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AQUACULTURE ASIA

Modern aquaculture in Indonesia

Supply and use of catfish seed, Vietnam

Better management practices

Organic scampi, India

Innovative fish marketing

Himalayan river life

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is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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NACA
An intergovernmental organisation 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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Join us for the aquaculture event of the decade

In 1976, FAO held the first ever global conference on aquaculture, the Kyoto Conference, which triggered the recognition of aquaculture as a significant food production sector and explored opportunities for aquaculture development. In 2000, the Global Conference on Aquaculture in the Third Millennium explored the sector's progress and trajectory as it continued to emerge amid the stagnation of wild capture fisheries.

Today, **aquaculture contributes around 50% of global food fish supplies** and is poised to become our main source of fisheries products. The 'future of fishing' has arrived, bringing a whole new world of opportunities and challenges with it.

FAO in partnership with NACA and the Thai Department of Fisheries, are organising the next conference in this series, the *Global Conference on Aquaculture 2010*, to evaluate where the sector stands today and prepare for the challenges ahead. The objectives of the conference are to:

- Review the present status and trends in aquaculture development.
- Evaluate the progress made in the implementation of the 2000 Bangkok Declaration and Strategy.
- Address emerging issues in aquaculture development.
- Assess opportunities and challenges for future aquaculture development.
- Build consensus on advancing aquaculture as a global, sustainable and competitive food production sector.
- Provide a global forum to build consensus to advance sustainable aquaculture development and contribute to the Millennium Development Goals.

The conference will consist of plenary lectures together with six regional reviews and one global synthesis, which will set the scene for six thematic sessions and associated expert panel discussions on key aspects of aquaculture development in the coming decades. For details of the programme, registration and accommodation, please visit the conference website at the link below:

http://www.aqua-conference2010.org

The conference will be held from 22-25 September at the Movenpick Resort and Spa, Karon Beach, Phuket, a truly beautiful location. Join us and have your say on the future of aquaculture development. We look forward to seeing you there.

Simon Wilkinson

AQUACULTURE ASIA

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Peter Edwards writes on

Rural Aquaculture

Dr Edwards is a consultant and Emeritus Professor at the Asian Institute of Technology in Thailand where he founded the aquaculture programme. He has over 30 years experience in aquaculture education, research and development in the Asian region. Email: pedwards1943@gmail.com.

The development of 'modern' aquaculture in Java, Indonesia

This is the second and final column following a visit I made to West Java in June and July last year to witness changes that have taken place in inland aquaculture over the past three decades. My column in the previous issue (Volume XIV, No.4, pp. 3-8) considered traditional aquaculture based on natural food produced by organic fertilisation and its augmentation by supplementary feed whilst here I discuss the development of 'modern' aquaculture, defined simply as the use of formulated pelleted feed from agro-industry. I also include some recent developments in Central Java, hence the broader title of this column. I spent another two days in the field in October last year following the annual meeting of the Aquaculture Society of Indonesia, 'Aquaculture Indonesia 2009', held in Yogjakarta for which I was I was sponsored by the Aquaculture Society of Indonesia to present a keynote on comparing small-scale aquaculture in West Java and other Asian countries.

Indigenous giant gourami are fed mainly commercial pelleted feed supplemented with elephant ear plant grown on pond dikes.

As mentioned in the previous column, there has been a dramatic 6-fold increase in inland aquaculture production over the past three decades in Indonesia. This has been made possible in part by introduction of new species and culture systems and especially by intensification of production of fish in monoculture through use of agro-industrial pelleted feed. I write ‘in part’ because these recent developments have built upon the long tradition of Javanese aquaculture and fish marketing.

Changes in species

Traditional polyculture has declined and several of today’s major farmed species are exotic species. The indigenous common carp (*Cyprinus carpio*) still dominates inland aquaculture production at 36% of the total inland production of 740,000 tonnes in 2007 and production of native giant gourami (*Osphronemus gouramy*) has increased 9-fold over the past three decades although only comprising 5% of production as it is a high-value fish species. However, other major farmed species are exotics. There has been a major rise in production of Nile tilapia (*Oreochromis niloticus*), comprising 28% of national inland aquaculture production. African catfish (*Clarias gariepinus*) is a species being promoted by the government for national food security along with common carp and tilapia and its production in 2007 was 92,000 tonnes or 12% of the total.

Exotic African catfish being fed commercial pelleted feed in a small-scale farmer's pond.

African catfish is processed and packaged at village level.

Unlike several other Asian countries where pangasiid river catfish are major farmed fish, here they are relatively minor. Striped catfish (*Pangasianodon hypophthalmus*) was introduced from Thailand about 30 years ago but is not popular among consumers in Java. The indigenous *Pangasius djambal* is raised in traditional wooden cages in rivers in Sumatra but attempts to breed it in Java have not been very successful as fecundity is low, fingerling production is unstable, and mortality is high in static water ponds. As the flesh quality of the native species is higher than that of the introduced striped catfish, a hybrid has been developed by crossing male *P. djambal* with female *P. hypophthalmus* to combine the best attributes of the two species; the hybrid has a faster growth rate and higher tolerance to low dissolved oxygen than *P. djambal* and retains its white flesh. It was distributed to farmers in 2006. A species that is being increasingly cultured is pacu or freshwater pomano as it is sometimes called (*Piaractus* sp.) which the government would like to ban due to concerns about possible adverse impacts on native fish although it is now widely farmed.

While production of the native giant gourami, a herbivore traditionally fed soft leaves of plants, especially elephant ear plant (*Alocasia macrorrhiza*), has increased, today the main diet is pelleted feed although fish raised only on pelleted feed are reported not to have a good taste. Giant gourami can be bred naturally without artificial induced breeding provided that materials are provided in the pond for it to make a nest to lay eggs. Thus, it has potential to be bred by small-scale farmers and a small-scale farming family could keep 30-50 brood stock and sell the eggs. Unfortunately the growth rate of the species is only about half that of tilapia even when fed pelleted feed although the farm gate price is double that of tilapia as it is a prized restaurant fish.

The culture of African catfish (local name lele) has expanded rapidly as it can be raised at high density in small ponds and can be marketed at a relatively small size of 125-200g, the traditional Javanese size for eating fish. In my previous column I wrote about a large-scale farm using dried marine trash fish and chicken offal (in what may be considered traditional ways of feeding fish) as well as pelleted feed. However, most of the African catfish being farmed in Java is pellet-fed as I witnessed in Mangkubumen Village, Boyolali Regency near Yogyakarta in Central Java. Here almost all the rice fields in the village have been converted into 1,600 small ponds, mostly very small, about 40-50m^2. About 100 families in the village raise African catfish with most families having 10-16 ponds with a range from 6-160 ponds per family. The usual rate of production is 800-1,200 kg/pond equivalent to about 160-300 tonnes/ha per 3.0-3.5 month grow-out cycle. Such high small-pond production makes it very attractive for poor farmers. Harvested fish are sorted into three categories: large fish which fetch a lower price and are processed; optimal sized fish for marketing fresh; and small fish which are restocked. There is also village-level processing of fish by women to make fried fish skin and fried flesh which are marketed in attractively designed packages. Fingerlings are mainly produced in another village, Tulungagung, in East Java, a six hour drive.

A newly constructed running water pond farm in Subang.

Changes in systems

Two major new grow-out systems were introduced into Java by government aquaculture officers in the 1970's: running water ponds and floating net cages, both developed in Japan, the former directly from Japan and the latter indirectly via Taiwan.

Running water ponds

Mountainous areas in West Java have lots of water to supply running water ponds (RWPs) constructed alongside streams and irrigation canals by gravity. The RWP system was rapidly taken up by farmers from about 1975 and at its peak a decade later there were said to be 10,000 such farms raising common carp in West Java as it was a good business. Most farmers were not poor because of the high capital construction and operating costs. I saw several fully operational RWP farms during my visit in 1981, mostly quite large operations, but last year I saw mainly abandoned systems. Most RWPs ceased to function in the late 80s as they were outcompeted by floating net cage culture in reservoirs which was developed a few years later. Floating net cage culture has a lower cost of production of carp than RWPs and now dominates grow-out production. The RWP farms were small because of highly intensive production, ranging from 100-5,000m^2 although most were less than 1,000m^2. Gravity-fed water exchange was estimated at up to 100 times/day with annual fish production up to 90kg/m^2, equivalent to an extrapolated fish harvest of 900tonnes/ha/year.

Red tilapia being fed with commercial pelleted feed in a floating net cage farm in Cirata Reservoir by Dr Agus of JAPFA an AIT alumnus who arranged and guided my visit.

Farmers were observed mincing and sun drying farm-made feed during my visit in 1981 but the RWP system stimulated the development of factories to produce pelleted feed, the availability of which encouraged more farmers to build RWPs, a good example of positive feedback. Use of commercially produced feed is universal in intensive culture in Java today.

A tilapia floating net cage farm owned by AquaFarm in Gadjah Mungkur Reservoir.

On my recent visits I saw a few RWPs still in operation but to hold table fish harvested from reservoir cages until they are sold on the local market and to hold common carp brood stock which are rented to seed producing farmers. RWPs are also used for high density nursing of giant gourami, pacu and striped catfish. However, I visited a RWP system in Cisalak subdistrict in Subang which had been closed until recently for several years but had been renovated; and also a newly constructed RWP farm. These are used to produce

Bambang Gunadi an AIT alumnus feeding commercial feed in a high density pond trial of common carp at the Research Institute for Freshwater Aquaculture Sukamandi.

Pond nursing of common carp fingerlings with commercial pelleted feed in Subang.

Close up of pellet-fed common carp fingerlings Subang.

higher-value large common carp, greater than 1 kg, for sports fishing and restaurants. This is a niche market with relatively low demand but as the farm gate price is about one third higher than that of reservoir cages which produce smaller and lower-value fish of a preferred size for the domestic market of 0.20- 0.33 kg, they are profitable. Furthermore, cage-raised common carp often have an off-flavour, unlike those from RWPs.

Cages

Dams constructed in the 1970s and 1980s in the densely populated lowlands of Central and West Java displaced tens of thousands of poor rice farmers as their rice farms and communities were flooded. Cage culture was subsequently developed in the reservoirs and the intended beneficiaries were poor farmers. However, today cage farming is dominated by urban entrepreneurs and in some reservoirs by multinational companies, with some of the local former farmers employed as labourers on the cages, as related by interviewed cage farmers and also well documented in the literature.

Caged fish production in reservoirs has become the main source of fish for the domestic market and supplies about 80% of the total consumption in Java and so is extremely important for national food security. The main species is common carp raised in two cycles annually on pelleted feed with one crop of tilapia usually raised in a separate cage below the main cage on the wastes from carp culture.

I visited the first trial of floating net cages during 1981 in the small 20 ha, 15m deep, Lido Lake, which had started in 1978 and revisited it last year. Last year I also visited Cianjur Reservoir in West Java and Gadjah Mungkur and Kedung Ombo Reservoirs in Central Java.

Lido Lake

In 1981 there was a government farm and two private farms. The 10m^2 net cages had a metal frame and oil drum floats and a 1.5m deep net and were stocked with either common carp or Nile tilapia at 6kg/m^2, fed with a 25-30% protein pellet, and harvested at 28.5 kg/m^2 after 4.5 months. Earlier trials in polyculture had been unsuccessful as common carp exhibited poor growth. During my recent visit to Lido Lake, Nile tilapia, pacu and striped catfish were being raised by 26 farmers but in smaller 12 m^2 cages with 12 cages/farmer. Poor water quality was now reported to be a problem, especially during January and February when heavy rain caused a water 'turnover'.

Cirata Reservoir

A successful cage trial with common carp had also been conducted in Jatiluhur Reservoir which had been constructed earlier in the1970s by the time of my visit in 1981 but Cirata and Seguling dams only came into existence in 1985 and 1988, respectively.

Cirata with an area of 62 km^2 has about 73,000 cages but during my visit about 50% may not have contained fish as many farmers lacked capital. Fish are raised in cages 7m x 7m x 3m deep. A stock of 100 kg of fingerlings of common carp per cage grew to 1.8-2.0 tonnes in 4 months when cage culture was first established but there has been a gradual decline in production to due to increasingly poor water quality. Now farmers stock only 50 kg of fingerlings per cage, with a correspondingly reduced use of feed, and the fish grow to only 0.8 tonnes in 4 months. Food conversion ratio is 1.6 with good quality feed. One hundred kg of normal coloured black tilapia are stocked in the lower cage and grow to 0.3 tonne in 6 months. Some farms are now raising pellet-fed red tilapia in the main cage which fetches a higher price in the restaurant trade. Some cage farms are trialling milkfish and silver striped catfish.

Small-scale farmers nurse common carp and tilapia fingerlings in Subang.

Mr Imsa inside an aquarium filled nursing shed belonging to one of his small-scale farmer network memebers in Darmaga.

Nursing giant gourami in aquaria.

Central Java reservoirs

Gadjah Mungkur, an 84 km^2 reservoir in Wongojiri to the south of Solo has 15 farms each with 10-50 cages which are mostly owned by investors from the local area but Aquafarm, a Swiss-owned multinational company which exports tilapia has more than 500 cages. Interviewed cage operators reported that there used to be about 20 farmers but the number declined as some farms went out of business due to low profit as the local market, unlike in West Java, is not good. Farmers reported concern over mortality of Nile tilapia but not common carp or striped catfish due to declining water quality. Dead fish are either used by a local factory to make fish powder or are fed directly to common carp, neither practice being advisable from a fish health management perspective.

Kedung Ombo reservoir to the north of Solo has an area of 47 km^2 but also with only a small number of about 30 farms each with 10 to 200 cages, mostly owned by off-farm investors who hire operators, including one belonging to AquaFarm with 240 cages. A notable exception was the farmer interviewed who used to be a construction worker but had saved and invested his own money in aquaculture. He now operates 25 cages and hires five workers. He copied cage farming from other farmers as well as learning through experience. During his first year in 2000 he had only a single cage but he re-invested the profit to operate 6 cages in 2001. Four other farmers started small like him but with four cages initially rather than a single cage. The interviewed farmer was also building a restaurant at the side of the reservoir. He intended to use his own cage raised tilapia, barbecue them and sell them at double the farm-gate price to local mainly weekend tourists. The water quality was also declining as in other reservoirs, with increasing fish mortality although the number of cages was now stable as the local government had recently introduced a regulation to curb a rise in the number of cages.

Experimental systems

Two systems are being trialed at the Research Institute for Freshwater Fish Breeding and Aquaculture in Sukamandi: intensive culture of common carp in lowland stagnant water but aerated ponds; and static water pond culture of striped catfish. Trials are being conducted with intensive culture of common carp and striped catfish in ponds as a possible alternative grow-out system in anticipation of a decline in reservoir production due to pollution.

Common carp fingerlings stocked at high densities of 50-75 individual 6-10g fingerlings in a 200m^2 pond with a 1-HP paddle wheel and fed commercial pelleted feed, which produced an extrapolated yield of almost 100 tonnes/ha of 0.25-0.3 kg fish in 4-5 months. The idea for raising striped catfish in ponds was borrowed from Vietnam. An extrapolated yield of 100 tonnes/ha has been obtained with pelleted feed in a 6,000m^2 pond.

Seed production and marketing

Traditional small-scale wastewater-fed ponds are probably still the major source of seed for common carp and Nile tilapia. However, because of the tremendous increased demand for fingerlings to stock grow-out systems, especially cages in reservoirs, these two species are also produced in pellet-fed nursing systems in areas close to the reservoirs such as in Subang.

It is not economic for small-scale farmers to still be involved in grow-out of traditional low-value species if they want aquaculture to make a significant contribution to their income. Grow-out also needs much more water than nursing and more time is needed for table fish to reach marketable size compared to fingerlings. Thus there has been a major shift in production of small-scale aquaculture from grow-out to nursing because of its inherent advantages for small-scale farmers. Nursing requires less investment as the fish are small, especially in terms of feed required, and the cash flow is better and the risk less because of the shorter cycle. Many small-scale farmers nurse high-value species as I saw when visiting hatcheries and nurseries in Darmaga near Bogor for giant gourami, pacu and striped catfish.

I visited two areas where small-scale farmers have been organized into nursing networks, in Subang for common carp and tilapia and Darmaga for high-value species.

Common carp and tilapia

In Gembor Village, Pegaden subdistrict, Subang more than 1,000 former rice farmers each has a minimum of one 0.5-1.5 ha pond for nursing common carp and Nile tilapia to provide fingerlings for RWP systems in Cisalat subdistrict, Subang and cages in Cirata Reservoir. Fish culture started in the area about 20 years ago after the current village head moved there from Saguling Reservoir where he had learned how to raise fish and the other farmers copied from him. There are six large farmers in the village, each with a network of 70-100 small-scale farmers, to facilitate input supply, credit and marketing fingerlings. Nightsoil was used to be used to fertilise ponds but now commercial feed is used.

High-value species

Mr Imsa, a large-scale seed producer with 6 farms informed me that the Darmaga area has changed from mainly RWP farms for grow-out of common carp to mainly hatcheries and nurseries of high-value species such as pacu and striped catfish. There are about 50 hatcheries for pacu and about 20 hatcheries for striped catfish, both large and small. Mr Imsa has organized 10 farmers into a nursing group to strengthen his business. He supplies his group with eggs and one day-old larvae of pacu (10% of the total) and striped catfish (90% of the total). *Artemia* are fed for 4-5 days followed by *Tubifex* and finally crumbled shrimp pelleted feed. Mr Imsa buys back 21-40 day-old nursed fingerlings from the group and sells them to many regions in Java, Kalimantan and Sumatra. He supplies the farmers with feed and an aquarium production facility for nursing and also provides working capital if needed. Each farmer has 70-100 units of 100-120 l aquaria with each aquarium stocked with 200,000 to 400,000 larvae / batch; there are an average of 7 batches/year.

The aquaria are a fairly low-cost nursing system as they are installed in bamboo-framed sheds covered in plastic to maintain a high temperature of 30 degrees celsius. This system was developed by Bogor Agricultural University and has replaced nursing in concrete tanks in the area.

A small-scale farmer feeding commercial pellets to striped catfish fingerlings.

Checking for ripe eggs in a pacu broodfish.

The main business at Cibaraja Fish Seed Market in Sukabumi is now ornamental fish rather then food fish fingerlings.

Most of the farmers in Mr Insa's nursing group are small-scale operators who used to be rice or vegetable farmers but now have a most profitable extra livelihood; some were laid off from other jobs or were government officers. Nursing now provides them with 70-100% of their total income. Mr Imsa who has 10 years experience is a university graduate who used to work for a feed company. He pointed out that operating a hatchery requires considerably more skill than nursing or grow-out.

Cibaraja Fish Seed Market

I also visited the famous Cibaraja fish seed market in Sukabumi which has been operating for over 50 years. The sale of fingerlings is much reduced today as purchases of the large number of fingerlings required to stock cages in reservoirs is done directly from nursing farms. Table fish harvested from cages are also held live in the running water system at the market prior to being sold but the largest business is now ornamental fish, especially gold fish and koi carp. I also visited a local government project near Sukabumi in which about 100 poor farmers were raising ornamental fish in suspended net cages in a small reservoir. The project was ideal for poor farmers as it did not require land, each cage was small and little capital investment was required. Harvested fish were quarantined in aquaria in a building by the side of the reservoir prior to marketing.

Towards the future

The biggest concern expressed repeatedly during my visits is the future of cage culture in reservoirs, especially in Cirata Reservoir, which currently supply about 80% of the domestic fish supply of the densely populated island of Java. A major concern is the declining water quality due to massive inputs of nutrients from pelleted feed. In Cirata the early morning dissolved oxygen is often as low as 0.8 ppm at 1m depth. During the last turnover of the reservoir's water two years ago, there was an 80% mortality of all species.

A local government project in which poor farmers are raising ornamental fish in suspended cages in a small reservoir.

Of the three large reservoirs in West Java, I was informed that common carp can no longer be grown in Saguling Reservoir as the water quality is now so poor, only more tolerant species such as giant gourami, Nile tilapia and striped catfish. Production and intensity of cage culture have been reduced in Cirata and if water quality continues to decline only species more tolerant of poor water quality will be able to be farmed. A new reservoir in under construction to the east of Bandung, Rajamandala. It is to be hoped that the introduction of cage culture in the new reservoir will be regulated so that poor rice farmers will be able to farm fish in cages and fish production will be within the reservoir's carrying capacity. The trials of high density pond culture of common carp and striped catfish have been stimulated by the need to develop an alternative grow-out system to cage culture.

There is concern about sustainability of the water supply in West Java as it is declining year by year due to population growth and the development of settlements in rural areas, especially in the watersheds in the mountains. I was informed that Sumatra is about 10 years behind Java in the development of aquaculture and has great potential for seed and grow-out production. Many areas in Sumatra are similar to the main aquaculture areas of West Java so it is likely to become a major frontier for aquaculture development and may eventually supply fish to Java.

Better Management Practices (BMPs) - gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities

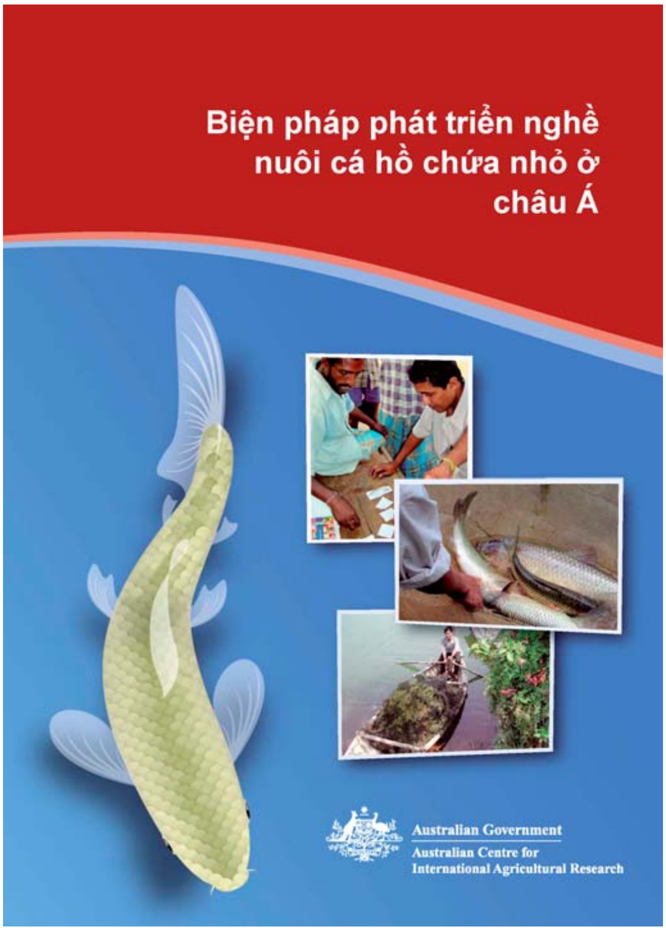
Mohan, C.V. and De Silva, S.S., NACA

Development and adoption of Better Management Practices (BMPs) for key aquaculture commodities is gradually increasing in the region. However, there appears to be lot of confusion in the minds of farmers, policy makers and other stakeholders about the concept and approaches. Often, it is confused with standards and certification. The purpose of this article is to highlight the concept of better management practices, how they can be developed and adopted for specific commodities and or farming systems, and their benefits to small scale farmers and rural communities. NACA has been involved the development and adoption of better management practices since 2000 in a number of countries in the Asia-Pacific region, working in conjunction with country partners and donors, and international organisations. The lessons learned and experience gained strongly suggest that better management practices are the gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities. The purpose of this article is to apprise all stakeholders how NACA has gone about its task of developing and adopting BMPs and to enumerate a few successes in this regard.

Asian aquaculture is dominated by small scale farmers, conveniently defined as those who own or lease, operate and manage farms. These farmers face numerous challenges in a globalised market place, amongst which are: access to technical knowledge, lack of enabling government policies and programs, access to credit and insurance, compliance to food safety standards (e.g. antibiotics), minimising disease related losses, meeting stringent market requirements, including certification, meeting environmental and ethical standards and wildlife and biodiversity requirements. At the same time, the demand for quality and responsibly produced and certified aquaculture products is predicted to increase substantially in coming years. It is very important that small scale farmers are better prepared to meet these challenges in order to sustain their livelihoods, and indeed continue to provide sea food to the consumers. The way to meet the above challenges and the most rational, practical and technically and economically feasible option is to implement better management practices through a cluster management approach, in a given locality.

What are better management practices?

Better Management Practices (BMPs) in the aquaculture context outline norms for responsible farming of aquatic animals, the implementation of which is voluntary. BMPs are not a certification standard. BMP implementation improves the quantity, safety and quality of products taking into consideration animal health and welfare, food safety, environmental and socio-economical sustainability. Implementation of BMPs can help to achieve compliance with quantifiable standards and indicators set by international agencies and third party certification bodies.



Standards are set from a consumer view point, taking into consideration social equity and well being, environmental, food safety and quality, national regulations and other criteria. BMPs, on the other hand, are commodity specific and location specific management practices that have been developed to meet the norms of responsible farming and at the same time reduce risks to culture operations and maximise returns, the adoption of which by and large satisfies by implication many of the issues of concern to consumers. In doing so, BMPs have most of the ingredients that are required to meet independent standards. Most standards use the principles of responsible farming which takes into account both mandatory and voluntary standards. BMPs are not a onetime solution, they are subjected to gradual evolution, improvement and revision. BMPs can be tailor made and contextualised to meet some of the quantifiable standards, where and if necessary. In simple terms, standards tell us what is expected while BMPs tell us how farmers can reduce risks to their culture operations, maximise returns, reduce losses and at the same time achieve compliance to quantifiable standards.

How are BMPs developed and validated?

As emphasised earlier, BMPs are commodity specific and location specific and have to follow the generic principles of responsible aquaculture. It is generally agreed that for all cultured commodities it is necessary to underpin the general principles for responsible farming that would cover environmental, social, ethical, food safety and husbandry issues. The first step in developing BMPs is gaining an in depth understanding of the culture system(s) and cultured species. This should be done at the population level and not in one or two ponds. Population based approaches to understand the problems and issues confronting a cultured commodity in a specific farming area are gaining importance. Identifying risk factors (e.g. environment, disease, food safety, market access) to the long term sustainability of the farming system, at the population level using epidemiological principles (e.g. risk analysis) is fundamental to developing BMPs. Once risk factors are identified, new management interventions are either developed or existing management methods revised/modified to address the identified risk factors. This must be done in consultation with the practitioners and other stakeholders.

Once a set of science based interventions are developed, through farm surveys, stakeholder consultations and scrutiny of existing scientific knowledge, it is necessary to test the interventions and validate them. This is normally carried out through farm demonstration studies set up for scrutiny by the community. Interventions validated through pilot testing, demonstrations and farmer consultations are referred to as better management practices. These have to be rational, practical and technically and economically feasible for small scale farmers to implement. BMPs are constantly evolving and changing and it is necessary to consider approaches to continuously evaluate and improve BMPs.

Examples of science based information used in the development of the BMPs for shrimp (India) and catfish (Mekong Delta, Vietnam) are entailed in the following scientific publications:

- Umesh, N.R., Chandra Mohan, A.B., Ravi Babu, G., Padiyar, P.A., Phillips, M.J., Mohan, C.V. and Bhat, B.V. 2009. Shrimp farmer in India: Empowering small scale farmer through a cluster-based approach. In: Success Stories in Asian Aquaculture (S.S. De Silva, F.B. Davy, eds.), pp.43-68. Springer-IDRC-NACA, Dordrecht

- Umesh, N.R., Mohan, C.V., Phillips, M.J., Bhat, B.V., Ravi Babu, G., Chandra Mohan, A.B. and Padiyar, P.A. 2008. Risk analysis in aquaculture – experiences from small-scale shrimp farmers of India. In M.G., Bondad-Reantaso, J.R. Arthur and R.P. Subasinghe (eds). Understanding and applying risk analysis in aquaculture. FAO Fisheries Technical Paper. No. 519. Rome, FAO. pp.237-244.

- Mohan, C.V., Phillips, M.J., Bhat, B.V., Umesh, N.R. and Padiyar, P.A. 2008. Tools for preparedness and response: Farm level plans/ husbandry measures. In: Changing trends in managing aquatic animal disease emergencies. Rev. Sci. Tech. Off. Int. Epiz., 2008, 27 (1): 161-173

- Phan Lam T., Bui Tam M., Nguyen, T.T.T., Gooley, G.J., Ingram, B.A., Nguyen Hao V., Nguyen Phuong T. De Silva, S.S., 2009. Current status of farming practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. Aquaculture, 296: 227-236.

- Bui Tam, M., Phan Lam, T., Ingram, B.A., Nguyen, T.T.T., Gooley, G.J., Nguyen Hao, V., Nguyen, Phuong, T., De Silva, S.S. Breeding and seedstock production practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. Aquaculture (in press)

- De Silva, S.S., Ingram, B.A., Nguyen, P.T., Bui Tam, T., Gooley, G.J., Turchini, G.M. Estimation of Nitrogen and Phosphorus in Effluent from the Striped Catfish Farming Sector in the Mekong Delta, Vietnam. Ambio (in press).

The type of dissemination material on BMPs will be commodity, community and need based, but always simple and easily comprehensible. An example used for catfish (Mekong Delta) popularisation of BMPs.

Promotion of adoption of BMPs among small scale farmers

Promoting the adoption of BMPs by small scale farmers is not simple. A dedicated team of field workers need to work with farmers day in and day out to bring about attitudinal changes in the farmers and wean them off preconceived ideas and concepts and conventional practices that are not conducive to the environment, sustainability and food safety. This is a slow process and takes lot of time and resource investment. Using appropriate extension methodologies to bring about change in the attitude of famers and encouraging them to change their

culture practices by incorporating BMPs is vital for successful adoption. In NACA's experience, a critical aspect of the introduction of BMPs has been the role of farmer groups/ clusters (cluster management). Provision of science based information to farmer groups through effective networking and communication is one important key to the success. The best example of this model is the modus operandi of NaCSA (see references in Box 1).

What is cluster/group management?

Aquaculture practices occur in areas that are conducive to the practice and availability of basic resources primarily water. Unlike land based agriculture in the case of aquaculture there is a much higher degree of interaction, e.g. use of a common water resource; common discharge channel etc. among adjacent practices/ farms. Therefore, in a group of farms sharing these common resources if one farmer does not practice BMPs there is a possibility of the others who are practicing BMPs being negated; in other words "all or none principle" is applicable to aquaculture practices in a locality in respect of BMP adoption. This calls for a cluster and or a group approach; all farms acting collectively and in unison and not individually.

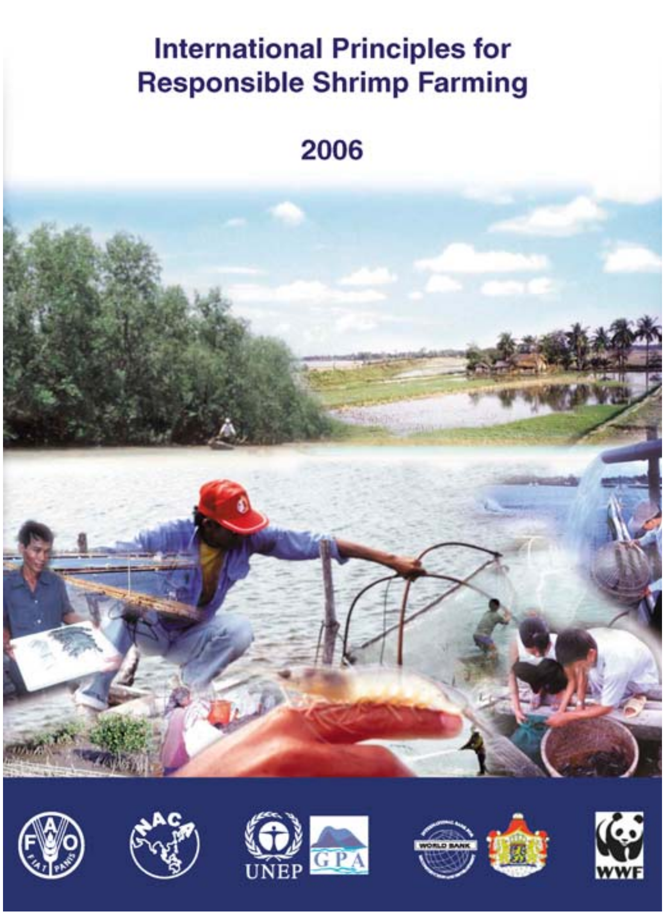
Cluster management in simple terms can be defined as collective planning, decision making and implementation of crop activities by a group of farmers in a cluster (defined geographical area for example sharing common water source) through a participatory approach in order to address the common risk factors and accomplish a common goal (e.g. maximise returns, reduce disease risks, increase market access, procure quality seed,). Promotion of BMP adoption through a cluster management approach reaches more farmers. Cluster management brings several advantages to individual farmer members which otherwise is not possible. Because of the economy of scale which a cluster can achieve, forward and backward integration of culture operation with processors and hatcheries, respectively, is possible. A cluster approach increases the bargaining power and helps farmers to source quality inputs. Certification, which is cost prohibitive for individual farmers, can be accomplished through cluster certification. A cluster approach makes it easy to access credit and insurance compared to an individual farmer. The principle of sharing costs in a cluster approach ensures that common facilities such as feeder canal, roads and other infrastructure can be developed and maintained properly. Peer pressure prevents fellow farmers from resorting to irresponsible culture practices such as the use of banned antibiotics, release of water from disease affected ponds. Above all, cluster farming brings social harmony in a community, fundamental to the progress of society.

The key to cluster management is continuous and regular communication within and among groups. This can be achieved through regular meetings and or through the use of modern communication tools, which contrary to popular belief, rural farmers acquire the skills to use easily.

BMP work in Asia-Pacific

NACA's experience with BMP promotion work in India, Indonesia, Thailand and Vietnam in relation to commodities and that in Sri Lanka, Vietnam and Lao PDR in relation to culture based fisheries - a multi-species farming system - clearly suggests that BMPs improve yields, safety and improve quality of products taking into consideration animal health and welfare, food safety, environmental and socio-economical sustainability. Key BMP and cluster management work carried out in the region include:

- A shrimp farming project in India in collaboration with the Indian Marine Products Export Development Agency and the National Centre for Sustainable Aquaculture, ongoing since 2000.
- Shrimp farming work in Aceh, Indonesia under the ADB-ETESP project (2005-2009) in collaboration with FAO and IFC.
- Catfish farming work in Vietnam under the CARD program supported by AusAid (2008-2010) in collaboration with DPI, Victoria and RIA2 and CTU, Vietnam.
- WWF supported work on shrimp farming in Thailand and India in collaboration with DOF, Thailand and MPEDA, India, respectively.
- ACIAR supported work of strengthening networking and information sharing amongst BMP project implementers in the region.
- In addition NACA has also developed BMPs for the farming practices on culture-based fisheries in Sri Lanka, Vietnam and Lao PDR, under the auspices of ACIAR.



The activities undertaken by these projects is summarised below.

Indian shrimp farming work

Since the early 1990s, the Indian shrimp aquaculture sector has been hard hit by viral diseases. To address rising concerns about the effect of diseases on the sustainability of the sector, the Government of India's Marine Products Export Development Authority (MPEDA) with the technical assistance of NACA and the support of the Indian Council of Agricultural Research (ICAR) and the Australian Centre for International Agricultural Research (ACIAR) initiated a programme in 2000 on "Shrimp disease control and coastal management". The programme started in 2001 with a large epidemiological study aimed at identifying the risk factors for key shrimp diseases. It also undertook to develop and disseminate BMPs to minimise farm-level risk factors for disease outbreaks and to address shrimp farming sustainability more broadly. The programme, which is now in its tenth year, was implemented in a phased manner. Some of the key stages of the programme included:

- A baseline study of the major diseases affecting the shrimp aquaculture operations (2000).
- A longitudinal epidemiological study in 365 ponds in Andhra Pradesh, east coast of India, to identify major risk factors associated with white spot disease and low productivity in *Penaeus monodon* culture ponds (2000-2001).

- Development of farm level contextualised BMPs to address the identified risk factors (2002).
- Pilot testing of BMPs in selected farms (2002).
- Production of a simple and practical shrimp health management manual based on the outcomes of the risk factor study and piloting of BMPs, to support farm and village level extension programmes (2002).
- Development and testing of the concept of cluster farming for effective BMP adoption amongst farmers in a cluster, and expansion of BMP promotion to a large number of clusters (2003-2004).
- Extension of some of the BMPs to downstream activities like hatcheries.
- Review and refinement of BMPs, and production of BMP extension leaflets for each stage of the culture operation (2005).
- Expansion of the BMP programme to clusters in five different states in India (2005-2006).
- Conceptualisation of an institutional framework for maintaining the BMP and shrimp health extension programme (2006).
- Establishment and inauguration of the National Centre for Sustainable Aquaculture (NaCSA) to carry forward the MPEDA/NACA programme activities (2007).
- 2008-2010 and ongoing: consolidation of the program in the state of Andhra Pradesh and expansion to neighbouring states. Supporting clusters to access markets through certification programs on a pilot scale. Development of cluster certification guidelines.

As of March 2010, NaCSA has formed 531 societies (clusters) covering 12091 farmers and 12889 ha. At present 54 staff members are working in NaCSA and majority of them are field based and working directly with farmers.

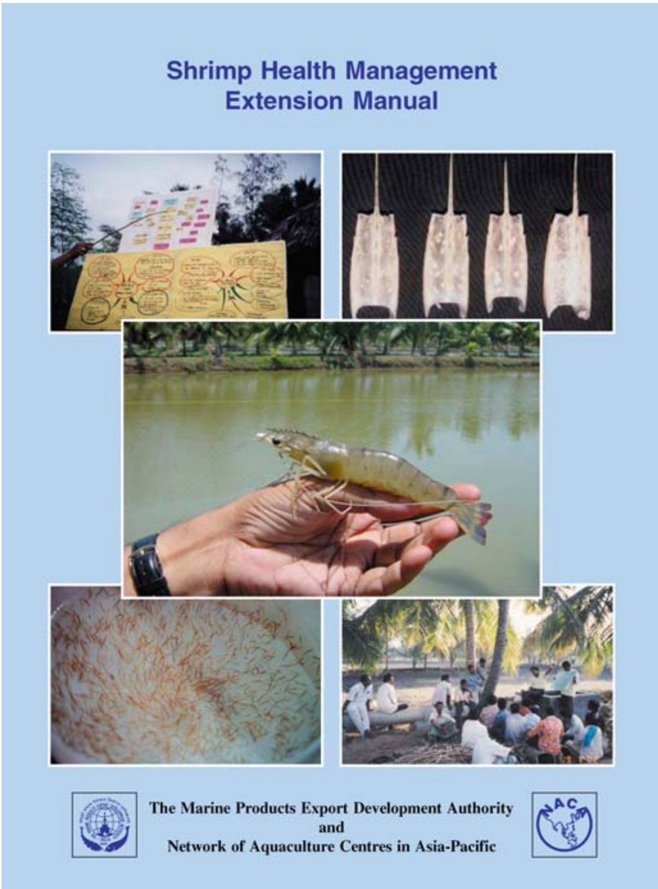
Shrimp farming work in Aceh, Indonesia

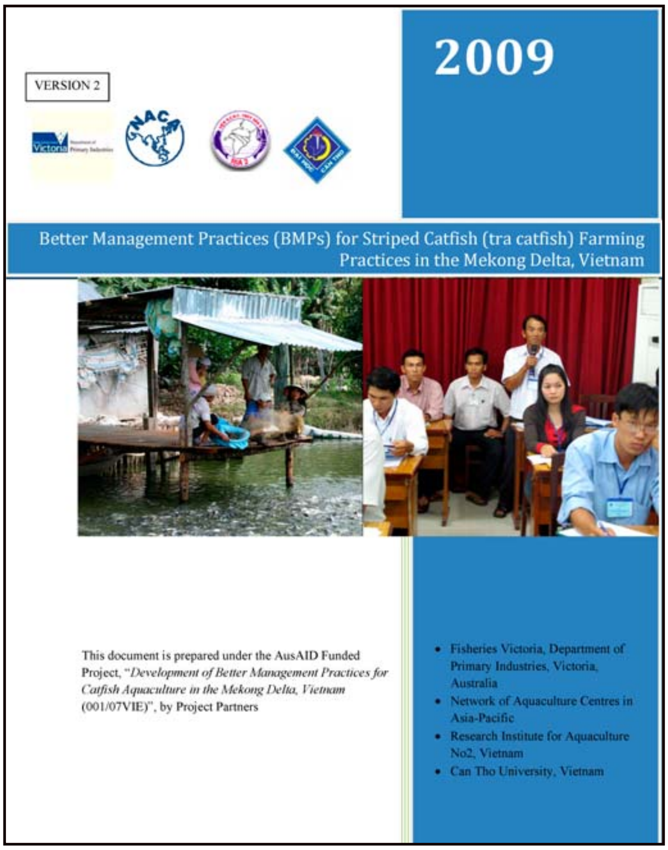
Using the Indian lessons BMPs were developed promoted to support rehabilitation of shrimp farming in tsunami affected Aceh, working in close collaboration with FAO, OISCA, WFC, ACIAR and other partners. The project:

- Established farmer groups, one Aceh aquaculture communication centre (AACC) and four Aceh Livelihoods service centres (ALSCs).
- Farmer groups were established from clusters of farms around ALSCs.
- The concept of BMPs and the cluster management approach was widely promoted.
- Catfish farming work in the Mekong Delta, Vietnam
- BMPs were developed through a process involving:
- A questionnaire-based risk factor study involving hatchery, nurseries and grow out farmers.
- Identification of risk factors and possible interventions.
- Convening stakeholder workshops to discuss and refine prospective BMPs, and to provide training of farmers in record keeping.
- Pilot testing of BMPs in selected clusters through the establishment of demonstration ponds and regular monitoring thereof.
- Promotion of farmer groups and cluster management concept.
- Vietnamese catfish farmers visited Indian shrimp farmers and clusters to observe their operation and BMP implementation.
- WWF shrimp farming work in Thailand and India

The project supported farmer group formation and BMP adoption. The project undertook activities to:

- Create awareness about the criteria, indicators and standards of certification, including WWF standards.
- Provide small scale farmer feedback to the WWF shrimp aquaculture dialogue.
- Pilot test WWF shrimp standards in selected farmer groups in India and Thailand.





- Evaluating the financial and technical aspects of compliance to WWF standards by small scale farmers.

Networking of key BMP project implementers in the region

ACIAR supported a project to network and share experience amongst key personnel involved in implementing BMP projects in five countries, India, Indonesia, Thailand, Vietnam and Australia.

Conclusions

BMP projects, in India, Indonesia, Thailand and Vietnam provide good examples of translating the principles of responsible aquaculture into specific BMPs adapted to local farming conditions and ensuring their implementation by relevant stakeholders, with consequent gains in production, quality improvements and market accessibility. They also show evidence of the advantages of small-scale farmers being organised (farmer groups/societies), sharing resources, empowering the stakeholders, helping each other and adopting BMPs. The implementation of the better management practices has provided benefits to the farmers, environment and society.

BMPs need to be grounded in valid scientific justification, rather than perceptions and or superficial experiences. Thus there is a need for R&D to validate key BMPs, and to quantitatively assess their impact on farm production and economics. Equally, there is a need to develop implementation mechanisms to permit large-scale scaling up of BMPs to create impacts among large numbers of small-scale farmers. Implementation mechanisms should also, far as possible, be supported by and built on systems already in place in the relevant country i.e. the cultural contexts prevalent in each country have to be taken into consideration.

Market links are now being explored between BMP implementers and buyers, but considerable further R&D work is necessary on strategies that connect small-farmers to markets. Enhanced regional cooperation is required to build on existing experiences and promote wider adoption of better management practices across selected commodities and countries in the Asian region.

Way forward

The lessons learned from BMP programs in the region should pave the way for development and implementation of BMPs for other key aquaculture commodities. BMPs should be simple, science based and cost effective and pragmatic, so that farmers can readily adopt them. Development, validation and implementation of commodity-specific BMPs should be seen as a way forward for promoting sustainable aquaculture in the region.

The regional BMP work of NACA and its partners has received a further boost with the support from the recently approved EU-ASEM project under the 7th framework. In the EU-ASEM project an attempt will be made to assess the true holistic impact of BMP programs and develop practical and feasible strategies for national and regional scaling up of BMP and cluster management programs.

NACA is open to collaboration and partnership with national, regional and international stakeholders interested in furthering the BMP and cluster management work. Please visit www.enaca.org for details about various projects and get in touch with the R&D Manager, Dr CV Mohan at mohan@enaca.org.

An update on organic scampi aquaculture in Andhra Pradesh

The National Centre for sustainable Aquaculture (NaCSA) and India Organic Aquaculture Project (IOAP), MPEDA took up organic fresh water prawn (*M. Rosenbergii*) farming in two societies of West Godavari District of Andhra Pradesh. A total of 27 farmers, from Sri Venkateswara Aqua Farmers Welfare Society, Matsyapuri and Sri Sainadha Aqua Farmers welfare Society, Velivela were involved in the project covering 31 ha area. As the organic concept is new to the farmers a series of awareness meetings with the society members and officials of MPEDA/NaCSA were organised. In two of such meetings

the consultant for the project Mr. Mathias Krebs from Blueyou, Germany also took part. The different phases of project implementation are as follows.

Organisation of societies

Sri Venkateswara Aqua Farmers Welfare Soceity, Matsyapuri (279/2006) and Sainadha Aqua Farmers Welfare Society, Velivela (67/2007) are registered societies under *Societies Registration Act 35* of 2005.

Application for cluster organic certification

An MOU on the collaborative organic project in India was signed by MPEDA and the Swiss Government during IndAqua 2007. Following the signing of MOU initial awareness meetings were conducted on 20th March, 2007 by the SIPPO team along with their consultant from Blueyou. These two society farmers were already following traditional prawn farming practices without using any chemicals and antibiotics in their farms. These farmers were technically supported by NaCSA, which involved implementation of Better Management Practices through its field officials and also through training of the Society Coordinator in minimisation of disease risks and improvement of food safety. This work has been carried out for the last five years. The society farms are managed mainly by family members with the help of seasonal workers during the harvest period. Farmers used to sell most of their scampi production to the local traders.

Once the project started the supply of critical organic inputs like seed and feed was taken up by IOAP. The IOAP team conducted several meetings and successfully coordinated activities among all the key stake holders including the hatchery, feed mill, farmer society and processing plant. Prior to the beginning of farm operations the hatchery and feed mill were certified by Naturland for implementing organic standards. Later the two societies applied to Naturland for Organic Cluster Certification in the prescribed format through IOAP.

Preparation of internal control system

Societies were managed by a Managing Committee and an internal control system (ICS). The ICS was developed by societies to implement Organic Internal Standards prepared in consultation with farmers by the project team consisting of IOAP and NaCSA officials along with the consultant for the project on 9th July, 2007 during a workshop at Narsapur, West Godavari Dt., AP. Farmers, MPEDA, NaCSA officials and other stakeholders involved in the organic project were trained in the internal control system at M/s Indocert, Aluva, Kerala during the training workshop in 2008. With the help of knowledge acquired from training, farmer societies prepared internal control system along with NaCSA.

Implementation

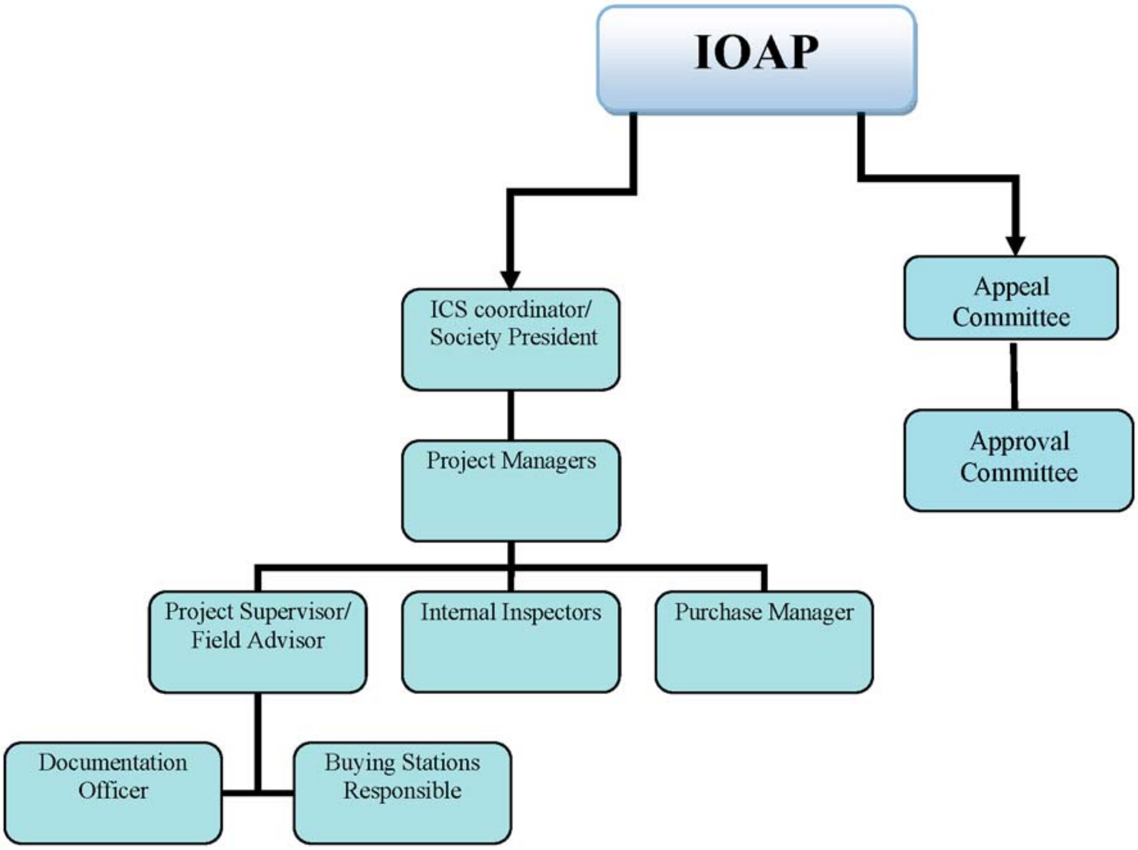
Coordination meetings among the society farmers were conducted regularly to coordinate all the activities of organic project. All decisions on the crop activity was reviewed during the meetings and it was properly recorded in society minutes book. Mr.Phani Raju President of Sri Venkateswara Aqua Farmers Welfare Society from Matsyapuir and Mr. Meher, President of Sri Sainadha Aqua Farmers Welfare Soceity from Velivela lead the Internal Control System Team as ICS project coordinators in the respective societies and were key contact persons in implementing the project. Farmers willing to join the IOAP approached the ICS team stating their willingness. Then field officer of ICS team visited the ponds and based on the assessment of the farmer's entrance form screened by the ICS coordinator.

The basic criteria to be eligible for organic certification are:

- Should be a member of the cluster/society.
- Farmers in possession of records on land ownership or leaseholdership/.
- Should have local legal farm registration.
- Should abide internal standards of the cluster/society.
- Willing to convert the whole farm into organic production.
- Farm premises should be kept clean and hygienic
- 50% of farm should be covered with vegetation.
- No track record of chemical, antibiotic or pesticide usage in the farm.
- Water source should be free of pollutants and chemicals.
- All the inputs used in the farm should meet internal standards.

The detailed organisational structure is schematically represented below

Figure 1: Organisational chart.



Organic certified seed

Organic scampi seeds were procured from Naturland Organic Certified Prawn Hatchery M/s Rosen Fisheries, Thrissur, Kerala during last week of July, 2008. As a general practice for scampi farming, seeds were stocked in nurseries. Common nurseries were maintained in Sri Sainahda Aqua Farmers Welfare Society, Velivela and individual nurseries were maintained in Sri Venkateswara Aqua Farmers Welfare Society, Matsyapuri. Both practices show a better result of ~80% survival in nursery. After 45 days of nursing period juveniles were shifted to the grow out with 1.5 PL/m^2 stocking density. Organic nursery feed was used during the nursery phase. Overall survival rate in the nurseries was 62%.

Naturland

Certificate of registration
2008 / 2009

This is to certify that
Sri Sainadha Aqua farmers Welfare Society
West Godavari Dist, A.P., Andhra Pradesh
INDIA

Code: 98407
is registered as grower group complying with Naturland standards.
Certification covers products resp. product groups* purchased according to the approved farmers list.

organic:	20.69 ha with 10,735 kg of freshwater prawn (Macrobrachium rosenbergii)

By signing the producer contract with Naturland Association Sri Sainadha Aqua farmers Welfare Society has committed to run the operation according to Naturland standards in their currently valid version, to comply with Naturland standards and all applicable certification procedures, and to undergo inspection at least once a year.
The operation is inspected by: Indocert
Sri Sainadha Aqua farmers Welfare Society has run the operation according to Naturland standards.
Naturland is accredited under the European norm EN 45011 / ISO 65.

Certification documents issued:
Date: 26/01/2009
Validity of certificate until renewed or cancelled, but at the latest until 31.01.2010

signed:
Certification Committee International (Angelika Raith)

Organic certified feed

Societies purchased organic feed from organic certified feed company, M/s Waterbase limited directly without any middlemen/dealers. Through this process society farmers were able to purchase the feed at factory price with out any additional cost. Feed procured by the society in bulk was distributed to the farmers from society's central store. It was distributed to the individual farmers based upon their requirement, after verification of the IOAP dairy. Every day feed consumption was monitored by the society coordinator. A total of 18.4 tonnes of organic feed was used by these two societies.

Farm management

Water

The water source was from irrigation water supply canal from Godavari River Delta which met the organic standards. Water quality and growth rates were monitored regularly by the ICS team.

Data management

All the farm management data including farm entrance form, IOAP dairy, bill copies were kept in the society office. These data were maintained by the farmers and monitored by society coordinators in both the societies.

Certification

Societies implemented the organic standards under the supervision of MPEDA and NaCSA. Periodic meetings were conducted to emphasise the organic farming standards to every farmer. The internal control system was implemented by both societies. Internal inspections were conducted by internal inspectors involving farmers, society coordinators and NaCSA staff and external inspections was carried out by NATURLAND authorised inspection agency, Indocert, Kerala to ensure the implementation of organic standards. Both the societies were cluster certified by Naturland for organic scampi farming. This is the first of its kind in aquaculture. Below are the copies of the cluster certificates issues in the name of societies.

Table 1: Proportion and average size of harvest.

	Male	Female
% in number	53	47
% in production	38	62
Average Size	59 g	30 g

Marketing

M/s Jagadeesh Marine Exports, Bhimavaram which is a Naturland certified processor was the natural choice for marketing of organic prawn. The prices for the organic prawn were fixed well before the beginning of the crop. Based on a mutually agreed price structure during October, 2008 an agreement had been signed between Jagadeesh Marine Exports and both of society representatives for the quantities of organic prawn to be supplied and its final price.

Harvest

Scampi ponds were harvested partially as is the common practice. The inaugural harvest was conducted on 29-01-2009. Harvests within the society were coordinated, to give maximum possible quantities for the processor. Harvested prawns were chill killed immediately and there was no pre processing at farm site. Prawns were sold head on along with, claws. Average survival rate was 49.6% from PL stage. A total of 12.6 tonnes of organic scampi was produced from these societies and processed by M/s Jagadeesh marine exports (Table 1). Average FCR was 1.46. The crop outcomes are summarised in Table 2.

Way forward

Organic prawn farmers are happy with the over all outcome of the crop. There were no disease incidents, growth was good and farmers could make decent profits.

As a result 88.62 ha of new scampi farming potential areas are being identified and assessed for feasibility to implement the organic project.

India Organic Aquaculture Project

Table 3: Crop summary report of Organic project in AP during 2008-09

Item	Value
Total Area under Organic Aquaculture Project	30.85 ha
Total no. of juveniles stocked by societies	427,350
Total feed utilised by societies	18,400 kg
Total production	12,557 kg
Average production	407 Kg/ha
FCR	1.46

Table 4: Economics of Organic Scampi Project completed in AP during 2008-09.

Item	Production cost / kg
Lease cost	31.00
Pond preparation	17.00
Diesel cost	13.00
Seed cost	39.00
Feed cost	59.00
Labour charges	22.00
Certification cost	13.00
Cost of production per kg	193.00
Average revenue per kg	280.00
Profit / hectare	Rs. 55,495

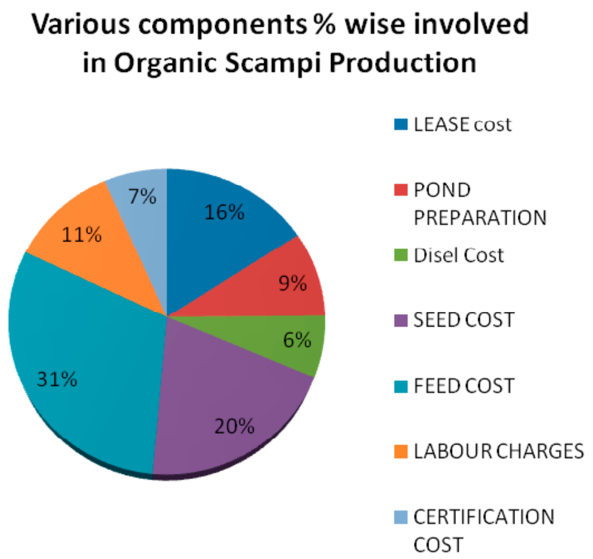


Table 2: Crop outcome.

	Area	Farmers	Total Production
Sri Venkateswara Aqua Farmers Welfare Society, Matsyapuri	10.26 ha	10	3,964 kg
Sri Sainadha Aqua Farmers Welfare Society, Velivela	20.89 ha	17	8,593 kg
Total	**31.15 ha**	**27**	**12,557 kg**

Unique and innovative cases of emerging domestic fish marketing arrangements in South India

Kumaran, M., Ravisankar, T., Krishnan, M., Vimala, D.D., Mahalakshmi, P. and Ganeshkumar, B.

Both in terms of nutrition to general public and livelihood security especially to coastal poor, capture and culture of food fish are important to any developing country. India currently produces around 6.8 million tonnes of food fish of which 55% is cultured and 45% captured respectively. It has been estimated that high value fishes and shrimps/prawns constitute 20% of the country's fish production which are exported mostly and approximately 10-15% of the fish produced is lost in post harvest handling. About 50% of fish produced is locally consumed mostly by the fish eating population by and large living in coastal hinterland and remaining is used as ingredients in poultry and aquatic feed production. The overall market for aquatic food will expand with population growth (UNDP, 1997) and the capacity of aquaculture to deliver more regular supply of uniform product, adapted to meet down stream specifications offers better opportunity than capture fisheries (Young and Muir, 2002). Domestic demand for fish and its consumption is progressively increasing among the people living in the metros and cities owing to the growing awareness of the nutritional and health benefits of fish consumption among the educated middle class, their rising living standards, parity of prices of fishes (like shrimps, pomfrets, seer fish and prawns) with red meats and availability of processed fish at retail stores (Cheran and Kumar, 2008). Further, the highly fluctuating global market price for the cultured high value shrimps/prawns has forced the Indian fish producers to look for the domestic buyers.

In this rising domestic fish demand scenario, both producers and the marketers have evolved in their own style, with some innovative marketing arrangements to realise better prices for their hard earned fish produce and products. Conventionally fisherwomen were the major force in the domestic marketing of fishes forming the lowest rung of market channel starting with wholesalers and a host of 5 to 8 middlemen categories in India. Ever since commercial aquaculture came in to being, farmers, traders and processors have also made innovative and successful attempts in domestic marketing of fishes. Having understood the growing demand for fish among the public, modern retail chains also entered into marketing of fishes in customer savvy ways and forms.

Farmers as groups have adopted new strategies to collectively market their produce to bargain for a better price. In this scenario, it is imperative to study such innovative marketing mechanisms to emulate and scale up such successful initiatives by others, identify hindering issues and suggest appropriate strategies to promote domestic marketing of seafoods/fishes in the country.

Research methodology

This exploratory study was undertaken in Tamil Nadu and Andhra Pradesh States of Southern India. Seven unique marketing arrangements as indicated in the box were studied using case study method. Fisherwomen, aqua farmers, processors and food retail corporations were the major players in these domestic fish marketing arrangements. Hence, the views, issues and implications discussed in this paper are pertaining to them only. Two main approaches existed in the marketing arrangements. While the producers (fisherwomen and aqua farmers) adopted group mode, the processors and retailers followed more individualistic/enterprise approach.

Marketing arrangements

A brief description of the innovative arrangements explored is presented here to give an overall exposure to the readers.

Farmers group enabled shrimp marketing: Marketing tie-up with traders in Tamil Nadu

Shrimp culture is beset with dichotomous negatives of a hike in production cost and low market price plus disease risks. In this dismal scenario, shrimp farmers operating along a creek / in a cluster organised themselves as group to enforce certain better management practices (BMP) intended to prevent the entry of fatal disease pathogens in to the culture system and market their hard earned produce for a better price collectively. Pamini River Shrimp Farmers Association (PRSFA) in Thiruvarur district of Tamil Nadu was the true example of adopting a group approach to shrimp aquaculture enforcing a crop calendar and compulsory adoption of BMPs including farm bio-security (Kumaran, 2009). This collective cluster management paved the way further for collective marketing. The association invited quotations from the available few buyers to negotiate and finalise the sale price for the shrimp produced in the cluster. However, this sale price could be further negotiated for an extra higher price by individual members showing their produce. PRSFA followed this strategy since 2003 and it was reported as continuously successful. Compulsory total membership of all farms in the creek, deliverability of economic tangibles, social cohesiveness, transparency and conviction of the members in group approach were the factors determining the success of this mechanism.

Farmers group facilitated marketing: Post harvest handling and marketing of the cultured shrimp through farmers' association in Andhra Pradesh

Shrimp farmers in the Paleru and Moosi creeks in the Tangutur mandal of Prakasam District in Andhra Pradesh had the apprehension that the buyers mishandled their harvested shrimps at the latter's place especially in weighing and fixing of count (shrimps/kg) using miscalibrated instruments, resulting in a loss of 15 kg shrimp/tonne and a count which is the criteria to fix the shrimp market price. To end these malpractices, the farmers organised themselves into Tangutur Aqua Farmers Association (TAFA) in the year 2004 and collectively demanded the buyers to handle and weigh harvested shrimps at farmers place instead of buyer's. TAFA

Fisher women self-help group works on domestic marketing.

collected funds from all its members and constructed its own office premises with laboratory and washing-cum-weighing yard for the hygienic handling and weighing of harvested shrimps of its members and then transported to buyers factory.

Since, 2004 it was made mandatory that buyers who purchased shrimp from the members have brought the harvested produce to the TAFA office premises for washing and weighing the shrimps, using the weighing machines of the association. The association charged 60 paise per kg of shrimp up to 50 counts (50 shrimps/kg) as its service charge for washing and weighing from the buyers. Weighing was done in the presence of association office bearers, concerned farmers and the traders. After weighing, the produce was iced and taken for processing by the trader. Smaller shrimps (above 50 counts) were not charged for washing and weighing. The process was transparent with minimal disputes and this strategy earned better handling of shrimps and good price to the farmers. Unlike the previous case, TAFA had neither interfered in the collective management of shrimp culture operation nor directly involved in price negotiation, but provided only 'market intelligence'. The association decided the starting and the closing dates of water drawing from the creek for the year and the same was written on the notice board of the TAFA. Beyond that date none was allowed to draw water from the creek. TAFA advised farmers to procure seeds from reputed hatcheries mostly located in the same

Operational matrix: Mechanism of marketing arrangements.

Marketing arrangement	Major players	Market structure (buyers & sellers)	Approximate volume handled	Consumers	Pre-contracts/ agreements/ norms
Self help group enabled domestic fish marketing	SHG women, corporate buyer; bankers, govt. facilitators	Women SHG and Few buyers	Around 500 kg per month	Domestic consumers	Pre-agreed price, consistent supply and quality
Farmers group facilitated marketing	Farmers, farmers association, buyers	Collective marketing Many sellers and few buyers	500-750 tonnes per crop/ association	Mostly for foreign consumers	Group agreed norms
IT enabled market Access	Aqua farmers, ITC, collaborator and prathinidhi	Many sellers and few buyers	1500 tonnes per crop	Mostly for foreign consumers	Pre-disclosed % of commission
Corporate retail chains in domestic marketing of fish	Fishers, fish farmers and retailers	Few sellers and Few buyers	150-200 kg per shop per day	Domestic consumers	Pre-agreement between fishers /fish farmers and retailers

district. The farmers and the TAFA office bearers reported that collective effort under TAFA umbrella gave them the bargaining power to bring the buyers to their place and helped them to have a fair post harvest handling and marketing.

To summarise the above two cases of farmers groups adopting certain kinds of innovative marketing arrangements for the benefit their member farmers:

1. Collective marketing is the most important component, which leads to organising the farmers into associations or cooperatives allowing them to negotiate prices much better with the buyers. Both the farmers and buyers gained equally in terms of fair dealing and reasonable price and required volume and quality respectively.

2. Collective marketing has increased the prices for farmers by five to 15 percent.

Many recent research reports also showed that farmers marketing together tend to gain more favorable prices and terms of trade than they can on their own (Grow et al 2003; Levins, 2005; Cole Mallard, 2006).

Self help group enabled domestic marketing: Case of Thenkumari Women Self Help Group, Chennai

Fisherwomen are the major marketing force in domestic fish marketing in India. A group of 15 active fisherwomen engaged in fish marketing in Chennai formed as "Thenkumari" Womens' Self Help Group (TWSHG) in 2003 to avail the institutional credit offered under WSHG scheme by the Government. These fisherwomen procured fishes at landing centres or wholesale markets and transported them to local fish markets for sale. They handled high value fishes like seer fish, pomfret, crab, barracuda and anchovy for their marketing since they were the preferred fishes by the middle class consumers. Despite their hard work their earnings were very low and they were desperately looking for a better opportunity which came through a friendly women development project officer who introduced this women group to the Taj Coramandal, a five star hotel for fish supply. Taj under corporate social responsibility gave them an order to supply fresh seafood on contract basis but strictly insisted on high quality material, good hygiene, and timely delivery. TWSHG supply passed through the stringent quality parameters insisted by the Taj. Their initial order was two kg for three days in a week and the same has grown progressively to 500 kg/month at present. Both Taj hotel and the women benefited from this mechanism of domestic marketing. Taj management extended their purchase for their other group hotels subsequently (Taj Connemara & Fishermen's Cove) and presented best vendor award for the year 2008 to Thenkumari SHG to appreciate their performance. TWSHG availed institutional credit support to increase their business and the pattern of loan utilisation showed that their loan amount was productively used for income generation (Deboral Vimala et al. 2009). Further, it was confirmed from the bank records that the TSHG had an excellent repayment record and to appreciate their performance, the bank awarded State level SHG - Bank Linkage Programme Award for the year 2006-07 to Thenkumari Women Self Help Group. Access to corporate buyer, access to institutional credit, self discipline, confidence, saving habit and capacity as an SHG were critical factors for their success.

IT enabled-web kiosks in aquaculture marketing: Aqua-choupal model in Andhra Pradesh

Information and communication technology (ICT) is increasingly being utilised in agriculture and allied sector to link rural farmers with markets to maximise their returns (Mahalakshmi et al., 2006 and Matani, 2007). In this line, the Indian Tobacco Company (ITC) which had stake in fish processing initiated a web supported initiative – the Aqua-Choupal model in Godavari districts of Andhra Pradesh designed to provide market and farming related information to enhance farmers productivity and their farm-gate price realisation. This approach revolved on a network of information units (Aqua-Choupal) equipped with a computer connected to the internet, located in villages. The ITC had a collaborator in its operational area to identify an influential shrimp farmer (Prathinithi) in whose house the aqua-choupal was located. The farmers through aqua-choupal accessed daily closing prices in local markets and global price trends. ITC offered a standard price which was the closing market price of the previous day at the market. To initiate a sale, the farmer had to approach prathinithi, who inspected the produce and based on his assessment of the quality prescribed the farmer a conditional price. This benchmark price was fixed for a given day and was the maximum price a prathinithi can quote. If the farmer agreed to that price, took a note from the prathinithi and proceeded with his produce to the nearest ITC procurement hub (processing center) in Andhra Pradesh. At the ITC procurement hub, the farmer's produce was tested for quality, then weighed and full payment was made immediately. The farmer was also reimbursed for his transport costs. At the ITC processing hub every stage of the process was appropriately documented and the farmer was given a copy of lab reports, agreed rates, and receipts for his records. In addition to this, through the aqua-choupal the farmers were provided with production related technical content and access to other welfare information. Further, through the collaborator, ITC supplied seed, fertiliser and other inputs at subsidised cost to the farming community. This model of domestic marketing was working well in Godavari districts of Andra Pradesh and was a win-win approach for both ITC and farmers.

Modern retail chains in domestic marketing of fish

The advent of retail market chains popularly known as super markets in India is one of the recent developments brought about by globalisation. They market all kinds of house hold use items in a relatively better ambience where the new

Processed and packed fish & prawns for domestic marketing.

generation Indians preferred to buy their provisions and other products. Fresh vegetables and non-vegetarian red meat items like mutton and chicken are also being marketed in these stores. Of late, considering the people's preference for seafood some of these retailers have started marketing fishes too in their outlets.

Reliance – Delite, Chennai

Reliance Fresh is one of the corporate domestic market chains involved in retail marketing of farm made vegetables, fruits and their value added products. Whenever, a retail store is opened in a particular locality with a surrounding area of one to 3 square km covering 2,000-3,000 households known as 'catchments' in business parlance. The catchment was thoroughly surveyed (a sort of market research) before opening a store and whenever new segment was introduced in the existing store. Their survey indicated that 91% of the Chennai city population was non-vegetarian and based on that, the company opened Reliance Delite non-vegetarian retail outlets. Similarly, they found that the preference for seafood was growing among the people and they introduced fish food in their stores. To introduce fish foods, they entered into contracts with fishers and fish farmers in nearby villages for supply a fixed quantity of fish food (fish/prawn/shrimp) properly processed and adhered with all quality parameters. They marketed mostly high value fishes/shrimp & frozen items of seer fish, pomfret, black tiger, and carps. Customers preferred the fish around 300-500g and shrimps/prawns at around 15-20 gm respectively. Fish food sales were peak during holidays and dull on Tuesday and Friday owing to religious sentiments. Fish was the second preference in Chennai after chicken. Reliance ensured quality and consistent price. On an average they handled 150 kg of seafood per stall and they have plans to open couple of more stores in Chennai. Finding sources for consistent supply of required quality was their main concern. Since there was demand for organic fish foods the Reliance was willing to promote it.

Spencer's Daily, Chennai

Spencer's Daily was another retail chain involved in fish food marketing in Chennai. The fishes sold, size and their average per day sales were almost similar with Reliance. But, unlike Reliance retail which directly handled seafood, Spencer's Daily transacted through vendors (franchise mode). They allotted space for fish food vendors in their store, where vendors offered their fish for sale. The store took a pre agreed percentage of commission. The fishes were allowed to be stocked for 1-2 days and unsold fishes were taken back and fresh fishes were brought. The store ensured consistency in quality and stable price. As a promotional measure Spencer's Daily had undertaken an awareness programme for educating school children on the benefits of sea food with supportive literature which they felt had an impact in their sales. It was felt that establishing fish food brands and novel advertisements for fish food promotion are the key encouragements needed to give fillip to domestic fish marketing.

Farmfed, Nellore, Andhra Pradesh

Farmfed was a mutually aided co-operative society promoted by a group of aqua- professionals based at Nellore, in Andhra Pradesh. Farmfed associated with farmers of nearby villages to produce quality target size shrimp continuously, so that the farmers reduce the risks involving in producing larger shrimp. They procured 10-20 g sized fresh shrimp and fresh fishes such as seer fish, sea bass, pomfrets, catla, rohu, murrels and tilapia at an attractive and stable price from farmers. Shrimp was peeled without deveining and IQF frozen, packed to retain freshness for longer duration and presented in 250 g packing. Fishes procured fresh were cleaned and sliced and packed in 500 gm packs. There were four different grades on the shrimp packing depending on the size and quality. At present Farmfed have eight retail outlets at Nellore, Guntur, Vijayawada, Hyderabad and Chennai. More retail outlets will be operational in the next six months, in different parts of the southern states. The contractual arrangement between retailers and farmers helped the struggling farmers in to plan for market driven farming by reducing his production costs and diversifying their species as per the market demand.

Market structures

The marketing arrangements studied have highlighted combinations of market structures existed in domestic fish marketing. In case of SHG and farmers groups collective marketing was made by the groups to few buyers either corporate or independent processors. Nevertheless, in farmers groups the individual farmers had the flexibility for further negotiations and in some cases it was individual marketing facilitated by the association. However, in both cases the market price was mostly buyer determined though negotiations were permitted. It was reported by the farmers that the buyers offered premium prices during the beginning of the culture season to lure the farmers to stock their ponds and at the time of harvest quoted lesser price. Since there was no alternative, the farmers were forced to sell their produce to them. Hence, the farmers felt that government may develop a central market intelligence mechanism to convey global and domestic price information to the farmers which would help them in better negotiation with buyers. It is hoped that development of domestic marketing may bring more buyers and new marketing arrangements through that the farmers might get a fair deal. In case of retail marketing also presently there were few buyers, who had pre-arrangement with few farmers and fishers to ensure consistent supply and assured quality. It is expected that domestic marketing might bring more marketing innovations like market driven farming, vertical and horizontal integration of aquaculture operations.

Consolidation of findings

The domestic fish marketing arrangements, major role players, critical factors, issues to be addressed and implications are presented as operational and policy matrices.

Conclusion

The innovative marketing arrangements studied have explicitly shown that in every arrangement both the buyers and sellers gain equally. It facilitated the SHG women access to institutional credit, provided self confidence, better employment, group cohesiveness and a sense of empowerment. Similarly, it helped the farmers groups to manage other farming operations in their farm clusters

Policy analysis matrix on issues and implications from all the model cases.

Marketing arrangement	Critical factors	Issues to be addressed	Implications
Self help group enabled domestic fish marketing	Access to corporate buyer Access to institutional credit Self confidence and discipline SHG – group capacity	High transport cost Lack of storage facility – insulation box Unemployment during off-seasons Higher interest rates in institutional credit Lack of skill in value addition of fishes	Subsidised loan for fish transport vehicle, modern fish stall, insulation boxes Linking SHGs with corporate buyers; Awareness and capacity building on existing schemes for SHG, value addition Lower interest rate for SHGs institutional credit Involvement of state fisheries co-operative federation in branding SHGs products
Farmers group facilitated marketing	Full membership Economic deliverability Social cohesiveness Conviction of the farmers Collective bargaining	Fluctuating market price at harvest time Farmers at the mercy of few exporters	Establish a central market intelligence mechanism access through e-connectivity Link farmers associations with all the processors through e – connectivity Educate the farmers for a planned staggered stocking of fishes to ensure round the year supply. Link retail chains with farmers groups to plan for market driven farming for regular assured supply on contract farming mode. Facility for block freezing of shrimps to store and transport to other local markets.
IT enabled market access	Market intelligence / price information Accurate weighing and Immediate payment Supply of inputs and lab analysis of soil, water animal samples On-line access to other welfare information	Increasing production cost Lack of institutional credit and insurance.	As above
Corporate retail chains in domestic marketing of fish	Hygiene, quality and ambience Fish with other provisionary items in one place. Stable sale price Agreement with fishers/fish farmers for regular supply Awareness programme to school students	Lack of brand and advertisement Demand for organic products Lack of assured supply at acceptable quality standards Poor consumer perceptions on processed fish food items	Removal of sales tax on processed fish sold in domestic market Creation of fish market and consumers - advertisement in mass media Awareness creation on health benefits and frozen and iced products Capacity building of domestic marketers on brand development and positioning Contract with farmers groups to ensure consistent supply and assured quality

collectively, facilitated better dealing with processors and fetched fair price for their produce. On the other hand, the buyers too benefited in terms of assured quality, reduced intermediary expenses, required volume and consistent supply. Therefore these arrangements were a "win-win arrangement" for both producers and marketers. Further, these marketing arrangements will ensure quality and safe fish food to the domestic consumers. Further, the analyses of theses marketing innovations amply indicated that the following interventions are needed to promote domestic fish marketing and domestic fish food consumption as a mass movement in India:

- Establishment of interfaces to link SHGs and fish farmers with corporate buyers and retail chains on 'contract mode' would facilitate planned farming, consistent supply, assured quality of fish/shrimp to the market, elimination of middlemen and better prices for farmers.

- Subsidised credit support for SHGs and retailers for transport, establishing fish stalls, small and distributed cold storage facilities, retail outlets and concession in power tariffs will facilitate domestic fish marketing.

- Branding and advertisement and awareness campaigns on nutritional benefits of sea foods would certainly widen the horizon of domestic fish marketing and enhance per capita fish food consumption.

- Capacity building of women SHG and retailers for value addition, novel fish food preparations and presentations would promote domestic marketing and fish food consumption.

- Government support in the forms favourable domestic fish marketing policy and investments in infrastructure development-whole sale and retail markets, storage facility and would give fillip to domestic fish marketing in India.

- Policy Analysis Matrix on issues and implications from all the model cases

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Management in seed rearing of Asian catfish, *Clarias batrachus*, in hatchery conditions

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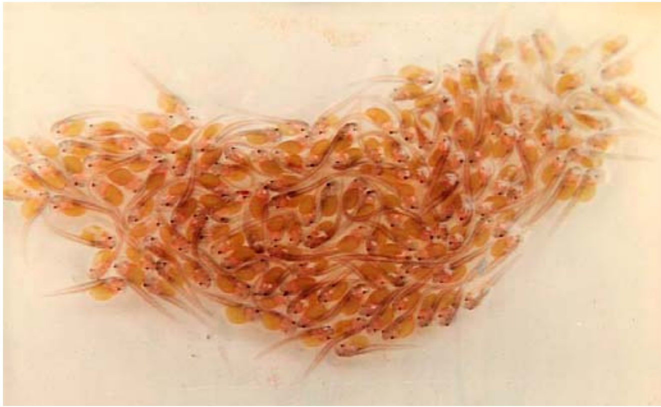
Aquaculture gained industry status in the Indian agriculture sector in the 1980s. Freshwater aquaculture has registered an annual growth rate over 6% during last decade and achieved a total production level of 2.4 million tones at present. The share of three Indian major carps is 1.8 million tonnes in the above fish production.



Catfishes are the most accepted fish variety in the Indian market for their delicacy. Now researchers in India have suggested for diversification of aquaculture considering catfish as a component for aquaculture development. Research on the production of different varieties of catfish is in progress by different institutions, among which *Clarias batrachus* is one of them. The potentiality of yielding 100 tonnes / ha has been reported in *Clarias* culture with high stocking density. Although a lot of work has been done on its artificial spawning, seed rearing and culture, the availability of quality stocking materials is still a constraint in the aquaculture sector. The culture of *C. batrachus* consists of four basic steps: Captive spawning, primary rearing phase (larvae to fry), secondary rearing phase (fry to fingerling) and final rearing phase (growing to marketable size). Usually a noticeable loss is observed during seed rearing phase in this catfish. However, availability of desirable seed is always considered to be the most important pre-requisite for successful aquaculture of any species. Hence CIFA, a premier research institute has been involved in developing and standardising the seed rearing of *C. batrachus*. This article will communicate the management involved during seed rearing of this catfish for production of stocking material.

Larval rearing for fry production

C. batrachus larvae are very delicate and require utmost care for their growth and survival during hatchery rearing. The larval rearing phase includes stocking management, water management and feeding management.

Stocking management

The newly hatched larvae are separated from unhatched eggs and eggshells by frequent washing. The larvae measure about 5.0-5.5 mm in length. They are released in rectangular or circular tanks with a smooth bottom in the hatchery. The tanks are filled with clean water with aeration. Due to a heavy yolk sac, they do not have capacity to move, showing only tail lashing until the yolk sac is absorbed, which takes 3-4 days. During this time the larvae migrate to the side of the rearing containers and aggregate in patches. A few partially hatched eggs as well as deformed larvae are visible at the center of the containers, which are immotile. Usually they die within 5-6 days of their life so it is essential to remove them, or else the dead larvae will pollute the rearing container leading to disease in other fish larvae.

A stocking density of 2,000-3,000 larvae per m^2 should be followed for optimum growth and survival. The growth and survival range from 40-50 mg and 70-80% respectively at these density levels as observed in our study during larval rearing. Lower population compared to this may lead to under-utilisation of the rearing space. Similarly in higher stocking density (4,000-5,000/m^2), the growth and survival rate are affected due to crowding, discrimination of feeding among the larvae and stress factors, as also observed in other fishes. The larvae usually grow to 20-30 mg in weight with a survival rate of 50-60% at these densities during 14 days rearing.

Water management

Larvae being small and delicate require good aquatic environment for survival. The importance of water quality/ environment on growth and survival of aquatic organisms is well established. Hence the quality and depth of water during indoor rearing system play a major role for optimum survival of *Clarias* larvae. To optimise high larval survivability, water management is an important aspect during rearing. Aerial respiration commences after 10-11 days and hence, aeration must be provided to the larval rearing tank by blowers/ aerators. Accumulation of metabolites and unconsumed feed in the rearing containers pollute the environment and ultimately lead to oxygen depletion, disease incidence and mortality. Therefore, it is advisable to clean the bottom of the tank and replenish 70-80% water twice daily to maintain 10-15 cm depth. Care should be taken to give less stress to the delicate larvae while exchanging water from the tanks.

The waste from fry and decaying unconsumed feed under high density rearing produce free ammonia (NH_3), ionized ammonia (NH_4^+) and hydrogen sulphide (H_2S). Among these, free ammonia is toxic at low concentration affecting the gills and accessory respiratory organ whereas hydrogen sulphide causes stress to the fry. During high density fry rearing an increase in carbon dioxide in the environment may result to stress. CO_2, NH_3, NH_4 concentration level up to 15 ppm, 0.05 ppm, 0.25 ppm, respectively may not affect larvae of

this species but it could be dangerous if the level continues for a longer time. Aeration and frequent water exchange are required to get rid of the above problem.

Feed management

The yolksac of newly hatched larvae serves as the stored food during first three days of life. After its absorption, the hatchlings become longer with the prominent barbels, jaws, operculum and gills. The quantity of feed usually varies depending on the density of larvae reared in the container. The growth of larvae is also influenced by the quality of feed and their acceptability. The acceptability of feed depends on the feed type and their particle size, which influence the growth and survival rate during their rearing. Mixed zooplankton, *Artemia* nauplii, molluscan meat, tubifex or egg custard are considered to be the larval feed during hatchery rearing of *C. batrachus* larvae. These feed items contain 41-65% protein. Mixed zooplankton is observed to be well-accepted feed for these catfish larvae, which can be easily collected from a well prepared carp nursery ponds. Live plankton is considered to be the well accepted feed for rearing of fish larvae as observed in other fish larvae. As the plankton remain in live condition in the rearing tanks, the larvae get opportunity to feed on them as and when required. Feed containing 45% protein in the form of small ball is offered along with live plankton from 7-8 days of rearing. The supply of live plankton may be withdrawn gradually during the rearing period of 13-14 days. This mixed feeding not only enhances growth, but also ensures higher survival rate. Organisms/particles ranging from 20-30µ are ideal for the initial feeding. Size can be increased gradually to 50-60µ for a week old fry. Since there may be a differential growth in fry from the beginning, it is wise to proceed with the visual observation for selecting size of the feed. The fry develop gregarious habit within a week and being nocturnal and photonegative in nature, they normally congregate in the corners of the rearing container to avoid light during daytime. However, they get fully dispersed all over the container during night and as soon as they are exposed to light, they move to the corners of the container in groups.

Fry rearing for fingerling production

Healthy fry should be considered for stocking in nursery tank for higher growth and survival. Good fingerling production requires attention to nursery tank preparation, size of fry at stocking, feeding of fish and segregation of fingerlings.

Nursery tank preparation

Small earthen ponds may be used for this purpose. Generally, the advanced fry reared in pond condition do not show good survival due to natural mortality or predation as at this stage the fish does not have much capacity to escape from predators. Therefore, small-sized cemented tanks of 10-20 m2 are suitable for easiness in rearing and management. Also the fish at this stage do not have much capacity to search feed in the larger water body, which leads to mortality. These cisterns are provided with 2-3 cm soil base and a water level 25-30 cm. Single-super-phosphate (100 gm) and filtered cow dung (2 kg) are provided. The tanks are inoculated with plankton and the advanced fry are stocked after 6-7 days of preparation. It can be provided with floating weed like water hyacinth to give shade and shelter to the fry.

Stocking of fry

The production of fingerlings always depends on the quality and size of fry during stocking. The fry should be stocked after the development of a plankton bloom in the tanks. After initial stocking, the fry may take some time to be acclimatised to the artificial feeding. Until that time they will utilise the natural plankton as feed, which may reduce initial mortality. Overcrowding during transportation of fry may cause mortality if released in the nursery tanks immediately. So it is better to acclimatise them to indoor conditions before releasing them in the nursery tanks. The sizes of 40-50 mg fry are suitable for initial stocking. They are reared at a density of 200-300 fry/m^2. Increasing the density may affect the size during harvest, rate of survival and homogeneity in growth among the fingerlings.

Feeding of fish

Plankton in the environment is an important feed for the larvae during the first few days. Prior acclimatisation with compound feed during larval stage also helps in quick acceptance to compound feed during tank rearing. They require good quality compound feed containing at least 30% protein. The feed should be provided in crumble form for easy consumption by the larvae. They are fed @ 5% body weight in two divided meals. The ration for the fish may be increased after assessment of fish biomass by weekly sampling. The feed quantity may be increased or decreased by visual observation depending on the left out feed in the feeding tray.

Other management

As the water height during rearing is usually low, it is better to give shelter in the form of floating weed or providing pipes to protect the fish from high water temperature. The tanks should be covered with nets to prevent birds and other predators from entering. Sometimes the unconsumed feed and waste matter during intensive rearing pose problems for maintaining water quality. Monthly water exchange is essential for good growth and survival. The growth of filamentous algae cannot be ruled out in low water height of the rearing tanks. The filamentous algae developed during rearing period should be netted out. The presence of too much weed can cause oxygen depletion during the night as well as pose problem for fish to move freely in the tank.

Harvest/segregation

The fingerlings thus produced can be harvested depending on the demand. Usually the fish grow up to 1 g in size during 30 days rearing, resulting 40-50% survival rates. Sometimes long term rearing of another 3-4 months period is seen in the catfish farm to produce bigger fingerlings. Regular segregation is essential during longer rearing period, as few populations among the fish grow first. It is essential to separate them from smaller individuals to reduce the competition during feeding. Not only segregation of fingerlings plays an important role at this stage, but also regular water exchange and feeding results higher growth and survival during rearing. The fish usually grow to a size of 7-8 g during this period, which are suitable to stock in the grow-out ponds.

Conclusion

The increase in demand for stocking material has been felt for all cultivable fish. The success in *Clarias* culture also depends on the availability of seed. Hence successful rearing of catfish seed at different stages becomes important. It is felt that rearing of this catfish requires utmost care during fry and fingerling production. The growth and survival of seed during rearing depends on the careful management of rearing tanks, feeding and environment. A combined effort is highly essential for successful rearing of this catfish under hatchery conditions.

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Supply and use of catfish (*Pangasianodon hypophthalmus*) seed in the Mekong Delta of Vietnam

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Aquaculture in inland water bodies in the Mekong Delta has developed rapidly since the 1990s, and is the most important contributor to Vietnam's fishery sector in terms of both domestic consumption and exports. Pangasius catfish, including *Pangasianodon hypopthalmus* (ca tra in Vietnamese) and *Pangasius bocourti* (ca basa) were traditionally cultured in the region from 1960s using wild caught seed harvested from the Mekong River. Farming of tra fish in particular has become highly developed since the closing of the lifecycle in 1996 and the development of a commercial hatchery sector from 1998 onwards. Good bio-physical conditions, improved farming techniques and growth of international markets are the main reasons for the broad spread of tra farming in freshwater areas of the delta, and this species now contributes more than 98% of the total production of Pangasiid catfish in Vietnam.

For years, An Giang and Dong Thap provinces, located close to Cambodia where much wild seed was harvested, were the major sites for production of tra in the delta, but a shift from cage-based to pond-based culture has provided opportunities for the expansion of production into other provinces lying along the main Hau and Tien branches of the Mekong. In the 10 years from 1998 to 2007, the total area under culture increased six times, to about 6,000 ha. Annual commercial production of tra increased 45 times over this period, from 22,500 tonnes to more than 1,000,000 tonnes. The volume of exported tra fillets jumped more than 55 times over this period from 7,000 tonnes to 386,870 tones, and export values increased 50 times, from US$ 19.7 million to US$ 979,036 million. Tra is now exported to more than 80 countries and territories, in all continents. By 2008, nine of the thirteen provinces and cities of the Delta produced tra for export. Total production of tra in 2008 was estimated about 1.2 million tonnes, and the total production of exported fillets was 650,000 tonnes, with a total export value of approximately US$1.45 billion (Dung, 2008). Sinh (2007) also estimated that a total of about 0.2 million people in the Mekong Delta are associated with the tra fish industry.

Further development of the tra culture in the Mekong Delta is limited by a number of interrelated factors, however. Lack of appropriate planning is said to be a macro problem for development of the Pangasius industry. Seed accounts for about 10-20% of the total production costs and many catfish farmers reported that the stocking time or the time to stock fingerlings, quality, and quantity of purchased fingerlings as important concerns. Feed usually accounts for more

Pond culture of tra catfish.

than 75% of the operating costs for tra production and can negatively impact water quality, resulting in increased incidence of disease in stocked fish. The increasing prevalence of environmental issues and marketing problems related to the quality of products and high levels of competition are also serious considerations for the entire Pangasius industry, in the Mekong Delta of Vietnam and in neighbouring Cambodia (Dung, 2005; Sinh & Nga, 2004; Sinh et al., 2006; Phuong et al., 2007; Son, 2007; Dung, 2008; Loc et al., 2008; Phan et al., 2009). This study therefore aims to describe and to analyze the supply and use of tra seed (both fry and fingerlings) in order to provide a set of recommendations for further development of this species in the Mekong River Delta.

This study was carried out from June 2007 to December 2008. The investigation covered nine provinces of the delta where producers engage in export-led tra production. These provinces were categorized into two groups. Group 1 included five inland provinces (An Giang, Dong Thap, Can Tho, Vinh Long and Hau Giang), and group 2 consisted of four coastal provinces (Tien Giang, Ben Tre, Tra Vinh and Soc Trang). The total sample size comprised 33 hatcheries; 39 nursery sites; and 293 grow-out farms. A structured survey based approach was used to generate quantitative data which would provide an indication both of major issues affecting the industry relating to seed, and allow for analysis of the links between differing management practices and the profitability of operations.

The results show that the age of experience in the Pangasius industry were 7.6 years, 10.6 years, and 3-5 years for hatchery owners, nursery site managers and grow-out farmers, respectively. Fish farmers in inland areas had longer experience than those in the coastal provinces (5 years compared with 3 years). The owners/farmers combined the knowledge from experience and training courses (56.3% of the number of hatcheries; 31.6% for nursery, and 39.2% for grow-out) or only rely on their own experience (hatcheries: 40.6%, nursery: 50%, and grow-out: 48.8%).

Hatcheries and nursery sites (supply side)

Tra hatcheries

At the end of 2007 and the beginning of 2008, there were 93 hatcheries of tra fish in the Mekong Delta, mostly located in Dong Thap and An Giang provinces. These hatcheries had an average total area of 8,303 m^2, of which maturation ponds comprised 864 m^2 (±643 m^2) with an average water depth of 2.2 m (±0.4). The average design capacity of hatcheries was 818.3 million hatchlings/year, and ranged from 50 to 1,500 million hatchlings, but most had a capacity smaller than 500 million hatchlings/year. On average hatcheries had 290.4 m^3 of weis tanks (incubation jars for hatching fertilized spawn), with a range from 50 to 1,152 m^3.

Low fecundity during the cold season (lunar November to January) meant that most hatcheries operated from lunar February to October. February to June was reported by 65.2% of hatcheries to be the best time for reproduction. On average hatcheries were run for 29.8 production cycles/year, with a duration of about 7 days per cycle from the hatching of eggs to the sale of fry. This is an increase in the number of cycles/year compared with the 17-19 reported by Yen (2006). This might suggest a growing potential for negative impacts on the yield and quality of hatchlings if broodstock replacement is not adequate.

Broodstock were sourced from other farms (78.1% of the number of hatcheries) or from the wild (6.3%). The remaining hatcheries (15.6%) used broodstock from both sources. The amount of broodstock conditioned for spawning depended on hatchery size. The average size of male and female fish was found to be approximately 4.0 kg/fish (±0.9), with an average ratio of females to males of 3.45 (±1.28). This is considerably lower than the 1:1 ratio recommended by Tave (1993). A quarter of hatcheries reported that the quality of broodstock was not good enough in terms of fecundity and egg quality. The average age at breeding females was 4.6 years (±1.1). Each breeder was used about 4.2 times/year (±1.4, ranging from 2 to 8 times). Average fecundity was 150g of eggs per kg of female (a GSI of 15%). Eggs were stocked in incubation jars at a density of 179,000 eggs/litre; a range of 86,000 to 300,000 eggs per jar. The hatching rate was from 70% to 95% and averaged 83.8±6.8. Hatchery operators considered the hatching rate of eggs, and good movement, good color, and uniform size of hatchlings to be the main indicators of good seed quality.

The total annual production of tra fry produced in the Mekong Delta in 2007-2008 was estimated at 52 billion. Average yield per litre of weis tanks was 2.85 million fry/litre/year (±3.39). Using the exchange rate in 2007-2008 (USD 1 = VND 16,500), each hatchery spent an average of VND 588.3 million (±564.0) or USD 30,655 per annum, of which 96.7% was for variable costs. Among the annual production costs or variable costs, the three most important items consisted of: 1) feed (44.0%); 2) chemicals and drugs (24.2%); and 3) new broodstock (10.3%). On average hatchery owners gained a total net income of VND 802.2 million/hatchery/year or USD 48,618 but this figure obscures a great deal of variation (± VND 798.2) much of which is related to differences in hatchery size. It is noteworthy that all the hatchery operators interviewed made a profit.

Among the list of 15 tentative independent variables for multiple regression analysis, the yield of hatchlings from hatcheries was significantly affected ($p < 0.05$) by 3 factors. These were: (1) total volume of weis tanks used for hatching; (2) number of spawnings per breeder per year; and (3) costs of chemicals and medicine.

Yen (2007) reported the average total volume of weis tanks in tra hatcheries to be 150 litres, and that this was sufficient for the continuous operation of hatcheries throughout the year. In the present study, total average volume of weis tanks was larger (290.4 litre per hatchery), suggesting that owners had increased hatchery capacity to meet growing demand for tra seed. IN our study, the results from multiple regression analysis shows that in 2007-2008 the total volume of weis tanks was negatively related to the fry yield. Total volume of weis tanks of about 100-300 litres per hatchery seems to be appropriate (Table 1).

The results of multiple regression analysis also show that during 2007-2008 the number of times female broodfish were spawned each year was positively related to the fry yield. The spawning of individual female brood 5-6 times per year returned the highest yield and profit per litre of weis tanks per year. Using female broodstock 7 or more times resulted in a slight decline in both the fry yield of and profit (Table 1), as well as the quality of the fry.

Nursery sites of tra fish

Nursery sites averaged 1.1 ha in area, with 3-7 nursing ponds of average water depth of 1.9 m (±0.5), and average stocking density of 545.9 fry/m^2 (±215.4), and average survival rate of 22.3% (±9.5). Nursery sites were operated for a mean 4.6 cycles per year (± 1.5, and ranging from 3 to 10 cycles). The seed were stocked for 59.8 days (±22.4) and the fingerlings were harvested when 1 to 3.5cm. The average total production of each nursery site was 7.581 million fingerlings/ year, but varied quite considerably (±13.591) due to the variable size of operations and other factors such as stocking strategy (large numbers of short stockings or fewer longer stockings). The average yield of fingerlings was 122.5 million fingerlings/ha/year (±75.4).

The average total costs of a nursery site were VND 572.2 million or USD 34,679/ha/year (±366.7), of which variable costs accounted for about 96.2%. The four largest variable cost items included: feed (28.4%), fries and transportation of fries (22.4%), chemicals and drugs (14.2%), and pond preparation (12.6%). The owners earned an average total net income of VND 1,409.4 million or USD 885,418/ha/year but this figure obscures a very strong variation (±VND 1,859.7), in part because 15.4% of the total number of nursery site owners obtained negative profit, and in part due to highly variable nursery size and stocking strategies used.

The results of multiple regression analysis for nursery sites show that the yield of fingerlings harvested depended significantly on five factors ($p < 0.05$). These were: (1) depth of pond water; (2) frequency of water exchange; (3) stocking density; (4) size of harvested fingerlings; and (5) application of best management practices such as those required to attain certification under schemes such as VietGAP, SQF1000, or organic standards.

Above, below: A tra hatchery in the delta.

Fingerling yields in 2007-08 were positively related to the depth of water in nursing ponds. About 27.5% of the total number of nursery sites had the depth of water in ponds equal or higher 2.0 m and these sites obtained highest level fingerling yield but not net income. The water depth of 2.0-2.5 m was most appropriate. Very small or big size of ponds and very deep or shallow level of pond water may cause some difficulties in water and pond management.

Table 1: Factors affecting the yield, production costs and net income of hatcheries.

Variables	Fish yield		Production costs		Net income		Ratio of net income / costs	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unit	Million fry/litre		VND million / tank/yr		VND million/litre/yr		% year	
Total volume of weis tanks								
< 100 litres	3.1	1.6	3.5	2.3	6.3	3.0	41.8	28.2
100-200 litres	3.0	3.3	3.0	3.0	7.7	4.2	56.5	30.3
200-300 litres	3.8	3.1	3.5	1.9	8.2	4.6	56.8	21.6
> 300 litres	1.8	1.0	1.5	1.5	3.8	3.3	52.4	24.7
Number of times of spawning per brooder/ yr								
≤ 2 times	2.6	0.9	2.6	1.8	5.2	1.8	51.4	28.8
3-4 times	1.9	1.3	2.3	1.3	5.7	4.1	49.8	26.2
5-6 times	5.3	3.6	5.1	2.9	9.3	5.1	46.8	16.1
≥ 7 times	4.2	3.5	3.1	3.7	7.3	4.5	63.7	27.5
Costs of chemicals and medicines								
< VND 0.1 million	1.5	0.9	1.0	0.6	3.5	2.7	54.1	34.3
VND 0.1-0.3 million	2.9	1.8	1.8	1.5	6.2	4.2	67.5	17.5
VND 0.3-0.5 million	1.8	1.3	2.2	1.3	4.5	2.9	40.9	30.1
> VND 0.5 million	4.0	3.2	4.7	2.4	8.8	4.0	45.4	19.8

If the farmers exchanged water daily, about 19% of the total volume of water was exchanged. If water was exchanged every 2 or 3 days, then an exchange rate of about 27% was applied. Daily exchange of water for high stocking density of fry, or exchange every 7 days for low stocking density helped to bring about higher yields, but the highest level net income was observed with the exchange frequency of 3-5 days/time and medium density.

The nursing density from the surveyed sites had a positive relationship with the yield of fingerlings harvested. A nursing density of 500-750 fry/m^2 seemed to be most appropriate for both the yield and net income. However, an increase in the density can lead to a decrease in survival rate, and VINAFISH (2004) recommended a nursing density of just 250-400 fry/m^2.

The size of harvested fingerlings was positively related to nursing duration but negatively related to the numerical yield of fingerings harvested. 45% of the total number of nursery sites harvested fingerlings with a body eight equal to or greater than 2.0 cm. This resulted in a lower yield of fingerlings but a good income level.

Application of best/good practices based on the requirements of schemes such as GAP, SQF1000, or organic standards, was not common at the time of survey due to high costs and complicated management involved, which can directly lead

Table 2: Factors affecting the yield, production costs and net income of the nursery sites.

Variables	Fish yield		Production costs		Net income		Net income : costs	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unit	1,000 fingerlings / 1000 m^2 pond / cycle		VND million / 1,000 m^2 pond area / cycle		VND million / 1,000 m^2 of pond / cycle		%/cycle	
Water depth of the nursing pond								
≤ 1.5 m	75.0	44.5	10.4	7.6	9.9	12.2	104.5	136.6
1.5-2.0 m	118.9	76.1	16.5	10.9	41.1	63.0	378.6	599.3
2.0-2.5 m	127.7	65.3	11.6	8.4	49.6	48.8	682.3	897.2
≥ 2.5 m	156.3	97.3	11.9	6.0	18.3	15.6	221.8	236.5
Frequency of water exchange								
Every day (1 day/time)	133.3	78.5	13.4	9.2	32.9	41.3	473.1	867.5
3 days/time	87.6	43.3	13.5	8.9	37.1	60.4	369.3	662.2
5 days/time	119.1	63.4	11.8	6.7	45.9	64.3	523.4	611.2
7 days/time	137.4	99.0	13.8	11.2	22.3	22.7	201.5	235.9
Stocking density of hatchlings								
≤ 250/m^2	63.9	44.1	13.4	10.5	34.5	75.8	378.7	820.6
250-500/m^2	111.1	55.1	15.8	9.9	39.4	50.0	436.4	744.6
500-750/m^2	115.9	52.6	11.8	4.1	45.4	48.3	446.2	554.3
≥ 750/m^2	184.6	102.6	7.5	2.8	17.0	13.8	296.4	262.5
Size of the harvested fingerlings (height)								
≤ 1.5 cm	140.2	96.5	10.2	4.6	20.1	43.6	199.4	352.9
1.5-2.0 cm	118.8	69.5	14.3	10.7	35.5	44.1	400.2	498.8
≥ 2.0 cm	102.7	42.7	15.8	10.4	51.9	53.7	665.3	963.5
Application of best/good practices								
No	109.2	47.9	12.0	7.2	40.4	55.5	457.2	562.8
Yes	138.0	97.6	14.5	10.5	27.0	36.0	328.4	723.2

Table 3: Major information on tra catfish grow-out farms.

Description	Inland area	Coastal area	Total of MKD
+ 2 crops / year (%)	67.7	30.2	51.2
+ 1 crop / year (%)	18.9	41.9	29.0
+ 3 crops / 2 years (%)	13.4	27.9	19.8
Farm size (ha/farm)	1.0 (± 1.9)	0.9 (± 1.3)	1.0 (± 1.7)
Stocking density (fish/m^2)	47.2 (± 17.8)	38.7 (± 15.3)	43.5 (± 17.2)
Stocking size (cm)	1.8 (± 0.5)	1.7 (± 0.4)	1.7 (± 0.5)
Survival rate at harvest (%)	77.4 (± 11.8)	74.5 (± 14.8)	76.2 (± 13.2)
Fish yield/ha/year (tonne)	651.3 (± 347.2)	399.4 (± 207.4)	540.4 (±319.1)
Fish yield/ha/crop (tonne)	369.7 (± 164.5)	280.9 (± 128.8)	330.6 (± 156.0)
Total costs/ha/crop (VND million)	4,230.5 (±1,655.6)	3,248.3 (±1,427.9)	3,798.1 (±1,631.7)
Total net income/ha/crop (VND million)	809.9 (±1,044.7)	605.5 (±514.4)	719.9 (±857.6)

to a lower level of net income but better yield of fingerlings. Changing the perception of stakeholders participating in the industry will require improvements in education, a better sector management, and also time.

Grow-out farms (demand side)

Of the 293 grow-out farmers interviewed most (60.3% using multiple responses analysis) were aged 40-60 years. The great bulk practiced (91.5%) based on their own experience, whilst 72.7% also learnt from other tra farmers, and 67.6% had participated in various different formal short training courses. Grow-out farms had a mean pond area of 1.0 ha but there was a great deal of variation (±1.7) due to differences in farm size and the area of land available for pond construction. Most (57.3%) farms comprised of a single pond, whilst 36.2% and 6.5% of farms operated 2-4 ponds and more than 4 ponds, respectively. This indicates that most grow-out farms are small in terms of surface area and number of ponds.

About 51.2% of the surveyed farmers stocked tra fish two crops/year, 29% conducted only one, whilst 19.8% cultured three crops in each two year period. Most farmers growing two crops per year were located inland (67.7%), whereas the other two types of stocking were more common in the coastal provinces.

Grow-out farmers often bought the tra fingerlings from middlemen (45.7% of the total number of fingerlings stocked) and or directly from nursery sites (38.5%). Fingerlings were mainly purchased between March and May (38.5% of the total number of farms) and between July and September (37.8%). Long body, bright colour, uniform size, and good feeding behaviour as well as high survival rate of fish were considered as important indicators of quality by grow-out farmers.

Average stocking density in ponds was 43.5 fingerlings/m^2, with a survival rate of 76.2%. Farmers in inland provinces stocked 47.2 fingerlings/m^2 (±17.8), whereas in coastal provinces tended to stock at a lower density (38.7 ± 15.3 fingerlings/m^2). All of the tra seed used in coastal provinces originated from hatcheries and nurseries in provinces upstream, especially Dong Thap and An Giang. The results from study of Sinh et al. (2006) show that the following factors are important and should be given more emphasis by tra fish grow-out farmers: (1) seasonality, (2) source of seed, (3) stocking density, (4) size of seed, (5) price of seed, (6) checking and screening of seed, and (7) pre-treatment of seed.

This study in 2007-08 revealed that the stocking density of 60-75 fingerlings/m2 (1.2-2.0 cm in height) was optimal in terms of both yield and net income but the environmental impacts must be considered. The results from multiple regression analysis helped to show that there were six factors affecting the density of tra fish stocked in grow-out farms. These were: (1) size of fingerlings; (2) quality of fingerlings; (3) depth of pond water; (4) frequency of water exchange; (5) location of the farms; and (6) application of best/good practice guidelines. The effects of each factor are as follows:

- Size of fingerlings upon stocking is negatively correlated to stocking density. Fingerlings of 1.2-2.0cm height (at which size they weigh between approximately 7 and 33g per individual), and nursed for a duration of 2-2.5 months yielded the best results.
- Quality of seed: better yield and income, medium and good quality of seed was more acceptable while high quality seed might go in hand with higher density and more costs.
- Water depth in grow-out pond is positively correlated to stocking density, and a depth of 4-5 m is most appropriate.

Figure 1: Marketing channels of catfish in the Mekong Delta (2007-08).

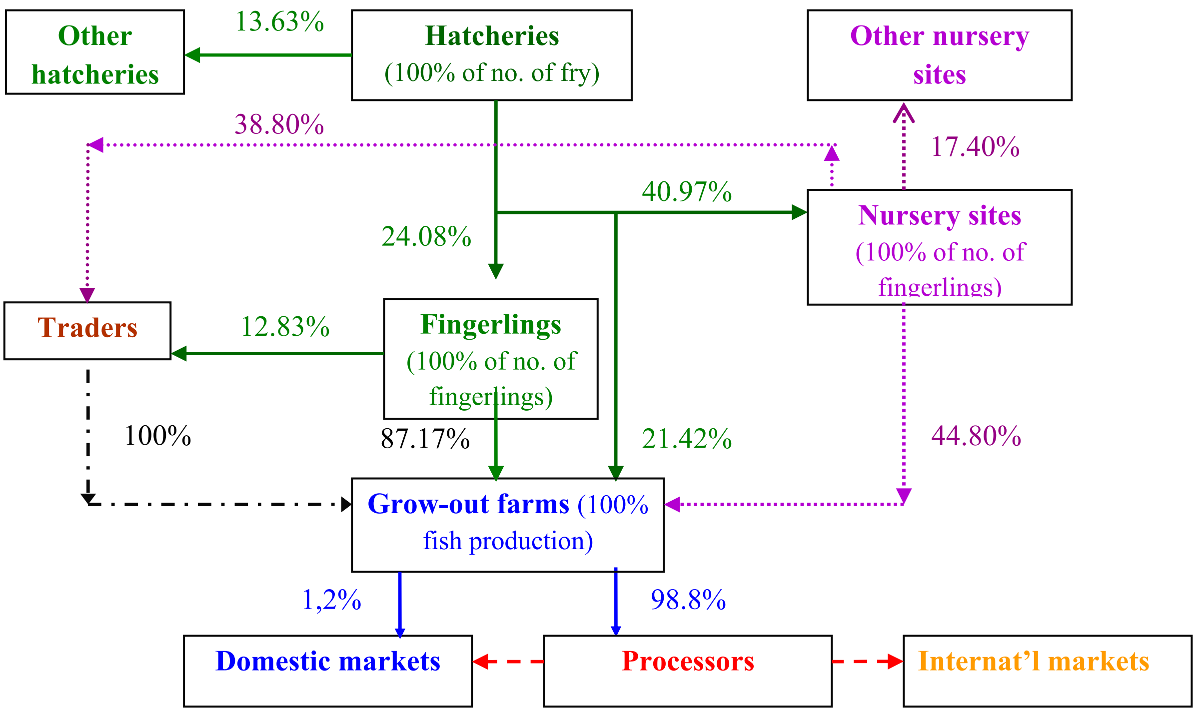
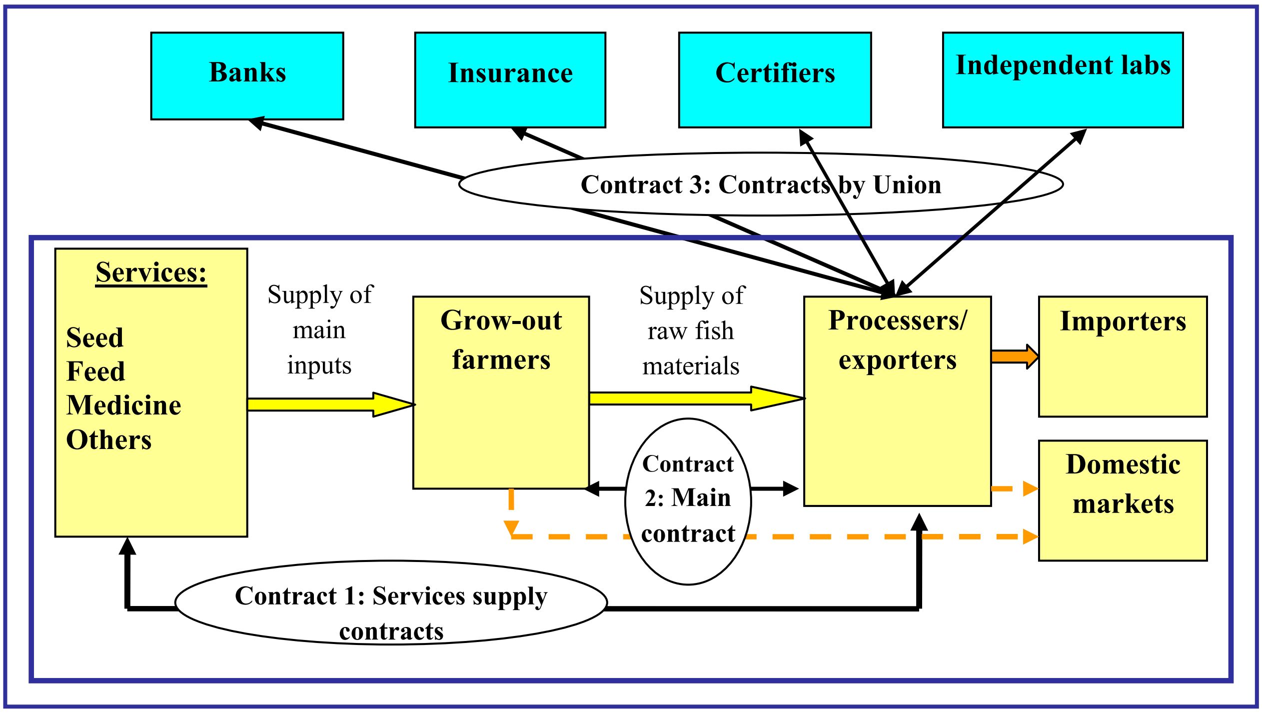


Figure 2: Suggestion for the development of horizontal linkage of Pangasius industry in Vietnam (Revised from the diagram of Nguyen Huu Dung, 2008).



- Exchanging pond water at a rate of about 20-30% of the total pond volume every 2-3 days also yielded the best results.
- Farms in inland provinces and close to big rivers were shown to stock fish at highest densities.
- Finally, adherence to best/good practice guidelines such as GAP, GMP, SQF1000 was shown to result in reduced stocking densities.

Mean crop duration was 6.7 months (±0.8), but ranged from 4 to 10 months depending on the size of fingerlings stocked, and availability of capital of the farms, as well as the market price of feeds, and the farm gate value offered by processing plants. Farms in inland provinces harvested at an average yield of 369.7 tonnes/ha/crop, while the average yield for farms in coastal provinces was lower at 280.9 tonnes/ha/crop. The average survival rate of fish across all of grow-out farms was 76.2% (±13.2) and the average size of harvested fish was 1.1 kg/fish (±0.1).

The total cost per ha per crop for farming tra fish in inland areas was VND 4,230 million (±1,655.6) or USD 256,394, higher than that for coastal farms at VND 3,248.3 million (±1,427.9) or USD 196,867. Total net income per ha per crop also followed the same trend, with VND 809.9 million and VND 605.5 million (or USD 49,085 and USD 36,697) for inland and coastal farms respectively. Because of good market condition in 2007 and the beginning of 2008, the rates of unsuccessful farms (those with negative net income) in 2007-08 were respectively 11.6% and 5.4% of grow-out farmers in inland and coastal areas (the average of this rate in previous years was 20-30%, Sinh 2007; even 40% for the crop at the end of 2008).

For further improvement of the management of grow-out farms, factors significantly affecting yields need to be considered. According to the results of multiple regression analysis, these factors are: (1) depth of pond water. Optimal productivity was obtained with a pond depth of 4-5 m; (2) stocking density of fingerlings, for fingerlings of 1.2-2.0 cm in height a density of 45-60 fingerlings/m^2 yielded appropriate results with some environmental concern; (3) efficient use of chemicals/drugs, this is particularly important given concerns about the environmental impacts of tra production and the quality of fish produced; (4) quantity of pellet feed should be 800-1,000 tonnes/ha/crop with FCR about 1.6; (5) quantity of home-made feed, about 900-1,500 tones/ha/crop seemed to be appropriate; (6) stocking duration, a grow-out cycle of 5-7 months, depending on the size of fingerlings, was best; and (7) size of fish at the harvest, individual fish weighing 1.0kg were best because bigger size of fish might help to increase the yield but much higher costs.

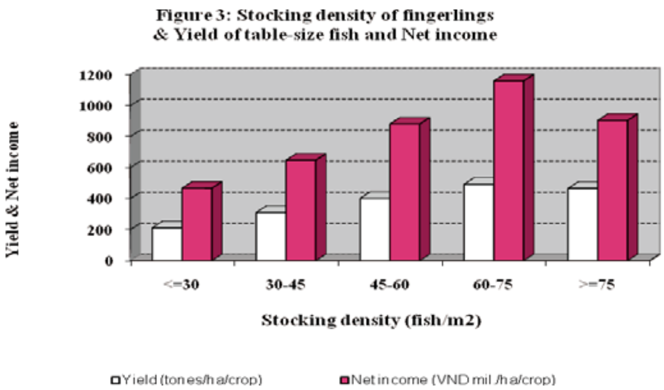
Estimation of the supply and demand, and other issues

Tra hatcheries can be divided into three groups by capacity and proportion (≤ 300 million fry/year, 36.4%; 300-500 million fry/year, 27.3%; and ≥ 500 million fry/year, 36.4%). Using average production of fry per hatchery a maximum total of 52,953 million of fry could be reproduced by 93 hatcheries in 2007-08. This amount of fry could yield 11,809 million fingerlings. Using the breeder size, number of eggs/kg of breeder, use of breeders and hatching rate can help to estimate the total weight of females needed (about 130-160 tonnes of females per year, plus an extra 20% for replacement).

By the year of 2008, total production of tra fish in the MKD was estimated at 1.2 million tonnes. This amount of fish was produced from farms with a total surface area of just 9,000 ha, of which 6,100 ha is ponds. Combining these figures, with average stocking densities for fingerlings of different sizes, and survival rates during nursing from hatchlings to fingerlings, and grow-out from fingerlings to table-size fish gives an estimated demand for 3.911 billion fingerlings (equal to a total of 23.015 billion hatchlings) in 2007-08.

Decree 102/2008/QD-BNN issued by the Ministry of Agriculture and Rural Development (MARD) of Vietnam approved a development plan for production and marketing of Pangasius catfish in the Mekong Delta to the years 2010 and 2015, and including a vision to 2020. Total cultured area of tra fish are expected to be 8,600 ha; 11,000 ha and 13,000 ha for these years, respectively. It is intended that these culture areas will produce 1.250; 1.650 and 1.850 million tonnes of tra fish, respectively. The total number of tra hatcheries envisioned by the plan for each of these years is 290; 400 and 510. These will be capable of providing, in order, 17; 32; and 51 billion fry or hatchlings.

Comparing estimates of hatchery capacity generated from the data presented in this paper with the MARD catfish development plan therefore reveals that the capacity of tra hatcheries in the Mekong Delta is already sufficient to meet the projected demand for seed for grow-out farms, and may continue to be so even for the next 10 years. Therefore, more careful consideration must be given to ensuring that good hatchery management practices are implemented in order to ensure seed quality, along with timeliness of production, viable prices for producers and users, and effective systems for the distribution of fish seed produced. In addition to the management of seed quality, management of environmental parameters during grow-out and greater attention to the marketing of fish products will also be important.



Only 48.5% of the hatchery operators interviewed reported that that they were satisfied with the quality of their broodfish. This statistic may give some cause for concern given that the quality and management of broodfish may impact on the quality and survival of fry or hatchlings which, in turn, may affect the quality and survival rate of fingerlings. These effects may result in the quality of food fish at the harvest. Satisfaction level of nursery site owners on the quality of fry bought was 59.0%. A higher proportion of grow-out farmers (73.6%) reported that the quality of the seed they used for farming was good, although 3.6% thought the fingerlings were of poor quality (Table 5).

These results are perhaps not surprising when few hatcheries, nurseries and grow-out farms follow the best practice guidelines provided by the Ministry of Fisheries for tra culture (e.g. broodfish should be spawned only twice per year; hatchlings should be stocked at a density of 250-400 fry/m^2 for nursing; fingerlings of 10-14 cm in length should be stocked at a density 15-20 /m^2 for growing-out; the depth of water in grow-out ponds should be 2-3 m). Sinh et al. (2006) report that 16.7% of tra grow-out farmers consider government directions on seed and stocking to be important, but that only 4.6% of them follow these directions because of lower yield and net income. This indicates that these

Table 4: Relationship between stocking density, production costs and net income of the grow-out tra catfish farms.

Affecting variables	Fish yield		Production costs		Net income		Net income : costs	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Unit	Tonnes/ha/crop		VND million/ha/crop		VND million/ha/crop		%/crop	
Stocking density of fingerlings								
< 30 fish/m^2	212.5	98.1	2442.9	1045.8	468.1	510.8	14.5	11.8
30-45 fish/m^2	311.0	104.5	3706.6	1238.7	648.3	649.6	14.0	13.4
45-60 fish/m^2	401.8	149.8	4572.6	1401.8	882.4	1090.1	14.2	13.6
60-75 fish/m^2	493.1	167.7	5376.8	1343.6	1159.7	1174.6	15.4	13.1
≥ 75 fish/m^2	466.4	152.8	5649.6	2095.3	906.0	928.1	14.9	13.8
Size of the fingerlings stocked								
≤ 1.5 cm	302.3	152.6	3451.0	1577.6	738.6	881.1	15.7	11.7
1.5-2.0 cm	321.2	140.7	3858.8	1709.1	615.3	673.7	13.1	13.0
2.0-2.5 cm	383.3	166.1	4231.2	1573.0	986.8	1059.9	17.6	12.7
≥ 2.5 cm	329.7	174.6	3653.8	1482.3	609.2	909.9	11.1	14.0

Table 5: Assessment (% farms) on the quality of broodstock, fry and fingerlings.

Assessment	Hatcheries (broodstock)	Nursery (fries)	Grow-out (fingerlings)
Sample size	33	39	280
1- Very bad	-	-	0.4
2- Bad	24.2	15.4	3.2
3- Medium	27.3	25.6	22.9
4- Good	27.3	28.2	46.8
5- Very good	21.2	30.8	26.8

standards are unrealistic and therefore not appropriate to producers. In addition, given the depth of ponds stocking densities are best expressed in cubic meters.

Marketing channels of catfish seed are complex. About 41% of the total amount of fry are sold directly to nursery sites, 13.6% to other hatcheries, and the remainder directly distributed to grow-out farmers or nursed up to fingerlings. Fingerlings produced by nurseries were sold to three main groups of buyers: directly to grow-out farmers (38.5% of the fingerling production), through middlemen (12.8%), and 48.7% to other nursery sites for re-nursing and subsequent resale. About 80% of the nursery sites supported their customers by offering transportation of seed, providing extra fingerlings (usually 1-3% extra) to compensate losses during transport. Fingerling movement, colour, length, uniform size, survival rate were the main concerns of nursery managers.

Even though most fingerlings were traded during the periods March to May, and July to September, there was a lag in the price signals received, meaning that seed prices were highest from April to the beginning of June, and again from August to the beginning of October. The seasonality in both reproduction and grow-out of catfish, should therefore be carefully considered in association with the trends in the export market price of tra when planning for production.

When export market saturation occurred in 2008, many farmers found it necessary to delay harvesting fish for two months or more because they found it impossible to break even given the low farm-gate prices. This is a risky strategy and often results in fish becoming over-sized (more than 1.1kg per fish). In 2007 and 2008, most harvested fish were sold directly to the processors (98.8% of total production). This rate is higher than in the past; that is, 45.6% in 2002 and 81.3% in 2006-07 (Son, 2003; and Son 2007). The decreasing proportion of food fish distributed through the middlemen indicates the increasingly important role of direct supply of raw fish from the grow-out farmers to processing companies. Dung (2008) recommends the establishment and development of vertical linkages in which the processors play a key role and fish is provided by grow-out farmers via direct contracts. Under this type of arrangement processors also have contracts with suppliers of seed, feed, medicines, loans and insurance, and transfer these inputs to grow-out farmers via the farmer-processor contracts. The certifiers of international standards and the independent labs need to be involved. One of the important things is that how to establish and develop concentrated areas for hatcheries and nursery sites as well as for grow-out farms, in which farmers work together in order to improve the investment and operation activities for a better participation in the linkage and to utilize the advantages of a larger scale and also generate synergies.

Conclusions

The design capacity of Pangasius catfish hatcheries in the Mekong Delta is estimated as close to 52 billion hatchlings per year. Using the survival rate of nursery sites, average stocking density of fingerlings, total grow-out areas and number of crops per year, it is estimated that about 36.3% of this total production capacity is adequate to meet current demand for fish seed. However, there are deficiencies in seed supply in terms of quality, time and price. Therefore, appropriate planning, operation and management of the hatcheries and grow-out sectors are important. More consideration should be given to the seasonality of the industry and the training on reproduction and grow-out activities with the application of best practices to ensure production of good quality fish. It should be also said that BMPs/guidelines etc. also have to be updated so that they are more realistic and take into the need to optimise profits and productivity of the farm/nursery/hatchery operations. Provision of better marketing information is also important to both producers and users of fish seed while improvements in the linkages among stakeholders are needed for long-term development of the Pangasius catfish industry in the Delta.

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Risk analysis and sustainability of *Pangasianodon hypophthalmus* culture in India

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Pangasianodon hypophthalmus was introduced into India possibly during 1997 clandestinely via Bangladesh and adopted for culture in the state of West Bengal. Because of its remarkable growth rate (almost one kg in 90 days), there has been much enthusiasm among fish breeders and farmers particularly in West Bengal and Andhra Pradesh for its culture and propagation. It is estimated that over 200,000 tonnes of *P. hypophthalmus* catfish are produced in the country per annum. Therefore, a study was conducted to assess the risk and benefits of the *P. hypophthalmus* culture in India. The details of the biological characters of introduced *P. hypophthalmus* were collected from field studies. The information and data on culture, food and feeding habits, maturity, breeding and reproduction under grow-out and hatchery conditions, diseases of concern, if any, the gut contents and maturity stages of escapee fish in the wild were generated for assessing its potential to compete with other fish species.

Culture and seed production

Information from grow-out farms revealed that the fish is cultivated both under monoculture as well as polyculture with Indian major carps and Chinese carps. However, monoculture was found to be more profitable to the farmers. Therefore,

most of the farmers preferred monoculture practice. Farmers located in Krishna and West Godavari districts of Andhra Pradesh are culturing *P. hypophthalmus* in big ponds ranging from four ha to 40 ha. It was found that there is a shift in culture practice from carps to sutchi catfish in some of the areas in Andhra Pradesh. The total area of fish culture of *P. hypophthalmus* was estimated to be over 20,000 ha covering roughly 15% of the total culture area, which has increased over the years. Due to closure of shrimp ponds on account of disease, farmers suffered heavy losses and many adopted *P. hypophthalmus* farming as an alternative crop in the same areas that were disease affected.

The state of West Bengal was found to be the hub of seed production of *P. hypophthalmus* in the country. About 300 to 500 million *P. hypophthalmus* seed is produced every year with the bulk of it being sent to Andhra Pradesh and the rest to Orissa, Tamil Nadu, Maharashtra, Kerala, Karnataka, Bihar, Rajasthan and Uttar Pradesh. The seed production of *P. hypophthalmus* is not only used for aquaculture but is also sold for the aquarium trade. Different varieties of fingerlings (striped and albino) are produced for aquarium trade. The culture production of *P. hypophthalmus* ranges from 7 tonnes per hectare per year to 20 tonnes per hectare per year and the average production are found to be higher than carp production in the same areas.

Food and feeding

This catfish is an omnivorous fish feeding on crustaceans, molluscs, plant debris and small fishes. However, farmers use several local ingredients for feeding the fish under culture. Most of the farmers fed cooked de-oiled rice bran (DOB) and broken rice at the rate of 5% of the body weight. The locally available agricultural waste product is also used along with DOB for feeding. Even discarded potatoes are also used along with DOB. Bag feeding is practiced by most of farmers.

Maturity and breeding

P. hypophthalmus is a riverine fish attaining maturity at an age beyond 3 years however, under captive conditions it has been found to mature at an age of 2 years and above. Males and females are easily distinguishable; females are identified by their big, soft and swollen and reddish pink distended belly and males by their reddish genital opening and oozing of milt, when the abdomen is pressed. Breeding starts from April and continues until mid September. One brooder can be used at least two times during the same breeding season. After the hormone injection (pituitary extract/Ovaprim) the fishes release eggs which are fertilised. The spawn is rinsed in milk powder solution in Aluminium 'hundi' to remove the adhesive gelatinous covering of the fertilised eggs. The fertilised eggs are then transferred to a Chinese hatchery 20 minutes afterwards for hatching and rearing.

Disease and management

Catfish culture is faced with severe disease problems. Heavy mortalities have been noticed and the fish exhibited off-feeding, circular motions, edging and other morbid conditions. All sizes of fish ranging from 5 g to 1.5 kg have been found disease affected and causing heavy losses to farmers. Parasitic diseases have been found to be very common but occurrences of 'red disease' in *P. hypophthalmus* catfish from grow out farms have also been confirmed which was haemorrhagic septicaemia. In some specimens swelling of the liver has been observed. Microscopic examinations of gill by squash preparation of infected fish reveal presence of *Trichodina* parasitic infection of moderate degree.

Harvesting and marketing

P. hypophthalmus ranges from 8 months to one year, in general. However, according to marketability farmers harvest the fish from 6 months onwards. In most of the farms multiple harvests are in practice. Fishes weighing above 1.5 kg are the preferred size for harvest and marketing. The packing and loading of harvested *P. hypophthalmus* for trade are well organised and it is ice packed. The chilled storage condition is most widely used active packaging technology. By using this technique, the product's shelf-life becomes up to 20 days[1].

Occurrence of *Pangasianodon hypophthalmus* in natural waters

A few specimens of *P. sutchi* have been caught from the wild in Andhra Pradesh and also from wetlands in West Bengal. Bench mark surveys indicated the availability of *P. sutchi* in natural waters. The present occurrence of P. sutchi in natural waters is in need of further study with regards to the conditions it can survive in and its impacts on native fish fauna. However, gut analysis of the collected specimens from wild showed presence of shell and plant debris in the stomach. The gonads of the wild caught specimens have not been found fully developed and mature.

Risks associated with culture of *P. hypophthalmus*

Biodiversity

The locations of culture and hatchery sites of *P. hypophthalmus* in India have been found to be close to open waters and hence there exists every chance of its escape. Escapee fish have been recorded from wetlands of West Bengal as well as Kolleru lake area of Andhra Pradesh. The culture activity is spreading fast in India and now it is not only restricted to Andhra Pradesh and West Bengal, rather it has extended to other coastal areas including fishery hotspots of Western Ghats and also in the northern and north- eastern parts of the country. It has potential to mature and breed naturally in wild and hence escapee fish may colonise and form feral populations in different agro-climatic conditions impacting the ecosystem and in turn affecting the biodiversity. In India, the breeding of local *P. pangasius,* which has a similar spawning period which will be overlapped by *P. hypophthalmus* in case of its establishment in the wild. The presence of similar numbers of chromosomes in both the species (2n=60) may facilitate hybridisation leading to genetic pollution which in turn could dilute the gene pool of local *P. pangasius* whose population has declined critically[2]. An experimental trial for cross breeding between *P. pangasius* with *P. hypophthalmus* has already been successfully attempted in Bangladesh[3,4]. The husbandry practices are now improving and hatcheries have begun selection for traits favourable to aquaculture or aquarium purpose for *P. hypophthalmus*. Hence, escapee fish may become a concern in future[5].

Environmental issues

Irrational use of antibiotics and chemicals in *P. hypophthalmus* farms in India is of great environmental concern. Frequent outbreaks of bacterial diseases have put considerable pressure on farms to use a variety of antibiotics and chemicals and also at hatcheries. In fact, the contamination with banned chemicals and antibiotics which is in practice might occur at any stage throughout the production chain. It is therefore, necessary to have a nationwide campaign to improve sanitation and ensuring quarantine warranty, environmental purity and food safety.

Issues of fish health

Gill fluke infection is commonly seen in all *P. hypophthalmus* farms with infection rates varying from 60% to 90% of fish. The highest mortality due to gill fluke is manifested during the first week after stocking. The incidence of visible infections or disease in spawn and early fry at the hatcheries is low, except for gas bubble disease which is probably due to high ammonia level and eutrophic conditions. Farmers pay attention only to the direct economical loss from diseases other than that from gill fluke infection. In fact, gill fluke has been understood to contribute significantly to the loss due to secondary bacterial infection which was followed by the initial infections with the parasite. Catfish diseases have been considered as the major problem in its culture. Due to the open culture of *P. hypophthalmus*, risk of disease and parasite transfer to wild stocks would be possible. Recently, the bacteria *Edwardsiella ictaluri*, a disease native to North America and reported from ictalurid catfish, was identified in farmed *P. hypophthalmus* cultured in the Mekong River Delta. This is the first instance of this disease being observed in pangasiids. *Edwardsiella ictaluri* has been isolated from *P. hypophthalmus* in Vietnam, which has not been reported from the co-habitant *P. bocourti*[6]. A previous report of bacillary muscle necrosis reported from Vietnam[7] has now been identified as being attributable to *E. ictaluri*[6]. It remains unclear as to whether the bacteria are introduced or local but previously unknown, however transmission of pest could be an issue in the future. A report from New Zealand on risk assessment of Vietnamese *P. hypophthalmus* has highlighted the possible transfer of *Edwardsiela ictahuri* in aquaculture areas in Vietnam which is a concern of OIE listed disease[8]. It is pertinent to mention that infection of *P. hypophthalmus* does not result in clinically apparent disease. Therefore, septicaemic fish are quite likely to be harvested for human consumption. There remains the possibility that some fish could be carrier of *E. ictaluri* without displaying clinical signs. In India, the septicaemic fish infections were observed at some of the *P. hypophthalmus* farms. If such infected fish is harvested and processed for consumption, it will have a serious concern with human health. Further, there is no treatment of the effluent water from culture ponds and lacking knowledge of farmers, dead fish and/or diseased fish from aquaculture and aquarium facilities are released directly to public canals and rivers. Hence, there is prevailing threat of disease risks associated with culture of *P. hypophthalmus*.

Socio-economic issues

Easy management of culture operations in recent years attracted farmers to catfish culture. *P. hypophthalmus* is now available at a low cost of Rs 30-40/ kg. Carp production is declining due to the fact that farmers are cultivating *P.*

hypophthalmus in carp as well as shrimp aquaculture farms. It is important to point out that demand for carps is still greater and it costs more, at Rs.50-70/kg. Farmers are producing *P. hypophthalmus* at a lower investment but the cost of production is escalating considering the cost of antibiotics and other chemicals. This situation is impacting marginal farmers, consumers, culture environment and socio-economic conditions.

Conclusion

The study was based on interaction with aquaculturists, state fishery officials, fish dealers in the markets, laboratory studies of diseased samples in the states of West Bengal and Andhra Pradesh and desktop analysis of the world literature related to the culture of *P. hypophthalmus*. Based on the study the following scenario emerges for *P. hypophthalmus* culture in India:

- The culture of *P. hypophthalmus* was found to be prevalent in the states of West Bengal and Andhra Pradesh.
- Further spread of *P. hypophthalmus* farms in fishery sensitive and biodiversity rich areas such as Western and Eastern Ghats can harm indigenous fish diversity.
- *P. hypophthalmus* is a riverine fish and it has a great potential to mature and breed in rivers.
- The escapee *P. hypophthalmus* may enter the natural waters and compete with wild fish affecting the ecosystem balance.
- Use of fishmeal, trash fishes in *P. hypophthalmus* feed will deplete resources on which other local fish depend as food.
- *Pangasianodon hypophthalmus* is prone to diseases such as haemorrhagic septicemia, bacillary diseases, *Flavobacterium columnarae*, *Trichodina* and can impact farmed and wild stocks.
- Inappropriate use of antibiotics and chemicals practiced in *P. hypophthalmus* culture can have adverse impacts on the environment and human health.

Consequently, the culture of *P. hypophthalmus* in India warrants a very cautious and regulated approach. It is suggested to discourage and prevent the practice of free and widespread culture of *P. hypophthalmus* in the country as it could be a threat to our aquatic biodiversity.

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Life of a river in the Himalaya: An ecological study of Trisuli River system in Nepal

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There are three major river systems in Nepal – the Koshi in the east, Gandaki in the centre, and Karnali in the west. All of them drain into the Ganges River basin, flowing through northern India and emptying in the Bay of Bengal.

The Trisuli River, one of the seven major tributaries of Gandak River Basin, originates in the Gosainkunda Lake (approximately 4,500 altitude) of Rasuwa District in Central Nepal. According to Hindu legend, the Trisuli River originated by Lord Shiva driving his trident 'Trisul' in the hill just above the Gosainkunda to create three springs when he needed a cool place to rest in the Lake Gosainkunda. The Gandaki River system is the main tributary and mixes with other rivers such as Buri Gandaki, Marsyangdi and Seti Rivers as it flows ahead. Trisuli River starts from Betrawati (625 altitude) and flows to Narayanghat (170 altitude) over a distance of 141 km. Trisuli joins the Bhote Kosi that flows from Tibet, and which is a most popular rafting river with impressive gorges and exciting rapids. After Betrawati it joins other major rivers to its flow such as Buri Gandaki, Marshyangdi and Seti. The Kaligandaki River originates in Mustang and converges with Trishuli at Deoghat in Chitwan and changes its name to the Narayani, which goes on to meet the Ganges in India. The river runs about 240 km traversing through high mountains, midhills and terai of Rasuwa, Nuwakot, Dhading, Gorkha, Tanahu and Chitwan Districts, and merges with six other rivers - Burhi Gandaki, Kali Gandaki, Madi, Darondi, Marsyangdi and Seti to become Narayani in Devghat.

The main source of the Trisuli River discharge is the snow and glacier melt from the higher Himalayas. The Bhotekoshi River is the major tributary that feeds the river in the upper stretch, although there are many other tributaries. Fish biodiversity in the Trisuli is rich and the average catch is 18kg/ha, amounting to about 7,031 tonnes annually, providing essential income and nutrition for the local people living around the river system.

We conducted a study of the Trisuli river system with the objectives to:

- Study the seasonal and spatial variations in physico-chemical parameters.
- Study the flora and fauna of the river.
- Evaluate the influence of ecological settings and human behaviour on the river system.
- Forty seven sampling stations were taken based on mainly perennial tributary confluence of Trisuli River along the longitudinal stretch from Gosainkunda, Rasuwa to Trivenighat, Nawalparasi except in some stations based on riparian urbanisation and industrial activities in the Narayani River (Figure 1). A field survey was conducted in two seasons during post monsoon in September 2008 and pre-monsoon in March/April 2009 respectively.

The temperature, dissolved oxygen, turbidity, conductivity, pH, alkalinity, and total hardness were measured on site whereas for nutrients analysis NH_4-N and NO_2-N+NO_3-N inorganic phosphate (PO_4-P), total phosphorus, and chlorophylla and pheopigment[1] were carried out in the laboratory.

Phytoplankton and zooplankton were measured qualitatively up to species and quantitatively with the help of microscope using standard methods. Fish samples were collected through the fishermen and the local markets along the river sides including information fish species available in the river system through local people and fishermen. The fish species were identified and classified according to classification of Jayaram[2], Shrestha[3] and Talwar and Jhingran[4].

Findings

Physico-chemical parameters

Water temperature in the Trisuli River system widely differed along with the altitude between the origin of water at Gosaikunda (4,400 msl) and Narayani River-the Trivenighat (84 msl) from 12.5-27.4°C during post-monsoon and from 6.1-29.6°C during pre-monsoon season (Table 1). The maximum water temperature (29.6°C) was after direct mixing of untreated effluents from a beer factory in the Narayani River that might have increased the water temperature. Glacial waters dominated the Trisuli River system until the Tadi River joined Trisuli at Devighat. Water temperature has shown a strong positive correlation ($r=0.75$, $P\leq0.01$), which was reported similarly by Sharma and Shrestha[5]. Weather, altitude, stream bank vegetation, impoundments, discharge of sewage and polluted water, urban storm water, rain and flood, landslides, settlement of dense population, groundwater inflows to the river etc. are the causes of changing in water temperature.

Water temperature affects the ability of water to hold oxygen, rate of photosynthesis by aquatic plants and the metabolic rates of aquatic organisms. The pH value was almost within the permissible level (6.5-8.5) having mostly alkaline ranging from 6.5-8.6 during post monsoon and from 5.5-8.2 during pre monsoon (Table 1). The pH in Trisuli River system is favourable for all types of aquatic organisms since the optimum standard is 6.5-8.5[6,7,8,9] except in few places (5.5), where direct discharge of sewerage and household waste mixed into the river.

Turbidity ranged from 0.5->440 NTU showing highest during post-monsoon and from 0.9-185.6 NTU during pre-monsoon. The turbidity is high in Nepalese river systems due to mostly to feed by glaciers ranging from 300-1,500 NTU for 6 months from April to September[10,11]. Turbidity was high after joining at Narayani due to the direct discharge of untreated effluents from paper and beer factories. High turbidity during post-monsoon might be due to flow of high suspended particles which can absorb more heat and raise water temperature.

Table 1. Physico-chemical parameters of water quality of Trisuli River system.

	AT	WT	pH	Turbidity	CON	DO	TA	TH	TP	PO_4-P	NH_4-N	NO_2-N + NO_3-N	Chlorophyll[a]	Pheo-pigment
Post-monsoon														
Min	11	12.5	6.5	0.5	8.2	5.6	30.0	0.0	0.002	0.000	0.002	0.000	0.002	-0.163
Max	38	27.4	8.6	440	251.0	9.6	140.1	94.0	0.200	0.003	0.013	0.138	0.096	-0.002
Mean	29.5	21.9	7.7	259	110.4	8.4	65.8	42.6	0.060	0.001	0.005	0.032	0.037	-0.062
SD	4.8	3.2	0.6	178	51.8	0.8	21.1	17.5	0.056	0.001	0.001	0.042	0.031	0.053
Pre-monsoon														
Min	7.8	6.1	5.5	0.9	12.2	7.8	10.0	0.0	0.000	0.000	0.000	0.000	0.001	-0.125
Max	36.3	29.6	8.2	186	534.0	12.5	190.2	320.0	0.177	0.177	0.003	0.056	0.073	-0.002
Mean	27.8	20.4	7.4	53.1	190.8	9.3	66.2	188.7	0.015	0.010	0.0004	0.031	0.008	-0.015
SD	5.3	4.2	0.6	43.1	81.5	1.1	28.5	64.8	0.026	0.026	0.0008	0.016	0.014	0.023

High turbidity can leads to decrease photosynthetic activities and dissolved oxygen affecting the aquatic organism, especially fish fauna mostly during post monsoon due to rain washed into the river from different places including soil erosion making more turbid water.

Conductivity ranged from 8.2-251.0 µS/cm during post-monsoon and from 12.2-534.0 µS/cm the higher during pre-monsoon (Table 1) but mostly within range acceptable for fisheries (150-500 µS/cm) except little higher in some places. The conductivity was low in the upper stream as glacial fed water is low in content of ions and minerals but increased downstream after mixing with many large and small rivers or tributaries and the discharge of untreated effluents from a beer factory including heavy ionic load in Narayani River, similar to the reports of Bhat[12,13]. The variation is due to the ionic composition of the precipitation and diluting effects of the large volume of the rain[8,14]. The conductivity is influenced by temperature and high temperature will improve conductivity[9]. Water temperature and conductivity have shown strong direct correlation in our study ($r=0.75$, $P\leq0.01$).

Dissolved oxygen ranged from 5.6-9.6 mg/l during post-monsoon and from 7.8-12.5 mg/l during pre-monsoon showing above the limit (>5 mg/l) that considered good for all kinds of aquatic organisms[6,15] (Table 1). It was found higher during pre-monsoon due to more turbid water with heavy rain flows into the river. Dissolved oxygen showed inverse correlation with temperature ($r=-0.60$, $P\leq0.01$) similar report made by Mishra and Yadav[13,16]. The low temperature and high speed of water flow increase dissolved oxygen in upstream and high temperature with low speed of water flow decrease dissolved oxygen in downstream. So the fast moving water and colder water contain higher dissolved oxygen than slow or stagnant water and warmer water.

Total alkalinity ranged from 30.0-140.1 mg/l during post-monsoon and from 10.0-190.2 mg/l during pre-monsoon (Table 1). Alkalinity is the measure of weak acids and weak acid-salts14 and is important factor for aquatic life to protect against pH changes keeping pH fairly constant. Alkalinity >20 mg/l is considered to be very good in buffering capacity[9] and it was >20 mg/l in all stations except in Gosainkunda (10 mg/l) and was highest (190 mg/l) near beer factory. A positive correlation has shown between alkalinity and pH ($r=0.50$, $P\leq0.01$) and alkalinity and phosphate ($r=0.75$, $P\leq0.01$). Total hardness varied from 0.0-94.0 mg/l during post-monsoon and higher from 0.0-320.0 mg/l during pre-monsoon (Table 1), which might be due to the low concentration of calcium and magnesium ions during post-monsoon[17] and has shown strong positive correlation ($r=0.75$, $P\leq0.01$) with total alkalinity. High content of total hardness is a characteristic of Nepalese river systems due to heavy rocks available containing high amounts of calcium and magnesium. Total hardness was high downstream after joining the Narayani River near Narayanghat bajar due to intense bathing and washing activities. Total phosphorus and phosphate-phosphorus were very low in Trisuli River system ranging from 0.002-0.200 mg/l during post-monsoon and from 0.0-0.177 mg/l during pre-monsoon (Table 1). The highest value recorded (0.177 mg/l) after joined river at Narayani River near the beer factory followed by the paper mill.

Total phosphorus was slightly higher in post-monsoon than pre-monsoon similar to reports by Panigrahi24. PO_4-P ranged from 0.000-0.003 mg/l during post-monsoon and from 0.000-0.177 mg/l during pre-monsoon. Total phosphorus and phosphate-phosphorus come from human and animal wastes, phosphate-rich rocks, wastes from laundries, cleaning and industrial processes, and farm fertilisers[14], which are present in high amounts near the beer factory and paper mill. Phosphate stimulates the growth of plankton and provides food for fish and might support aquatic life, particularly fish populations, to enhance and improve productivity in the Trisuli River system. NH_4-N was absent in almost all stations during pre-monsoon except some places near farmland, settlements and industrial areas and varied from 0.002-0.013 mg/l during post-monsoon and from 0.0-0.003 mg/l during pre-monsoon. NH_4-N above 0.02 mg/l concentration is lethal to fish species[18] but it was below in both seasons and unionised ammonia is toxic to aquatic organisms, especially to the fish species and it was very low during post monsoon which might be due to dilution and flushing by rainwater. NO_2-N+NO_3-N ranged from 0.0-0.138 mg/l during post-monsoon and from 0.0-0.056 mg/l during pre-monsoon (Table 1). NH_4-N, nitrate, nitrite and phosphate showed very limited concentration indicating the water in the Trisuli River system is not polluted and good for aquatic life particularly for fish except in heavy flood during monsoon and when landslides occur and unwanted things are washed into the river system.

Plankton

Plankton is a very important source of food in some rivers[19,20] and they form basic food source in any aquatic organism, especially for fish species. Phytoplankton was observed from 32 species belonging to 6 groups dominating by Bacillariophyceae (84%) with 19 species followed by Chlorophyceae (9%) with seven species, Cynophycea (4%) with four species, Eugleniae (2%) with two species and Dinophyceae (0.5%) and Chrysophyceae (0.5%) with one species each, respectively (Figure 2). Similar results were reported by Kostkeviciene[21] and Nwadiaro and Ezefili[22]. Among bacillariophyceae, *Synedra ulna* (30.3%) was the highest density followed by *Navicula hasta* (12.2%) and *Cocconeis placentula* var. lineata (7.1%) and others, respectively. *Closterium gracile* (3.5%) and *C. acerosum* (2.4%) were dominated in Chlorophyceae, whereas *Surirella sp, Gyrosigma distortum*, *Elakatothrix gelatinosa*, *Spirogyra* sp., *Ceratium hirundinella*, *Amphora ovalis*, *Frustulia* sp., *Nitzschia* sp., *Dinobryon bavaricum* and *Oscillatoria* sp. were the least abundant (<1%). Phytoplankton density (48 cell/ml) and species richness were high after joining in the Narayani River at Trivenighat near the beer factory. Zooplankton were predominantly protozoa (41%) and rotifera (39%) (Figure 3) in the Trisuli River similar finding by Ali[23] and Djurkovic[24]. 17 species of Rotifera were observed: *Brachionus angularis*, *B. forficula*, *B. rubens*, *B. quadridentatus*, *Keratella cochlearis*, *Platyias quadricornis*, *Euchlanis dilatata*, *Kellicottia longispina*, *Lepadella patella*, *Lecane luna*, *Monostyla bulla*, *M. hamata*, *Trichocera cylindrical*, *Polyarthra trigla*, *Conochilus unicornis* and *Philodina roseola*, and nine species of protozoa: *Enchelydium* sp., *Bursaria* sp., *Actinophrys* sp., *Arcella vulgaris*, *Difflugia corona*, *Cileatea* sp., *Nebella* sp. and *Centropyxis aculeate*. Seven species of cladocera were observed: *Diaphanosoma brachyurum*, *Daphnia* sp., *Bosmina longirostris*, *Bosminopsis deitersi*, *Chydorus sphaericus*, *Alona* sp. and *Camptocercus rectirostris* and four species of copepoda: *Cyclops vicinus*, *Mesocyclops leuckarti*, *Nauplius* sp. and *Bryocamptus* sp., respectively. *Difflugia corona* (16%) was the highest in number followed by *Keratella cochlearis* (12.9%), *Brachionus rubens* (10.2%), *Difflugia* sp. (9.8%) and other species, respectively. Zooplankton diversity, species richness and density (67,500 individuals/l) were recorded to be highest after the join of the Narayani River, before entering urban territory near the beer factory.

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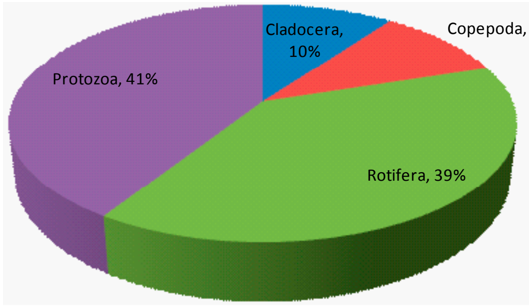
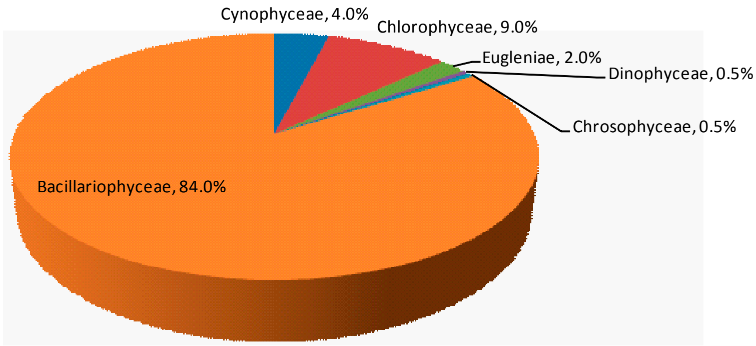
Phytoplankton composition.



Zooplankton composition.



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Marine Finfish Aquaculture Network

Induced spawning and larviculture of grey mullet, *Mugil cephalus* (Linnaeus 1758) in the Emirate of Abu Dhabi

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Grey mullet, *Mugil cephalus*, is one of the most widely distributed food fishes in the world (McDonough et al., 2003). In the United Arab Emirates (UAE), the fish, locally known as Biah or Wagena, is considered as one of the most highly demanded fish. However, it was recently recognized that the landings of this species have drastically decreased and its presence in the local fish markets became rare (MAF, 2003). In captivity, grey mullets do not spawn spontaneously and that could be achieved successfully by hormone administration (Lee and Tamaru, 1988, El-Gharabawy and Assem, 2006).

This has lead to increasing interest by the Aquaculture Center, Abu Al Abyad Island (ACAAB), Emirate of Abu Dhabi, UAE to propagate the fish. The ACAAB is situated in Abu Al Abyad Island which is the major island of the Emirate of Abu Dhabi covering an area of 490 km². The island is characterised by its harsh environmental conditions where water temperature and salinity during summer time reach as high as 36 ºC and 58 ppt, respectively (Al Abdessalaam and Yousif, 2002).The results of the first induced spawning and larviculture trials of this species under the environmental conditions of Abu Al Abyad Island (50 -55 ppt) are presented in this article.

Ten day old mullet larvae preying on rotifers.

Broodstock and spawning

Wild grey mullet fingerlings averaging 4 g body weight (bw) were introduced in 2002 from Egypt and grown in indoor 40 tonne circular concrete tanks at ACAAB. The fish were first stocked in freshwater and after an acclimation period of seven days the water salinity in the tanks was gradually raised by 8 ppt/day until the fish were completely acclimatised to the natural seawater salinity of Abu Al Abyad Isalnd (55 ppt). During the grow-out period the fish were fed floating marine fish feed (45% protein and 10% lipid). In September 2008 a number of six years old fish were selected and conditioned by feeding with 6 mm pelleted feed supplemented with 1% fish oil (DHA 20-22%, EPA 4%) and 0.5% vitamin mix and vitamin E. In the first week of December 63 ripe females averaging 1.03 kg with average cannulated oocytes diameter of 427 µm, and 126 males averaging 0.83 kg with running milt were transferred to indoor 30 tonne concrete oval shape and 36 tonne concrete rectangular spawning tanks at a rate of 1 male : 2 females. Clove oil (4-Allyl-2-methoxyphenol) in a dose of 0.01 ppm was used to anaesthetize the fish during transportation, cannulation and injection processes. The selected broodstock was acclimated to 37 ppt salinity by gradually adding freshwater over a period of seven days.

Table 1: Effect of different hormones on induction of females spawning and hatching rate of fertilised eggs.

Primary/resolving	Males injected	Females spawned	Eggs ($x10^3$)	Eggs/ female ($x10^3$)	Eggs/g body weight	Fertilised eggs ($x10^3$)	Hatched larvae ($x10^3$)
CP/LH-RHa	11	4	1060	265	257.28	520	440.3
CP+HCG/LH-RHa	25	23	3404	148	143.69	2040	1111.2
HCG/LH-RHa	21	8	480	60	58.25	160	None
TP/LH-RHa	6	1	160	160	155.34	100	None

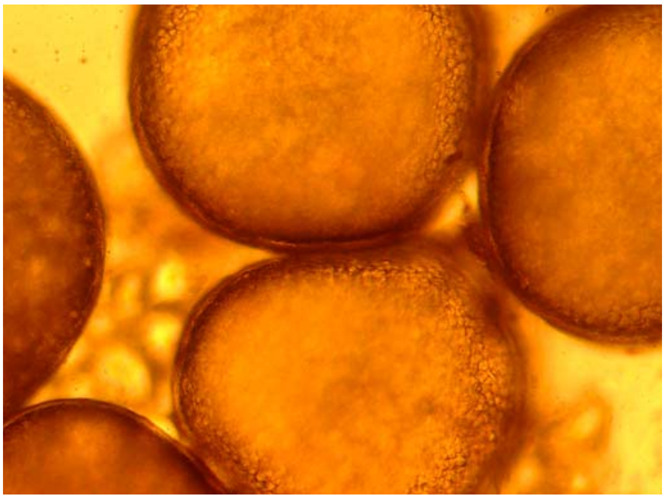
The fish were induced with carp pituitary (CP, 20mg/kg body weight), human chorionic gonadotropin (HCG, 1000 IU/kg bw) and tilapia pituitary, extracted from local tilapia stocks (TP, 20 mg/kg body weight) administered as priming injections to four groups of females and each was followed 24 hours later by a resolving injection of luteinizing-hormone-releasing-hormone-analogue (LH-RHa) at dose of 200 µg/kg bw. Spawning took place 24 hours following the resolving hormonal injection at an average water temperature of 20.8 ± 1.08ºC. All hormonal applications were successful in inducing spawning and females receiving carp pituitary as a priming injection achieved the highest fecundity (257.28 eggs/g bw). This was followed by the females injected with the priming dose of tilapia pituitary (155.34 eggs/g bw). The priming dose of HCG produced the lowest fecundity (58.25 eggs/g body weight). Use of a combination of carp pituitary and HCG as a priming injection improved spawning (Table 1). These fecundities are very much below those reported elsewhere for captive mullets (Nash and Koningsberger, 1986, El-Gharabawy and Assem, 2006). The low fecundity values obtained in this study could be attributed to the hypersaline conditions (55 ppt) under which the fish were grown from the fingerling stage until they attained maturity. The spawning season in this trial was observed to be very short extending only for 17 days. For the aquaculture of this species to succeed, a plan for a consistent supply of fingerlings should be developed and thus it is recommended to study the possibility of its induction out of the spawning season (El-Greisy and Shaheen, 2007).

Buoyant eggs were collected, washed and placed in measuring cylinders for separation of fertilised eggs and volumetric counting. Fertilised eggs were incubated in 600 µ mesh baskets placed in 5 tonne rectangular fiberglass tanks supplied with gentle flow of 37 ppt seawater and aeration. The incubation period was 48 hours following the second resolving injection at an average water temperature of 20.84 ± 1.08ºC. The average hatching rate was 60.07% ranging between 26.5 and 84 %.

Larval rearing

After hatching, the larvae averaging 2.3 ± 0.11 mm in total length were counted and stocked in 4 tonne fiberglass rectangular larval rearing tanks (LRTs) at a density of 30 ± 2.71 larvae/litre. All LRTs were indoors under clear acrylic sheets roof. The green algae, *Tetraselmis* sp. was added to the LRTs from day 3 to day 22 post-hatch (ph) at a daily rate of 400 l per tank. From day 3 to day 20 ph, rotifers, *Brachionus rotundiformis* (66-146 µm), were added twice daily at 8:00 and 17:00 hr. A density of 15 rotifers/ml was always maintained in the LRTs. Prior to their introduction into the LRTs, rotifers were enriched for 6 hours after harvest with super HUFA (>45% ω3 fatty acids, >16% EPA , >30 DHA, >2.0% ARA, Salt Creek Inc. Utah, USA) at a rate of 0.25-0.35 ml/million rotifers. Newly hatched *Artemia* salina nauplii were enriched following the same protocol of rotifers enrichment and introduced beginning day 15 ph at 0.5-1 nauplii/ml. *Artemia* nauplii were added twice daily until day 25 ph at 9:00 and 17:00 hr to maintain the initial starting density. The artificial feeding started on day 11 ph with the 198 µm love larva 1 (57.40% crude protein, 12.42% lipid, Hayashikane Sangyo Co. Ltd., Japan) and lasted on day 25 ph. From day 20 to day 35 ph and from day 30 to day 40 ph artificial progression feed 2 (<200 µm) and progression feed 3 (300-500 µm) were served, respectively (crude protein 56.6%, 13.8% lipid, 0.8% DHA, 1.1% EPA, 1000 pm vitamin C, Salt Creek Inc., USA). From day 35 until day 40, crumble feed 300 -900 µm (45% crude protein, 10% lipid) was added.

Water exchange in the LRTs was carried out by flow-through filtered and sterilised 37 ppt seawater systems. In the first two days post-hatch, water exchange was carried out during night at a rate of 60-80% and from day 3 to day 33 ph at 80-100%.



Cannulated 427µ mullet oocytes

Postlarval mullet in the rearing tanks.

Outlet screen fixed to the larval rearing tank

1kg female.

From day 34 to 40 ph a continuous flow of 37 ppt seawater was maintained throughout the day this was stopped only during the administration of the artificial food. In the first 2 days post-hatch, the LRTs were kept under complete darkness and from day 3 to day 40 ph, a photoperiod of 14 h light : 10 h darkness was maintained. The water temperature, dissolved oxygen, ammonia, nitrite and pH recorded during the larval rearing stage were 21.4 ± 0.5 ºC, 5.15 ± 0.8 mg/l, 0.24 ± 0.04 mg/l, 0.029 ± 0.003 mg/l and 7.5 ± 0.5 , respectively.

All LRTs were harvested on day 40 ph and the total number of 40-day old post larvae collected was 240,700 averaging 15.10 mm in total body length and 21.4 mg body weight. The average survival rate of the larvae was 15.52 ± 7.32%. The survival rate achieved is encouraging and demonstrates the possibility of successfully producing grey mullet in captivity despite the prevailing environmental conditions of Abu Al Abyad Island. Although the stocking density adopted in this study (30 /litre) seems acceptable, the use of lower densities in the future trials might further improve the survival rates.

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Inception meeting on methodologies for aquaculture society certification

Small scale farmers are the mainstay of Asian aquaculture and generate the bulk of production, yet the small-scale nature of the sector poses special challenges in confronting emerging issues such as globalisation, the evolving international trade environment and maintaining environmental integrity.

In response, NACA and India's Marine Products Export Development Authority and National Centre for Sustainable Aquaculture have made extensive efforts to facilitate the formation of small-scale farmer societies. These provide small scale farmers with a louder and more unified voice, and assist them to face the challenges of production through adoption of better management practices. They also help prepare farmers for certification through improved understanding of issues such as food quality and traceability, in addition to providing a mechanism for imparting technical guidance and sharing experience on the concepts and procedures and methodologies involved. As certification of their produce offers small-scale farmers the opportunity to improve their economic independence with responsibility, by providing them a premium price with assured marketing for production of quality products.

An inception meeting on methodologies for certification of aquaculture societies was held from 1-2 September 2009 at Kakinada, Andhra Pradesh, India. The objective of the meeting was to develop a draft methodology for certification of small-scale farmer 'aqua societies', independent of commodities and certification standards.

The inception work shop was attended by nineteen participants comprising of aqua society leaders, as well as representatives of certification programmes, central aquaculture research institutions, MPEDA, NaCSA, NACA and FAO. An informal meeting structure was adopted to encourage and facilitate free exchange of ideas and discussions. The meeting comprised of four sessions.

Session I: Cluster certification of *Macrobrachium*: issues, challenges, opportunities and solutions

Mr Meher, President of Sri Sainadha Aqua Farmers Welfare Society, Velivella, shared his society's experiences on organic certification by Naturland. He emphasised that the internal control system (ICS) is the key step and the efficiency of the same reflects in the success of the certification programme. He acknowledged the support extended by MPEDA and NaCSA in terms of financial subsidy and guidance in connection with the Organic Certification Programme and also thanked Indocert (Inspection Agency of Naturland) for imparting training on ICS that forms the foundation of the certification programme.

Mr Phaniraju, President of Sri Venkateswara Aqua Farmers Welfare Society, Matsyapuri pointed out that convincing member(s) of the society on organic certification was the key issue and after seeing the success of the organic members of society, more farmers joined the Organic Certification Programme.

Mr Narayanamurthy, President of Sri Subrahmaneswara Aqua Farmers Welfare Society, Mogultur, a pioneer in aqua club formation during 2003 indicated that assessment of the capacities of water sources, farms and farmers is important to successful Aquaculture operations. He reiterated the importance of better management practices and internal control system for aqua societies towards certification.

Mr Anil of Indocert pointed out the importance of ICS and emphasised the need to impart requisite Training on ICS for better understanding and efficient operation. He added that the standards are set in keeping in view of site characteristics and the methodology practiced by the farmers to facilitate compliance with the set standards.

Dr Muthuraman, Joint Director of MPEDA gave a presentation on the Indian Organic Aquaculture Programme (IOAP) mentioning the SECO (Formerly known as SIPPO) - MPEDA - arrangement involving Naturland Certification Programme.

Session 2: Cluster certification of *Penaeus monodon* – issues, challenges, opportunities and solutions

The NaCSA presentation was dealt by Mr Chandra Mohan, which provided various suggestions and possible solutions to several of the issues and concluded with a positive note that aqua society certification for *P. monodon* is a possibility.

Mr Koji Yamamoto gave an account of NACA work in Thailand with reference to Samyroid Shrimp Cluster.

Dr Santhanakrishnan, Auditor for the Aquaculture Certification Council (ACC) stated that by adopting better management practices the societies are moving in the right direction towards sustainable aquaculture. He mentioned that water quality monitoring (both influent and effluent) is a mandatory procedure in the Certification Programme.

Session 3: Presentation of draft paper on aqua society certification

A draft paper concerning aqua society certification was presented. Mr Kalyanaraman acknowledged the co-operation / enthusiasm shown by small scale aquaculture farmers in formation of aqua societies and adoption of better management practices towards sustainable aquaculture. With a little more focused efforts certification would become a reality for many aqua societies, he added. A detailed power point presentation of the draft guidance document outlining various suggested steps for preparing small scale farmers' society certification was presented.

Session 4: Discussions on the draft paper on aqua society certification

Dr CV Mohan (NACA) summarised the proceedings of the first day. The second day of the workshop was devoted for discussing each of the steps in detail and making suggestions for improving and revising the draft guidance document. Suggestions were made on ICS, SOP and the organisational structure of the certification programme and effluent monitoring plan. All the participants actively provided comments and suggestions on the draft methodology paper.

Outcomes

The outcome of the inception meeting was as follows:

- The workshop strongly felt that the steps suggested for aqua society certification in the draft guidance document were meaningful, practical and achievable.
- It was agreed that the revised document could be used by NaCSA to promote the concept of society certification in its 200+ societies in addition to the better management practices that are being promoted.
- The certification methodology developed is independent of commodity type and related certification standards.
- The methodology developed would enable aqua societies to seek certification from independent third party certification programmes or could be used for proposing voluntary self certification by the aqua societies themselves.

Follow up action

Three aqua societies have been identified for pilot testing the guidelines and discussion has been initiated with their members on the need, advantages and steps involved in obtaining society certification. Work on the preparation of a related training manual is in progress.

More information is available from the project page on Certification of Aqua Societies, at:

http://www.enaca.org/content.php?page=Certification_of_aquaculture_societies

Meetings discuss impacts, adaptation to climate change of Vietnamese shrimp farmers

Focus group discussion meetings and stakeholder workshops about the impacts and adaptation of small scale shrimp farmers to climate change were held in Ca Mau, Vietnam, 15 and 16 October 2009, respectively. The meetings were held as part of a case study on improved extensive shrimp farming in Ca Mau and Bac Lieu provinces in the Mekong Delta in southern Vietnam.

Using similar methodology to the other case studies in the project (Tra catfish farming in Vietnam and milkfish farming in the Philippines) the focus group discussion meetings mapped farmer perceptions of climate change including climate change issues, climate change impacts on production and the economic impacts, solutions and responsible agencies. Farmer perceptions of climate changes and their impacts on shrimp farming were matched with seasonal and cropping calendars.

Climate change impacts described by the Vietnamese shrimp farmers showed some similarity to other case studies particularly the coastal shrimp farmers in Vietnam and coastal milkfish farmers in Philippines. It was also identified that climate change has also created both opportunities and risks for some Vietnamese farmers.

The project is now conducting an extensive survey of small scale improved extensive shrimp farmers in Ca Mau and Bac Lieu, Vietnam, which will be used with secondary information to assess their vulnerability and adaptive capacity to climate change.

These activities are part of one of a number of case studies of the regional project *Strengthening adaptive capacities to the impacts of climate change in resource-poor small-scale aquaculture and aquatic resources-dependent sectors in the south and south east Asian region* funded by NORAD. For more information about the project, visit:

http://www.enaca.org/modules/inlandprojects/index.php?content_id=10

Aquaclimate project: India case study

NACA's 'Aquaclimate' project is taking up the case of small-scale shrimp farming in Andhra Pradesh, India, to investigate the impacts and adaptation to climate change. Andhra Pradesh has had many weather related impacts in recent years such as the worst drought in half a century, which occurred in early to mid 2009, followed by a severe flood of once in 100 years in October 2009. These extreme climatic events have had severe consequences including heavy economic losses to shrimp farmers in the state.

This case study aims to assess the degree of vulnerability of the small-scale shrimp farmers in Andhra Pradesh, and to provide guidelines on suitable measures to assist them to adapt to climate change and sustain their livelihoods.

On 3 December 2009 two focus group discussion workshops on the impacts of and adaption to climate change were conducted with sixteen small-scale shrimp farmers in Chinnapuram (an inland area), and seventeen in Gullalamoda (a coastal area), respectively, in Krishna District, Andhra Pradesh.

Focus group discussion is a participatory process that involves all participants to obtain their perceptions, in this case about climate change impacts and adaptation measures that are being used or that they think could be used to adapt to climate change. The focus group discussions were facilitated by a skilled moderator using a semi-structured discussion guide.

On the following day a larger stakeholder workshop was conducted in Vijayawada, Andhra Pradesh, with shrimp farming stakeholders. The focus group discussion results about the key impacts on shrimp farmers from climate change from the previous day's workshops were presented to the stakeholder workshop participants and were used as the starting point for group discussions.

The focus group discussion and stakeholder workshop were conducted in Telugu language and English with translations between the two languages. High levels of participation were observed from all stakeholders about the key climate change impacts and current and possible adaptations.

The stakeholder workshop was attended by 90 stakeholders including eighteen small-scale grow out shrimp farmers, five hatchery operators, four fishermen (shrimp broodstock collectors), five non government organisation (NGO) representatives, five inputs dealers, five aquaculture consultants, four credit institutions representatives, sixteen government officials in aquaculture development and policy, ten researchers and the fourteen local and four international project partners.

International partners supporting the workshop included Dr Nigel Abery the overall project coordinator from the Network of Aquaculture Centres in Asia-Pacific (NACA), Dr Udaya S. Nagothu from Bioforsk, Norway, Ms Sirisuda Jumnongsong from Kasetsart University, Thailand and Ms Jocelyn Hernandez from Akvaplan-niva, Norway. Local partners included Dr M. Muralidhar, local coordinator and Dr M. Kumaran, local co-coordinator from Central Institute

of Brackishwater Aquaculture (CIBA) and N. R. Umesh from National Centre for Sustainable Aquaculture (NaCSA) part of the Marine Products Export Development Authority (MPEDA).

The use of such participatory processes (the facilitated semi-structured focus group discussion and facilitated stakeholder workshop) in assessing the impacts and adaptation of aquaculture to climate change was a novel technique for the shrimp farmers and stakeholders in Andhra Pradesh.

The stakeholder workshop participants discussed adaptation measures in three key themes: farmer adaptation measures, scientific/technical adaptation measures and institutional/policy adaptation measures.

Stakeholders suggested that these types of workshops about climate change in relation to shrimp farming should be repeated more often as farmers generally interact among themselves in their local area and not with other farmers outside their area, scientists and government officials. Such meetings provide them with an opportunity to express their problems and opinion about climate change to high ranking officials.

Government officials in particular felt that it is good to have stakeholder workshops like these as it exposes them to the issues that the farmers are concerned about. During the workshop it was generally expressed that there is a clear need for the development of policy related to climate change adaptation to enhance shrimp farmers' adaptive capacity.

Next steps in the Aquaclimate project will include collection and analysis of secondary data about climate, geography, aquaculture production and related issues, together with primary data through a survey of shrimp farmers in parts of Krishna District of Andhra Pradesh about their perceptions about climate change / global warming impacts, farmer vulnerability, adaptive capacity, mitigation measures and their livelihoods.

For more information about the project, please see the Aquaclimate webpage:

http://www.enaca.org/modules/inlandprojects/index.php?content_id=10

In memory of Gagan Bahadur Nhuchhe Pradhan

A real gentleman and a beautifully spoken man, Gagan Pradhan was one of the longest-standing friends of and contributors to NACA, the Network of Aquaculture Centres in Asia-Pacific, having participated in and supported the network's activities since near the earliest days of its existence. We at NACA would like to express our gratitude to our friend and colleague for his many years of unwavering support to both NACA and the region, and to recount some of his personal achievements and also our involvement with him over the years.

Gagan's academic training began with a Bachelor of Science degree at Tribhuwan University in Kathmandu, Nepal. He followed on with a Master of Science in Zoology, graduating in 1976 with a specialisation in fish and fisheries, setting out on the path that would later define his long and distinguished career. He immediately entered government service, taking up his first post as Assistant Fisheries Development Officer at the Programme Planning Unit of the Fisheries Development Section, Lalitpur. He would later complete a Master of Aquaculture at the University of the Philippines (Visayas), graduating in 1983.

It is testimony to Gagan's abilities that in 1977, the year after entering government service, he was promoted to Station Manager for the Fisheries Development Centre at Godawari. He remained there for three years before moving to the Programme and Training Unit of the Fisheries Development Division in 1979, where he worked on development plans for both capture fisheries and aquaculture. In 1985 he took up a post as Station Manager at the Hetauda Commercial Fisheries Centre in Makwanpur, before moving back into policy formulation for the Planning, Programming and Monitoring Unit, and the Inland Aquaculture Programme. Having completed his Master's Degree in Aquaculture, he was promoted to Senior Aquaculturist in 1995, taking a post as Station Manager for the Fisheries Development Centre at Janakpur in 1996.

Gagan's three stints as a Fisheries Development Centre Station Manager and intervening periods of policy and planning work had given him an enormously broad range of experience. In 1999, he was given the opportunity to apply his expertise to the development and implementation of national fisheries development and extension programmes as Senior Fisheries Development Officer at the Directorate of Fisheries Development in Balaju. He was also charged with coordinating with foreign research and development agencies.

Gagan's association with NACA began in 1991, some two years after it had become an independent organisation, as National Environmental Coordinator for an FAO Technical Cooperation Project Regional Study and Workshop on the Environmental Assessment and Management of Aquaculture Development. His promotion to Senior Fisheries Development Officer marked the beginning of an even closer relationship with NACA as he took on responsibility for international affairs. From 2002-2005 he was Nepal's National Coordinator for NACA's regional Aquatic Animal Health Programme, where he played a key role in facilitating development of a National Aquatic Animal Health Plan for Nepal. In 2003 he became the Government of Nepal's Representative to NACA, participating in the Technical Advisory Committee and the NACA Governing Council.

The pinnacle of Gagan's career was his appointment as Programme Chief (Senior Aquaculturist) for the National Inland Fisheries and Aquaculture Development Programme in 2007, a post that enabled him to strengthen collaboration with NACA and other regional and international development organisations. He was instrumental in arranging the 18th Governing Council meeting, hosted by the Government of Nepal in Kathmandu in 2008, and was contributing to NACA's Regional Project on Asian Reservoir Fisheries Development and Management, a project that is still running today.

Gagan passing is a great loss to his family to his many friends and colleagues throughout the region. However, we at NACA take some condolence in the fact that his many contributions to fisheries and aquaculture development live on in the rural communities whose livelihoods he helped to improve, both in Nepal and internationally. He is survived by his wife and two children.

Version 2 of the draft better management practices for catfish farming released

The second Version of the draft better management practices for catfish farming in the Mekong Delta are now available for download. The first version of the document was developed based on analysis of an extensive farm survey. This second version has been amended based on feedback received at two stakeholder meetings held in Dong Thap and Can Tho, 6-7 and 9-10th October, respectively.

Version 2 will form the basis for discussions with all stakeholders of catfish farming to be conducted in May-June 2010 at a national workshop to be held in An Giang Province. The meeting will finalise the better management practice guidelines for implementation in the catfish farming sector. Extension materials with suitable illustrations are also being developed for wider distribution, providing practical guidance on implementation of the better management practices BMPs for each stage of the culture cycle.

For more information, please see the project webpage, Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta:

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

Technical course on federating digital library systems

A technical course and stakeholder workshop on Federation of Learning Repositories for Agriculture, Food and Environment and Stakeholder Workshop were held in Budapest, Hungary, 2-6 November. The course was an activity under the Agricultural Learning Repositories Task Force.

The workshop was essentially about how to make online libraries interoperable with one another, so that people can search across digital library collections owned by different organisations simultaneously and automatically. The course focused on metadata standards and protocols for automating data exchange, using examples drawn from existing federated systems including the European Schoolnet project, which is attempting to facilitate sharing and access to digital educational materials across the EU, ARIADNE, CGIAR and others.

The training course included hands-on implementation sessions during which participants set up a Simple Query Interface target, and an Open Archives Initiative Protocol for Metadata Handling (OAI-PMH) target, and also tools to run queries and harvest metadata against those targets. The course also covered metadata standards such as the Dublin Core, Learning Object Metadata and the construction of custom XML application profiles.

The workshop included two demonstration sessions where participants displayed their digital library systems to others. This provided a good opportunity get some feedback on a new software module in development for the publications section of the NACA website. This will provide improved indexing and presentation of publications, not only in PDF format (as now) but will also offer streaming audio, embeddable video, plain text records and presentation of images as well. The module will permit its records to be harvested via an OAI-PMH web service, allowing the NACA website to interconnect with distributed digital library networks worldwide. The Agricultural Learning Repositories Task Force aims to pilot a globally federated network of digital libraries over the next year or so.

The training course was organised by the ASPECT Best Practices Network, Organic.Edunet and FAO. It was sponsored by the United Nations University, CGIAR, Rural Inclusion Project, iQTool Project, Organic Mednet and the European Foundation of Information Technology in Agriculture. NACA would like to thank all involved for a very useful workshop and for sponsoring the participation of NACA's Communications Manager at the workshop.

Below: Participants and teachers at the workshop.

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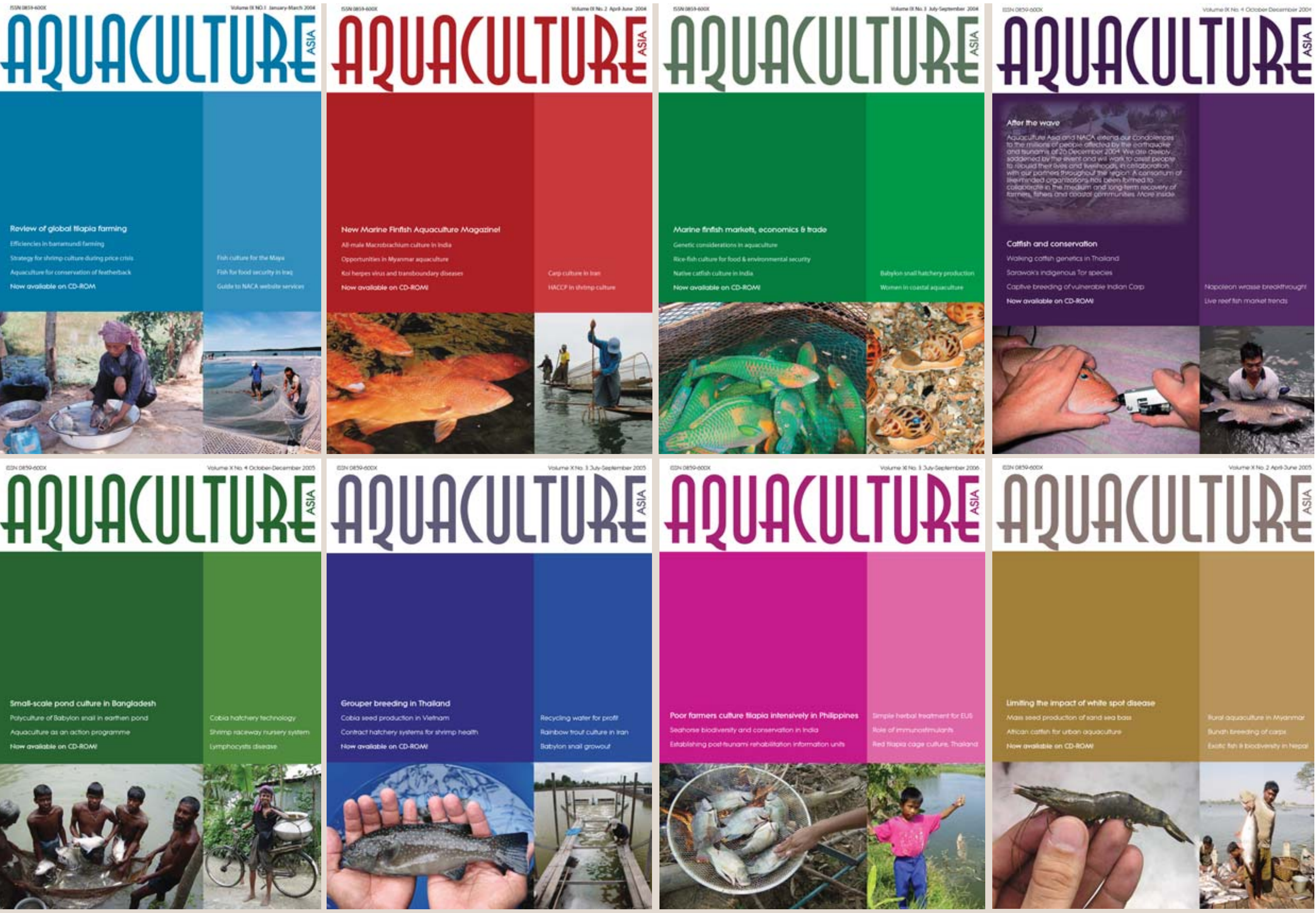

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Enquiries and further information

Please visit website for more information, or feel free to contact the conference secretariat:

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