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AQUACULTURE ASIA

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Magur seed production using low-cost hatcheries in India

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Research needs to sustain the aquaculture sector

The Canadian-based International Development Research Centre (IDRC) recently sponsored a workshop on Research Needs in Sustaining the Aquaculture Sector in Asia-Pacific to Year 2025 and Beyond. The workshop was held from 4-7 June in Thailand, with a cast of experts from throughout the region.

The primary objective of the workshop was to conduct a review to identify the main research issues and needs to sustain Asian aquaculture into the first quarter of the 21st century. Participants were invited to submit concept papers, which were circulated ahead of the meeting as part of the preparatory activities. Three country reviews were also prepared to document the status of aquaculture and its constraints for Nepal, Pakistan and Sri Lanka.

It isn't possible to run through all the research needs that were identified in just one page, but I've done my best to pull out some of the more significant researchable issues below, in no particular order:

- The economic and social costs of complying with international trade standards and mechanisms to help the small-scale producers characteristic of the region to adapt and remain competitive.
- Based on the successful development of better management practices (BMPs) for shrimp farming, development of BMPs for other major cultured species and work with farmers to facilitate the uptake of the findings.
- Genetic status aquaculture broodstock, development of improved management strategies and implications for seed quality.
- Review successes and failures in stock enhancement aspects of inland fisheries in the region and evaluate the impacts on diversity of wild genetic stocks, including potential introgression or dilution of the wild gene pool with hatchery reared stocks.
- Review approaches to management and community-based organizations involved in inland fisheries development, evaluate the successes, failures and lessons learned thereof and make suitable recommendations on policy changes.
- Production of genetically improved strains in order for aquaculture production to meet the rising demand for food fish supplies in the years ahead.
- The potential for aquaculture to provide alternative livelihoods in low-lying areas, given that climate change models predict an incursion of brackish water that will inevitably impact on land use patterns.
- Status, use and improvements in the quality of farm-made feeds with regards to traditional use of fertilizers, supplementary feeding and the increasing use of factory-made formulated feeds.

And of course, there was much more, this is just a taste of the discussions. The full report of the workshop will be made available on the NACA website shortly, www.enaca.org if you are involved in aquaculture research then I encourage you to download it and have a read.

Simon Wilkinson

AQUACULTURE ASIA

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Buffaloes in favour of culture-based fisheries in Sri Lanka

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Buffaloes wading in the water in large numbers is a common scene at non-perennial reservoirs of Sri Lanka.

During the reigns of the Sinhalese kings Sri Lanka was popularly known as the "Granary of the East" because of its high rice production. Throughout thousands of years of this history cattle and buffaloes were reared hand in hand with the agrarian community nourishing the nation. In these civilizations, 60–80 % of the population was involved in some form of agricultural activity. As developing countries, people in this region use cattle and buffaloes rather than machinery in each step of their agricultural activities. Other than this draft power for agricultural operations, cattle/buffaloes are a valuable resource as a source of milk, meat and hides. Also, within the agrarian community cattle/buffaloes have a sociological value as property, possessions and a readily available currency converter[1].

Cattle-borne fertilizers for agriculture and aquaculture

Another major output from the livestock that is seldom taken into account by economists is the faecal matter that can be used as an organic fertilizer. An adult buffalo produces about 4–6 tons of wet manure per year[1]. People in Sri Lanka conventionally use cow dung as a fertilizer for vegetable crops in chena (shifting) cultivation as well as for flower pots in their home gardens. Buffaloes help in each step of the paddy cultivation, so that paddy fields get automatically fertilized during the process. These droppings are rich with nitrogen (N) and phosphorus (P), the two major essential elements for plant growth.

Many countries have tested the applicability of cow dung as an organic fertilizer for fish culture in ponds. Adding cow dung results in an enhanced biological productivity and thereby increased aquaculture production. By now, animal faeces have become a conventional type of fertilizer commonly used in aquaculture systems all over the world. Farmers can add organic fertilizer either manually or through a self nourishing system introduced as "integrated farming". This usually appears as fish-cum-poultry farming or fish-cum-duck farming, by setting poultry/ duck cages over the fish ponds. Then the bird droppings directly reach water through the bottom lattice of the cages.

It is rather impractical to build a cattle farm over a fish pond. Instead, farmers can add cattle manure manually to

Draw down area of a non-perennial reservoir mottled with cow dung during the dry.

their ponds considering the nature of cultured organism, water quality and soil characteristics of that area[2]. In pond fish culture, farmers often use cow dung in combination with poultry manure and/or inorganic inputs. For rearing Indian and Chinese major carps the conventional manure dosage for pond fertilization may vary between 10–50 tons per hectare per year[3,4,5]. This can be an unachievable target with increasing pond size.

Cattle/buffaloes and culture-based fisheries

In culture-based fisheries, juvenile fish are released into a natural or a man-made water body relatively far larger than a fish pond and harvested upon reaching a desirable size. During the growth period fish feed on available natural food in that water body. If there is a possibility to manually fertilize the water body the harvest will be a rewarding one. The large size of the culture system makes manual fertilization impractical. However, if it is a non-perennial (seasonal) water body, which is smaller in size, and if there is a higher density of cattle/buffaloes grazing within the catchment the scenario would appear as an integrated farm setup. For example, an experimental introduction of grazers for a 10 hour period to a small catchment in New Zealand was reported to increase particulate phosphorus in the water 100 times as in the pre-grazing status[6].

Livestock grazing within catchments contribute a large amount of nitrogen and phosphorus through their faecal matter. The amount of phosphorus in cattle urine is low[7] but a remarkable amount of phosphorus is transferred to the soil via faeces[8,9,10]. It has been estimated that approximately 70% of phosphorus in feed concentrates of cattle is exported to land in excreta[11]. Nevertheless, when inundated, the nutrient release rate from dung is normally higher than that of submerged vegetation despite slight differences between that of different animal species[12].

Resources for culture-based fisheries

There are more than 12,000 non-perennial reservoirs in Sri Lanka scattered mainly throughout the dry zone. These rain-fed reservoirs are commonly known as seasonal or village tanks. These non-perennial reservoirs often do not exceed 20 hectares in area at their maximum capacity and dry out almost completely at least once a year. Throughout history, the agrarian society of Sri Lanka has been characterized by a “one tank–one village” ecological pattern[13]. Each village consisted of a non-perennial reservoir, paddy fields irrigated under that reservoir and the dwellings of the owners of the paddy lands. Many scientists have pointed out the suitability of non-perennial reservoirs for culture-based fisheries[14,15,16,17]. With onset of rain farmers can stock the reservoirs with fingerlings of Indian and Chinese major carps. As water is retained usually for 6–11 months table-size fish can be harvested by the dry season.

Every cattle / buffalo in the village grazes in the reservoir catchment and at least once a day wade in the shallow water. According to statistics of the Food and Agricultural Organization (FAO) in 2005 there were estimated to be 280,000 buffaloes and 1,150,000 cattle[18] predominantly in the same agricultural areas of the country. Therefore, village tanks get direct or indirect inputs of allochthonous nutrients (externally sourced nutrients) via cattle / buffalo urine and faecal matter. The resulting high nutrient levels favour algal growth, which is the main food item for culturing carps.

Survey

We carried out a research with a view to find out if there was any existing correlation between culture-based fisheries yield and associated cattle/buffalo densities in non-perennial reservoirs. As non-perennial reservoirs are most abundant in administrative districts of Anuradhapura, Hambantota, Kurunegala, Monaragala and Ratnapura we randomly selected 37 non-perennial reservoirs from those. We could record data on number of cattle/buffaloes associated with each reservoir from resource profiles in village authorities and Divisional Secretariat Division offices. To know the exact reservoir area we had to map the reservoirs by marking the geographic position with a GPS while walking along the shoreline at full supply level. Cattle/buffalo density (BD) was calculated by dividing their number by reservoir area.

With the help of farmer communities we conducted one fish culture cycle (of 6–10 months) during 2002-2003. The reservoirs were stocked with fingerlings of exotic species rohu (*Labeo rohita* Hamilton), catla (*Catla catla* Hamilton), common carp (*Cyprinus carpio* L.), bighead carp (*Aristichthys nobilis* Richardson), mrigal (*Cirrhinus mrigala* Hamilton), the GIFT strain of Nile tilapia (*Oreochromis niloticus* L.) and the indigenous species, giant freshwater prawn (*Macrobrachium rosenbergii* De Man). Stocking densities ranged from 218 to 4,372 fingerlings ha^{-1} and four species combinations were used.

Future of farmer communities with a happy harvest.

When the water level of reservoirs fell to 0.5 – 1.0 m in the dry season, all surviving fish were caught using a 5 cm mesh 62 m x 8.5 m seine net. The total fish yield was estimated for each reservoir. Since culture-based fisheries are a relatively a new phenomenon for the farmer communities of Sri Lanka we faced some socio-economic problems during the process. Poor organization in some farmer communities led to incomplete harvesting, poaching and false reporting of data on harvest. Therefore, we could make reliable estimates on total harvest only for 23 reservoirs.

The limnological condition of selected non-perennial reservoirs was closely monitored from November 2001 to January 2004 period. By sampling at the surface 0.3 – 0.6 m above the deepest point of each reservoir we measured about 13 major limnological parameters.

Those were water temperature, Secchi disk depth, conductivity, pH, dissolved oxygen, phenolphthalein alkalinity, total alkalinity, nitrate, dissolved phosphorus, total phosphorus, chlorophyll-a, and organic and inorganic fraction of seston weight.

Research findings

Five key limnological parameters best describe the variations in trophic condition of non-perennial reservoirs of Sri Lanka[19]. Those are Secchi disc depth, total phosphorous, chlorophyll-a, inorganic turbidity and organic turbidity. All five parameters showed significant correlations ($P < 0.05$) to cattle/buffalo density in the initially selected 37 reservoirs. Total phosphorous, chlorophyll-a content, inorganic turbidity and organic turbidity increased against cattle/buffalo while Secchi disc depth decreased showing the effect of cattle/buffalo density on reservoir productivity.

For the 23 reservoirs with a successful culture-based fisheries harvest, cattle/ buffalo density showed a significant positive correlation ($P < 0.02$) to the fish yield. In harvested reservoirs fish yield varied from 53 to 1801 kg ha^{-1}. And cattle/buffalo density varied from 1 to 216 animals per hectare. The reservoir called Dozer Wewa in Hambantota administrative district possessed the highest fish yield as well as the highest cattle/ buffalo density. The derived equations through these relationships can be utilized to predict culture-based fisheries yield by associated cattle/ buffalo density. Therefore, for fisheries management it is not necessary to measure chlorophyll content or other limnological parameters in which technical skills are essential.

Towards sustainable development

In comparison with other developing countries, Sri Lanka has attained living standard criteria such as maternal deaths at childbirth, literacy rates, basic education levels, longevity, etc. comparable to industrialized countries[20]. Nevertheless, still one fourth of the pre-school children suffer from malnutrition. Around 72% of the total population inhabit rural areas, with around 36% of the labour force engaged in agriculture, forestry and fishing. According to the Department of Census and Statistics, by 2002, 24.7% of the rural community was found to be poor and the Dry Zone districts had a high percentage of population below the district level poverty line[21]. On the other hand, a majority of the reservoirs that have fishery potential as a source of cheap protein and additional income, are scattered in these rural areas of the country. Therefore, among so many other benefits from the cattle/buffaloes, their importance to increase fisheries potential is worth consideration in our management strategies.

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Jayasinghe, U.A.D., Amarasinghe, U.S., De Silva, S.S., 2006. Culture-based fisheries in non-perennial reservoirs of Sri Lanka; Influence of reservoir morphometry and stocking density on yield. Fisheries Management and Ecology, 13, 157-164.

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Aquafeeds in Myanmar: A change from farm-made to factory-made feeds

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This article originates from a survey undertaken under the auspices of a NACA sponsored program on aquaculture related activities in Myanmar in March 2007.

Aquaculture in particular is a fast-growing sector in Myanmar. the small-scale farmers mostly utilize farm-made feeds made from locally available ingredients such as rice bran and ground nut cake. Myanmar is also experiencing a fast developing local commercial fish feed sector. All of the plants use locally available ingredients including fishmeal. There is a need to improve the quality of farm-made feeds as well as commercial pellet feeds. Feeding is often conducted through the use of feeding stations consisting of perforated polythene bags or mosquito netting suspended at the surface of the pond by use of bamboo poles. Feed in the bags are replenished on a needs basis, on average once or twice per day.

Aquaculture in Myanmar

Since 1988, aquaculture has been rapidly expanding at about 40% per year compared to only 5% for capture fisheries. In Myanmar, aquaculture is conducted in ponds which cover a total area of about 163,000 ha consisting of 48% freshwater fish ponds (mainly in the provinces of Ayeyarwady, Bago and Yangon) and 52% shrimp ponds (mainly in Rakhine state). Aquaculture in Myanmar is mainly confined to freshwater fish species such as Indian and Chinese carps, tilapia and catfish, freshwater prawn (*Macrobrachium rosenbergii*) and marine shrimp (*Penaeus monodon*). Aggressive efforts were recently initiated by the Department of Fisheries (DOF) to promote the culture of marine fish. There is huge potential for the development of the aquaculture industry in Myanmar.

Most fish farmers practice polyculture using Indian and Chinese carps, and more recently together with tilapia and *Pangasianodon* catfish. Farmers in Yangon and Ayeyarwady usually stock larger carp yearlings in various combinations with tilapia and/or catfish, depending on their experience and market demands. In more established farms catering to the export market, carps account for about 70% of the pond population together with 20% of *Pangasianodon* catfish and 10% Nile tilapia. Pond sizes are usually large varying from four to eight ha, and larger ponds are not uncommon. Monoculture of tilapia, catfish and freshwater prawn are becoming increasingly common. Monosex Nile tilapia is available for sale by private hatcheries (7-10 kyat/fingerling). Farm-gate prices of rohu (*Labeo rohita*) varies from Kyat 1,300-2,500/viss, mrigal (*Cirrhinus mrigala*) Kyat 1,200-2,200/viss, bighead carp (Aristichthys nobilis) Kyat 1,300-

Fish are sequentially harvested from large polyculture ponds, sorted by species, weighed and loaded onto ice trucks parked beside the fish farms in Nyaungtone, Ayeyarwady State.

Carps and tilapia are commonly sold at road-side markets in Yangon. Annual per capita fish consumption exceeds 26 kg in Myanmar.

1,800/viss, catfish (*Pangasianodon hypophthalmus*) Kyat 1,100-1,440/viss and tilapia (*Oreochromis niloticus*) Kyat 900-1,550/viss, depending on fish size (US$1 = Kyat 1,330; a 'viss' is a local unit of weight equivalent to 1.6kg).

Farm-made feeds

Freshwater finfish culture started in Myanmar in the 1950s and became popular in the 1980s. In 1989-91, a National Aquaculture Legislation was introduced and this sparked a rapid acceleration in the expansion of the aquaculture industry. Before 1990, cultured fish were fed exclusively with farm-made feeds. Ingredients such as broken rice, groundnut cake and rice bran (1:2:7 ratio) were cooked overnight in large woks and fed to fish as a moist mash. However, with increasing farm sizes and intensity of fish stocking in later years, it became a tedious task to cook the ingredients and many farmers resorted to placing rice bran and groundnut cake (4-5:1 ratio) directly into feeding bags made from mosquito netting and placed in ponds. Since groundnut cake comes in

Table 1. The total production of agricultural crops in Myanmar and the inclusion rates of its by-products in factory-made fish feeds.

Agricultural crop / product	Production in thousand MT (2004/05)	By-products for use in aquaculture	Price kyat/viss* (2007)	% in fish feed formulation
Cereals				
Paddy	24718	Rice bran	245-270	20-50
		Broken rice	316	-
Maize	784	Broken corn	340	-
Wheat	-**	Wheat bran	235	16-25
Oil seeds				
Groundnut	946	Groundnut cake	630-650	5-10
Sesame	539	Sesame seed cake	570	5-10
Sunflower	385	Sunflower seed cake	-	-
Soybean	165	Soybean cake/flake	640-680	5-10
Oil palm	-	Palm kernel cake	-	-
Canola	-	Rapeseed cake	400	5-20
Pulses				
Chick pea	3574			
Cow pea	130			
Toor whole	547			
Mung bean	778	Pea/bean powder	300-350	5-10
Black gram	899			
Others	823			
Other crops				
Cotton	195	Cottonseed cake	360-400	5-10
Cocunut	-	Copra cake	-	5-20
Cassava	-	Cassava by-product	150	-
Fishery products	-	Fish offal oil	1000-1400	0.5-4
		Shrimp meal	450-700	5
		Dried fish powder	500-1200	4-12

* 1 viss = 1.6 kg; ** = data not available or not applicable.

A large wok on top a charcoal stove used to cook feed ingredients.

Feeding bags are made from mosquito netting to concentrate finely powdered feed ingredients such as rice bran.

Farm-made feeds are air-dried and fed directly to fish as a moist mash.

A farmer using a small boat on the way to replenish the feeding bags put in place at various locations by long sticks in the large pond.

Ingredients are mixed in a large drum mixer for about 5 minutes and fed to fish immediately as a moist mash.

An on-farm grinding machine used to grind dried fish and groundnut cake.

Groundnut, rapeseed and sesame cakes together with dried fish, shrimp and fish offal oil are some of the locally available ingredients used in fish feed formulations.

hard compressed pieces, some farmers would soak this in water before mixing with the rice bran. Placing the ingredients in the feeding bags allows farmers to monitor feed intake and to replenish the supply as needed.

Based on limited interviews with aquaculture stakeholders, it is estimated that 50-60% of freshwater fish farmers are still using farm-made feeds in Myanmar at this time. While most only feed with rice bran and groundnut cake and do not use any equipment for feed preparation, some farmers were able to come up with their own feed formulation. A fish farmer (U Han Tin) in Twantee Township uses a mixer to blend rice bran, bean powder, groundnut cake, dried fish powder, cassava by-products and water at 4:2:1:2:1:2 ratios. A grinder is available on farm to grind the various ingredients into powder before mixing. He decided to use this formulation when he started introducing *Pangasianodon* catfish in his polyculture ponds.

Myanmar has 2,832 km of coastline facing the Indian Ocean, Bay of Bengal and the Andaman Sea together with vast inland water bodies such as lakes, rivers, reservoirs and flood plains covering about 8.2 million ha. It is not surprising that the fisheries sector plays an important role in the socio-economic life of Myanmar and together with the livestock sector contributed about 9% to the gross domestic product. Fishery production amounted to 2.6 million metric tons in 2006 with 22% from aquaculture, 25% from freshwater capture fisheries and 53% from marine capture fisheries. Fishery exports brought in US$360 million to the country.

Factory-made feeds

From 2000-2006, the export demand for cultured fish coupled with the culture of Pangasianodon catfish has increased the intensity of aquaculture production and many fish farmers are switching from farm-made to factory-made aquafeeds. Several large feed mills owned by the private sector have been established within the Yangon area (Htoo Thit Co. Ltd., Myanmar Resource Corporation, Armanthit Co. Ltd., Golden Myanmar Aquafeed Mill, Shwe Yi Win Co Ltd., etc.) and two in Mandalay (Sanpya Co. Ltd. and Manshin Co. Ltd.). There are five government-run aquafeed mills giving a total of about 26 feed mills in Myanmar. It is estimated that the current total aquafeed production capacity from these feed mills is about 2,800 tons per day even though the actual daily production is much lower, depending on demand. Only sinking pellets are produced at the moment but at least one feed mill is planning to purchase an extruder to produce floating fish feeds. The rapid expansion of the aquafeed industry is also fueled by the thriving marine shrimp culture which relies almost exclusively on factory-made feeds.

Feed ingredients and additives are vital to the successful production of aquafeeds. Of the 14 states of Myanmar, four (Kachin, Sagaing, Chin and Shan) are situated in the temperate region and this allows temperate crops to be grown. A wide variety of locally available agricultural by-products are used in the formulation of freshwater fish feeds (Table 1). This includes various by-products from cereals, oilseeds, pulses, roots and tubers. Myanmar also has plenty of marine fish for fishmeal production.

Pellets placed on top a plastic sheet. Both these methods allow the fish farmer to monitor the feeding behavior of fish and adjust feeding rates.

Agriculture is the number one activity in Myanmar and contributes 41% of its GDP. Paddy is the major crop planted with a total rice production of 25 million tons in 2004/05. Assuming a product fraction of 20% hulls and 7% bran from rice milling, an estimated 1.4 million tons of rice bran were produced as a by-product. It is not surprising that this valuable resource is greatly exploited in both farm-made and factory-made feeds. Oilseed is the second most important crop after paddy in the diet of the people of Myanmar. The edible oils traditionally consumed are groundnut and sesame oil but newer crops such as oil palm and sunflower production are vigorously promoted by the Ministry of Agriculture and Irrigation. Oilseed cakes from edible vegetable oil extraction constitute a valuable source of dietary protein for fish feeds. There are 17 varieties of pulses produced in Myanmar and the processing of these beans and peas for export gives rise to by-products that can be used in fish feeds as a mixed pea/bean powder. Small dried marine fish and shrimp are sometimes bought whole and ground to powder in the feed mill for use in fish feed formulations. Fish oil are obtained from fish offals from seafood processing plants or sourced on-farm from the perivisceral fat of harvested mrigal carps. A wide range of commercial feeds from fry to grow-out stage formulated specifically for carps, tilapia, catfish and shrimp using locally sourced agricultural by-products are available.

Since fish feeds produced are sinking pellets, some fish farmers have devised innovative feeding contraptions to ensure that they are able to monitor the right amount of feeds given. Feeding bags with large mesh size and trays made from plastic sheets are placed near the water surface at various locations throughout the pond using long sticks. Other fish farmers construct feeding platforms in the ponds and manually broadcast the pellets. Feeds are stored in direct sunlight on these platforms until fed. Since old habits die hard, some fish farmers place commercial pelleted feeds into feeding bags previously used for containing rice bran and groundnut cake. Since the net mesh sizes of these bags are small, fish can only consume the feeds after it disintegrated in the water and much of the nutrients leached out.

A feeding bag with appropriate mesh size to contain the sinking pellets.

Various types of feed ingredients are stacked up inside the feed mill and staff are specially assigned to keep rodents away.

The way forward

The rapidly expanding aquaculture industry in Myanmar must be supported by a vibrant aquafeed production industry. It is anticipated that more fish farmers will be changing from farm-made to factory-made feeds in the near future. Several recommendations are given here to further strengthen this growing industry.

Development of cost-effective farm- and factory-made feeds

More effective use of locally available agricultural by-products can be achieved by conducting research on nutrient and feeding requirements of the major culture species. For example, despite the wide use of rice bran and groundnut cake, no studies have been conducted on the use of these easily rancid and mycotoxin contaminated ingredients in aquafeeds. The potential wide variation in ingredient quality can affect aquaculture productivity. Teaching farmers how to make good quality farm-made feeds and proper feeding techniques are also important and this can be done by conducting training courses for DOF extension workers.

Government policies prohibiting or limiting the export of ingredients used in aquafeeds to prevent the rise of domestic prices and allowing the import of high quality in-demand ingredients can contribute to maintaining cost-effectiveness of factory-made feeds. At present, only feed additives and premixes are allowed to be imported.

National feed analysis laboratory

Most commercial feed mills do not have the expertise to set up analytical laboratories on site. The DOF has set up a Nutrition and Quality Indices Laboratory in Thaketa Township (Yangon) which caters mainly to checking the quality of dried fish and shrimp targeted for export. Despite the availability of modern equipment in this DOF laboratory, most aquafeed millers send their ingredients and pelleted feeds for analysis to the Veterinary Assay Laboratory (Insein Township) which is under the direct control of the Livestock Breeding and Veterinary Department. Combining the equipment and technical personnel from these two government-run laboratories will greatly benefit the aquafeed industry as well as any future R&D projects in animal nutrition. Staff should be sent for specialist training since there are very few nutrition specialists in Myanmar and those qualified are often assigned to other job functions in departments deemed more critical.

Good Aquafeed Manufacturing Practices

Feed ingredients are stored stacked up in their original bags in the feed mills and some were observed to be moldy. Small whole fish are commonly laid out to dry on the floor inside the feed mills before grinding to produce fishmeal. Insect pests and rodents are not uncommon problems in such conditions. Under the Marine Fisheries Law No 9/1990, the DOF has issued a large number of directives on food safety for fishery products destined for the human consumer. However, there is currently no guideline for feed safety. Guidelines for good aquafeed manufacturing practices should be established to address sustainability and traceability issues. There is currently great interest among feed millers to improve on productivity and be informed of the latest technology in ingredient evaluation, feed formulation, feed technology and quality assurance. Government policies to ensure a more dependable and adequate supply of electricity to feed mills will definitely attract more investments in this sector.

Challenging myths about fish seed quality and potential benefits to the rural poor: Lessons learnt in Asia

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Setting the scene

Aquaculture has spread most rapidly where fish makes an important contribution to the diet and where natural stocks have declined or become less reliable. Traditionally, fish culture developed close to both a source of wild seed and a perennial water supply, but significant potential remains for aquaculture to contribute to the livelihoods of the poor in marginal, rain-fed areas of Asia. In this context fish are often cultured in water bodies that have a range of functions, further contributing to on-farm diversification. Poor availability of quality fish seed appears to particularly constrain adoption of aquaculture in such areas. Private sector traders typically provide the critical function of distributing seed from producer to customer, but where these linkages are weak or uncompetitive the quantity, quality and timing of seed arriving at the pond-side is inconsistent.

Over the past few decades, hatchery technologies that improve the control of fish reproduction have been developed and widely applied. China was first to apply such induced breeding technology more than 40 years ago, from where it spread to neighbouring countries. Such hatchery techniques have allowed greater consistency of production, and increased availability of seed outside of natural breeding seasons. Most fish seed hatcheries are small or medium scale enterprises operated by entrepreneurs who have learnt their business as employees, or through relatives and friends. Formal institutions, training farmers in groups, have also provided a critical stimulus in many areas.

In places where fish culture is already established, a cornerstone to further gains is the maintenance and upgrading of seed quality. Development and distribution of genetically 'improved' seed is commonly advocated but in practice most fish culture remains based on unimproved strains and species.

This lack of impact can be explained to some extent by the needs of farmers producing food fish being rarely sought or prioritised by those attempting to upgrade seed quality. Accessibility and availability of fish seed may be more of an issue for farmers in marginal areas, particularly those dependent on seasonal water for raising fish.

Efforts should be made to ensure researchers and promoters of aquaculture understand the constraints of producers and those of entrepreneurs in seed supply networks. Focusing on key species of aquatic animals that have clear benefits to poor should be a key priority.

There are two important areas to understanding the ways in which improving fish seed supply can benefit poorer people. The first is to understand how the public and private sectors have developed to date and to consider trajectories of change. Secondly, a better understanding of demand and the nature of the support required for improved seed to reach farmers.

After this we consider ways in which seed quality might be maintained through improved linkages between the major stakeholders and greater cooperation and information sharing within producer communities.

The private sector and the government

The increasing economic significance of aquaculture over the last few decades in Asia is reflected in the growing interest of private, government and non-government organisations (NGOs) in the sector. Understanding the current status of fish seed quality and supply requires an analysis of the changing relationships between these major stakeholder groups.

Government efforts to promote aquaculture focused on establishing hatcheries. The knowledge of controlled breeding techniques quickly spread to enterprising farmers, with hatcheries appearing in clusters close to government institutions. In these early stages of hatchery seed production the relationship between the government and private producers was close. Over time private sector hatcheries have developed and expanded, often rapidly in terms of numbers of practitioners and quantities of seed. A broader range of promoters including externally assisted projects and NGOs have supported this development. More recently there has been a tendency for these linkages to weaken and a lack of clear strategy and poorly targeted resources has undermined relationships between stakeholders. Attempts to upgrade or even maintain seed quality are frequently ineffective; even if government institutions research improved strains and production technologies there is little capacity to deliver them. NGOs have focused on promoting food fish farming, often on a limited geographical scale, rather than supporting quality seed production per-se.

Projects have had real impacts in many parts of the region, but their influence is now declining rapidly due to the increasing role of commercial and other interests.

Understanding demand and quality

Planners and policy makers often misunderstand the nature of the demand for seed among rural producers. This frequently results in misplaced priorities and poor development as illustrated by these examples:

- *Only commercial, often export orientated, aquatic crops are important.* This perception has resulted in missed opportunities closer to home where different species and strains that meet local needs remain undeveloped. This misunderstanding has been influenced by the success of the broiler chicken model in the livestock sector which has been widely introduced in countries in Asia. Commercial intensive production of broiler chicken tends to focus on meeting urban, or export, demand. Producers tend to specialise, be resource rich and entrepreneurial and situated in, or close to, urban areas. Limited purchasing power tends to impede domestic demand by poorer rural people; traditionally chicken was an occasional 'feast' food. In contrast a large variety of aquatic animals characterise everyday diets in rice growing areas. As aquaculture develops in rural communities and people try to supplement wild fish by culturing them, demand for seed tends to be for a variety of species and is relatively dispersed in nature. This dispersed pattern of fish seed demand for stocking contrasts greatly with intensive poultry monocultures around urban centres.

- *Demand for seed is either from subsistence or commercial producers.* In reality inland aquaculture in Asia is more complex than a simple dichotomy of subsistence and commercial practice. Although poorer subsistence orientated producers may typically seek to minimise seed costs, farmers producing primarily for the market may also seek to improve net returns by reusing their own seed or buying unimproved varieties at lower costs. In contrast, farmers in Northeast Thailand producing fish mainly to feed their families or to sell locally often preferred mono-sex tilapia over cheaper, local mixed sex fish. Introducing a new species or strain may stimulate change in attitudes and practice. For instance the introduction of improved tilapia to households in Northwest Bangladesh already producing common carp seed in rice fields on a subsistence basis accelerated adoption and commercialisation of seed production of both species. Increasing fish seed production for cash generation has become an attractive option, especially as household seed and food fish needs are also met.

- *Big fish are popular.* Yes, they are! But a large individual size of fish at harvest has become the main indicator of success for researchers and many promoters; perhaps these are perceptions of better off urban people. In reality a high yield of smaller fish can often bring more benefits to poor consumers, intermediaries and producers. Typically in poorer areas there is a larger market for smaller, cheaper fish. High densities of smaller fish thinned out regularly can improve cash flow, reduce risk to producers and enhance availability to consumers. The greater numbers of seed required in turn benefits seed producers and traders, many of whom are poor. Selection programs should focus on improving yields of small fish rather than enhancing individual growth to a large size at harvest.

- *All current seed quality problems are related to genetic quality.* The view of most national and international organisations is that the majority of seed quality problems are related to deterioration in the genetic quality of stocks. Many causes of poor quality, however, occur at the farm level or during distribution and are related to poor husbandry or management practices. Deterioration in genetic quality is exacerbated by poor management; recent research indicates important differences in the quality of stock available to farmers but relatively few can be related to genetic quality alone.

- *Establishing central repositories of improved broodfish will improve the quality of seed available to farmers.* If higher quality germplasm is available to commercial hatcheries it should not be assumed that it will reach the farm level through a 'trickle down' process. Limited pond area of private hatcheries and thus limited capacity to maintain and improve their own broodfish often reduces the impact of disseminating improved strains. Intense competition between producers typically leads to low prices for hatchlings, squeezes profit margins and further reduces incentives to invest in broodfish production. Changes appear to be happening in the hatchery sector in some parts of Asia, whereby smaller operations disappear and the larger better resourced operations survive and focus on quality.

- *Once you have introduced improved broodstock there is no further need to work at quality issues.* There are often unrealistic expectations of poorly resourced institutions to maintain and even upgrade the genetic quality of their fish. Highly trained staff and expensive facilities do not necessarily translate into successful breeding programs. In order to maintain high quality seed production, a well focused and motivated team with a clear understanding of basic good husbandry and management techniques is essential. This is possible in either the public or private sector but long term planning and commitment by both individuals and institutions is necessary. It is also important that 'quality' is understood as a process rather than a final product.

- *Quality of fish seed can be upgraded by improving techniques used by hatcheries and nurseries and through the establishment of standards and certification.* Formal and informal training has been an essential part of stimulating and establishing a vibrant private sector in Asia. Commercial seed producers typically remain interested in new knowledge but conventional training and extension has often been inappropriate and poor value for money. Typically seed producers now obtain information from a variety of sources especially through commercial channels and each other. Government and non-government promoters are usually constrained by a lack of resources and need to identify new roles focusing on strengthening links between research and the private sector. The development and introduction of quality standards should involve the producers themselves if they are to be widely adopted and effective.

Key issues to maintaining and improving seed quality and availability

Understanding the current priorities and needs of different stakeholders and improving communication between them is clearly critical to the maintenance and improvement of seed quality and availability.

If such positive linkages between producers and other stakeholders are to be sustained, they need to be beneficial. The cost effectiveness of conventional research and development approaches has often been poor but a range of different approaches have promise.

These include:

- Stimulating producer groups. These have developed informally and independent of formal government networks, often in response to a mutual need for information. Formalisation, regulation or unrealistic expectations of producer groups by their members or promoters can however, be counter-productive.

- Increasing linkages between producer groups and secondary stakeholders (e.g. seed traders) in seed supply and distribution through contract farming and vertical integration.

- Supporting action learning among stakeholders to enable practical lesson sharing.

- Supporting public-private partnerships making information locally available (e.g. communication centres, one stop shops supplying multiple rather than specialised rural services).

- Motivating researchers to better understand the reality of field conditions, including production and marketing. This would require better initial and ongoing training and better integration with career structures and rewards.

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Magur (*Clarias batrachus*) seed production using low cost hatcheries: A participatory approach in Dakshin Dinajpur District of West Bengal, India

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Magur, *Clarias batrachus*, is the most popular of the air breathing catfish and has a good market especially in the Northern part of West Bengal where it fetches a higher price than the major carps, owing to its good taste, nutritional and medicinal value. The fish is sold at more than Rs. 200 per kg in the market of Dakshin Dinajpur. The striking feature of this fish is that it can thrive even in adverse ecosystems such as marshes, swamps and derelict water bodies with low dissolved oxygen and high organic loads. It is generally cultured in ponds along with carps. Due to inadequate supplies of seed and suitable feeds, the culture practices of this fish have not yet received much attention. In West Bengal during rainy season, the magur migrate to low-lying areas and paddy fields to breed.

Due to the indiscriminate use of pesticides in paddy fields which are the main breeding ground of magur the potential to obtain seed from natural water bodies has become scarce. However, considering the presence of vast water resources in the form of unutilized and derelict water bodies in the state (i.e. 26,000 hectares), there is tremendous potential to culture this fish.

Regarding the growth of magur, it has been reported that it may reach about 20 cm length in the first year, 20 cm in the second, 30 cm in third and 33 cm in the fourth year.

We conducted an experiment in a hatchery owned by Mr Bisu Tudu to develop farmer proven induced breeding and seed production technologies for magur using a low cost hatchery in Dakshin Dinajpur.

A bird's eye view on Bisu Tudu – a progressive farmer

Mr Bisu Tudu, a 45 year old hatchery owner from Mahala village Panchayat (a group of villages) in the district of Dakshin Dinajpur, West Bengal, has contributed commendably towards fisheries development through his own effort. His pain staking trials and above all self confidence have earned him long awaited acclaim in ways move than one.

Bisu Tudu setup his fish breeding centre eleven years ago and after that he never look back. He has a compact farming unit comprising of brood stock ponds, hatcheries and livestock complexes. He possesses two running hatchery units and four brood stock tanks. The breeding effect was restricted to catla, rohu, mrigal, bata and bighead carps. But after the intervention of Krishi Vigyan Kendra (Farm Science

Bisu Tudu's hatchery infrastructure.

Centre), his interest was aroused to breed magur in a participatory mode, for the following reasons:

1. Dakshin Dinajpur district has high market demand for magur and magur seed.
2. The species is threatened due to indiscriminate use of pesticide.
3. Decrement of breeding ground of magur due to unavailability of rainfall, pesticide use and other anthropogenic activities.
4. Farmers could not culture magur due to unavailability of magur seed.
5. At present there is no other such magur hatchery in the district prevailing.
6. Provision for replacement of African magur (*Clarias gariepinus*), an alien species, on which Govt. of India has imposed a ban.
7. Involvement of rural youth in this cultural practices as a means of employment since magur has a high market value.

Materials and methods

Construction of the hatching trough

The low cost hatchery we have developed has two main structures – (a) a circular trough of 70 cm diameter made of cement and (b) a circular hatching ring of 70 cm diameter made of iron to which a nylon net is fitted and stretched. The fertilized eggs are spread over a circular net fixed inside the hatching trough and water is sprinkled over it through a perforated bottle of which one side has a water pipe/outlet and/or control taps. The tap water supply is essential, as this enables the adjustment of flow and oxygenation as well as allowing the controlled application of treatment to combat the spread of bacterial and fungal disease.

Breeding technique

A total of 1.5 kg of female and male magur were selected for 2 sets of experiment. The standard breeding technique developed by Central Institute of Fresh Water Aquaculture (CIFA) was employed with little modification. We used magur that were about one year old and weighing about 150 gm each. Males are easy to identify as they have elongated and pointed genital papilla where as gravid female are comparatively heavier having a round and bulging abdomen and reddish vent. The broodstock magur were placed in a cemented tank three months before the breeding programme was conducted.

Mature magur.

The fish were fed with the mixture of rice bran and mustard oil cake at the ratio of 1:4 at about 10% of body weight daily. For induced breeding both male and female fish were given a single dose of pituitary extract at the same time.

The dose was about 1.5 mg per fish. Hypodermic syringes with a small size needle (No. 24) were used to inject the hormone into the muscle of broad stock. We kept the injected male and female in two separate tanks. After 16 hours of injection, it was observed that the fishes were ready for stripping. The eggs were released by gently pressing the abdomen towards the vent, collecting them on a stainless steel pan. At the same time the milt is then added and mixed well with help of a feather followed by addition of water to activate the sperm. Earlier, the injected males were sacrificed to prepare a sperm suspension in clean water. The testis were dissected out and cut into small pieces with the help of small scissors and macerated in normal physiological saline (0.9% NaCl in distilled water) to prepare the sperm suspension, which was sprinkled evenly over the eggs followed by addition of clean water. Eggs and sperm were allowed to mix by gently moving the tray for 4-5 minutes. The fertilized eggs were washed thoroughly and transferred to hatchery specially prepared for the study. The unfertilized or dead (opaque/white) eggs were removed immediately to prevent fungal infection. On the fourth day we transferred the hatchlings to a rearing tank.

Operation of the hatching trough

Eggs of two female magur were spread on a circular net ring for hatching. The fertilized eggs were evenly spread on the surface of the nylon tied to circular cemented tank and a mild water current was maintained. A few clean weights were placed to keep the net submerged in the water. The eggshells and debris were removed periodically from cemented hatching trough. The three day old larvae fed with live plankton beginning on the 4th day.

Evaluation of the experiment

Altogether two trials were conducted on magur breeding using the small scale cemented hatching trough. The results showed that on an average about 5,000-6,000 eggs are obtained from a fully ripe female. The fertilization rate varied from 60-75% with an average of 68.5% where as the hatching percentage varied between 20 and 55% with an average of 36.5%. An average of 10.5% survival was achieved from spawn to fry stage with a maximum of 27%. Hatching time varied between 23 hours to 27 hours at a temperature range of 33-36°C.

The low hatching rate and survival of the magur seed produced in the hatchery can be attributed to several factors such as (a) plankton rich pond water used for magur breeding (hard water), (b) absence of aeration facilities (only water circulation was maintained), (c) delays in removal of egg shells resulting in deterioration of water quality.

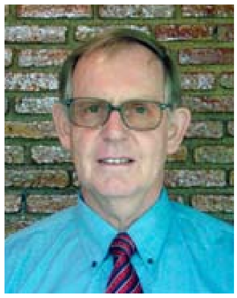
The maximum survival percentage from spawn to fry stage was 27% which was a good percentage in the village level production system, as this stage is regarded as crucial in magur seed production. Several experiments were conducted on magur breeding in West Bengal, where nearly any success has been obtained. However, this attempt

Continued on page 41.

Production of magur hatchlings in trough (circular cemented tank).

Peter Edwards writes on

Rural Aquaculture



World Vision promotes aquaculture for the poor in Northeast Thailand

Poor farming household earthen pond with cages to nurse fingerlings, Surin.

Close up of solar dried pellets.

Dr Edwards is a consultant and Emeritus Professor at the Asian Institute of Technology in Thailand where he founded the aquaculture program. He has over 30 years experience in aquaculture education, research and development in the Asian region. Email: pedwards@inet.co.th.

Background

The Northeast is the poorest region in Thailand. In spite of the country's rapid economic development, widespread poverty remains in the area, with large-scale temporary and sometimes permanent migration of people of working age seeking employment elsewhere in Thailand or abroad, leaving mainly children and older family members in the villages. The region has infertile soils, often sandy with low water holding capacity and a rather extreme monsoonal climate with annual floods in the wet season and a prolonged dry period in the hot season. Consequently, on-farm resources for feeding fish and the ability of shallow ponds to retain water are limited.

Fish comprise an important traditional part of the diet. As local fish supplies from diminishing wild fish and relatively limited aquaculture in the region are insufficient to satisfy demand, the price of fish is higher in rural than urban areas, providing a market opportunity for aquaculture. Urban areas are readily supplied with fish from Central Thailand through a well established road network but rural areas have a high unmet demand for fish.

The World Vision Foundation (WV) of Thailand is a humanitarian Christian organization with programmes in North-east Thailand to help the poor. Their approach involves the construction of community centres, the establishment of community-based cooperatives, child sponsorship, and training and education in practical skills, nutrition, financial management and income generating activities. Poor farmers are provided with credit so that they can avoid becoming heavily indebted because of high short-term interest rates charged by money lenders. The overall goals of WV's involvement in aquaculture are to increase the availability of nutritious fish for children and to create employment for poor farmers and increase their income through farming fish. Community cooperatives are assisted to become self sufficient over time so that WV is able to withdraw their support.

The WV aquaculture programme

The initial impetus for the WV aquaculture programme in Northeast Thailand was an Australian Centre for International Agricultural Research (ACIAR) funded project through the two WV community centres in Udornthani and Surin provinces with technical support and training provided by ACIAR and the Thai DoF. The aim was to establish individual household and community fish farms to improve food security through providing fish to consume by farming farmer as well as to provide income through sale of fish surplus to domestic need, and through sale of farm-made fish feed to other farmers in the area.

Considerable training in and demonstration of aquaculture to WV staff and farmers was carried out at the community centres with over 1,000 families now farming fish as a result of the project. Fish breeding in the WV community centres has produced over 200,000 fingerlings of hybrid walking catfish and tilapia which were distributed to participating farmers.

Farmers stocked fish in small earthen or plastic-lined ponds at household level or in larger community level reservoirs, the latter also containing floating cages. Low-cost farm-made feeds made from a mixture of local ingredients and ingredients purchased in Bangkok were produced at the two community centres for use by project farmers. Fish growth on this feed compared favourably with that on commercial feed from Bangkok. Manufacture and sale of pelleted feed is a significant income generating activity as the feed is cheaper than commercially produced extruded pellets and generates about Baht 4-6/kg (US$1=Baht 34 approximately). Commercially produced pellets are available locally but tend to be expensive and difficult for poor farmers to purchase. The strategy is to produce pelleted feeds on-farm or in farmer-based cooperatives using locally available feed ingredients.

Poor farming household plastic-lined pond, Surin. Photo courtesy Dr. Geoff Allan.

DoF staff demonstrating laboratory-scale pelleting during the workshop at the WV Community Centre, Surin.

WV plans to expand the programme to other provinces by integrating aquaculture into existing WV Area Development Programs in East Thailand (2 provinces), North Thailand (4 provinces), West Thailand (1 province) as well as an additional 9 provinces in Northeast Thailand. It has recently partnered with Aquaculture without Frontiers (AWF), an independent non-profit organization that promotes and supports responsible and sustainable aquaculture in the alleviation of poverty by improving livelihoods in developing countries. AWF in collaboration with DoF will provide technical support and help to run training programmes in fish nutrition and manufacture of low-cost feeds based on local ingredients; and on fish-hatchery techniques, particularly of monosex tilapia.

AWF also contributed to the development and delivery of an intensive 2 week Master Class on Aquaculture Nutrition held at the Asian Institute of Technology in August 2006 in collaboration with ACIAR, the Crawford Fund of Australia and several other supporting agencies and sponsors.

WV staff member demonstrating a small-scale 300 kg/day pelleting machine at the WV Community Centre, Surin.

WV staff member inside a small-scale solar pellet drying shed at the WV Community Centre, Surin.

Surin workshops

The basis for this column was an invitation to attend the Feed Manufacturing Workshop at the World Vision Community Centre, Surin in February 2007. A Tilapia Hatchery Production Workshop followed that on feed. Seventy one participants attended the two workshops, the majority of whom were WV staff but lead farmers and government extension officers also took part. The main aim was to provide WV staff who are actively involved in the WV Area Development Programs with an understanding of feed manufacture and hatchery techniques so that they will be able to guide their incorporation into activities within their regions.

The workshop comprised both formal lectures and hands-on training. Key topics were principles of aquaculture nutrition, potential feed ingredients, diet formulation, feed manufacture, feed management and storage, and feeding strategies. Lectures were presented concurrently in Thai by Dr. Mali Boonyaratpalin for farmers and in English (with Thai translation) by Dr. Geoff Allan for WV regional staff and government officers. Professor Jowaman Khajarern lectured on feed ingredient quality and assessment in Thai and I lectured on pond fertilization, natural food and integrated farming in English (with Thai translation). Thai DoF staff Ms. Montakarn Tamtin and Ms. Pitsamai Sonserb assisted Dr. Mali in practical sessions on laboratory-scale feed manufacture and World Vision technicians from the Surin Community Centre demonstrated small-scale (up to 300 kg/day) feed manufacture and solar drying. Laboratory and small-scale feed preparation both involved mixing and pelleting. Dr. Md. Akhteruzzaman formerly of the Bangladesh Fisheries Research Institute presented both lectures and practical sessions in the following Tilapia Hatchery Production Workshop.

Sustainability

The poor farming households selected to participate in the WV aquaculture programme have undoubtedly benefited by being trained and assisted financially, logistically and technically to farm fish for domestic consumption and sale. The major issue is the number of households that will be able to, or would wish to farm fish independently without subsidies so that aquaculture continues to contribute to their welfare.

Most farming households seek to maximize their income to achieve food security and improve their livelihoods. The question is to what extent is aquaculture an attractive use of farm resources, in particular in comparison to the opportunity cost of labour of household family members for other on-farm and off-farm employment opportunities? On-farm income generating activities are limited in Northeast Thailand with its poor resource base so aquaculture is an attractive possibility although the expanding economy of Thailand provides considerable competing off-farm livelihood options.

Some of the participating farmers with a better resource base who were able to dig relatively deep earthen ponds to store water for most or all of the year are more likely to develop aquaculture as a long-term activity than those who grow fish only in shallow, plastic-lined ponds. During the workshop in February I asked to be taken to visit a household with a plastic-lined pond but was informed that none still held water in the area – and the rainy season was still several months away.

Semi-intensive aquaculture is generally considered to be a more appropriate way for poor farming households to farm fish than intensive aquaculture as fertilizers and supplementary feeds are cheaper and more affordable and expose the farmer to less risk than relatively expensive formulated pelleted feed. However, as Northeast Thailand has such limited on-farm resources to fertilize fish ponds and feed fish, it is justified to explore the feasibility of using pelleted feed to promote small-scale farmer aquaculture.

A major thrust of the programme is the production of farm-made feeds to lower feed input costs and make intensive aquaculture more appropriate for poor farmers. The production of low cost feeds is a critical factor to economically viable aquaculture. At the start of the programme, the cost of commercially produced pelleted feeds were too expensive for farmers to use. The programme addressed this by surveying local feed ingredients, analyzing those considered suitable and then formulating least-cost diets using a majority of local ingredients. Manufacture was achieved using relatively simple small-scale grinding and pelleting equipment. A common constraint to the widespread use of such feeds is drying pellets for storage and transport in a monsoonal climate. The programme addressed this by constructing solar dryers. Experimental trials established that fish performed as well or better on the feeds manufactured on site by the programme staff than commercially available floating pellets. These feeds were also cheaper, even allowing for production costs.

It is possible that farm-made feeds will not be able to compete with commercial feeds once the latter become readily available in an area. The development of farm-made feed may well be only a transient phenomenon as shown by experience elsewhere e.g. many giant freshwater prawn farmers in Central Thailand made their own feeds in the early days of the development of the farming of this species but seldom do today in a mature industry well supplied with several commercial brands of feed. Once farmers successfully produce a significant amount of fish for sale, they may find it more convenient as well as

Cages in a reservoir at a community-based cooperative, Surin.

Dr. Akhterazzaman and a newly established tilapia hatchery at a community-based cooperative, Surin.

cost effective to purchase commercially available feed and use their labour for other activities, including expanding their aquaculture operation. However, provided profitable aquaculture is established, the programme will have achieved the overall objective of assisting poor farmers in Northeast Thailand.

One key challenge will be the long-term sustainability of farmer cooperatives which have a poor track record globally, and especially in Thailand where farmers are well known for their individualism.

WV is to be congratulated for helping poor farming households to alleviate their poverty through aquaculture. It is not easy to help poor farming households improve their lot through aquaculture or indeed agriculture as they face so many constraints. The WV programme is undoubtedly helping many families at least in the short term to improve their lot; and for some with better resources and entrepreneurial skills, aquaculture may well become a long term and sustainable activity and contribute in a major way to family welfare.

Cage fish culture and fisheries for food security and livelihoods in mid hill lakes of Pokhara Valley, Nepal: Post community based management adoption

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Subsistence and sport fisheries are practiced at different levels of intensity in all waters in Nepal. A large number of fisher communities living primarily along rivers, lakes and reservoirs depend on fishing for livelihood. The fishers use traditional fishing gear mainly for subsistence production, generating only marginal economic benefit. Nepal has some 103 ethnic groups (CBS 2003) and about 20 of these are traditionally wetland dependent (IUCN 2004). There were estimated to be about 80,000 such fishers before the 1980s (Swar 1980) but this had increased five fold by 2003, to more than 400,000 (Gurung 2003).

Harvested fish are often sold by the fisher community at the lakeside.

An ethnic fishing community known as “Pode” or “Jalari” live around lakes of Pokhara Valley and whose livelihoods are entirely dependent on fishing in these waters. The Pode community was deprived of traditional agricultural land, lacked other skills, jobs and income until the early 1960s. Most of them led a nomadic life moving between different water bodies, with cast nets being the only gear used for fishing. In the early 60s and 70s, when fish catch declined in lakes of the Pokhara valley due to over fishing, the only source of the Pode’s livelihood was threatened. A livelihood support program for rehabilitation for this deprived community through small scale fisheries and subsistence cage aquaculture was initiated in these lakes in 1972. In the beginning only a single cage of 50 m^3 capacity was provided for use in Phewa Lake (Gurung et al., 2005). Since then, cage aquaculture has grown at a steady rate and now up to 20,250 m^3 of cages in these water bodies are producing more than 80 tonnes of fish annually and supporting the livelihoods of 85 fisher families. This article describes the evolution of cage aquaculture and capture fisheries as well as changes in the lakes of Pokhara valley, through the participation of a socially marginalized fisher community. The livelihood outcomes of cage aquaculture and capture fisheries and their implications on nutritional, micro-economic and social nexus are presented.

Harvested fish from cages.

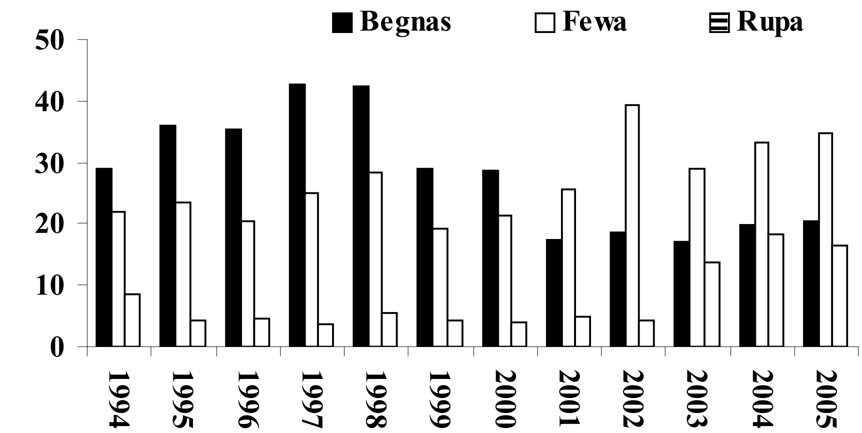
Pokhara has eight lakes of varying sizes. Among the lakes, Phewa, Begnas and Rupa are utilized for fish culture using planktivorous fish species, with cage fish culture being predominant in Phewa and Begnas and to a lesser extent in Rupa. Based on chlorophylla and phosphorous concentrations, these lakes may be characterized as oligo-eutrophic (Rai 2000; Nakanishi et al. 1988). Fishing is the main occupation of the low-income communities living around the lakesides. Cage fish culture, as well as fish culture in enclosures and fish stocking in open waters are common practices in these lakes. The planktivorous bighead carp (*Aristichthys nobilis*) and zooplankton feeding silver carp (*Hypophthalmichthys molitrix*)

Regular fish restocking is undertaken.

are commonly used in cage culture. In addition, rohu (*Labeo rohita*) are also stocked in cages, although in lower numbers as a cage cleaning agent. Fisher communities have recently begun culturing grass carp in cages using aquatic weeds available in the lakes as feeds and the practice is becoming popular. Grass carp (*Ptenopharyngodon idella*) culture in cages has dual benefits, helping to keep the lakes clear from proliferations of aquatic plants, and making use of a readily available low cost feed. Grass carp, bhakur (*Catla catla*), naini (*Cirrhinus mrigla*) and common carp (*Cyprinus carpio*) are used in polyculture in enclosure and in open water stocking. The annual fish yield was higher in Lake Rupa (223-445 kg ha^{-1}) followed by Lake Begnas (43-122 kg ha^{-1}) and Lake Phewa (30-59 kg ha^{-1}) during 1984/85 to 1993/94 (Rai and Yamazaki 1995). However, Lake Rupa is silting in due to land slides and erosion from surrounding areas, and is becoming covered with aquatic plants. If the siltation continues Lake Rupa will disappear entirely within 20 Years (IUCN, 1996). Presently there is no cage fish culture in Lake Rupa but enclosure and open water fisheries activities are being carried out by cooperatives of local farmers. However, Lakes Phewa and Begnas are still under cage fish culture. Fish growth rates showed positive correlation with water temperature and fish slightly lost weight in January when water temperature was below 16°C. Fish growth was better in Lake Phewa compared to Lakes Begnas, for example growth rate of silver carp (5.8 g d^{-1}) and bighead carp (4.7 g d^{-1}) were recorded in Lake Phewa when *Ceratium hirundinella* and *Peridinium* spp. were abundant in August through October (Rai 2000).

The accumulated nutrients, in part from human activity around the lake, are flushed out during heavy monsoons which helps control eutrophication. The important physico-chemnical features of the three lakes are summarized in Table 1.

Fish yield (Mt) from capture fishery in the lakes Fewa, Begnas and Rupa of Pokhara valley.



On the spot training in lake fisheries management to fisher community at Phewa Lake.

Community based cage fish culture and resource management

Children of fisher community heading for school.

Before the gill net seining was introduced in lakes of Pokhara valley around late 1960s, the fishery was subsistence barely supporting the livelihoods of the fisher community (Jalaris) living around the lakes. The fisheries used mainly cast nets for targeting indigenous fish species. The most common craft used were dug-out canoes. With the introduction of gill net initially fish catches increased and, after two years fish catches began to decline due to over exploitation of the fish resources and it became harder for fishers to sustain their livelihoods. The Fishery Research Centre of Pokhara (FRC) (formerly known as the Fishery Development Centre), was established in 1962 to improve the livelihood of poor fishers through sustainable fisheries and aquaculture development. Its relation with local fishers was strengthened in 1972 when the caged fish culture program was initiated with the cooperation of the Food and Agriculture Organization (FAO), the United Nations Development Program (UNDP) and Ministry of Agriculture and Co-operatives, Government of Nepal.

To organize the local fishers (Jalari) in a forum where issues of participatory fisheries management could be discussed, lake specific fisheries associations known as Phewa Fish Entrepreneurs Committee (PFEC) and Begnas Fish Entrepreneurs Committee (BFEC) were established in 1990. Rupa Fish Entrepreneurs Committee (RFEC) was transformed into Rupa Lake Restoration and Fish Farming Cooperative (RLRFFC) in 2001 by involving 325 households. The fishing operations were carried out on a full-time basis by most of the fishers in Phewa and Begnas Lakes while part-time fishing operation was carried out by cooperative members in Rupa Lake. Crop farming, especially during the rainy season; livestock raising and other non-agricultural business are the main alternative forms of employment in the Rupa Lake community.

The participatory approach of fisheries management refers to the customer-focused program where the targeted group participate in the entire process, learning the situation, identifying problems, discussing alternatives, selecting solutions, designing and implementing activities, evaluating and disseminating results (Gurung et al., 2005). In line with participatory natural resource management, at first the fisher families were trained to manage cage fish culture in the lake. Later, unsecured loans were offered for cage material and fingerlings (Swar and Pradhan 1992, Gurung and Bista 2003). The PFEC and BFEC later formulated a code of conduct for gill net operations, cage fish culture, marketing and loan repayment systems. The major strategies adopted in the participatory approach were community mobilization for resource management and conservation, and fish stock enhancement. In 2000, a womens group was also formed as a part of the association in Phewa and Begnas Lakes. This group has been found to be more practical and effective in measures to control illegal fishing during the monsoon season at the inlet streams in the lakes. It has been found that the traditional fishers do not indulge in destructive fishing such as use of electricity, explosives and poisons. These destructive fishing techniques are usually carried out by visiting urban people.

Decision-making and communication on fisheries management

The key partners in the participatory fishery management of the lakes of Pokhara valley included the fisher communities and government organizations. However, there are other stake-

Table 1. Physico-chemical characteristics of three the lakes of Pokhara valley, Nepal. Data from Rai (2000); Nakanishi et al. (1988), Rai et al. (1995).

Hydrological parameter	Lakes of Pokhara valley		
	Phewa	**Begnas**	**Rupa**
Elevation (meters above sea level)	742	650	600
Area (km^2)	5.23	3.28	1.35
Catchment area (km^2)	110	19	30
Mean water depth (meters)	7.5	6.6	2.3
Volume of water (m^3)	393.2 x 105	179.6 x 105	32.5 x 105
Limnological parameters			
Sechi disc visibility (meters)	0.95-3.5	1.0-3.6	0.9-2.25
Water temperature (°C)	15.0-29.5	15.0-32.0	14.0-30.0
Dissolved oxygen at surface (mg/L)	5.6-9.1	6.1-10.1	3.0-7.2
pH	7.5-9.3	7.7-10.1	7.2-8.6
Chlorophyll-a (mg/m^3)	2.0-22.83	2.88-52.8	0.6-17.0
Ammonium (NH_4-N) (mg/L)	0.0-0.39	0.0-15.8	0.0-0.07
Nitrite+nitrate (NO_2+NO_3-N) (mg/L)	0.0-0.24	0.0-0.26	0.0-0.22
Phosphate (PO_4-P) (mg/L)	0.0-0.06	0.0-0.02	0.0-0.03

Net cage installation with bamboo frame in Phewa Lake.

holders such as NGOs like Li-BIRD, Bhattarai Trust, Seed Foundation, Swarup Nepal, World Vision, Lions Club that are working in the development of the fisher communities, for example in removing aquatic weeds and providing support for cages and net material. The Fish Entrepreneurs' committee (FEC) for each lake conducts meetings once a month. Messages or issues tabled for discussion may include fisheries regulations, conflict resolution due to cases of fishing gear theft, loan repayments, control measures to deal with excessive aquatic plant growth, fish seed management, fund raising to improve the lake environment and conservation initiatives. Technical and extension messages from FRC and ADO are delivered at the meetings. Meetings are also called by FRC to discuss issues on technological advancement, general extension messages on fish processing, water hyacinth control and licensing of gears, the importance of participatory approaches to resource management etc. The meetings may also be held when there are some issues to resolve such as market arrangements during production surplus, designing a survey frame or when the FRC is organizing a meeting involving all FEC representatives in terms of training. Training is provided on an irregular basis on the spot when there are specific technical problems to resolve or when admitting new technologies.

FEC members participate in exchange visit programs organized by the FRC and extension offices to raise awareness. FEC members have been exposed to activities in Kulekhani reservoir, Kali Gandaki reservoir and Terai's wetlands. Fisheries management messages are sometimes disseminated through radio and articles in news papers. Aquatic biodiversity conservation campaign and world wetland day are celebrated jointly by FEC and Government offices to create mass awareness among public.

Cage fish culture-introduction and practices

Cage fish culture was first started in Lakes of Pokhara Valley in 1972 (Swar and Pradhan 1992). In Nepal, it is primarily restricted to traditional communities living nearby water bodies and people displaced by water development projects for sustaining their livelihood. Since the system is targeted at poor people, an extensive type of cage fish culture has been practiced using planktivorous fish depending entirely on natural food available in the water. Fish are raised for about one and half years to harvest for marketable size. At present cage fish culture activities are carried out with community participation in two Lakes; namely Lake Phewa and Lake Begnas of Pokhara Valley.

In the beginning several types of ready made cages were imported, but now local fisherman have started to weave their own netting of the desired mesh size and to tailor the cages locally. Ready made cages of mesh smaller than 25 mm are preferred for rearing fingerlings, while cage with larger mesh size (35-50 mm) are stocked with 80-100 g fish for grow-out. The nylon cages are mounted on bamboo frames, which also serve as a float and are anchored using stones as sinkers. The nylon or polyethylene cages have a life expectancy of more than 15 years. For cage fish culture, rohu (*Labeo rohita*) also stocked with bighead and silver carps as biological cleaning agent of fouling of cages (Sharma 1990). Besides the planktivorous carp, the grass carp is also cultured in lake Phewa. Fish are frequently checked in the cages for their condition including cage fouling.

The stocking density of fish varies with the trophic status of the lake. Usually, farmers get 2-3 g fry or 10-15 g fingerlings from a government hatchery. They first stock the fry at 20-100 per cubic meter in fixed or floating nursery cages with a mesh size of 5-15 mm. After they reach about 20 g fish are stocked at 8-12 individuals per cubic meter in a 25 mm mesh cage. After attaining 80-100 g the fish are transferred to grow out cages until they reach the harvestable size of 500-1000 g. Depending upon the type of plankton dominance and the market, stocking usually constitutes 60% bighead carp and 40% silver carp and vice versa. To grow from 5 g to market size of 500-1000 g takes about 12-18 months depending on the trophic status of water body. Periodic cleaning is carried by manual brushing in-situ or the cage is removed, brushed, washed, and sun dried. Fish in cages are not fed, and few diseases are reported from extensive cage fish culture. Since the cage is covered from all sides predator attacks (such as by otters) rarely occur. Farmers harvest fish from the cage in two ways: partial and complete harvest. In partial harvest only a certain number of selected fish are removed. In such cases, harvested fish are usually the largest or the least healthy individuals. Their removal reduces competition for food and thereby allowing small fish to reach marketable size faster. Harvesting unhealthy fish can also remove sources of disease. A complete harvest is carried out when overall production is planned and cages are immediately restocked with new fingerlings.

The productivity of cages largely depends on the nutrient and plankton status of the lakes. Cage productivity estimated at various times revealed that fish production rates in cages ranged from 1.3-5.0 kg/m^3 in lakes Phewa, 1.8-4.7 kg/m^3 in Begnas and 2.0-5.0 kg/m^3

in Rupa, respectively (Table 2). The total number of cages in the three lakes Phewa, Begnas and Rupa of Pokhara valley is 638 with a volume of about 23,700 m^3 and with an annual production of about 94.9 t with a mortality of less than 10% (Table 3). Women play the major role in cage fish culture in the fisher communities.

Table. 2. Change in production rate (kg fish/m^3/year) of fish from cage fish culture in lakes of Pokhara valley, Nepal.

Year	Cage productivity (kg/m^3/year)			Source
	Phewa lake	**Begnas Lake**	**Rupa Lake**	
1980	3.4	4.7	5.0	Wagle 2000
1985	3.4	4.7	5.0	Swar and Pradhan 1992
1990	1.3	1.8	2.6	Sharma 1990
1998	5.0	3.0	2.0	Wagle 2000
2004	4.2	3.0	3.2	Gurung et al. 2005

Table 3. Present status of private sector cage fish culture in Lakes Phewa, Begnas and Rupa of Pokhara valley, 2005.

Lake	No. families	No. cages	Cage volume (m^3)	Annual production (Mt.)
Phewa	55	470	16450	70.7
Begnas	33	76	3800	12.1
Rupa	26	92	3450	12.1
Total	114	638	23700	94.9

Open water fisheries and conservation of the resources

Fishing is the traditional occupation of "Pode" or "Jalari" community in Pokhara. Commercial capture fisheries using gill nets were widely adopted during 1960s in Pokhara valley (Rajbanshi et al. 1984). Since the gill net fishery could not be sustained without a well planned stocking program, restocking was initiated from 1977 for fisheries enhancement in Lakes Phewa and Begnas, which is based on both exotic and indigenous species. The fishery is carried out using gill nets of different mesh size up to 200 mm. Before the 1960s the fishery was more cast net dependent, later fishers started to use gill nets for off shore fishing. The main commercial species around 1960-75 were *Tor* spp, *Neolissocheilus hexagonolepis*, *Chagunius chagunio*, *Labeo dero*, *Labeo angra*, *Mastacembelus armatus* etc (Bista et al. 2002). Later after substantial decrease of the catch of these species, restocking of exotic species commenced (Shrestha et al. 2001) and after the introduction of exotic carps in these lakes, the yield of Chinese carps became dominant (Rai and Yamazaki 1995). Now, in the recapture fishery substantial contribution comes from the introduced species *Aristichthys nobilis*, *Hypophthalmichthys molitrix*, *Labeo rohita* and *Catla catla*. Although fisheries in these lakes exhibit inconsistency in landing, the highest catches recorded were 50.7 t and 42.3 t from lakes Phewa and Begnas, respectively (Wagle and Bista 1999).

Most days fishers fix gill nets in the lakes to trap larger sized fish at night. Fish production rate in Lake Phewa ranged from 0.1 kg/ha in 1985 to about 215 kg/ha in 2005. Gurung et al. (2005) reported even higher productivity of about 219 kg/ha in 2001. The productivity of Begnas Lake remains almost consistent between 90.7 kg/ha in 1994 and 92.6 kg/ha in 2005. Mean fish production rate from reservoirs in Asia was estimated to be 20 kg/ha/year (De Silva 1988) suggesting that Phewa and Begnas Lake are more productive than average Asian reservoisr.

There are 23 native fish species reported in Phewa Lake (Gurung et al. 2005) while Begnas Lake has 21 native species. The abundance of some fish has changed over time. For instance, *Channa* spp. and *Clarias batrachus* have appeared more frequently in the catches. Katle (*Neolissocheilus hexagonolepis*) populations have decreased noticeably. It has been reported that the total catches of the lakes of the Pokhara valley have increased substantially over the years (Wagle and Bista 1999), but there is evidences of decline of native fish species in terms of both catch and population diversity after the introduction of exotic species (Swar and Gurung 1988; Wagle and Bista 1999). Inter-annual variation in fish catch in these lakes might have attributed with the varied contribution of native species in catch and harmony of stocking program with non-recruiting exotic species. However, fisher communities in both lakes Phewa and Begnas have commenced conservation programs to restore native species to their original status in the lakes. The fisher communities have formed groups on their own initiative to patrol inlet streams during the breeding season (monsoon) of vulnerable species (eg. *Tor* species) and suppress illegal fishing (Gurung 2003). The community managed to restock fingerlings in the lakes annually.

The communities in close cooperation with other stakeholders have formulated and enforce the following code of practice:

- Fishing zone: Fishing in lakes by any means is prohibited within 100 m of the Ratna Mandir, FRC, the Barahi temple and the inlet stream Phewa Lake.
- Fishing methods: Fishing using explosives, chemicals and battery operated electric rods are prohibited. Fishing by hook and line, gill net, and cast net are allowed, except in restricted areas and monsoon seasons. However, gill nets with mesh smaller than 100 mm are not allowed in the offshore of the lake.
- Fish culture areas: Cages for fish culture can only be set at Khapaudi, in front of FRC and Sedi area of Phewa Lake, Majhi Kuna and Piple corner of Begnas Lake. Women's groups have also been mobilized, and they have proven more effective than their male counterparts at controlling fishing. Recently, the fisher community has also been engaged in manual removal of water hyacinth and other invasive macrophytes from the lake.

Marketing system for fish

Pokhara city is a traditional market for fish products. Only a small portion of the total fish production of Pokhara valley is marketed in adjacent districts and Kathmandu, mostly during winter when yield surpasses local consumption. In summer, when fish catch is low, fish is supplied to Pokhara from outside sources. The reason for localized marketing during summer is the fish demand in Pokhara sub-metropolitan exceeds the total production from these lakes. A multi-stakeholder body that includes PFEC, BFEC, the Fishery Research Centre, Agriculture Development Office and local fish-marketers determine the wholesale price of caged fish (Gurung et al. 2005). The respective committee (PFEC and BFEC) determines the turn for marketing each owner's fish. In order to secure the best price, many fishers deliver their product live.

Fish captured from lakes are collected mainly at Khudi of Begnas Lake and, Gai Ghat and Sedi of Phewa Lake. The marketing is well organized for fish products from the recapture fishery. The prices for the different fish species are determined at the tripartite meeting among the fisher community members, officials from fisheries office and contractors. A contactor can purchase only the fish caught from the lake weighing more than 2 kg. Other smaller fish captured from the lake are marketed by women fishers in local markets. The contractor collects the fish from fixed locations of the lakes every morning. The fish are brought at market places of Pokhara city and sold freshly.

The supply of quality fingerlings has became a major bottleneck. This was resolved when a fish hatchery was constructed in Begnas, Pokhara with the support of Japan International Cooperation Agency (JICA). The weakest link for sustainable fishery and aquaculture development is the input supply of twine and cage net materials in Pokhara. In the near future attempts should be made towards the development of a fishing and fish farming gear enterprise in the Pokhara area.

Table 4. Average yield and input in 40 caged fish farmers in lakes Phewa and Begnas, Pokhara Valley, Nepal, 2005.

Production parameters	Average of Lakes
Sample size (number of farmers)	40
Average holding (m^3 of cage volume)	135-250
Production cage	222.0
Nursery cage	73.0
Average yield (kg/m^3/year)	3.6
Stocking rate (No/m^3)	10
Survival rate (%)	>70
Harvesting size (g)	>500
Family labours (man hours/m^3)	1.87
Hired labour (man hours/m^3)	0.8
Investment in cage (NRs/m^3)	180.7
Investment in boat (NRs/m3)	20.4
Investment in facilities (NRs/m^3)	13.5
Cropping intensity (crop/year)	0.85
Farmers experience (year)	>12

Table 5. Cost, revenue and returns of fish in 40 caged fish farms in the lakes of Pokhara valley, 2005 (NRs 71= US$ 1).

Description	NRs/m^3	NRs/kg
Variable cost (fingerlings, labour, maintenance, interest)	31.04	8.65
Fixed cost (depreciation of cage frame, net material, boat and facilities, and interest on debt)	46.09	12.80
Opportunity costs (family labour, Interest on fixed capital)	54.54	15.15
Total costs	131.67	36.60
Gross revenues from fish sold	270	75.00
Returns		
Operating profit	238.96	66.38
Net income	192.87	53.58
Net profit	138.33	38.40
Rate of return to capital investment (%)	213.69	
Rate of return to total investment (%)	125.18	
Ratio of net profits to variable cost	445.65	
Ratio of net profits to gross revenues	51.23	

Economics of cage fish culture

Extensive cage fish culture with planktivorous carps was found to be more economical in Lake Begnas than in Phewa (Pradhan and Shrestha 1997), but over the years the status has reversed, perhaps due to changes in trophic status of the lakes. Economics of extensive form of cage culture, where stocked fish are fed natural food only, showed that the net return to total investment was 125.2% and average net profit generated was US$ 467.3 (27.3% of income) and US$ 252.4 (18.8% of income) for a fisher family with an average cage holding of 250 m^3 in Phewa lake and 135 m^3 in Begnas lake, respectively. Swar and Pradhan (1992) showed that net return of a five-cage system (250 m^3) would be feasible to sustain a fisher family but a recent study revealed that cage fish culture with planktivorous carps in the lakes of Pokhara Valley is feasible yielding a net benefit of NRs. 138.3 (US$ 1.94) per cubic meter with promising prospects for development (Tables 4 and 5). There is no cost involvement beside the nylon cage, fingerling purchase, and minimal labor, thus returns from cage fish culture may considered to be lucrative than other fish culture systems.

Livelihood outcomes

Cage aquaculture and recapture fishery made up more than 75% of the total annual income of the fishers (Table 6). However, the average income of fishers conceals the poverty of about 30%. The standard of living of a household depends largely on its disposable income relative to its size as well as on the availability of public services and social amenities. The disposable cash income is the sum of fishing, cage fish culture and non-fishing income earned by fisher's household minus taxes paid. Disposable household income of Pode families in Pokhara valley is not very different from total income because taxes are insignificant. Taxes ranged between NRs. 1988 in Begnas Lake and NRs. 2,581 in Phewa Lake (levy to respective FEC at NRs 2.0 per kg of caged fish and NRs 1.0 per kg of captured fish from open water to DDC).

Alternative or rather supplementary to income indicators of standard of living are the ownership of consumer durables and the private consumption expenditure. The preliminary results of a socioeconomic study of the Pode community revealed that the living standard indicated by access to a variety of social amenities and community services has improved considerably over the past three decades with the adoption of cage aquaculture and recapture fisheries management under the frame of community based fisheries management in the lakes of Pokhara valley. Most families (81.3%) now own their housing land in Phewa Lake, while 44.4% households of the fisher community in Begnas Lake became able to acquire housing land after the adoption of fisheries and allied business since 1980s. A remarkable change in housing facilities of fisher community has been seen in Begnas Lake i.e. most of the thatch roofed houses are converted into either concrete or tin roof. Differences in living standard of fisher communities in lakes Phewa and Begnas after 25 years of adoption of fisheries and cage fish culture are compared in Table 7.

The water supply for more than 90% household of fisher communities in 1980 was from spring and lake water or other similar sources. At present, over 90% households have access to piped water in both locations. Similarly, for cooking and lighting facilities, most household used fuel wood and kerosene during 1980. A significant departure was evident in terms of energy use in the forms of LPG gas and electricity in Phewa Lake. The fisher community in Begnas Lake, however, still relies on fuel wood for cooking, because of the availability of fuel wood at low cost from nearby community forest. Most families of fisher community have access to mass media (radio, television) and few also possess motorbikes.

With the increased income and improving livelihood, community members are able to send their children to school. The level of formal education (literacy-compulsory first five-grade) has increased to 46% and 41% in 2005 from 17% and 21% in 1980, for fisher community in lakes Phewa and Begnas, respectively. In both locations, a few have gone beyond high school graduate and some are attending university level.

Expenditure on food as a percentage of total household expenditure, known as the Engle's coefficient, is another important indicator of standard of living; the poorer a family or a nation, the larger is the percentage of expenditure that must go to food – at the limit, a very low income may be spent entirely for biological needs. As income rises, an increasing proportion of expenditure goes to other less mandatory items such as clothing, transport, and education. Improvement in quality of life for Pode community is also evidenced by the low value (<40%) of Engel's coefficient, with Begnas fisher highest at 37.9% and Phewa fishers the lowest 33.3%. Expenditure on food for fishers in Begnas and Phewa are about equal despite the considerable differences in total expenditure and even greater differences in income between the fisher communities.

Table 6. Production assets, proportion of annual income and expenditure from different sources of Pode fisher community, Pokhara valley, Nepal 2005.

Assets/Household	Phewa	Begnas
Experience in fishery and cage fish farming (years)	>13	>10
Boat, No./HH)	0.96	0.92
Gillnet, No./HH (322 m^2 each)	18 (2-50)	17 (5-35)
Cages		
Nursery cage, No/HH (23 m^3 each)	2.5 (1-8)	1.6 (1-4)
Production cage, No/HH (50 m^3 each)	5.3 (1-16)	2.7 (1-8)
Annual income (NRs.) /Household	126,848.0	99,522.0
Proportion of annual income (%)		
Cage fish culture	27.3	18.8
Capture fishery	54.1	60.9
Fish marketing	3.3	1.6
Employment and agricultural labor	6.4	9.6
Shop/hotel and farming	6.2	5.5
Tourism services	2.7	3.6
Annual expenditure (NRs.) /Household	80,786.0	76,891.0
Proportion of annual expenditure (%)		
Food items	50.6	49.1
Clothing	8.2	10.7
Education	10.5	7.4
Health care	6.7	8.1
Household amenities	12.8	12.8
Entertainment, transportation etc.	8.0	9.2
Taxes	3.2	2.7
Engle's coefficients (savings included in expenditure)	0.33	0.38

Table 7. Sociodemographic profile and change in living standard of fisher community in lakes of Pokhara Valley, Nepal 2005.

Indicators	Phewa		Begnas	
	1980	2005	1980	2005
Socio-demography				
Total household (No.)	47	59	31	39
Family size (No.)	4.3	5.1	5.6	6
Formal education (% population)				
Literate	17.2	46	21.2	41.6
High school	2.1	3.3	2.6	11.1
University	0	2	0	1.9
Working members as % of family size		56.1		54.0
Indicators of living standard (% HH)				
Housing land	62.7	81.3	0	44.4
Concrete & tin roof house	73.0	100.0	5.0	95.0
Access to potable water	8.0	100.0	0.0	93.2
Access to public health services	10.2	97.6	6.8	93.2
Use of water sealed toilet	0.0	21.8	0.0	10.1
Energy use (LPG gas and electricity)	3.4	94.6	0	53.8
Use of mass media (radio, television, papers)	5.8	83.2	5.6	75.3
Use of own automobile	0.0	10.2	0.0	7.7
Engel's coefficients		33.3		37.9

Major problems of the fisher community

The Fish Entrepreneurs Committees (FECs) cited a number of problems encountered in the community based fisheries management in lakes of Pokhara valley. These included:

- Poor access to quality fishing gear and cage net material in Pokhara valley.

- Fishing business is characterized by its seasonality and hence demands financial prudence in utilizing benefits while considering short- or long-terms. Viable investment measures and savings made in a fishing business could yield long term benefits. For this government organization should equip the fisher in money saving measures by encouraging and opening of a Finance Cooperative with training in business management.

- Lack of an enabling environment: Whilst responsibilities are with FECs in terms of resource management in major lakes of Pokhara valley, they are not legally empowered. The District Development Committee (DDC) reserves the property rights of these lakes. For the development of a community association and thereby self-regulation and a coordinated method for distribution of income and encouragement of fishery innovation, the users should be provided tenure over the resources so that the management systems and decision-making structures are centered in communities.

- Catastrophic fish mortalities have been experienced in cage culture facilities of Phewa Lake during the onset of winter (October-November) due to turnover of water column. FRC need to access a suitable and safe site of lakes where fishers' cages can be transferred in advance to save caged fish.

- Theft of fishing gear and fish from cages are common. Civic education may in long term assist to reduce the problem. It may be difficult to eradicate the problem as it is associated with behavior and attitude of individual fishers.

Conclusions and recommendations

Community based lake fisheries management in Pokhara valley was introduced to address the sustainability of livelihoods of resource users who were indigenous fisher groups operating traditionally the cheaper fishing gears and dug out canoes. Community based management programs that comprise socially deprived ethnic minorities can take a long time to become self-sustaining in the mainstay of the society. The cage fish culture and fishery management can only be sustainable if the income generated is substantial and adequate to support the involved families. The technology and management practices for cage fish culture and fishery management developed in the lakes of Pokhara valley has been applied successfully in the Kulekhani manmade reservoir. This model can be easily applicable in other large water bodies or manmade reservoirs in future.

The present status of fisher communities must be upgraded or at least maintained. Otherwise open access to the fishery resources and cage fish culture in lakes will lead to overexploitation of such resources and alternative sources of income are hard to find. Under such conditions, reduction of poverty in this sector calls for a general improvement of the environment under which the small-scale fisher community operates. The fishers lack incentives in the form of property rights over the resources and community management is unlikely to take off unless communities have rights over defined fisheries. Since the District Development Committee (DDC) charges tax on captured fish, long term informal property rights of fishing and aquaculture area of the lakes may be awarded to fisher community.

The levels of income and other indicators of well-being for fisher community have risen with the adoption of cage fish culture and capture fisheries. However, annual incomes are variable and irregular due to differences in catch and changes in lake productivity. In the present context, high levels of profitability from fisheries in lakes of Pokhara valley need to be transferred into a meaningful and realistic saving scheme for fisher community. Policy should be directed at educating fishers to perceive their incomes within a long term perspective. The lakes of Pokhara valley provide a substantial attraction for foreign tourists. Policy could aim at directing a part of fishers' saving into an appropriate sector of the tourist industry as there is little opportunity in the environment of fisher's village for investment other than the fishing and cage fish culture.

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Water hyacinth - a little known role and potential in aquatic ecosystems

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The water hyacinth, *Eichhornia crassipes* (Mart.) Solms under the family Pontederiaceae. It is also known as 'blue devil' because of its attractive lilac flower (Vietmeyer, 1975) and is found growing in many of the tropical and subtropical parts of the world (Holms et al., 1977; Gopal and Sharma, 1981; Ganga Visalakshy, 2005).

Water hyacinth was introduced to India as an ornamental plant about half a century ago, but unfortunately it quickly lost its charms and became a considerable pest (Gratch, 1965). It spreads prolifically in any nutrient enriched water body and also grows over and can obstruct a wide variety of wetlands including ponds, canals, channels, ditches, backwater areas, streams, reservoirs and lakes. Water hyacinth can reproduce vegetatively by means of runner. Although it also flowers, its vegetative mode of reproduction is generally far more effective than its sexual one. Its capacity to grow and reproduce is remarkable as its biomass (dry weight) increases in the range of 10-15 tonnes / hectare / year, far exceeding the recorded biomass yielded from any other terrestrial, marine or

Reservoir peripheral area covered by Water hyacinth showing luxuriant growth.

freshwater plants (Mohnot et al., 2005). Therefore its menace needs no further mention.

In spite of its disadvantages, which are well-known worldwide, water hyacinth is utilized for a variety of beneficial purposes. It has been used as a material for the manufacture of a range of different items including paper, fiberboard, yarn and rope, baskets, charcoal, biogas, animal fodder, fertilizer, fish feed and medicines. However, one important property of water hyacinth, which has not received the attention it deserves, is its role in improving water quality through removal of harmful and undesirable substances.

Role of water hyacinth in maintaining water quality – a case study

A reservoir of about 32 hectares located close to PPTI (Paradweep Port Trust of India) in Paradweep, Orissa, was being utilized for multiple purposes, including as source of drinking water to the limited inhabitants staying in peripheral area. They were solely dependent upon this reservoir because of its importance of a variety of uses to them. This reservoir, however, had no ongoing maintenance or special care arrangements until a survey team visited the place and observed that it was infested with water hyacinth along with a variety of other kinds of plants. The team found that water hyacinth alone covered more than 25% of the total area of the reservoir, and that other mostly submerged plants collectively covered about 30%, viz. *Hydrilla verticellata*, *Vallisneria*

Man holding uprooted submerged V. spiralis growing in the bottom of the reservoir.

spiralis, *Najas minor* and *Ceratophyllum demersum*. Emergent plants occupied only about 10% of the area, where they were found as sparse vegetation confined within small patches.

The water hyacinth remained restricted around the edges of the reservoir. Its biomass and density were measured and it was found to be constitute about 50 kg/m^2 (wet weight) and 40 individuals/m^2 water area. The proliferation of water hyacinth and other plants suggested that a huge quantity of nutrients were bound within the biomass of the reservoir ecosystem. However, the water was so clear that the bottom was visible even at depths of 4-5 m, which was thickly infested with submerged plants. The transparency of water body indicated a very low level of algal bloom. Other emergents that were growing in that water body include *Ipomoea aquatica*, *Jussiae repens*, and few *Cyperus* spp., and a small amount of free floating plants as; *Azolla pinnata*.

Effect of water hyacinth removal from the reservoir

One year later when the same team surveyed the area, again, they observed the reservoir to be in a substantially different state to the previous year. No water hyacinth was present and it was reported to have been removed. A huge blue-green algal bloom was present, and the transparency of the water reduced to less than 10 cm. The survey team observed that the bottom of the reservoir was choked with submerged vegetation covering the area. The water emitted pungent smell that worried the local inhabitants, who depended on it for their daily livelihood, and that could not be suppressed even with bleaching powder.

To investigate the cause behind it, the team collected samples of algal bloom even from the last point of supply: the water was pumped in and sent to a processing plant through a long pipe which was placed in the reservoir. The processing plant treated the water with bleaching powder at different points before making it usable for drinking.

The team analyzed the possible reasons responsible for reservoir becoming unusable based on comprehensive study pertaining to biotic and abiotic characteristics. The following observations were made:

Man holding uprooted submerged N. minor growing in the bottom of the reservoir.

- Earlier the water body had been covered with different types of plants, both floating and submerged, which played an important role in the ecology of the reservoir, none the least due to their substantial biomass and coverage of the water body. The removal of the floating plants, particularly the water hyacinth, would have a substantial impact on ecological balance of the system.
- The water hyacinth would have accumulated a very large quantity of nutrients in its biomass, released through the natural decay and mineralization of nutrients from aquatic plants and other organisms by microbes. The removal of water hyacinth discontinued this process, reducing competition for nutrients.
- The increase in available nutrients triggered a prolific growth of other, mainly submerged plants, and also lead to an increasing accumulation of organic detritus and nutrients on the bottom.
- Removal of the floating water hyacinth canopy greatly increased the penetration of light in the water column and to the bottom, further stimulating the growth of other plants and algae. This, combined with the higher nutrients, resulted in a dense blue-green algal bloom.
- Excessive deposition of dead and decayed plants onto the bottom transformed the soil surface into a rich organic peat-like substance, which was the source of the pungent smell.

Aquaculture – a possible solution for sustenance

The team studied the state of the reservoir and suggested a simple plan for restoration of the reservoir ecosystem and to increase its utility to local people:

- The reservoir required partial coverage with water hyacinth to 'soak up' and control excessive quantities of nutrients, thus initiating the process of restoration as before.
- The reservoir required some initial clearance of submerged plants by manual or mechanical means. This would check the massive deposition of nutrients and organic material that were being produced as a result of the decomposition of dead submerged plants.
- After completion of six months of those process, reservoir would require initial stocking of grass carp (*Ctenopharyngodon idella*), a herbivore, with an initial body weight varying between 350-500 g at a density of around 500-600 individuals per hectare. The large size of stocked fish would help avoid predation.

Submerged weed visible due to transparent water.

This process would help to restore the water body to its former state and increase the quality of the water. Upon reaching an appropriate state, the water body could then be stocked with Indian major carps to provide some additional income for local people making use of the water body for their livelihoods.

Conclusion

Any water body remaining fallow due to plant infestation is not an isolated phenomenon, rather is a common scenario prevalent in tropical and subtropical regions. Again, human interference to make it waste water body is also a common phenomenon. Gang et al. (1998) mentioned that India has about 1.5 million hectares of natural and about 2.6 million hectares of man-made wetlands, distributed in various ecological regions ranging from arid Rajasthan to wet Imphal and cold Ladakh to wet humid Southern India via the cosmopolitan climate of central India. They also highlighted that the large proportion of wetlands are seriously infested with aquatic plants. However, slowly and steadily, the necessity of restoration of fallow wetlands is increasing day by day with the rapid growth of the population. The entire fresh water culture depends upon them to meet the demand for protein rich food, which usually comes from fresh water fish. Even a 15 % revival of these fallow wetlands could result in a significant increase in the area available for fish culture in India. However, this revival is only possible through the concerted efforts of local populations in collaboration with scientific intervention. However, application of common sense along with keen observation and appropriate action altogether can help restore many water bodies to their previous shape, although making them usable for human purposes requires a specific plan. In this regard, aquaculture may be considered as a potential application that can make fallow water bodies not only usable but also profitable, through stocking of species such as grass carps, Indian major carps and the like. The above example indicates the need for monitoring of water bodies and that simple management strategies may be needed, and also indicates that in some circumstances plants, even 'weed' species, may play an important role in maintaining the balance of the ecosystem, or in restoring water quality.

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The effects of the application of different concentrations of trichlorfon on the survival and growth of the larvae and fry of Caspian kutum, *Rutilus frisii kutum*

Nasrin Choobkar

Trichlorfon (dimethyl 2–2, 2 trichloro-1-hydroxyethylphosphonate) is an organophosphate pesticide. A property of organophosphate pesticides is that they tend to degrade rapidly on exposure to sunlight, air, and soil, although small amounts can persist and end up in food and drinking water. Their ability to degrade makes them an attractive alternative to the organochlorine pesticides such as DDT, which can persist for long periods in the environment. Trichlorfon, as with other organophosphates, deactivates the enzyme acetylcholinesterase, which is essential to nerve function, as well as other enzyme systems that affect carbohydrate metabolism.

Trichlorfon is used in concentrations of 0.5 to 1 ppm to facilitate selective growth of zooplankton such as rotifer, that are desired food for larvae of kutum, a warm water fish of the family Cyprinidae, in order to eliminate predators such as copepods (eg. *Cyclops*) that may predate on larvae or interfere with live food production (Meister, 1992). Three to seven day old larvae of kutum (*Rutilus frisii kutum*) are typically introduced to ponds 24 to 48 hours after application of trichlorfon by spray (Faridpak, 1986).

There is a risk with the use of any pesticide that it will not only destroy pest species but that it will also have a negative effect on aquatic animals, for example fish, either by disturbing the food chain or by affecting desirable species directly (Hayes and Laws 1990), and exposure may also pose a risk to farm workers. One example is of a village in the southwest of Hungary, where consumption of fish from farm ponds where trichlorfon had been applied was reported to result in a higher incidence of abnormalities of the heart and lung, Down's syndrome and miscarriages (Svobodva et al,1998).
It is the long term effects of chemical exposure and residues within animals, such as on their fertility, fecundity, growth and health of offspring are the most difficult to observe.

Ecologic toxicology studies offer one way of assessing the effects of pesticides and other toxic materials on living animals, and provide guidance on the development of appropriate regulations on their use (FAO,1986).

Using of trichlorfon in concentrations ranging from 1.67 to 180 ppm in fish creates acute effects with some variation according to species (Pimentel,1971). However there are few references in relation to the effects of different toxins and their effects on fish, including kutum, a native Iranian species. Also in practice, the effects of trichlorfon in fish reproduction and farming workshops are only considered in the context of suitable concentrations to control *Cyclops* pests and generally not with regard to the long term effects on fish that may be later released into the environment.

The aims of my research into the effects of trichlorfon were to:

- Estimate the most suitable concentration of trichlorfon in the pond environment that would achieve pest control while creating the least negative effects on kutum larvae and fry.
- Introduction of suitable accounting mechanism for trichlorfon to ensure that consumption is more closely controlled.
- Determine the effects of different concentrations of trichlorfon on growth and survival of larvae and fry of kutum.
- Determine an appropriate time delay between application of trichlorfon to a pond and introduction of larvae and fingerlings, to allow for natural degradation of the pesticide to take place prior to stocking.
- It is worthy of mention that at the start of the trials, larvae were exposed to solutions containing different concentrations of trichlorfon within of period of 2 days from hatching. They were then counted and transferred to net compartments in earthern ponds. The fish were around 700 mg in body mass when placed into the compartments, and were grown for a period of 52 days with biometric assessment conducted every two weeks.

The study aimed to investigate the effects of application of trichlorfon in different treatments with concentrations of 0, 5, 1, 2, 3, 4, 5 and 10 ppm. The effects on survival and growth of fish larvae and fry introduced into treated waters at different times after trichlorfon application (24, 48 and 72 hours) was also investigated. This research was conducted at Ansari Aquaculture Center in April 2004,in Rasht province, Iran.

The experiment was conducted without use of flowing water and results were tested statistically using analysis of variance. In sampling fish from different treatments no differences were observed in studying exophthalmia of eyes, and the skin and fins appeared normal.

The results of the study show that application of trichlorfon reduces the growth of fish, with lower growth rates observed after initial exposure, with growth rate returning to normal later on. This effect was most marked in treatments with the higher concentrations of trichlorfon, in which growth rates remained depressed for longer. This may have been caused by negative effects on the nervous system and control of the acetylcholinesterase enzyme, resulting in reduced appetite and thereby reduced growth of the fish.

Russian scientists studied the growth rates of the bream *Abramis brama* after exposure to the dibrominaled contaminant dichlorvos. The first major effect detected was a significant reduction in the growth rates of the fish. Researchers believed this may have been due to the subtle neurotoxic effects of the pesticide and its effects upon the areas of the brain involved in feeding or food search mechanisms (Chiuko and slynko,1995).

Kimura et al (1971) found that exposure to a concentration 1.1 ppm of trichlorfon for 6 weeks in cherry salmon fingerlings *Onchorhyncus masou* caused decreased growth at the beginning of exposure later returning to normal rates and condition factor (length-weight) relative to the control. These results were similar to the results of our research, but also suggest that salmon is more sensitive than kutum.

There have been more studies on the histological and haemological impacts of organophosphate pesticides. In one study a concentration of 32.5 ppm of diazinon, another organophosphate pesticide, caused a significant reduction in the hemal erythrocyte, hematocyte and haemoglobin counts in common carp (Svoboda et al, 2001), and decreasing lymphocyte counts have also been reported (Svobodva et al,1998).

Nile tilapia *Oreochromis niloticus* exposed to lethal and sublethal concentrations of trichlorfon have been reported to show restlessness, excess secretion of mucus, convulsions, rapid body movement and difficulty in respiration. The 96-hour LC_{50} value computed from a probit graph was 21.7 mg/l. The erythrocyte counts, haemoglobin concentration and haematocrit value increased significantly whereas leukocyte counts declined after trichlorfon exposure. Values of mean corpuscular volume (MCV) were also changed. Levels of protein, triglycerides and cholesterol in the serum of exposed fish were decreased while glucose levels increased after pesticide treatment (Alkahem et al,1998).

Organophosphate pesticides enter the body of fish by the gills, food, water and skin. The signs of toxic effect in exposed fish depends on the concentration of the chemical, with effects including excited or irritated behaviour and decreasing appetite. Silver carp exposed to a concentration of 1 ppm of trichlorfon suffer a significant increase in hemal phosphorus and decrease in hemal protei, urea nitrogen and blood serum sodium concentration as their nutritional status declines.

The suggested concentration of trichlorfon required to control *Cyclops* is in the range 0.25 to 0.5 ppm, with the actual concentration applied depending on *Cyclops* biomass and water temperature (Jalali, 1987). Although this dosage may successfully destroy *Cyclops* a second issue is what is the minimum period of time to wait after applying trichlorfon before fish larvae may be safely stocked.

Significant differences were seen in the survival rate of larvae stocked at different times after application of trichlorfon. Our research showed that after application of trichlorfon it is better to wait at least 72 hours before stocking kutum larvae, as the natural breakdown of trichlorfon to less toxic substances by this stage greatly reduces the impact on larvae. Impacts on larvae stocked earlier were far greater, particularly after the first 48 hours when the effects, such as mortality and reduced growth, seemed to peak. It was clear that exposure to trichlorfon lead to lower survival rates relative to the control (no trichlorfon), particularly as concentration increased.

While there was an initial acute effect of larval exposure to trichlorfon the subsequent mortality and growth rates returned to normal, with no statistically significant difference between fish exposed to different concentrations by the end of the experimental growout period. Overall, total survival was still fairly high at 75% under the concentrations and post-treatment stocking times tested. More recent information on the toxicity of trichlorfon on kutum indicates that lethal exposure is preceeded by darkening of the body, loss of equilibrium and exopthalmia of they eyes, but none of these signs were observed under the conditions of the current study, ie. up to 10 ppm.

The lethal concentration of trichlorfon to rotifers is higher than 100 ppm and the resistance of advanced larvae of warm water fish is reported to be similar (Horvath and Tamas, 1976), so the experimental concentrations of 10 ppm are unlikely to have a serious effect on the survival rate of the fry. Of course the toxic effect on fish increases with increasing temperature, pH and hardness of water (Woodward &Mauck,1980). The lethal concentration LC50-96 hours in common carp is 27.5 ppm at 16 to 20°C. The lethal concentration LC100-2 hours is 50 ppm in Carassius at 19 to 22°C (Jalali,1987). Differences in the sensitivity of different species and variations in the parameters mentioned can change the acute poisoning concentration of the toxin from a range of 1.67 to 180 ppm (Pimentel,1971).

Stocking larvae immediately after applying trichlorfon produced very low survival. However, larvae that survived this treatment showed high growth rates compared to other treatments. It is likely that this was due to subsequent reduced competition.

The harmful effects of trichlorfon fall away rapidly as the substance degrades, and it is recommended that larvae should not be stocked for at least 72 hours after application of pesticide. Overall, trichlorfon is not dangerous if appropriate precautions, concentrations and pre-stocking delays are observed.

Further research

Additional research required to elaborate the toxic effects of trichlorfon pesticide on fish include:

- Estimation of appropriate concentration and application protocols for the safe use of organophosphate pesticides for pre-stocking pest control in warm water fish production.
- The histological and hematological effects of trichlorfon on laboratory held and farmed fishes.
- The effects of high concentrations of trichlorfon on the larvae of kutum and other fish species and inter-specific differences in the tolerance.
- The breakdown of the toxin to different substances and changes in toxicity with time.
- Further research on the appropriate pre-stocking withholding period following application of trichlorfon to minimise the risk of negative impacts on fish growth.

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Magazine

SKRETTING

Update: Marine finfish research and development at the Research Institute for Mariculture, Gondol, Bali, Indonesia

Sih Yang Sim, Ketut Suwirya and Mike Rimmer

The Research Institute for Mariculture Gondol (RIM Gondol), Indonesia, is renowned for its breeding success with mouse grouper *Cromileptes altivelis* and tiger grouper *Epinephelus fuscoguttatus*, and the development of 'backyard' hatchery technology. RIM Gondol continues to undertake R&D to apply this technology to other marine finfish species including groupers (*Epinephelus* and *Plectropomus* species) and golden trevally (*Gnathanodon speciosus*).

Hatchery-reared coral trout fingerling.

Coral trout *Plectropomus leopardus*

Currently, RIM Gondol is holding F1 coral trout for use as future broodstock. These fish are fed with an artificial diet developed by RIM Gondol – no 'trash' fish is used. The F1 fish are >600 g and are fed three times daily at 2–3% body weight per day. If the feeding rate drops by 50%, the broodfish may develop a parasite problem, particularly with the gills. Two treatments are used for parasite infestations: freshwater bath and formalin treatment. Freshwater baths for coral trout are limited to less than five minutes because coral trout are very sensitive to salinity fluctuation. Formalin treatment at 100 ppm for one hour is sufficient. Coral trout is very sensitive to fluctuations in water quality and need consistently good water quality, otherwise mortality is inevitable. Presently, the survival rate for coral trout in the hatchery is around 2–3%. The hatchery gate price in May 2007 for coral trout is about IDR 1,500 (USD 0.17) per cm.

Grow-out trials at RIM Gondol floating cages at Pegametan Bay have demonstrated high (90–95%) survival of juvenile coral trout (average 100 g body weight) after three months of the growth trial. The average body weight for these juveniles was 300 g after three months.

RIM Gondol has also started collecting *Plectropomus maculatus* broodstock since January 2007, but so far no spawning has taken place.

Golden trevally *Gnathanodon speciosus*

RIM Gondol has also succeeded in producing golden trevally using backyard hatchery technology.

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The survival rate from egg to 5 cm fingerlings (3 months) is around 5–10%. The broodstock average around 0.7–2 kg. Spawning occurs naturally and follows a lunar cycle. The hatchery gate price during May 2007 is IDR 600 (US$ 0.07) for 5 cm fingerlings. The fingerlings are weaned to artificial feeds in the hatchery. The demand for golden trevally is limited and fingerlings are only sold to fish farmers in Batam for grow-out. RIM Gondol is also conducting feeding trials for golden trevally in floating net cages. A comparison of a commercial feed and RIM Gondol made feed is currently under study. The stocking rate for a 1×1×1.5 m nursery cage is 40 fish at body weight of 40 g each. After two months of feeding trials, the fish had reached 100 g, and the survival rate was greater than 87%.

Above: *Juvenile golden trevally (larvae inset). Below: Juvenile coral grouper.*

Coral grouper

Epinephelus corallicola

Coral grouper is a new species for aquaculture in Indonesia. It is known locally as kerapu pasir ('sand grouper'). Broodstock are smaller than other cultured *Epinephelus* species, and are ready to spawn at 0.6 – 3 kg body weight. The largest broodstock available at RIM Gondol is around 5 kg. Broodstock mature at relatively small sizes (0.5–0.6 kg), and 1.5 kg fish are still female. Although the coral grouper now spawn every month at RIM Gondol, the eggs tend to have low fertilization rate. This may be due to the limited number of male broodfish available in the spawning tanks. As of May 2007, RIM Gondol is holding 50 coral grouper broodstock of which only 5 are male. Spawning normally last for 5 days and takes place before the full moon, which is different from the other grouper species that have been produced at RIM Gondol.

Survival rate from egg to 3 cm fingerling averages 5% with the highest at around 9%. The larviculture period from egg to 3 cm fingerlings takes about 45 days. This species is easier to culture as the cannibalism is lower compared to tiger grouper, and it more readily accepts artificial feed. Fertilised eggs of coral grouper sell for IDR 1/egg. The hatchery gate price for 3 cm fingerling during May 2007 is IDR 700 (USD 0.08), which has dropped from IDR 2,000 (USD 0.23) per fingerling in late 2006.

Feeding trials with artificial feed are currently ongoing. The stocking size is around 6 g, and stocking density for 1×1×1.5 m nursery cage is 100 fish. Survival rate is relatively high at around 80 - 97%. The sampling conducted at 2 months showed that the average body weight was around 15–18 g.

Tiger grouper

Epinephelus fuscoguttatus

The survival rates for tiger grouper from egg to 5 cm fingerling average around 10%. The hatchery gate price for 5 cm fingerling is presently IDR 800 (USD 0.09) /fish in May 2007. RIM Gondol is conducting weaning trials for tiger grouper fingerlings with artificial feed. Fish are fed between 6 am and 6 pm during the weaning trial period. Moist feed is fed every two hours while artificial feed is fed every four hours. The trial began with 4 cm fingerlings and after 2 month the fingerlings reach 12–15 g. The weaning process begins with 3 days of conditioning process where mysids are fed, followed by moist feed. Moist feed is mixed with the enzyme transglutaminase which binds the diet components. After one week, artificial feed is introduced to the fingerlings in the mornings. The juveniles can be fully weaned to the artificial diet in two weeks. Survival rate for the trials are relatively low at around 20–25%; cannibalism remains a major problem with hatchery and nursery phases of tiger grouper culture

Marine fish hatchery training for aquaculture technicians from the South Pacific Region, in Krabi CFRDC, Thailand

By Antoine Teitelbaum
SPC Aquaculture officer, www.spc.int/aquaculture

Between May 12 and June 2, 2007, a group of 6 Pacific Islanders, coordinated and mostly sponsored by SPC attended a training course on marine finfish hatchery techniques, organized by NACA. The group flew from Pacific Island Nations with representatives from New Caledonia, Papua New Guinea, French Polynesia and Fiji, to Thailand, at the Krabi CFRDC, in the Krabi province, where the 3 week course was held.

The focus of the training was on marine finfish hatchery techniques with an emphasis on grouper species. Tiger grouper (*E. fuscoguttatus*) was induced to spawn and the group followed up on larval rearing and larvae development for the duration of their stay in Krabi.

The training was a subtle balance of practical hands-on work, lectures on all topics relevant to grouper/tropical finfish farming aquaculture and field visits to government and commercial ventures of Southern Thailand (Satun, Songkhla, Krabi and Phucket Provinces).

Researchers from aquaculture centers from Southern Thailand gave lectures various topic ranging from health and disease, feeds and nutrition, to specific grouper culture or broodstock management. Together, 18 lectures of prime quality were presented to the SPC group.

Thanks to the very knowledgeable and helpful staff of the Krabi CFRDC, the SPC group gained tremendous practical knowledge on grouper culture, larvae handling and rearing which will, for most, have direct application to the developing finfish aquaculture in their respective island countries.

Overall, the group got to understand the constraints and the potential of developing Marine finfish and grouper aquaculture in the Pacific by witnessing daily exposure to success and achievement of their Thai counterpart in this venture.

Holding salinity during the breeding season affects final oocyte maturation and egg quality in sand bass (*Psammoperca waigiensis*, Cuvier & Valencienes 1828)

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Sand bass (*Psammoperca waigiensis*) is a commercial marine finfish present in coastal waters in Vietnam. Induced spawning with hormone injection and salinity stimulation has been achieved in captivity (Nguyen Trong Nho et al., 2003). It is said that this species can live in a salinity ranges from 10 ppt to 30 ppt commonly found in estuaries and coastal waters of Vietnam (Nguyen Trong Nho et al, 2003). However, there is no study on the influence of salinity on final maturation, spawning performance and egg quality to date. Salinity may have a profound influence on various aspects of fish reproduction, from the hormonal regulation of gonadal growth to the timing of spawning and embryonic development (Nguyen Tuong Anh, 1998). Unfavorable salinity may deteriorate to gonad development, inhibit the ovulation, delay in the timing of spawning and reduce embryonic survival (Moksness et al., 2004). In some marine finfish species, ovulation may be inhibited and egg quality might be reduced when the broodfish were exposed in low salinity. It has been proposed that processes associated with final oocyte maturation (FOM) and ovulation may be particularly sensitive to environmental factors (Moksness et al., 2004). Sand bass is a marine species living around coral reef and rocky areas in salinity of 25-34 ppt (Tamaki Shimose and Katsunori Tachihara, 2006). In this article, understanding the salinity experienced on maturity effecting on final maturation and egg quality of sand bass is examined to determine the implications for seed propagation.

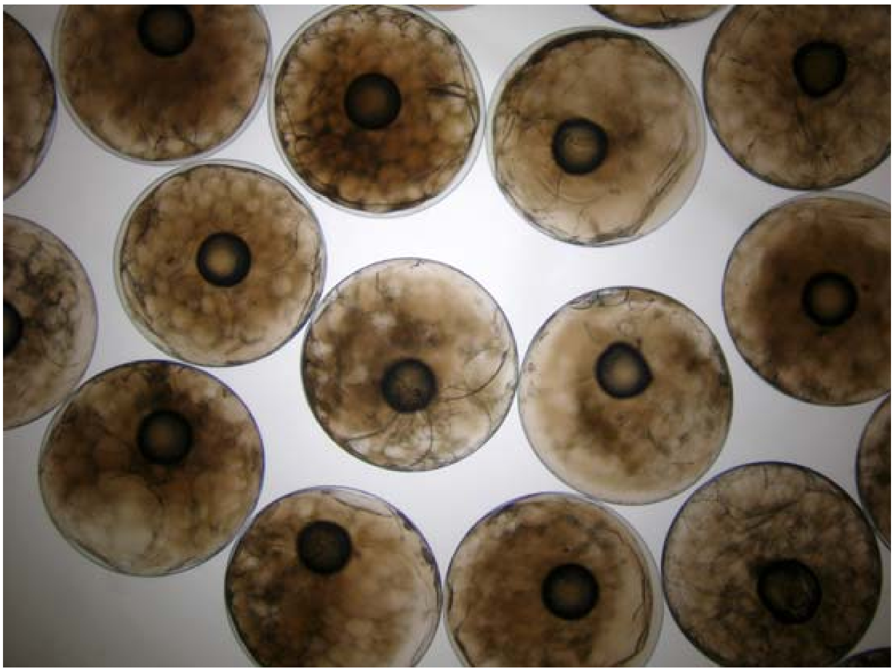
Materials and methods

The study was conducted in a backyard-shrimp hatchery at Nha Trang city, Vietnam. Three year old brood fish, hatched in late 2004, were kept in the ponds at a salinity ranging from 28-32 ppt before the experiments. On 21 February 2007, three groups each of 60 fish (sex ratio is 1:1) were distributed in concrete tanks. The holding density was 3 kg broodfish per cubic meter. Broodfish were daily fed of 3-5 % body weight with trash fish and once per week with squid. Vitamin E and C were also supplied once per week in order to help stimulation the gonadal development and maturation (Syamsul Akbar, et al, 2005). Water temperature during the experiments was maintained of 27-30°C and water exchange of 100 % was taken place twice per week.

The fish were anaesthetized in cold freshwater to measure weight, length and for stripping. Once each month fish were weighed to the nearest 0.1 g and had their length measured to the nearest 0.1 cm. Both males and females were anaesthetized for checking maturity. No hormone injection was used in this study. The fish was stimulated for spawning by exchanging water in the tank. Absolute fecundity (FA) was calculated from counting of egg samples (0.5-1 g) at stage IV (complete yolk formation), and relative fecundity (FR) calculated from the formula FR=100 FA.W -1 where FA is absolute fecundity and W is total weight of the female. Egg diameter (immediately after stripping) was determined as the average from measurements of 50 eggs under microscope equipped with micrometer. Fertilization rate was estimated by examining at least 50 eggs at the 32-cell stage. Eggs were cleared in a solution of glacial acetic acid and saline (1:20 v/v), examined under stereomicroscope and cleaved eggs were classified as fertilized (Tveiten et al, 2001).

Eggs were considered normal when cleavage was symmetrical, cells had similar size and cell formation was complete, whereas abnormal eggs were associated with irregular cleavage, poor cell formation with vesicular inclusions, and deformation of blastomeres (Kjørsvik et al., 1990). The proportions of eggs, which survived to the eyed stage, and until hatching, were assessed relative to the number of fertilized eggs. Hatching rate was possible to assess at the group level only. Hatching time was determined as the number of days from fertilization until 50% of the eggs were hatched.

The effect of different salinities on the ovulating females, fecundity, egg diameter and embryonic development

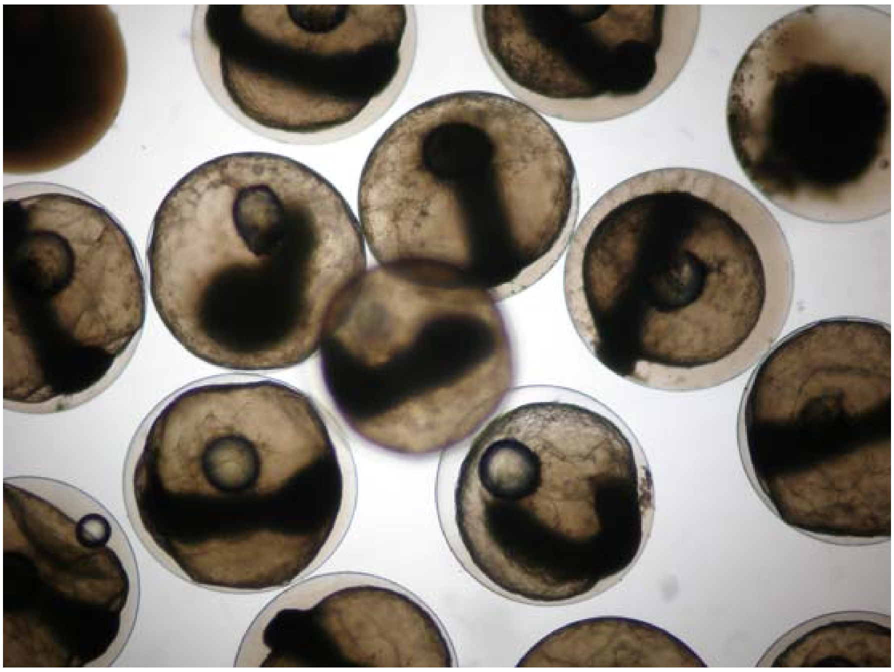


Sand bass egg.

parameters were assessed using one-way ANOVA. Treatment means were compared by least significant difference (LSD) at 95 % confident level. All computations were performed with SPSS 12.0 and excel software program. Values were expressed as mean ± standard deviation (SD).

Results

The present study indicated that holding mature sand bass in different salinities during the breeding season had no significant affects on final oocyte maturation and spawning incidences. The first spawning was observed on 8th of April for all groups after exchanging 100% water at night. During the period from April to May, no significant differences about number of ovulated females and males between the groups were observed. The inspection for ratio of ovulated females was taken every two weeks and the mean values were 30.14%, 32.26% and 29.17% for 10 ppt, 20 ppt and 30 ppt group, respectively (n= 40). The males were also checked for sperm at the same time with females and found that around 90% males (n= 30) in all groups reached final mature and gave sperm. The average weight of the females used in this study was from 296.7g to 313.5g and length ranged from 25.6 to 27.2 cm. No significant differences of batch fecundity and relative fecundity were found between groups as shown in table 1. Table 2 shows egg and larval quality when eggs were incubated at temperature of 28°C. The mean values were derived from five spawns.



Sandbass eyed stage embryo.

3-day old larvae.

Discussion

Sand bass held at 10 ppt salinity during the breeding season could spawn naturally, but no hatching was observed at the same salinity. This indicated that salinity limits for FOM or ovulation and subsequent spawning might be as low as 10 ppt, but embryonic development requires a higher salinity. The effect of salinity on embryo development and hatching rate suggests that in breeding season the brood fish spawn in a certain areas where the salinity and other parameters are favorable. The female can spawn in low salinity, but the quality or viable of larvae was negatively affected at salinity as low as 10 ppt.

Hatching rates were quite low, less than 50% in all groups and were somewhat lower than those compared with other studies (Nguyen Trong Nho et al, 2003, Syamsul Akbar et al, 2005). This might suggest that the observed differences were caused by poor male quality and /or water environmental parameters. In

Table 1: Some reproductive characteristics (mean ± S.D) of three year old female sand bass (*Psammoperca waigiensis*) exposed to different salinities during the breeding season.

Group	Weight (g)	Length (cm)	Absolute fecundity	Relative fecundity (egg kg^{-1})	Egg diameter (µm)	n
10 ppt	313.5 ± 3.2	26.3 ± 2.1	102,250 ± 230	326 ± 2.4	750 ± 25	11
20 ppt	305.2 ± 2.6	27.2 ± 3.7	116,421 ± 280	381 ± 4.5	770 ± 28	8
30 ppt	296.7 ± 4.5	25.6 ± 4.3	92,160 ± 195	311 ± 6.6	765 ± 31	8

the present study, the male size was quite small at about 80 to 100 g each, which gave a small volume of semen. Other reason could also affect the fertilization rate was ratio between male and female. The learning lesson that could be drawn from this study was that the ratio of spawners should be 2 males to 1 female to make sure sufficient sperm are available for fertilisation if the body size of males is smaller than females. Egg quality may be affected by salinity during the breeding season held in captivity. Sand bass can be easily induced to spawn through water exchange and respond shortly after treatment (Nguyen Trong Nho et al, 2003). The first spawning was observed in early April in all groups shortly after exchanging water. This implies that the fish in all groups were at the same stage of gonadal development such as the end of vitellogenesis, for example.

In fish, final oocyte maturation is controlled by the maturation inducing steroid (MIS) 17,20-dihydroxy-4-pregnen-3-one (17,20-P) (Nguyen Tuong Anh, 1998). This steroid may also be involved in FOM in sand bass. Ovulation is often mediated by prostaglandins (PGs) (Barannikova et al 2001). Therefore, further investigation should examine whether MIS and PGs are affected by salinity during the breeding season for this species. Further study might need to assay the steroid hormone concentration in plasma for the three groups exposed in different salinities. The observations from this study indicated salinity is a very important factor influencing on embryo development and hatching rate. Poor embryonic development and no hatching were observed at low salinity, suggesting that embryonic development and survival rate are influenced by the differences of salinity between inside and outside the eggs. Further study is needed to reveal the physiological mechanisms involved in these effects.

Table 2: Salinity effecting on egg quality (mean ± S.D) of female sand bass (*Psammoperca waigiensis*) exposed to different salinities during the breeding season.

Parameters of egg quality	Group		
	10 ppt	20 ppt	30 ppt
Fertilization rate (%)	15 ± 1.2 a	55 ± 2.2b	60 ± 2.4b
Survival to the eyed stage (%)	2 ± 0.4 a	34 ± 2.5b	48 ± 4.2c
Survival to hatch (%)	0	30 ± 2.6b	45 ± 3.3c
Survival to finished yolk sac stage (%)	0	12 ± 5.6a	23 ± 4.3b
Embryonic development duration (h)		17.5± 3.4	18± 1.4
Fertilized egg diameter (µm)	900 ± 40	850 ± 32	750 ± 22
Oil drop diameter (µm)	220 ± 20	240 ± 13	230 ± 16
Larvae length at 1-day old (mm)		1.77 ± 0.2	1.82 ± 0.2
Larvae length at 2-day old (mm)		2.33 ± 0.1	2.38 ± 0.2
Larvae length at 3-day old (mm)		2.40 ± 0.1	2.45 ± 0.4

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Rabbitfish *Siganus guttatus* breeding and larval rearing trial

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Rabbitfish (*Siganus guttatus*) has considerable aquaculture potential in Indonesia because of high demand and its increasing value. Domestic consumers prefer rabbitfish to other marine fishes because of its taste. Makassar (local) restaurants buy the fish for Rp.20,000–25,000 (US$ 2.30–2.85) per kilogram. The advantages of rabbitfish to culture include tolerance toward crowded conditions, ready acceptance of artificial diets, and its low trophic level which require less protein or inexpensive feed. Rabbitfish can be cultured in either brackishwater ponds or in marine floating net cages.

Currently, lack of seed supply inhibits further development of rabbitfish grow-out. Wild-caught seedstock are hard to access because they are found seasonally and in specific locations. A trial on rabbitfish breeding was recently carried out at a hatchery in South Sulawesi but this yielded a very limited number of juveniles (Lante et al. 2007). The effort to improve breeding and larval rearing techniques rabbitfish is reported in this article.

Spawner maintenance and gonad maturation

Thirty wild-caught spawners weighing >300g fish-1 were held and acclimatised in a 1.5 × 1.5 × 1.0 m^3 concrete tank at a female to male ratio of 2:1 and water exchange rate 150-200% day-1. Artificial diet containing 46% protein, 20% lipid, and 21.0 MJ kg^{-1} gross energy was fed to the spawners three times a day at 3-5% biomass weight day^{-1}. In addition, seaweed was fed to the spawners three times a week at 20-25% biomass weight.

Gonad maturation was accelerated with LHRH-a implantation at 10 µg kg^{-1} fish weight and canulation was carried out to check gonad development in term of Gonad Somatic Index (GSI). Chitosan oligosaccharide ascorbate, a source of vitamin C, was added to the diet at 3,000-4,000ppm to improve gonadal maturation performance and egg quality.

Spawning

Rabbitfish spawn at night from 23.00 to 03.00 just before full moon. Morphologically, the ready to spawn fish can be identified from swollen abdomen, loss of appetite, and continuous schooling movement. The fecundity of rabbitfish ranges from 245,000 to 500,000 eggs, depending on the size of the fish. The ripe egg diameter is in the vicinity of 550 µm. Peak spawning season in Southern Sulawesi is from September to November. The fertilized eggs need a substrate such as a net to attach to. The unfertilized eggs float or sink to the bottom.

Siganus guttatus.

Embryo development

Rabbitfish larvae were reared at 28–30°C. The development of the embryo is observable eight hours after fertilization; egg colour is blackish and filled with small bubbles. After ten hours, eight small and four larger transparent rings appear. After twelve hours, four large and many small types of foam appear in the centre. Heartbeat is observable fourteen hours after fertilization and becomes more visible sixteen hours after fertilization. At hour eighteen the embryo starts to move and the yolksac appears. Finally, at hour 20 the eggs hatch.

Larval development

The newly-hatched (day 0) rabbitfish larvae are transparent and 1.7 mm in total length. At day 1 after hatching, total length reaches 2.0 mm and the size of yolksac reduced. On day 2 (2.1 mm), larvae start to open the mouth and eyes, the digestive tract develops, and gills, pectoral fins and tail appear. The yolksac disappears. Three days after hatching the larvae begin to feed on exogenous food which fit the size of mouth opening such as *Nannochloropsis* sp; larval length at this time is around 2.2 mm. Because of the small mouth size, even small rotifers and oyster trochopores are too large for day 3 rabbitfish larvae to ingest.

Natural food production

Chlorella (*Nannochloropsis oculata*) cultured in concrete tank is used to feed rotifers and develop green water for water quality stabilization in larval rearing tanks. Rotifers are in turn fed to the larvae. Oyster trochopores are fed to the larvae at transition stage from indigenous to exogenous feeding. S-type rotifers (140-200 µm) are too large for day 1-6 rabbitfish larvae. In fact, the mouth gape of day 6 rabbitfish larvae is only 125 µm. Day 25 rabbit fish larvae can consume L-type rotifers as well as Artemia nauplii.

Table 1. Feeding scheme and water exchange rate applied for rabbitfish (*Siganus guttatus*) larval rearing.

Items	Age of larvae (days)														
	0	1	2	3	4	5	6	7	8	9	10	15	20	25	35
N. oculata		*	*	*	*	*	*	*	*	*	*	*	*	*	*
Oyster trochophore		*	*	*	*	*	*	-	-	-	-	-	-	-	-
Rotifers	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Artemia nauplii	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
Water exchange (%)	-	-	-	-	-	-	-	-	-	-	-	10-15	15-20	30-30	30-40

Larval rearing

Day 1 larvae were harvested from the spawning tank using 67-100 µm mesh size net and then stocked into 500 L fibreglass tank at density of 5,000-10,000 larvae $tank^{-1}$ or 10-20 larvae L^{-1}. Microalgae (*N. oculata*), SS-strain rotifers and oyster trochophores were fed before the yolksac was completely consumed, starting on day 1 (Table 1) and continuing to day 5. A combination of *N. occulata* and S-type rotifers was fed from day 5-24 larvae. Day 25-35 larvae were fed on the combination of N. occulata, L-type rotifers, and Artemia nauplii. The density of rotifers and Artemia nauplii in larval rearing tanks was maintained at 20 rotifers ml^{-1} and 2-3 nauplii ml^{-1} respectively. Survival rate of day 35 seed was very low, < 2 %. After 115 days of rearing the surviving juveniles were 12 cm total length and weighed around 50 g each. The preferred size of rabbitfish served in Makassar restaurants is 20-30 cm or 250-400 g weight. Presently, supply is only from wild-caught sources.

Current constraints

The main constraint faced in rabbitfish larval rearing is the availability of adequate size and quality of natural food for day 1-5 larvae. Appropriate feed should increase the survival rate and quality of the juveniles. A continuous and sufficient supply of hatchery-reared juveniles in turn would encourage fish farmers to develop rabbitfish culture.

Magur seed production using low cost hatcheries (continued from page 16).

Harvesting fry.

to produce magur seeds is presumably first of its kind where farmers hatchery using low cost village level hatchery technique been employed.

Future vista of the study

After trials, it was found that an ample number of fish farmers and hatchery owners felt interested to adopt the technology for magur seed production. This technology for magur breeding will help partially in meeting up the demand of seeds of the district. By this attempt and endangered fish species could be observed for future. Such field achievement will certainly evoke a greater diffusion of technology among farmers.

Magur fry are being nurtured in a small tank.

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18th NACA Governing Council held in Bali, Indonesia

The 18th meeting of the NACA Governing Council (GC) was hosted by the Government of Indonesia in Bali, 2-5 May 2007. It was attended by 75 people representing 15 member governments and one associate member. The GC is NACA's peak policy-making body.

The meeting was opened by the Hon. Minister for Marine Affairs and Fisheries of the Republic of Indonesia, Mr Freddy Numberi, and also graced by the Deputy Governor of the Province of Bali.

In his opening speech, the Minister noted the need to look to aquaculture as an alternative source of fish supply, given the current global trends in capture fisheries production, and in this regard Indonesia was quite fortunate to have large development potential for future expansion of the industry. He also noted, however, that many concerns needed to be addressed in order to ensure the sustainability and social acceptability of the aquaculture sector, and in order for aquaculture development to fully meet its potential to contribute to poverty alleviation, provide more job opportunities and spur economic growth, particularly in rural areas.

"I commend NACA's effort to promote sustainable aquaculture for food security and sustainable development in our region through cooperation among member governments. For many years we have been involved in numerous activities aiming to implement the NACA vision of promoting rural development through sustainable aquaculture, seeking to attain improved rural income, increased food production and foreign exchange earnings, and to diversify farm production where the ultimate beneficiaries are farmers and rural communities", the Minister said.

In addressing the meeting, Indonesia's Director General for Aquaculture, Dr Made, said "NACA has played

Delegates to Governing Council 18. Front row (left to right): Deputy Governor of Bali, Mr Freddy Numberi (Minister for Marine Affairs and Fisheries), Prof. Sena De Silva (NACA DG) and Made L. Nurdjana (Director General for Aquaculture, Indonesia).

a key role in promoting sustainable aquaculture development in our region, and has undertaken many aquaculture development programmes which have already provided great benefits to aquaculture development in Indonesia and in other member countries. It is my understanding that during our progress so far it has been proven that we have many common interests, and that cooperation with our partners in NACA is essential to establish a strong foundation for aquaculture in this region."

Professor Sena De Silva, the Director General of NACA, noted that "NACA also plays an active role, in facilitating bilaterally funded R & D programs, the foremost amongst this being the tripartite link between NACA, Indonesian Institutes - in particular the Directorate General of Aquaculture and the ACIAR and the associated Australian institutions. These programs have impacted very positively in sustaining not only Indonesian aquaculture but impacting on the whole region. NACA looks forward to a further strengthening of these links, some of which could possibly even lead to global initiatives such as in the case of the PCR calibration program, in shrimp farming."

"In essence NACA, in conjunction with the member governments and their institutions and supporting national, regional and international donor agencies, wishes to be pro-active in its approach; this strategy I believe is crucial to maintain sustainability of the sector, meet the increasing demands of consumers, exporters and so forth, all crucial in the coming years to sustain the livelihoods of small scale aqua farmers in Asia, the major supplier to the global seafood basket," he said.

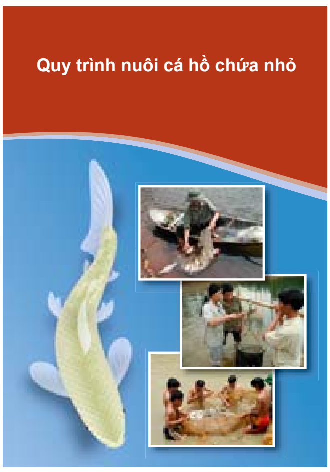
With regards to the NACA work programme, key themes in the discussion were:

- Strong interest was expressed in expanding the work on Better Management Practices for shrimp farming to cover additional commodities and countries throughout the region.
- Additional support was requested on addressing aquatic animal health issues, which are an ongoing concern.
- Support in the development of capacity in management of aquaculture broodstock in the interests of maintaining seed quality.
- Members requested support to address biodiversity issues.
- The Director General undertook to reinvest savings to create additional projects in other members for which it is difficult to obtain funding from international donors.
- The Governing Council introduced a policy of making use of the expertise available within members wherever possible, in line with NACA's mandate to build technical capacity amongst members.

The NACA Secretariat would like to thank the Government of Indonesia, Dr Made and his staff for their excellent arrangements and hospitality extended to all participants. We also look forward to the 19th Governing Council meeting, which will be hosted by the Government of Nepal in March 2008.

Strengthening Aquatic Animal Health Capacity and Biosecurity in ASEAN - final workshop

The final workshop under the ASEAN-Australia Development Cooperation Program's Regional Partnership Scheme (AADCP-RPS) project "Strengthening Aquatic Animal Health Capacity and Biosecurity in ASEAN" was held from 7-10 May 2007 in Bali, Indonesia, attended by around 20 government nominated delegates from 10 ASEAN countries and resource experts from AusVet, NACA, ASEC and other regional and international organizations. The workshop reviewed the progress made by ASEAN countries on the identified action plans of the 1st policy workshop held in April 2006, built consensus on minimum harmonization required within ASEAN and developed a way forward program for accomplishing minimum harmonization within ASEAN. This project supports the implementation of key elements contained in the FAO/NACA Asia Regional Technical Guidelines on Responsible Movement of Live Aquatic Animals. Further information about the project activities can be obtained from CV Mohan at mohan@enaca.org.



Vietnamese extension manual on culture-based fisheries

The Research Institute for Aquaculture No. 1 has produced an extension manual on culture-based fisheries in Vietnamese language, with technical assistance from Deakin University, NACA and funding support from the Australian Centre for International Agricultural Research. Get hard copies from RIA1 or get it from the NACA website, www.enaca.org.

Aquatic Animal Pathology Master Class

Pathology is in importance, at least first among equals, being the basis of medicine on which health management is built. An accurate appreciation of what is happening in the tissues will form the basis of health management and aquaculture medicine. Histopathology provides the simplest and easiest means of learning about interactions going on between the host and the pathogen at the cellular level. Through rational interpretation of histopathological findings, it is possible to arrive at conclusions on the pathogenicity mechanisms of pathogens, functional status of target organs, severity of a disease, cause of morbidity and mortality. Acquiring skills in histopathology requires considerable investment of time and resources. In view of the rapidly increasing popularity of rapid diagnostics including molecular diagnostics (e.g. PCR), the capacity for histopathology in the Asia Pacific region is dwindling at a phenomenal rate. This is alarming.

Recognizing the need to build capacity in aquatic animal histopathology, Australian Centre for International Agricultural Research (ACIAR) and Crawford Foundation have come forward to fund a 2 week master class on aquatic animal pathology, coordinated through the University Murdoch and the Department of Fisheries Western Australia. The master class will be conducted in Bangkok, Thailand from 12-23 November 2007. Murdoch University and Department of Fisheries Western Australia, AAHRI in Thailand and NACA will collaborate in implementing the master class. The master class will focus on training candidates in reading and interpreting slides to understand normal histology, pathological process, tissue pathology, disease case studies, artifacts, etc.

From the region 15 candidates will be supported for the master class. Support includes air travel in economy, accommodation and DSA for the duration of the master class. Target countries include Thailand, Cambodia, Vietnam, Myanmar, Singapore, India, Indonesia, Malaysia, Bangladesh, Sri Lanka, Nepal, Pakistan, and Philippines.

New project: Culture-based fisheries development in Lao PDR

The MOU between the Department of Livestock and Fisheries, Ministry of Agriculture, Lao PDR, NACA, Deakin University and Australian Center For Agricultural Research (ACIAR) for initiation of the project FIS/2005/078, “Culture Based Fisheries Development in Lao PDR”, funded by the latter (ACIAR), amounting to A$398,000 was completed in Vientiane Capital, on 23-May 2007. This three year project will involve research into the development of community based and managed culture-based fisheries in non-perennial water bodies of the flood plain areas and reservoir coves, in Vientiane and Borikhamxay Provinces, and will also include a major component of broodstock management of selected indigenous species to be used in the aquaculture activities. The project will also entail significant capacity building amongst Laotian researchers and provincial extension officers in relevant areas.

Photo (left to right): Prof. Sena De Silva (DG NACA), Dr Bounthong Bouahom (Secretary, Ministry of Agriculture & Forestry, Lao PDR) and Dr. Somphanh Chanphengxay (Deputy Director General, Department of Livestock and Fisheries).

Professor Sena S De Silva, DG NACA and Honorary Professor, Deakin University, Victoria, Australia, is the Principal Investigator and the Laotian component will be supervised by Mr. Bounthong Saphakdy, Chief technical Officer and Fisheries and Dr. Somphanh Chanphengxay, Deputy Director General, Department of Livestock and Fisheries. The project is also supported by the Department of Primary Industries, Victoria, Australia by providing the services of Dr. Brett A. Ingram to work on the breeding and broodstock management of selected indigenous species in conjunction with Dr. Thuy Nguyen of NACA, and Professor Uthairat Na-Nakorn of Kasetsart University, Thailand. The first mission of the team will start on 10 July 2007.

NACA would like to thank ACIAR for their support to this project. The details of the project will be posted on this site in due course.

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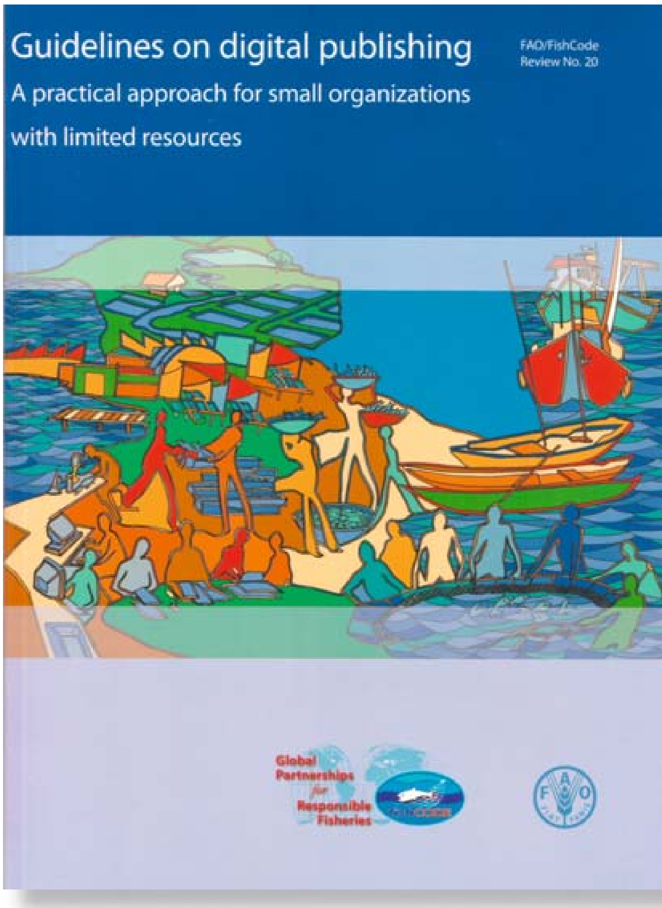
Guidelines on digital publishing: a practical approach for small organizations with limited resources

By Simon Wilkinson and Jean Collins
FAO/FishCode Review. No. 20. Rome, FAO. 2007. 68p.



The importance of research in fisheries and aquaculture is referred to throughout the Code of Conduct for Responsible Fisheries, as is the need to disseminate and share the results of research. Stakeholders in developing countries generally are still waiting for reliable, high speed and cost-effective Internet access that is widely available in the industrialized world. Once connected, users must grapple with, and make decisions about, myriad technological solutions that exist.

These guidelines on digital publishing are targeted primarily at small organizations with limited resources in developing countries, in order to facilitate decision-making on how to publish and disseminate their information, with emphasis on the internet. The Guidelines are based on the years of experience of the Network of Aquaculture Centres in Asia-Pacific (NACA) and its partners. The approach is practical in orientation, covering topics including: (a) planning, building and maintaining a sustainable digital publishing system, focusing on a common scenario of setting up a Web site as a digital publishing platform; (b) producing user-friendly digital publications and making them accessible; (c) some recent international developments in digital publishing; and (d) recommended software tools and technical resources for further reading.

These guidelines summarise NACA's experience in building the website you are now viewing. If your organization is interested in setting up a low-cost website/digital publishing operation, then I recommend that you read this document. Ed.

Workshop on Understanding and Applying Risk Analysis in Aquaculture

As a food-producing sector, while aquaculture surpassed both capture fisheries and the terrestrial farmed meat production systems in terms of average annual growth rate, it has a number of biosecurity concerns that pose risk and hazards to both its development and management, and to the aquatic environment and society. Responding to requests from the 2nd and 3rd sessions of the COFI Sub-Committee on Aquaculture a Workshop on Understanding and Applying Risk Analysis in Aquaculture was held in Rayong, Thailand, from 8-11 June 2007. The objectives of the workshop were to:

- Present a desk top study on this subject, focusing on seven major risk factors (pathogens, food safety and public health, ecological, genetic, environmental, financial and social);
- Discuss the unifying principles for analysis of the various risks and identify the inherent differences between approaches between sectors, and what risk analysis methodologies are available for the particular hazards being addressed;
- Provide a platform for better understanding the hazards, vulnerabilities, uncertainties and risks affecting the aquaculture sector, as well as the connections between the different risk events and patterns in order to identify integrated approaches to risk management and reflect on how to share risks and responsibilities.

The workshop began the process of bringing together parallel initiatives in a consultative and participatory way aiming for a productive outcome. Plenary presentations on the identified major risk sectors in aquaculture were given by the invited experts based on the desk study, which formed the basis for subsequent workshop discussion groups tasked to identify key issues and actions. The discussions will form the basis for further elaboration of the Manual on Understanding and Applying Risk Analysis in Aquaculture.

GISFish: Remote sensing and mapping for aquaculture and inland fisheries

GISFish is a new website on geographic information systems (GIS), remote sensing and mapping for aquaculture and inland fisheries. It is managed by the Aquaculture Conservation and Management Service of the Food and Agriculture Organization of the UN (FAO) and a number of collaborating institutions. It is evident there are many opportunities to use GIS, remote sensing and mapping to improve the sustainability of aquaculture and inland fisheries, but the more widespread use of these tools is impeded by a limited of awareness of their benefits and a lack of access to experience on how they can be deployed. GISFish was created to overcome these impediments. It is aimed at GIS practitioners and fisheries and aquaculture professionals in developing countries. GISFish makes the global experience on GIS, remote sensing and mapping as applied to aquaculture and inland fisheries issues easily accessible. Past experience is packaged as searchable data bases of applications published in the mainstream and grey literature. Applications are in the form of case studies, abstracts, and often, downloadable full publications. Sharing of current experience is promoted through discussions and posting of on-going projects. Additionally, case studies, training opportunities, data sources, tools and freeware, news and events are featured.

Material in GISFish is constantly updated and expanded. Near future improvements will include increased coverage of abstracts and of full papers. Additional links to Cultured Aquatic Species fact sheets will also be made available. Visit the GISFish web site: http://www.fao.org/fi/gisfish/index.jsp.

Online encyclopaedia to list 1.8 m known species

Scientists from around the world plan to collaborate on a free website aimed at providing information on all 1.8 million known species of animals, plants, and other living creatures on the planet.

The effort, called the Encyclopedia of Life, will include species descriptions, pictures, maps, videos, sound, sightings by amateurs, and links to entire genomes and scientific journal papers. Its first pages of information will be shown Wednesday in Washington where the massive effort is being announced by some of the world's leading scientific institutions and universities. The project will take about 10 years to complete. If the new encyclopedia progresses as planned, it should fill about 300 million pages.

The MacArthur and Sloan foundations have given a total $12.5 million to pay for the first 2 1/2 years of the massive effort, but it will be free and accessible to everyone.

The pages can be adjusted so that they provide useful information for both a schoolchild and a research biologist alike, with an emphasis on encouraging "citizen-scientists" to add their sightings. While amateurs can contribute in clearly marked side pages, the key detail and science parts of the encyclopedia will be compiled and reviewed by experts.

Other institutions helping head the undertaking include Harvard University, Chicago's Field Museum, the Marine Biological Laboratory in Woods Hole, Mass., the Biodiversity Heritage Library Consortium, the Missouri Botanical Garden and the Atlas of Living Australia.

For more than a decade scientists have tried to compile simply a list of all species on Earth, but failed. It's been too complicated, too expensive and too cumbersome.

This effort may succeed where the others have faltered because of new search engine technology - the same kind that Google uses. It will scan the Web for scientific information on the Internet and "mash up" all of the material into a file that then gets reviewed by expert curators, said Harvard's James Hanken, a steering committee member.

For scientists, especially those in developing countries, this can open up new worlds of research, said Samper, who has worked as a biologist in Colombia studying South American plants. And that means more science from different areas, he said. Research papers that used to limited to northern science libraries will be easily accessible in remote Botswana, he said.

DELTA 2007

Managing the coastal land-water interface in tropical delta systems is the theme of the Delta 2007 conference, which will be held from 7-9 November, Bang Saen, Thailand.

Delta 2007 will examine the state of tropical coastal deltas with a particular focus on agriculture-fishery-aquaculture-environment conflicts and coastal hazards experienced in developing countries. The conference is forward-looking and will identify both research priorities and planning, management and governance strategies that promote environmental sustainability and improve the socio-economic conditions of marginalized rural communities.

Conference sessions will include: Sustainability at the land-water interface, planning and management of coastal resources, Coastal hazards and tropical delta systems, synthesis and research collaboration opportunities.

For more information contact Dr. Chu Thai Hoanh, IWMI-SEA, c.hoanh@cgiar.org, Dr. Brian Szuster, University of Hawai'i, szuster@hawaii.edu, or Ms. Florine Lim, IWMI-SEA, f.lim@cgiar.org.

The conference is organized by the International Water Management Institute, International Rice Research Institute, WorldFish Center, Challenge Program for Water and Food, FAO Regional Office for Asia and the Pacific (FAO-RAP) and Burapha University.

NACA/FAO partnership working to establish guidelines for certification of farmed fish

Where did that shrimp scampi you're about to tuck into come from? Do you know? Was a sea turtle accidentally killed when the shrimp were netted? Were the shrimp grown in a pond where once a biodiverse mangrove swamp stood?

What about the soup you just ordered? Is the farmed-raised seabass it contains healthy? Does the sea farm it came from pollute, or produce responsibly?

Who'd have ever guessed that eating seafood could be so complicated?

But as the world's appetite for seafood increases and greater amounts of it are farmed in captivity by humans rather than raised in the wild (45% of all fish eaten today), retailers and consumers alike are paying lots more attention to where their fish fry comes from and if it's safe to eat.

One way through the maze, experts say, is certification. Essentially, certification of a seafood product indicates if it was produced in a sustainable, healthy, socially responsible and environmentally-friendly way.

The practice is being used in both capture fisheries and aquaculture with growing frequency. Retailers and consumer groups alike support certification, but still the issue is not without its controversies.

"Establishing transparent, fair and reliable certification schemes is not at all straightforward," explains Lahsen Ababouch of FAO's Fisheries and Aquaculture Department. "Who sets the standards? Can producers be sure they are grounded in good science? Are they out of reach of poor fish farmers in the developing world? Are they a cover for efforts to protect domestic industries? To what extent should private-sector standards supplement governmental consumer protection policies, and how can the two be reconciled? All of these are issues that need to be resolved."

And, he adds, as certification programs proliferate, consumers and producers face choices as to which to trust. Competing schemes could confuse consumers, causing them to loose confidence in standards and undermine the entire approach.

Putting certification standards on the same page

FAO recently began collaborating with NACA to hold consultations with a large group of certification bodies, producer groups, processors and consumer organizations in order to draw up global guidelines on how aquaculture certification standards ought to be established and applied.

"The idea is to bring together a broad group of all the different people involved in the industry, look at what's already being done in terms of certification, and come up with an overarching framework that can help put aquaculture certification schemes on the same page," says Rohana Subasinghe, also with FAO's Fisheries and Aquaculture Department. "That will help ensure that certification standards, wherever they are being applied, are credible, trustworthy, and fair and will give producers clear goals to shoot for."

The guidelines won't be certification standards in and of themselves but rather a shared roadmap that will help ensure that whoever is certifying farmed seafood - be it a government, an NGO, or a private company -- is going about it in a common way, he added.

The group recently held its first workshop in Bangkok. The event brought together 72 representatives of certification bodies, aquaculture farmer associations, governments, and major buyers from 20 countries across the world's major aquaculture producing and importing regions.

"There was wide consensus on the roadmap that is being proposed, that certification schemes should address four main areas: food safety and quality, social impacts of fish farming on local communities, environmental issues and economic feasibility," notes Ababouch.

A follow-up workshop is scheduled to take place later this year in Brazil, following which FAO and NACA will undertake a series of public consultations with various stakeholders on the issues with the goal of presenting a draft set of international guidelines for consideration by governments at the next meeting of the UN Agency's Subcommittee on Aquaculture, to be held in November 2008 in Chile.

Asia-Pacific Aquaculture 2007, 5-8 August 2007, Vietnam

From 5-8 August 2007, the Research Institute for Aquaculture No.1, in collaboration with the World Aquaculture Society, is going to organize an international aquaculture conference: Asian-Pacific Aquaculture 2007. The conference will be held in the Melia Hotel, 47 Ly Thuong Kiet Street, Hanoi.

The conference will be the first chance for the international aquaculture community to visit Vietnam and see the rapidly expanding Vietnamese aquaculture industry. Asian-Pacific Aquaculture 2007 is also the place to learn about the latest developments in the regional aquaculture industry and see the newest technology in the trade show with exhibits from around the world.

Deadlines for conference registration are 10 July (by mail) or 31 July (by fax); alternatively you may register at the show. Registrations can also be conducted online at the World Aquaculture Society website or by contacting Mrs Doan Thanh Loan, Research Institute for Aquaculture No.1, Dinh Bang - Tu Son - Bac Ninh - Viet Nam, Tel: 04 8 273 072, Fax: 04 8 273 070 or email: ria1@hn.vnn.vn.

Details on registration rates and exhibitor fees are available from the above contact points.

Skretting sponsorship & scholarships for the Marine Finfish Aquaculture Network

NACA is pleased to announce the extension of the sponsorship of the Asia-Pacific Marine Finfish Aquaculture Network by Skretting, Nutreco's global aquafeed division. This inaugural commercial sponsorship will continue to support the further expansion of the communications and training programs of the network.

Professor Sena S De Silva, Director General of NACA, said "this new agreement strengthens our partnership with Skretting and will enable further development of this important and increasingly active marine fish aquaculture network. The marine fish farming sector is one of the most dynamic in Asia and Skretting's support will be crucial in disseminating research, including some of the ongoing work funded by ACIAR, and building industry capacity to adopt new techniques and farming practices".

"Even though Skretting is a commercial fish feed company, we feel that we have similar objectives to NACA", said Rik van Westendorp, Managing Director of Skretting's Asian operations". We want to contribute to modern, profitable and sustainable aquaculture practices in the region. Teaming up with NACA makes sense. Together we can reach more farmers and provide local farm management training and know-how transfer".

The cooperation will continue to support development of the Asia-Pacific Marine Finfish Aquaculture Network web site and the regular marine finfish newsletters and e-magazines, and will also provide annual sponsorship of three people from developing countries in the Asia-Pacific region to attend the network's popular Grouper Hatchery Training Course. Farmer training programs and feeding trials are also planned under the new cooperation agreement.

Skretting Scholarships for the 5th Regional Grouper Hatchery Training Course 2007

Skretting offered two annual scholarships for the regional Grouper Hatchery Training Course in 2005 and 2006. The Skretting Scholarships have been successful in training aquaculturists from developing countries including India, Myanmar, Thailand and Vietnam in the production of high-value marine finfish. Because of the success of the scheme, Skretting has increased the number of scholarships to three per year for 2007 and 2008 to further assist in the development of sustainable marine finfish hatchery technology in the Asia-Pacific region. Applications for the 2008 scholarships will be announced on the NACA website and in the newsletter.

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NACA is a network composed of 17 member governments in the Asia-Pacific Region.

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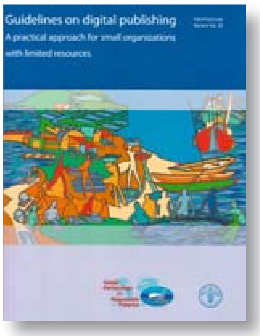
The eleventh regular session on genetic resources for food and agriculture

The FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) convened its 11th Regular Session from 11th to 15th of June 2007, at the FAO Headquarters in Rome. This session was of special interest to all those dealing with fisheries and aquaculture in that for the first time the commission addressed genetic resources of aquatic organisms. The meeting was attended by NACA's Director General, Prof. Sena De Silva.

In regard to this, and as announced by the Assistant Director General (Fisheries and Aquaculture) of the FAO at the Committee of Fisheries in March 2007, a general work program on aquatic genetic resources for food and agriculture has been put forward by the FAO for discussion at the Commission (The world's aquatic resources: status and needs).This document was tabled at the recently concluded 18th Governing Council of NACA on 5th May 2007 in Bali, where it was fully endorsed and adopted. NACA will be attending the Commission as part of its ongoing working relationship with FAO and will raise important issues that will help guide the work of the commission.

For more information on the FAO CGRFA please visit http://www.fao.org/ag/cgrfa/.

NACA Bookshelf: Highlighted publications



Guidelines on digital publishing: A practical approach for small organizations with limited resources

These guidelines on digital publishing are targeted primarily at small organizations with limited resources in developing countries, in order to facilitate decision-making on how to publish and disseminate their information, with emphasis on the internet. The Guidelines are based on the years of experience of the Network of Aquaculture Centres in Asia-Pacific (NACA) and its partners. The approach is practical in orientation, covering topics including: (a) planning, building and maintaining a sustainable digital publishing system, focusing on a common scenario of setting up a web site as a digital publishing platform; (b) producing user-friendly digital publications and making them accessible; (c) some recent international developments in digital publishing; and (d) recommended software tools and technical resources for further reading.

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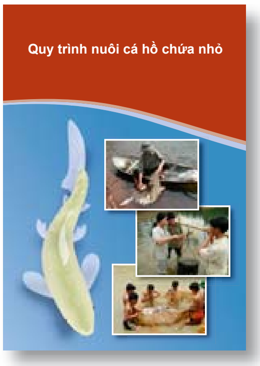
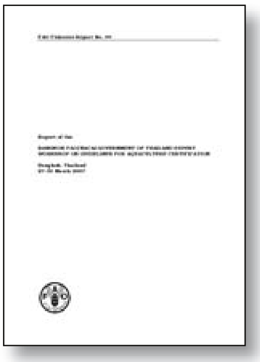


Quy trình nuôi cá hồ chứa nhỏ

Nuôi cá hồ chứa là hình thức nuôi thả cá để tận dụng thức ăn tự nhiên có sẵn trong hồ. Hình thức nuôi này ít tốn kém vì kỹ thuật đơn giản, dễ áp dụng và phù hợp với điều kiện kinh tế miền núi. Nhằm mục đích khuyến khích mở rộng việc sử dụng hồ chứa nhỏ để nuôi cá và cung cấp một số kiến thức cơ bản về kỹ thuật nuôi cá hồ chứa nhỏ cho các hộ nông dân sẽ và đang tham gia nuôi cá hồ chứa tại những vùng miền núi phía Bắc Việt Nam, chúng tôi xin giới thiệu cuốn sách “Quy trình nuôi cá hồ chứa nhỏ” đến với bạn đọc. Tài liệu này do hai tác giả Nguyễn Quang Diệu và Nguyễn Hải Sơn biên soạn, dựa trên kết quả nghiên cứu của hai dựa án FIS/97/68 và FIS/2001/013, do Trung tâm nghiên cứu nông nghiệp quốc tế Úc (ACIAR) tài trợ cho Viện nghiên cứu nuôi trồng thuỷ sản 1, phối hợp với trường Đại học Deakin (Úc) đồng thực hiện từ năm 1997 đến năm 2004.

- **Download:** http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=3&lid=826



Report of the FAO/NACA/Government of Thailand Expert Workshop on Guidelines for Aquaculture Certification

This report is the final draft of the FAO/NACA/Government of Thailand Expert Workshop on Guidelines for aquaculture Certification held in Bangkok, Thailand during 27-30 March 2007. The workshop addressed many of the key issues around the growing interest in certification of aquaculture products. The status and trends in aquaculture, experiences in certification of aquaculture products, certification standards, harmonization and equivalence among certification schemes, stakeholder involvement and ownership, costs and benefits, and the participation of small-scale farmers were among the wide ranging issues discussed.

- **Download:** http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=175&lid=819

Use of fishery resources as feed inputs to aquaculture development: trends and policy implications

Although aquaculture’s contribution to total world fisheries landings has increased ten-fold from 0.64 million tonnes in 1950 to 54.78 tonnes in 2003, the finfish and crustacean aquaculture sectors are still highly dependent upon marine capture fisheries for sourcing key dietary nutrient inputs, including fishmeal, fish oil and low value trash fish. On the basis of the information presented within this fisheries circular, it is estimated that in 2003 the aquaculture sector consumed 2.94 million tonnes of fishmeal and 0.80 million tonnes of fish oil, or the equivalent of 14.95 to 18.69 million tonnes of pelagics.

- **Download:** http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=111&lid=825

Approaches to linking producers with markets

This paper examines experiences of linking farmers to markets, in order to reach some tentative conclusions regarding success factors. It mainly considers examples of linkages promoted by outside organizations such as NGOs. Issues discussed include the choice of markets, the capacity of the linking organizations, and the relationship between the private sector, NGOs and farmers. Linking farmers to new markets invariably involves farmers organizing into formal or informal groups. Experiences with group organization are reviewed, as is the question of finance. Problems faced by farmers in maintaining linkages are examined and sustainability and scaling-up of linkage activities considered.

- **Download:** http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=85&lid=818

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For more information surf
www.aqua.biomin.net

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