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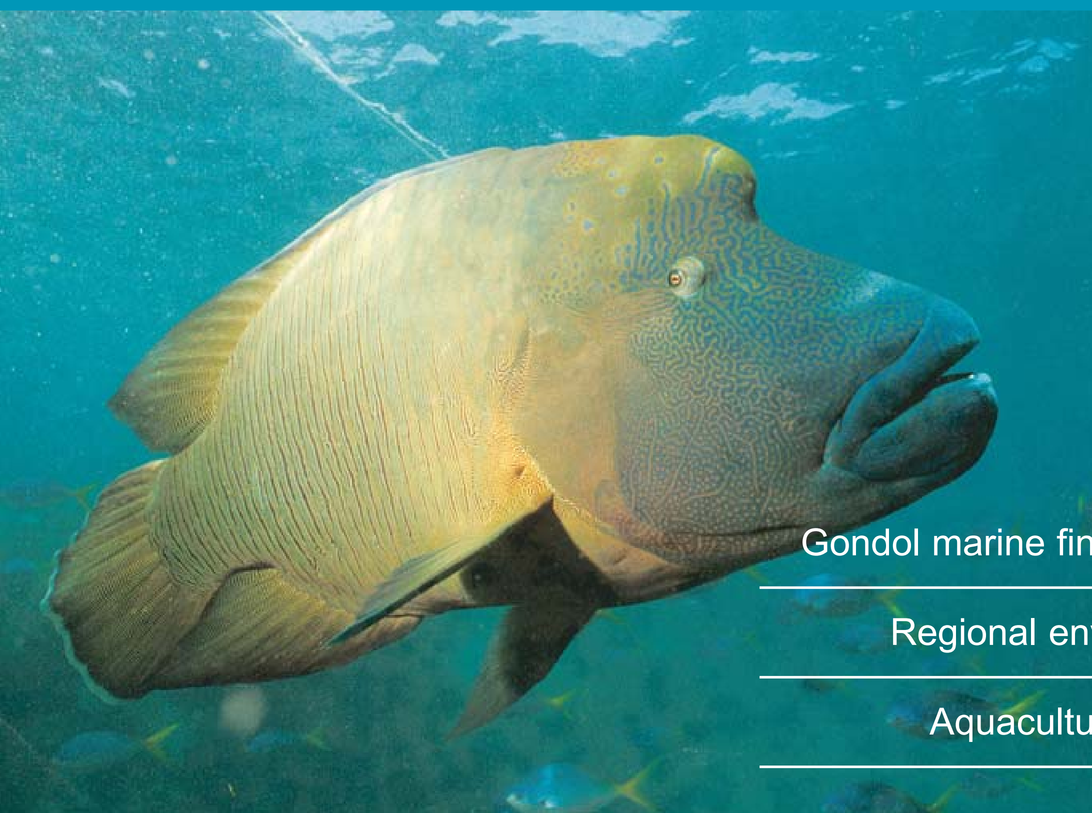
aquaculture Asia

Focus on environment

Breeding threatened fishes

Sewerage-fed aquaculture systems



Gondol marine finfish aquaculture training

Regional environmental assessment

Aquaculture for poverty alleviation

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

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From the Editor's desk

More on eNACA

NACA's electronic communications network – eNACA – has finally taken off in a serious way with the launch of our revised website www.enaca.org. The major change is that the homepage has been altered to become an 'information portal', rather than a fixed (static) site, so it now carries a lot of news content, many free publications for download as PDF files (including an electronic version of Aquaculture Asia and the Asia Diagnostic Guide to Aquatic Animal Diseases) and links to major databases. A CD-ROM version of the website is now available for distribution to areas that do not have internet access. It will be updated quarterly, and provided for free in the first instance to institutions with no net access, and for a nominal fee for those that do and for individuals. I've covered the changes to the site in more detail in the regular column 'What's new on the web'.

We've also launched an email news service, which will deliver regional content and network news right to your mailbox, once a month. It's free, carries no advertising and you can sign up from the NACA home page (or by emailing me at simon.wilkinson@enaca.org). The idea is that this newsletter will provide an easy way for people and participating network centres to share information on their research, training courses, publications and other activities. Announcements that are likely to be of use to the wider NACA network are welcome.

This issue of Aquaculture Asia focuses on the environment. Like most human activities, it is not usually the activities of any one individual that cause significant environmental problems; it is generally the aggregate impacts of large numbers of individuals that creates an issue. So environmental impacts need to be considered at two levels.

Firstly, farmers need to consider the cumulative impacts of their activities and look for ways to improve their individual operation. Secondly, there is a need for regulators to pursue more integrated management strategies, taking into consideration the environmental pressure of all activities in a catchment or area. Emphasis is usually placed on water quality released from individual farms, while the total number of operations goes unchecked. Point sources of nutrients are regulated, while non-point sources of nutrients are not.

Addressing issues such as these can be difficult, sure - but we won't see the full environmental picture until we put all of the pieces together.

Simon Wilkinson

Aquaculture Asia

In this issue

Notes from the Publisher

Institutional capital

Pedro B, Bueno, Director-General of NACA, conceived of and was Editor of Aquaculture Asia for six years. He now writes from the vantage view of the Publisher.

When a disease – suspected to be Koi Herpes Virus but being confirmed - of ornamental and common carps broke out very recently in Indonesia, with potentially devastating consequences for the country's small farmers, the Government of Indonesia sent an urgent request to NACA for assistance in containing it. NACA took less than a week to muster global assistance and mobilize a task force of three regional experts. The government has estimated initial losses to be from 50 to 80 billion Rupiahs.

Coincidently, NACA's regional aquatic animal health specialist, Dr Melba Reantaso, was in Indonesia at the time assisting the government in finalizing and fine-tuning their National fish health management strategy. Such national health management strategies are a component of the regional aquatic animal health program that NACA have developed for the Asia-Pacific region with much expert and material assistance from the government of Australia, FAO, OIE and other institutions. She immediately sent out calls for assistance ranging from information from individual experts to requests for organizations to provide experts for a joint task force. The response was an outpouring of information and offers of assistance, and NACA would like to thank all those who offered to contribute.

The Task Force - composed of an epidemiologist from Australia, a viral specialist from Thailand's Aquatic Animal Health Research Institute, and Dr Reantaso, a parasitologist herself – worked with Indonesia's fish health specialists in a one-week mission. With assistance and advice from various laboratories, including those in USA, UK and Thailand, and that of a multinational animal health care products and services company based in Singapore, Intervet Norbio, the team is collating and analyzing the field findings and clinical results. Meanwhile, a management program to contain the disease has been proposed to the Government. This program was developed in collaboration with Indonesian specialists and based on the regional aquatic animal health guidelines developed by governments with the assistance of FAO, OIE and NACA. A longer-term program to check further spread of this and other pathogens both within and from out of the country is being planned, with further assistance from FAO and OIE. We also expect that further assistance will also be provided by other agencies that have been NACA's institutional partners in developing a regional aquatic animal health framework.

To highlight the theme of this "Note" I cite the short message to NACA from the Fisheries Adviser of ACIAR that supported the participation of the epidemiologist from Australia in the task force on very short notice. He said the Center had to find a way to get the assistance processed very rapidly because the problem warranted quick action rather than excuses. I appreciate that ACIAR does not do this under normal circumstances and applaud their flexibility. I also think that the other reason was ACIAR's confidence in NACA and its partners to be able to get things done; ACIAR along with many others has been part of the years of efforts that it has taken NACA to build up some track record. That track record has assumed a more practical purpose by being parlayed into institutional capital.

Institutional capital is the sum of the goodwill and confidence that an organization has earned. It is earned by doing work recognized by its clients as beneficial, it is multiplied by working with others and sharing the benefits and recognition with them, it has to be earned the hard way. Happily, the more an institution uses it, the bigger the capital becomes. Over the years, NACA has strived to build up this capital. It had a good start with a pedigree as the offspring of UNDP and FAO, and the useful inheritance of an already functional and cohesive regional network founded and operating on technical cooperation and global connections that both parents built up and passed on.

Nonetheless, an assured source of a generous amount of funding was not one of the legacies to NACA. While lack of money cannot be counted as a blessing, the absence of one large source of project and operational funding (the Task Force of 2000 constituted to analyze the strengths and vulnerabilities of NACA and identify opportunities had colorfully called such entities "Godfathers") compelled the Organization to devise suitable strategies to generate resources, first to achieve self-reliance and second to effectively implement priority development activities, both purposes not mutually exclusive. Core operational costs of NACA are borne by member governments, through their mandatory contribution to the Organization, which in a way is a significant step in the climb to self-reliance.

In preparing for independence, NACA formulated a regional aquaculture development program that would be implemented through a consortium of collaborating organizations. That initial consortium program – adopted in 1991 by the member governments and, more to the point, based on their needs, served as the framework for subsequent regional activities; only the program thrusts have been revised or updated subsequently to respond to additional demands and meet new needs.

One highly rewarding strategy that the consortium program had adopted was for those with stakes and interests in the aquaculture development of the region to join in a collegial framework of relationship. This fostered a climate in which agencies could work together and cross-feed results into each other's programmes, add value to each other's efforts and multiply the beneficial results for their common and respective clients. This strategy has served the region well: Modest resources were pooled into an effective mass. It also reduced the vulnerability of the aquaculture development program to the waxing and waning of a few or a single donor's assistance.

The activities of the past 12 years since NACA became independent invariably involved multi-institutional cooperation. Since 1990, NACA has accomplished nearly 50 regional and sub-regional as well as bilateral projects that have regional relevance, implementing these with a wide range of partners. The projects are assimilated into the regional program that the NACA governments themselves have adopted, thus assuring that two important conditions happen: (i) uptake of the results into government policies and programs and (ii) continuity of the activity under NACA's regional program.

The added value to NACA and the region of these accomplishments is their being transformed into institutional capital. A fairly good amount of it has been accumulated, which is not a self-serving nor immodest statement but a grateful acknowledgment of the generous cooperation of its numerous partners and the strong support of its member Governments.

That stockpile of institutional capital – which is not equivalent to a lot of money - has been collectively earned with them. It is being used to benefit the governments and their people.

Cooperation in the Mekong on aquaculture and aquatic resources management

During the 9th yearly meeting of Mekong River Commission's (MRC) Fisheries Management and Cooperation Programme, on 11-12 June, MRC and NACA entered into a cooperation agreement that covers the following areas:

1. Research, Training, and Information activities to support the Mekong River Basin with emphasis on poverty alleviation; in particular, the implementation of the programmes on aquaculture of indigenous fish species, movement of live aquatic animals, aquatic animal health, and best management practices in inland aquaculture,
2. Aquatic resources management for the rural poor
3. Education and training
4. Development of guidelines for policy and best management practices for inland fisheries
5. Institutionalizing linkages for regular information exchange

The memorandum recognizes the complementarities of NACA and MRC and the larger benefits that cooperation can bring to their members. It also formally institutionalizes a number of past, ongoing and planned cooperation such as those in information exchanges, women in fisheries, development of indigenous species for aquaculture, and fish health management.

The Cooperation Agreement was signed by Mr Joern Kristensen, Chief Executive Officer of the Mekong River Secretariat (left) and Pedro Bueno of NACA.

Prawn farm energy audits and five star ratings

Dr Eric Peterson, PhD, Adjunct Senior Research Fellow
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I have conducted energy audits at five Australian prawn farms. Last year audits were completed for Gold Coast Marine Aquaculture, Rocky Point Prawn Farm and Sea Ranch, which were funded by the Australian Greenhouse Challenge in partnership with the Australian Prawn Farmers Association. Previously the Queensland EPA Sustainable Industries Division funded my investigations of power use at Seafarm Ltd. in Cardwell and Pacific Reef at Ayr in 1999. These audits were followed by trials of control systems which I developed again with funding assistance from EPA Sustainable Industries Division.

80% of farm electric power is required by pond aerators, 10% for pumping, and 10% for other uses (food processing and workshops). Surveys excluded hatcheries.

Electricity generation and transmission is expensive. Electricity use also has an environmental impact, since one kg of carbon dioxide is produced by coal-fired power stations for each kilowatt-hour (kWh) unit of power consumption. It turns out that the carbon dioxide effect of cooking prawns with liquid petroleum gas is only about 1% of the total of farm electric power demand. Total fuel use by farm vehicles is less again except during construction when many truckloads of material need to be carted.

So I decided to focus my research efforts into developing more efficient aeration control systems. Aerators actively strip oxygen out of a pond during daylight, when phytoplankton are utilizing the suns light. Mechanical aerators only produce oxygen at night when oxygen is less than 100% saturation, but they do serve a purpose as circultators to prevent stagnation. Some prawn farmers believe it is dangerous to switch aerators off, and so my response is that the speed of aeration ought to be actively controlled by the real-time pond water quality. Aeration at half-speed requires one-fifth the power of full speed operation. So there is 80% reduction in power load, while circulation continues and motors are kept warm and ready for the next night of full speed aeration. Demonstrations are ongoing at Rocky Point Prawn Farm and at NQ Barramundi near Townsville.

Individual prawn farmers may have developed other aeration systems that are effective and efficient, but how can the industry learn from these diverse experiences? Laboratory aeration system tests do not account for mechanical wear and tear, pond management practices, or the effects on production of pond sediment quality. I proposed that APFA members annually evaluate their energy performance with a "star rating". These star-ratings should be based on the aquaculture production divided by the total electric power consumption. An audited improvement of 5% after a couple of years would be sufficient for a prawn farmer to be certified under the Australian Greenhouse Office.

Around ten tonnes of CO_2 exhaust from the stacks of coal fired power stations for each tonne of intensive prawn farming production. Star units would be awarded at a rate of 50 per tonne of production, pro-rata per tonne of CO_2 emission. So a typical well-managed operation might be able to market its product with five stars of audited greenhouse performance, and increase star unit from time to time by adding speed control equipment or any other means. I believe ten stars would be achievable after gradual investments are made to retrofit all ponds on the farm. More information from the AFPA website www.apfa.com.au under "Environment",where there are details of how an energy audit can be arranged for your farm. *[Note: Australian farmers only. Reprinted from the Newsletter of the Australian Prawn Farmers Association. – Ed.]*

Development of freshwater fish farming and poverty alleviation A case study from Bangladesh

Gertjan de Graaf[1] and Abdul Latif[2]

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2: Char Development and Settlement Project, Noakhali, Bangladesh

Aquaculture development in the last decade

Being a country of rivers and floodplains with a high potential of aquatic resources, fish plays a very important role in the daily life of many people in Bangladesh. The Bengali expression “Mache Bhate Bengali”, or “Fish and Rice make a Bengali,” illustrates this importance. Bangladesh produces 1,400,000 tonnes of fish annually mostly through inland capture fisheries and aquaculture. The development of the fisheries sector in Bangladesh during the last two decades has mainly been “donor driven” and emphasis has always been laid on the improvement and expansion of the aquaculture sector, which received or will receive around 60% of the donor funding over the period 1986-2005.

Table 1: Donor funding in fisheries development, Bangladesh, 1986-2005

Fisheries sub sector	Donor funding (US$ million)	%
Aquaculture	205	59%
Fisheries	107	31%
Research	34	10%
Total	**345**	**100%**

The increase in farmed fish from about 100,000 mt in the early 1980s to 400,000 mt nowadays is impressive, but still, it only accounts for 30% of the total production. In the meantime, we see that the major sources of fish - “capture fisheries” – are in trouble. Riverine fisheries are declining, the major carps are disappearing, and estuarine set bag nets are destroying the juvenile fish in the Bay of Bengal.

Half of the 130 million people in Bangladesh are poor and 30 million are living in extreme poverty. Poverty reduction and improvement of the livelihoods of the poorest of the poor has always been one of the major goals of development programmes in Bangladesh and is a major objective in all the aquaculture development programmes. Whether the benefits of these programmes have been made available to the poor can be questioned, as their basic strategy: “growth of the overall fish production through fish farming” was in most cases not consistent with the socio-economic reality of the rural poor in Bangladesh. We want to illustrate this point with two case studies.

Fresh water fish farming developments in the Compartmentalisation Pilot Project (CPP) and the Char Development and Settlement Project (CDSP).

The Compartmentalisation Pilot Project

The Compartmentalisation Pilot Project is a water management project where a traditional aquaculture development project was conducted from 1993-1998. During this period, all 3,000 ponds in the area were engaged in a simple aquaculture extension programme focused on rearing Indian carp (Catla catla, *Cirrhinus mrigala*, *Labeo rohita*) and silver carp. The production was thoroughly monitored and socio-economic data of the participants was collected.

Figure 1: The bulk of fish production is by medium and large farmers.

The programme was successful as the yields increased from 800 kg/ha to 2,100 kg/ha and the total production in the project area increased by about 300 mt/year. However, from the socio-economic data, we learned that the programme had a very limited impact on poverty alleviation. This can be attributed to a large degree to the fact that only 1% of the landless families and 19% of the marginal farmers have access to a pond (Table 2).

Further, the ponds owned by the landless and marginal farmers tend to be small and often do not contain water throughout the whole year, which results in only 60% being suitable for raising Indian carp (Figure 2).

Therefore, the landless and marginal farmers produce only 4% of the farmed fish. Small farmers produce 22%, but the bulk (75%) is produced by the medium and large farmers.

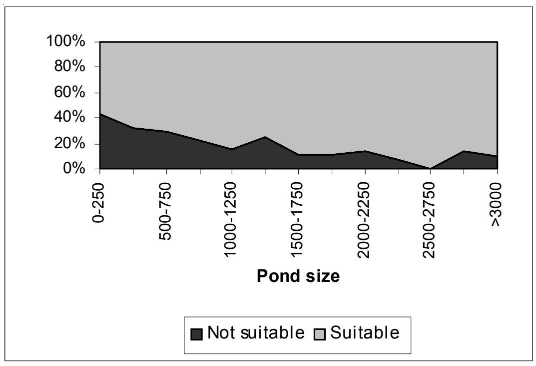

Figure 2: Suitability of the ponds for the farming of Indian carps in the CPP project area

Table 2: Distribution of ponds and the aquaculture production over the different social strata in the CPP project area.

Social strata	No of rural households in CPP	No of ponds in CPP	% of households owning a pond	Pond size (m^2)	% on pond number	% of total pond area	% aquaculture production
Landless	19,890	237	1%	248	8%	2%	1%
Marginal farmer	2,509	475	19%	379	16%	7%	3%
Small farmer	4,589	623	14%	899	21%	22%	22%
Medium farmer	1,362	1276	94%	1073	43%	53%	57%
Large farmer	475	326	69%	1232	11%	16%	18%
Total	28,825	2937					

This highly disproportionate distribution was recognized in the late '90s, and a "Homestead Fish Culture" programme aiming at the poorest of the poor was developed and successfully implemented. This programme was needed; as in the CPP project area, the poorest of the poor do not possess suitable ponds. This in contrast what is generally believed, i.e. that most houses constructed in rural Bangladesh are built on a raised earthen plinth to avoid flooding, and that therefore all households have a pond. This situation is somewhat different in the coastal areas of Bangladesh.

The Char Development and Settlement Project

The main activity of the Char Development and Settlement Project (CDSP), located in the south-eastern part of Bangladesh, is the official settlement of households that installed themselves on the newly accreted coastal lands, the char lands. The project also assists productive development, in particular agriculture, and to some extent aquaculture.

One of the major problems in the coastal belt and the CDSP project area is the shortage of fresh water during the dry season. The shallow ground water is saline and therefore tube wells cannot be used to provide fresh water during the dry season, as is the case in the rest of Bangladesh. To overcome the dry season shortage of fresh water, the digging of ponds for the storage of rainwater is essential for the population in the coastal belt. Because of this, relatively more ponds, on average 85 per square kilometre, are found in the coastal belt if compared with 22 per square kilometre found in the CPP project area. Further, many more of the landless and marginal farmers (38%) possess a pond (Table 3), and small farmers own the majority of the ponds.

In the CDSP project area, medium and large farmers own only 14% of the ponds. The major reason is that there are not many rich farmers because most of the population are new settlers. The improvement of the ponds for aquaculture could improve the situation of the rural poor. However, the selected strategy of such an aquaculture development programme is very important in terms of its actual impact on poverty reduction.

Another development strategy

It is often assumed that improvement of ponds for aquaculture will automatically lead to an improvement of the livelihood of poorest of the poor. Unfortunately, it is not that simple, because improvement of fish farming in Bangladesh is not "neutral". Owning a pond does not necessarily mean that this pond is suitable for the rearing of fish. On the contrary, the suitability for aquaculture is mainly determined by its size and water retention ability. In most cases, the latter are interrelated; small ponds do not retain water for a long period, while large ponds can retain water for over nine months. Still, experiences in Bangladesh have proved that small ponds can be used for production if appropriate fish species and management systems are selected.

In general, fish ponds can be classified according to production and rearing system as follows:

- Small ponds (100-200 m^2), retaining water for less than 4 months. Not suitable for fish (other than African catfish)
- Small ponds (200-300 m^2), retaining water for 4-5 months. Suitable for Thai Puti (*Puntius Gonionotus*) and Tilapia, production 600 kg/ha/year
- Small ponds (300-500 m^2), retaining water for 5-6 months. Suitable for Thai Puti, Tilapia and common carp, production 700 kg/ha/year.

Table 3: Distribution of the ponds over the different social strata in the CDSP project area.

Social strata	No of rural Households	No of ponds	% of Households owning a pond	Pond size (m^2)	% on number	Pond area (ha)	% on area
Landless & marginal farmers	9164	3912	43%	355	38%	139	28%
Small farmers	6266	5862	94%	500	56%	293	58%
Medium farmers	562	553	98%	1011	5%	56	11%
Large farmers	94	94	100%	1706	1%	16	3%
Total	16086	10421				504	

- Medium-sized ponds (500-800 m^2), retaining water for 7-10 months. Suitable for silver carp, Thai Puti and Common Carp, production 1,200 kg/ha/year.
- Medium-sized or large ponds (larger then 800 m^2) permanently containing water. Suitable for Indian carp and silver carp, production 2,000 kg/ha/year.

Over the last decade of aquaculture extension, programmes in Bangladesh were aiming at the larger ponds of 1,000 m^2 or more and mostly the use of Indian carps and silver carp was advocated. Using this traditional strategy again would mean that the poorest of the poor would not be reached (Figure 3).

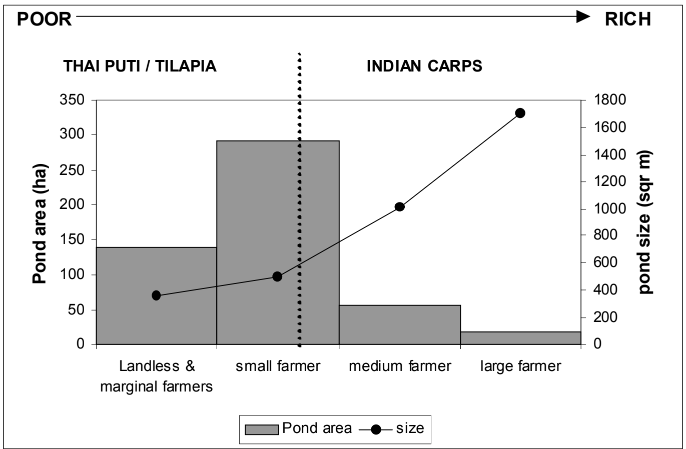

Figure 3: Pond distribution, pond size, poverty alleviation and aquaculture techniques in the CDSP-II project area.

That is because most of the ponds are smaller than 400 m^2, most of them are seasonal as they dry up in February or March. Due to their size and seasonality, these ponds cannot be used for the rearing of Indian carp. Landless, marginal and small farmers mostly own these. If we consider that poverty alleviation and improvement of the livelihood of the settlers is a major goal then we have to conclude that development of fresh water fish farming has to concentrate on the small and medium-sized ponds owned by the landless and small farmers.

What can be expected of this strategy?

There are about 10,000 ponds in the CDSP project with a total area of about 500 ha, the majority (85%) owned by small farmers. In principle, about 550 mt of fish could be obtained annually from these ponds, taking into account the earlier discussed production system.

The largest part (55%) of the production potential lies with the small farmers as the size of their ponds is reasonable and together the have a large number of ponds (Table 4). Landless and marginal farmers own Twenty-seven percent of the total pond area, but the prospect for improvement is limited as their ponds are small and they can achieve only 24% of the potential production. This situation also reflects itself in the annual production potential of the individual households.

Social strata	Annual production (t/year)	% of total production	Kg/family/year
Landless	132	24%	34
Small farmer	309	55%	53
Medium farmer	84	15%	152
Large farmer	32	6%	303
	557		

Table 4: production perspectives of freshwater fish farming in the CDSP project area

With 34 kg/family/year incremental production, the impact for the landless seems to be poor; but for the involved families, it will be a substantial improvement as the production means two months of meals with fish for the whole family.

The development dilemma: Growth of fish production or poverty alleviation?

Despite a declining population growth rate, 2.2 million people are added each year to the population of Bangladesh and they have to be fed. Rice production has increased tremendously over the last two decades, and in the early 1990s, Bangladesh became self-sufficient. Over the same period, however, the average per capita protein intake declined from 58 to 40 grams per day. Therefore, it is logical for the policy makers and planners try to stop this downward trend, aiming mainly at the growth of the total fish production through improvement of fish farming. Implementation of such programs is not complicated; results are obtained quickly within 3-4 years. Costs are not high - $25-50 US per pond owner trained - and a high economic rate of return can be obtained if the larger ponds are targeted with yields of 2000 kg/ha plus. However, it should be realised that despite the growth in farmed fish, the poorer segment of society has no access. It is simply too expensive for them to buy.

If fish farming is being developed in order to alleviate poverty, it should be realized that the poor have only small and relatively unproductive ponds. Aiming a fish farming development programme at this group is from a macro-economic point of view less attractive then aiming at the richer pond owners. This as the investments are still about $25-50 US per pond owner and the yields will be only 600-1,000 kg/ha, resulting in low economic rates of return. However, for the involved poor, such production has a significant impact as it means two months of meals with fish for the family, or a 5-10% income increase.

Therefore, if poverty alleviation is concerned in aquaculture development, instead of using the traditional criteria, such as total increase in production and total financial or economic value of the increased production, more relative parameters such as growth in availability of protein for the rural poor and relative growth in income of the rural poor should be used. If the major donors take their objective to reduce poverty seriously, then they should take the lead in this aspect and should seriously review the objectives of ongoing and further planned developments in the fisheries sector of Bangladesh.

Small ponds, lower productivity but greater potential impact on poverty.

Conservation of endangered fish stocks through artificial propagation and larval rearing technique in West Bengal, India

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The sustainable utilization of genetic resources, including fish, is a vital part in improving the standard of living in a populous country like India. Concern over declining harvests and an obvious reduction in biodiversity of fish species has lead to a more holistic approach to fisheries management and research. About 11% (2,200) of the total world fin fish species (more than 20,000) have been recorded from the Indian subcontinent[1].

Unfortunately, many fish species are in decline and some have become endangered due to a combination of over-exploitation, pesticide and aquatic pollution, spread of disease, uncontrolled introduction of exotic fishes, and habitat modification due to industrialization, river-valley projects, excessive water abstraction and siltation due to clearing.

However, there is no comprehensive list of the threatened species of fishes critically in need of protection. This lack of information on threatened species of fishes and the general lack of identification manuals are barriers to the recognition and conservation of our vanishing fishes. An essential prerequisite to any broad programme of resource conservation is the proper taxonomic study of fish species occurring in the area concerned and a full checklist indicating the status of each species. Such a list would enable the IUCN to prepare an international list of endangered species, to be included in the Red Data Book.

We have identified 39 such local fish species that we believe are going to disappear from their natural habitat in West Bengal (Table 1).

The Department of Fisheries, Government of West Bengal is trying to conserve these species with the following objectives:

1. Brood stock management: Artificial breeding of threatened species for restocking in their natural habitat and to establish gene banks using cryopreservation techniques.

Table 1: List of 39 species of local fishes from West Bengal, India, that are likely to become locally extinct in their native habitat

Freshwater		
Endangered:	1.	*Ompok pabo*
Vulnerable:	2.	*Ailia coila*
	3.	*Anguilla bengalensis*
	4.	*Bagarius bagarius*
	5.	*Eutropiichthys vacha*
	6.	*Ompok bimaculatus*
	7.	*Puntius sarana*
	8.	*Semiplotus Semiplotus*
	9.	*Osphromenus nobiliis*
	10.	*Labeo diacanthyus*
	11.	*Anabas testudineus*
Threatened:	12.	*Notopterus chitala*
	13.	*Notopterus notopterus*
	14.	*Pangasiuspangasius*
	15.	*Balitora brucei*
	16.	*Gudusia chapra*
	17.	*Labeo fimbriatus*
	18.	*Labeo gonius*
	19.	*Mastocembelus armatus*
	20.	*Mystus tengara*
	21.	*Mystus aor*
	22.	*Rasbora rasbora*
	23.	*Setipinna phasa*
	24.	*Bengala elanga*
	25.	*Wallago attu*
	26.	*Nandus nandus*
	27.	*Amblypharingodon mola*
Cold Water		
Vulnerable:	28.	*Tor putitora*
	29.	*Tor tor*
	30.	*Raiamas bola*
	31.	*Barilus vogra*
Brackish & Marine		
Vulnerable:	32.	*Lates calcarifer*
	33.	*Mystus gulio*
Threatened:	34.	*Osteogeniosus militaris*
	35.	*Periophthalmus koelreutri*
	36.	*Etroplus suratensis*
	37.	*Plotosus canius*
	38.	*Tachsurus thalassinus*
	39.	*Polydactylus indicus*

2. To overcome disease problems in larval rearing tanks & culture ponds.
3. To generate income, self-employment and skill for interested farmers through demonstration & training.
4. To provide technical support to private hatchery owners to help them to maximize production of quality seed.

As little is known about the reproduction of many species, research is needed to develop and standardize techniques for their artificial propagation. This technology can then be used to help conserve threatened species through captive breeding programs and also to generate new employment opportunities for rural people.

We would like to share our findings with farmers and extension/conservation workers throughout the region with regard to the breeding techniques of two endangered species: 1) A freshwater fish Pabda, *Ompok pabo* and 2) a brackish-water fish, Tangra, *Mystus gulio*.

Figure 1a) Nandos broodstock, Nandus nandus

Gene banks

For conservation purposes, we have applied artificial reproduction techniques to establish an Endangered Fish Species Breeding Programme. The two main components of this programme are a) a live gene bank and b) gamete/embryo bank. In a live gene bank, the endangered species are reared in captivity and genetically managed to avoid inbreeding depression, domestication and unintended selection. In the gamete/embryo bank, 'adequate samples representative of the natural genetic variation of endangered species are held in a state of suspended animation, frozen under liquid nitrogen.

In the first phase of the programme, we have selected some freshwater fish species, reared them in captivity and attempted to artificially induce reproduction and rear the larvae. The results of some of our experiments on reproduction are given in table 2.

Captive breeding of Pabda and Tangra

Pabda, *Ompok pabo* and Tangra, *Mystus guillo* are Indian major catfishes belonging to the family siluridae (eel-tailed catfish). Both are important components of riverine and brackish-water fisheries in the Indian sub-continent. Little information is available on the biology and culture practices of these two species[2,3]. Pabda dwells and breeds in the rivers and reservoirs and in connected water sheds during floods. Tangra are found in seas and estuaries throughout the India. Tangra dwells and breeds in the estuaries during the monsoon. There are no prior reports of captive breeding in either of these two species.

Brood Stock Management

Pabda

Pabda, juveniles were collected from the river Punarvava, in the vicinity of Malda District, West Bengal, India. They were stocked in a polyculture tank with Indian Major Carp in a 0.5 ha pond. Along with regular liming the fish stock were fed with conventional feed consisting of mustard oil cake and rice bran in the ratio of 1:1. Pabda were maintained throughout the carp culture period. The brooders (Fig. la) attained maturity after one year and the average body weight was 85g Both male and female broodstock were found to be mature in May.

Matured males have a rough first ray in the pectoral fin at the lower side and have a narrow and rather pointed genital papilla, which releases white milt if slight pressure is applied to the abdomen. Females have a smooth pectoral fin and the genital papilla has a thick muscular round opening.

Table 2 : Experiments on some threatened fish species

Fish species	Hormone used	Sex ratio M: F	Dose of hormone used per kg body weight	Percentage hatching
Pabda *Ompok pabo*	Pituitary extract Ovatide	2:1 2:1	• 16 mg (in female only) • 3.0 ml (in female only)	50% 70%
Chital *Notopterus chitala*	Pituitary extract	3:1	• 11 mg (in female only)	60%
Pholni *Notopterus notopterus*	Pituitary extract	2:1	• 4 mg (in female) 2.5 mg (in male)	70%
Indegenous tangra *Mystus vittatus*	Ovatide	2:1	• 8 ml (in female)	80%
Saral punti *Puntius sarana*	Pituitary extract	2:1	• 4 mg (in female) • 2.5 (in male)	70%
Indigenous magur C/art us batrachus	Ovaprim	1:1	• 2.5 ml in female • 1.0 ml in male	50%
Nuna tangra *Mystus gulio*	Ovaprim	2:1	• 2.5 ml in female • 1.0 ml in male	80%
Mourala *Amblypharingodon mola*	Pituitary extract	2:1	• 4 mg (in female) • 2.5 (in male)	80%

Figure 1b) Pabda broodstock, Ompok pabo

Tangra

Adult Tangra, (Fig. 1c) were collected from the local bheri at Digha, Midnapore and were stocked in a round cement tank in the hatchery for a period of 15 days for acclimatisation. Along with regular water exchange the fish stock were fed with conventional feed consisting of mustard oil cake, rice bran and dry fish in the ratio of 1:1:5.

Males had a muscular, conical reddish-pink genital papilla. In the case of females, the genital papilla was found to have a thick muscular ring round the opening.

Figure 1c) Tangra broodstock, Mystus gulio

Induced breeding techniques

Pabda

Gravid females were identified with a simple cathet ring device[4]. Free oozing males and ripe females were used for breeding in the ratio of 2:1.

Breeding was carried out in a bundh. These are special type of impoundments where riverine conditions are simulated during monsoon months. The bundhs, after a heavy shower, receive large quantities of rainwater from their extensive catchment and provide a large spawning ground. Broodstock were kept in a hapa in the bundh and conditioned for 24 hours.

Two techniques were trialed to induce breeding, one with carp pituitary extract and second with a synthetic hormone 'ovatide' (Hemmo pharma, Mumbai, India). For each experiment six males and three females were kept in a separate breeding hapa. Single doses of hormone were administered to females only. The dose of hormone used, as pituitary, was 16mg/kg body weight and as Ovatide 3.0 mg/kg body weight. The synthetic hormone was diluted with double distilled water before use and the main water quality parameters of the tanks were recorded regularly (Table 3) following the method given by APHA[5].

Figure 2a) Induced breeding in Mystus vittatus

Tangra

Broodstock were selected in June 2001. Free oozing males and ripe females were used in the ratio of 2:1 respectively for breeding, which was conducted in a in 200 liter round earthen cistern (60cm in diameter), filled with saline water (salinity 20 ppt), vigorously aerated.

For the breeding operation (Fig. 2b), a synthetic hormone 'ovaprim' was used. Double doses of hormone were administered to the female. Male fish were injected with a single dose at the time of final dose to the females. The dose of hormone used was 2.5 ml/kg body weight in females and 1.0 ml/kg body weight in males.

The first batch of eggs (about 20%) was released about 10 hours post-injection and a second batch (about 35%) were released at 12 hours post-injection. The remaining eggs (45%) were released in a third batch 15 hours post-injection.

Table 3: Major water quality parameters managed during experiments

Pabda

Pond	Temp (C)	pH	DO (ppm)	NH_4N (ppm)	Alkalinity (ppm)	Hardness (ppm)
Brooders tank	29±1	7.5-8.0	6-6.5		130±10	110±15
Breeding tank	31±1	7.6-7.9	7-7.6	-	140±15	112±10
Larval rearing tank	29±1	7.5- 7.8	6.9-7.2	-	135±15	115±10

Tangra

Pond	Temp (C)	pH	DO (ppm)	NH_4N (ppm)	Alkalinity (ppm)	Salinity (ppt)
Brooders tank	29±1	8.0-8.2	7-7.5	-	130±10	20±3
Breeding tank	29±1	7.5-7.9	6.8-7.0	-	140±15	20±2
Larval rearing tank	30±1	7.9-8.0	6.5-7.0	-	135±15	20±2

Hatching and larval development

Pabda

22 hours post-fertilization, the embryos hatched. The newly hatched embryo were 5-6 mm in length with a small yolk sac attached After 24 hours, we transferred the larvae from the hatching hapa to a nursery tank for further development. Larvae were fed with formulated feed after three days of hatching, prepared by steam cooking a mixture of egg and mussel[6]. We mixed "Piscimix" powder into the prepared feed at the rate of 10mg/ kg feed. We sieved the mixture and thoroughly washed it in tap water.

The synthetic hormone (ovatide) gave the best results, with the number of eggs released 80% higher than that from pituitary extract (Table 4). The number of egg released with the ovatide-induced hormone was 80% higher than that of pituitary extract. Hatchery percentage was higher in ovatide and 28% higher than the pituitary extract.

Figure 2b) Injecting hormone in Tangra

Table 4a: Larval production of Pabda

Set	Hormone used	No. of fish	Dose of hormone (per kg)	No. of eggs released	Percentage hatching
I	Pituitary gland extract	Female 3 Male 6	16 mg	4,200	50%
II	Ovatide	Female 3 Male 6	3 ml	20,500	70%

Table 4b: Laval production of Tangra

Set	Hormone used	No. of fish	Dose of hormone (per kg)	No. of eggs released	Percentage hatching
I	Ovaprim	Female 9 Male 18	2.5 ml 1.0ml	30,000	80%

Figure 3a) Close up view of Chital eggs Notopterus chitala

Tangra

The embryos hatched after 20 hours of fertilization. Newly hatched embryos were 3.5 - 4.2 mm in length with a small yolk sac attached, which was consumed within 36 hours from hatching. We fed larvae with *Artemia* nauplii after complete absorption of yolk sac.

Larval rearing

Feeding is the most important factor in the larval period rearing, In Pabda, formulated feed with the addition of piscimix helps to combat mortality, enhances survival rates and allows larger growth. It also checks malnutrition and helps to maintain steady growth of bones and muscles.

The technique for induced breeding of Pabda and Tangra is comparable to the induced breeding of carp but special attention is needed in larval rearing as large mortalities occur mostly after 24 hours from hatching. Decomposing of eggshells can cause deterioration of water quality in the hatching hapa. However, after the initial mortality the rest population of survived to become fingerlings without additional problems.

Future work

In the near future we are going to try to breed some other locally endangered fish species such as Nados, *Nandus nandus*; Parse, *Mugil Persia*; Bhagan, *Mugil tade*; and Pangus, *Pangasius pangasius*. An improved breeding technique using bio-filtration in the hatchery and making suitable larval feeds is expected to help to increase larval survival.

With a view to making the conservation effort more effective, we are also attempting to store gametes and embryos in a liquid nitrogen gene bank as representative samples of the natural genetic variation of locally endangered species.

While a gamete/embryo bank is more cost effective in comparison to live gene bank, the present state of technology allows only cryopreservation of fish spermatozoa. Successful cryopreservation of fish eggs and embryo are yet to be achieved.

Figure 3b) Fertilized eggs of Pabda

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Fertilized eggs of Nados, Nandus nandus

Aquaculture Fundamentals

The use of lime, gypsum, alum and potassium permanganate in water quality management

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It is desirable to provide cultured fish with conditions that are within their favoured range for optimum growth and production. However, local environmental conditions may make a pond unfavourable or completely unsuitable for fish culture. Problems that are frequently encountered include soft acidic waters, low natural productivity, high clay turbidity, oxygen depletion and acid sulfate soils. In such circumstances it is desirable to adjust the water chemistry of a pond in order to bring it back into the favoured range of the culture species.

Lime, gypsum, alum and potassium permanganate are all chemicals frequently used in aquaculture to regulate water quality and the conditions described above. The usefulness of these chemicals in water quality management for fish culture is reviewed below.

Lime

Pond waters with pH of 3.6-5.4 have been reported to exert toxic effects on a range of fishes including mortality, reduced growth and poor reproduction. Waters with a pH of less than 6.0 have also been associated with poor productivity[1]. Freshwater ponds with acidic waters may therefore be unsuitable for use in fish culture without remedial action. Total hardness and total alkalinity are normally within acceptable limits in brackish or marine ponds[2].

Liming materials contain calcium, or calcium and magnesium in combination with an anionic radical capable of neutralising acidity[2]. Common liming materials include agricultural limestone and liquid lime, calcium hydroxide, calcium oxide and basic slag. Liming materials react with acidity as follows for dolomite[3]:

$$CaMg(CO_3)_2 + 4H^+ = Ca^{2+} + Mg^{2+} + 2H_2O + 2CO_2$$

This reaction neutralises acidity, increases pH and total hardness of water, and results in an increase in total alkalinity. The addition of lime can be used to increase these properties to levels favoured by culture species[4,5].

Rapid pH changes, even within the range normally tolerated by a species, may also cause the death of fishes[1,6]. Some liming materials such as calcium oxide and calcium hydroxide can result in a pH increase above 11, which is considered to be the alkaline death point for pondfishes[1]. However, these materials will react with atmospheric carbon dioxide (CO_2) to form less hazardous carbonates if applied to empty ponds several weeks before refilling[1]. This will prevent such excessive increases in pH occurring from the use of these materials.

Ponds with substantial populations of phytoplankton or aquatic plants may also experience wide diel fluctuations in pH. This is caused by fluctuations in CO_2 concentration due to respiration and photosynthetic activity[7].

The addition of liming materials to increase the total alkalinity of ponds has the desirable effect of increasing buffering capacity and pH stability[1,7].

Liming to reclaim acid-sulfate soils

Acid-sulfate soils contain iron pyrite, (iron sulfide) which is oxidised to sulfuric acid if the soils are exposed to air[3] as per the following reaction[2]:

$$FeS_2 + 3.75\ O_2 + 3.5\ H_2O = Fe(OH)_3 + 2SO_4^{2-} + H^+$$

Drainage from acid sulfate soils can cause extremely low pH in ponds outside the tolerable range of most species[3]. Acid sulfate soils within a pond or its watershed must therefore be treated if the pond is to be used for production. However, large amounts of lime are typically required and the technique may not be economically feasible unless used in conjunction with other methods[2].

Liming to increase the effectiveness of fertilisation programs in soft acidic waters

Fertiliser is often added to ponds to increase fish yields by increasing the availability of food organisms for fish. However, fertilisation programs are usually ineffective in ponds with acidic waters and sediments[3]. This reduced response is caused by two factors. The first is a deficiency of carbon in the alkalinity system, which cannot support high rates of photosynthesis by phytoplankton and plants[8]. The second is the increased adsorption of dissolved inorganic phosphorus by sediments[9]. Phosphorus is a key nutrient for phytoplankton growth and its availability limits phytoplankton production[8,10]. Liming materials may be used to support fertilisation programs or to improve productivity in acidic waters by addressing both of these factors. Lime is generally recommended as a treatment for ponds when total alkalinity and total hardness are below 20 mg/litre[11].

Heavy phytoplankton growth can deplete free CO_2 which is required by phytoplankton and aquatic plants for photosynthesis[4,5]. Bicarbonate ions provide an alternative carbon source for photosynthesis in the absence of free CO_2[1]. The increase in total alkalinity resulting from properly applied liming materials is primarily by bicarbonate ions[3]. Liming can therefore favour greater rates of photosynthesis at times when the availability of free CO_2 is limited, leading to substantially higher phytoplankton densities[4,5].

Phosphorus added to ponds rapidly disappears from solution. Some of this dissipation is due to adsorption by phytoplankton, but most phosphorus is removed through reaction with the sediment to form iron and aluminium phosphate compounds. This process is pH dependent[9]. Applying lime to neutralise the acidic muds of ponds to pH 6.5 has been shown to increase soluble phosphorus concentrations. This reflects the greater solubility of phosphorus from muds at this pH[5]. This may enhance phytoplankton productivity and substantially increase fish yields in limed fertilised ponds relative to unlimed fertilised controls[4].

Agricultural limestone cannot be applied simultaneously with phosphate fertilisers as this will cause phosphorus to precipitate[12]. This is due to the high calcium concentrations from the limestone reacting with phosphate to form tricalcium phosphate[18]. It is therefore desirable to add liming materials well in advance of fertilisers.

Liming is not usually considered to be a form of fertilisation[13]. However, liming increases the concentration of calcium and/or magnesium,which can be limiting nutrients, for phytoplankton, at low concentrations[5]. These nutrients are most likely to be limiting in waters of low total hardness.

Lime must be periodically reapplied to remain effective. Ponds treated with approximately 1000kg/ha agricultural limestone or hydrated lime have been reported to show increased productivity for two to four years[3]. The effective period of an application, as indicated by water hardness, is determined by the rate of water loss to seepage and overflow from ponds[3]. Liming has been reported to be ineffective in a pond with a water retention time of less than three weeks[12].

Alum (Aluminium sulfate)

Clay turbidity restricts light penetration in ponds. This reduces the depth to which photosynthesis can occur and reduces primary productivity[14]. Clay turbidity is caused by ultra-fine colloidal particles, 1-10m in diameter. These particles carry a negative charge which maintains them in suspension.

Positive ions react to reduce the negative charge of colloids, causing them to coagulate into larger particles and settle out[2]. Electrolytes with appropriate positive ions can therefore be added to water to remove colloidal particles. Alum (aluminium sulfate), hydrated lime (calcium hydroxide) and gypsum (calcium sulfate) are often used as sources of electrolytes for reducing turbidity[14].

Liming materials increase the concentration of calcium and magnesium ions, which flocculate colloidal particles[14]. Gypsum can also be used to flocculate colloids by increasing the concentration of calcium ions[7]. However, in one comparative study, alum was found to be more effective than lime or gypsum in the reduction of turbidity. Alum reduced turbidity by 89-97% within 48 hours at doses of 10-30 mg/litre[14]. The cost of treatment with alum is significantly lower than for gypsum[7].

Alum is acid forming and can substantially reduce total alkalinity and pH as per the following reaction[14]:

$$Al_2(SO_4)_3 + 6H_20 = 2Al(OH)_3 + 6H^+ + 3SO_4^{2-}$$

This effect makes alum unsuitable for use in ponds with low total alkalinity as it may lower pH to the point where it is toxic to fish[14]. Alum also reduces dissolved inorganic phosphate levels through the precipitation of insoluble aluminium phosphate, reducing phytoplankton growth[14]. The use of alum may therefore necessitate the addition of lime to correct total alkalinity and pH if these parameters fall below acceptable levels. Fertilisation to increase dissolved phosphorus concentrations may also be necessary to maintain productivity.

Gypsum (calcium sulfate)

Gypsum (calcium sulfate) is more soluble than liming materials and can be used to increase the total hardness of waters beyond that possible with lime, although it does not neutralise acidity[7]. The low cost and high solubility of gypsum makes it ideal for use in the maintenance of calcium levels in hatchery situations. Adequate levels of calcium are critical for bone formation in fish and exoskeleton formation in crustaceans[7].

The increased calcium concentrations associated with the addition of gypsum to ponds may cause a gradual, but substantial, decline in total alkalinity, pH and phytoplankton abundance[7,15]. The increased concentration of calcium associated with the addition of gypsum has been shown to reduce total alkalinity through the precipitation of calcium carbonate[15,16]. High calcium concentrations have also been shown to limit the concentration of dissolved phosphorus through precipitation of insoluble tricalcium phosphate[10]. The reduction in phosphorus in this manner is not normally enough to make ponds unproductive[7]. However, phosphorus concentrations are normally low in acidic waters due to the exchange acidity of sediments[4]. The use of gypsum may therefore reduce the productivity of acidic ponds. It may be necessary to correct total alkalinity with lime and increase phosphorus levels with fertilisation if treatment with gypsum causes these parameters to fall below acceptable levels.

The calcium ions supplied by gypsum act as electrolytes in the flocculation of colloidal particles. For example, gypsum applied at rates of 100-500 mg/litre substantially reduced turbidity in one study. However, similar reductions in turbidity were achieved using 20-25 mg/litre of alum, which is a more cost effective treatment[7].

Potassium permanganate

Potassium permanganate ($KMnO_4$) is an oxidizing agent, which is sometimes used as a pond treatment for oxygen depletion. It is also sometimes used as a disinfectant or treatment for fish[8].

The addition of potassium permanganate at concentrations above 4mg/litre has been reported to reduce the biological oxygen demand of water in plastic pools[17]. The effect lasted for one to two days post-treatment and was attributed to reduction in the abundance of aerobic bacteria. However, treatment also reduced daylight rates of oxygen gain by suppressing photosynthesis and reducing algal abundance. This technique may in fact be detrimental since it is only useful if potassium permanganate is added in advance of oxygen depletion occurring[17]. However, this technique might possibly be of some assistance as an emergency measure if combined with additional supplementary aeration to increase dissolved oxygen levels. This would be of particular benefit at night when dissolved oxygen levels are at their lowest.

The use of potassium permanganate appears to be incompatible with the application of fertilisers to enhance primary productivity of ponds. Treatment of ponds with potassium permanganate has been reported to substantially reduce the concentration of dissolved orthophosphate concentrations[17]. The loss was attributed to the formation of insoluble precipitate formed upon the oxidation of ferrous iron by potassium permanganate. Phosphorus is a key nutrient for phytoplankton and its availability limits phytoplankton growth[18]. Fertilisation with phosphorus may be required after treatment with potassium permanganate in order to maintain the primary productivity of ponds.

Potassium permanganate may also be used to oxidise the piscicides such as rotenone and antimycin[7]. However, potassium permanganate has been shown to be toxic in itself, with adverse effects observed in some fish at concentrations of 2mg/litre in tap water[17]. The toxicity of potassium permanganate, and its effectiveness as a treatment appeared to be reduced by the presence of organic matter in ponds.

Conclusion

Liming materials may contribute substantially to fish yields by improving conditions for fish, and by enhancing the primary productivity of the pond. Alum is an effective flocculant for reducing clay turbidity. Gypsum is less useful in this regard, but is better suited to raising hardness than lime or alum because of its greater solubility. Potassium permanganate is a useful disinfectant, but may actually be detrimental if added to ponds suffering from oxygen depletion.

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The utilizations of heterosis in common carp in China

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Common carp *Cyprinus carpio* is one of the principal cultured species in China. The production of cultured common carp reached 2.05 million ton in 1999 and accounted for 20% of total freshwater fish production. Since the farming of this fish extends back to ancient times, common carp has a wide distribution in China. As a result of long-term selection (both natural and artificial), common carp populations have acquired a great deal of genetic diversity – there is a great deal of polymorphism in its phenotype and genotype and its genetic structure has high heterozygosity. This heterosis provides the opportunity to improve the productivity of carp through selective breeding.

The utilization of heterosis in selective breeding is an effective way to improve fish quality and increase fish production. Since 1970s, Chinese fisheries scientists have made broad studies on the utilization of heterosis in common carp and achieved significant results. Traits in which crossbreeds express heterosis include improved survival, growth and tolerance to cold and specific diseases. The followings are some hybrids of common carp that have been successfully extended to the practice.

Applications of heterosis in common carp

Feng carp

This hybrid comes from the combination of Xingguo red carp × scattered mirror carp, first developed by staff at the Hubei Institute of Hydrobiology. At the fingerling stage, the growth rate of Feng carp is typically 1.5-1.6 times of that of maternal fish, and at the adult stage, 1.32 times.

Heyuan carp

This crossbreed is obtained from the hybridization between purse red carp × Yuanjiang carp. It has some advantages included a high growth rate, good body shape, high feed conversion rate and a high capture rate.

Yue carp

These are the first generation offspring (F1) of the hybridization combination of purse red carp × Xiangjiang carp. Their growth rate is 50-100% more than the paternal fish and 25-50% than the maternal fish. Field trials have shown that they can reach market size after 200 days culture in the Hunan area (central China).

Triple-hybrid carp

The maternal and paternal fish of this hybrid is Heyuan carp and scattered mirror carp, respectively. The growth increment of the hybrid is 15% and 50% greater than the maternal and paternal fish, respectively.

Lotus carp

This was first obtained by crossing scattered mirror carp and Xingguo red carp, first conducted in 1975. This carp may reach 6kg after the first year of cultivation.

Jian carp

The varieties of carp we mentioned before are all hybrids. The traits of the offspring of the hybrid carps will be segregated. So new hybrids should be made every year and at least two varieties of parental fish must be conserved in order to obtain the hybrid carps. This can be inconvenient in practice. Jian carp is the first variety of common carp that was produced by artificial breeding in China. The technique applied in its breeding procedure includes hybridization, family selection and gynogenesis. Jian carp has several advantageous characteristics, for example, a high growth rate and fine body shape. The growth advantage of Jian carp is significant. The body weight increment outperforms purse red carp, Yuanjiang carp and Heyuan carp by a factor of 141-250 %, 80-96 % and 40-42 %, respectively. The gross production of this carp may be more than 30% greater than other varieties of common carp.

Molecular studies on the mechanism of heterosis

It takes several years for fish to reach maturity and selecting heterotic crossbreeds from hybrid combinations often takes a lot of selection work, time and effort. Therefore, a study looking for a stable and practical index to predict heterosis is a highly desirable aid for fish breeding. Fisheries scientists in China also have tried to study the mechanism and prediction of heterosis at a molecular level. Random amplified polymorphic DNA (RAPD) technique was applied to analyze the genetic relationship within and between Feng carp and the parental fish. The genetic distance between parental fish and genetic similarity indices between Feng carp and parental carps were calculated. The results showed that the genetic distance between Xingguo red carp and scattered mirror carp was farthest in the experimental fish. The genetic similarity indices between Feng carp and two parental fish were almost same, which indicated that Feng carp inherited equal genetic material from maternal and paternal fish. The same technique was also used to examine the heterozygosity of Jian carp. The result revealed that Jian carp has a higher ratio of polymorphic loci and higher average allelic heterozygosity compared to other carp populations. The advantageous traits of Jian carp may come from the greater heterozygosity of these fish.

Suggestions on the utilization of heterosis

The major factors influencing heterosis include the genetic relationship and the purity of the parents. We know that within a certain range, hybrids generated by varieties with a farther ‘genetic distance’ (ie. that are less closely related) have a greater heterosis. So in practice, we should use varieties with a farther genetic distance as the parental stock to generate hybrids with high heterosis and superior characteristics. But how can we know which varieties have a greater genetic distance? Molecular biological methods are highly accurate but are not available to farmers. Fortunately, there are some general guidelines that farmers can use to select broodstock varieties with a greater genetic distance:

1. Varieties whose native habitats lie in widely separated geographic regions usually have a greater genetic distance and can be used as parents to produce heterotic hybrids. For example, the crossbreeds of purse red carp (native habitat in Jiangxi, mid-east of China) and Yuanjiang carp (native habitat in Yunan, southwest of China) have a high heterosis.
2. Varieties with greater differences in morphology/body shape or physiology can be used as parental stock to produce crossbreeds of high heterosis. Evidence of this comes from Feng carp and lotus carp whose parental fish are Xingguo red carp (red color and all scales) and scattered mirror carp (caesious color and scattered scales).
3. Another factor influencing heterosis is the genetic purity of the parental fish. Usually, more pure the parent fish are, higher the heterosis of their crossbreeds. It is necessary to select broodstock every year in order to get the hybrids with higher heterosis.

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Progress of fish gene technology research in China

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Research on the genetic modification of fish (transgenic and nuclear transplantation) has been undertaken in China for over two decades, since the first successful human growth hormone gene transfer in goldfish[1]. To date, most research in this area has focused on improving the growth rate of species or other useful traits such as cold-tolerance and resistance to disease. Most of the Chinese research can be categorized into three main groups: 1) Growth hormone gene transformation, 2) anti-freeze protein gene transformation, or 3) disease-resistance gene transformation.

To date, the Chinese researchers have engineered more than 20 species of fishes. Some of these are cloned[2]. However, the first engineered fish to enter commercial production is likely to be a carp developed by the Zhu research group. In this fish the carp beta-actin promoter and grass carp growth hormone have been fused using a combining of gene cloning with nuclear transplantation.

Progress of studies on engineering fish

Growth hormone gene transformation

In the Wuhan Hydrobiology Institute, researchers have conceived and developed an “all fish” growth hormone model. They have cloned and sequenced the grass carp and common carp carbonic anhydrase (CA) gene and growth hormone gene. The grass carp CA gene (beta-actin) promoter has been linked to a grass carp growth hormone cDNA to form a high efficiency expression vector called pCAZ. Using the CAT gene as a reporter gene, a pCA grass carp growth hormone recombinant was microinjected into fertilized, non-activated common carp eggs via the micropyle, generating "all fish" transgenic carp. The presence of the transgene was detected by reverse-transcriptase PCR and Northern blotting. A number of these transgenic fish showed dramatic increases in their growth rate (137% of the control). The growth rate in the first generation offspring is up to 120% of the control[3,4,5]. The transgenic fish from this group has successfully passed field-testing and safety assessment and commercialization has sanctioned.

In other work, an ocean pout anti-freeze protein promoter has been constructed and fused with salmon growth horomone (*Oncorhynchus keta*) (i.e. opAFP-GHc) and microinjected into Tangtufang (*Megalobrama amblycephala*). Carp metallothionein (MT) promoter has been fused with salmon growth hormone then microinjected into the carp. Similar growth-promoting effects were observed in both experiments and field tests.

Anti-freeze protein gene transformation

The ocean pout (*Macrozoarces americanus*) possesses an anti-freeze protein that enables it to reduce the effective freezing point of its blood and tissue. In contrast, the mud carp (*C. molitorella*) is a tropical species with poor cold tolerance that is of economic importance in south China. We tried to improve the cold tolerance of mud carp through gene technology. In our experiments, we microinjected genomic DNA from common carp and ocean pout. In the latter, four out of 73 samples (about 5%) were positive for the presence of the transgene[6]. Field assays of cold tolerance showed that the transgenic fishes could survive better than controls under average temperatures that are 4.0°C lower than normal winter temperatures. Expression of the ocean pout anti-freeze protein in transgenic goldfish (*Carassius auratus*) and its enhancement of cold adaptation has been successfully demonstrated in the Chinese Oceanology Institute. Ocean pout anti-freeze protein genes were microinjected into the oocytes of goldfish. Mature anti-freeze protein, detected by immunoblotting, was expressed in both first and second generation offspring demonstrating successful transfer and expression of the protein gene. Transgenic goldfish were significantly more cold tolerant than controls when challenged with low temperatures. The anti-freeze protein gene may have application in enhancing cold tolerance as well as freezing resistance for a variety of fish species.

Disease-resistance gene transformation

In the Chinese Wuhan Virology Institute and Ichthyology Institute, some researchers have piloted a gene contributing resistance to the grass carp haemorrhagic virus (GCHV). Eleven different gene fragments encoding protein were cloned and isolated from translation in vitro using GCHV genomic single gene fragments. A random library was constructed. Based on the information of capsid protein SP6 and SP7 gene cDNA, 3 oligonucleotides were synthesized and fused with SV40 MT promoter and transferred into grass carp cytokine-induced killer (CIK) cells via a constructed expression vector and transfected with GCHV. The results indicated that the mortalities were reduced by one order after challenge with the virus.

Another transgene anti-disease strategy trialed used a combination of electric fusion and nuclear transplantation methods. Somatic cells from grass carp liver cell strain (GLA), which are resistant to GCHV, were transferred into unfertilized eggs of grass carp by means of electric fusion and microinjection. Morphological studies have shown no distinguishable differences between engineered fish and donor grass carp, which suggests that the nucleus of the engineered grass carp may originate from somatic cells of the GLA. This technique has the potential to provide cell-engineered fish for aquaculture and for basic biological research. Further study on disease–resistant properties of cell-engineered fish to GCHV has been carried out[2].

Other studies on transgenic fish related to basic scientific research

Genetic modification of fish has been carried out to study the relationship between the nucleus and the cytoplasm in terms of the controlling effects determined by nucleus or cytoplasm or both during the development, cell differentiation and phenotypic expression in developing animals. This has generally been carried out using nuclear transplantation (cloning) techniques to produce nucleocytoplasmic hybrid (NCH) adult fish between different varieties, species, genera and subfamilies that are capable of producing viable offspring. These experiments have revealed that while most phenotypic characteristics are controlled by the nucleus, a few are controlled by the cytoplasm or by a combination of both. Some were found to be superior in certain characteristics of economic importance such as growth rate, high protein or low fat content.

Some of this research has indicated that the cultured or uncultured adult somatic cells in fish can support the nuclear transplantation of eggs, which develop into viable adults. A seventeen-month-old goldfish was obtained by transplanting an adult erythrocytes into an enucleated eggs[7]. A sub-cultured kidney cell nucleus of Crucian carp (*Carassius auratus*) has also been transplanted into the enucleated egg of the same species, developing into a three-year old adult female[8].

Our own research with serial nuclear transplantation has shown that a NCH embryo can be developed into blood circulation stage through an inter-genus combination (nucleus of crucian carp and enucleated egg cytoplasm of common carp). A NCH embryo of heart beat stage was obtained in an interfamily combination (nucleus of mud carp and enucleated egg cytoplasm of common carp). A NCH embryo of muscular contraction stage has also been reported from an inter-order mix (nucleus of mouth breeder and enucleated egg cytoplasm of common carp)[9].

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Advice on Aquatic Animal Health Care

VISIT TO INTENSIVE VANNAMEI FARMS IN PERU

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On my first visit to Peru two years ago, only semi-intensive shrimp farming systems had been developed which were generally stocked at 5-15 PL/m^2. When the severe outbreak of whitespot disease occurred, water and pond bottom qualities could not be efficiently controlled or managed due to the large size of shrimp ponds (1.6-8.0 ha). Recently, I had the opportunity to visit Peru again and I visited some shrimp farms at Tumbes on the border with Ecuador. I was surprised to see that over 80% of shrimp ponds were empty. These farmers usually stop their operation during this time of year (May 2002) due to the onset of the cold season, which causes high mortality by whitespot disease outbreak. This further confirms that severe outbreaks of whitespot always happen during the sudden drop of temperature in every country. I was very surprised to see that intensive ponds have been developed mostly in large farms (over 48 ha). Areas of 8-32 ha in these large farms have been converted to several small ponds (0.6-1.0 ha) with plastic lining. Groundwater from 80-100 m depth is used as the water supply to prevent the entry of viral pathogens into the pond.

"...confirms that severe outbreaks of whitespot always happen during the sudden drop of temperature in every country."

From interviews with farmers, I found that the traditional practices with semi-intensive culture in large ponds are now entirely impossible. Therefore many farmers have developed intensive ponds with plastic linings in sandy soil area to prevent seepage. This makes the total investment cost per 1 ha pond (including pond construction, aeration, water pumps, electricity and water supply system) up to US$ 47,600. Therefore, only high stocking density (60-80 PL/m^2) is feasible to support such a high capital investment. Last year, most crops were successful due to less temperature variation during the change of season. Some farms could produce 14 ton/ha of 15-18 gm size shrimp with 100-110 days culture period. This is more feasible than the production of 0.8-1.0 ton/ha in traditional system. However, most farmers have had to stop their operation since the recent price crisis early this year, which also affected Thai farmers. Another reason is that most crops early this year failed due to the whitespot outbreak caused by an unusual low temperature (22-23C).

"Groundwater from 80-100 m depth is used as the water supply to prevent the entry of viral pathogens into the pond."

The main causes for this whitespot disease outbreak were:

- Infected PL imported from Ecuador, which have higher degree of infection than PL from Columbia. Heavy mortality occurred within a month for ponds stocked with local wild fry, which have been fully contaminated.
- Decrease in water temperature and cloudy sky cause the collapse of phytoplankton, which always leads to oxygen depletion, later causing disease infection due to shrimp stress.
- During plankton collapse, pond water could not be changed in order to improve water quality and to remove the dead plankton due to the lack of reservoirs. The accumulation of dead plankton and left over feed will cause the release of toxic ammonia and hydrogen sulfide gases, which also cause shrimp mortality.
- Poor feed quality, which has less stability in water, causes accumulation of feed waste.

These factors are similar to those contributing to the outbreak of whitespot in *P. monodon* in Asia. Therefore, *P. vannamei* culture is not easy although it has less disease problems as some farmers expected. Although ponds were stocked with PCR negative PL imported from Columbia, which were 1.5 time more expensive than normal PL, whitespot outbreak still occurred during the sudden temperature drop. Therefore, farmers should be careful about the selection of high health PL and adopt efficient farm management practices to reduce water quality problems and toxic gases. Production cost, particularly high seed cost, should be also considered when production yields are low.

Seed production of Magur (*Clarias batrachus*) using a rural model portable hatchery in Assam, India – A farmer proven technology

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Figure 1: A mature female magur

Figure 2: A mature male magur

Figure 3: Stripping the eggs

The Asian cat fish (locally known as Magur fish, *Clarias batrachus* is an important air-breathing cat fish with good markets especially in North-Eastern parts of India where it fetches a higher price than the major carps. In some parts of Assam, the fish is sold at more than Rs. 250 per kg ($US 5.21). The fish is revered as nutritious and therapeutic in nature. It is generally cultured in ponds along with carps. However, the culture practices of this species have not received much attention, probably due to inadequate supplies of seed and proper feed.

In natural waters, the fish spawns during rainy season in Assam (June-August). For spawning, the fish swims to shallower regions of the already flooded ponds, swamps, streams, rice fields and other water bodies. It has been reported to grow to 198 mm in the first year, 262 mm in the second, 305 in the third and 335 mm in the fourth year. It attains maturity at the end of first year.

The potential to obtain magur seed from natural sources has become low due to the increasing use of pesticides in the paddy fields-which are the main breeding grounds of this fish. Therefore, we conducted an experiment to develop a farmer-proven induced breeding and seed production technology for magur using a low-cost hatching device in Assam. The project was conducted under a farmer participatory small-scale aquaculture project funded by the ARIASP (World bank).

Breeding techniques

The standard breeding technique developed by the Central Indian Fisheries Research Institute was employed with little modification. We used Magur that were about one year old and weighing about 100 g. each. Gravid females are easy to identify as they are comparatively heavier, have a round and bulging abdomen and their vent is more red than that of the males. In the female, the genital papilla is short, oval and slit-like (figure 1); whereas in males, the papilla is conical and elongated with a pointed reddish tip (figure 2). We stocked the brood fishes in a specially prepared fish pond in the month of April. The fishes were fed with a mixture of trash fish and rice bran at 9:1 proportion at about 10% of the body weight of the stocked fish daily. For induced breeding, both female and male magur were given single dose of hormone ovaprim at the same time. Hypodermic syringes with a small size needle (No.24) were used to inject hormone into the muscle of broodstock. We kept the treated male and female fishes separately in two tanks.

18-21 hours after injection we examined the fish for ovulation by hand stripping. Fish that yielded a good stream of transparent green-brown eggs were rated as ovulated. We released the eggs by gently pressing the abdomen towards the vent, collecting them on a stainless steel plate. The milt is then added and mixed well with the help of a feather and a small amount of water to activate the sperm. Earlier, the injected males were sacrificed to prepare sperm suspension in clean water. The testes were dissected out and cut into small pieces with the help of small scissors and a clean blade. The sperm suspension was sprinkled evenly over the eggs and clean water was added. We fertilized the hand-stripped eggs artificially using the dry method. Eggs and sperm were allowed to mix by gently moving the tray for 4-5 minutes. We washed the fertilized eggs thoroughly and transferred them to hatchery specially developed for our study before the eggs began to adhere. We removed unfertilized or dead (opaque/white) eggs immediately to prevent fungal infection. On the fourth

Figure 4: Eggs & milt are mixed with a feather

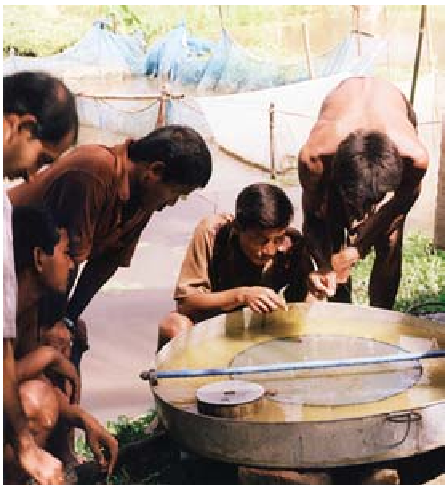

Figure 5: Production of magur hatchlings with farmer participation.

Figure 6: Harvesting fry

day, we transferred the hatchlings to a hapa fixed in a pond fertilized with pig manure for further rearing.

Construction and operation of the hatching trough

The low-cost hatchery we have developed has three main structures (Figure 5): a) a circular trough of 140 cm diameter made of galvanized iron sheets, b) a circular hatching ring of 70 cm diameter made of iron to which a nylon net is fitted and stretched and c) an ordinary water drum with a water storage capacity of 170 liters. The fertilized eggs are spread on the circular net fixed inside the hatching trough and water is sprinkled over it through a perforated 1.25cm diameter PVC pipe. The piped water supply is essential, as this enables the adjustment of flow and oxygenation as well as allowing the controlled application of treatments to combat the spread of bacterial and fungal disease. Eggs of two female magur fish (not exceeding total weight of 200 g) can easily be spread on the circular net ring for hatching. The fertilized eggs are evenly spread on the surface of the nylon net tied to a circular steel frame and a mild water current (20 ml / second) is maintained. At a water temperature of 27 – 300C, eggs normally hatch out within 26 hours. The emerging larvae have a large yolk sac, which gets absorbed in 4 days. A few clean stones are placed on it so that the net is always submerged in water and provide shelter for the hatchlings. The eggshells and debris should be removed periodically from the hatching trough. The three-day old (4th day) larvae can be fed with boiled hen egg yolk and zooplankton. In our trial, we used pond water fertilized with pig manure in the hatchery.

Evaluation of the technique

Altogether we conducted six trials were conducted on magur breeding using this small-scale hatching trough. The results of the trials are summarized in Table 1 and 2. On an average, about 6,000-7,000 eggs are obtained from a fully ripe female. The fertilization percentage obtained varied from 89 to 96% with an average of 93.16% whereas the hatching percentage varied between 23 and 75 % with an average of 55.10 %. An average of 21.55 % survival was achieved from spawn to fry stage with a maximum of 34 %. Hatching time varied between 23 hours and 26 hours at a temperature range of 31 – 37.5 C and water pH range of 7.6 – 8.1.

The low hatching rates and survivability of the magur seeds produced in our hatchery can be attributed to several factors such as a) high air and water temperature b) high water pH c) absence of aeration facility (only a water circulation was maintained) d) delay in removal of egg shells and debris, resulting in deterioration of water quality and e) inadequate densities of zooplankton and other live food for the hatchlings.

"...rearing magur can be achieved at the village level using a simple low-cost technology."

The maximum survival percentage from spawn to fry was 34%. This is fairly a good percentage for a village level production system, as this stage is regarded as the most crucial in magur seed production. We tried three different dosages of ovaprim. Out of these, a single injection of 0.6ml/kg body weight was the most effective. The males were given a single dose of 0.1-0.2 ml/kg body weight. In hapa nursing of magur, we achieved an average survival of 51% while feeding with rice bran and mustard oil cake mixture at 1:1 ratio and termite twice daily.

There is little information available on the use of low–cost rural model magur hatcheries in India. Several experiments were conducted on magur breeding in the natural condition in Assam, but with little success. This is the first attempt to produce magur seeds using a low-cost village-level hatchery technique in Assam.

Figure 7: Magur seeds are being nursed in hapa

Lessons learnt

Our trials show that the breeding and rearing of magur (*Clarias batrachus*) can be achieved at the village level condition using a simple low-cost technology. Since it is a small-scale unit a greater number of farmers can adopt the technology for producing the seed as per requirement. The following lessons were learnt during the magur seed production trials.

1. The condition of brood fish must be excellent and over 100 g in weight.
2. Water quality plays an important role in hatching and survival of magur seed. Water temperature over 33 C. and water pH over 8.0 lead to reduced development and survival of eggs and larvae.
3. Addition of aeration facilities, and prompt removal of eggshells and debris would likely improve survival by preventing the deterioration of water quality.
4. The survival of larvae can be increased if boiled egg yolk and adequate densities of live food are provided.

The simple technique thus developed under this study can easily be adopted by farmers and this would help in meeting the growing demand for seeds of magur fish to some extent.

Acknowledgement

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What's New in Aquaculture

Vietnamese Trading Centre Opens

In the past local shrimp farmers of Can Gio region of Vietnam have had difficulty in selling their product, there were simply to many sellers and too few buyers. As a measure to alleviate this situation the Can Gio Fisheries Trading Centre has been opened in Ho Chi Minh City.

In its initial session in April, 14 farmers accounting for 16.9 tonnes of sugpo shrimp have enlisted at the trading centre. The opening of the centre is a direct response to the demands of local shrimp producers for a well-organised trading centre. By May 27 shrimp farmers had registered to sell 74.3 tonnes

The center currently comprises of transaction offices, markets and booths for trading. Cholimex, the company responsible for its construction plans ice production and freezing stores for a second stage.

In addition to its trading function the center will also serve as a source of information regarding prices and demand for shrimp, breeding techniques, feed and veterinary medicines, loans and transport services. *(Source: Saigon Times Daily, April 23, 2002, Saigon Times Daily, May 14, 2002; Asia Pulse Pte Ltd, May 28, 2002, Tuesday).*

Thai Prawn Farmers address the EU ban

In Thailand, the Surat Thani Prawn Farmers Club in association with Thai Prawn Raisers Association is implementing chemical free treatment programmes. Black tiger prawn farmers have stopped using antibiotic chemicals in response to the EU banning of shipments containing excessive amounts. In addition prawn farmers have rehabilitated mangrove forests by reducing the use of these antibiotics and discharge of wastewater into the sea. 300 members have contributed to a laboratory where prawn fry can be screened for disease prior to release. The organisation is campaigning to correct the misunderstanding that prawn farming is environmentally degradating. Mangrove forests along the coasts of Chumphon and Surat Thani have recovered and prawn farms have moved inland allowing mangrove recovery to take place. Organic shrimp farming is also making an appearance. *(Source; Bangkok Post May 6th, 2002).*

Hazard analysis vital for US fish exports

At a workshop at the Saigon Times Club on May 13th the director of International Seafood Quality Assurance of Surefish relayed the importance of obtaining a Hazard Analysis and Critical Control Point certificate (HACCP) in order for fish processors to export fish to the US. The meeting hosted by Surefish and the Vietnam Association of Seafood Export Processors (Vasep) discussed aspects of food safety management with reference to the US Food and Drug Administration (FDA). *(Source: The Saigon Times Daily, May 14, 2002).*

CP reorganizes in China, to focus on the wealthy

CP, The Charoen Pokphand group is reorganizing its agribusiness sector in China, where it is known as Chia Tai (CT), to focus in on high-value-added products. The group is now integrating plants in seven provinces and four or five smaller provinces. It is investing in aquaculture facilities within China, all products of which will be distributed within the Chinese market. One of these products is turbot to be raised in Shandong province and expected to market to the 130 million individuals in China classified as rich. Other species targeted include mouse grouper. Turbot, which brings in a price of around (44 US$) per kg will be mainly marketed in the east coast including Beijing and Shanghai, Grouper which brings in a coast of over (88 US$) per kg will be focused upon southern regions such as Guangxi and Guangdong. *(Source: AFX News Limited, May 1,Wednesday, 2002, Bangkok Post, May 1, 2002).*

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Aquaculture calendar

Australian Prawn Farmers Association and the Australian Barramundi Farmers Association Joint Annual Conference, 19-20 July, Sydney.

Over 400 delegates are expected to attend from around Australia and overseas. The Conference will include 30 Trade Exhibitors. *For more information contact Martin Breen on ph +61 (417) 006639 or +61 (7) 3255 1070, or visit www.apfa.com.au.*

The 4th Japan International Seafood and Technology Expo, 24-26 July 2002, Tokyo, Japan

The expo will be held at the Tokyo International Exhibition Center. *For more information phone +81-3-5775-2855, fax +81-3-5775-2856, email. info@exhibitiontech.com, or visit http://www.exhibitiontech.com/seafood*

The World Congress on Aquatic Protected Areas 2002, Cairns, Australia, 14-17 August 2002

This event is hosted by the Australian Society for Fish Biology in conjunction with their 31st annual conference. The themes of the conference are 1) Who and what are the beneficiaries of aquatic protected areas; 2) How to design and select aquatic protected areas; 3) success factors in the implementation and management of aquatic protected areas; 4) how good are aquatic protected areas – measuring their performance; and 5) the role of aquatic protected areas in the aquatic ecosystem. *For details contact OzAccom Conference Services, Ph +61(0)7 3854 1611, Fax +61(0)7 3854 1507, email apa2002@ozaccom.com.au. Further details are also available from the website http://www.ozaccom.com.au/apa2002.*

The 5th International Acid Sulfate Soils Conference, 25 - 30 August 2002, Tweed Heads, Australia.

The theme of the meeting is the "sustainable management of acid sulfate soils". Researchers, land managers and legislators have become very aware of the potential environment degradation for the unsustainable use acid sulfate soils. The conference embraces four broad themes: 1. Characteristics of acid sulfate soil hazards; 2. Management of acid sulfate soils; 3. planning, legislation and regulation and 4. Acid sulfate soil education and communication. *For more information visit http://www.out.at/acidsoil.*

4th Aquaculture Expo 2002, 25-27 August 2002, Nellore, India.

A three-day national exhibition and Technical Conference on Aquaculture, will be held at TTD Kalyana Mandapam, Nellore in Andhra Pradesh. The Expo is being organised by NRS Publications, publishers of Aqua International, the national magazine on the sector. The Expo will have participants from all over India, besides some from abroad.

In connection with the Expo, there will be a full day Technical Conference on 26th August 2002, with different topics on aquaculture with the objective of providing a common platform for stalwarts, scientists, experts and farmers in aquaculture sector to assemble and discuss on present status of this sector and the work to be done to take aquaculture sector into further brighter prospects. The Conference will also help the participating members to exchange views for mutual advantage and benefit. *Contact M A NAZEER, Convenor, Email nrspubns@hd2.dot.net.in*

Second International Symposium on GIS and Spatial Analyses in Fishery and Aquatic Sciences, 3-6 September 2002, Brighton, UK

Spatial Analyses has been added to the conference focus as GIS alone implies just the tool and we are essentially more interested in Spatial Analyses using GIS, and Aquatic Sciences has been added because there is now a strong realization, manifest especially in the ecosystems approach to fisheries management, that neither inland nor marine fisheries or aquaculture can be studied in isolation from the aquatic environment in which the activities take place. *Visit http://www.esl.co.jp/Sympo/sympo10.htm for more information.*

Fish Eye View Exhibition 2002, 6-8 September 2002, Kuala Lumpur, Malaysia.

An international exhibition on tropical fish, fishing and aquaculture accessories, products and technology. The exhibition will be broadly grouped under three main themes: 1. Aquaculture and Fish Farming, 2. Recreational Fishery and 3. Ornamental fish. *For more information contact Jungle Motion Sdn. Bhd., ph +603 5638 2019, fax +603 56382069, email enquries@fisheyeview.net or visit www.fisheyeview.net*

Coastal Environment 2002, 16-18 September 2002, Rhodes, Greece

This conference will address the subjects of monitoring, analysis, and modelling of coastal regions including, air and ground phenomena. The fourth in this international series, the conference will focus on topics which need to be recognised in order to prevent, alleviate or minimise environmental problems, allowing a balanced use of the coastal regions as a common resource around the world.

As population growth and industrial and tourist activity development continues in coastal zones, the environmental stress on near-shore water, air and ground increases. Due to the ecological, social, economic and cultural interests within the coastal zone, almost all activities or actions within this area generate conflicts amongst different interested parties such as users, landowners, engineers, ecologists, economists and politicians. Effective strategies for management should therefore consider the coast as a dynamic, integrated system in which inputs, outputs and re-circulation of matter and energy control the environmental quality. The conference places great emphasis on the practical applications of computer modelling of seas and coastal

Accessing and meeting the requirements of markets for aquaculture products: Regional seminar and exhibition, 3-5 February 2002, Manila, Philippines

Interact with co- participants and with resource persons from various UN specialized agencies and other international organizations including ADB, ESCAP, ICLARM, INFOFISH, FAO, IBRD, ITC, OIE, UNCTAD, WHO, WTO and others. The topics: various issues and policy approaches relating to access and competitiveness in markets for aquaculture products and impacts of certain trade issues on poverty and environment. Join the panel discussions on specific marketing related issues on the following themes:

- Product standards, safety and quality
- Production and marketing efficiency
- International trade agreements and national import regulations
- Tariff and non- tariff barriers to trade

The exhibition will cover new products and services for progressive aquaculture. Attend the exhibition/ information forums on:

- Health
- Processing and packaging
- Production efficiency and product quality
- Accessing markets

A consultation will also be held from 5-7 February. Be a part of the search for strategies for action on accessing markets and on meeting market requirements. You will have the opportunity to take an active part in the deliberations which will address the role of governments and of international organizations in providing support to accessing and meeting requirements of markets for aquaculture products.

Contact Mr Malcolm Sarmiento, Director, BFAR, Quezon City, Philippines, tel: (632) 373 7452, fax: (632) 372 5048, email: director@bfar.stream.ph

areas around the world. *Visit http://keywater.vub.ac.be/External.asp?http://www.wessex.ac.uk/ for more information.*

Aquaculture Europe 2002, Trieste, Italy 16-19 October

The theme of the meeting is Seafarming – Today and Tomorrow and will address key issues related to the future of the farming of the seas. In addition to the main conference, three workshops will be held to encourage interactive discussion on future perspectives with industry. The workshops will address 1) applied solutions to health management in Mediterranean aquaculture – a practical approach for farmers; 2) new technologies for Mediterranean aquaculture; and 3) certification in aquaculture – HACCP, ISO Standards, Eco-labeling and organic.

More detailed information is available from the European Aquaculture Society website www.easonline.org or email ae2002@aquaculture.cc

Fourth International Conference on Environmental Problems in Coastal Regions, 16-18 September 2002, Rhodes, Greece

The conference will address the subjects of monitoring, analysis, and modeling of coastal regions including, air and ground phenomena, focussing on topics which need to be recognized in order to prevent, alleviate or minimize environmental problems, allowing a balanced use of the coastal regions as a common resource around the world. As population growth and industrial and tourist activity development continues in coastal zones, the environmental stress on near-shore water, air and ground increases. Due to the ecological, social, economic and cultural interests within the coastal zone, almost all activities or actions within this area generate conflicts amongst different interested parties such as users, landowners, engineers, ecologists, economists and politicians. Effective strategies for management should therefore consider the coast as a dynamic, integrated system in which inputs, outputs and re-circulation of matter and energy control the environmental quality. *For more information visit http://keywater.vub.ac.be/External.asp?http://www.wessex.ac.uk/*

Global Shrimp Outlook 2002, September, Bali, Indonesia

Charoen Pokphand Indonesia will provide in-country support for the next edition of this annual conference organized and sponsored by the Global Aquaculture Alliance. At Global Shrimp Outlook: 2002, major international shrimp buyers, sellers, producers and processors will help forecast the shrimp market during clearly focused, half-day sessions. The program will answer tough questions like what will happen when China's fast-growing shrimp production exceeds its internal consumption? When will Ecuador's faltering industry recover? How does my company fit into the changing global equation? For more information on Global Shrimp Outlook: 2002, contact the Global Aquaculture Alliance Home Office — e-mail gaa@mo.net, telephone +1-314-293-5500, fax +1-314-293-5525.

Aquafest Australia 2002: "Meeting the Challenge", 19-22 September, 2002, Hobart, Australia.

Call for papers. *For more information contact Convention Wise, Mures Building, Victoria Dock Hobart, Tasmania 7000, ph +61 (03) 6234 1424, fax +61 (03) 6231 5388, or you can inquire at email mail@conventionwise.com.au*

Workshop on Health Management, 16 October, Trieste, Italy

Organized in cooperation with the European Fish Pathologists (EAFP). *Contact: EAS, Slijkensesteenweg 4, B-8400 Oostende, Belgium, Tel: +32- 59-32-38-59, Fax: +32- 59-32-10-05, E-mail: ae2002@aquaculture.cc*

Workshop on Certification in European Aquaculture,16 October, Trieste, Italy

Contact EAS, Slijkensesteenweg 4, B-8400 Oostende, Belgium Tel: +32- 59-32-38-59, Fax: +32- 59-32-10-05, E-mail: ae2002@aquaculture.cc

Offshore Mariculture, October 29-31 2002, Bali, Indonesia

Contact: Jean Pritchard, Society for Underwater Technology Innovation Centre, Offshore Technology Park, Bridge of Don Aberdeen AB23 8GX, Scotland, *Tel: +44.0.1224.823637, Email: jeansut@sstg.demon.co.uk or visit http://www.sut.org.uk/pdf/maricultureflyer.pdf for more information.*

ExpoPesca and Acuicultura 2002, 20-23 November 2002, Santiago, Chile

Email Sue Hill for more information on email sue.hill@informa.com

Seventh Pacific Islands Conference on Nature Conservation and Protected Areas, 8–12 July 2002, Rarotonga, Cook Islands

The theme of the conference is mainstreaming nature conservation. The objectives of the meeting are to review progress in the implementation of the region's Action Strategy for Nature Conservation and to define priorities and the region's nature conservation agenda for the next four years. The Seventh Pacific Islands Conference has widened its traditional appeal to attract trade specialists, economists, development planners, tourism operators and others in the more mainstreamed sectors of economic development. The agenda includes keynote presentations on different perspectives and synergies on mainstreaming nature conservation. Working groups will explore the following areas from a mainstreaming nature conservation perspective: Biodiversity conservation, protected areas, species conservation, new funding mechanisms and planning and legal processes. The conference is jointly organized by the South Pacific Regional Environment Programme (SPREP) and the Cook Islands Environment Service and Ministry of Culture. *For more information visit www.pacificbiodiv.org/conference or contact Kate Brown, at SPREP in Samoa on 685 21929 fax 685 20231 or email kateb@sprep.org.ws.*

Second International Tropical Marine Ecosystems Management Symposium, 25-28 November 2002, Manila, Philippines

Tropical marine ecosystems are under increasing pressure from many sources, including coastal land use and development, pollution, unsustainable fishing and tourism and the impacts of global climate change.

The 2nd International Tropical Marine Ecosystems Management Symposium (2nd ITMEMS) will provide an opportunity for managers to engage in multidisciplinary discussions and sharing of experiences and lessons learned to identify gaps and priorities for future management action. The output and recommendations from the symposium will be disseminated through the partners of ICRI (including member countries, the International Coral Reef Action Network, IUCN, UNEP, WWF, the World Bank, donor agenices) and considered in the implementation of management programs for tropical ecosystems at local, national, regional and global levels.

The 2nd ITMEMS will be conducted through a number of concurrent workshops that address the topics listed below. Each workshop will start with presentations of exemplary case studies that illustrate relevant experiences and lessons learned either by their successes or, equally important, their inadequacies. These will form as bases for subsequent facilitated discussions that aim to achieve clear recommendations and priorities for the management of tropical ecosystems in the future. The results of each workshop will then be reported to all participants and discussed in plenary sessions. The number of participants in each workshop group will be limited to approximately 20. Preliminary topics for workshop sessions include co-management and social impacts of marine and coastal management; economic benefits of conservation and sustainable use; the role of the private sector in protection and management; the role of protected areas and management; monitoring to facilitate successful management; management to mitigate the effects of climate change; dissemination of information for coastal and marine management; targeted research for management support; securing sustainable funding for management; restoration and rehabilitation of damaged ecosystems; and achieving sustainable fisheries.

Contact the ICRI Secretariat: +63 2 928 1225 / +63 2 926 2693 or e-mail to: secretariat@icriforum.org or olof.linden@cordio.org. Organized by the International Coral Reef Initiative (ICRI), Joint Philippine-Sweden Secretariat, 2nd/F FASPO Bldg., Department of Environment and Natural Resources (DENR), Visayas Ave., Diliman, Quezon City, 1101, Philippines.

International Symposium on the Management of Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity in the New Millennium, 11-14 February 2003, Phnom Penh, Cambodia

The symposium are will review and synthesize the current status, management and development of large rivers systems including their ecology, fisheries, environmental impact assessments, multiple uses of resources and associated socio-economic considerations. The symposium will also raise the political, public and scientific awareness of the importance of river systems, the living aquatic resources they support and the people that depend upon them and contribute to better management, conservation and restoration of the living aquatic resources of large rivers. It is organized by the Mekong River Commission, the Cambodian Department of Fisheries and the FAO. *Visit http://www.lars2.org for more information.*

5th Symposium on Diseases in Asian Aquaculture, 25-28 November 2002, Gold Coast, Australia

The Fish Health Section of the Asian Fisheries Society will host the 5th Triennial Symposium on Diseases in Asian Aquaculture (DAA5) from 25 – 28 November 2002 at the Gold Coast International Hotel, Australia. Two satellite workshops will follow the Symposium: Epidemiology and Risk Assessment 29-30 November 2002, and the Asia-Pacific Regional Molluscan Health Management Training Program Phase II 2-6 December 2002. For more information about the symposium contact OzAccom Conference Services, ph +61 7 3854 1611, or you can inquire at email daa5@ozaccom.com.au. *For more information about the workshops, contact Dr Chris Baldock - ph +61 7 3255 1712 (Epidemiology and Risk Assessment), email chris@ausvet.com.au and Dr Rob Allard - ph +61 7 3840 7723 (Molluscan Health).*

Topical issues in genetic diversity and breeding

Genes and Fish

Graham Mair

Graham Mair is a research fellow at the University of Wales Swansea, on secondment since 1997 to the Aquaculture and Aquatic Resources Management Group at the Asian Institute of Technology, Bangkok. Based in Asia for the past 14 years, he has been coordinating and conducting research projects under DFID's Fish Genetics Research Program, focusing on the appropriate aplication of genetic technologies to species for low-input aquaculture systems.

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Supply of good quality fish seed for sustainable aquaculture

Deadlines are tight again and I'm drafting this column while traveling in the Philippines. Having lived in the Philippines from 1988 to 1997, when I was intimately involved with developments of improved breeds of tilapia, its very interesting to get a snapshot each time I return on the changes that are taking place in the tilapia industry here. It seems now that the genetic advancements that have been made, particularly with the selectively bred Genetically Improved Farmed Tilapia (GIFT) and the monosex Genetically Male Tilapia (GMT), are starting to have significant impacts and may indeed be contributing to changing the very structure of the tilapia industry itself. I'll make this the topic of a future column but what the story of improved tilapia in the Philippines does highlight is the paramount importance that factors related to the supply of good quality seed have on the sustainability of aquaculture as a whole.

These issues were one of the foci for discussion at the ASEAN-SEAFDEC conference on "Sustainable Fisheries for Food Security in the New Millennium" held in Bangkok towards the end of 2001. At this meeting I sat on a panel that chaired an open forum on the supply of good quality seed in relation to sustainable aquaculture, and it is the outputs from this meeting that provide the basis for this column. The panel focused on four major elements:

Seasonality and inconsistency of seed supply

In the tropics most aquaculture species can be grown year round, subject to suitable availability of water (neither too little nor too much) and demand for cultured fish is also largely year round with seasonal troughs and peaks associated with availability of fish from capture fisheries and with cultural preferences. However, for the majority of species, spawning and thus seed supply is seasonal. This is a major factor behind the relative importance of multiple spawning species, which are often exotic to Asia, and I'm thinking here particularly of common carp and tilapia. Domestication of species and advances in induced breeding have enabled us to breed fish in captivity and extend the spawning season to a limited degree but have not yet enabled us to produce seed substantially outside the normal spawning season for the species. A lot of seed supplied for aquaculture, particularly marine and brackish water aquaculture is still wild caught and thus supply is completely dictated by the natural breeding cycle of the species. Domestication and extension of breeding seasons, for example in shrimp production, could have profound influences on productivity and markets. Other factors that cause unpredictability of seed supply include flooding and other natural disasters, disease outbreaks and limited availability of feeds for broodstock and larvae. The major

Smaller scale, decentralized hatcheries may be more effective in overcoming inconsistency of seed supply and undoubtedly have an important role to play in the sustainable and equitable distribution of quality seed.

recommendations to address these constraints included research on domestication and fish reproduction including induced spawning, broodstock nutrition etc. A note of caution was sounded concerning the potential effect on marginal fisherman deriving income from wild seed collection whose livelihoods would be negatively impacted by a switch to dependency on seed from domesticated stocks.

Inadequate support for seed production

In most countries it is anticipated that the private sector will be the primary producers of seed for aquaculture. However, in newly introduced species or species with long generation times or for hatchery systems requiring large capital input, development of seed production for some species may require the joint effort of government and private sectors. Governments could be proactive in stimulating market demand and in supporting the initial development of seed production facilities. To better ensure consistent quality of seed, governments should also introduce systems of hatchery and seed certification. Furthermore governments and private sector could introduce cost-sharing schemes for introduction of new or improved varieties (with appropriate impact assessment) and advancing research. In promoting seed supply, consideration should be given to the fact that small localized hatcheries, whilst delivering seed locally, can be more responsive to changing trends in demand, more economically flexible, and have lower startup costs. They can thus play an important role in the sustainability and equity of seed supply and in many cases may be more appropriate media for seed distribution than larger centralized seed supply systems. Such a trend is currently evident in Cambodia for example. Trading networks can overcome some of the problems associated with centralized seed supply systems and traders can be effective agents for extension and thus such networks should be encouraged in certain circumstances.

As sectors mature, governments should work to avoid competing with the private sector in seed supply and take on a responsibility for supplying good quality broodstock including improved breeds.

Governments and NGOs will take the major responsibility to ensure that benefits of improved seed quality are disseminated equitably to ensure that small-scale farmers are not further marginalized.

Deterioration in quality of seed stocks

The potential negative impacts of genetics related broodstock management issues such as inbreeding, genetic drift, introgressive hybridization and unconscious selection have been discussed in a previous columns and it is well established that many, if not the majority, of aquaculture stocks that have been negatively impacted by poor genetic management. I would however, again, sound a note of caution that there is a temptation to attribute genetic deterioration (usually inbreeding is the prime culprit) as the cause of declines in productivity, often over such short timescales (in terms of generations) that it would actually be very unlikely that inbreeding was a major contributor. We should also look for management or environmental factors that might be responsible for problems in seed quality.

During panel discussions it was recognized that it is of considerable importance to raise general awareness of the impacts of domestication and broodstock management practices on the genetic status of stocks in terms of both performance and potential impact upon natural biodiversity. In addition, to mediate some of the negative impacts of poor management, it was considered important to maintain in situ and ex situ gene banks, including sperm cryopreservation, for conservation of genetic diversity and enhancement of broodstock management capacity. Research on embryo storage was also recommended due to the substantial management benefits that such a technique would bring. It was further cautioned that full consideration must be given to the issue of intellectual property rights over genetic resources held in gene banks. In addition to promoting awareness of genetic management issues, efforts should expand to improve our important commercially cultured stocks, with conventional techniques of selection being the primary method. It was agreed that there are lessons to be learned in this regard from other countries outside the region where aquaculture may be more advanced, for example the salmonid breeding programmes in Europe. Efforts to improve stocks should be accompanied by the development of practical criteria for assessing and certifying genetic and non-genetic aspects of both broodstock and seed quality. With the dissemination of improved breeds, efforts should be made to ensure that this is done equitably so that small-scale farmers are not further marginalized and to maximize benefits to poor fish consumers. The latter two points were both covered in some detail in a recent ICLARM-INGA sponsored expert consultation on “strategies/plans for the dissemination of improved fish breeds” issue surrounding which may be the subject of a future column.

Impacts of releases of cultured seed stocks

As anthropogenic effects on wild fish stocks increase, the need to replenish natural fish populations through stocking of seed from hatchery stocks (which are genetically changed by the processes listed above) will increase. There are, however, serious concerns to be addressed on the impacts of enhanced fisheries including a wide range of ecological and genetic effects on habitats and on wild populations. Some such effects arising through predation, competition, introduction of diseases and genetic introgression have been documented but surely many have not. There is a need to conduct more considered impact assessments before introductions and, subsequently, to conduct research to quantify actual impacts in order to broaden our knowledge base on this topic.

The advent of molecular methods for assessing genetic interaction between wild and introduced domesticated stocks should allow more detailed analysis of genetic impacts and there are now many examples of the power of this kind of study outside of the region. Breeding wild caught broodstock from the same population or releasing sterile fish are options that should be actively considered under the precautionary principle although the latter option of sterile fish could still have impacts on reproduction or ecological displacement of wild stocks. The panel went as far as to recommend that broodstock should be developed and maintained separately for aquaculture and for stock enhancement, with the former being genetically improved for enhanced efficiency while management of the latter stocks should strive to minimize genetic change. Whilst there is little doubt that such a recommendation is idealistically sound, there are clearly many logistical constraints to adopting such a recommendation.

My initial fear was that the panel sessions at the ASEAN-SEAFDEC meeting may simply echo many of the points raised at the earlier NACA-FAO sponsored conference on Aquaculture in the Third Millennium that then appeared in the Bangkok declaration. However, for me, the focus on seed supply issues rather than just genetics, ensured that original discussion was stimulated and I found some of my own views somewhat modified by the discussion, particularly with regard to the relative roles of centralized and decentralized seed supply systems.

Silver barb, Barbodes gonionotus*, is a species in which natural population structure has been compromised by the widespread stocking of hatchery-produced seed in enhanced fisheries.*

These fish were produced by a subsistence farmer in Nakon Sawan, Thailand [and they tasted great ! Ed.]

Following shortages of wild broodstock, Australian industry is now investing in domestication programmes. This is a broodstock rearing facility at a farm near the Gold Coast.

Domestication gets the thumbs up

The Australian Fisheries Research & Development Corporation (FRDC) has approved an application by the Australian Prawn Farmers Association (APFA) to remove barriers to domestication of Black Tiger Prawn *Penaeus monodon*. The AUD$ 1.8 million, 3-year project is a collaborative partnership between the FRDC, the Australian Institute of Marine Science, Commonwealth Scientific and Industrial Research Organization (CSIRO), Queensland's Agency for Food and Fibre Sciences and three leading Australian prawn farms.

Details are still being finalized however an early start to the project has been granted with broodstock collection hopefully to get underway this month.

According to APFA domestication has been the number one industry R&D priority for several years and is of international importance. Details of the project will be announced at the upcoming APFA Annual Conference in Sydney in July. *For more information contact Martin Breen, Executive Officer of the Australian Prawn Farmers' Association, Email apfa@qff.org.au.*

Farmers as Scientists

This is a series anchored by M.C. Nandeesha. It describes farmer-driven innovations and experiences.

Sewage Fed Aquaculture Systems of Kolkata A Century-old Innovation of Farmers

Dr. M.C.Nandeesha has taken up a new position as Professor and Head of the Department of Aquaculture, College of Fisheries, Central Agricultural University, PO Box No. 120, Agartala-799001, Tripura, India. This is a four-year old institution established to cater to the manpower and research requirements of the Northeastern part of the country in the fisheries sector. He has nearly two decades of experience in teaching, research and development and has worked with Universities, NGOs and multilateral organizations within and outside the country. Email address: mcnraju@yahoo.com.

Farmers around Kolkata city in India developed a technique of using domestic sewage for fish culture almost a century ago. This technique is widely used to meet the growing demand for fish in this thickly populated Indian city. The technique is considered to be unique and is the largest operational system in the world to convert waste in to consumable products.

The system appears to have started nearly a century ago although large-scale usage of sewage for fish culture began in the 1930s. Early success of fish culture in stabilized sewage ponds, which were used as a source of water for growing vegetables, provided stimulus for the large-scale expansion of sewage fed fish culture system. The area under this unique system of culture peaked at 12,000 ha, but in recent years there has been a steep decline in the area due to the increasing pressure from urbanization. Currently, the area under the sewage fed culture system has been reduced to less than 4,000 ha and the poor people dependent on these wetlands for their livelihood have been severely affected. However, even today, a considerable amount of fish consumed in Kolkata city is produced from this system. There are appeals to Government to declare the existing sewage fed aquaculture area as sanctuaries and to protect them from further encroachment by the rapidly expanding population of Kolkata city.

The waste recycling system that has evolved in Kolkata city involves garbage based vegetable farms, wastewater fed fishponds, paddy fields using fish pond effluent and sewage fed brackish water aquaculture. The practice of using pond effluent for paddy cultivation is of recent origin.

Sewage fed system

The sewage fed ponds, which are locally called "Bheries" are usually large and can be as big as 40 ha in size. Although these sewage-fed ponds are generally shallow and vary from 50 cm to 150 cm in depth. Though most of the sewage fed ponds are static in nature, with the increase in size, they tend to become lotic. In general, these ponds have five distinct phases covering pond preparation, primary fertilization, fish stocking, secondary fertilization and fish harvesting. Pond preparation is undertaken during cooler months (November-February) during which time the growth of carps is also reported to be slow. Whenever possible, ponds are drained, dried, silt is removed from the silt traps (perimeter canal dug along pond dike), the pond bottom is tilled and the dikes are prepared. Sewage from the canal is drawn in to the pond and allowed to stabilize for 15-20 days.

The photosynthetic activity in the pond is the basis for biological purification of the sewage. Once the water turns completely green, stocking

Sewage fed fishponds; locally called "Bheries" have a bamboo sluice structure to prevent the entry of wild fishes and escape of the stocked fishes.

Open channel through which sewage is flown. Lush growth of Colocasia seen on either side of the channel.

of fish is initiated. Before stocking fish, some are kept in hapas in the pond to test pond condition through survival. If the results are positive, large scale stocking is undertaken. Fish stocking takes place several times in a year depending on the intensity of operation.

Species cultured

Although both Indian and exotic carps are grown, farmers have specific preference for the Indian carps, namely catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus mrigala*) and bata (*Labeo bata*) with bulk of the stocking consisting of mrigal. Exotic fish like silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*) are stocked as a small percentage. However, the popularity of tilapias (*Oreochromis niloticus* and *O. mossambicus*) is increasing and they constitute 5-30% of the species stocked with different farms. There is also a tendency for some farmers to stock *Pangasius hypophthalmus* to control mollusc populations and some are attempting to culture high value species like giant freshwater prawn, *Macrobrachium rosenbergii*.

Periodic fertilization

After stocking, sewage is drawn regularly from the canal in small quantities. It is fed to ponds at doses varying from 1-10% of the total volume of water in the pond at intervals throughout the culture period. In bigger ponds, continuous inflow and outflow are maintained by allowing the same level of water to flow out of the pond. Water color, transparency, temperature and depth are used as measures to decide on the amount of sewage to be introduced in to the pond. Fishes are generally not fed with any supplementary feed, except on occasions such as the monsoon season when there is difficulty in getting enough good quality sewage.

Rotational cropping system

Farmers have evolved culture systems that are responsive to market demand. Fish are stocked and harvested throughout the culture period leading to periodical stocking and regular harvest. In larger ponds, harvesting takes place continuously for almost fifteen days in a month. After completion of one cycle of harvest in a large pond, fishes are restocked at the rate of one kg of fingerlings for every five kg of fish harvested. After restocking, fishes are left undisturbed for the subsequent fortnight and harvesting will start again after that period. Drag nets are commonly used for harvesting fishes through an encircling technique. However, for the bottom burrowing and difficult to catch species like common carp and tilapia, encircling with the net and hand picking are adopted as common techniques. There are specialized people to harvest fishes using these strategies.

Sewage fed ponds are pumped out to dry.

Drying of ponds is undertaken during winter.

Silt is removed at least once in three years.

Dried water hyacinth is kept in heaps in the ponds for decomposition.

The bulk of the harvested fish consists of Indian major carps and tilapia.

Dikes are some times used for the cultivation of horticultural crops like banana.

Specialists carry out harvesting of fish in large ponds. Tilapia and common carp are largely harvested through hand picking.

Large plastic containers are used in tricycles for the transportation of fish in live condition.

Live fish marketing

Live fish marketing is becoming more popular. Fish are harvested and kept in a depuration pond for varying lengths of time, but at least for one day. Depurated fish are harvested and transported to the market site live using containers placed on bicycles, tricycles and trucks. Based on the market demand, fishes weighing more than 100 g are generally harvested and sold. For example, if there are ten fishes in a kilogram, they are called hotel fish as they serve the needs of the restaurants that cater food to poor people. There are also skilled persons for the transportation of fishes in live condition for marketing using bicycles and they earn about Rs. 40-50 for 3-4 hours of work.

Aluminium vessels, called "hundies", are used to transport seed as well as live fish to market.

Dike protection

Aquatic weeds like water hyacinth are grown along pond dikes of larger ponds to break waves and prevent damage to dikes. In addition, these weeded areas, provide shelter to fish when the temperature rises, prevent poaching of fishes to some degree and most importantly serve as filters to extract nutrients and metals from the system. When these weeds grow in excess, they are periodically harvested and decomposed in the pond to enhance fertility of water. Surrounding these large ponds, silt traps 2-3 m wide and 30-40 cm deep are dug. These get filled with regular harvesting of fishes. Farmers restrict themselves to cleaning of these silt traps instead of digging the entire pond. Silt rich in nutrients is used for various purposes, including strengthening of dikes.

Disease problems

In sewage fed farms, bacterial diseases are not common. Even when there were problems with Epizootic Ulcerative Disease (EUS) in recent years with carps in other areas, carps in these sewage-fed ponds remained uninfected. However, parasitic infections by *Lernea* (anchor worm) and *Argulus* are common and there is a need to develop techniques for the control of this problem.

Ownership pattern of sewage fed ponds

Sewage fed ponds are operated both through individual operation as well as through cooperatives. Cooperatives have been largely successful in sewage-fed aquaculture systems and the poor are deriving good benefits from such systems. The practices adopted by some of the management systems visited by the author are presented here to highlight how the poor are deriving benefit from this system.

Jagrashisha Farm

This farm is 120 hectares in area. This large water area has been taken on lease from the owners by a group of three people for a period of twenty-one years and has more than 200 employees. One part of the farm complex consists of 58 ha comprising three large ponds with the largest pond having an area of 23 ha. The raw sewage drawn in to the pond is

Some sewage fed farms also integrate with pig farming.

conditioned for 20-30 days before stocking with carps and tilapia once the stabilization process is completed and water turns green. For every hectare of pond, about 40,000 – 50,000 fingerlings are stocked and the total weight of these fingerlings would be about one ton.

Most of the stocked material are major carps (70%) with other species including common carp, silver carp, grass carp and tilapia. Multiple stocking and multiple harvesting is the strategy adopted by this farm. Each pond is harvested continuously for fifteen days in a month. After harvesting one kg of seed is stocked for every five kg of fish harvested. Each farm maintains its own nursing area (about 10% of farm area is used for growing fingerlings) and stunted seed are stocked in to the pond continuously. While common carp and tilapia are produced on the farm, other species seed are obtained from local hatcheries. Fingerlings are generally more than 10-15 g in size when stocked. Fishes are grown mostly on the natural food produced in the pond and sewage is regularly drawn in at a rate of 2-3% of the total volume of pond water, using the color of water as an indicator. Aerators are used when oxygen depletion problems are noticed. Feeding of fish is generally not practiced, except when there is a heavy monsoon, resulting in shortfall of quality sewage. The market price of the harvested fish varies between Rs. 30-50 depending on variety and season.

The sewage fed system is threatened by the increasing urbanization. Note the multistoried commercial complexes behind the fishponds.

Employees are compensated adequately following the local systems and regulations with a weekly paid holiday, annual bonus and special holidays for festivals. Fish are harvested everyday by these laborers and depurated and transported by another group of hired contract workers who are paid Rs.40/ person for 2-3 hours of work. The farm also hires specialists to hand pick bottom dwelling fishes like common carp and tilapia and they receive at the rate of Rs. 3/- for every kg of fish harvested. Fish are harvested from all the ponds on rotational basis and on an average, there are 300 fishing days per year. The average fish productivity of the farm is more than five ton / ha / year.

Cooperative system of management

Bheri No. 4 is one of the cooperatives started in mid 1980s with the support of the government. The Society has 265 members with sixteen female members. The Society owns water area covering about 60 ha. A Management committee consisting of nineteen members manages the Society. Elections are held once in three years. The Secretary of the Society has been working in that position for the past ten years. This demonstrates the high level of confidence created by the leaders through their completely transparent system of management and provision of equal benefits to all members. Every member of the society takes part actively in the work and activities of the society and thereby conflicts are avoided. Each member receives a financial benefit of Rs. 2,000-2,500 /month along with a weekly paid holiday, annual festival bonus and special holidays. Members are also given limited medical reimbursement facilities. The annual transactions of the Society are large in magnitude with financial transactions amounting to more than Rs. 13 million. This is a huge sum in the local context and there is lot to learn from these successful cooperatives. The Society uses its own labor force for harvesting fishes and marketing them in live condition.

Several of the aquaculture management practices adopted by the Society are similar to those described earlier. The major expenditure of the farm is on procurement of seeds from hatcheries since the farm produces only common carp and tilapia seed on site. The Society has also set up a good integration system with pig farming and on an average 300 pigs are raised on a continuous basis. The Society has a number of assets like nets, boats and trucks, which are required for the efficient operation of the farm. Fish are harvested continuously almost everyday throughout the year, except for a month break in the whole year.

Dr. Amitabh Ghosh and his team from CICFRI (Central Inland Capture Fisheries Research Institute) have been involved in carrying out research in partnership with the Bheri No.4 Cooperative.

"Cooperatives have been largely successful in sewage-fed aquaculture systems and the poor are deriving good benefits..."

Conclusion

Integrated resource recovery systems and waste recycling using peripheral wetlands around cities are some of the planning concepts suggested to maintain the good environment around urban areas. Unfortunately, Kolkata wetlands, which served as the best examples to the world on these concepts are slowly being lost due to the urban expansion without understanding the ecological, environmental and economical benefits of this sewage fed fish culture system. While there is a necessity to protect this unique system in Kolkata, there is a much more urgent necessity to understand the science behind the management practices evolved by farmers. The quality of fish grown in sewage fed ponds remains as one of the major concerns, though the practice followed by farmers for nearly a century demonstrates the robustness of the system. Some of the studies conducted to understand the microbiological and chemical qualities of fish grown in sewage fed ponds indicate that the fish are safe to consume.

An international seminar held in 1988 in Kolkata city with the support of UNDP – World Bank Water and Sanitation Program, ESCAP and the Government of India, brought together experts and countries, which have some form of sewage fed systems. The seminar also recognised the uniqueness of the Kolkata system and recommended that detailed studies should be undertaken to understand the existing practices and also assesses the quality of fish. Dr. Peter Edwards from the Asian Institute of Technology and Dr. P.S.V. Pullin from ICLARM have edited and published the proceedings, which has wealth of information and a number of other recommendations. As it is clear, even within the country, even after a century of this important innovation, the technique has not spread to other parts of the country. What is preventing the adoption of this novel system – is it social, economic or technical constraints or are a combination of all these?

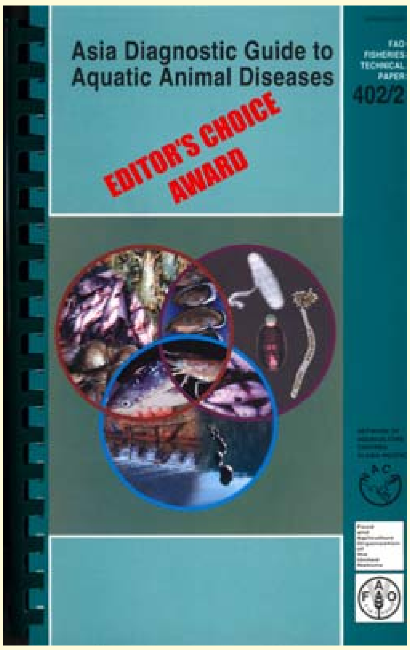
"There is opportunity...to produce fish...and avoid environmental damage being caused by the discharge of untreated sewerage."

Perhaps bringing farmers living around urban areas and "doers" from the scientific and development community to see this practice of Kolkata might help in applying the system elsewhere in the country with suitable modifications. The Public Health Engineering Department has to be impressed with the potential of this system and the Fisheries Department has to work closely with them to develop new systems in other urban areas. The Central Institute of freshwater Aquaculture located in Bhubaneswar has reported the development of an improved method of sewage fed fish culture system, which avoids the direct use of raw sewage in fish culture. Though there are fears about the safety of the fish grown in sewage fed systems, it is the general belief in Kolkata that the fish grown in sewage tastes better. This has been partly attributed to the good nutrition obtained from the rich plankton growth in ponds. Plankton for the growing fish.

There is opportunity to develop systems suitable to each of the urban centers to produce fish using sewage and avoid environmental damage being caused by the discharge of untreated sewage.

Acknowledgements

I am thankful to Dr. V.V. Sugunan, Director, Central Inland Capture Fisheries Research Institute (CICFRI), Barrackpore, West Bengal and Dr. Amitabh Ghosh, Principal Scientist and Officer–in-Charge, Kolkata Centre, CICFRI, Barrackpore for the provision of various information and also for arranging visit to sewage fed farms around Kolkata city. Dr. M.L. Bhowmik, Dean, College of Fisheries, Lembucherra and Dr. Peter Edwards, Professor, AIT Aquaculture Division, provided additional information and literature and encouraged me to write on this significant innovation of farmers.



Asia Diagnostic Guide to Aquatic Animal Diseases

The Asia Diagnostic Guide is a comprehensive, up-datable diagnostic guide for the pathogens and diseases listed in the NACA/FAO and OIE Quarterly Aquatic Animal Disease (QAAD) Reporting System including a number of other diseases which are significant in the Asia region. It jointly published by FAO and NACA under the Asia-Pacific Regional Programme on Aquatic Health Management.

This 240 page volume contains a general introduction on health and aquatic animals and the roles and levels of diagnostics. Section 2 to 4 cover Finfish Diseases, Molluscan Diseases and Crustacean Diseases. Each host section commences with a chapter on "General techniques" which covers essential starting points that will enable prompt and effective response(s) to disease situations in aquatic animal production. These chapters are not disease specific and emphasize the importance of gross observations and how and when they should be made, including information on environmental parameters worth recording, general procedures for sampling and fixation and the importance of record-keeping. The guide is illustrated with more than 160 colour photos. Limited hard copies and a CD version are available for cost of postage. A free electronic (PDF) version is available from the NACA website (http://www.enaca.org/aapqis/ - visit the publications link).

When policy makers begin hearing voices

Graham Haylor, William Savage and SD Tripathi

Demographic and Livelihoods Poverty Focus

One year ago, the Indian population stood at 1.027 billion, with 320 million Indian people (especially in rural areas) living below the Government of India's official poverty line. Five hundred million people in India live on less than US$1/day, representing one third of the world's poor people. India's successes in poverty alleviation will seriously affect international success with international development targets (such as halving absolute poverty by 2015). The Eastern Plateau region of India is characterised by poverty and inequality, land alienation and seasonal migration. The scheduled castes and tribes targeted by the project are amongst the poorest communities in India.

Poor women and men, recipients of the envisaged improved aquaculture service provision, typically belong to scheduled tribes or castes, and many lack the means to produce sufficient food throughout the year. Their livelihoods may be characterised as in Box 1.

Geographic Scope of the Project and Key Stakeholders

Service provision impacting on the lives of people such as have been characterised above is prescribed by national as well as state government policy. Therefore key stakeholders in a policy change process would be (potential) service provision recipients, policy actors at national, state and local levels, as well as non-government advisors on service provision to poor men and women (Table 1). The states where the project will consult with poor men and women in tribal areas are Jharkhand, Orissa and West Bengal, facilitated by GVT and DOF.

How did the current policy come about?

Freshwater fish culture has been an age-old tradition in India. Though originally confined to the eastern region of undivided India, presently covered by West Bengal, Assam, Bihar and Orissa, it gradually spread to Uttar Pradesh, eastern Madhya Pradesh and some parts of Tamil Nadu, where the seed of Indian major carps was transported from Calcutta and stocked in ponds, tanks and reservoirs in the thirties and forties. With independence, the state and national governments focused attention on food production as well as production of animal protein that included small and large livestock and also fish. Fish seed, though not available locally, was imported from Calcutta, and stocked in ponds and tanks under UNICEF's Applied Nutrition Programme. As survival of the spawn and fry imported from Calcutta was low, owing to crude indigenous practices of seed transport, research investigations were directed at improving the methods of seed transport and rearing of spawn to fry and fingerling size. The package of seed-rearing practices was developed by the mid-fifties and rates of survival increased in nursery and rearing ponds. As the Indian major carps (catla, rohu and mrigal) normally spawned only in flooded rivers and streams, the seed collected from such sources was poor in quality, being a

Table 1: Key Stakeholder Groups

(Potential) service provision recipients	Poor men, women and youth, including tribal as well as other marginalized and disadvantaged groups
National policy actors	Fisheries Development Commissioner, Planning Commission, Finance Ministry, Fisheries Division (Deputy Director General) of Indian Council of Agricultural Research (ICAR) and technical and learning centres (CIFE and CIFA).
State policy actors	Chief Ministers, Fisheries Ministers, Fisheries Secretaries, Department of Fisheries (Directors, Deputy Directors, Assistant Directors, District Fisheries Officers, Fisheries Extension Officers), Fish Farmers Development Agencies (FFDA), Directors of Gram Panchyats, Tribal Welfare and Department of Forests.
Local government	Zila Parishad and Gram Panchyat
Non-government advisors on service provision to poor men and women	Gramin Vikas Trust (GVT), donors (DFID, IFAD), international organisations

Livelihoods of poor people in rain-fed tribal areas of eastern India

They may farm about 0.4 ha of poor upland, where they might grow finger millet and about 400 kg of paddy (sufficient for 2.5 months consumption by 5-6 family members). (Wild) fish would be a popular but rare source of vital high-grade protein, polyunsaturated fats, calcium and iodine. Without food security, livelihoods depend on local labouring for better-endowed farmers, for a daily wage of 30 (women) to 50 (men) Indian Rupees (64-106 US cents/day). Agricultural daily labouring will be most commonly available to women and highly seasonal, resulting in high (socially divisive) seasonal migration rates of 40-50%. Men or families will tend to migrate after planting work is over in June, returning for possible harvest work in September-October; there is no Rabi cropping (November-April) in most of the dry Eastern Plateau. Seasonal (urban) labouring opportunities in Chhota Nagpur are commonly mediated through a Sardar who will recruit and sell the labour of 30-40 people. Piecework, perhaps at a brick-works, enables those labouring long days to earn 70 Indian Rupees (149 US cents/day). However, power relations are skewed against migrant labourers who may be inclined to report exploitation and underpayment.

mixture of several varieties including trash and predatory species. Urgent attention was therefore paid to developing the techniques of breeding them in confined waters.

With success in induced spawning of Indian carps, followed by Chinese silver carp and grass carp research programmes on increasing fish production were taken up. Polyculture of Indian major carps and Indian and Chinese carps resulted in achieving production levels of over 4,000 kg/ha/yr at the Central Inland Fisheries Research Substation, Cuttack, by the end of the sixties. In 1971, the Central Inland Fisheries Research Institute launched an All India Coordinated Research Project (AICRP) at 12 centres in the country from the northwest (Haryana) to the northeast (Assam), west (Gujarat and Maharashtra), east (Orissa) and southeast (Tamil Nadu). AICRP achieved high levels of production ranging from 3,000 to 10,000 kg/ha/year and the technology thus developed was popularly called Composite Fish Culture. Some of the states established a number of Demonstration Centres to transfer the technology to farmers and entrepreneurs. AICRP also helped in spawning the fish, especially the difficult-to-breed exotic carps, at all 12 centres and organised training programmes for state officers and farmers.

The technology of composite fish culture comprises pond preparation (removal of trash and predatory fishes), liming, nutrient management through periodic application of organic manures and inorganic fertilisers, supplementary feeding twice daily at 2-3% of the total fish biomass, monthly sampling for checks on health and growth to determine the quantum of feed, and finally harvesting at the end of one year. Though several variants have been developed now, the basic technology remains the same.

High production levels (average of 3,000 kg to over 6,000 kg/ha/yr) in farmers' ponds were also registered in various northern, central and southern districts of West Bengal and Orissa, when the Central Inland Fisheries Research Institute implemented an Operational Research Project called the Rural Aquaculture Project in collaboration with IDRC (Canada) from 1975-79. Based on the initial results achieved at the Central Inland Fisheries Research Station, Cuttack, and under the AICRP on Composite Fish Culture, the Government of India launched a centrally sponsored scheme called Fish Farmers Development Agency (FFDA) in 1973-74. The scheme was initiated with a view to increasing fish production from ponds and tanks all over the country and supporting poor and disadvantaged people, especially the scheduled castes and tribes. An FFDA was gradually established in each potential district and today there are 422 FFDAs in the country, of which 400 are functional. FFDA provides a package of technical, financial and extension support to fish farmers. It is a sort of autonomous organization under the administrative control of the District Collector, to help allotment of government land for pond construction or organize leases of government ponds to farmers, entrepreneurs and cooperatives. The central government initially shared 50% of expenses, with the states sharing the other half. However, since the beginning of the Ninth Plan, the share of the central government was increased to 75%.

"The FFDA has so far trained 634,000 fish farmers, with 934,000 beneficiaries who developed 531,000 ha of water area."

Besides revising the rates of subsidies, some new components were also added to the scheme and its scope enlarged. The FFDA has so far trained 634,000 fish farmers, with 934,000 beneficiaries who developed 531,000 ha of water area. The all-India average productivity from fish ponds under the FFDA scheme stood at 2,226 kg/ha/yr during 1999-2000. The performance of the seven states with large tribal populations under consideration for the present project is shown in Table 2.

Table 2: FFDAs in States with Large Tribal Populations

State	No. of FFDAs	Water area (ha)	Farmers trained	No. of beneficiaries	Average productivity (kg/ha/yr)	Production (MT)
Bihar	49	24,769	24,769	26,574	2,175	53,785
Gujarat	17	49,270	17,970	15,341	1,244	61,292
Madhya Pradesh	45	76,180	35,162	79,374	1,739	132,477
Maharashtra	29	22,547	13,383	60,030	1,749	39,435
Orissa	30	33,215	46,654	122,162	2,059	68,390
Rajasthan	15	3,164	9,405	2,710	2,053	6,496
West Bengal	18	107,712	196,820	354,695	2,950	317,750

So what might be a Policy Change Mechanism?

Recognising the Need for Change

An important prerequisite for transacting policy change is recognition of the need for change. That policy change (including poverty alleviation involving aquaculture) is an appropriate way forward has been highlighted by recent research and development in aquaculture in India (DFID NRSP Research, DFID EIRFP, 1996-2002), by the Government of India (Committee of High Level Experts, 2000-01), by the UK (Blair, 2002) and other governments, and more broadly by the international community (NACA/FAO Aquamillenium Conference, 1999).

The Government of India (GoI) recognises the need to develop the fisheries sector and in particular aquaculture. A government target for fisheries and aquaculture of 7.8 million metric tonnes (mmt) of fish production has been identified based on a per capita requirement of 12 kg. Current fish production is 5.9 mmt, and freshwater aquaculture contributes a third of this. Aquaculture has made tremendous progress in India during the last ten years, its production increasing by threefold. The current annual growth rate in aquaculture is 7.5%. While efforts are being made to achieve the planned target, it is a question as to how far poor and disadvantaged groups are able to profit from national and state government schemes.

From 1996-2001, the Institute of Aquaculture (IoA), University of Stirling, Scotland, co-ordinated a DFID-funded NRSP research project (R6759) to select, test and develop integrated aquaculture innovations relevant to poor groups and to their local needs and conditions in eastern India. The work was conducted in participation with farmers in farm-based trials integrated with on-station research and contextual information collection. Project partners included the Eastern India Rain-fed Farming Project (EIRFP), now the Gramin Vikas Trust (GVT), and a supporting team of consultants recruited by the Centre for Development Studies, Swansea, the DOF and CIFA. Research and development work undertaken has clearly shown that there are certain constraints in the adoption of technologies by poor and disadvantaged people in rural sectors. It was felt that some policy changes are necessary to bring these groups into the mainstream and to take advantage of government services.

The need for policy change was also recognised by the GoI, which set up a Committee of High Level Experts in July 2000 that submitted its report in May 2001. The report indicates that there is much that needs to be done to popularise aquaculture and to bring the benefits to the doorsteps of disadvantaged groups who constitute an important and sizable component of the total population. These include, among others:

- To ensure the timely supply of fingerlings of desired species and of proper size.
- The procedure for financing loans should be simplified and time-bound.
- The lease period for Panchyat and village ponds should be increased.
- The need for coordination and adequate extension was recognised.

Time for a Change

Despite considerable economic growth and reduction in the numbers of people below the poverty line in India, the situation has not substantially improved for the poorest groups, including tribal populations, as the programmes meant to help poor people have not been effectively implemented. Huge sums have been invested in anti-poverty programmes involving subsidies. Far less effort has gone into empowering people to contribute to policy change processes, to give recipients of service provision a voice and to help them to realise their rights. However, for a range of key stakeholders, the time is right for change. For example:

Donors (especially DFID)

The development assistance that comes into India from abroad is still insignificant when compared to the national budget. Increasingly, outside agencies recognise that they can achieve strategic impact on poverty through influencing specific policies at the national level. As the British Prime Minister said in a speech to the Confederation of Indian Industry in Bangalore on 5 January 2002, "… donor nations are realising that help with a proper system of government or law is at least as crucial, sometimes more so, than cash."

"Huge sums have been invested in anti-poverty programmes involving subsidies. Far less effort has gone into empowering people to contribute to policy change processes."

DFID in India is a partner in health and education, science and technology, and trade and investment. It proposes to work in close collaboration with local, state and national governments to develop policies that could be used to bring about a change in national policy. Aquaculture is an important component within the portfolio of livelihood activities that are considered valuable. DFID India welcomes the STREAM Initiative approach to contribute to policy change processes and to give recipients of service provision a voice.

Implementers (especially GVT)

A focus of GVT (formerly the Eastern India Rain-fed Farming Project) is now the sharing of processes and outcomes from their work (including six years of experience of working in aquaculture with poor marginalized people, mainly from tribal groups). Through extensive use of participatory approaches, and the development of social capital as an entry point (involving the formation of 193 groups, 25% of which were women's groups), more than 4,500 farmers who were unable to produce sufficient food throughout the year (the majority of whom belong to scheduled castes and tribes in Jharkhand, West Bengal and Orissa), had benefited from aquaculture. Aquaculture has been one of the most successful interventions of the project (which includes soil and water conservation, small-scale livestock and forestry, as well as special issues like participatory crop varietal selection). The use of seasonal water bodies for aquaculture was a new and successful undertaking researched in partnership with NRSP and ICAR. The opportunity for incorporating such learning into policy change processes is wholly welcomed by GVT.

Government of India

During discussions with the Fisheries Development Commissioner, it was evident that despite all efforts, the aquaculture development needs of scheduled castes, scheduled tribes and farmers in the north-eastern region, have not been adequately addressed. A Committee of High Level Experts (comprising the CIFE Director; Fisheries Development Commissioner; Directors (Fisheries) of Madhya Pradesh, Karnataka and Himachal Pradesh; FFDA representatives and others) recommended policy changes and the Tenth Five-year Plan is with the Fisheries Development Commissioner at the final drafting stage.

A Mechanism for Transacting Change

Based on DFID's research and development experience in Bihar (now Jharkhand), West Bengal and Orissa and some further work in the western (Madhya Pradesh, Gujarat and Rajasthan) and central (Maharashtra) regions covering tribal populations, the Fisheries Development Commissioner encouraged the STREAM Initiative, with funding from DFID NRSP, in collaboration with NACA, to play a role in recommending reforms under the FFDA scheme or even suggest a new "tribal" rain-fed farming component that could be launched in the next year. In order to exemplify such work on constraints and policy concerns, within the Tenth Five-year Plan (currently being finalised), a "Component Concept Note" was drafted and provided to the Commissioner in March 2002. This will provide opportunities for interactive workshops, meetings and consultations that might lead to recommendations for developing either a new scheme or a component of an ongoing scheme.

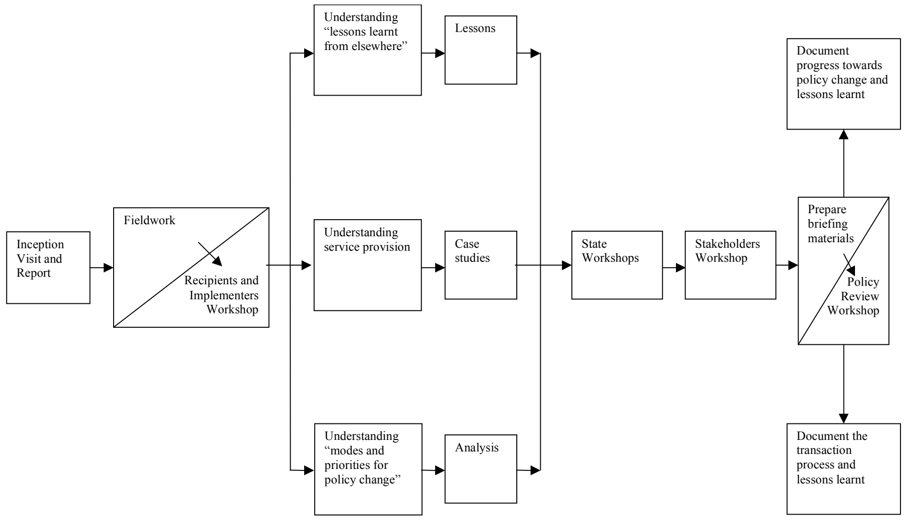
Fieldwork was carried out before hosting a Recipients and Implementers Workshop, with an aim to gain an initial understanding of people's experiences of aquaculture service provision. Community colleagues from the fieldwork villages were invited to participate in the workshop, including

Jankars from two GVT-supported villages, recipient farmers from a government-supported village, and farmers from a village with no support. As a result of the Inception Visit, and the fruitful, enthusiastic discussions with a range of colleagues and stakeholders at the subsequent workshop, the following plan has been agreed (Figure 1).

The "central" of the three parallel strands to follow this inception phase, and to inform each other and subsequent project activities, is a set of case studies. A number of these, using a variety of media, will be commissioned in Jharkand, Orissa and West Bengal.

The purpose of the case studies is to show people's experiences of aquaculture service provision from their perspective, about specific issues, with specific groups of fishers, farmers and other relevant "actors", in Schedule Tribe, Scheduled Caste and "Backward Class" communities. *For more information contact Graham Haylor, email ghaylor@loxinfo.co.th*

Figure 1: STREAM plan for Investigating Improved Policy on Aquaculture Service Provision to Poor People



What's New on the Web

Launch of eNACA V2.0 www.enaca.org

The NACA information team has rebuilt the NACA homepage to make it a lot more useful to network participants. Our website now features a lot more 'dynamic' content and is updated at the end of each week, so there is always something new. We have completely changed the page to include:

- Regional aquaculture news headlines;
- Announcements on upcoming conferences, workshops and updates on network activities;
- Links to NACA programmes and major databases;
- An online library of network publications, all available for FREE download as PDF files;
- An email newsletter service;
- The average file size of our pages has been reduced by about 25% so you can open them faster.

In the interests of maximizing sharing of information, we have put all currently available network books on our publications page for FREE DOWNLOAD, as PDF files. Everything !! Totally free !!! This includes some very useful things like the Asia Diagnostic Guide to Aquatic Animal diseases and a low-resolution version of Aquaculture Asia (suitable for online viewing, but you will still have to subscribe if you want a printed hard copy, sorry). New NACA publications will continue to be added to this page as they are released - usually before the hard copies have been printed.

A particularly useful feature is our new email newsletter, which will be delivered once per month. If you would like regional aquaculture news headlines and announcements on network activities delivered to your computer, please subscribe. Its easy, just type your email address in the box on the homepage and press the 'submit' button. The first edition will come out at the end of July.

What, no internet access ? Order our website and publications on CD-ROM !!

In recognition of the fact that many people have limited access to the internet, we have started producing copies of our entire website on CD-ROM (including our publications) for distribution via post.

We will provide copies of this CD to organizations with restricted internet access for free (in member countries), and to others and individuals for the cost of production. The CD will be updated quarterly.

New CIBA website launched www.icar.org.in/ciba/index.htm

The Central Institute of Brackishwater Aquaculture in Chennai, India, has also re-launched its website. This site contains a profile of the institute and research achievements, lists of available publications and extension materials, profiles of resident scientists and a training calendar. Also worth a mention, if you are trying to contact institutes in India, is the homepage of the Indian Council of Agricultural Research (ICAR), which contains links to most major institutions, www.icar.org.in.

Marine finfish section

The Grouper Section has taken on a new and broader name: It has become the Marine finfish Section to take account of other species. This Section is almost wholly based on the Grouper Electronic Network which is prepared by Sih Yang Sim (Editor), Michael Phillips (NACA Environment Specialist) and Mike Rimmer (Principal Fisheries Biologist of the Queensland Department of Primary Industries). Visit www.enaca.org/grouper for more information on the network.

Grouper Hatchery Production Training Course, Gondol Research Institute for Mariculture, Bali, Indonesia, 1 - 21 May, 2002

Sih Yang SIM[1] and Adi Hanafi[2]

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The training course was organized and supported by the Ministry of Marine Affairs and Fisheries, Indonesia, the Network of Aquaculture Centres in Asia-Pacific (NACA), the Australian Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC) and the Japan International Cooperation Agency (JICA). It is one of the activities of the Asia-Pacific Marine Finfish Aquaculture Network http://www.enaca.org/grouper/. The training course was conducted at the Gondol Research Institute for Mariculture (GRIM), northern Bali, Indonesia, which is equipped with good facilities for training and research activities and has excellent experience in breeding of groupers. This is the first time that GRIM offered a regional training course on grouper hatchery production in cooperation with NACA and the Asia-Pacific Marine Finfish Aquaculture Network, although it has provided training for Indonesian scientists, technicians and farmers for some time.

Preparation of larvae culture tanks by participant from Thailand

The training course was attended by fourteen participants from eight economies in the Asia-Pacific region; Thailand, Indonesia, Hong Kong China, Singapore, Vietnam, Malaysia, the Philippines and Colombia. The training course attracted four people from private sector and ten from government research institutes around the region.

Opening and Institute Tour

The training course was started with a welcome speech by Gondol and NACA staff, and resident JICA marine fish breeding expert. After the official opening the participants were given opportunity to introduce themselves and toured the GRIM facilities with Dr Adi Hanafi, the director, and staff.

Theoretical Components

During the 21 days of training, participants were provided with a mix of practical, hands on training, supported by lectures and working discussions on various topics, broadly covering the following:

- Grouper Seed Production
- Live Food Production
- Broodstock and egg management
- Sex and maturation manipulation
- Parasitic diseases
- Bacterial diseases
- Viral diseases
- Transportation of eggs and seed
- Nutrition and feed development
- Floating net cage culture
- Mariculture development in Indonesia

Practical Components

One of the essential components of the training course was on the job training. The participants were divided into four groups, in which each group was assigned to handle and take care of one larvae tank. The responsibilities of the group members were to feed the larvae, clean tank bottom, counting rotifer in the larvae tanks, harvest rotifer in the live feed section, enrich live feed such as rotifer and *Artemia*.

The participants are also provided with other on the job training which include the following:

- Preparation of larval rearing tanks
- Larviculture
- Aeration control
- Management for prevention of surface tension death
- Rotifer density estimation
- Live feed culture
- Microalgae
- Rotifer
- *Artemia*
- Egg harvesting, handling, examine egg quality and estimation of hatching rate
- Broodstock, feeding, handling and post spawning handling
- Feed preparation and feeding
- Examine gut contain of early larvae
- Diseases


Participant counting rotifer population under supervision of GRIM technician


Lecturer explaining the microalgae pure culture in indoor system


Harvesting enriched rotifers for feeding larvae

PCR Test

After the theoretical section on diseases, particularly viruses, participants were provided a one day session on step-by-step PCR test procedures for grouper larvae to determine whether the larvae are infected with Viral Nervous Necrosis virus.

Observe Activities

Participants were also provided chances to observe broodstock selection and examine eggs development stage for napoleon wrasse. Activities such as blood sampling and injecting microchips for broodstock of napoleon wrasse and mouse grouper were also observed by participants.

Feed Preparation and Manufacturing

After the lecture on Nutrition and Feed Development, participants were given a hands-on practical lesson on feed preparation and manufacture. The group was brought to the feed production section at GRIM and shown how to prepare and produce artificial pelleted feed. The formula for the feed was provided by GRIM. The participants were provided step-by-step guideline for making the pellet feed, and explanation of the feed machineries. Some participants were given the opportunity to do work on pellet spreading on the drying tray.

Field Trips

Field trips were organized to visit grouper backyard hatcheries, grouper nursery, live fish traders and exporter, fish market and also floating cages. Participants were also provided opportunity to visit some milkfish hatcheries nearby.

Grouper backyard hatcheries

Three commercial backyard hatcheries were visited, this provide an opportunity for the participants to see for themselves how the system actually operates and works.

Grouper nursery

One big commercial nursery was visited. The nursery cultured mouse grouper and tiger grouper, this nursery bought fry at 2 cm in length and grow them to juveniles.

Live fish traders and exporters, and fish market

A one-day trip was organized for participants to visit live fish traders and exporters. Two live fish exporters were visited. One was dealing on coral trout and


Napoleon wrasse eggs development sampling


Hand pressure to check spawned broodstock


Observing packing of eggs for distribution

Some coral reef fish species selling in the local fish market

GRIM technician shows participants on how to make pelleted feed from small machine

the other is mixed of grouper species, but mainly on *Epinephelus* spp., such as tiger grouper. After the live fish section the group was brought to visit the local fish market, which is the main fish market in Denpasar area.

Field trip visit to GRIM nursery floating net cages for grouper species

Floating net cages

The participants were provided a chance to visit the broodstock holding cages nearby GRIM and also visited GRIM's floating net cages for grouper nursery from 2 inches to stocking grow-out cage size. The group also went to visit a floating net cage farm which mainly culture milkfish, and also beginning to do grouper culture, particularly for mouse grouper.

Private Sectors Interaction and Discussion Session

Additional activities such as informal meetings with the private hatchery operators were also arranged so that participants could hear the success stories and problems that were facing by the private sector in Indonesia for grouper seed production. Discussion sessions with technicians and lecturers were also being organized as needed.

Certificate and Closing

Overall the training course was a successful one, participants experiencing a lot of activities and also provided some commercial interaction that provides opportunity for participants as well as the local hatchery operators, traders and exporters and products suppliers.

Future similar training course may be run, anyone interested please contact grouper@enaca.org.

Marine finfish section

ACIAR Grouper Project – Six Monthly Report (July – December 2001)

The ACIAR project Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region is now into its second year. There have been several breakthroughs for grouper breeding and larviculture during the past two years of research. Promising results have also been obtained for the grow-out diet development component. The following summarizes the research outcomes:

Larval rearing

Research at SEAFDEC has shown that a range of environmental factors affect the survival of newly hatched grouper larvae. Significantly higher survival rates ($P<0.05$) were observed at aeration levels of 0.62 and 1.25 ml/min/l, at salinity levels of 16 and 24 ppt and at light intensity of 500 and 700 lux than at the other conditions tested.

Analyses of live prey at SEAFDEC have provided baseline data on the nutritional composition of the live prey diets used for larval rearing. Analyses of early larval stages has shown some interesting patterns of fatty acid utilization, including a high level of conservation of docosahexaenoic acid (DHA) in the polar lipid fraction of Day 4 larvae. In Day 8, 18 and 28 larvae arachidonic acid (ARA), eicosapentaenoic acid (EPA) and DHA were more highly conserved in the polar lipid fraction than in the neutral lipid fraction.

Morphological and histological descriptions of *Epinephelus coioides* larval stages are largely completed. On-going histochemical and biochemical analyses of grouper (*E. coioides* and *Cromileptes altivelis*) larvae are being undertaken at SEAFDEC and at NFC and an accurate profile of the ontogeny of digestive enzymes is being developed from these studies.

A new component has recently been added to the project: selective breeding of super small (SS-) strain rotifers *Brachionus rotundiformis*. Experimental work undertaken at Gondol demonstrated that development of rotifers is dependent on salinity and that measuring egg-bearing females older (post hatch) than 12 h at 5 ‰ salinity, 15 h at 20 ‰ salinity and 18 h at 30 ‰ salinity provides an accurate indication of any change in the average body size of the initial rotifer population. A second experiment to evaluate the effect of diet particle size on rotifer body size indicated that the *Sticchococcus* diet resulted in a significantly smaller rotifer population and that this difference was detectable after 5 days.

Grow-out diet development

Diet development work to examine a range of ingredients to develop practical compounded diets for groupers using (where practical) locally available ingredients.

Experimental work at SEAFDEC comparing several diets showed that fishmeal can be substituted with high-quality terrestrial meals. Specific growth rate (SGR) of fish fed control (3.1%), meat and bone meal (3.0%), gluten meal (2.8%) and tuna fish meal (3.1%)-based diets were comparable, and significantly higher than that of fish fed blood meal-based diet (2.4%).

Diet trials at Gondol and at RICF Maros have demonstrated that:

- the minimum dietary carbohydrate requirement of *C. altivelis* is 7%;
- dietary carbohydrate affected the growth, feed efficiency, growth, protein and lipid retention as well as the digestibility nutrient of *C. altivelis*;
- glucose is the appropriate carbohydrate source of juvenile *C. altivelis* diet.

Marine finfish section

The vitamin C requirements of *C. altivelis* are currently being examined at RICF Maros. Preliminary results indicate that fish weight tends to increase with increase levels of L-ascorbyl 2-polyphosphate (APP) in the diet. The highest weight was observed in fish fed diet with APP 150 mg/kg diet.

For the full report visit the Marine Finfish Network website www.enaca.org/grouper/ or contact:

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Country Status Overview 2001 on Reef Fisheries Exploitation and Trade in Indonesia

International Marinelife Alliance (IMA) Indonesia, Ministry of Marine Affairs and Fisheries, and Telapak Indonesia Foundation

This report cover reef fisheries exploitation and trade dynamics in Indonesia, describes the type of commodities, fishing ground and trading centers in Indonesia for ornamental fish, live coral and reef food fish. This report also covers the price structure for both ornamental and food fish in Indonesia. Destructive fishing methods used such as cyanide, blasting, coral extraction etc are also being described. External natural threats such as red tide, coral bleaching are also briefly included. The report also describes the intervention methods that are implemented for controlling the destructive fishing activities such as fishing ground and catching season management models, technical intervention on fishing methods by introducing sustainable methods such as hook & line, bubu, barrier net, and also introduce mariculture.

Country Status Overview (CSO) 2001 is the first part of a series which will be developed and published annually. CSO is an open document that can be, and is expected to be, written by as many parties as possible with interest in the Exploitation and Trading of Reef Fisheries in Indonesia. Data for the compilation of CSO will be collected/gathered from all involved players in the exploitation and trading of reef fisheries, including parties which cause the decrease in the quality of the habitat. And of the life of the community, indirectly or directly.

Most of the data collected is secondary data, varied from export tables issued by several government institutions, to the observation reports made by export and science agencies. A series of interviews have been conducted to support specific data. CSO 2001 decided on three monitoring sites (Jakarta, Denpasar and Makasar, which are the main export gates) as the first points in information and collection, and observations in several fishing areas (Nias, Lampung, Ujungkulon, Thousand Islands, Karimun Jawa, Sumenep, Maluku Tenggara, and Biak).

For full report please visit International Marinelife Alliance website at http://www.imamarinelife.org/

Proceedings of The Live Reef Fish Trade Workshop April 23, 2001

International Marinelife Alliance

This report includes summaries of the papers presented at the Live Reef Fish Trade workshop in Hanoi, Vietnam on April 23, 2001 and it also provides a record of the discussions and recommendations from the workshop. The following are the list of presentations given in the above workshop:

- Overview of the Worldwide Live Reef Fish Trade, IMA's Indo-Pacific Destructive Fishing Reform Initiative
- Overview of Live Reef Fish Trade in Vietnam
- The impact of cyanide fishing on coral resources in Vietnam
- Activities for coral reef conservation in Vietnam
- Legal issues concerning the management of fisheries resources including the Live reef Fish Trade
- Marine culture strategies n Vietnam, the concept of coastal resources co-management

The full report can be obtained from International Mainelife Alliance – Vietnam website at http://www.ima-vietnam.b2vn.com/.

New aquarium species database

Dr Edmund Green

The UNEP–World Conservation Monitoring Centre (UNEP–WCMC) is pleased to announce a new database on the trade in aquarium species, the Global Marine Aquarium Database (GMAD), which is available at http://www.unep-wcmc.org/marine/gmad.

Users of the database will have access to approximately 50,000 records of trade in live aquarium species and may query these geographically and taxonomically.

Further data collection is ongoing and the database is continuously being updated, with the release of the next version scheduled for April.

Reprinted from the SPC Live Reef Fish Information Bulletin # 10.

...from page 21

From sandwiches to sashimi - the success story of Australia's southern bluefin tuna industry

In the early 1980's Australia's Southern Bluefin Tuna (SBT) industry was in a precarious position.

SBT was regarded generally as suitable only for the low-value canned fish market, destined for use on Australia's lunchtime sandwiches. As a result, fishers needed to catch high tonnages of the species to earn a living. The Australian SBT catch peaked in 1982 at 21,500 tonnes.

Concerned over the sustainability of the species, fisheries managers and the industry established quotas in 1984 to limit the tonnage of fish caught to 14500 tonnes. It was reduced to 6,250 tonnes in 1988 and 5,265 tonnes in 1989.

These days, things are different. The wild-catch tonnage caught has stabilized at that set in 1989 and a Convention for the Conservation of SBT has been established between Australia, New Zealand and Japan.

Fish are produced by a combination of wild-catch and aquaculture (farming).

The product's destination is no longer canned tuna but the high value Japanese sashimi market with prices averaging $1200 per fish. By adding value through tuna farming, operators have increased the value of their catch from $12.5 million to $252 million in 2000.

Fisheries Research and Development Corporation (FRDC) Programs Manager Dr Patrick Hone said this remarkable transformation has been achieved through systematic improvement in the knowledge of the species, husbandry processes, technology and marketing.

"This has been led by innovative companies and an industry association that are focused on sustainable development; and establishing partnerships within the industry and with customers and research investors such as the FRDC," he said.

These partnerships began in 1991, when the FRDC collaborated with the Tuna Boat Owners Association of Australia, the South Australian Government and the Japanese Government, in funding the world's first research and development project associated with farming SBT.

"Farming offered a potential mechanism for improving fish quality, increasing the weight of fish and optimizing the time that fish were marketed," said Dr Hone.

"An experimental farm was established as the focus for developing technology in Port Lincoln. Initially it began with two pontoons, fifteen tonnes of captured SBT and full participation of Japanese farm experts and Australian fishers. The rest, as they say, is history."

However, the industry and FRDC are continuing to look forward, already working on the challenge of breeding SBT in captivity-the success of which could have enormous environmental, economic and social benefits.

The industry and FRDC has ensured that this innovative momentum will not be lost with the recent signing of a Memorandum of Understanding between the Tuna Boat Owners Association of Australia and FRDC that will see an increased investment in R&D by the industry.

"It is partnerships such as these that will ensure the sustainability of the industry and the natural resources on which it depends," said Dr Hone.

For further Information contact: Dr Patrick Hone, FRDC Program Manager, Ph: +612 6285 0412 or Mr Brian Jeffries, Tuna Boat Owners Association of Australia CEO, Ph: +61 0419 840 299

Seafood retains healthy oils after cooking: CSIRO

There's more good news on the 'good oils' in seafood. Cooking doesn't diminish the high level of beneficial oils found in seafood, according to research released today by the Australian CSIRO.

The research, funded by the Fisheries Research and Development Corporation, shows that seafood – cooked, uncooked or processed, wild or farm-raised – is the best source of nutritionally-important omega-3 polyunsaturated fatty acids.

These fatty acids are needed to help prevent and treat heart disease and other disorders, but the human body only produces them in small amounts, so they must be obtained from the diet.

The research findings are presented in Seafood the Good Food II, a book recently released in Hobart.

Information in Seafood the Good Food II is intended to help the seafood industry, nutritionists and consumer groups to communicate the health benefits of eating Australian seafood.

The book contains detailed oil profiles for 79 seafood species, as well as information on cooking, processing, aquaculture production and seasonal influences for selected species. It brings the total number of Australian seafood species profiled by CSIRO to nearly 300.

"Most Australian seafood is high in omega-3 polyunsaturated fatty acids and low in cholesterol." project leader Dr Peter Nichols of CSIRO Marine Research says.

"In fact, it contains 10–100 times higher levels of omega-3 polyunsaturated fatty acids than foods such as beef, chicken and lamb.

"But the nutritional value of farmed seafood, and the effects of cooking and processing on these beneficial oils were unknown, until now.

"We've determined that frying, grilling, steaming, microwaving and curing have no adverse effects. That must be good news for seafood lovers.

"And farmed fish such as Atlantic salmon, barramundi, silver perch and striped perch are high in omega-3 PUFA, and feeds can be tailored to increase this nutritional value," he says.

Nutritional studies continue to emphasise important links between seafood and human health.

"There is now good evidence in humans that the omega-3 polyunsaturated fatty acids in fish reduce heart attacks and particularly death from heart attacks," Dr Manny Noakes of CSIRO Health Sciences and Nutrition says.

"Animal studies have shown that this may be because omega-3 polyunsaturated fatty acids stop arrhythmias, the irregular heart rhythms that can lead to sudden death from cardiac arrest."

Dr Noakes says omega-3 polyunsaturated fatty acids from seafood act to lower triglycerides, one of the fats in the blood thought to contribute to heart disease.

They also appear to be involved in blood pressure regulation, platelet function and blood clotting, all of which may contribute to the prevention of heart disease.

The benefits of fish don't stop at heart disease prevention.

"Omega-3 polyunsaturated fatty acids from seafood may prevent stroke, may reduce the risk of premature births and may guard against prostate cancer," Dr Noakes says.

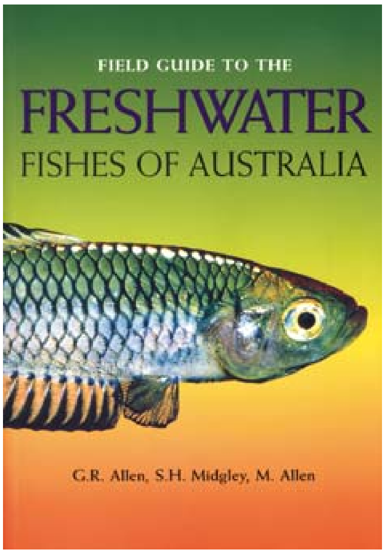
"They are also helpful in the treatment of rheumatoid arthritis and some recent studies indicate a benefit in some forms of depression."

Steve Gill of the Master Fish Merchants Association of Australia says the findings are great news for the seafood industry.

"Our association will be spread the message through distributing posters and brochures explaining the results of the study to fish retailers throughout the country," he says.

Seafood the Good Food II is available from CSIRO Publishing on +61 1800 645 051.

For more information please contact Dr Peter Nichols, CSIRO Marine Research, on +61 (3) 6232 5279 or email peter.nichols@csiro.au.



Field Guide to the Freshwater Fishes of Australia

This book is the definitive and only complete work on Australia's freshwater fish fauna. The 302 species covered in the book are accompanied by good quality colour photographs, a brief taxonomic description, advice on how to recognize the species, details about its preferred habitat, its status and geographic distribution and remarks about its habits and breeding behaviour. Thirty-four Australian native fishes - more than one-in-ten of our identified species - appear on the IUCN's "red list" of threatened species. Their fate is a stark indicator of the ailing condition of the continent's rivers and freshwater systems.

The Field Guide to the Freshwater Fishes of Australia is the work of Gerald Allen, Mark Allen and Hamar Midgley, supported by a host of Australia's best museums, biologists and aquarists. It is a copublication between the Western Australian Museum and CSIRO Publishing, ISBN 0 7307 5486 3. RRP $45.00 in softback. To order copies contact CSIRO Publishing Customer Services +61 1800 645 051 or email publishing.sales@csiro.au.

I would say that this guide complements, rather than replaces, the previous definitive book 'freshwater fishes of Australia', also by Gerald Allen. While the guide covers a great deal more species - around 300 as opposed to 200 in the previous book, it does so in less detail which I found a little disapointing, however I guess length was an issue. Most of the extra species covered in this book are the more unusual and arcane (and interesting !) ones. Still, if you are into native Australian fishes, this is a great (and lets face it the only) book. Highly recommended. The Editor.

Training course - Population Genetics: Applications in Fisheries Resources Management"
22 August - 3 September 2002, Penang, Malaysia.

The objectives of this training course, organised by the International Center for Living Aquatic Resources (ICLARM), include providing participants with a background to the use of genetic markers as a tool for fisheries resource management and to present the pros and cons of the different genetic techniques that may be used for the assessment of genetic variability. *See http://www.iclarm.org/Training/training_19Aug02.htm or contact m.ablan@cgiar.org for more information.*

FISH FARMING IN RICE ENVIRONMENTS OF NORTH EASTERN INDIA

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Fish have been harvested from rice fields as an additional crop since ancient times. Biologically, rice fields can be considered as agriculturally managed marshes, which remain dry for varying periods of time during the year. Physically, the aquatic phase has varying water depth according to the land topography and local rainfall patterns and water tables. In its flooded state, the rice field is a rich and productive biological system which can produce a crop of aquatic organisms, both plant and animal, for human consumption in addition to the rice.

The farmers of the Northeastern part of India (Fig-1) in all the seven states viz. Assam, Arunachal Pradesh, Nagaland, Meghalaya, Mizoram, Manipur and Tripura cultivate rice as their staple food. The ecology of their rice fields in the region is quite diverse, but can be divided primarily into upland, lowland and deepwater rice ecosystems. On the basis of water sources there are two types of fields viz., irrigated and rain fed rice fields. In this region of the country, a fish crop is traditionally raised only from the paddies of rain fed lowlands (both shallow and deepwater). In many areas, irrigation-fed rice fields have also been adapted locally by the farmers to include fish farming. Traditional rice-fish production systems have an important socio-economic part in the life of the farmers and fishers in the region.

Rice-fish farming

Unlike most agriculture and animal husbandry, which evolved millennia ago, many aquatic farming systems have relatively recent origins. Traditional rice fish farming may be considered to derive solely from the farmer-based technology, where modern rice fish farming involves a shift from completely farmer-based technology relying mainly on use of on-farm and agricultural by products to science-based technology such as use of improved breeds, inorganic fertilizers and formulated feeds.

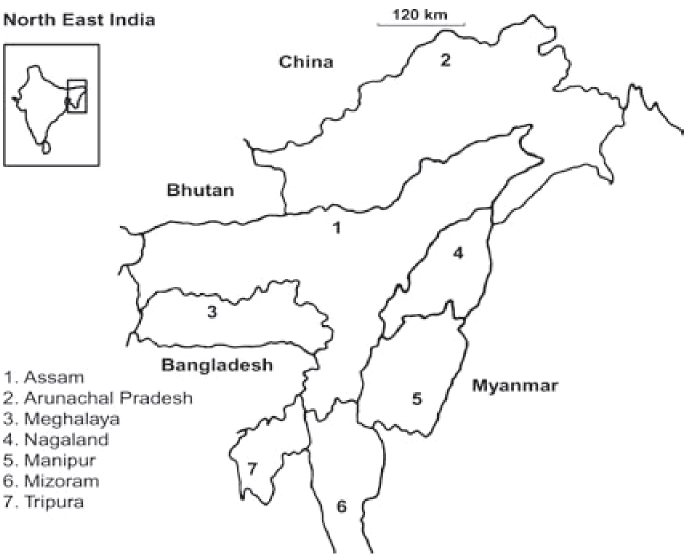

Figure 1: Northeastern states of India

The system of raising fish from the rice fields probably started in the northeast with the beginning of rice cultivation itself. Since the water logged rice field forms natural habitat for wild fish so it is believed that it appeared first only as the simple capture. The fish communities of rice fields were exploited as common property resources for rice growers as a whole in the earlier days. The concept of intentional rearing or culture farming evolved later, particularly when the farming communities faced a demand for increased and organized fish production. Even then the impact of modern research and developmental endeavors hardly touched the rice farmers of these remote region of India.

Existing farming practices: Methods and Status

The indigenous rice-fish farming practices prevailing among the farmers in the northeastern India can be categorized as (a) rice field capture fishery systems (b) wild aquatic cropping systems (c) mountain valley rice fish farming system and (d) running water terrace rice-fish farming systems.

Rice field capture fishery system

In the unmanageable vast waterlogged rice environments, perennial waterlogged wet rice lands, oxbow type rice fields or flooded river basin rice fields, naturally occurring fishes and prawns enter the field during the monsoon and grow together with the rice crop. The gravid females and young fingerlings enter the field during the wet season when field water overflows and connects neighboring watercourses to form a vast sheet of water under the rice canopy. The floodwater carries huge and diversified community of fish, prawn, crabs and other aquatic organisms into the rice paddies. This situation is very common in the flood plain rice fields of whole of the Brahmaputra and Barak Valleys of Assam. The fishing activities there start just after arrival of the floods from late June and continue until the water recedes in November-December. In a true sense, these areas become temporary fishing grounds. The farmers and fishers use those fields as common property resources for about 5-6 months of the year using gill nets, cast nets, and various indigenous traps, either operating them in the rice-free spots or fixing the traps at appropriate water entry and exit points in the fields. In such fisheries, the average capture rate is typically around 3kg/ha/yr[1,2]. Such practices are highly prevalent in the districts of North Lakhimpur, Dhemaji, Barpeta, Nalbari, Bongaigaon, Dhubri and Kachher district of Assam and certain districts of Manipur and other Northeastern states. The deepwater rice environment where such practice is most common covers more than 460,000 hectares in Assam State alone.

All of the states of Northeastern India lie in a heavy rainfall zone and therefore a longer aquatic phase is possible in these areas than in rain-fed low lying rice fields. Harvesting of the rice starts in November-December after the recession of floodwater at the end of wet season. All the low-lying ditches, marginal swamp and natural depressions inside the field area are also harvested at the same time. This is done either by pumping out the water or by using traditional nets or traps. The fish fauna from such flooded fields are very diverse (figure 4).

In Barpeta district, Assam, this is a very common system among the local tribal and fishers for collecting fish and other aquatic resources from the paddies. The yield of fish from such indigenous practice ranges from 45-280 kg/ha/season[3] (table 1). The tribal folks of lower Assam traditionally practice community fishing during the night. They use indigenous night lamps made from bamboo or burning bicycle or rickshaw tires for light fishing. By walking in and around the flooded field at night with the light they can attract and capture stunted fish, frogs, crabs and other animals with a sharp weapon. In rice-less patches of open deepwater rice fields or oxbow lakes the farmers also practice cast netting using bait during the evening hours.

The tribal women of the lower Assam traditionally collect wild resources through group fishing of the flooded rice areas using local devices. In general, small fishes, snails and crabs are the common harvests from most of the rice environments. Group fishing is performed throughout either the either the whole of the wet season or at the end of the season. Aside from animals, various aquatic vegetables like Ipomea, Alternathera, Nymphaeia are also harvested for family consumption.

Figure 2. Open deepwater rice fields during October- November i.e. water recession period

Wild aqua cropping system

The practice of wild aquatic cropping is a common practice in the rice fields of Assam, Manipur and foothills of other hilly states of Northeastern India. In this system the farmers or fishers trap and rear the fish, which enter the fields from the wild and thus intentionally utilize the rice environment. This practice is mostly carried out in impounded rain fed lowland and the closed deepwater rice fields, which are embanked all around and linked with canal systems of varying sizes and designs. On average, canals occupy 8% of the area of such fields and average 0.6-1.5m in depth[4]. The rice cultivars traditionally grown in these fields are a tall type commonly known as Sali rice in lower Assam and Aman rice in Cachhar district. In some closed deepwater rice field, tall traditional Bao cultivars are grown. These plots are seasonal wetlands where water depth may reach 2.5 meters or more during the monsoon, but partially or completely dry up during December-January. The rice is planted during April-May by direct seeding and after getting first shower of rain the seeds are germinated. In many areas, tall seedlings are also transplanted after accumulation of rainwater during June-July. The fields connect with neighboring watercourses during the monsoon when they overflow, allowing seeds of various wild fish and prawns into the field. Sometimes farmers dig trap ponds inside the field intentionally to give the animals refuge and facilitate their entry in the field. In addition to direct capture during the wet season, the farmers also rear wild seed until the water level drops down below the level of the fields. During this phase wandering fish accumulate in the trap ponds or natural ditches in and around field contour. These fishes are harvested after dewatering the ditches and canals. The rate of production is ranges around 200-300kg/ha/season.

Figure 3. Use of trap in the field at the entry &exit points in post flood low land rice fields

Figure 4. Wild fish and prawns commonly available in rice fields in northeastern India

In Assam, many of the old fortresses constructed by tribal chief of the state are being used under this type of farming practices. One such fortress Jangal Balahu garh (37ha) in Nagaon district has a high perimeter dyke surrounding the entire area, horizontal deep trenches and wooden sluice structures present in one corner of the plot offering a readymade site for rice-fish farming[5]. In districts of Barpeta, Bongaigaon and Kokrajhar rice fields are often connected by canal systems locally called as 'Dong'. To facilitate aquaculture the Dong are enclosed by bamboo pens to prevent escape of the fish from the rice field, which are harvested after recession of the water. The tribal communities of Boro and Rajbangshis are very well trained in this type of aquaculture and local fishers supply huge fish to local markets from such harvests. In the lowland areas of Barpeta and Nagaon district 'wild' aquatic farming is so popular among the farmers that they often use their jute retting tanks as trap ponds in the field. In many areas farmers deliberately stock their closed rice fields with fish seed during the wet season but they normally they do not normally follow and any scientific system of culture.

Mountain valley rice-fish system

In the hilly states of Northeast India many rice fields are located in mountain valleys where water accumulates from adjoining slopes and flows down the valley. Dwarf varieties of rice are generally cultivated in such plots mainly integrated with culture of common carp *Cyprinus carpio*. Naturally various weed fishes from colonize in those fields during the period of inundation.

The states of Arunachal Pradesh, Mizoram, Meghalaya, Nagaland and Tripura have a type of huge rice field where farmers intentionally allow various fish species to grow along with their rice crop. These are harvested at the end of rice season either from the irrigation channel or from the specially dug fish refuges in the plots. The production rate from such plots could be raised up to 200kg/ha/season.

The best example of mountain valley rice fish culture in the region is in the Apatani plateau of Arunachal Pradesh. These plots have more or less uniform elevation. Mountain valley plots are gently sloping and are characterized by two- and three-sided dykes. These types of plots are common in the valley areas of the northeast but are not generally utilized for culture fisheries.

Running water terrace rice-fish system

In the hilly terrain of Meghalaya, Sikkim and in certain parts of Arunachal Pradesh, the rice fields are in the form of terraces spaced over mountain slopes. This provides opportunities, as in Japan, to develop running water fish culture systems in the rice fields. The water from the stream irrigated and rain-fed plots trickles down from plots at higher altitude to lower ones creating a flow through system within the plots. The terrace type of plots are stocked with common carp at a density of 6,000/ha and fed either with 1:1 mustard oil cakes and rice bran at 1kg/ha or simply provided with domestic kitchen waste, giving an average production of 186kg/ha in two months.

Farmers practice terracing in certain areas of Arunachal Pradesh, particularly in most of the hilly areas adjoining the Apatani plateau contour. To reduce soil erosion, water is funneled into trench constructed at the edge of each terrace. This seems to have good potential for replication in hilly areas where soils have good water retention. A dyke on one side is usually sufficient to retain water in an

Figure 5. Community harvesting of a marginal swamp of the rice fields

Figure 6: Dewatering of perimeter canal for harvesting of fish

Figure 8: Use of bamboo pens in wild aqua-cropping system

800-1000 m^2 trench. An earthen spillway in the dyke is needed to drain off excess water. A one-way bamboo gate across the spillway serves to prevent stocked fish from escaping but also allows wild fish to enter the field. Traditionally a simple bamboo gate is used to prevent stocked fish from escaping.

Fish farming in rice fields has become an additional source of income and important economic avenue among the Apatani farm families of the state. Local farmers have modified the system in such way that it has become an excellent example of rice fish-farming system in hill tracks and it has also become intimately related with the agrarian life of Apatani people in Northeastern states of India.

Indigenous versus modern culture systems

All the rice fish systems prevailing in Northeastern states of India (except mountain valley and terrace culture systems) are chiefly dependent on wild fish seed resources. The wild fish and fry enter the rice fields during initial flooding and additional water exchange from the permanent lakes and rivers. Therefore, the success of fish output from such fields depends on adequate natural spawning and survival of fingerlings, much of which occurs in seasonally flooded rice fields during the monsoon. This natural stocking system is hampered if (a) indiscriminate fishing at first flooding is allowed due to depletion of gravid females leading to poor spawning in the field or (b) if rice cultivation is intensified adopting modern management practices, which will also inhibit spawning and fry production.

> ***"Fish farming in rice fields has become an additional source of income and important economic avenue..."***

Figure 7: Wild stream fishes from waterlogged mountain valley rice fields

Irrespective of the rice ecosystems the indigenous farming of rice and fish are mostly concurrent in nature. So, the capture fishery and wild aquatic cropping systems are commonly found in areas that are water logged during the water season and where inundated fields become connected with perennial water bodies. The capture system is a customary and seasonal habit of rice farmers and fishers living around waterlogged rice agricultural systems. These areas face a lot of constraints in adopting modern rice production systems. The indigenous practices that prevail there were developed locally by farmers. The supplementary harvest of fish from rice fields is an innovation to increase returns.

In upland or shallow water rice fields where dwarf high yielding rice varieties are cultivated, modern tools and practices are required. The seepage of agricultural chemicals through runoff water into flooded fields can cause the destruction of aquatic fauna. As a result, the capture yields of fishes from rice fields are gradually declining in many states of India. A survey report from the district of Barpeta, Assam revealed that many species of wild fishes and prawns are

Table 1: Wild fish production from deep-water rice field environment of Barpeta district, Assam

Development bocks	No. pockets surveyed **	Fish production (kg/ha/season)	Average yield (kg/ha/season)
1. Barpeta	10	45.0-136.0	98.4
2. Chenga	5	80.0-118.0	97.8
3. Mandia	5	105.0-215.0	135.5
4. Bhabanipur	12	82.5-280.0	138.0
5. Gobardhana	5	63.5-115.0	75.0
6. Rupahi	4	49.0-120.0	71.0
7. Bajali	5	82.0-160.0	89.8
8. Jalah	4	58.0-116.2	78.0
Total	**45**	**45.0-280.0**	**97.9**

** Individual farmers were interviewed during the period of fish capture*
*** Based on farmers interview during the Season (June-December) 1992*

Table 2: District-wise rice area, developed rice fish culture area and total fisheries area in Arunachal Pradesh

District	*Rice area (ha)		Culture fisheries area (ha)**	
	Irrigated	Un-irrigated	Rice-fish culture	Total
Tawang	216	533	50.0	66.23
West Kameng	133	1433	75.0	114.70
East Kameng	954	3475	15.0	39.18
Lower Subansiri	4443	8867	547.0	626.76
Papum Pare	-	-	10.0	136.19
Upper Subansiri	913	7461	69.0	123.19
West Siang	4335	9853	40.0	87.14
East Siang	6011	3717	22.0	72.22
Upper Siang	-	-	17.0	42.25
Dibang Valley	684	6249	-	38.98
Lohit	1428	8466	7.0	148.97
Tirap	11	4120	10.0	45.22
Changlang	2677	6583	-	70.70
Total	21805	60757	862.0	1611.73

** Approximated land census data*
*** Approximated data from fisheries report, Govt. of Arunachal Pradesh*

Table 3: Potential rice-fish culture areas of the Northeast India

State	Scope for Cultivation (ha)	Area under cultivation (ha)	Total production (ha)	Average (Kg/ha/year)
Arunachal Pradesh	2,650	150	2800	125
Assam	15,000	N/A	15,000	N/A
Manipur	1,600	400	2,000	200
Meghalaya	2,200	50	2,250	380^{+}
Mizoram	400	N/A	400	N/A
Nagaland	400	120	520	250
Tripura	5,000	N/A	5,000	300^{++}
Total	27,250	720	27,970	251

NA Not Available
** Adopted after Lipton, 1983*
\+ Experimental observations (Ghosh, 1981)
\+\+ Experimental observations (Lipton, 1982)

declining sharply in their availability throughout the season. In that context, the traditional wild capture and aqua cropping systems should either be improved or replaced by adopting suitable culture techniques. Almost in all the states of Northeastern India have plenty of areas under flooded paddy fields (Table 2,3). This would definitely increase yields, enhancing socio-economic development in rural areas.

Figure 9. A terrace plot under rice-fish farming in Apatani plateau, Arunachal Pradesh, India.

Acknowledgement

I am highly indebted to all the fisheries and agricultural workers of the Northeastern India who supplied the information time to time on my personal communication. I also gratefully acknowledge the help forwarded by my fellow colleagues in the department of Zoology, Arunachal University during the preparation of this manuscript.

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A REGIONAL APPROACH TO ASSESSING ORGANIC WASTE PRODUCTION BY LOW SALINITY SHRIMP FARMS

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The need for large volumes of brackish water to fill pond enclosures has traditionally limited the cultivation of marine shrimp to a relatively narrow band of coastal land in Thailand[1]. This was certainly the case during the first wave of intensive shrimp aquaculture development in the Upper Gulf of Thailand during the late 1980s. Farm expansion during this period was concentrated in the estuaries of major rivers such as the Bangpakong, Chao Phraya, Tha Chin, and Mae Khlong. Intrusion of saline water during the dry season is a common characteristic of these low gradient river systems, and this permitted the construction of a second generation of tiger shrimp farms along natural stream channels and irrigation canals some distance from the coast[2]. However, brackish water is unavailable in upstream areas when higher stream flows counteract tidal influences during the wet season[3]. Low salinity shrimp culture techniques were developed to overcome this seasonal limitation, and shrimp farming expanded inland rapidly during the second half of the 1990s. The low salinity culture system spread from seasonally brackish areas, to freshwater areas that never experience salt water intrusion[4]. Low salinity shrimp farms that draw freshwater from existing rice irrigation infrastructure now exist over 100 kilometers from the coast in areas such as Prachinburi and Nakhon Nayok. Approximately 18,530 hectares of low salinity shrimp ponds have been identified in the Bangpakong River Basin as part of our study, and as much as 40 percent of Thailand's total cultured shrimp production could come from shrimp farms located in freshwater or seasonally brackish areas throughout the country[5].

The rapid emergence of low salinity shrimp farming within inland freshwater areas has, however, raised concerns regarding potential water quality impacts[6]. The main concern is usually the disposal of organic-rich effluent from shrimp farms into freshwater streams or irrigation canals. Water quality impacts associated with an individual low salinity shrimp farm are typically quite limited because of their small size (0.5 - 5 hectares). However, the simultaneous operation of a large number of these farms within a river basin could produce a serious cumulative impact on regional water quality[7]. Given the proliferation of shrimp ponds within freshwater areas of Thailand, it is imperative to obtain a better understanding of the regional organic waste production characteristics of this activity. Unfortunately, most previous investigations have been site-specific case studies[8,9] or have focused on brackish water shrimp farms located in coastal environments[10,11,12,13]. Few broad-scale environmental studies have been undertaken assessing the regional water quality impacts associated with low salinity shrimp farming.

Figure 1: The Bangpakong River Basin study area

Study Area

The Bangpakong River Basin is approximately 18,758 km^2 in area (Figure 1). Two major tributaries (Nakhon Nayok and Prachinburi Rivers) join in northern Chachoengsao Province to create the Lower Bangpakong River (Figure 2). This major watercourse then flows 122 kilometers through a flat alluvial plain before empting into the Upper Gulf of Thailand. The lower Bangpakong sub-basin is a highly productive agricultural region with fertile clay soils and an extensive man-made irrigation network dating back over one hundred years[11]. Irrigated rice is the most common crop, but fruit and field crops such as tomatoes and corn are also produced. Intensive animal husbandry (chicken, pig and cattle) has also developed with many large farms located in Chonburi and Chachoengsao provinces. A substantial industrial complex and numerous towns and cities are located along the lower Bangpakong River.

Regional assessment techniques

Shrimp farming can develop very rapidly in suitable areas. This rapid pace of development places on a premium on the availability of farm inventory data and can render time consuming management approaches such as basin planning or integrated coastal zone management largely ineffective[15]. Given these characteristics, a technique that combines the use of satellite imagery, geographic information systems (GIS), and organic waste modeling was developed to study aquaculture-related water quality impacts in the Bangpakong River Basin.

Shrimp farms in the study area were identified by a recent survey of low salinity shrimp farms in the Central Plains Region of Thailand4. This survey utilized LandSat 5TM (level 8) satellite images obtained on March 10 and March 17, 1998. Interpretations of these images were later ground-truthed to produce 1:50,000 base maps identifying individual shrimp ponds. These base maps digitized, and entered into a geographical information system with other data (e.g., hydrology, soils, land use). This process identified the location of individual low salinity shrimp ponds, and provided a calculation of total pond area within individual sub-basins (Figure 3). A field reconnaissance of the study area was also conducted during the latter half of 2000. No new low salinity shrimp farms were found outside of the areas surveyed in 1998, but a substantial number of new ponds were found to be under construction within existing development zones. This may have been in response to the rise in world shrimp prices that occurred as a result of disease-related crop failures in Ecuador[16].

Shrimp farm organic waste production was evaluated using biological oxygen demand (BOD) loading estimates. BOD is one of the most commonly applied indicators of both organic waste production and overall water quality in Thailand[17]. BOD provides a measure of the potential for aquaculture wastewater to cause pollution by "de-oxygenation"[18]. Three scenarios for farm-level BOD production estimates, based on farm level studies[8,9,10,11,13,14,19] were combined with the shrimp farm locational data to estimate organic waste loads within individual sub-basins. Shrimp farming BOD production was also compared to other sources of agricultural, industrial and municipal organic pollution to assess the relative significance shrimp farm effluent discharges.

Figure 2: The Bangpakong River is rises from the fusion of the Nakhon Nayok and Prachinburi Rivers in Chachoensao Province

Existing Water Quality in the Bangpakong River

Water quality and hydrological conditions in the Bangpakong River Basin were recently investigated as part of a Water Quality Management Plan for the Eastern Region of Thailand[14]. Streamflows in the Bangpakong River Basin are extremely seasonal as a result of the monsoon which creates a distinct dry season (November - April) and wet season (May-November).

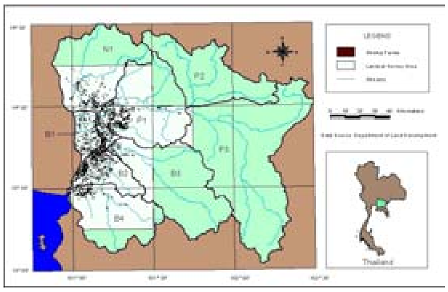

Figure 3: Pond area within sub-basins

Threshold levels for key parameters identified by the Pollution Control Department (dissolved oxygen – DO; biological oxygen demand – BOD; total coliforms and ammonia – NH_3) were used to create water quality classes representing the needs of beneficial water uses in the Bangpakong River. Class 1 water quality essentially corresponds to natural conditions, while Class 5 water quality is very poor and only suitable for navigational purposes. Water quality meeting the Class 2 level has been targeted for most reaches of the Bangpakong, Prachinburi and Nakhon Nayok Rivers. Currently, only the most distant headwaters of the Prachinburi and Nakhon Nayok Rivers comply with the Class 2 target for dissolved oxygen (6.0 - 7.6 mg/l). Most of the Prachinburi River and all reaches of the lower Bangpakong River above kilometer 82 possess a Class 3 designation (4.0 – 6.0 mg/l). The lower Bangpakong River and several reaches of the Nakhon Nayok River were rated as Class 4 (2-4 mg/l).

Several important points are highlighted by this water quality

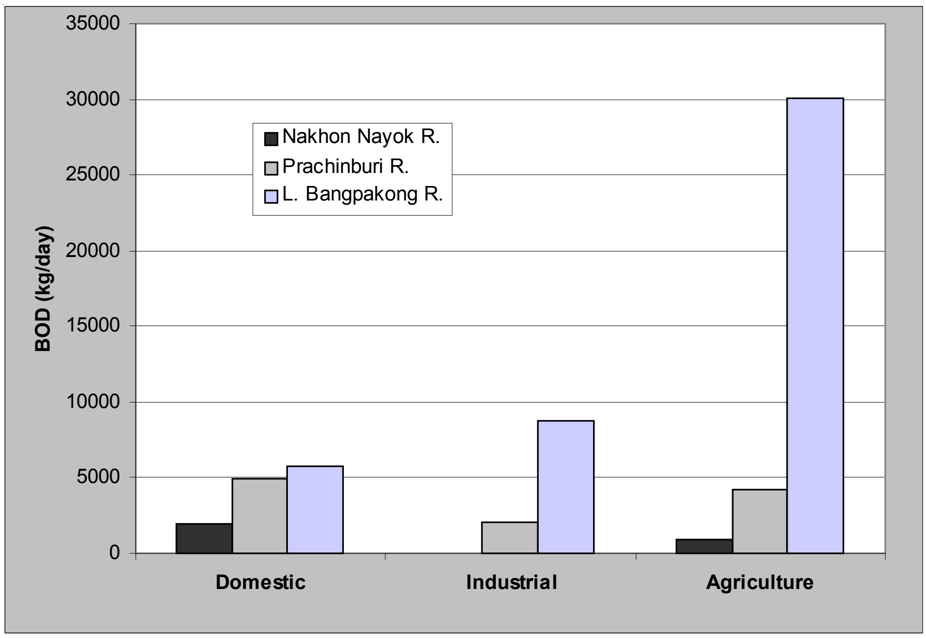

Figure 4: Total pollution load from the industrial, domestic and agricultural sectors

assessment. Low dissolved oxygen and high BOD levels suggest that many portions of the Bangpakong River Basin are heavily loaded with organic wastes to the severe detriment of water quality. The lower Bangpakong River receives the largest total pollution load from the industrial, domestic and agricultural sectors (Figure 4). Agricultural BOD inputs from intensive animal husbandry (pig, chicken and cattle farms) are significant in each of the three major rivers, but exceed 30,000 kg/day in the lower Bangpakong River. Substantial industrial and domestic pollution loads were also identified in the lower Bangpakong River as a result of effluent produced by major industrial estates and urban centers located within this sub-basin[20]. Population growth and economic development will likely result in a further degradation of water quality unless municipal wastewater treatment facilities are constructed, industrial effluent discharges are controlled, and the flow of untreated agricultural pollutants is greatly reduced[14].

Shrimp Farm Organic Waste Production

Low salinity shrimp farm effluent production and water exchanges are modest during the first 60 days of the grow-out cycle because the juvenile shrimp are small and require little supplemental feeding[21]. Larger shrimp require substantial feed inputs and more frequent water exchanges to maintain a suitable growing environment. Uneaten food pellets, faeces, and eroded pond soil tend to accumulate at the center of the pond enclosure due to the action of mechanical aerators. This "sludge" is enriched in nitrogen, phosphorus and carbon relative to sediments in the surrounding environment. The organic waste load of shrimp farm effluent is determined by the quantity and rate of waste production, feed nutrient levels, feed conversion ratios, and site-specific conditions[10].

Untreated liquid effluent discharged during the early to mid grow-out period typically contains organic nutrient loads only slightly higher than many receiving waters in Thailand[8,17]. This effluent is also generally within a range acceptable to native freshwater and marine organisms and complies with aquaculture effluent quality standards such as those proposed by the Thai Pollution Control Department[17]. The nature of untreated effluent released during the late grow-out period and at harvest is quite different with significant concentrations of nutrients, solid organic matter, and salt.

Figure 5: Small waterways have limited assimilative capacity

Larger shrimp farms typically treat pond sludge using on-site settling ponds. Small-scale low salinity shrimp farms in Thailand generally do not possess either adequate land or the experience to apply this even basic form of waste management[22]. Many shrimp farmers simply flush pond sludge directly into adjacent water bodies[17]. Accumulated pond sediments may be removed with high-pressure water sprays. A second disposal technique involves simply allowing pond outlets to remain open over several tidal cycles[19].

Sludge disposal is problematic in all shrimp farming areas, but this issue is particularly important within inland regions containing low salinity shrimp farms[6]. The small streams and irrigation canals that support shrimp farms within inland areas may have little assimilative capacity (Figure 5) and water quality can be significantly degraded by sludge dumping. The disposal of pond sludge into any water body is illegal in Thailand, but this practice is not uncommon due to a lack of farmer awareness and difficulties in enforcing regulations[19,17].

Regional Impact of Shrimp Farming on Water Quality

Water quality in the Bangpakong River Basin is affected by a number of pollutants, but organic nutrient loading is the biggest concern[17]. Given the degree to which husbandry practices affect organic nutrient levels within shrimp farm effluent, three BOD scenarios were developed to estimate regional water quality impacts. Scenario A represents a "best case" situation in which shrimp farms apply efficient husbandry procedures and basic waste management practices. Effluent discharges in Scenario A comply with the existing Thai standard for aquaculture wastewater of 10 mg BOD^5 per litre or less throughout the production cycle[17]. It is assumed that no effluent discharge occurs during the early grow-out period and pond bottom sediments are stored on-site. Based on these assumptions, BOD production in Scenario A is estimated at 163 kg/ha/crop or 326 kg/ha/year.

BOD Scenario B presents a "worst case" situation. Poor husbandry and waste management practices result in effluent that exceeds Thai aquaculture standards for BOD during the mid-late grow-out period and at harvest. BOD production figures for these stages of the production cycle were drawn from a recent study of low salinity shrimp culture within freshwater areas of the Thai Central Plains Region[8] which corresponds to the findings of other recent studies[12,13,17]. BOD production in Scenario B is estimated at 2,768.5 kg/ha/crop and 5,537 kg/ha/year.

BOD Scenario C represents an intermediate case. It assumes that 50 percent of existing low salinity shrimp farms comply with effluent discharge standards, while the remaining 50 percent utilize poor management practices that results in non-compliance and sludge dumping.

The magnitude of water quality impacts associated with low salinity shrimp farming in the Bangpakong River Basin was estimated using shrimp pond area calculations (Figure 2), effluent production estimates[19], and the three BOD production scenarios outlined above. Assuming a shrimp farm wastewater outflow of 16,300 m^3/ha/crop, the operation of 18,531 hectares of low salinity ponds would generate approximately 332,613,500 m^3 of effluent per crop or 665,227,000 m^3 per year (assuming 2 shrimp crops per year are produced). A substantial proportion (59 percent) of the total effluent flows originate from shrimp farms located in the lower Bangpakong River (Table 1). High organic pollution loads in the Bangpakong East and West Bank sub-basins are associated with dense concentrations of low salinity shrimp farms in the Muang, Bang Khla, Ban Pho, and Khong Khuain districts of Chachoengsao Province. Effluent volumes are relatively smaller in the Prachinburi sub-basin (26 percent of the basin total), but are almost completely concentrated within the Ban Sang district located near the confluence of the lower Prachinburi and Nakhon Nayok Rivers. Only 15 percent of the total effluent flow is produced by shrimp farms in the Nakhon Nayok sub-basin, mostly located along the lower Nakhon Nayok River or operating within irrigation projects in the Ongharak and Muang districts.

Total annual organic pollution loads in the three BOD scenarios range from approximately 6 million kg/year (Scenario A – best case situation) to over 102 million kg/year (Scenario B – worst case situation). BOD production in Scenario C (a combination of good and poor shrimp farm effluent management practices) is estimated at approximately 54 million kg/year. The extreme difference in BOD production rates provided by the three scenarios is largely attributable to sludge handling practices. Shrimp farm effluents that contain sludge removed by wet

Table 1: Estimates of BOD under different scenarios

Sub-Basins	Pond Area (hectares)	Effluent Volume[1] (m^3 / year)	BOD Scenario 1 (kg / year)	BOD Scenario 2[2] (kg / year)	BOD Scenario 3 (kg / year)
Nakhon Nayok River	2,861	93,268,600	932,686	15,841,357	8,387,022
Nakhon Nayok Sub-Basin	**2,861**	**93,268,600**	**932,686**	**15,841,357**	**8,339,815**
L. Prachinburi River	4,746	154,719,600	1,547,196	26,278,602	13,912,899
Hanuman River	0	0	0	0	0
Phraprong River	0	0	0	0	0
Prachinburi Sub-Basin	**4,746**	**154,719,600**	**1,547,196**	**26,278,602**	**13,834,590**
Bangpakong (west bank)	4,039	131,671,400	1,316,714	22,363,943	11,840,329
Bangpakong (east bank)	4,494	146,504,400	1,465,044	24,883,278	13,174,161
Khlong Luang	1,613	52,583,800	525,838	8,931,181	4,728,510
Khlong Thalat	777	25,330,200	253,302	4,302,249	2,277,776
L. Bangpakong Sub-Basin	**10,923**	**392,135,700**	**3,200,439**	**60,480,651**	**32,020,775**
Total Bangpakong Basin	**18,530**	**665,227,000**	**6,040,780**	**102,600,610**	**54,320,695**

flushing possess very high suspended sediments loads and are heavily enriched in both nitrogen and phosphorus. In the "worst case" management scenario (BOD Scenario B), slightly less than 90 percent of the total BOD load associated with each hectare of shrimp pond is attributable to pond sludge disposal. Only approximately 10 percent of the total BOD load within Scenario B reflects late grow-out period water exchange or effluent disposal at harvest.

A comparison of annual estimated organic pollution loads for other forms of intensive animal husbandry suggests that low salinity shrimp farming represents a large new source of agricultural BOD in the Bangpakong River Basin (Table 2). Depending on which BOD scenario is applied, low salinity shrimp farming could produce somewhat less or considerably more BOD per year than the intensive chicken or pig farming sectors. A more accurate estimate of shrimp farm BOD production is not possible because detailed data on sludge handling practices in the Bangpakong River Basin are unavailable. Given the explosive growth of low salinity shrimp farming in eastern Thailand, and the widespread prevalence of poor waste management practices, BOD loads are likely at least as large as those produced by intensive pig or chicken farming and could reach the levels described in BOD Scenario C.

Management implications

Existing water quality in many portions of the Bangpakong River Basin is not suitable for aquatic life or for water uses that involve human contact such as fishing, swimming, bathing[14]. The situation is particularly serious in the lower Bangpakong River during the dry season when nutrient loading from agricultural, industrial and municipal sources produce algae blooms and low dissolved oxygen levels. Construction of the Bangpakong Diversion Dam has also affected dry season water quality conditions, and it appears unlikely that this facility will operate as planned until organic pollution levels in the lower

Table 2: Annual estimated organic pollution loads for animal husbandry

SUB-BASIN	CHICKEN (BOD kg/year)	PIG (BOD kg/year)	LOW SALINITY SHRIMP (BOD kg/year)		
			Scenario A	Scenario B	Scenario C
Nakhon Nayok	7,651,875	1,030,778	932,686	15,841,357	8,339,815
Prachinburi	7,574,130	3,003,158	1,547,196	26,278,602	13,834,590
Lower Bangpakong	13,468,946	14,777,968	3,200,439	60,480,651	32,020,775
TOTAL BASIN	**28,694,952**	**18,811,904**	**6,040,780**	**102,600,610**	**54,320,695**

Bangpakong River are dramatically reduced[22].

Achieving the water quality targets outlined in the Action Plan to Improve Water Quality in the Eastern River Basins will require a major reduction in organic nutrient loads within the lower Bangpakong and Prachinburi Rivers (Pollution Control Department, 1998). Proposed remedial actions include limiting industrial waste flows, constructing municipal water treatment faculties, and reducing organic waste flows from intensive chicken and pig farms. However, a large number of low salinity shrimp farms have been constructed in the Bangpakong River Basin since these remedial actions were proposed. This additional source of organic pollution has undoubtedly increased total agricultural BOD production and placed further stress on water quality. The dry season also represents the main production period for shrimp. Given the likely contribution of shrimp farm waste to total annual agricultural pollution loads, and the implications this has for meeting BOD reduction targets, it is reasonable to conclude that low salinity shrimp farming is having a significant impact on the water quality in the Bangpakong River Basin.

Confidence in the assessment is affected by several factors. Firstly, water quality monitoring data are limited to the main channel reaches of the Prachinburi, Nakhon Nayok and lower Bangpakong Rivers. Information describing environmental conditions in tributary streams are unavailable, but given the more limited assimilative capacity of these systems, water quality impacts could be even more severe than those identified in the main river channels. Dry season water quality effects within irrigation districts could be particularly acute because outflow from areas are limited to prevent the intrusion of saline tidal flows from the main channel of the Bangpakong River. Assumptions concerning average annual shrimp crop production are also based on a relatively small data set, and very little information is available concerning sludge management practices. The latter issue is particularly critical given the influence of sludge on the overall production of organic pollutants by low salinity shrimp farms.

Controlling the regional water quality impacts associated with low salinity shrimp farming will be difficult, but eliminating the illegal disposal of pond bottom sediments into freshwater streams or irrigation canals is critical. Management actions that could reduce the prevalence of illegal sludge disposal include increased environmental monitoring, more stringent enforcement practices, and extension programs for shrimp farmers that focus on waste management techniques. Imposing a requirement for all shrimp farmers to construct and utilize waste treatment ponds could also reduce water quality impacts. Addressing waste management issues in the shrimp farming sector does not, however, guarantee regional water quality improvements. A wide range of agricultural, industrial and domestic activities produce organic pollutants in the Bangpakong River Basin, and a multi-sectoral pollution reduction strategies is required. In the absence of a broad-based approach, improved waste management practices introduced by shrimp farmers will have a limited effect on regional water quality.

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Peter Edwards writes on

Rural Aquaculture

Aquaculture for Poverty Alleviation and Food Security

There was a lively and stimulating session on "Aquaculture for Poverty Alleviation and Food Security" at World Aquaculture 2002, the recent annual meetings of the World Aquaculture Society and The China Society of Fisheries, held in April in Beijing. This issue's column, based on five presentations of speakers kindly sent to me on request for this purpose as chair of the session with Professor Li Sifa, will enable persons unable to attend the meeting to benefit from the collective experience and wisdom of the speakers. My column in the next issue will outline another six presentations from the session.

"...there is a need for a paradigm shift in philosophy away from food for the poor, which addresses the symptoms of poverty, not causes, to creation of weath..."

Simon Funge-Smith from FAO's Regional Office for Asia and the Pacific led off with background to one of the main themes of the session with a presentation entitled, "Focusing Aquaculture on Poverty Alleviation". Simon's presentation was based on a recent FAO/NACA Expert Consultation of field-level professionals in Asia who shared experiences and prepared a platform for future networking. Living aquatic resources play a fundamental role in sustaining the livelihoods of many of the rural poor in Asia with poorer people often the most dependent on aquatic resources, particularly low-value fish and other living aquatic organisms. Such resources provide opportunities for diverse and flexible forms of income generation and contribute towards food security. Aquaculture may offer significant advantages over other activities such as cash crops and livestock and may be easily integrated into other farm and livelihood activities. Low-cost aquaculture technologies using available on-farm inputs exist, providing limited need for investment, low levels of risk and low labor requirements that "fit" with household divisions of labor. Low levels of production may still provide an important source of household nutrition, and buffers against shocks. Women often benefit from aquatic resource use and management in production, processing or trading the extent to which aquaculture can improve the position of poor women will also be taken up with Cecile Brugere's presentation in the next issue.

To realize the potential for small-scale aquaculture and aquatic resource management to alleviate poverty, it is recommended that poverty alleviation be taken as the strategic starting point for aquaculture interventions. This has significant implications for how interventions are conceptualized, planned and executed as well as the institutional arrangements and partnerships. Distinctions between "farmed" and "wild" living aquatic resources are often artificial and thus mask flexible and often complex relationships between the two in the livelihoods of the rural poor. As with any production–based intervention, poor people face significant constraints to entry into aquaculture. Those currently involved in aquaculture may not be the very poorest since aquaculture requires resources such as land, ponds, water, credit and other inputs. Furthermore, many aquaculture interventions have not always directly addressed the needs of the poorest people. However, as Simon pointed out, experience from the consultation clearly demonstrates that there are considerable opportunities for poor people's entry into aquaculture, if appropriately planned. Previous thinking was in terms of aquaculture development. Now the emphasis now is on aquaculture *for* development.

Small-scale integrated aquaculture with pigs (above), chickens or vegetables usually has too low a production to provide a significant income. Photo courtesy Thomas Hecht.

As aquaculture technologies for poor people are largely in place, greater emphasis should now be given to more effective extension of low-cost technologies and appropriate management practices for poor people, and securing their right of access to and control of resources, rather than technical research. Targeting the poor to understand their needs and to identify opportunities for them to benefit from aquaculture and aquatic resources management is essential. Targeting should be based on a range of criteria and participatory methods. Local people's views of categories of the poor and poor people, including those of women, should be taking into consideration in defining objectives, strategies and indicators of "success". Opportunities for the entry of the poor and / or landless can be created by breaking up the aquaculture production cycle, facilitating access to fingerlings by decentralizing seed production, supporting seed traders and seed distribution networks, facilitating pond lease or purchase, and by providing inputs. Collective action of poor people should be supported through securing access to or leasing common water bodies, enhancement of communal water bodies including the establishment of locally devised pro-poor rules and regulations, introduction of small cages into water bodies, dry season refuge management, establishing farmer groups and supporting credit and savings groups.

The enabling institutional environment for the poor to benefit significantly more from living aquatic resources management than at present is wanting as fisheries institutions are traditionally oriented to technical issues, often have limited experience in training and extension methods appropriate for the poor, and usually face serious budget and personnel constraints. New learning opportunities are required for these institutions, including increased interaction with other agencies as "aquaculture for development" should not be the sole responsibility of fisheries institutions. This will require innovative institutional arrangements and partnerships between governments, NGOs, civil society groups, donors and poor people.

Considerable donor funds were spent on construction of fish stations in Africa...

The next two presentations, by John Moehl, FAO Regional Aquaculture Officer for Africa, and Thomas Hecht of Rhodes University, South Africa, outlined the current low level of aquaculture in Africa and possible reasons for limited adoption by farmers, in spite of significant investment, and offered views on strategies to promote aquaculture for development.

...and on supporting field extension workers. Photos courtesy John Moehl.

John, in his presentation entitled, "Aquaculture Development as a National Strategy for Poverty Alleviation and Improved Food Security in Africa", explained that to understand the potential for aquaculture development in Africa, there is a need to appreciate the past as remnants of early efforts still very much affect present processes aimed at increasing the impact of aquaculture. The donor community spent millions of dollars in the 1970s and 1980s on aquaculture development across Africa to introduce technology and reinforce government programmes. Significant funding was spent on creating infrastructure, particularly fish stations / hatcheries and supporting aquaculture extension services which were frequently linked to the new government fish stations through subsidized transport for extension staff.

The technology extended by many of these externally-funded operations was based on maximizing outputs often presented as a "cook book" methodology as it was assumed development was resource-limited and an injection of funds and technology would translate into increased fish yields. Indeed, most countries demonstrated a dramatic increase in the number of fish farmers as revitalized extension services stimulated interest in aquaculture but adoption was at times marginal and at best has had a minor impact on food security and poverty. Yields did not progressively increase as foreseen but often declined, as did the number of active fish farmers, especially when donor funds dwindled.

Although aquaculture failed to fulfill expectations, Africa now has a core of practicing fish farmers producing low yields with little government support i.e. aquaculture has evolved from an introduction into an enterprise with which a few farmers are familiar. These are the persistent and resistant individuals who form the foundation for future development and expansion of aquaculture in Africa. While there are a limited number of medium- and large-scale aquaculture enterprises that supply fish to urban centers and also employ poor people, it is estimated that 95% of African aquaculture production comes from small-scale rural farms. Most household aquaculture is of tilapias and/or catfish, integrated within a traditional farming system, producing an average of 0.5-1 tonnes/ha in one or more 100-500 m^2 ponds, and providing fish for the home and market.

Present day development of aquaculture in Africa is constrained by both political- economic and technical issues. Aquaculture has acquired a high degree of donor dependence but external funds have become extremely scarce. Macro-economic difficulties have precipitated adoption of national structural adjustment programmes, accompanied by decentralization and down-sizing of government agencies. The situation has been exacerbated by geo-political turbulence, economic recession, natural calamities, and significant and often negative changes in demographics. In aggregate, these have led to weakened public sector institutions, reduced extension / outreach, declining infrastructure, and chronic shortages of human and financial resources. Aquaculture development has also been affected by persistent input supply problems: unreliable supplies of good quality seed; difficulties in obtaining adequate quantities of cost-effective feeds; and no ready access to capital. At the same time, a combination of swelling populations and declining natural resources puts increasing pressure on aquaculture to fill the growing fish supply: demand gap. The capacity to fill this gap appears to exist as there is un- or under-utilized land and water resources, available labor and suitable climate. These attributes can justify development of small-scale integrated aquaculture and large-scale intensive fish farms, as well as raising crustaceans and molluscs.

Relatively high value grass carp is cultured on grass grown on pond dikes, supplemented with pelleted feed. Souchow, China.

According to John, a holistic view is required for growth and increased impact of aquaculture in Africa that examines aquaculture in a matrix of variables, addressing size / scale, intensity and ownership i.e. there is need for proper technical and socio-economic fit for aquaculture in each location. Each production system should have a target group, utilizing a specific set of inputs and producing a product aimed at a defined market. This requires increased understanding of the socio-economics of target groups, participation and sharing of responsibility with stakeholders, increased private sector involvement, divestment by government, and enhanced information exchange / flow. The effort to generate information and match systems and producers will require considerable up-front expenditure but will reduce long-term maintenance costs and promote sustainable aquaculture.

Thomas Hecht in his presentation, "Strategies and Measures for Sustainable Aquaculture in Sub-Saharan Africa", explained that sustainable aquaculture has a dual meaning: first and foremost it refers to placing aquaculture on a sustained growth trajectory in terms of production, job creation, poverty eradication and enhanced trade; but also that it is dependent on aquatic ecosystems and the maintenance of the integrity of the environment will ultimately determine the sustainability of the sector as a whole. Aquaculture in Africa will only reach a sustainable threshold once it enters a steady growth phase, is less dependent on foreign donor aid, and is practiced in an environmentally sustainable manner.

Africa contributes < 0.5% to global aquaculture production. Three Mediterranean countries produce almost 60% of the African total and 6 sub-Saharan countries produce 93% of the remaining 40%. But the 27 countries that produce 7% (2,400 tonnes) of the sub-Saharan total receive the bulk of donor support. Although sub-Saharan aquaculture is generally practiced within environmentally sustainable boundaries, aquaculture makes little if any contribution to sustainable livelihoods, as also pointed out by John Moehl, except in certain countries and circumstances.

According to Thomas, there is the need for a paradigm shift in philosophy away from focusing on food for the poor, which addresses symptoms of poverty not causes, to creation of wealth (financial, knowledge, health etc.). He believes that capture fisheries have a greater role to play in providing food for the poor than aquaculture. The sustainable aquaculture threshold will only be attained when production changes from low-yielding small-scale ponds to larger-scale and higher-yielding fish ponds.

Ferrocement boat used to harvest aquatic weeds from canals and lakes to feed grass carp. Souchow, China.

Thomas also presented a plan for promoting aquaculture development in sub-Saharan Africa, including the recognition of both the down-side and the up-side of past mistakes. The over-arching mistake was allowing economic reality to be overshadowed by philanthropy and political expediency. Specific mistakes included a flawed developmental philosophy, inadequate planning, transfer of inappropriate technologies, inappropriate channeling of donor funds, neglect of the private sector and the consequences, and a focus on hatcheries and the poorest of the poor. On the up-side, a fundamental knowledge base has been established e.g. ponds, species and integration; it is now recognized that profit motivates activity; and it is also recognized that there are resource limitations for which appropriate plans need to be made to overcome them. To establish a self-sustaining sector requires a change in philosophy, appropriate strategies, careful participatory planning, goal oriented donor participation, private sector investment, capacity building and appropriate technology.

With respect to appropriate technology, Thomas highlighted poor nutrition for the fish, which translates into poor production efficiency. The previous focus has been on organic fertilizers that are available in limited amounts, and maize bran. Use of maize bran is logical as it is widely available but it is a waste of money with a FCR of 25:1. Previous research on alternative feeds has been unfocused and should be redirected to legumes as soybean with a FCR of 5:1 has led to considerably increased extrapolated fish yields of 5 tonnes/ha/year.

It is ironic that there was no Chinese presentation on the role of aquaculture in food security and poverty alleviation as China dominates global aquaculture production, has had the fastest growth rate in total production over the past few decades and the meeting was held in Beijing. Fortunately, Miao Weimin sent me a copy of his paper presented in another session, "Economic Profile of Aquaculture Practices in China: Implication for Sustainable Aquaculture Development" which is of relevance. The rapid development of aquaculture over the past two decades has significantly increased the availability of aquatic produce from less than 10 kg to over 30 kg/caput, making an important contribution to national food security. There has been tremendous diversification of species and culture systems in China but traditional pond fish culture still dominates aquaculture production.

Recent experience with intensification of pond culture in China has involved increased use of commercial formulated feed, reduced integration and a change from polyculture to monoculture of high value species. A degraded culture environment has led to increased frequency of disease requiring extensive use of various medicines and chemicals. A further adverse environmental impact

Small grass carp fed with duckweed cultured between fish ponds. Souchow, China.

is the current practice of discharging effluents from pond culture to natural water bodies without any treatment. This has led to the conclusion that traditional pond fish culture with moderate intensity and integration with other agricultural activities is a sustainable aquaculture system. Clearly, more widespread application of the principles of Chinese aquaculture practice elsewhere in the world would help aquaculture to fulfill its potential contribution to food security and poverty alleviation.

There were two presentations on India, the second largest aquaculture production in the world : "Role of Fish Consumption in the Food Security of India" by Ramachandra Bhatta, M.M. Dey and F. Parguas; and "Contribution of Aquaculture to Poverty Alleviation and Food Security in India" by M.C. Nandeesha. According to Ramachandra, the growth rate of fish production in India is second only to eggs and is considered to be one of the most promising sectors to achieve food security. Their presentation was based on a comprehensive survey of food consumption of rural and urban fish consumers in five Indian states known to be prominent in inland fisheries (Haryana, Karnataka, Orissa, Uttar Pradesh and West Bengal).

Fish contributed more to the welfare of poor than better-off consumers. The percentage of expenditure on fish relative to total expenditure decreased with an increase in income; furthermore, the percentage contribution of fish protein to total animal protein was relatively higher among poorer than medium and rich income classes. This indicates that higher fish production would benefit the poor more than the better off. Rural consumers who mainly represented producer–consumers had an annual fish consumption twice that of their urban counterparts. Rohu was consumed the most by all income classes in all states, followed by catla, mrigal and marine fish. The average annual consumption of fish was about 15 kg / caput, two to three times higher than previous estimates but ranged from 5 for urban Karnataka to 30 kg/caput for rural Haryana, the latter indicating the impact of increased production and accessibility of fish on consumption, and greatly underdeveloped potential for aquaculture in India.

Nandeesha pointed out that more than half of the more than 1 billion people in India are non-vegetarians. Although most fish consumers live in the eastern part of the country, demand for fish is increasing throughout most of the country. However, overall growth of aquaculture has been slow compared to several other countries, calling for a vigorous campaign if aquaculture is to fulfill its potential.

In several parts of India, family fish ponds are common with the majority of farmers being poor and raising carps for both household consumption and sale. Although the national average for inland fish production is only 2 tonnes/ha/year, farmers have demonstrated the commercial viability of carp farming with yields of more than 15 tonnes / ha / year in several areas where aquaculture has been introduced. Nandeesha described the development in Andhra Pradesh of a system based largely on rohu, which has the highest market demand in a previous issue (Volume 6, No. 4, pp. 29-32, 2001).

Anabas, Channa, Clarias and Heteropnustes are important cultured fish in some areas. Tilapias are also widely cultured and are increasing in popularity. In Kolkata (Calcutta) tilapia is the most sought after fish by both poor and rich people. Culture of prawn, *Macrobrachium rosenbergii*, has increased dramatically in several states with small-scale and poor farmers also involved. Contrary to the perception that penaeid shrimp farming is carried out largely by big business, more than 90% of the area is farmed by small farmers who mostly hold < 2 ha. Low salinity and freshwater shrimp culture are also widely practiced.

According to Nandeesha, there is a need to employ a farming systems approach to increase aquaculture production with a change in extension strategies to focus more on people than on technologies. There is also a need to evolve more farmer friendly technologies that minimize risk to reap the full benefits from aquaculture.

Shrimp Farming and the Environment

Michael Phillips and Jesper Clausen, NACA

Development of coastal aquaculture, and shrimp farming in particular, has generated debate in recent years over the social and environmental costs and benefits. Rapid expansion of shrimp farming in some countries in Asia has focused attention on the need for effective management strategies to improve farming and to minimize environmental complications. Such strategies are needed to enhance the positive contributions that shrimp farming and other forms of coastal aquaculture can make to economic growth and poverty alleviation in coastal areas, while controlling negative environmental and social impacts that may accompany poorly planned and regulated developments.

The Network of Aquaculture Centres in Asia-Pacific (NACA) has been involved in environmental aspects of aquaculture for a long time and since August 1999 been part of a Consortium dedicated to the often discussed relationship between shrimp farming and the environment. The other partners besides NACA are the World Bank (WB), the World Wildlife Fund (WWF) and the Food and Agriculture Organization of the United Nations (FAO).

So far the Consortium have supported 35 complementary case studies prepared by more than 100 researchers in more than 20 shrimp farming countries. These cases have been developed through consultation with numerous stakeholders throughout Asia, Africa and the Americas. Cases range from specific interventions within single operations to thematic reviews of key issues in shrimp aquaculture. The overall goal is to document and analyse experience around the world in order to better understand what works, what doesn't and why. The reports are intended for discussion with a range of stakeholders, to ensure that the findings from the Program have broad impact and relevance.

Stakeholder Meeting in the World Bank

As part of the process of consultation, the World Bank hosted a small meeting for relevant stakeholders at the World Bank in Washington DC, end of March 2002. The objectives of the meeting were:

- To present the findings of the Consortium program on Shrimp Farming and the Environment for review and discussion.
- To discuss implementation of better management practices identified through the program case studies and synthesis report.
- To identify future activities to support implementation, including recommendations for further work by the Consortium.

The meeting was attended by a broad range of people from the sector and from different regions were shrimp farming is important namely from the industry, governments, civil society/NGOs. This created a rare opportunity for stakeholders to interact and share experiences across different levels in the marked chain and across regions.

Initial discussions among stakeholders focussed on a set of "core" Better Management Principles (BMP) that could be widely adopted throughout the shrimp industry. There was a broad interest in BMP's that could be used to improve the sustainability of the industry from farmer to consumer. The meeting also felt that there should be a focus on key issues and BMPs with potentially the most significant benefit and that indicators and a monitoring procedure for BMPs should be developed. The meeting suggested that activities that support the implementation of BMPs in selected countries and provide wider experiences for the consortium program should be initiated. The countries nominated by participants included Bangladesh, Vietnam, Madagascar and Brazil, however specific criteria for selecting countries are still in development, and other countries may become involved as opportunities and needs arise.

Another important task in ensuring a healthy environment for shrimp aquaculture was to undertake studies and consultations to support development of government, investor and purchaser screens based around the core BMP principles including:

- Certification
- Financial incentives for implementing BMPs
- Tax incentives to support BMP implementation
- Mechanisms to address key gaps in the consortium program

The meeting made recommendations on further work and studies within the Consortium. These included:

- Social dimensions of BMPs and small scale producers, including poverty affects of BMP implementation. These studies should also consider socially responsible issues and differentiation between farmed and wild shrimp in certification systems.
- Economics of BMP implementation and cost reduction studies, including studies on reducing energy costs.
- Inland shrimp farming.
- BMPs and coastal polyculture aquaculture systems.
- Legislation – examples of where is it working, and minimal requirements to support implementation of key BMPs.
- Mangroves and options for restoration of abandoned shrimp farm land. A possible case study is being planned in Thailand.
- Chemicals and quality – focus on anti-microbials, including understanding of background levels.
- Genetics, immunology and biodiversity. Implement a review on major current and future issues.
- Effluent water quality standards and capacity to conduct effluent analyses.

Some of these recommendations have already been implemented. A study on inland shrimp farming supported by the Consortium has started and work on chemicals/antimicrobial issues is also taking off.

Conclusions and Further Work

One of the important outputs of the consortium has been to bring together experiences on management and environmental measures from the eastern and the western hemispheres. The exchange of knowledge between government representatives from the two regions could turn out to be indeed very productive.

Overall it can be said at the stakeholder consultation there seems now to be a very positive atmosphere and a broad interest from producers, processors and NGO's in working towards a more sustainable shrimp farming industry.

The case studies from the consortium and draft synthesis report are available for free download from the NACA website *www.enaca.org*

Regional seminar consultation and exhibition

3-7 February 2003

Come to Manila!

Accessing and Meeting Requirements of Markets for Aquaculture Products Regional Seminar, 3-5 February 2003

We invite you to a seminar of fish farmers, fishery product traders, entrepreneurs, prospective investors, suppliers, technical service support providers, industry analysts, experts, advisers, technologists, researchers and government policy makers from more than 25 countries from Asia- Pacific, Europe and North America.

Interact with co- participants and with resource persons from various UN specialized agencies and other international organizations including ADB, ESCAP, ICLARM, INFOFISH, FAO, IBRD, ITC, OIE, UNCTAD, WHO, WTO and others. The topics: Various issues and policy approaches relating to access and competitiveness in markets for aquaculture products and impacts of certain trade issues on poverty and environment. Join the panel discussions on specific marketing related issues on the following themes:

- Product standards, safety and quality
- Production and marketing efficiency
- International trade agreements and national import regulations
- Tariff and non- tariff barriers to trade

Be a part of the search for strategies for action on accessing markets and on meeting market requirements.

Regional Consultation, 5-7 February 2003

You will have the opportunity to take an active part in the deliberations of the Joint Sessions of the Seminar and the Consultation. These deliberations will address the role of governments and of international organizations in providing support to accessing and meeting requirements of markets for aquaculture products. Share your experiences and views with other participants, resource persons and observers on the pertinent issues and policy approaches that could be brought to bear on those issues. Decide on the action proposals that would contribute towards an effective integration of the aquaculture producers and exporters into the global trading system through market penetration and sustained competitiveness.

Exhibition, 3-5 February 2003

Participate in the Exhibition of new products and services for progressive aquaculture. Attend the exhibition/ information forums to be convened in the afternoon, 3-5 February 2003, to provide an opportunity for exhibitors to present their views on the following themes:

- Health
- Processing and packaging
- Production efficiency and product quality
- Accessing markets

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