issues where the development of better management practices may benefit the industry. The project will focus on simple, practical measures that farmers can easily implement, and will work closely with grass roots producers.

For more information visit the Catfish BMP webpage, which will be maintained as a summary of progress, developments and publications over the life of the project:

http://www.enaca.org/modules/inland_projects/index.php?content_id=1

The project is being implemented over a period of two years by the Department of Primary Industries Victoria, the Research Institute for Aquaculture No. 2 and Can Tho University together with NACA. It is funded by AusAID's Collaborative Agricultural Research and Development Programme.

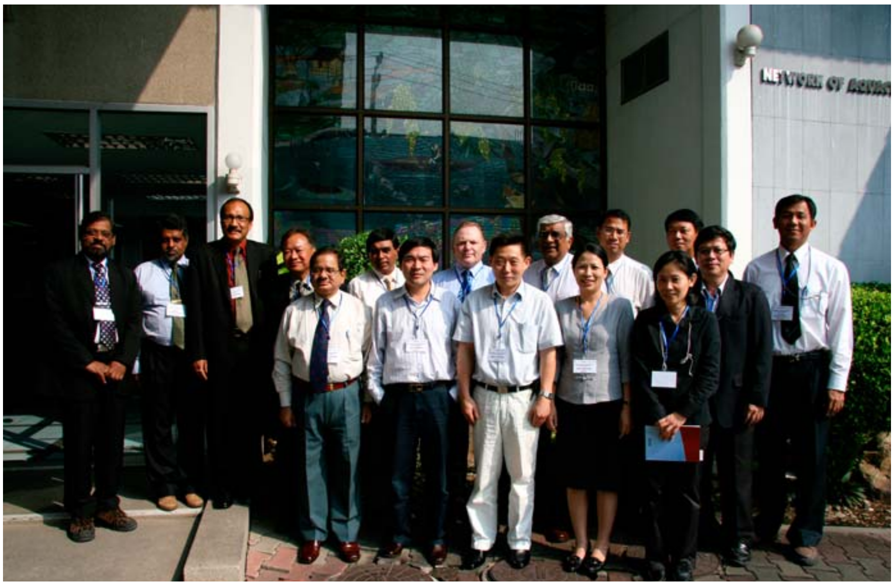
Planning meeting, Regional Project on Reservoir Fisheries Development and Management

A planning meeting for the Regional Project on Reservoir Fisheries Development and Management was held from 14th to 16th January in the NACA Secretariat, Bangkok. This three year project is funded by the Icelandic Development Agency (ICEIDA). The meeting brought together 17 representatives of the five participating countries (China, India, Nepal, Sri Lanka and Thailand),and from the South East Asian Fisheries Development Centre, who also expect to support the future participation of Lao PDR and Cambodia in the project activities.

Opening the meeting, ICEIDA representative Mr Arni Helgason noted that fisheries resources were of great importance both to Iceland and to Asia, and that ICEIDA had supported this project as a contribution towards the development of alternative ways to meet the increasing demand for fisheries product within the global scenario of stagnating wild fisheries production. He advised that ICEIDA had been similarly providing support in Sri Lanka since 2005, and hoped that the project would be the starting point of a long term partnership between NACA member countries and Iceland in this field.

The meeting reviewed the current status of reservoir fisheries in participating countries. The needs for improving the reservoir fishery yields and the livelihoods of fisher communities in each country were discussed along with opportunities for regional collaboration, leading to development of a number of concept proposals for implementation of the project both within and between participating countries.

Based on the deliberations, ten projects have been selected considering the importance of each to the proposing country as well as its degree of relevance to reservoir fisheries management and development in the region. NACA is pleased to announce that the activities selected for funding are:



Participants in the reservoir workshop planning meeting.

- Role of fish species introduction in reservoir fisheries in China. A case study on successful introduction of icefish in Chinese reservoirs. Implemented over two years by the Institute of Hydrobiology and the Freshwater Fisheries Research Centre, Chinese Academy of Fisheries Sciences.

- Investigation of successful practices of culture-based reservoir fisheries in China. Implemented over two years by the Freshwater Fisheries Research Centre and the Institute of Hydrobiology, Chinese Academy of Fisheries Sciences.

- Capacity building of field staff on scientific aspects of inland fisheries development and effective data collection methods. Implemented over 6 months by the National Aquaculture Development Authority of Sri Lanka and Aquatic Resources and Quality Improvement Project.

- Exploitation of untapped fishery resources in reservoirs through proper management. Implemented over two years by the University of Kelaniya, the National Aquaculture Development Authority of Sri Lanka and the National Aquatic Resources Research & Development Agency.

- Impact of stocking size of fingerlings on culture-based fisheries in village reservoirs and their implications on the economics of mini-nurseries. Implemented over two years by the National Aquaculture Development Authority of Sri Lanka and National Aquatic Resources Research & Development Agency.

- Strengthening and consolidation of the knowledge of reservoir and lake fisheries management for livelihood improvement of near by communities. This will have two components implemented over a total of two years the Nepal Agricultural Research Council and Directorate for Fisheries: i) complete documentation of the success story of provision of alternative livelihoods to displaced communities at Indrasarrobar Reservoir, Kulekhani, and ii) Updating the database/profile on reservoirs and lakes (tectonic and oxbow) in respective to fisheries development and conservation management, specifically Jagdishpur Reservoir, and the Pokhara and Rupa lakes, Kapilvastu.

- Trend analysis of reservoir fisheries in Thailand. Implemented over 18 months by the University of Udornrachathani.
- Evaluation of the contribution and performance of tilapia and Macrobrachium rosenbergii to the fisheries in selected reservoirs in Thailand. Implemented over 18 months by the University of Udornrachathani.
- An evaluation and critique of tilapia fisheries outside Africa. Implemented over 18 months by NACA; the University of Kelaniya, Sri Lanka; the Department of Fisheries, Thailand, and the University of Udornrachathani, Thailand.

Presentations and selected audio recordings of the meeting are available for download from:

http://www.enaca.org/modules/workshops/index.php?content_id=1

You can also track the progress of this project at its dedicated webpage:

http://www.enaca.org/modules/inland_projects/index.php?content_id=4

NACA to document "Aquaculture Success Stories"

One of the main recommendations of the workshop on Sustaining Aquaculture to 2025 and Beyond held in Rayong, Thailand (June 2007) was that there is a need to document "success stories" in aquaculture in suitable forms for dissemination to policy makers, mid-level technicians and practitioners. The workshop was of the view that such documentation will help bring about policy changes, particularly in emerging aquaculture nations to pursue aquaculture development in a sustainable and an environmentally friendly manner.

NACA through its MoU with the World Fisheries Trust (WFT), a NGO based in Vancouver, Canada, and the Institute for International Sustainable Development (IISD), Winnipeg, Canada, have linked to commence this work. Approximately US$ 48K have been made available for the initial phase from the latter two organizations and a "Write Shop" where prospective experts on eight selected success stories will be brought together to achieve the task. It is planned that the "Write Shop" will be held in September-October 2008 and plans are now being finalized to commence the preparatory work.

6th Regional Grouper Hatchery Training Course – 5-25 May 2008

NACA is pleased to announce the 6th Regional Grouper Hatchery Production Training Course for the Asia-Pacific Marine Finfish Aquaculture Network. The course is schedule for 5 to 25 May 2008. For further information and registration form please send your request to Dr Sih Yang Sim at sim@enaca.org.

Registration and payment deadlines

The training course fee for NACA members is US$2,000 (non NACA members US$2,400) per person if registration and payment are received before the deadline. The training fee covers most lunches and some dinners, airport pickup, local transport for field trips and training course related activities only. The fees and payment deadlines are:

Participants from NACA members

- Now until 14th March 2008 – US$2,000 per person
- 15th March to 4th April 2008 – US$ 2,300 per person
- 5th April to 25th April 2008 – US$2,600 per person

Participants from non-NACA members

- Now until 14th March 2008 – US$2,400 per person
- 15th March to 4th April 2008 – US$ 2,700 per person
- 5th April to 25th April 2008 – US$3,000 per person

The hotel is around US$18-30/night/person inclusive of breakfast, depending of the type of room one chooses. Participants will pay direct to the hotel. However, booking is made through the organizers. The training course only accepts limited number of participants and it is operated as first come first served. A copy of the training report for 2007 is available for download at NACA website at:

http://www.enaca.org/modules/news/article.php?storyid=1085

Establishing a Working Party on Aquaculture Statistics

FAO in collaboration with NACA will hold a workshop on, "Establishing a Coordinating Working Party on Aquaculture Statistics (CWP-AS)" in Nakorn Nayok, Thailand between the 8th to 10th of January 2008. The need to establish a CWP-AS has long been recognised, and has been endorsed at many consultations and fora including the Sub-Committee on Aquaculture of the Committee on Fisheries at its meeting in New Delhi in September 2006, and then by the Committee on Fisheries itself at its meeting in Rome in March 2007. The CWP-AS will have the same terms of reference as the Coordinating Working Party on Fishery Statistics (CWP-FS), i.e. to:

- Keep under continuous review the requirements for aquaculture statistics for research, policy-making and management
- Agree on standard concepts, definitions, classifications and methodologies for the collection and collation of aquaculture statistics, and
- Make proposals for the coordination and to streamline aquaculture statistical activities amongst relevant intergovernmental organizations.

It is expected that the establishment of the CWP-AS will result in improved statistical collection in aquaculture and related activities and consequently will help the countries to plan aquaculture developments better and more strategically.

Implementing the ASEAN Roadmap for Integration of Fisheries Sector

At the invitation of the Department of Fisheries, Thailand, the Regional workshop on implementing the ASEAN Roadmap for Integration of Fisheries Sector was held from 16 to 18 January 2008 in Bangkok, Thailand.

The Workshop was initiated to support ASEAN Member Countries in the realization of the ASEAN Economic Community (AEC) by 2010 through the implementation of the Roadmap for Integration of the Priority Sectors, including fisheries, in order to further deepen and accelerate regional economic integration and enhance international competitiveness of ASEAN products. The workshop reviewed progress and status in the implementation of the Roadmap for the fisheries sector; developed an ASEAN common framework for the specific key issues/measures of the Roadmap; and clarified and formulated supporting mechanism and follow-up actions to facilitate future coordination and implementation of the Roadmap.

The workshop was attended by 62 participants from the 10 ASEAN Member Countries, the ASEAN secretariat, FAO, NACA, SEAFDEC, SEAFDEC - Marine Research Development, and Department of Fisheries - Thailand (DOF–Thailand). The participants included experts from government agencies, international and regional organizations and observers from the private sector.

The Workshop was organized under the ASEAN-SEAFDEC Strategic Partnership (ASSP) in collaboration with FAO and NACA, with funding support from SEAFDEC-SIDA collaborative project.

London Expert Workshop on Aquaculture Certification

The Expert Workshop on Guidelines for Aquaculture Certification took place on 28-29 February at the headquarters of the Department of International Development (DFID) in London, organised by FAO in cooperation with NACA and the Seafood Choices Alliance. The workshop was the fourth in a series of stakeholder meetings to assist the preparation of international guidelines for aquaculture certification, as requested by the FAO Aquaculture Sub-Committee. The three aquaculture certification export workshops to date have focussed largely on Asia and Latin America, as major producing regions of the world. The London meeting gathered views and expert inputs from stakeholders in Europe on certification of aquaculture products, including representatives of European aquaculture farmers, and large importers and retailers of aquaculture products. The workshop also explored the status, opportunities and mechanisms for enhanced supply chain partnerships to support aquaculture certification in producing countries and market access for aquaculture in the European market.

Further background documents and presentations from the workshop and aquaculture certification program, along with the latest draft of the International Guidelines for Aquaculture Certification, are available at the Certification section of the NACA website:

http://www.enaca.org/modules/workshops/index.php?content_id=3.

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NEW GENERATION OF BLACK TIGER SHRIMP
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