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Future prospects of inland aquaculture

C/N, periphyton and pond productivity

Constraints to fish production, India

Investment by youth

Vannamei success factors

12 years of QAAD

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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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As foreshadowed in the last issue, NACA has begun making audio recordings of technical presentations given at aquaculture workshops, meetings and projects in which we are involved. We are doing this to allow people throughout NACA member countries to access these materials. Due to cost constraints, only a handful of people can ever physically attend a workshop, but now anyone can listen to the proceedings, wherever they may be.

The first set of recordings was the entire proceedings of the Global Conference on Aquaculture 2010. In the three months since the conference, presentation recordings have been accessed more than 27,000 times. Considering that around 600 people attended the conference in person, it is apparent that the recordings have substantially extended the reach of the proceedings. We have also found that countries where English is not widely spoken seem to have much greater uptake of audio recordings than they do of written materials.

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Simon Wilkinson

AQUACULTURE ASIA

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Peter Edwards writes on

Rural Aquaculture

Recent developments and future prospects of inland aquaculture in Asia

This issue's column is based on my keynote presentation at the Asia-Pacific Aquaculture 2011 and Giant Prawn 2011 conference held in Kochi, India in January 2011. It encapsulates the rapid changes in the 'face' of aquaculture that I have observed over the past decade. Many of these changes for individual countries have been reported in earlier columns as well as in a recent review article (Edwards, 2009).

I defined and contrasted traditional and modern aquaculture, presented case studies of the expansion of modern aquaculture with some environmental and social issues as well as a case study to link traditional and modern practice to lower the cost of production and address a major environmental issue of modern aquaculture, that of effluent treatment. I raised the neglected issue of the role of aquatic plants in food

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Pellet-fed monoculture of tilapia in China.

security and the role of aquaculture in poverty alleviation with case studies. I ended by making a few concluding comments on what I believe to be the future prospects of inland aquaculture in Asia.

Traditional and modern aquaculture systems contrasted

Traditional aquaculture has been developed by farmers or local communities using locally available resources. It is mainly integrated with other human activity systems as these were the only sources of nutritional inputs for farmed aquatic organisms in the past prior to relatively recent manufacture of agro-industrial pelleted feed and chemical fertilisers. Traditional integrated aquaculture systems are integrated agriculture/aquaculture (IAAS) systems such as rice/fish, crop/fish, livestock/fish and crop/livestock/fish; integrated peri-urban aquaculture systems such as wastewater-fed aquaculture reuse of cottage-level agro-industrial wastes; and integrated fisheries aquaculture or low-value, trash fish fed systems.

Advantages of traditional aquaculture are use of local resources rather than globally traded animal and plant meals; manure disposal from feedlot livestock with excess nutrients mostly tied up in sediments; fertiliser nitrogen is cheaper than feed nitrogen although it is less efficiently converted to fish. Fish are produced at lower cost and can possibly be marketed at lower price.

Fed aquaculture is more nutrient efficient than fertilised aquaculture by factor of 2-3 and it has higher retention of nitrogen and phosphorus/kg fish produced. However, modern aquaculture is more intensive with a higher unit area nutrient loading rate and is therefore potentially more polluting than traditional aquaculture. Life cycle analysis also reveals that modern aquaculture has a higher energy/carbon footprint than traditional aquaculture.

Traditional aquaculture is also the best entry point for poor farmers to farm fish as it is relatively low cost with minimal risk and can be the first step on the ladder of intensification for farmers to gain experience and confidence before intensifying.

In contrast modern aquaculture is science/industrial-based, in particular use of agro-industrially manufactured feed and/or inorganic fertilisers; and it has higher investment but more profit. The profit/unit area of culture system is the key measure of economic viability: although there is a higher cost of production/kg fish produced, there is a correspondingly much higher production/unit area and therefore farm profit.

We should not forget farmer hopes and aspirations as we promote aquaculture. Aquaculture should make money and be profitable as farmers compare the money-making potential of aquaculture to alternative livelihood options, both on-farm and off-farm. While small amounts of fish may be highly significant to the relatively small overall household economy of traditional crop-dominated farms, small-scale aquaculture (SSA) needs to evolve into a small and medium enterprise (SME) for aquaculture to be major livelihood for farmers.

Improved breed of tilapia, Thailand.

Large-scale tilapia hatchery since closed due to unsuccessful competition from China in tilapia export.

High density pellet-fed pond culture of striped catfish, Vietnam.

Economic growth through aquaculture

There is a huge on-going increase in aquaculture production in response to market opportunities and available technology and resources. The major facilitating factor is intensification through formulated feed although hatchery-produced seed and other science-based inputs are playing a contributory role. The changing 'face' of aquaculture is also characterised by de-linking of traditional integrated enterprises with increasing specialisation or monoculture as outlined below.

Carps in China

Large-scale integrated farms became less integrated in China following privatisation.

Dike crops have mostly been eliminated except for grass on some farms to feed relatively high-value grass carp but although pelleted feed is the major input even in grass carp dominated systems. Ponds have excess nutrients from residual fertiliser effects of pelleted feed so livestock are mostly not integrated today. A major reason for the trend towards intensive monoculture e.g. higher value common carp and crucian carp is production up to 30-40 compared to 12-15 tonnes/ha for traditional carp polyculture.

Carps in India

Andhra Pradesh is often called the 'fish bowl' of India as it produces 0.8 million tonnes of Indian major carps, mainly rohu and catla. Production is indirect IAAS based on local off-farm by-products such as feedlot chicken manure as well as inorganic fertilisers and brans and oil cakes as supplementary feeds. Carp farmers are reluctant to use commercial pelleted feed.

Indian major carps were not given a 'fair trial' in the past as research carried out by Indian government scientists in the 1970s led them to recommend to farmers a polyculture (composite culture) of three species of Indian major carps and three exotic carp species to attain high carp production. However, farmers from the 1980s onwards have demonstrated the production 10-15 tonnes/ha of carps with a simplified culture of only two Indian major carp species, rohu and mrigal.

The government scientists did not have enough experimental treatments to even make their recommendations. They did not separate species and improved fertilisation and feeding rates with improved pond nutrition introduced at the same time as exotic carps were added to the traditional polyculture of only Indian major carps. In other words, there were no treatments with only Indian major carps and high fertilisation and feeding rate until farmers started to experiment themselves to produce mainly higher value rohu.

Striped catfish culture in static water ponds, Bangladesh.

Tilapias

Tilapias today are one of the most important group of farmed fish species. China is the largest global producer and the largest exporter. Most tilapia produced in China for export is raised in monoculture in pellet-fed aerated ponds.

Most Asian countries cannot compete with China for export markets. A recent example is Myanmar where several large-scale tilapia hatcheries set up to export tilapia have closed.

The Philippines is major producer of tilapia in ponds and cages, mostly intensively with commercial feeds. Local people are caretakers in tilapia cage culture in Lake Taal as they cannot afford the high feed cost and have entered into profit-sharing agreements with external financiers. Lake Taal experiences occasional mass mortality as estimated tilapia production of more than 100,000 tonnes is 2-3 times more than the carrying capacity of the lake.

Charoen Pokphand (CP) Company created a new premium fish, pla tap tim (ruby fish), a red tilapia to raise in cages in Thailand. CP also initiated contract farming of red tilapia in cages. The company supplies fry and feed to franchised aquatic feed dealerships who harvest and market the fish. Raising tilapia through contract farming is usually convenient for small-scale farmers as it arranges harvest and marketing of fish but sometimes there are disagreements over cost of feed and harvesting schedules.

Tilapia cage culture has recently been introduced into Bangladesh following observation of Thai cage culture and is expanding rapidly in the country.

Several good strains of tilapia are available. More important than farming a particular well recognised breed or strain is how it is managed, in particular adequate nutrition and stock management.

Linking traditional and modern practice - cage-in-pond system (courtesy C. Kwei Lin).

Cage-based tilapia production may be ultimately unsustainable due to increasing pollution in rivers which leads to disease and occasionally causes mass fish kills. A few years ago there was a well-publicised loss of 8,000 tonnes of red tilapia due to river pollution in Thailand.

Pangasiid catfish

There has been a recent and rapid increase in production of striped catfish (*Pangasianodon hypophthalmus*). It is raised traditionally in waste-fed ponds in Thailand and Vietnam but flesh is quality is poor with high fat content and

Water spinach and tilapia for lunch on a Vietnamese fish farm.

off-flavour. High-quality catfish was first raised in quantity in Vietnam but has now expanded to Bangladesh, India, Indonesia, and Myanmar with Nepal now just starting production.

Pangasiid catfish are air breathing species and in Vietnam are stocked at high density in 4-5 m deep ponds with considerable water exchange. Previously marine trash fish was fed to fish in cages in the Mekong delta but today farming is mainly in pellet-fed ponds. Production is 300-400 tonnes/ha/6-8 month crop with an investment of over $200,000/ha/crop.The total annual production in Vietnam is about 1 million tonnes worth $1 billion and the fish is exported to over 80 countries.

In contrast striped catfish is stocked at lower density in shallow ponds in Bangladesh. Smaller farms have static water ponds, whilst larger farms have limited water exchange, mainly using groundwater. Production is 30-40 tonnes/ha on small farms and 60-70 tonnes/ha on large farms. There has been a rapid increase in production to 0.3 million tonnes but as there is a limited export market the domestic market has been saturated. The price dropped and striped catfish is now the cheapest fish on the local market which is good for national food security although less so for the farmers due to reduced profitability.

Striped catfish production in India increased dramatically over the last 3 years, especially in Andhra Pradesh. Higher production of striped catfish in pellet-fed ponds, 20-25 tonnes/ha compared to 8-10 tonnes/ha for IMC, provides more profit than IMC. The pond area in Andhra Pradesh increased from 4,500 ha in 2006 to 32,000 ha in 2010 with a total annual production 0.6-0.8 million tonnes.

Linking traditional and modern practice

Some of principles of traditional aquaculture may be used to reduce the cost of production and adverse environmental impact of modern pellet-fed aquaculture. Inorganic fertilisers may be used by large-scale farmers to reduce feed costs, especially in nursing and early grow-out when fish are small through producing

Culture of the aquatic macrophyte water mimosa, Thailand.

'green water' ponds with high-protein phytoplankton to feed plankton-feeding carps and tilapias.

A 'cage-in-pond' culture system has been developed through research at the Asian Institute of Technology (Yi, Lin and Diana, 1996; Yi, 1999). Fish are stocked in grow-out in cages suspended in the pond and are fed pelleted feed. Fingerlings are nursed in the same pond on spilled feed and 'green water' from faeces of caged fish fertilising the pond. Pond nursing of tilapia is from 2 to 100g whilst grow-out in the cage is from 100g to 500g. Nursing and grow-out cycles are coordinated in a single cage-pond integrated unit. Furthermore, the system is protected from external agricultural,

Integration of fruit and vegetables with fish culture in a pellet-fed 'improved VAC' system, Vietnam.

industrial and urban water pollution and may have increasing relevance as surface water pollution increases.

Aquaculture and food security

It is well known that fish are important in national food security in many Asian countries, and provide high-quality protein, healthy fats and minerals and vitamins. It is less appreciated that aquatic plants such as water mimosa (*Neptunia oleracea*) and water spinach (*Ipomoea aquatica*) also play a vital role Asian food security. Water spinach is inexpensive, high in fibre and vitamin A and is easy to digest. All parts of the plant are consumed: stem, leaves and especially the young apex. Remarkably the production of freshwater aquatic plants is not recorded by national governments nor FAO, possibly because they 'fall between the stools' of terrestrial vegetable agriculture and zoology dominated aquaculture.

Two case studies of aquatic plants were presented. Water spinach accounts for nearly half of the fresh vegetables in Phnom Penh, Cambodia. It is grown by poor communities on the surface of sewage-fed lakes. Almost 60,000 tonnes of water spinach are produced in peri-urban Bangkok. Water from nearby canals is pumped into former rice fields and chemical fertilisers are the main source of nutrients.

Aquaculture and poverty

It is commonly stated that Asian aquaculture is dominated by small-scale aquaculture farmers, many of whom are poor. While this may be true in terms of number of farmers, it is unlikely to still be true in terms of total aquaculture production.

For small scale aquaculture to become a major livelihood option there is a need to intensify aquaculture to become a small and medium enterprise (SME).

Small-scale farmer culture of African catfish, Indonesia.

Traditional IAAS has limited potential for intensification because of the poor-resource base of small-scale farms. The main options are to intensify are to use off-farm fertilisers and supplementary feeds i.e., to move from direct IAA to indirect IAA, or to use pelleted feed i.e., join the major trend towards intensification or modern aquaculture. Case studies were presented of poor farmers benefiting through aquaculture in Vietnam.

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

Traditional integrated small-scale IAAS in the Red River Delta or VAC has provided food and some income for generations as most farming households have small ponds located near the house dug for soil for use as fill to raise the level of the land for the homestead and surrounding garden. VAC is an acronym for the Vietnamese words vuon (garden), ao (pond) and chuong (livestock quarters) on crop-dominated farms. Ponds are traditionally multipurpose: domestic water; watering vegetables; cultivation of floating aquatic plants for feeding pigs; and harvesting wild fish. Farmers traditionally raise a polyculture of common carp (*Cyprinus carpio*), Chinese carps (grass carp, *Ctenopharyngodon idella* and silver carp, *Hypophthalmichthys molitrix*) and Indian major carps (mrigal, *Cirrhinus mrigala* and rohu, *Labeo rohita*) integrated with livestock (pigs and poultry) and crops (fruit and vegetables). The three main traditional pond nutritional inputs are rice bran, grass and pig manure with pond mud periodically removed to fertilise dike crops. Recently 'improved VAC' has been introduced with use of pelleted feed to supplement the traditional pond inputs. The government promotes conversion of unproductive rice fields to ponds with wide dikes which has led to considerable improvement in poor farmer livelihoods.

African catfish (*Clarias gariepinus*) culture expanded rapidly recently in Indonesia. The air breathing species is stocked at high density in small ponds converted from rice fields and fed pelleted feed. Production is an extrapolated 160-300 tonnes/ha/ 3.0-3.5 month grow-out cycle. Such high small-pond production is very attractive for small-scale farmers and contributes significantly to local fish supply. It is a good example of the relevance of modern intensive aquaculture for poor farmers.

Small-scale farmers are increasingly involved in nursing to produce fingerlings as aquaculture becomes more specialised and segmented. Hatchery is usually a highly specialised business carried out by better-off skilled farmers but hatcheries in some countries such as Indonesia have linked up with small-scale farmers to nurse fry because of the large area of land needed for nursing and the more profitable production for hatcheries of larger numbers of fry than fingerlings. Nursing is more appropriate for small-scale farmers than grow-out because its short production cycle requires less skill than breeding or hatchery, lower investment is required, and it involves less risk. Freshwater fish seed production is dominated by small-scale farmer-operated hatcheries in Indonesia. Most small-scale farmers have changed from low-profit traditional IAAS grow-out to nursing fry to fingerlings. Common carp and tilapia are traditionally bred and nursed in wastewater where available but are otherwise pellet-fed. Small-scale farmers are organised into privately managed networks to nurse eggs or fry of high-value species such as giant gourami (*Osphronemus gouramy*), pacu (*Piaractus brachypomus*) and striped catfish which are provided by large-scale hatcheries to the small-scale farmers who subsequently buy back fingerlings for sale.

Culture of high-value giant river prawn (*Macrobrachium rosenbergii*) has been developed recently by poor farmers in rice fields in Bangladesh and Vietnam. Post-larvae are nursed concurrently with rice or in trenches in the rice field. Juveniles are stocked concurrently with rice in the rice field, in rotation after rice harvest as rains flood the field, and also in communal ponds in Bangladesh.

High value freshwater prawns raised by poor women, Bangladesh.

Large-scale carp farming is a major source of employment, Myanmar.

As it is recognised that aquaculture can provide an important source of livelihood for the rural poor, promotion of aquaculture through project support is a worthwhile strategy to help to reduce poverty through making smallholder farming more productive and sustainable. Following the development of a successful model to promote aquaculture for poor people in the lowland Terai region of Nepal with carps and tilapia stocked in small ponds fertilised with manure and urea and fed with bran and oil cakes, the NGO Aquaculture Without Frontiers (AwF) is now funding a project to assist poor women farmers in the middle hills region of the country. The women farmers reported several benefits from developing a small fish pond: raising a healthy food helps to solve child malnutrition: fish are readily available without having to leave the farm and having to spend money; some fish can be sold to earn income; and household women and children can easily feed the fish.

Concluding comments

Aquaculture is increasing in importance throughout most of Asia and is likely to continue to expand. The global population is predicted to increase by about 50% to almost 9 billion people, with the largest share in the region, before it stabilizes towards the end of the century. A 70% increase in food production will be required to support an increasingly affluent population; as incomes rise people diversify and improve their diet, including demand for more healthy fish.

With Asia's rapidly expanding and increasingly affluent populations, the greatest demand for fish will be for domestic rather than export markets.

Increasing production is mainly through intensification associated with modern aquaculture as traditional integrated inland aquaculture systems are not usually productive enough for farmers seeking to earn significantly more from aquaculture.

Traditional aquaculture still has relevance for the poor seeking to diversify their small farms and its principles have relevance for lowering the cost of production and improving the environmental sustainability of intensive aquaculture.

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Factors influencing in success of *Penaeus vannamei* culture

Palanikumar, P., Velmurugan, S. and Citarasu, T.

P. vannamei has been widely farmed in many parts of the world for some time. However, in India the craze for *P. vannamei* culture has only just come to its peak due to its relatively recent introduction. Due to its fast growth, good average body weight, high productivity and low protein requirement, the *P. vannamei* makes a good substitute species for *P. monodon*. Tackling *P. vannamei* culture is not a walk in the park though (Briggs et al., 2004). It requires a lot of input, management resolve and a lot of effort in order to attain a desired result. Here we will discuss problems that are commonly observed in *P. vannamei* culture in India and what can be the solution to these.

Pond preparation

Good pond preparation is an important measure in maintaining the hygiene of growout ponds. Pond preparation involves a few simple steps including drying and tilling of the pond bottom, eradication of predators and competitors, liming and fertilisation.

Drying of ponds at the end of each crop cycle ensures hygienic conditions are maintained and stimulates oxidation of materials that result in release of noxious gases such as hydrogen sulphide, ammonia and methane. Presently, most of farmers are stocking seed within one month of completing the previous crop cycle due to good material prices. This will lead to reduced pond carrying capacity, slow growth, gill issues and other problems. Complete drying may not be possible in winter. Under these conditions, sludge and black soil should be flushed out by water with force (Hirono, 1992).

Liming is practiced for various reasons in pond preparation. The most important is to maintain a conducive pH in the pond bottom and overlying water. Here, depending on soil pH and alkalinity, agrilime or dolomite is used. Presently, pure dolomite is supplied by some companies with good quality. Using this type of dolomite gives a good result in buffering pH level during the culture period.

To fertilise ponds, gypsum ($CaSO_4$) @ 80 kg/ha and nitrate composition product should be applied. Some good quality of product with an appropriate level of N.P.K composition is presently available in the market. This type of product was developed exclusive to aquaculture to improve soil fertility and oxidation of soil (Briggs and Funge-Smith. 1994).

Biosecurity system

Biosecurity should be practiced with a strong emphasis on preventing viral carriers and vectors from entering ponds. As a high density and financial investment are more required for *P. vannamei* culture than *P. monodon* in the early stage, we should take care to reduce the risk of viral disease by instituting biosecurity controls. Changing species (from *P. monodon* to *P. vannamei*) under culture will not in any way prevent white spot (WSSV) outbreaks. *P. vannamei* is not immune to WSSV infection. Only strong and serious biosecurity can prevent shrimp from WSSV infection. Therefore bird and crab fencing should be implemented as first job before filling pods. Farms must ensure that ponds do not contain unwanted animal life as far as possible. Any live organism that exists in the pond should be eliminated. Inlet canals and reservoirs must also be dried and cleaned from time to time (many farmers fail to do this). Direct pumping should not be conducted, only water from treatment ponds or at least sedimentation ponds should be used. Water should also be pumped through a fine filter bag into the culture pond. When treating water to remove pest species, a correct dosage of chemicals must be calculated to kill viral carriers in the pond, such as 30 ppm active chlorine powder (for low ph pond) or 2-3 ppm Trichlorofon (for high ph pond) (Findlay, 2003).

Personnel should observe personal hygiene measures such as wearing sterile boots and washing hands with $KMnO_4$ before entering ponds.

Bird and crab fencing helps keeps out predators and disease vectors.

Water quality

Aquatic organisms have an intimate relationship with the water they live in as their bodies and gills are in constant contact with what is dissolved and suspended in it. Therefore, water quality directly affects the health and growth of the cultured organisms. Water used for aquaculture is more than just H_2O. Water contains many organic and non-organic elements that collectively make up what is termed as 'water quality'.

The quality of water is not a fixed characteristic, is very dynamic, changing overtime as a result of environmental factors and biological processes. Water quality is initially related to the source of water. In the culture environment its quality may be altered by biological processes such as photosynthesis, respiration and excretion of metabolic wastes, as well as by physical processes such as temperature and wind.

For shrimp culture, the most important parameters determining the suitability of water for aquaculture are the pH, alkalinity, dissolved oxygen and phytoplankton diversity. Therefore, all of these water quality parameters should be strictly managed at their optimum level to create conducive environment to culture species (Boyd and Green. 2002).

pH and alkalinity

pH is defined as the negative logarithm of hydrogen ion activity. Exposure of aquatic animals to extreme pH level can be stressful or lethal. But the indirect effect and interaction of pH with other variables are usually more important in aquaculture than the direct toxic effects. The pH of water is strongly influenced by both photosynthesis and respiration. As a result of respiration, carbon dioxide (CO_2) is released into the water. Dissolved carbon dioxide combines with water to form carbonic acid (H_2CO_3). A series of reversible equilibrium reactions occur which result in the formation of hydrogen ions, bicarbonate ions (HCO_3^-) and carbonate ions (CO_3^{2-}). These are the bases which give buffering capacity to water which is otherwise called "total alkalinity". Since the little water is exchanged in most high-density shrimp recirculating systems, alkalinity should be maintained at relatively high levels (>120ppm) (Tomasso and Brune, 1991).

One has to understand the basic reactions in water during day and night time to correlate the influence of phytoplankton on alkalinity and pH. During the extended daylight of summer excess photosynthesis by phytoplankton removes CO_2 from water there by disturbing the equilibrium of alkalinity, which in turn dissociates water. As a result hydroxyl ions (OH^-) accumulate and pH of pond water increases by late afternoon. The reverse happens during night time. As all the life in pond including shrimp, bacteria and phytoplankton respire to release CO_2, hydroxyl ions accumulated during day time will react with the inputs of hydrogen ions (H+) to form H_2O, hence pH decreases by early morning. This pattern happens all the seasons, but during summer, in systems where phytoplankton blooms are particularly heavy, or which have a low alkalinity, pH may rise above 9.0 in the afternoon. During the night, respiration release CO_2 into the water causing the pH to fall.

As high pH level (>8.7) and low alkalinity (<90 ppm) directly affect the shrimp behavior on feed intake and normal molting, pH and alkalinity has to be maintained at optimum level (pH = 7.5 to 8.2, alkalinity = 120 – 200 ppm) to create a conducive environment for culture of *P. vannamei*.

To maintain correct pH level, periodical application (twice weekly) of dolomite at 80 kg/ha at night and gypsum ($CaSO_4$) at 81 kg/ha during the day after 20 days of culture and up to the end of the crop gives better results than other methods understood by field experience in high density *P. vannamei* culture.

Dissolved or solubility oxygen

The solubility of oxygen in water is a function of temperature, salinity and altitude. As salinity and temperature increase as in summer, the solubility of oxygen in water decreases. To simplify, the saturation concentration of oxygen in water is low at high temperature and high at low temperature. Commonly, lower dissolved oxygen (DO) problems occur in summer itself. Evidence shows that almost 72% of the total dissolved oxygen in water is consumed by the phytoplankton itself. So it is very obvious that supplementing aeration during summer nights should never be over looked. Most of farmers doing *P. vannamei* finish out last meal of that day within 6pm and start running aerators from 7pm to next morning 6am. This method has given good result in maintaining acceptable DO levels (>3ppm) at night. Unlike *P. monodon*, *P. vannamei* have a schooling behavior and usually swim on water currents formed mainly by aerators. *P. vannamei* has a dissolved oxygen requirement of >3ppm as a minimum level. Aeration requirements should give due consideration to shrimp biomass in the pond as well. It is advisable to check DO level early in the morning eg. 5:30 am and in the evening around 9 pm daily to avoid DO stress to shrimp. Based on our field observations, 8 HP of aeration is required for each 100,000 seed stocked. The placement and position of aerators can also affect DO level, and aerators should be placed in proper positions to take advantage of mutual "pushing and pulling" effects, since high density shrimp culture requires proper water circulation.

Phytoplankton

Phytoplankton diversity has direct effects on water quality parameters. Maintaining a suitable plankton diversity makes it easy to manage other water quality parameters. Mostly, blue green algae and dinoflagellates create more problems on culture days. Unmanaged blue green algal growth in aquaculture ponds can cause poor water quality following degradation. When algae reach their maximum growth phase, they flourish for period and then die. This known as an algae "crash". After a crash or periodical collapse of algal population, the decomposition of these dead algae utilises a large amount of oxygen and can cause oxygen deficit problems and increased concentration of toxic ammonia. Insufficient oxygen and high ammonia concentration may, in turn, cause gill problems, promote abnormal molting and loose shell disease and / or temporarily reduce the feeding and growth rates of shrimp.

Dinoflagellates predominate in saline water during summer. Blooms of dinoflagellates seems to vary in colour according to the type and density of their pigment content. Photosynthetic species are generally chocolate-brown while non-photosynthetic species are grey. Luminescence is a key observation in ponds with dinoflagellate blooms that are dark

A healthy phytoplankton bloom.

Pond affected by blue-green algae bloom.

Bloom of dark-brown dinoflagellates.

brown colored and increase water pH substantially. Some dinoflagellates produce saxitoxin, but the lethal effect remains with high pH-associated hard shell. Commonly BKC is applied to control dinoflagellate plankton and this practice has given good results to control dinoflagellate bloom in *P. vannamei* culture too (Gárate-Lizárraga et al., 2009).

Mineral profile

In addition to basic water quality parameters, the mineral profile of water is an important parameter in *P. vannamei* culture. A balanced mineral level is required to support normal molting behaviour. Among other major minerals, calcium and magnesium are considered to be very important for molting and new shell formation, particularly for *P. vannamei*. The required calcium and magnesium ratio varies with salinity and is given below.

A minimum 300 ppm of calcium and 500 ppm of magnesium should be maintained for proper molting and good growth. Lower amounts will lead to soft shells, size variation, opaque muscles and mortality at molting time. Presently, good quality products containing calcium and magnesium minerals are available in the market. Therefore, calcium and magnesium levels should be checked twice weekly and based on that result, supplementary calcium and magnesium minerals applied as required (Chien, 1989).

Sometimes we can see the shrimp with blue coloration and loose shell. This problem is caused due to insufficient major minerals and mineral minerals in shrimp body. Apply major minerals in water and using good quality feed is a way to rectify this problem.

Table 1. Calcium and magnesium ratio in relation to salinity

Salinity	Ca:Mg ratio
0 to 10 ppt	1:1.5
10 to 20 ppt	1:2
Above 20 ppt	1:3

WSSV

WSSV is a common virus in penaeid shrimp. So, it should be again emphasised that *P. vannamei* is not a 'super shrimp' and is not immune (Lightner, 1996). The *P. vannamei* brood stock (and several generations before them) should ideally have been reared from specific pathogen free hatchery and nursery stock, while maintaining biosecurity. Several PCR checks are routinely conduced during their life cycle to confirm their health status. *P. vannamei* PL raised under such conditions are far more likely to be "clean" than wild captured brood stock for *P. monodon* PL. However the chance of WSSV infection is the same for both *P. monodon* and *P. vannamei* in non-bio-secure pond (or) when expose to WSSV agents.

P. vannamei may not show clinical sign such as white spot on the carapace and tail. It often shows a pale reddish color on the body followed by some mortality in the early days. Many infected or stressed animals show milky tail or opaque muscle as they suffer from low DO. So, awareness should be there to differentiate whether such signs are caused either due to WSSV or DO stress.

Comparison between a mineral-deficient shrimp (top) and a healthy one.

The route of cause of WSSV infection is the same as that of *P. monodon*. WSSV outbreaks in *P. vannamei* mainly come from horizontal infection through water, carriers, vector, cannibalism and contamination. Crabs, small penaeid shrimp and other crustaceans that live near by the or into the farm are also major routes of infection.

Once an WSSV outbreak has occurred in any pond first of all the ponds should be quarantined. Workers should be separated and be kept away any contact outside and with other ponds. Samples should be sent to be checked for verification. It is good idea to send the shrimp sample from any adjacent ponds to be checked as well. Once PCR results have been confirmed with positive WSSV infection, the affected ponds must be terminated. In other words, kill all the shrimp in the pond as early as possible.

Recent studies suggest that the following may be risk factors:

- WSSV infection is more common in the rainy season and winter season.
- There are more infections in colder months than in warmer months.
- When the temperature 32 degrees centigrade or higher, infection is quite rare.
- High pH is a triggering factor for WSSV outbreak.
- Most of the infected ponds show pH higher than 8.3.
- Low DO contributes to outbreak severity and fast mortality.
- Low salinity, especially low calcium shows good correlation to WSSV outbreaks and heavy mortality.

It is therefore recommended to control water quality during risky months, especially pH and D.O. Furthermore, turbid water and low D.O. are also susceptible to encounter more problems than green water.

Diseased shrimp affected by WSSV.

Conclusion

Harvesting 10 tonnes per hectare is not magic or big thinking once we follow good shrimp culture practices strictly. The following factors are significant in improving the success of *P. vannamei* culture:

- Proper pond preparation to improve pond carrying capacity.
- Implementation and upgradation of bio-security protocols to reduce the risk of known and unknown viral diseases in present and future.
- Good water quality management to make the culture environment conducive to shrimp.
- Provide sufficient aeration to avoid dissolved oxygen stress and susceptibility to disease.
- Maintain balanced mineral profiles to encourage proper molting and healthy growth.
- Achieve WSSV disease free farming of *P. vannamei*.

Table 2. Common problems observed & solutions in *P. vannamei* culture

Problem	Solution
Screw shells, clam and mussels relative to low alkalinity problem	To eradicate, apply 1ppm of $CuSO_4$ during water treatment.
Blue green algae	200kg/ha gypsum (or) 0.8ppm BKC.
Dinoflagellates	1 ppm BKC.
pH fluctuation	150kg/ha gypsum at evening time, 150kg/ha dolomite at night time, 25kg/ha jaggery (ferment 24 hours) at morning time.
Alkalinity fluctuation	150kg/ha dolomite at night time, 150kg/ha agri-lime at night time.
Black gill	Improve water exchange (flow through), 7ppm H_2SO_4 (commercial grade).
Brown gill	0.7ppm iodine (or) 0.7ppm BKC.
Red gill	1ppm calcium peroxide
Asphyxiation (low DO)	Calcium peroxide (temporarily) Increase aeration (permanently)
Red discolouration	0.5ppm $KMnO_4$
White muscle & muscle cramp	Products having calcium and magnesium minerals
Blue colour syndrome [or] blue discolouration	Products having all major minerals

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Freshwater prawn farming in a carbon-nitrogen controlled periphyton-based system: A sustainable approach to increase stagnant pond productivity

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Intensifying freshwater prawn production: needs and challenges

An integrated freshwater prawn farming pond in Mymensingh region of Bangladesh. This type of pond is mostly characterised with no inlet and outlet system and has limited water exchange facility.

Freshwater prawn (*Macrobrachium rosenbergii*) is an emerging crustacean aquaculture species, receiving considerable attention in recent years, and fetching attractive prices in both domestic and international markets. The global farmed production of freshwater prawn in 2007 was over 221,000 tonnes. Considering the giant freshwater prawn alone, the major producers in 2007 were China (56.3%), Thailand (12.3%), India (12.3%), Bangladesh (9.4%) and Taiwan (4.5%).

However, the average annual yields per unit area are still very low. Until today, freshwater prawn production in most countries is increasing primarily by expanding the culture area. This demands large additional quantities of water and land area, both being scarce resources. Therefore, a more practical and sustainable way to raise prawn production is by increasing pond productivity per unit land area and water. Mostly, aquaculture intensification comes with higher stocking densities and greater use of water, feeds and fertilisers, leading to increased waste production. In addition, in many countries the increase in production, particularly in shrimp aquaculture, has recently seen the negative impacts of unsustainable production method with regard to environment and consumer safety. Therefore, raising pond productivity in an ecological, social and economically sustainable way is essential to feed future generations.

Higher yields can be obtained by applying more energy, capital and technology. Unfortunately, these resources require capital, which is out of reach to the majority of the resource poor farmers in south Asia. Farmers need new pond production concepts, relying on locally available resources and requiring little investment, that are sustainable. To this end, several recent studies in many countries, have demonstrated various low-cost technologies that can significantly raise pond productivity, but that were so far never tested in combination.

Issues in optimising productivity in stagnant ponds

Stagnant ponds have mostly no inlet and drainage system. Such ponds provide the majority of crustacean and finfish production in South-Asian countries. With no water exchange, the farmer relies on the intrinsic self-purification capacity of the pond. The major problem associated with aquaculture in stagnant ponds is rapid eutrophication, resulting from increasing concentrations of nutrients and organic matter during culture. In these stagnant ponds, formulated feeds are the principal nutrient input. To produce 1 kg live weight fish one needs 1-3 kg of dry weight feed (assuming a food conversion ratio about 1-3), depending on the culture species and the quality of the feed. About one-third of the feed is not consumed and accumulates at the pond bottom in the form of organic waste. The microbial decomposition of organic matter in the system leads to an increased levels of total ammonia-nitrogen (TAN) and nitrite, both harmful to freshwater prawn even at low concentration. Bacteria present in water and sediment transform TAN into nitrite and nitrate by nitrification. However, in stagnant water ponds TAN tends to accumulate within the system due to insufficient nitrification activity. Deteriorated water quality can result in disease outbreaks and heavy financial losses and in criticism from various environmental organisations as being environmentally irresponsible. In addition, organic residues

Experimental ponds of C/N-controlled periphyton-based system.

create sites with a high biological oxygen demand in stagnant ponds. The oxygen supply to the pond bottom is limited, even in the periods of natural mixing and surface re-aeration due to strong winds. Therefore, the production potential of aquaculture in stagnant ponds is limited and often associated with poor water quality, disease outbreak, high production cost and low economic benefit.

Means for intensifying productivity in stagnant ponds

Recently, several studies in many countries demonstrated various low-cost technologies that can significantly raise pond productivity. Among these low-cost technologies, C/N ratio control through carbohydrate addition, providing substrates for periphyton development and fish driven re-suspension seems to be promising options for resource poor farmers. A brief overview of these technologies and their role in productivity are discussed below.

C/N ratio control

Carbon : nitrogen ratio control through carbohydrate addition seems to be relatively cheap and simple way to intensify freshwater prawn farming. The C:N ratio of most of the feeds used in semi-intensive freshwater prawn farming ponds is around 10:1, but bacteria require about 20 units of carbon per unit of nitrogen assimilated. Therefore, with such a low C:N ratio in the feed, carbon is the limiting nutrient for heterotrophic bacteria populations in aquaculture ponds. So, the bacterial population will not expand beyond a certain point due to the limited availability of carbon. If the C:N ratio is increased by adding carbohydrate sources such as maize flour or tapioca starch in addition to the regular feed, the increased availability of carbon allows the heterotrophic bacterial population to grow to a dense mass. The heterotrophic bacteria population utilises the ammonium in addition to the organic nitrogenous wastes to synthesise new cells (single cell microbial protein), and it may be utilised as a natural food source by carp, tilapia, shrimp and freshwater prawn. This promotes nitrogen uptake and decreases the ammonium concentration more rapidly than nitrification. Again, the conversion of ammonium to microbial protein needs less dissolved oxygen compared to oxygen requirement for nitrification. In a heterotrophic microbial based production system, bacterial flocs provide more stable water quality than does a phytoplankton-based production system. In summary, C/N ratio control benefits freshwater prawn farming by improving water quality through reducing toxic inorganic nitrogen content such as ammonia and nitrite, improving nutrient utilisation efficiency, reducing nutrient discharge and finally improving overall sustainability.

Bamboo kanchi (side shoots of bamboo) are posted vertically into the bottom mud as periphyton substrates in C/N-CP ponds.

Providing vertical substrates for periphyton development

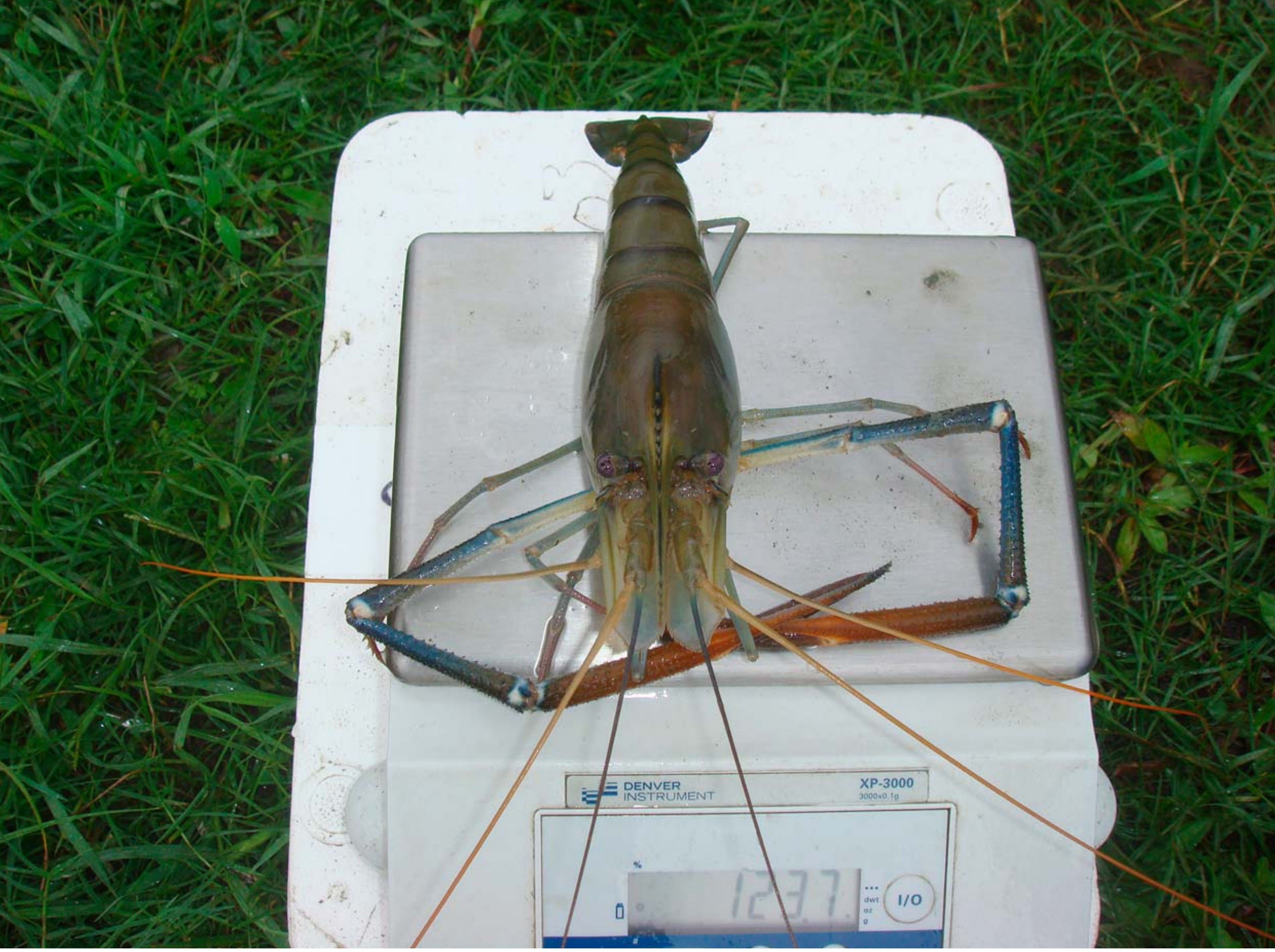
Another means to intensify production in aquaculture ponds is through stimulating periphyton development. Vertical surfaces (bamboo poles, plastic stripes etc.) placed in ponds are colonised with microbial communities, including bacteria, algae, protozoa and fungi embedded in an extra-cellular polysaccharide matrix. The assemblage of attached organisms on submerged surfaces, including associated non-attached fauna are referred to as periphyton. Supplying substrates improves the nitrogen-related processes (nitrification), thus keeping ammonia level low. In a traditional fish pond, phytoplankton is the most important component for energy fixation and fuelling the food web. When substrates are installed in the pond, inorganic nutrients can also follow the extra periphyton loop. This adds a third natural food source existing of periphytic microorganisms that can be consumed by the fish. It has been reported that both survival and growth of shrimps and freshwater prawn are significantly higher due to provision of substrates as compared to traditional production systems without substrates. In summary, the benefits exerted from periphyton-based ponds are periphyton as additional natural food, substrates as shelter to minimise territorial effects and improved water quality through trapping suspended solids, organic matter breakdown and enhanced nitrification.

Application of rotenone by graduate student during pond preparation.

Fish driven re-suspension

Stocking bottom browsing species in polyculture ponds is a traditional world-wide applied methodology to enhance pond productivity. Resuspension of bottom sediment can be also done mechanically, but very effectively through the action of fish, especially sediment browsing species like tilapia. By digging and sieving of sediments, benthivorous fishes increase oxygen availability in the sediment and cause re-suspension of bottom particles, which in turn has a large impact on the abiotic and biotic properties of the overlying

Segregation of male tilapia (approximate 20 g) by our expert field workers for stocking with freshwater prawn in C/N-CP ponds.



An individual freshwater prawn at harvest reached about 123.7 g.

water column. In fed ponds, organic matter in the form of uneaten feed, faeces and dead plankton settles to pond bottom, creating an anoxic zone where nutrients remain trapped. By fish driven re-suspension, the bottom nutrients are exposed to aerobic conditions in the water column and better mineralised, stimulating the natural food web. The digging and sieving of sediments by benthivorous fish also increased diffusion rates across the sediment-water interface, which in turn increases nutrient availability in the overlying water. In most cases fish driven re-suspension significantly improves production. In summary, fish driven re-suspension leads to better nutrients retention in combination with increased production, thereby improving farm productivity and sustainability.

C/N-controlled periphyton-based system

The C/N-controlled periphyton-based system (C/N-CP) combines and upgrades the above three approaches. The first is microbial control of water quality and recycling of protein through the adjustment of C/N ratio in the pond. The second is based upon the application of vertical substrates and development of periphyton, improving water quality and providing shelter and additional food for the cultured species and thereby improving productivity. The third one is fish driven re-suspension, improving nutrient retention and farm productivity. Previous studies showed that each of these techniques enhanced production in stagnant ponds, and further enhanced production might be obtained through synergism between the various techniques. This technology requires installation of hard substrates and application of cheap carbohydrates, resources which can be produced within the farmers' traditional agricultural systems. With this technology, the utilisation of the aquatic food web is optimised by encouraging bacteria and epiphytic production, hence recycling nutrients and enlarging the microbial based food web. The C/N-CP system of freshwater prawn farming carries a number of environmental advantages as well. The system is based upon the induction of an efficient food web that utilises natural feed sources and recycle waste components. In addition, less wastes accumulate in the pond.

C/N ratio calculation

Simply, farmers can calculate C/N ratio from the protein and ash content of feed and carbohydrates (manufacturers provide these information on their product). In order to calculate the C/N ratio, N can be measured from the crude protein content of the feed by dividing with the empirical factor 6.25 (this conversion factor is based on the assumption that the average protein contains about 16% nitrogen by weight, although in practice a variation of between 12 and 19%

Table 1. Proximate composition of artificial feed and maize flour.

Component	Moisture (%)	Protein (%)	Lipid (%)	Fiber (%)	Ash (%)	NFE (%)
Artificial feed	11.6	30.2	8.1	4.8	13.1	32.8
Maize flour (CH source)	11.08	7.72	4.64	5.40	1.14	70.02

nitrogen is possible between individual proteins). The carbon (C) can be measured based on the assumption that the feed contain 55% C of the volatile solid fraction following the formula is % carbon = (%VS)/1.8, Where %VS = 100 - % ash. The C:N ratio can be increased by adding different locally available cheap carbon sources separately from the feed. An example of C/N ratio calculation is given below:

From Table 1:

- Carbon content of the feed = (100-13.1)/1.8 = 48.2%
- Nitrogen content of the feed = 30.2/6.25 = 4.83%
- So, C/N ratio of the feed = 48.2/4.83 = 10.
- Carbon content of the maize flour = (100-1.14)/1.8 =54.9%
- Nitrogen content of the maize flour = 7.72/6.25 =1.23%
- Combined carbon content = 48.2%+54.9 = 103.1
- Combined nitrogen content = 4.83+1.23=6.06

Now, the amount of carbohydrate needed (kg) for each kg of feed to maintain the C:N ratio 20 can be calculated by the formula:

(Desired C/N ratio × Combined N content) / Combined C content = (20 × 6.06) / 103.1 = 1.18 kg.

Research methodology

We followed a step-wise approach to develop C/N-controlled periphyton-based freshwater prawn farming system. Initially, we evaluated if increasing C/N ratio (from 10 to 20) in combination with providing vertical substrates for periphyton development in freshwater prawn monoculture ponds can enhance overall pond productivity. Finally, we added finfish with freshwater prawn for effective utilisation of under-utilised natural food items and optimised their stocking density. In all experiments, we measured water and sediment quality parameters, qualitative and quantitative abundance of natural food communities (plankton, periphyton, heterotrophic bacteria and benthos), growth and production performance and economic benefits. In our research, a 81 × 8.9 m pond

Graduate students showing their harvested freshwater prawn from C/N-CP ponds.

was drained completely and partitioned by galvanised iron sheets into 18 small ponds of 40 m^2 each. Before starting the experiment, ponds were manually cleaned of aquatic vegetation and unwanted fishes were eradicated by rotenone application. Lime ($CaCO_3$) was applied to all ponds at the rate of 250 kg ha^{-1} (day 1). On day 2, ponds were filled with water from the nearby deep tube-well. On day 4, 15 bamboo kanchi (side shoots of bamboo) per m^2 water surface area were posted vertically into the bottom mud in substrate treatment ponds, excluding a 0.5 m wide perimeter. On day 5, all ponds were fertilised with semi decomposed cattle manure (3,000 kg ha^{-1}), urea (100 kg ha^{-1}) and triple super phosphate (100 kg ha^{-1}). After fertilisation, the ponds were left for 10 days to allow plankton development in the water column and periphyton growth on substrates. After that ponds were stocked with freshwater prawn and finfish with a stocking density of 2 individuals/m^2 and 0.5 individuals/m^2, respectively. A locally formulated and prepared feed containing 30% crude protein with C/N ratio 10 was applied to all ponds. In order to raise the C/N ratio of the feed input to 20, tapioca starch (0.9 kg for each kg of formulated feed) or maize flour (1.1 kg for each kg of formulated feed) was applied separately as a source of carbohydrate in addition to the artificial feed.

Figure 1. Effects of C/N ratio control on (A) total ammonia nitrogen (TAN) and (B) nitrite-nitrogen (NO_2–N)

A **B**

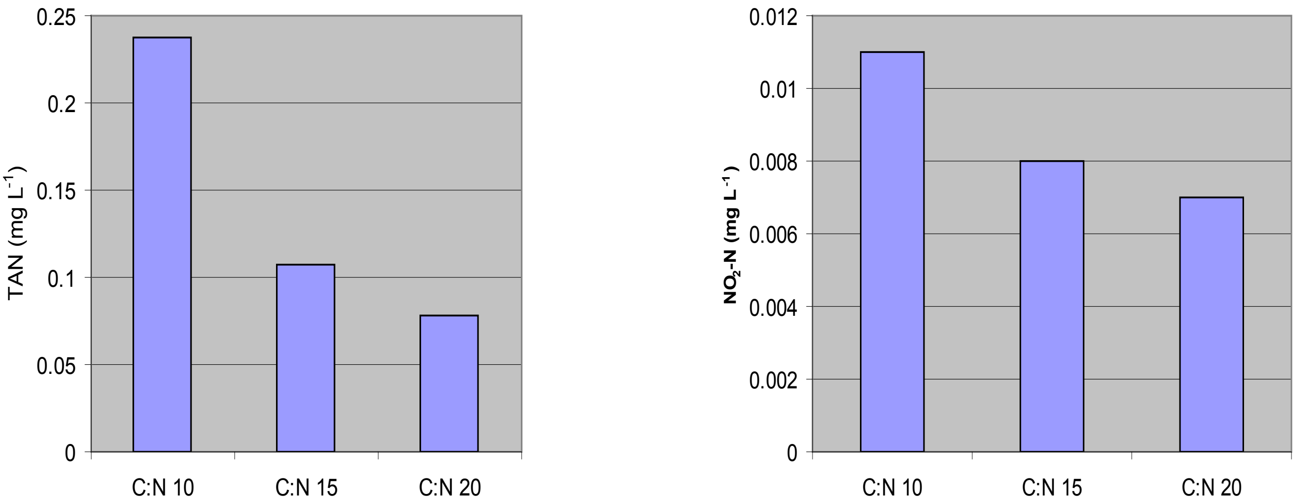
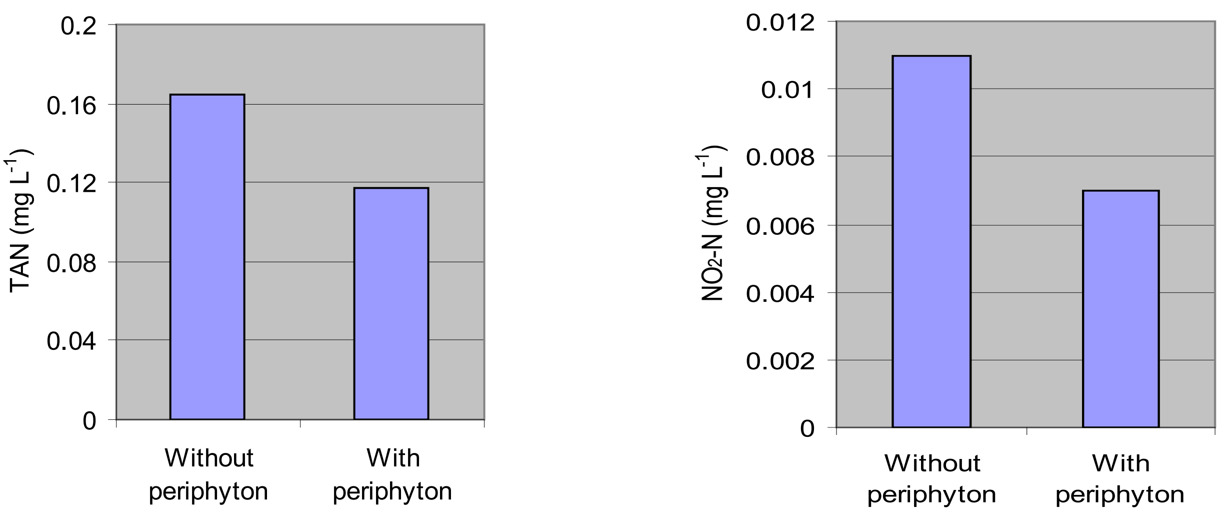


Figure 2. Effects of addition of substrates for periphyton development on (A) total ammonia nitrogen (TAN) and (B) nitrite-nitrogen (NO_2–N)

A **B**



A harvested tilapia reaching about 500 g in C/N-CP ponds.

C/N-CP improved toxic nitrogenous compounds problem

The uneaten feed and feces contribute to the organic matter load in the sediment of freshwater prawn farming ponds. In stagnant ponds, the oxygen supply to the bottom sediment is limited. Mineralisation of accumulated organic matter under anaerobic conditions leads to the formation of toxic metabolites like TAN and NO_2-N, spoiling the living environment of the freshwater prawn. The accumulation of inorganic nitrogen in a stagnant freshwater prawn ponds can be minimised by addition of organic carbon sources with a wide C:N ratio and by reduction of feed protein content. Increasing the C/N ratio from 10 to 20 significantly reduced the TAN concentration by 67.2% and NO_2–N by 36.4% (Figure 1), with a large fraction of the input N incorporated in new bacteria cells (single cell protein). Addition of substrates significantly decreased mean values of TAN and NO_2–N in C/N-controlled ponds (Figure 2). The periphyton community takes up both TAN and nitrate and edible biomass is formed. Therefore, C/N-CP systems improved toxic nitrogenous compounds problems in stagnant ponds thereby, offered a promising option to reduce frequency of water exchange into a limited or zero water exchange system.

C/N-CP system improved freshwater prawn production

In addition to water quality control, increasing C/N ratio led to the buildup of microbial protein that contributed to fish nutrition and thereby, improved production. The net yield of freshwater prawn increased by 22.2% due to increasing C/N ratio from 10 to 15 and a further increase of 14.8% due to increasing C/N ratio from 15 to 20 (about 40% increase in C/N 20 compared to treatment C/N 10). The higher yield in the present study showed that freshwater prawn could well utilise the additional protein derived from the increased bacterial biomass as a result of increasing C/N ratio from 10 to 20. Although not confirmed in our study, we hypothesised that as like other reported species, microbial floc might be utilised by freshwater prawn as a food source. Our hypothesis was supported by a 19% reduction of the FCR in C/N ratio 20 ponds compared to C/N ratio 10 ponds. C/N ratio control increased freshwater prawn production 40% while the water quality was better.

The substrates addition positively influenced freshwater prawn production. We observed that addition of substrates for periphyton development increased net yield of freshwater prawn by 23%. This increase in net yield was mainly due to the increased survival since periphyton substrates did not have an effect on individual weight at harvest. Addition of substrates might have reduced territoriality effects on freshwater prawn. In addition, substrates addition decreased FCR value by 13% contributing periphyton as additional food. Therefore, the possible explanations for increased freshwater prawn production due to the addition of substrates are i) increased survival due to minimised territoriality effects, ii) additional natural food in the form of periphyton colonised on bamboo kanchi, iii) improvements of water quality due to reduction of toxic nitrogenous compounds through a range of ecological and biological process, or iv) a combination of these factors. The effects of C/N ratio control and substrate addition for periphyton development were additive, therefore, C/N-CP system increased net yield of freshwater prawn 75%.

Conceptual framework of C/N-CP system

Our conceptual model of nitrogenous compounds, freshwater prawn and food organisms interaction, as influenced by the increasing C/N ratio from 10 to 20 and addition of substrates for periphyton development suggests that the uneaten feed and faeces contributed to the organic matter load of the system. The microbial decomposition of organic matter in the system led to increased levels of TAN and nitrite. The process of nitrogenous compound utilisation and transformations take place in water, sediment and periphyton mat as indicated by blue block arrows. In C/N controlled periphyton based ponds (CN20+P) the added carbon source, together with the waste nitrogen was converted into microbial floc, which in turn can be eaten by the cultured freshwater prawn. Nitrifying bacteria process the ammonia into nitrite, which is also toxic, and then nitrite into nitrate, which is much less harmful. Both TAN and nitrate were assimilated by the phytoplankton, periphyton and microbial floc present in the ponds. Increasing C/N ratio increased the abundance of plankton, periphyton, heterotrophic bacteria and benthos, and finally increased the freshwater prawn production. Among these natural food items, freshwater prawn effectively graze on benthos resulting in decrease of abundance over the time. The other natural food items were under-utilised by freshwater prawn.

Finfish addition in C/N-CP ponds improved net yield and economic benefits

The analysis of natural food communities in C/N-controlled periphyton-based ponds showed that the biomass of plankton and periphyton was totally unutilised in freshwater prawn monoculture ponds. Therefore, we considered that inclusion of plankton and periphyton grazing fish species like tilapia and/or rohu could further increased the production and improved environmental quality and system stability in C/N-CP ponds. Adding 0.5 finfish/m^2 improved total production without any additional artificial feed and significant negative effects on freshwater prawn production. This result suggested that natural food could compensate for the nutritional demand of finfish. In another experiment, we compared three different combinations of finfish stocked at 0.5 individuals/m^2: 100% tilapia, 50% tilapia + 50% rohu and 100% rohu. The net yield of finfish in the 100% tilapia treatment was the highest compared to treatments 50% tilapia / 50% rohu and 100% rohu, respectively (Figure 9). Again, the benefit-cost ratio in treatment 100% tilapia was 31% and 137% higher when compared with treatments 50% tilapia / 50% rohu and 100% rohu, respectively (Figure 10). The result confirmed that tilapia addition (0.5 individuals/m^2) in C/N-CP ponds improved the natural food utilisation, pond productivity and economic benefits.

Conclusion

C/N-CP system benefited freshwater prawn farming by i) improving water quality through reducing toxic inorganic nitrogen content such as ammonia and nitrite, ii) enhancing natural food availability, iii) improving nutrient utilisation efficiency, iv) improving farm productivity and economic returns, and v) reducing nutrient discharge. The system can be applied in different parts of the world and with different culture species. Therefore, C/N-CP will be able to satisfy future demands for aquatic products, while providing the opportunity to resource poor farmers to participate and benefit significantly from the growth of aquaculture production.

Acknowledgment

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More information

The findings of our research projects are published through a series of peer reviewed articles in aquaculture journal. The readers who are interested to detail information about our findings are suggested to read the following articles:

Asaduzzaman, M., M. A. Wahab, M.C.J. Verdegem, M.E. Azim, S. Haque and M.A. Salam 2008. C/N ratio control and substrate addition for periphyton development jointly enhance freshwater prawn *Macrobrachium rosenbergii* production in ponds, Aquaculture 280, 117-123.

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Asaduzzaman, M., M.M. Rahman, M.A. Wahab, S. Mondal, M.C.J. Verdegem, M.E. Azim and J.A.J Verreth 2010. Effects of C/N ratio control and addition of substrates for periphyton development on natural food communities in aquaculture ponds. Aquaculture (Submitted: under review).

Constraints to fish production in community ponds in Orissa, India

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The Gram Panchayat ponds (village community ponds) were created for multiple users and uses. The ponds account for around 60% of the total ponds that are available. However, these water bodies are under exploited for scientifically-based fish production, even though their potential is quite high.

We set out to investigate why these ponds are not being fully utilised and what could be done to make these resources more economically and socially useful. We also hope to raise awareness of these issues and to draw more attention towards management of these vital resources, which could play a more significant role in improving the nutritional security, income and employment opportunities of the rural poor.

We carried out a survey in villages in the Puri and Khurda Districts, Orissa, India interviewing a total of 81 randomly chosen community pond leaders using pre-set questionnaires. At the initial stage, we prepared problem-cause diagrams on low fish productivity in community ponds. From these we identified nineteen common constraints. These could be categorised into six major themes, ie., policy, technical, management, financial, marketing and social constraints. We ranked these constraints and discussed potential solutions or mitigating measures with participants. Our findings are presented below.

Technical constraints

Lack of technical support: The number one constraint identified by participants was a lack of technical support, which made it difficult for community farmers to strictly follow the prescribed package of practices. There are a limited number of people involved in fisheries extension work. The shortage of extension officers is made worse by their

Community farmers unhappy with a fish kill due to disease outbreak in community ponds.

frequent assignment to other work of general administrative nature, lack of training and poor motivation, leading to inadequate extension reach and technical support in rural aquaculture operations. A lack of proper rural connectivity also hindered provision of technical support in remote villages.

We advocate that extension officers must possess up to date expertise and knowledge on aquaculture technologies as well as extension education. They should exclusively handle fish culture activities with the provision of mobility, traveling allowance, training, freedom of decision making and a better working atmosphere5.

Lack of a net for sampling and harvesting: Community fish farmers often do not own nets for periodical sampling and harvesting of fish. They used hired nets and fishermen from the area for this purpose. Harvesting groups worked on a share basis which varied from 20 to 50 % depending upon availability of stock and ease of harvesting. In some cases harvesting groups buy out whole fish at relatively lower price in addition to their share of harvesting. Out of the surveyed community fish farmers over 86% were of the opinion that a lack of a net for sampling and harvesting was a severe constraint to effective management of the crop. This was the number two ranked constraint.

Due to lack of own nets community fish farmers resort to fish harvesting using traditional method from a community pond.

Lack of supplementary feeding: In a majority of the community ponds the fishes were deprived of balanced food. This constraint was ranked fifth. Community fish farmers should be made aware through training to use balanced supplementary feed or conventional supplementary feed or locally available supplementary feed in community ponds to enhance fish production.

Lack of technical know-how: Due to frequent change in lessee, new entrants were often not aware of essential technical know-how. Therefore, even though the knowledge was available in the communities, the same was not available consistently for aquaculture in village community ponds. This constraint was ranked sixth among nineteen identified problems. Provision of regular access to skills training was suggested as a mechanism to ensure lessees are supported even when there is turnover.

Disease outbreak in fish ponds: Most of the community ponds we surveyed were choked with weeds, causing anoxia and hypercarbic stress conditions for fish, which likely increased their susceptibility to pathogens. Participants ranked

Farmers growing fish in community pond after training.

Infestation of water hyacinth in a large community pond.

overgrowth of aquatic weeds as the fourteenth most significant constraint. Farmers need to be trained to understand the factors affecting fish health and contributing to risk of disease outbreaks along with symptoms and control measures.

Policy constraints

Participants identified three major policy constraints as significant problems for the full exploitation of community ponds. These were:

Short lease tenure: Most of the community ponds are under the control of panchayats and are leased for one, three, five or occasionally ten years to women's and men's self help groups, registered cooperative societies, village communities and individuals on priority basis in descending order. About 22% of the ponds were leased for one year, 56% for three years and 15% for five years. Average fish production was found to increase substantially with the length of lease: Ponds on one-year leases averaged 739 kg/ha/year, those on three-year leases averaged 994 kg/ha/year and those on five-year leases averaged 1,634 kg/ha/year respectively, indicating the needs of higher lease period for better production in community ponds. Participants ranked short lease tenures as the seventh most serious issue.

High lease-value of ponds: When a lease tenure is renewed the fee is set at least 10% higher than the previous term, as per existing government rules. At times, ponds are leased to influential people of the society at prefixed values, which was further subleased to actual farmers at a significantly higher price. Social rivalry, personal conflicts, vandalism, and multi-leasing approaches also lead to increases in lease fees of the community ponds[1]. Approximately 46% farmers felt this issue to be an important constraint, although it ranked twelfth in order of significance. Farmers advocated the removal of subleasing policies to mitigate this problem.

Non-availability of desired quality of fish seed: Community fish farmers often have difficulties obtaining quality fish seed at the right time for stocking their ponds[2,3,4]. This was the thirteenth ranked constraint in our survey. The paucity of quality fish seed forced the farmers to stock their ponds without consideration for proper stocking size, density, species and species ratio. As a mitigating measure, farmers proposed that the most practical approach would be procurement of quality carp fry when in season and growing them into larger size fingerlings in small village ponds before stocking out to the large community large ponds.

Management problems

Poor plankton production capacity: Factors contributing to poor plankton production included excessive silt deposition and a 'nutrient sink' in the pond bottom under anaerobic conditions[8], aquatic weed infestation, and inadequate application of manure and fertilisers leading to nutrient deficient conditions in the majority of community ponds. In our survey this was ranked as the third most serious issue, suggesting that farmers should be provided with training to help them improve plankton production in community ponds for higher fish production.

Working to eradicate aquatic weeds from a community pond.

Presence of weed and predatory fishes in pond: Predatory and weed fishes were rarely eradicated properly from community ponds causing poor fish recovery and production. This was felt to be a serious issue, ranked fourth by participants, indicating an urgent need of training and demonstration to help farmers better address this issue.

Heavy silt deposition in pond bottom: As described above, there was often a huge amount of organic matter deposition through surface runoff into community ponds. Death and decomposition of aquatic organisms including aquatic plants also contributed organic matter to the bottom. A huge quantity of nutrients are locked in such anaerobic sediments and remain unavailable for primary production. There is also the risk of harmful gasses being released and oxygen depletion[6] which may be detrimental to fish growth and production and at times lead to fish kills[6,7]. Silt deposition was ranked as the eighth most serious constraint by participants. As noted above, periodic desilting is required.

Aquatic weed infestation in community fish pond: Overgrowth by aquatic plants and excessive algal blooms were identified as the tenth most serious problem in community pond fish culture[6]. Aquatic weeds remove a large quantity of nutrients, subject to stress due to dissolved oxygen depletion, cutting off light penetration in water, restrict fish movement and interfere with fishing operations. This adversely affects primary productivity and fish production. Community fish farmers should be made aware about the adverse effects of aquatic weed infestations in fish culture ponds and to be motivated to eradicate them from the ponds to maximise fish production.

Damaged pond embankments and shallowness of pond: A majority of the community ponds we surveyed were irregular in shape and size. Ponds embankments were invariably damaged, at times without embankments, lacking safe outlet and inlet leading to village and agriculture surface runoff water entry into the ponds. This resulted in accumulation of organic matter on the pond bottom and potential entry of pesticides into ponds. Some of the community ponds were not de-silted for years and had become shallow, which may aggravate weed growth. This was the eleventh ranked constraint. Pond maintenance through periodical de-silting and embankment repair and the provision of appropriate sluice gates were identified as mitigating measures.

Poor water retention capacity of pond: The community ponds were located in a variety of soil types which exhibited a wide range of seepage characteristics. However, it was not a serious constraint in study area and ranked fifteenth of the issues identified. In ponds where water retention is a constraint, the application of excessive organic manure and appropriate plastic lining could minimise seepage loss.

Problem of mixed aquatic vegetation in community pond.

Financial constraints

Lack of financial support for culture operation: Community fish farmers usually did not have sufficient funds for investment in leased community ponds. They often failed to meet the requirement of operational expenditure in fish farming. This was ranked as the ninth most serious constraint. Alternative sources for financial support need to be identified to support for intensification of fish farming.

Marketing constraints

Marketing problems: Fish produced from the community ponds are sold to middlemen on the pond site at invariably low prices or directly into nearby market. Some farmers catch fish from larger ponds in the early morning and stock them in adjoining smaller ponds from which they sell live fish at a relatively higher price, although this is feasible for many people. The farmers did not feel marketing to be a serious constraint, ranking it nineteenth, the last of the issues raised, possibly due to easy access to local markets and increasing demand of fish consumers in rural areas.

Malnourished diseased fish from community ponds.

Social constraints

Fish poaching due to social rivalry/ conflicts: Some of the community ponds remained unutilised in derelict conditions in rural areas, due to social rivalry, vandalism among fisher folk and social stigma, poor cooperation among operational agencies and non-cooperation among the community members[7]. Multi-ownership and multi-leasing policy, dual-leasing policy, multi-water rights may also create enmity within the groups[7]. All the social problems lead towards fish poaching and deliberate poisoning of the ponds to destroy the crop. The ranking of this constraint was 17th only indicating less severity of the problem probably due to better understanding amongst the village communities. In sensitive community fish farming area, community leader should be rained in community management and conflict management to mitigate the constraints.

Resistance to manure/fertiliser/fish medicines application: With multiple ownership, multiple water rights and multiple uses of the community ponds, fish farmers often face constraints on following scientific fish culture, for example they may be prevented from applying fertiliser or other material inputs.

In our survey participants ranked this issue as the sixteenth out of nineteen, suggesting it is one of the less serious issues. However, awareness needs to

Catch of weed fishes from unprepared community fish pond.

be developed among the community farmers and other users of the water resource that fish farming, properly conducted, can improve water quality and not pollute. Application of lime and bleaching powder during culture operation also makes the pond water conducive for community use.

Conflict in distribution/sharing of produce/profit: Due to vandalism among fisher folk and social stigma, poor organisational capacity among rural farmers and lack of capable community leaders, community fish farmers are reluctant to participate in such schemes[1]. Inequity in multi-ownership of the community ponds[8] sometime develops into conflicts in the distribution and sharing of profit, although this problem was ranked quite low as an issue, in eighteenth place. It is possible that community leaders were efficient and cooperation generally good among the community members in the area we surveyed.

Conclusion

After understanding the limitations of low fish production in community ponds, an early insight and planning to improve community-based aquaculture management may provide a firm and realistic footing. Human resources are a vital input in aquaculture development and rural areas in particular require it for effective utilisation in community pond aquaculture. A suitable needs-based extension strategy required to be planned and implemented to support this activity. Attention should be laid to mitigate the constraints identified here and to educate fish farmers about different aspects of aquaculture operations, in order to improve rural food and nutritional security.

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Continued confidence in inland fisheries development of a Sri Lankan youth begins to pay off

Until recently Sri Lankan inland fisheries were mainly based on capture fisheries in perennial reservoirs. The Sri Lankan Government, realising the potential of developing fisheries using a stock and recapture strategy akin to culture-based fisheries, has embarked on the development of fisheries in the multitude of non-perennial reservoirs in the dry zone. These developments have been augmented by R&D projects funded by the Australian Centre for International Agricultural Research (ACIAR), Asian Development Bank (ADB) and the Icelandic International Development Agency (ICEIDA).

One of the main bottle necks for popularising culture based fisheries in non-perennial reservoirs was the availability of suitably sized seed stock. In order to remove this bottle neck, fry to fingerling rearing has been encouraged via the private sector, individuals and fishery societies, in perennial reservoirs in hapas and in purpose-built home garden ponds. This strategy has resulted in an increasing uptake of fry to fingerling rearing on a commercial basis by individuals and fishery societies. The following story illustrates the success of a young, educated individual who took a risk and persevered, and also encouraged surrounding communities to undertake culture-based fisheries in their communal water bodies through his example.

Twenty seven year old Asanka Rupasinghe of Pemuduwa village in Mahawilachchiya, Anuradhapura District, North-central Province became interested in the activity in 2000, whilst studying for his first General Certificate of Education (Advanced Level), the passport to seek a university education. His subsequent attempts at fry to fingerling rearing can be summarised as per the table below.

Asanka received a two-week short term training on fish culture and breeding technology at the Central Institute of Freshwater Aquaculture (CIFA), Bhubaneshwar in India, under the auspices of the ADB-funded Aquatic Resources Development and Quality Improvement Project.

Using his experience and training, he continues to make innovations; for example the recommended stocking density for fry to fingerling rearing is 5,000 – 6,000 fry per100 m^{-2} pond area, but Asanka uses a stocking density of about 14,000 fry per 100 m^{-2} by providing aeration twice a day at 12 noon and 7 pm using two improvised blower pipes.

His entrepreneurship has been extended in 2003 by signing a lease agreement with the Farmers' Organisation of Randuwa seasonal reservoir for culture-based fisheries. With the fish price of Rs. 60 per kg at that time, he earned Rs 480,000 from one culture-based fisheries trial, where he paid 10% of the profit to the Farmers' Organisation and also funded the renovation of the reservoir spillway. In the following year, the Farmers' Organisation decided to carry out culture-based fisheries in the reservoir. However, due to conflicts among members of the organisation, they could not continue. In

2010, Asanka, with his belief in this development activity, again stocked 75,000 fingerlings (rohu, catla and common carp in equal proportions) with 25,000 giant freshwater prawns; the potential success of this activity will likely trigger many adjoining farmer organisations to take up to culture-based fisheries, practical demonstration and observation of success being the most logical and effective way to spread the message.

Activity	Result
4 earthen ponds 500 m^2; carp fry rearing	Economic loss
Encouragement by an aquaculturist, Mr. R.H. Pothuwila donating Rs. 6,000; access bank loans; sold 75,000 fingerlings at the rate of Rs. 1.50/fingerling	Net profit Rs. 35,000
Training under NAQDA	Enthusuiasm raised; conviction fortified
8 earthen ponds stocked; 175 fry; 175,000 fry in his expected a harvest of 150,000 fingerlings and a monetary return of Rs. 225,000	Floods destroyed the harvest
Takes up job in garment factory in Colombo	Despondent; return back to the village after 2 months
Regional Aquaculture Extension Officer of NAQDA loans 100,000 rohu fry; harvests 75,000 fingerlings	Settles all loans
Continuation of rearing of fish fingerlings in ponds; Preparation of feeds using locally available ingredients	Saving of Rs. 2 million banked
Presently he owns a pond facility consisting of 4 mud ponds of each of 1100 m^2 in size. In addition, he has constructed a pond of 800 m^2 size for tilapia fry rearing. In this pond facility, capable of rearing up to 550,000 fry, with the expected harvest of 400,000 fingerlings per culture cycle	Built new house; provides fish fry (brought from NAQDA fish breeding centres) to an out-grower; provides the out-grower with fish feed required for fingerling rearing; buys back these fingerlings at the rate of Rs. 1.50 per fingerling and keeping a profit of 50 cents per fingerling, he sells them to NAqDA. In 2010, sold 1.6 million fingerlings to NAQDA and other governmental and organisations
Targets to produce 2 million fingerlings in 2011	

The Asia-Pacific Quarterly Aquatic Animal Disease Report: 12 years and beyond

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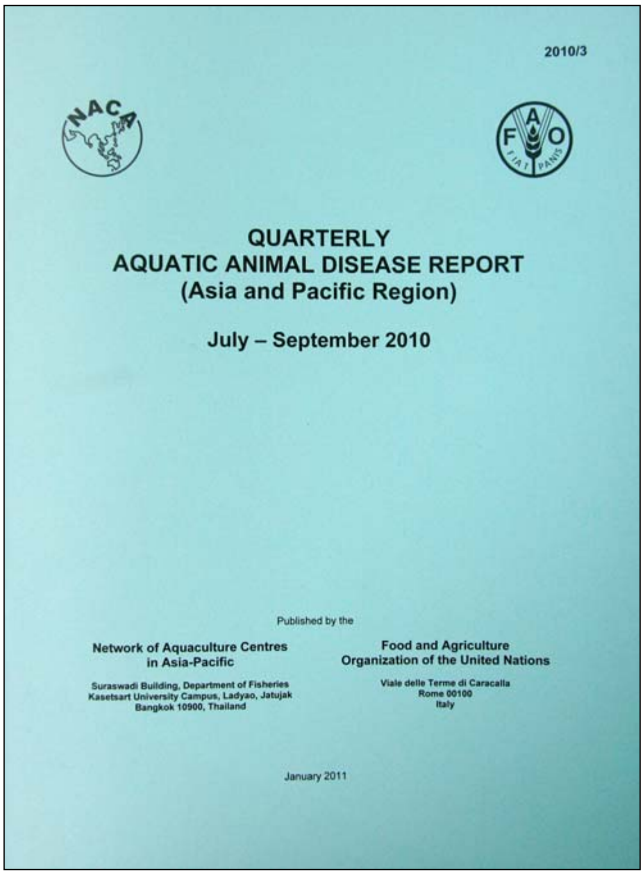
Network of Aquaculture Centres in Asia-Pacific

The inception

The Quarterly Aquatic Animal Disease (QAAD) reporting programme in the Asia-Pacific was initiated in the 3rd quarter of 1998, in response to the need to develop a cohesive strategy for aquatic animal health management in the region. This reporting system was developed following the recommendations of the Network of Aquaculture Centres in Asia-Pacific (NACA)/World Organisation for Animal Health (OIE) Expert Consultation in 1996 and was eventually integrated into the Regional Aquatic Animal Health Programme of NACA. In December 1997, upon the request by NACA, the Food and Agriculture Organization of the United Nations (FAO) approved a regional technical cooperation project with immediate objective of developing National and Asia Regional Technical Guidelines on Aquatic Animal Quarantine and Health Certification for Responsible Movement of Live Aquatic Animals in Asia, which was implemented by NACA in 1998 and participated by 21 countries and territories in the region. Through this project and with additional financial and technical assistance from various sources, FAO and NACA collaborated closely with OIE with the specific objective of establishing a reliable fish disease reporting system. As such, the maiden issue of QAAD Report (Asia and Pacific Region) covering the 3rd quarter of 1998 was published in April 1999 containing reports from 13 member governments. This was followed immediately by 4th quarter QAAD Report published in May 1999. Thereafter, the quarterly reports were published on a regular basis.



The reporting system serves not only at collecting and collating disease data but more importantly provides further insight into disease problems that are present or absent in the region, to assist in its resolution and in providing support for better and faster decision-making. This is of extreme importance for national policy-makers when planning and monitoring aquatic animal health programmes, as well as fulfilling international disease reporting responsibilities and providing accurate health certification for live aquatic animal exports. Likewise, it is useful to field- and laboratory-based aquatic animal health specialists in planning and implementing local or national aquatic animal health programmes.

Through the years

The following year after the launch of the reporting system, 21 governments have participated in the programme. These include Australia, Bangladesh, Cambodia, P.R. China, Hong Kong, India, Indonesia, Iran, Japan, DPR Korea, Republic of Korea, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. At present, an average of 16 member governments continuously submit QAAD reports on a regular basis. Countries which stopped submitting reports include Cambodia (since 2009), China (since 2004), DPR Korea (since 2000) and Pakistan (since 2008). Nonetheless, the reports received from other countries still reflect the current status of aquatic animal health in the region.

The list of diseases covered by the reporting system is revised annually by the Asia Regional Advisory Group on Aquatic Animal Health (AG). It is based on the updated OIE-listed diseases adopted by the OIE World Assembly of Delegates which meets annually. In addition, diseases of regional significance as well as other important and emerging threats are also included in the QAAD list of diseases. The AG is composed of 10 members, which include representatives from OIE and FAO, and invited aquatic animal disease experts from collaborating regional organisations and the private sector. They are tasked to provide advice to NACA members in the Asia-Pacific region on aquatic animal health management, through the following activities:

- Evaluate disease trends and emerging threats in the region.
- Identify developments with global aquatic animal disease issues and standards of importance to the region.

Table 1. Number of countries using different levels of disease diagnosis for surveillance.

Level of diagnosis	Year												
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
I	13	17	7	9	8	8	9	7	9	7	4	10	5
II	2	2	3	3	7	6	7	10	7	13	6	6	7
III	5	6	5	6	9	10	10	11	11	12	12	12	12

** I – observation of animal and the environment; clinical examination; II – parasitology, bacteriology, mycology and histopathology; III – virology, electron microscopy, molecular biology, immunology.*

Table 2. Important finfish and crustacean diseases in the Asia-Pacific region.

Country	Finfish disease				Crustacean disease			
	EUS	KHV	RSI	GIV	WSD	IHHN	IMN	MHD
Australia	+							
Bangladesh	+				+			
Hong Kong			+	+	+			
India	+				+			
Indonesia		+		+	+	+	+	
Iran					+			
Japan	+	+	+					
Korea PR								
Lao PDR								
Malaysia		+	+	+	+	+		
Myanmar					+	+		
Nepal				+				
Philippines				+	+	+		
Singapore								
Sri Lanka					+	+		
Thailand	+	+	+		+	+		
Vietnam					+			+

EUS – Epizootic ulcerative syndrome; KHV – infection with Koi herpes virus; RSI – Red seabream iridoviral disease; GIV – Grouper iridoviral disease; WSD – White spot disease; IHHN – Infectious hypodermal and haematopoietic necrosis; IMN – Infectious myonecrosis; MHD – Milky haemolymph disease of spiny lobster.

Table 3. Total number of web downloads of each QAAD reports from 1998-2010.

Quarter	Year												
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Q1		260	231	587	650	1229	914	1149	634	652	634	562	428*
Q2		264	201	554	550	950	1098	1321	613	658	687	547	269*
Q3	268	265	223	582	665	1132	795	1065	591	686	550	551	135*
Q4	238	665	512	212	659	824	681	1023	51	721	484	272	
Mean	253	364	292	484	631	992	872	1140	590	629	589	483	277

** Reports made available online in late July (Q1) and late October (Q2) 2010, and early February (Q3) 2011.*

Table 4. Aquatic animal diseases initially listed in QAAD that have been listed in OIE.

Disease	Year listed	
	QAAD	OIE
Infection with koi herpesvirus	2005	2007
Abalone viral mortality	2005	2007
White tail disease (MrNV)	2005	2008
Necrotising hepatopancreatitis	2005	2010

- Review and evaluate the QAAD reporting programme and assess the list of diseases of regional concern.
- Provide guidance and leadership on regional strategies to improving management of aquatic animal health including those under the framework of the Asia Regional Technical Guidelines.
- Monitor and evaluate progress on Technical Guidelines implementation.
- Facilitate coordination and communication of progress on regional aquatic animal health programmes.
- Advise in identification and designation of regional aquatic animal health resources, as Regional Resource Experts (RRE), Regional Resource Centres (RRC) and Regional Reference Laboratories (RRL).
- Identify issues of relevance to the region that require depth review and propose appropriate actions needed.

Important facts

To date, a total of 49 QAAD reports have been published. Disease reporting by each participating country has improved significantly in recent years. The number of countries applying Level III diagnosis has increased from five to six in 1998-2001 to more than double of 11-12 countries at present (Table 1). Efficient diagnostic techniques (e.g. histopathology, electron microscopy, molecular methods such as PCR and RT-PCR, and virus assays using cell lines) are now popularly used to screen and detect many important viral and bacterial diseases of aquatic animals. Epidemiological comments from some member countries, for each of the diseases that were reported, also improved significantly, providing very detailed information on the characteristics of the disease (signs), species affected, extent of the affected areas, mortality and economic loss, and some control and preventive measures taken.

Table 2 lists the important finfish and crustacean diseases that have been reported by member countries. Some of these diseases are commonly occurring in several member countries (e.g. epizootic ulcerative syndrome (EUS) and white spot disease) while others only occur in one country (e.g. infectious myonecrosis in Indonesia, and milky haemolymph disease of spiny lobster in Vietnam). The list is based on 2009 and 2010 QAAD reports received by NACA from member countries except China, Cambodia, DPR Korea and Pakistan.

QAAD reports are widely disseminated through distribution of printed copies or free downloads from NACA website. Table 3 shows the average annual downloads of QAAD reports from 1998 to present.

Relevant information contained in each published report have been instrumental in aquatic animal health awareness in the region. Diseases considered important in the region (aside from the OIE-listed diseases) are included in QAAD reporting system to encourage surveillance and stimulate reporting, as well as for disease awareness and preparedness. As such, QAAD reporting also served as an “early warning system” for some of the important aquatic animal diseases which are now listed by OIE. Examples of these diseases, which were initially listed in QAAD due to its importance at regional level and are currently listed in OIE, are presented in Table 4.

The commitment of the National Coordinators (NCs)/Aquatic Focal Points has been instrumental to the success of this disease reporting programme, through their diligence in continuous disease surveillance, collecting and collating information on aquatic animal diseases in their respective countries, and timely submission of the QAAD reports. Recognising the important role being played by NCs for aquatic animal disease surveillance and health certification in the region, the OIE has appointed some of the NCs to become its Aquatic Focal Points. These include NCs from Australia, Iran, Republic of Korea, Nepal, Philippines, Sri Lanka, Thailand and Vietnam.

Way forward

The QAAD reporting system has been a useful mechanism for recognising emerging and important aquatic animal diseases in the region. It also provides up-to-date information on important aquatic animal diseases in the region, serves as a guide to participating countries in revising their national list of reportable diseases and as early warning system for emerging diseases, and is a valuable source of information to support risk analysis. The programme also paved way in the establishment of an excellent regional networking in support of the regional surveillance and QAAD reporting. As such, aquatic animal disease surveillance in the region has improved significantly and the published QAAD reports have generated important information on the presence or absence of notifiable and other important diseases of aquatic animals.

QAAD reports are usually submitted within 75 days after the end of reporting quarter. Under emergency situation, immediate notification (both for OIE-listed and non OIE-listed diseases) is required in line with the provisions of the OIE Aquatic Code, and reporting can be coursed through the OIE’s World Animal Health Information System (WAHIS). WAHIS is an internet-based computer system that processes data on animal diseases in real-time and then informs the international community. The system consists of two components: an early warning system to inform the international community, by means of “alert messages”, of relevant epidemiological events that occurred in OIE Members; and a monitoring system in order to monitor OIE Listed diseases (presence or absence) over time. However, access to this secure site is only available to authorised users, namely the Delegates of OIE Members and their authorised representatives, who use WAHIS to notify the OIE of relevant animal disease information. Thus, the OIE/NACA WAHIS Regional Core, which will allow access to all NC’s and Aquatic Focal Points of NACA’s Regional Aquatic Animal Health Programme, has been initiated. The system is now being finalised and will be scheduled for pilot-testing with at least four member countries prior to its launch. Large communications on this initiative of harmonisation and integration between the regional information system (OIE/NACA WAHIS Regional Core) and WAHIS worldwide information are aimed at improving aquatic animal health management in the region. The OIE/NACA WAHIS Regional Core will replace the paper-based QAAD reporting once it is fully implemented.

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Better management practices for catfish aquaculture released

'Better Management Practices for Catfish Aquaculture' Version 3.0 was released at a national workshop in Long Xuyen City, An Giang Province, Vietnam on 24 November. These improved farming practices are the culmination of a three-year project investigating catfish farming practices in the Mekong Delta, funded by AusAID under the auspices of the program Collaboration for Agriculture and Rural Development (CARD), and conducted in partnership between NACA, the Research Institute for Aquaculture No. 2, Can Tho University, the Victorian Department of Primary Industries and catfish farmers in the Mekong Delta.

Speaking at the workshop, NACA's Director General, Prof. Sena De Silva, said that Vietnamese catfish aquaculture is the most productive farming sector in the world and has put Vietnamese aquaculture firmly on the global map. 'More than one million tonnes of fish are produced from an area of less than 10,000 hectares in the Mekong Delta. The industry provides around 180,000 jobs and generates more than US$ 1 billion in foreign exchange for the country', he said.

Catfish farming is highly intensive. The industry average yield in the delta exceeds 400 tonnes per hectare per crop, with farmers producing two crops per year. However, the profit margin is slim and farmers need to produce high volumes to survive. In this business, a few cents per kilo can make the difference between making a huge profit or a huge loss. 'But we have to understand that we cannot continue to intensify indefinitely', Prof. De Silva said.

Other aquaculture industries, notably shrimp farming, have undergone a classic boom-bust cycle at early stages of their development. An initial period of industry experimentation and intensification is often followed by a collapse and a period of readjustment when the production system is pushed too far. By 2008 the average yield in the catfish industry had already reached spectacular levels and downwards price pressure was becoming evident. NACA and its partners therefore began work on developing science-based better management practices for catfish farming. This was a forward-looking initiative to improve the efficiency of the sector and also to identify and forestall any potential problems before they emerged. 'Some of the problems facing the sector are real', said Prof. De Silva, displaying some negative articles from international newspapers, 'but some such as these are fiction circulated in the media by international competitors. This research will help the market distinguish fact from fiction'.

The project began by conducting a survey of industry management practices in May 2008 targeting hatcheries, nurseries and grow-out farms. Project staff visited a total of

Vice Minister for Agriculture & Rural Development, Madam Thu.

97 producers conducting detailed interviews. The survey data were analysed for indications of how variations in management practices may influence production outcomes. A risk assessment was conducted to identify areas of particular concern and opportunities for improvement. Based on this data, the project team developed draft better management practices which were evaluated by farmers at two consultative workshops in Dong Thap and Can Tho provinces in October 2009. After incorporating the feedback of producers, farm trials were conducted by volunteers on eleven farms in four provinces in the delta to assess their effectiveness. 'These improved practices have been developed through a science-based approach with direct involvement of farmers at every stage', said Prof. De Silva.

The project culminated in a final national workshop in Long Xyuen City 23-24 November to discuss the project findings with key stakeholders including farmers, policy makers and extension specialists related to the catfish sector. The workshop finalised the better management practices after considering an analysis of the on-farm trials and discussing the performance improvements. Key findings of the farm trials, presented by Can Tho University's Dr Bui Minh Tam, included a reduction in FCR, improved water quality, reduced incidence of disease and an increased profit margin.

The Long Xyuen workshop was asked to evaluate the impact of the project and the better management practices for catfish farming. Participants were asked to vote on a series of questions presented on screen at the meeting by Ian Dreher, DPI Victoria. 46 participants cast their votes using small wireless voting machines about the size of a credit card, which allowed them to select from a number of options displayed on the screen. Votes were automatically tallied live by software and the results displayed graphically on screen. The results included:

- 66% of participants believed that implementation of BMPs had improved financial returns for farmers. Production volume had not necessarily increased but 91% believed that BMPs had reduced production costs.
- 91% of participants thought that BMP implementation had improved environmental management, including sludgement management (84%) wastewater disposal (81%) and chemical useage (81%).
- 77% believed that BMP implementation was increasing support from buyers and processors.
- 85% felt that farmers using BMPs were likely to progress to certification of their product in future, suggesting a complementary rather than competitive relationship between BMPs and certification.

Wireless voting machine used by workshop participants to evaluate the project and BMPs.

Farmer volunteers participating in the BMP trials are awarded certificates by the Vice Minister for Agriculture and Rural Development and Director General of NACA.

Participants in the Long Xuyen workshop.

'I want to make it clear that these BMPs are not the final story', Prof. De Silva said. 'They are simply the first step in improving catfish aquaculture practices and will evolve over time as the industry develops and the state of knowledge improves'. He stressed that the BMPs are 'not certification standards, although the approach is fully compatible with standards-based certification systems'.

Better management practices have proven to be very successful in the Indian shrimp farming industry, where NACA has been assisting the industry to develop improved science-based farming practices for around ten years. Mr N.R. Umesh, Director of India's National Centre for Sustainable Aquaculture gave a presentation on the key role that farmer groups have played in the implementation of BMPs.

'The formation of farmer societies has enabled small-scale farmers to coordinate water abstraction and discharge, stocking and harvesting, health management and other issues relevant to better management practices. Common infrastructure development has been made possible through these societies such as the provision of electricity to their farms. Farmers have been able to eliminate middlemen such as seed, loan and purchase agents because the society has enough market power to arrange contracts directly with hatcheries, banks and processors on behalf of the members', he said. 'They are able to set requirements in terms of how seed is produced and screened in order to assure its health status. They also now have access to policy makers'.

Mr Umesh noted that farmer societies are helping producers to meet market requirements. 'The society provides a mechanism for registering farms, improving food safety and traceability, social and environmental sustainability. It also facilitates certification, because the society can apply for certification and auditing as a group rather than each farmer having to apply individually. We are seeing increasing interest in BMP product from sustainability-conscious buyers'.

The formation of farmer societies/clusters had also improved market access for small-scale producers. 'Brand building for the produce is very important', he said. 'The societies have established a quality label and pool sales to jointly promote their produce. Linkages with buyers have been established. The societies also help members to identify market trends and adapt quickly'.

There was general consensus at the Long Xuyen workshop that formation of catfish farmer societies based around local farm clusters would be a key strategy to promote industry adoption and implementation of the better management practices. Speaking at the meeting, Madam Nguyen Thi Xuan Thu, Vice Minister for Agriculture and Rural Development said 'Small farmers need to band together and work together to achieve better products through implementation of BMPs. The Government of Vietnam will provide support to promote the widespread adoption of BMPs in the future'. A proposal to establish an institution geared towards helping the industry adopt better management practices was favourably received by participants, and is slated for consideration by the Ministry.

The workshop strongly requested a second phase of the project be developed focusing on industry adoption and implementation of better management practices. NACA and its partners have undertaken to develop a proposal in consultation with industry and government and to seek further funding in this regard.

The third edition of the BMPs are available for download from the NACA website at:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=193&lid=1023

For more information about the project and its outputs, please visit the project webpage at http://www.enaca.org/modules/inlandprojects/index.php?content_id=1.

9th Meeting of the Asia Regional Advisory Group on Aquatic Animal Health

The 9th Meeting of the Regional Advisory Group on Aquatic Animal Health (AG) was held on 8-10 November 2010 at Maruay Garden Hotel, Bangkok, Thailand. It was attended by 10 experts representing the World Organisation for Animal Health (OIE), Aquatic Animal Health Standards Commission of OIE, Food and Agriculture Organization of the United Nations (FAO), SEAFDEC, aquatic animal health experts from Thailand, Australia and the private sector (Intervet, Singapore), and NACA Secretariat. One co-opted member from Inland Aquatic Animal Health Research Institute (IAAHRI) also attended the meeting.

Current concerns and issues on aquatic animal health as well as on biosecurity and other health-related issues were discussed during the three-day meeting. These include progress reports from NACA and other partner agencies (OIE, FAO, SEAFDEC AQD, DAFF Australia, and IAAHRI Thailand), updates of aquatic animal diseases in the region, status of disease reporting in the Asia-Pacific, the list of diseases for QAAD reporting in 2011, status of WAHIS online reporting, certifications and standards related to aquatic animal health, and revision of the scope and terms of reference of AG. One of the recommendations that need immediate action was the current threat of Infectious Myonecrosis Virus (IMNV) currently affecting cultured Penaeus vannamei in Indonesia. One regional workshop on emergency preparedness to deal with IMNV threat in Asia Pacific and one-page Disease Advisory are planned for implementation/publication at the soonest possible time.

The AG, established in 2001 by the Governing Council of NACA, provides advice to NACA members in the Asia-Pacific region on aquatic animal health management. Recommendations of the AG provide guidance to governments in coordinating the implementation of aquatic animal health management strategies. The detailed report with recommendations will be circulated to Competent Authorities and National Coordinators/Aquatic Focal points in Asia Pacific and made available on NACA website in due course.

Trialling ocean temperature forecasts for fish farms

Marine scientists are trialling the first near-shore water temperature forecasts to assist Australia's aquaculture farm managers contending with rising ocean temperatures.

While land farmers have used seasonal forecasting for nearly a decade, marine farmers in south-east Australia have sought the technology for a region identified as a climate change hotspot, with rates of ocean warming up to four times the global average.

CSIRO Climate Adaptation Flagship scientist, Dr Alistair Hobday, said the project, funded through the Fisheries Research and Development Corporation, is a response to requests by Tasmania's four major salmon companies for short-term ocean forecasts for their farm sites.

"Marine farms in this region, particularly south-east Tasmania, want to use all available resources to ensure proper planning and response measures are in place to combat against the warmer summer months which can have adverse effects on fish performance," Dr Hobday said.

"While adaptation to long-term change is seen as important by the sector, dealing with climate variability exacerbated by ongoing climate change is a more immediate need.

"Our objective is to provide marine farmers with forecasts at their salmon farming sites up to four months ahead. This will enable management to consider a number of responses that will help maintain industry profitability in an uncertain environment. It should also help this valuable industry to come to terms with long-term climate change and begin formulating adaptation strategies."

Valued at $380 million annually, salmon production is one of Australia's major seafood industries.

The work will be detailed in Melbourne during the CCRSPI (National Climate Change Research Strategy for Primary Industries) Conference 2011.

The trials began in September last year, with forecasts provided to Tasmania's four major salmon farmers each month. Historical data back to 1990 and a seasonal ocean-atmosphere model developed by the Bureau of Meteorology are being used in the predictions.

An associated cost-benefit analysis of the predictions applied to each site also will be generated. The project involves trialling advanced statistical techniques to determine how well scientists can resolve the variations at the different time scales.

Dr Hobday said warm summers can significantly impact farm production through an increase in operational expenses and direct impacts on salmon, while cool winters slow growth in salmon.

He said validation of the forecasts using historical data is improving their accuracy and illustrating the likely benefits to the industry.

Global Conference on Aquaculture 2010: Publications

Dear Participants

On behalf of the Organising Committee we wish to express our sincere thanks for your active participation in the Global Conference on Aquaculture 2010, held in Phuket, Thailand, 22-25 September. We wish to keep you updated of the follow up activities from the conference so that you are able to access the vast amount of information that was generated by the conference:

- Audio recordings of the keynote addresses, plenary lectures, invited guest lectures and presentations of the thematic sessions and the discussions thereof are now available for download / online streaming from the NACA website at: http://www.enaca.org/modules/aqua2010.
- The Organising Committee has also decided to make handouts of the unedited power point presentations available for download in PDF format. We request that any material you may use from these presentations be cited as per the citation format suggested in the covering page. These are also available from the link above.
- The edited manuscripts for each of the reviews and presentations made at the conference will be published in both hard copy and electronic form. This will take some time, so please bear with us, but it is our intention to have this task completed in early-mid 2011. Participants in the conference will receive a printed copy free of charge when it becomes available.
- The publications arising from the conference will include: i) one that will include the regional and global aquaculture reviews, and ii) one that will include all the keynote addresses, plenary speakers, presentations and invited lectures, and (iii) the Phuket Consensus and the recommendations of the conference.
- Please feel free to contact us if you have any suggestions or observations on improving the dissemination of the material from the conference. Once again we would like to thank you for joining us in Phuket and participating in this important landmark meeting in the development of aquaculture.

FAO/NACA/DoF Thailand

Capacity of small holder ASEAN aquaculture farmers for competitive and sustainable aquaculture strengthened

The ASEAN Foundation supported project Strengthening capacity of small holder ASEAN aquaculture farmers for competitive and sustainable aquaculture has been successfully implemented by NACA in five ASEAN countries. The project was conducted between May 2008 and August 2010 in Cambodia, Indonesia, Philippines, Thailand and Vietnam. It assisted ASEAN small scale aquaculture farmers improve their livelihoods by being competitive in markets and improving farm management practices to deliver quality and sustainably produced aquaculture products.

The project accomplished the following key results:

- Capacity building needs of small scale farmers along five commodity market chains identified (Cambodia-Snakeheads, Indonesia-Grouper, Philippines-Seaweeds, Thailand-Tilapia and Vietnam-Shrimp), assessment report completed and disseminated to relevant national stakeholders.
- Considering the findings of capacity building needs, training of trainers (TOT) manual developed with special focus on development and implementation of better management practices, business skills, competitiveness and farmer group organization and functioning.
- TOT conducted and 18 master trainers from 5 ASEAN countries equipped with skills and necessary information to conduct national commodity specific farmer training programs.

- Five sets of draft commodity specific farmer training manuals (FTM) for small-scale farmers developed with special focus on better management practices (BMP), development of business skills and the mechanics of organizing and managing farmers' associations/groups.

- Farmer training programs conducted in 5 countries by national teams for 5 commodities to strengthen the capacity of farmers to organize and operate effectively self-help groups and adopt better management practices.

- Final regional workshop conducted to share lessons from the methodologies and results with other ASEAN countries.

- Recommendations from the workshop discussed and placed before the ASEAN Fisheries Working Group.

In summary, the project enabled better understanding of key capacity building needs of small-scale aquaculture for competitiveness along five commodity market chains, increased awareness and capacity of small farmers in group approach and BMP adoption, helped build capacity of servicing institutions, developed farmer training material, built awareness and capacity of small holder farmers and shared the lessons learned with all ASEAN countries. The project has helped to promote the concept of responsible and sustainable aquaculture in ASEAN. The lessons learned and experience gained strongly suggest that adoption of BMPs through group or cluster management approach is the gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities. The project has increased awareness about the concept of BMPs and cluster management in ASEAN. The momentum created needs to be sustained and where possible integrated with the national activities so that the project outputs are sustained. The project results and lessons learned will be relevant for future regional programs and national initiatives. The project results can be used by ASEAN governments and regional organisations (e.g. NACA, SEAFDEC, ASEAN, ASWGFi) to widely promote the concept of BMP adoption through cluster/group management approach in the Asia Pacific region. Considering the various issues identified, lessons learned and feedback obtained by different stakeholders at various stages during the project implementation, the following key recommendations are provided from the project:

- National governments should be encouraged to develop supportive policies and strategies for setting up of farmer groups/organisations so as to ensure empowerment of small scale farmers through collective action.

- National governments should be encouraged to support small scale farmers (farmer groups/clusters) to implement BMPs to comply with mandatory and voluntary standards so as to promote responsible and sustainable aquaculture.

- Regional organisations (e.g. NACA, SEAFDEC, ASWGFi and ASEAN Secretariat) should consider providing necessary platform and facilitation mechanism for strengthening the capacity of small holder ASEAN farmers to remain competitive and sustainable.

- A regional project supporting farmer group formation in ASEAN members and linking to major markets should be initiated as a follow up to the present project.

- National demonstration sites of farmers group with good BMPs adoption should be set up for creating wider awareness and scaling up the models at the national level.

- Exchange visits for farmer group across countries should be organised to share experiences.

- Other commodities of ASEAN importance should be identified and more explicit BMPs covering the entire supply chain developed.

- Attempts should be made to develop cluster/group certification systems (focused on food safety and sustainable aquaculture) in ASEAN to support small scale farmers.

- Commodity specific FTM developed under the project should be printed in English and other ASEAN languages and disseminated widely in the region.

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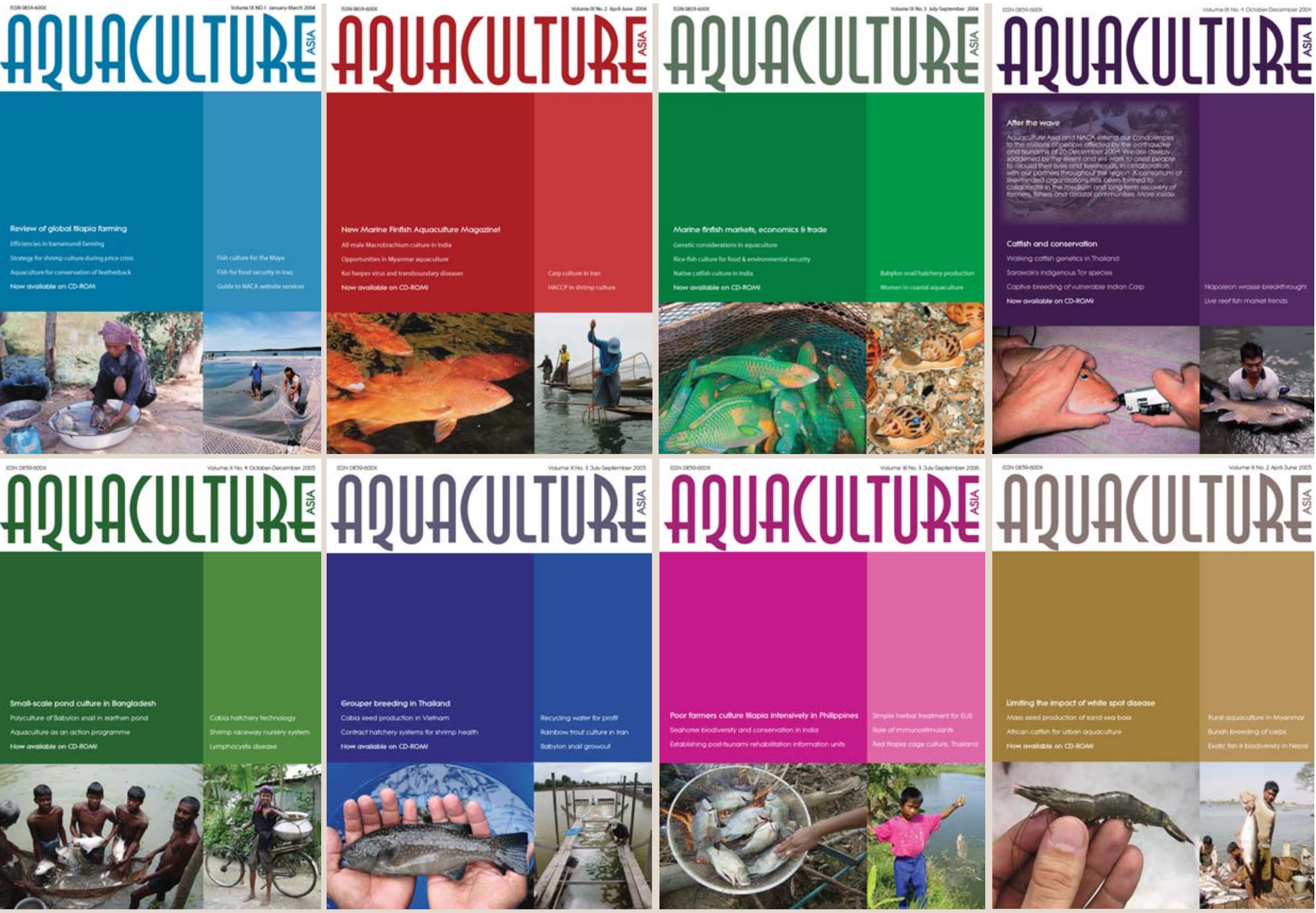
NACA is a network composed of 18 member governments in the Asia-Pacific region.

- As a long term goal, attempts should be made to establish ASEAN Fish Farmers Regional Network Forum to exchange experience and develop regional network.

All the project outputs are available for free download from NACA website. For further details about the project and possible collaborations please visit the project webpage at:

http://www.enaca.org/modules/bmpprojects/index.php?content_id=13



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AQUACULTURE 2010 Global Conference

All slides and audio recordings now published on conference website!

Have your say on the future of aquaculture development

With aquaculture now providing nearly 50% of global food fish supplies, FAO in partnership with NACA and the Thai Department of Fisheries, organised the *Global Conference on Aquaculture 2010*, to evaluate where the sector stands today and prepare for the challenges ahead. The objectives of the conference were to:

- Review the present status and trends in aquaculture development.
- Evaluate progress against the 2000 Bangkok Declaration & 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.

The presentations and complete audio soundtracks from the conference are now available for download from the conference website at the link below.

Enquiries and further information

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

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