



Better Management Practices for Striped (Tra) Catfish Farming in the Mekong Delta, Vietnam

Version 3.0
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- Network of Aquaculture Centres in Asia-Pacific
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This document is Version 3.0 of “*Better Management Practices for Catfish Aquaculture in the Mekong Delta, Vietnam*”. It incorporates revisions of Version 2.0, which are based on feedback and the experiences from the 11 demonstration farms that volunteered to adopt the draft BMPs (Version 2.0), and the numerous consultations that the project team has had with these farmers and other stakeholders. The BMPs are also provided to farmers in ‘handbook format’ with simple, Vietnamese translated language, together with standardised record keeping booklets for on-farm use. This ‘BMP package’ is effectively the primary dissemination material for the farmers designed to facilitate industry-wide adoption and implementation of BMPs in the catfish sector in Vietnam.

This revised document (Version 3.0) provides the basis for consideration at the National CatFish BMP Workshop, 23/24th November 2010, Long Xuyen City, An Giang Province, involving all stakeholders of the tra/striped catfish (*Pangasianodon hypophthalmus*) farming sector of the Lower Mekong Delta. It is expected that this Version 3.0 will be reviewed, amended as appropriate, and adopted at the National Workshop as the agreed *Better Management Practices* for industry-wide adoption and implementation.

This document is divided into the following parts:

- Part A: General background to Better Management Practices (BMPs)
- Part B: BMPs for Grow-out
- Part C: BMPs for Hatcheries
- Part D: BMPs for Nurseries (=fry to fingerling rearing)
- Part E: General Aspects in Relation to BMPs
- Part F: Way forward

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PART A. GENERAL BACKGROUND TO BETTER MANAGEMENT PRACTICES

1 What are Better Management Practices (BMPs)

BMPs refer to a set of standardised management guidelines that are developed, based on existing practices and associated risks, as determined in consultation with farming practitioners and relevant industry stakeholders. Where appropriate, new innovations are also routinely incorporated into BMPs to facilitate continuous improvement in farming practices. Adoption of BMPs by farmers is expected to lead to an improvement in the effectiveness and efficiency in farming practices, including improved water quality, reduced disease risk, improved yields and product quality, and overall contribute towards sustainability and economic viability of farmers.

BMPs are not designed for the purposes of achieving certification per se. Rather, they are considered to apply at the ‘pre-certification’ stage, after which farmers are likely to be better prepared to comply with more stringent certification standards, should they wish to proceed down this path for purposes of securing market access. BMPs ensure that adoption of standardised management guidelines is relatively easy to achieve without increased costs^{1 2}. The word “better” also implies that BMPs are always evolving as culture practices progress. The BMPs therefore need to be revised periodically to document and facilitate continuous improvements and to capture farmer innovations and learnings from R&D.

Adoption of BMPs are known to bring about benefits in other aquaculture sectors, such as:

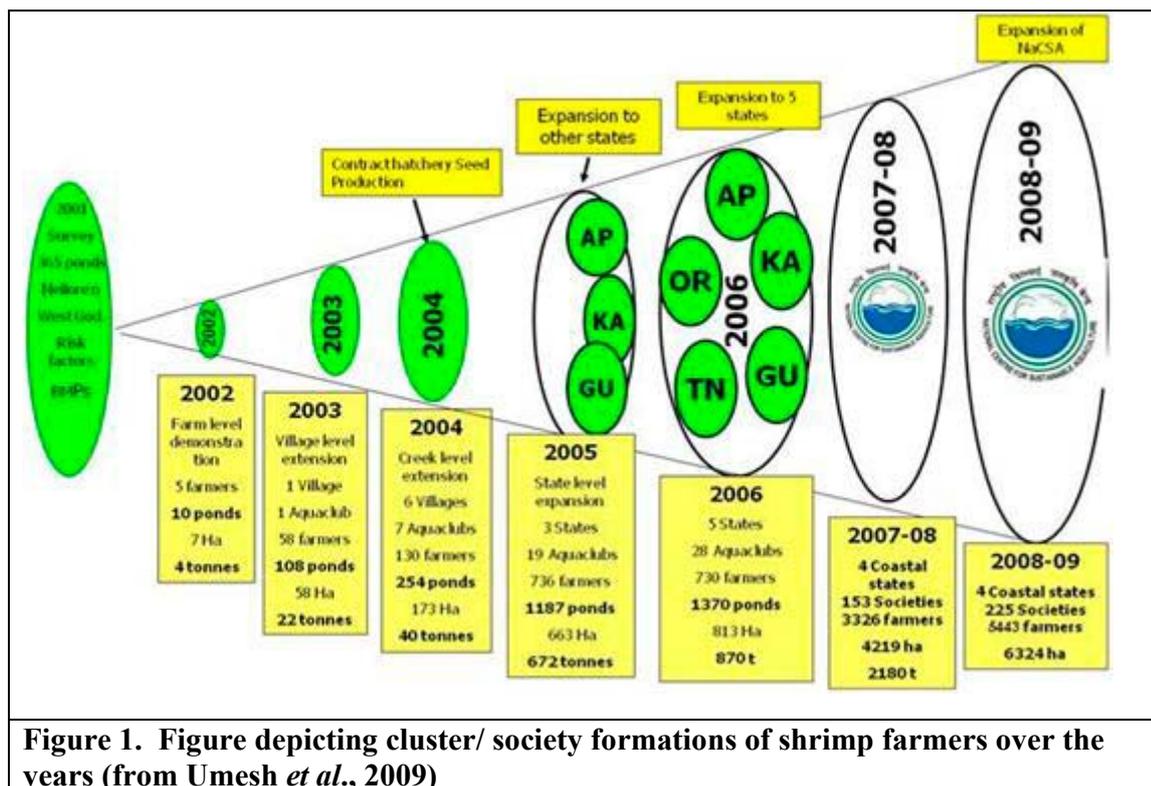
- Reducing and/or a minimising disease occurrence,
- Improving growth performance,
- Decreasing cost of farming (e.g. reduced feed and chemical costs),
- Improving pond and effluent water quality, and consequently minimise impacts on the local environment,
- Improving quality and marketability of the produce,
- Consolidating good relationships with local communities through perception of industry’s commitment to good environmental performance,
- Facilitating long term industry sustainability overall.

¹ Umesh NR, Mohan ABC, Ravibabu G, Padiyar PA *et al.* (2009) Shrimp farmers in India: Empowering small-scale farmers through a cluster-based approach. In: Success Stories in Asian Aquaculture (eds SS De Silva & FB Brian Davy), pp43-68. Springer, Dordrecht; NACA, Bangkok; IDRC, Ottawa.

² CV Mohan and Sena S. De Silva, 2010. Better Management Practices (BMPs) - gateway to ensuring sustainability of small scale aquaculture and meeting modern day market challenges and opportunities. Aquaculture Asia, XV (No.1), pp. 9-15.

Although most BMPs have an overall similarity in the management objectives and guidelines, there is a significant level of variation between commodities and locations. Development of location specific BMPs and contextualisation are an important part of the development process of BMPs.

It is very clear that adoption of BMPs has brought about very significant beneficial impacts to farming systems, as best exemplified in the case of the revival and the continued sustenance of shrimp farming in India by the shrimp consortium. In this instance not only have the BMPs been adopted by individual farmers, the collective actions of farmer “clusters” (through formation of farmer societies or ‘aquaculture’) have had improved yields, minimised disease occurrences, and brought about increased profits among other benefits. The results of this development, both adoption of BMPs and the formation of clusters/ societies are schematically depicted in Figure 1.



One question frequently asked by a wide range of stakeholders is:

“How do BMPs differ from other extension messages commonly disseminated to farmers?”

BMPs are typically science-based management tools that are developed from identifying the best existing farm practices and amending these as appropriate to address identifiable risks (analysed concurrently). Interventions developed to address identified risk factors are collectively referred to as BMPs. Extension messages are most often focused only on ways to increase production and quality of the product. BMPs have an overall goal of promoting responsible and sustainable aquaculture, and not just promoting higher production. Thus BMPs can help producers to farm commodities in a more sustainable way, taking into account also environmental and socio-economical considerations.

Good Aquaculture Practices (GAPs) are commonly used to address food safety issues in aquaculture. These tend to be farm management practices designed to minimise the potential for farm-raised fishery products to be contaminated with pathogens, chemicals, or unapproved or misused veterinary drugs. GAPs can be defined as those practices necessary to address food safety concerns in isolation of other farm management practices (which are typically also addressed by BMPs).

BMPs are primarily practices adopted voluntarily at individual farmer or farmer association level, but can also be used as a basis for local government regulations where broader industry benefits are expected. As previously stated, they also have the potential to facilitate, or even to meet and comply to standards set by third party certification programmes.

2 The term "better management practice"

The term "better management practice" (BMP) is used in several ways in the aquaculture sector. It can refer to the best-known way to undertake any farm activity at a given time. In this sense, it often refers to the practice or practices of only one or a very few producers. A second way BMPs have been used is to describe a few, often different, practices that increase efficiency and productivity and/or reduce or mitigate negative environmental impacts. Finally, BMPs are often required by government or other agencies/institutions to encourage a minimally acceptable level of performance (and eliminate bad practices) with regard to a specific on-farm activity. In this sense, the term is used in opposition to unacceptable practices.

Previous studies have shown that a number of individual BMPs relating to different activities on farm vary by intensity, scale and species. These practices were then analysed both to understand how they were developed (e.g. what problem did they solve and what result did they achieve), how they work and what it would take for them to be adopted by other producers. In the process of undertaking these studies, it has become clear that many BMPs today still fall short in both what is needed and what appears to be possible. In all likelihood, today's BMPs will be tomorrow's norm, and constant review and updating is required. The challenge is to encourage their further adoption while at the same time promoting continuous improvement.

In short, the goal must be to constantly seek out improved BMPs, not just because they reduce negative impacts, but also because they are more efficient and more profitable i.e. to improve the norm rather than to simply establish 'a benchmark' and declare everything above it to be best or good practice and everything below to be bad or unacceptable. From the shrimp Consortium's work in India (this work was awarded the Green Award by the World Bank in 2007), it is known that 'best' practice does not apply in the industry at this time. However, BMPs have been identified, and their positive impact on resource use efficiency, on productivity and more importantly on profitability is substantially better than from many previous practices.

3 Are BMPs needed for tra catfish farming?

3.1 Uniqueness of catfish farming in the Mekong Delta³

Tra catfish farming occupies a rather unique status in global aquaculture. The uniqueness of this farming system could be summarised as follows:

- It is a farming system that is capable of producing, on average, 300 - 400 tonnes /ha /crop; one of the highest recorded for any primary production sector in the world.
 - The industry essentially occupies approximately 5,400 ha of land but produces, for example, as much as 65 % of the total aquaculture production in Europe. It includes a range of farming scales, from small, household scale through to large, industrial scale enterprise.
 - It provides many livelihood opportunities to poor rural communities, particularly women (in the processing sector in particular), significantly bypassing that seen elsewhere in the aquaculture industry around the world.
- It is a farming system that is mostly conducted in earthen ponds of 4 - 4.5 m depth, with regular water exchange from the Mekong River and/or its tributaries.
 - The farming system is blessed with an adequate water supply through the year, but is also obligated to ensure that the same water source is not overly nutrient loaded through effluent discharge bringing about negative impacts on all downstream users of this common, valuable resource.
- It is a farming system that for all intents and purposes is both horizontally and vertically integrated, with specialised hatchery production, fry to fingerling/ nursery rearing and grow-out phases; even including various post-harvest activities including processing for some larger, industrial-scale producers.

³ 8°33' - 10°55'N; 104°30' - 106°50'E; 3.9x10⁶ ha; 17 million population as at 2007

- It is a farming system from which the produce is almost totally destined for export, being an acceptable and affordable substitute for ‘white fish’, particularly for the western palate/ taste.

3.2 The role of BMPs in tra catfish farming

This unique farming system has had its share of problems in recent years, particularly in respect of diseases and marketing, at various levels. Marketing problems are likely to intensify in the foreseeable future, and most of all the produce will have to meet increasingly stringent food quality and production standards, resulting indirectly from market globalisation and increasing demands of consumers. It is also noted that many tra catfish producers, especially small scale farmers, at this juncture do not have sufficient negotiating power to influence the market chain. Fish price is often determined by the buyers (processors) and so is difficult to predict. ***It is in the above context that tra catfish farming rather quickly needs to develop and adopt BMPs, to facilitate use of acceptable farming practices and most of all assist in achieving market-based food quality standards while maintaining environmental integrity.*** Adoption of BMPs, derived from science-based studies and agreed upon by all stakeholders, is a most logical way to meet the above challenges, and thereby ensure long term sustainability of the sector. Furthermore, ***experience elsewhere demonstrates that adoption of BMPs through farmer associations (aqua-clubs) and/or an equivalent organisational structure, is much more effective than for farmers working in isolation. The cluster-based approach provides one voice to the group and enables better bargaining power, in respect of purchases (e.g. feeds), marketing (e.g. negotiations with processors or importers), and more rational (coordinated) use of water resources.*** Collective action is a much more powerful tool overall, and enables farmer access to government and policy makers also in much more effective and a coherent manner.

The sector, especially that represented by **small, household-scale farmers that own, operate and manage their farms**, is operating under much financial stress at the present time. Profit margins have decreased in most instances, with fluctuating farm gate prices and the prices of inputs, such as feeds, having increased markedly. The current breakeven farm gate price of VND 16,500 - 17,000 (approximately US\$0.90 - 0.95) is often not sustainable, making the practices unprofitable and difficult to continue. The adoption of BMPs supported by farmer organisations will facilitate cost reductions to be achieved, and most likely provide a gateway to making the practices more economically and environmentally viable and sustainable (see Mohan and De Silva, 2010).

4 The process(es) undertaken in the development of BMPs for tra catfish farming

Stage 1:

Realising the need to ensure the long term viability and sustainability of the tra catfish farming sector in the Delta, a unique system as it is, a collaborative consortium of NACA, and Fisheries Victoria, in conjunction with key national counterparts, Research Institute for Aquaculture No. 2, (Ho Chi Minh City) and College of Aquaculture and Fisheries, Can Tho University (Can Tho City), proceeded to seek the required funding under the joint funding initiative “*Collaboration for Agricultural Research and Development*” (CARD) of AusAID (Government of Australia) and the Ministry for Agriculture and Rural Development (MARD; Government of Vietnam). The project entitled ‘Development of Better Management Practices for Catfish Aquaculture in the Mekong Delta, Vietnam (001/07/VIE) was commissioned by CARD in January 2008.

On availability of funds the following Stage 1 activities were undertaken between Feb 2008 until 2009:

- Planning meetings (HCMC and Can Tho) and technical workshop, Can Tho University(CTU), 3-4 Dec. & 8-11 Dec., 2008;
- Participation in ‘Catfish Aquaculture in Asia’ international symposium, CTU, 5-7 Dec., 2008;
- Design and test a questionnaire to understand the details of the existing farming systems;
- Survey 94 grow-out farms (89 owners), 45 hatcheries and 47 nursery farms between February - May 2009, through farm visits and discussion groups (**See Annex 1 for area surveyed**);
- Input the above data on farming practices using custom designed database and analyse using available statistical packages, and subjected to scientific scrutiny through publication in peer reviewed journals^{4 5};

⁴ Lam PT, Tam BM, Nguyen TTT, Gooley G, Ingram B, Hao NV, Phuong NT, De Silva SS (2009). Current status of farming practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. *Aquaculture* 296: 227-236.

⁵ Bui, Tam M., Phan, Lam T., Ingram, B.A., Nguyen, Thuy T.T., Gooley, G. J., Nguyen, Hao V., Nguyen Phuong V., De Silva, S. S., 2010. Seed production practices of striped catfish, *Pangasianodon hypophthalmus* in the Mekong Delta region, Vietnam. *Aquaculture* (in press)

- The following subsidiary activities which had a bearing on the development of the draft BMPs were also undertaken:
 - A Risk Assessment Procedure for tra catfish farming in the Delta that incorporated the following elements:
 - Compile initial Risk Register (list of key risks) categorised according to generic BMP framework, based on the farm data collected;
 - Review score key risks in terms of ‘likelihood’ and ‘consequence’ of risks occurring to provide Risk Ratings. Risk Ratings are ranked (= sum of likelihood + consequence scores) to provide the Risk Ranking. Risk Ranking determines appropriate level of management response according to Risk Ranking Matrix and associated BMP outcome.
- Based on the above and numerous discussions with farmers and other stakeholders develop draft BMPs for catfish farming in the Delta;
- Ten selected catfish farmers and four Provincial/ District officials undertook a visit (June 2009) to witness and learn from the organisation, functioning and effectiveness of clusters/ associations of shrimp farmers in Andhra Pradesh, India.
- Preparation of draft BMPs (Version 1.0) for consideration by stakeholders as part of progressing to project Stage 2

Stage 2:

The draft BMPs (Version 1.0) entitled "Development of Better Management Practices for tra catfish farming in the Mekong Delta, Vietnam" was translated into Vietnamese and distributed to many stakeholders for comments, and formed the basis for discussions at two stakeholder meetings held in Dong Thap and Can Tho provinces on 6/7 and 9/10th of October 2009, respectively.

The stakeholder meetings were attended by catfish farmers of all the provinces, processors, provincial, district and central governmental officials, when each of the recommended BMPs were discussed in detail and feedback obtained.

Version 2.0 of the BMPs were then developed in which the feedback from the two stakeholder meetings were incorporated, and provided the base material for the preparation of dissemination of BMPs to farmers, in a simple and comprehensible language. Version 2.0 of the BMPs also provided the basis for progressing to project Stage 3.

Stage 3:

At the Stage 2 stakeholder meetings, 11 farmers volunteered to adopt the draft BMPs to varying degrees, from one or two ponds to whole farms. These farmers were trained on-site by the project team and provided with a “practical” version of the BMPs and specially designed booklets for record keeping. Apart from changing farming practices, changes to on-farm infrastructure were also undertaken by some farmers to facilitate compliance with BMPs. The farms were visited on fortnightly-monthly basis by the teams from CanTho University and RIA 2 for water quality, record keeping and management monitoring.

An evaluation survey on “Smallholder farmer’s reactions to the implementation of BMP Demonstration trials” was undertaken in June 2010, as a component of a post-graduate study of the University of Melbourne, which provided further information for improving the BMPs on tra catfish. This survey was also supplemented by visits to the demonstration farms by the principal researchers.

This revised BMPs (Version 3.0) for catfish farming in the Mekong Delta is based on all of these inputs and is presented for adoption at the National Workshop on 23/24th of November, Long Xuyen City, An Giang Province.

PART B. BMPS FOR GROW-OUT

1 General aspects

BMPs are applied to single farms. However, experience shows that the clustering of farms as organisational units (e.g. farmer cooperative, association, 'aquaclub' etc) in the management of common, multi use resources greatly enhances the results of BMP application i.e. leading to beneficial impacts on the individual farms which could not have been achieved if actioned individually. In this context the BMPs take into account the advantages of clustering, and recommendations are made with this principle underpinning the adoption of BMPs for the tra catfish farming sector in the Delta.

It is recommended that a group of farms that are located in the same geographical area or administration unit, or share a common water supply source and/or outlet should form a cluster and jointly implement the same set of BMPs.

For example, as illustrated in Figure 3 farms within the frame could function as a cluster.



Figure 2. An impression of the concentration of catfish farms in the Mekong Delta. Note the relatively uniform pond size.

Another important aspect of the application of BMPs is accurate record keeping on all aspects of the implementation of BMPs, including stock inventory, feeding, fish health management, water management and water quality criteria. Record keeping is often a cumbersome and time

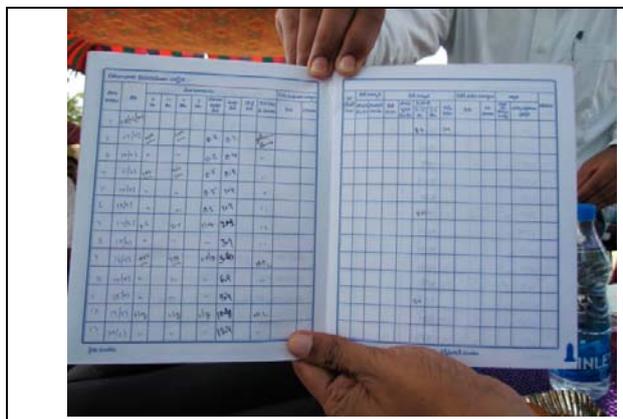


Figure 3. An example of the books used in record keeping in shrimp farms, India.

consuming process and its use and application may not be immediately evident, but complete and reliable records are the key to finding answers and solutions when on-farm calamities occur. Here again uniformity of record keeping within a cluster ensures that records become comparable between farms. Note that an adversary in one farm could impact on others, with time, and hence the importance of uniform record keeping through a cluster.

Record keeping also permits and facilitates traceability, to demonstrate to buyers that the farms have adhered to appropriate food safety and other guidelines relevant to market forces.

For example, throughout India where BMPS have been adopted and a cluster approach is functional, all records are maintained in a uniform manner, and as a consequence the whole cluster has been certified by some independent agencies.

It is expected that with the adoption of BMPs for the catfish farming sector in the Delta a uniform record keeping process will be developed by producers in consultation with all the stakeholders. It is proposed that the requisite documentation for adoption and implementation of BMPs by farmers will include the BMP document itself (also to be made available in convenient handbook format and in plain language with Vietnamese translation) and associated data record booklets; collectively to be referred to as the ‘BMP package’.

2 Pond siting and size

Catfish farming has taken route along the river and its branches in the Mekong Delta region. In essence, siting of farms is no longer an issue as the farms are already functional and it is unlikely in view of real-estate prices that any new farms of substantial nature would be developed. In this context this document does not endeavour to make recommendations on future farm siting. A Google map (Figure 2) clearly indicates the intensity of farm locations and pond layout in one location which provides a fairly general impression for the major catfish farming provinces in the Delta. Established pond inlet and outlet infrastructure is incorporated into this farming system

and very little change is possible. However, industry should endeavour in most cases to simply improve upon the existing system rather than attempt to re-locate or re-construct.

The extensive industry survey conducted in project Stage 1⁴⁵ gave an insight into the farm size distribution in the Delta. In general, the pond size was relatively uniform throughout the Delta (see also Figure 2). The farm size and the water surface area ranged from 0.2 to 30 ha (mean: 4.09 ha \pm 0.48 se) and 0.12 to 20 ha (mean: 2.67 ha \pm 0.33), respectively. The number of ponds per farm and pond size ranged from one to 17 (mean: 4) and 0.08 to 2.2 ha (mean of mean: 0.61 \pm 0.03 se), respectively. Approximately 72% farms were less than 5 ha, and only 9 % were 10 ha or greater in size. Large, industrial-scale operations that are few in number and belong to processing companies were not included in this survey.

Therefore, catfish farm size in the Mekong Delta can be categorised as being primarily small-medium, household scale. Moreover, the concentration of the farms in given localities, and the fact that a great majority of the farms are owned, managed and operated by families, make it feasible to introduce BMPs and the formation of farmer clusters/ associations for tra catfish farming in the Delta.

3 Pond preparation

Pond preparation is essential to reduce risks of disease outbreaks, to obtain a conducive environment for growth of stock, and therefore attaining better overall productivity.

All surveyed farms treated pond bottom before a new culture cycle. The fallow period varied between farms (2-45 days), but the majority of farms have a fallow period of either 7 days, 10 days, 15 days or 30 days. It is noted that in exceptional years, the farmers may have to wait longer than these set fallow periods until seed becomes available for re-stocking. Almost all farms removed the sludge during the fallow period, which was followed by the application of lime. Some farms dried the ponds. Other treatments included application of salt, or filling water then treating with chlorine before draining. Some farms use other products for pond bottom treatment as listed in Annex 2.

All farms did not screen the supply water. In fact this is necessary to minimise the introduction of unwanted materials and organisms. Farms also did not have water sedimentation before supplying water into the ponds. Although ideal this practice is difficult to comply with considering the amount of water typically used on most days, All farms treated the pond water before stocking and the list of chemicals/products used for treatment is given in Annexe 2.

The following factors/steps are recommended to significantly improve the pond environment. It also takes into consideration the fact that the location of some tra catfish farms is such that the possibility of making provision for a sedimentation pond and or even achieving complete drainage of the pond water between cycles is very limited (if not zero in many cases).

Step 1. Removal of the bottom sludge between culture cycles

Removal of bottom sludge ensures better water quality and an overall healthier environment for fish when the pond is refilled and stocked for the next cycle. The sludge contains organic matter which harbours pathogens and can be transformed into harmful gases such H₂S (also NH₃, NO₂⁻, CH₄) which can retard normal fish growth and impart off-flavour in harvested fish. Aerobic bacterial decomposition of organic matter is also an important drain on dissolved oxygen in the pond, which again can reduce feed conversion and otherwise retard normal growth of fish.

Removal of bottom sludge should preferably be undertaken after every harvest, but should be compulsory at least after every second harvest. The sludge must be disposed away from the pond site, so that it does not seep back into waterways, ponds, or cause other environmental problems. Removed sludge should preferably be disposed of to land, and should not be disposed of back into the farm water supply or adjacent rivers and canals. A parallel study on the use of catfish farm sludge and discharged water on rice fields⁶ has demonstrated that the use of sludge/ effluent water could reduce the inorganic fertilizer usage by 30% per rice crop, bringing about considerable savings and also an effective recycling of waste with positive environmental impacts.

The catfish farming system in the Delta has to, in due course, develop cluster-based strategies to use the sludge as a fertilizer for the vast acreage of crops (e.g. grass as fodder for animals, rice and fruit) under production in the Delta.

BMP 1. 1 Pond bottom treatment

- **Removal of bottom sludge:**
 - **If a pond can be completely drained, sludge should be removed and used as garden fertilizer or stored in a pond. Sludge should not be disposed of to nearby waterways**
 - **Drained ponds should be limed and dried for one week prior to re-filling; stocking of fingerlings to commence after a min. two week pond preparation.**
 - **If water cannot be drained completely, the bottom sludge can be siphoned onto gardens or into storage ponds. Apply lime and repeatedly flush the pond several times within 2-3 weeks before stocking of fingerlings.**
 - **If the bottom sludge cannot be removed (as in some farms), the pond should be treated by applying lime and salt.**
- **Clean and consolidate the pond dikes and sluice gates.**
- **Develop re-use strategies for sludge and to generate income e.g. as fertiliser for rice crops, gardens or landfill for planting grass for animal husbandry.**

⁶ Treating and recycling waste water and solids from fish ponds in the Mekong Delta to improve livelihood and reduce water pollution (023/06VIE). Project conducted by Vn Institution: Cuu Long Rice Research Institute (Dr. Cao van Phung) & Murdoch University (Dr. Richard Bell)

Step 2: Ploughing

Ponds located inland and or on high ground may dry easily. On removal of the sludge, light ploughing of the soil when wet, is desired. This step is generally lacking in the current practice. The main purpose of ploughing is to expose the black, organic rich soil layer(s) underneath to sunlight and atmospheric oxygen, which assist the breakdown and oxidation of the organic waste (sludge) into less harmful substances.

Presence of moisture in soil (*i.e.*, under wet soil conditions) during ploughing allows bacteria to work better in breaking down the black organic matter, thus making the ploughing process more effective. After ploughing, dry the pond bottom for 5 - 7 days.

Ploughing the pond bottom may lead to turbid water conditions during the culture period. Therefore, compaction of the bottom using heavy rollers after the whole process of pond preparation (*i.e.* before water intake), can avoid the turbid water condition. This step is not applicable to ponds located on the river bank or those that cannot be drained completely.

Step 3: Liming

Liming during pond preparation, a common and low cost practice, is useful for optimising the pH and alkalinity conditions of soil and water.

The type and amount of lime to be added depends mainly on the soil pH and also on pond water pH, which ideally should be checked before lime application.

Where a disinfectant such as bleach (calcium hypochlorite) is used, apply lime only 3-4 days after the application of the disinfectant. If lime is used earlier to disinfect, then the effectiveness of the disinfectant is reduced.

BMP 1. 2. Liming

- **Applying lime as recommended:**
 - **If water is completely drained, applying lime (CaO) at 10-15 kg/100m² in both pond and dike.**
 - **If water cannot be completely drained, applying lime (CaO) at 10-15 kg/m² mainly on the pond dikes and a part for treating pond water, depending on pH of pond water.**

Step 4: Pond filling

When ponds are filled/ or water is added care needs to be taken to filter the water using small mesh at the inlet pipe to prevent undesirable organisms entering the pond. Admittedly, this will not stop all organisms entering the pond, but this practice at least offers some control.

BMP 1. 3. Intake water

- **Water should be screened using small mesh device at the inlet pipe before entering the ponds**

4 Stocking

Stocking involves a number of crucial steps, from the time of procurement of the seedstock until they are introduced into the grow-out ponds (prepared as described in Section 3).

The process of seedstock selection (hatchery visit, transportation and screening) should be done at least 2 – 3 days prior to stocking.

Step 1: Procurement of seed stock

Procurement of seedstock is one of the crucial steps in any form of farming. Often farmers tend to procure the required seed stock from the same hatchery, year after year, based on a number of perceptions that the seed stock are of good quality, reliability in supplies, easy accessibility reduced transportation costs, affordable price, and the long-established business partnership, which even perhaps permit credit.

Catfish seedstock, unlike in the case of shrimp for example, until now do not need to be tested for any specific pathogens. However, it is advisable to evaluate the performance of the seedstock on a yearly basis, for growth, yield and percent mortality not only in your farm but also that of adjacent farms. In this manner, an evidence-based judgement can be made as to whether there had been a deterioration of the seed stock over the years, and if so steps to seek alternative supplies of seedstock can be taken.

The above on-going assessment should be undertaken with assistance by the District/ Provincial administrations, and the relevant information updated on a yearly basis and made available to farmers. This will be an essential element in the BMPs for catfish farming in the Delta.

Step 2: Choosing seed stock

At each procurement it is essential that the farmer visits the hatchery/ nursery operation and obtains a full ('certified') history of the potential seedstock supply. The details to be obtained are:

- How many female and male broodstock were used in the spawning and the approximate ages of these animals

- The number of times the female broodstock have been used in the current spawning season, and if more than once, which spawning the current seedstock originate from (for example first, second, third etc in the season)
- Ideally, the farmers should procure seedstock from females that are 3-5 years old and spawned no more than twice a year.
- Spawnings that have resulted in average or above average fry to fingerling survival
- The seedstock are of uniform size, active and show no signs of any abnormal behaviour nor any signs of disease or physical damage
- The seedstock are properly weaned (if appropriate).

BMP 1. 4. Selection of seedstock for stocking

- **Seed from ‘certified’ hatcheries, which could supply in sufficient quantity at once, should only be used. Test the seed quality before buying at nurseries and investigate the history of the seed such as chemicals used, nursing period, fish size etc.**
- **Criteria for seed selection:**
 - **To obtain a fairly uniform size at harvest, seed should be of uniform size is one of the key requirements.**
 - **Seed should be healthy and have no signs of external physical damage, malformation or abnormal behaviour.**
 - **30-40 fry or fingerlings should be randomly selected and left in a water bowl for 3-4 min and observed closely. If some fish do not school with the rest, it is recommended that these stock not be purchased.**
 - **The best fingerling seed size is 1.7-2.2 cm in body depth, or 75-80 and 30-35 fish/kg respectively.**
 - **Seed should be uniform in size, of brilliant colour, swimming actively and with no signs of deformity or other abnormal appearance or behaviour**
 - **If possible, seed can be sampled for testing common diseases (e.g. presence of bacterial or protozoan parasites) before purchasing.**

Step 3: Transportation of seedstock (fingerling)

The science of seed stock transportation is well developed for many species, and lessons can be taken from these experiences for the catfish farming sector.

The selected seedstock should be starved the day before being packed for transportation. In the Mekong Delta, catfish seedstock are mostly transported by boats in which water is continuously pumped through the transport tanks. The transportation of fingerlings should be done in the early

hours of the morning and away from direct sunlight to avoid sudden increases in temperature. In addition, land transportation may be used (very rarely in the Delta) for seed transportation, particularly for short distances from farm locations. The total duration of the transportation time from the nursery to the grow-out farm should be, ideally less than six hours duration..

BMP 1. 5. Seedstock transportation

- **It is a requirement that hatcheries/nurseries starve the seed destined for sale for 24 hrs before transportation .**
- **Transportation time should be less than six hrs.**
- **All seedstock transportation should be by specially fitted boats or trucks (permitting constant exchange of water and/or supplementary aeration).**
- **Transportation densities should not exceed 5% of holding capacities.**
- **Seed health management during transportation:**
 - **Siphon and exchange and/or aerate water.**
 - **If the transportation time is more than six hrs, siphon waste and apply salt at 5ppt (5 kg/m³ of water) and exchange water every 6 hrs.**

Step 4: Seedstock treatment and stocking

On arrival of seedstock at the farm site, the containers should be placed in the grow-out ponds (or special large tanks that could be used for this purpose), unopened, so that the water temperature in the pond and the containers are balanced. Sudden and immediate release of seedstock to the pond should be avoided.

Once the pH and the temperature of the containers are the same as that of the pond water, the seedstock can be slowly released into the ponds, in batches. Here again care should be taken that these operation are not carried out in direct sunlight, and preferably done during the period when the sun is setting. At the place of release of seedstock, salt can be used as a disinfectant.

Do not feed the released seedstock on the day of stocking; so as to permit time for the seed stock to acclimatise to the pond environment.

Feeding should commence the next day after release and initially be carried out at a very low level that is 30-50% of common requirement e.g. approximately 1 % of the body weight/day of the stocked fish for three - four days, and then raised gradually to 3 - 5 % of the body weight/day once the fish begin actively feeding.

BMP 1. 6. Seedstock treatment and stocking

- **Stock fingerlings after filling water for 5-7 days (when water colour is slightly green; as in young banana leaves), and when the pond water level reaches approximately 2 m (to reduce expenses for other unnecessary treatments).**
- **Newly added seedstock can be placed in a hapa in a corner or end of the pond for several days prior to the release to the pond to ensure they have acclimated and are feeding actively. They should also be treated with salt for 10-15 min prior to the release to the pond if there are any signs of disease.**
- **Feed mildly for the first 3-4 days after release, at a rate that is 30-50% of common requirement.**

Step 5: Stocking densities

The catfish farming sector in the Delta is one of the most intensive aquaculture practices in the world. The deep ponds, regular water exchange and the ability of the catfish to breath air permits this intensity of stocking.

According to survey results, the seedstock size at first stocking ranges widely: 1.0 - 8.5 cm total length (mean 4.5 cm) as fry, or 1.2 - 20 cm (mean 8.6 cm) as fingerlings. The survey results also indicated that the stocking densities (SD) used ranged widely:

- 18-125 fish/m² (mean 48 ± 2.1 se) and 5-31 fish/m³ (mean 12 ± 0.5 se), depending on the size and availability of seedstock and the financial capacity of farmers to purchase seedstock.

The survey results show that the pond yield increased linearly in relation to SD. However, it is suggested that the SD for average sized fingerling seedstock should not exceed 80-100 fish/ m² and/or 18-22 fish/ m³.

BMP 1. 7. Stocking density (SD)

- **Stocking density for average sized fingerling seedstock should not exceed 60 fish/m² or 15 fish/m³.**
- **Preferred size of fingerling seedstock size: 1.7-2.2 cm in body depth.**
- **Stocking should be carried out in the early hours of the morning and or late afternoon to avoid stock in the hottest part of the day**
- **Stocking season can be year round.**

5 Day to day pond/ stock management

Although complete and careful monitoring of all steps and all stages of a farming system are crucial to the well being of the stock, in grow-out operations this requirement is doubly so, especially in view of the fact that vigilance has to be maintained for the whole 6 to 8 months growth cycle, and is totally the farmer's responsibility.

There are a number of equally important elements that are crucial to the above, and these collectively contribute to achieving maximum benefits from adoption of BMPs.

The crucial elements of daily management are:

- Personal observations on the behavioural aspects of the stock
- Intake and discharge water management
- Record keeping of water quality parameters and other critical husbandry and farming parameters, including stock inventory control
- Feeding and feed management
- Monitoring the health of the stock and mortalities, and the presence of predators, e.g. birds.

5.1 Personal observations on the behavioural aspects of the stock

The farmer should train all technicians working on the farm to make observations on the stock and recognise what is not normal behaviour. Observations should be done on a daily basis, at least three times a day, especially at feeding times. The elements to be noticed are:

- Are the fish feeding normally and are most of the stock coming to the feed?
- Are there groups of fish not behaving normally, such as being huddled/ congregated together in a corner of the pond without much movement, and/or not responding to feed or to any other stimuli, such as water movement?
- Are groups of fish surfacing or otherwise excessively active (more than usual)?
- Are there areas of the pond with algal masses, or slicks of oil (can originate from excessive feed)?

If any abnormalities are noticed then remedial action needs to be taken. The specific actions are dealt with in each of the following relevant sections.

5.2 Intake and discharge water management

In a manner, the catfish farming sector is generally blessed with an abundant, unlimited and freely accessible supply of good quality water; an invaluable natural resource that most other farming sectors in the world would envy. It is equally convenient for the flushing of effluent that the farms are located at a relatively close distance to the sea mouth of the river (which has the 10th highest discharge rate of the world's rivers). Nevertheless, the catfish farming sector in the Delta has an obligation to ensure that minimal environmental damage is done to this resource through excessive nutrient discharge that could result in long term adverse impacts to all users, and the environment, now and into the future.

The project survey results gave a clear indication that on average 30% of pond water is replenished daily at least during the last two months of the production cycle, and that farmers felt that ***pond productivity was not related to either the amount of or frequency of exchange water.*** This observation is somewhat surprising in a way, and perhaps more scientific investigation is needed prior to making firm conclusions on the optimal pond water exchange rate and frequency. In the interim, it is suggested that without a loss in productivity, the exchange rate per week could be reduced by 5%, enabling the farmers to make a saving on electricity/ fuel from pumping, and to reduce water usage.

The intake water should go through a set of screens or filters before entering the ponds.

Equally, where possible, effluent should not be discharged directly to the river or other natural waterways, but to a reservoir tank or sedimentation pond where the water is allowed to settle for at least for 1-5 days before being discharged to the river. It is recognised that not all farms can afford the facility of a reservoir tank or sedimentation pond/canal, but every endeavour should be made to incorporate such a facility. Water exchange during the early stage of the culture cycle is less frequent compared to late in the cycle, and farmers within a cluster can organise a production calendar so that a shared facility for water sedimentation could be done on rotation. In such an arrangement, farmers should prepare a stock watering plan which is coordinated with other farmers in the area to avoid potential impacts from discharge water on intake water between farms. As pointed out previously, the water management of farms adopting BMPs is best done collectively in clusters/ groups.

Water intake and discharge should not be done on an individual farm basis, rather water intake should be based on a pre-determined schedule that covers clusters of farms divided into stretches of 2 km of the river. A calendar/ schedule (plan) will determine the discharge and intake of each farm that would minimise contamination between farms and also provide for a relatively good quality water for intake. This plan would require participating farmers to notify all the other farmers in the cluster via SMS in relation to intake/discharge activities to ensure appropriate coordination.

During the latter stages of grow-out, excessive sludge may be removed from the ponds by pumping onto adjacent rice and fruit crops or into sedimentation ponds/canals. Sludge should not be pumped directly to the river.

BMP 1. 8. Water exchange

- **Introduce a planned water intake and discharge schedule/calendar for all farms in each 2 km stretch of the river.**
- **In order to achieve this, the farms in a defined stretch of river should organise into a group or at least coordinate their activities through existing clusters/associations where possible.**
- **The group should develop a simple communication strategy, such as by SMS, to inform all farmers in the group of water discharge and intake activities on a regular basis.**
- **In the above manner, contamination from one farm to another could be minimised and all farms could ensure that pond water intake is fresh.**
- **Endeavour to have a reservoir tank/sedimentation pond or canal to store waste water before discharge.**
- **Exchange water:**
 - **Filter/screen the intake water.**
 - **First month: limited water exchange (twice a month).**
 - **Following months: exchange water daily.**
 - **In dry season: effluent can be moved to rice crops, fruit gardens or storage ponds**
 - **In rainy season: flood coming with a huge amount of water, when part of the effluent could be drained directly into rivers**
- **In case of disease outbreak: limited water exchange or completely stop exchanging water (until disease abates), and inform all farms of the groups of the disease incidence**

BMP 1. 9. Sludge management

- **From the third month on, the bottom sludge should be pumped or siphoned into rice crops, fruit gardens, sedimentation ponds/canals or storage ponds. During the culture period, pumping or siphoning can be done 2-3 times depending on the amount of feed supplied.**

Catfish, in addition to extracting oxygen from the water, are capable of breathing air, and this enables very high stocking densities to be maintained. In heavily stocked catfish ponds there is accumulation of metabolites excreted by fish, such as ammonia, and the decomposition of accumulated uneaten feed and fish faeces by bacteria which contributes to reduced oxygen concentrations in the water and build-up of ammonia and highly toxic hydrogen sulphide. The impacts of these may not necessarily cause mortality but may stress the catfish leading to increased susceptibility to disease and reduced growth. Farmers have noticed that stock sometimes tend to gather in the corners of a pond, reduce feeding and appear to be stressed; in all probability as a reaction to poor water quality. Also, these impacts can become more intense when the oxygen levels in the water are relatively low, particularly at night.

It is desirable to have some form of aeration device (a powerful airline for example) at the pond bottom that is operated for a few hours in the night to circulate the water, supplement oxygen levels and facilitate the oxidation of toxic metabolites.

This will involve an initial investment and an on-going operating cost, but this cost is likely to be offset by enhanced growth, survival and the improved well-being of the cultured stock.

BMP 1. 10. Improvement of pond water quality

- **Introduce and operate an airline at the pond bottom and operate for a few hours at night, especially into the second half of the growth cycle when a large quantity of feed is provided to the growing stock.**

5.3 Record keeping of water quality parameters

From the project survey results, a very small number of farms presently test the quality of water before supplying into ponds. Also, a majority of farms did not or seldom (max. 2-3 times a month, or only when farmers felt that water quality was deteriorating) monitor pond water quality during a culture cycle. For farms that test water quality, the two most often tested parameters are pH and ammonia. Water quality in ponds is crucial, as good water quality provides for a conducive environment for fish to survive and grow, whereas poor water quality will stress fish leading to poor health reduced growth and sometimes death.

Monitoring pond water quality should be undertaken and data recorded at a regular time each day, and preferably twice a day; once early in the morning (e.g. between 0700 and 0800 hrs) and once late in the day (e.g. between 1700 and 1800 hrs). Measurements should preferably be taken near the centre of the pond, and at two other random points, at 1 m below the surface and near the pond bottom.

The daily measurements to be taken are:

- Temperature

- pH,
- salinity (particularly in saline affected areas), and
- ammonia

For the above purpose commercially available probes can be used. Records of all daily water quality measurements should be kept, along with records of fish mortalities and general appearance of dead and/or moribund fish.

BMP 1. 11. Monitor and record pond water quality and fish mortalities

- **Measure/monitor pH and ammonia weekly. In saline affected areas, salinity should also be recorded at least weekly.**
- **Regular and uniform record keeping of water quality parameters, fish mortalities and other important or unusual behavioural patterns of the stock should be done .**
- **For the above purpose, properly designed record keeping booklets (provided) should be used.**

5.4 Feeding and feed management

Feeds, feeding and feed management are crucial elements in aquaculture. The project survey results of 94 farms indicated that most farmers purchase commercial feed on credit, and generally continue a binding relationship with the supplier, who may not necessarily be the feed manufacturer.

Currently, the grow-out feeds available for tra catfish in the Delta are of three basic types:

- feeds for 14-150 g range stock
- feeds for 20-200 g range stock
- feed for over 500g stock

Table 1 shows the specifications given on the bags of 12 randomly selected commercial feeds and Table 2 provides the results of laboratory analyses conducted on randomly selected commercial feeds, of each type, and farm-made feeds.

Table 1. The proximate composition of a random selection of 12 commercial feeds, as specified on the bags, used in catfish grow-out operations in the Mekong Delta. The names of the producers are withheld for ethical reasons (na - not available).	
Parameter	Range (mean)

Maximum Moisture (%)	10-11 (10.9),
Minimum Protein (%)	22-30 (25.8)
Minimum Total lipid (%)	3-5 (4.3)
Maximum Ash (%)	10-14 (11.3)
Maximum Fibre (%)	6-8 (6.9)

Table 2. Results of laboratory analysis on the proximate composition of randomly selected commercial feeds and farm-made feeds (FMF). The numbers in parentheses indicate the number of feeds sampled				
	14-150 g (5)	20-200 g (5)	>500 g (2)	FMF (4)
Moisture (%)	8.78	7.50	8.22	9.15
Protein (%)	27.07	27.21	20.42	19.65
Lipid (%)	2.10	2.26	2.52	10.45
Ash (%)	8.33	9.32	11.27	20.18
Phosphorous (mg/ g)	9.32	9.49	9.53	11.87
Energy (Kcal/g)	4.49	4.48	4.25	4.19

During growout, most fish are fed pellets with a protein content of 25-27% and a low lipid content, except in the case of stock over 500 g in weight, when the protein content is significantly reduced. On the other hand, farm-made feeds tend to have a significantly higher lipid and ash content.

The proximate composition is one thing but the ability for fish to digest the feed is another. There are no scientific data available on the digestibility of the different feed types used in catfish farming presently, and it is recommended that this should be urgently addressed.

Knowing the proximate composition of catfish feeds (Table 2), it is likely that some of the feed used in this sector is nutritionally inadequate, resulting in poor condition of stock, poor growth and even mortality through what is popularly designated as “whole yellow body symptom” or ‘jaundiced’ condition, characterised by swollen and pale liver, yellowing in the belly and the fin bases, muscle tissue and so on, and is thought to be brought about by nutritional deficiencies.. The demand for tra catfish is because it provides a suitable alternative to the traditional ‘white fish’ varieties. As such it is imperative that the stock does not acquire a yellow flesh colour.

BMP 1. 12. Feed management when fish show a symptom of ‘whole yellow body’ or ‘jaundiced condition’

- **Reduce feeding and test the fish in the ponds.**
- **Dissect a few fish and make observations (e.g. swollen liver; excess fat in the body cavity etc.) and send a few for investigation to a certified laboratory.**

- **Retest the feed on date of use and test for rancidity; if yes, change to new/fresher feed.**
- **Consider changing the feed if desired results are not obtained**

(Please note that the available evidence suggests that yellow body colour commonly referred to as “jaundiced condition” is caused by nutritional deficiencies and not due to any bacterial and or viral infection. As such, treating the stock with antibiotics and or other form of chemicals will not be effective)

5.5 Feed procurement and storage

The time lag between *the date of manufacture and the date of use of the feed should not exceed two weeks*, and particularly so at the high temperatures and humidity prevalent in the Delta region. Under these conditions the feed tends to oxidise (especially the lipids) and become rancid, which makes it unattractive/ unpalatable to the stock and will cause deleterious effects if eaten.

Feed should be stored in such a way as to permit air circulation at least 20 cm above the ground on a dry wooden platform, and protected from rain, sunshine and wind. At feeding, the contents of each bag should be smelled for signs of rancidity, and if found to be rancid the feed must be discarded as waste (not into the pond).

BMP 1. 13. Feed procurement and storage

- **Use feed that has not exceeded the use by date as indicated in the specifications of the manufacturer (on feed bag). Feed should be stored at least 20 cm above the ground on a wooden platform to permit air circulation, and protected from direct sunlight, rain and wind.**
- **Each feed bag should be smelled for rancidity before being used, and rancid feed should be discarded.**
- **Once a feed bag is opened, ensure that all feed in the bag is completely used within two days.**

5.6 Feeding

Currently in catfish farming in the Delta the feeding intensity is relatively high, ranging between 1-18% body weight/day and 1-10% body weight/day for commercial feeds and farm-made feeds respectively (feed rates are greatest at the beginning of the production cycle when fish are small). According to project survey results, fish are typically fed twice per day, but some farms fed up to six times per day. The food conversion ratio (FCR= Amount of feed used ÷ Increase in wet biomass) for commercial pellets and farm-made feed ranged from 1.0 to 3.0 (mean 1.69), and 1.3 to 3.0 (mean 2.25) respectively.

The perception by some farmers that excess feeding makes the stock grow better and faster is erroneous. Even though the stock may ingest the feed, when fed in excess, the great bulk of it will not be digested adequately and will not be used by the fish for growth, but rather be voided as faecal matter. Available scientific data suggest that no fish species at the growout stage (> 10 g or so in weight) requires more than 5 % of the body weight per day of a good quality feed, with the amount decreasing in proportion to the body size. In stock of 200 g weight, 2-3% of body weight per day of a good quality feed will be more than adequate to obtain optimal fish growth and well being. Feeding in excess of three times daily is unnecessary and costly, as it is a waste of feed and human resources and can lead to water quality deterioration.

Proper feed usage and management will lead to a reduction in FCR and thereby greater profitability, better quality stock and significantly reduced impacts on water quality.

Feed cost is the highest recurring cost in catfish farming. Also the feed cost has been increasing steadily over the year. For example the cost has increased from VnD 5,200 in 2007 to VnD 8,100/ kg in 2010 for commercially produced pelleted feeds. On the other hand the farm gate price has remained relatively static, ranging from VnD 15,500 to 16,500/ Kg over the same period of time. This has negatively impacted on profit margins for all growers, but many small-scale farmers in particular have become uneconomic and left the industry over the last 1-2 years.

All the information gathered from farmer surveys during this project indicate that in general there is excessive feeding in the catfish farming sector, based on erroneous perceptions by farmers themselves. Proper feed management is probably the easiest way to reduce production cost and to enhance economically viability.

BMP 1. 14. Feeding

- **Start feeding after 2-3 days of release, sufficiently to satisfy the requirement of the stock.**
- **Pelleted feed are recommended (commercial or homemade).**
- **Feed should not be rancid.**
- **Feed quantity and frequency:**
 - **Twice a day.**
 - **Feed early morning (before sunrise) and late afternoon (after sunset).**
 - **Feed should be dispersed as widely as possible and be done slowly e.g. in a 1 ha pond each feeding should be done over a period of 1 - 1.5 hrs**
 - **Feeding regime: a maximum of 4% of body weight per day from the early stages to about 50-80 g/fish, and then reduce the feeding rate to about 1-1.5% body weight per day.**
- **Endeavour to manage the farm to obtain a FCR of 1.3 - 1.5 and always be on the look out to reduce ways and means of reducing the FCR further such as through:**
 - **Feeding on alternate days**
 - **Using “mixed feeding schedules’ where feeds of high level of protein are alternated with feeds of lower protein levels**
 - **Use of the above may delay the harvesting time by two to three weeks at most, but the economic gains in feed cost savings and environmental (and associated production) benefits in water quality will far outweigh this delayed harvesting.**

Mr. Nguyen Ngoc Hai from Can Tho was the first farmer to trial a mixed-feeding schedule, as a result of the discussion he had with the project personnel during his travel to India as a component of the project in June 2009. He alternated a day of feeding at a slightly higher rate (normal rate + 7-10% of that), with a day of non-feeding. He observed that the use of this schedule, though extending the harvest time by four weeks (7.5 months as opposed to 6.5 months), enabled him to save 100 g of feed per kg of fish produced (equivalent to the reduction of the FCR from 1.6 to 1.5); a cost reduction of VND 800 / kg of produce. Importantly all the farmers observed that the adoption of mixed-feeding schedules such as this also resulted in a reduction in the frequency of disease occurrence from 6-7 times per cycle to 3-4 times per cycle, and consequently an overall reduction of mortality by approximately 50%. The group now does not use any chemical treatment, making a further saving on chemicals of VND 400/ kg of produce.

The overall production cost averaged VND 15,000/ kg, and the farms were able to maintain economic viability with a healthy profit at the current farm gate price averaging VND 16,500/ kg. Mr. Hai had a net profit for his farm of VND 250 million/crop in 2009, and the cooperative as a whole made a profit of VND 4 billion/ crop.

Use of the mixed feeding schedules is perceived to have also improved the flesh quality of the fish, being less “fatty”, with 2.8 kg fish yielding a 1 kg fillet as opposed to previously needing 3 kg fish to achieve the same yield.

This farming community has not reported any changes in the feeding behaviour of the fish, and there are no indications that the fish feed on the bottom debris on the non-fed days, contrary to the perception of some farmers who are rather reluctant to adopt the mixed feeding schedules.



5.7 Mortalities

Levels of fish mortality in growout ponds vary from one farm to the next, as well as throughout the production cycle. From project survey results, mortality of fish in the first week following stocking ranged between 0-30% (mean 7%). The survey indicated that the level of mortality was typically up to 30% during the early to mid months of the production cycle, and <10% in latter months. Three farms only reported a level of mortality > 30%. Diseases and poor weather conditions were the most common reasons given by farmers for mortality events.

Farmers reported 15 different symptoms and/or diseases, with Bacillary Necrosis of *Pangasius* spp (BNP) (Edwardsiellosis) (98% of farms), parasites (88%), redspot in flesh (61%), spot disease (58%), white gills (30%) and slimy disease (28%) being the more common diseases, and

BNP, parasites and white gills being the more severe diseases. BNP is recognised as an economically significant pathogen of catfish in the Mekong Delta, which can cause 50-90% mortality when it occurs. The occurrence of symptoms/ diseases was greatest in June and July which corresponded with the onset of the wet season and increased rainfall (**Figure 4**). Clearly, this is an area that warrants more systematic pathological and epidemiological investigations.

Management of the health of catfish on farms mainly involves chemical treatment, often with antibiotics, use of feed additives (vitamin C) and increased water exchange. Farmers mainly bury or sell dead fish and disturbingly, 30% of farms sell dead fish to other fish farmers, which represents a significant pathway for potential disease transfer in the Delta. ***Selling dead fish to other farmers may spread pathogens to other fish, farms and provinces in the Delta.***

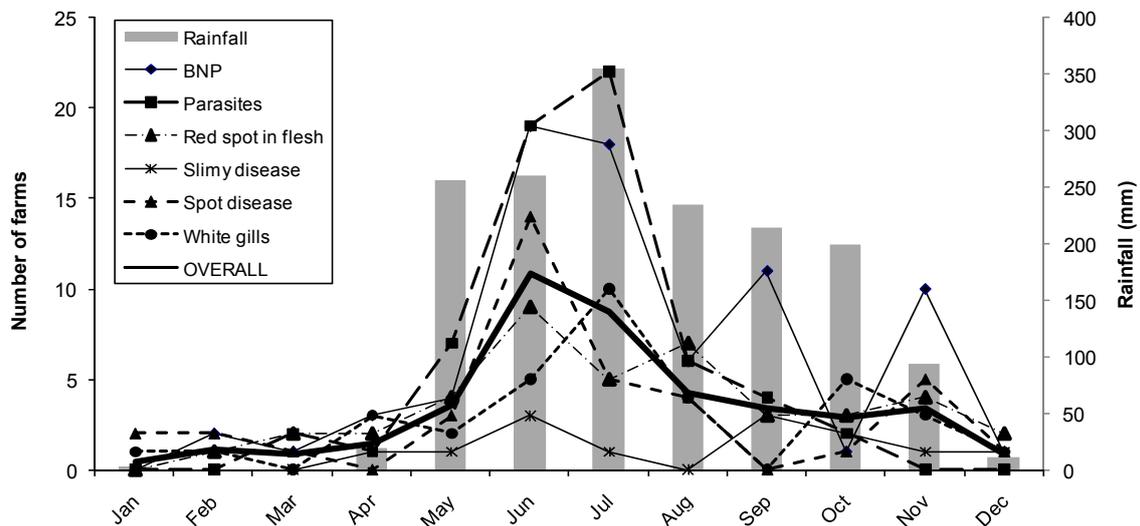


Figure 4. Common diseases found in catfish in the production cycle. Rainfall (mm) are average values obtained from nine provinces of the Mekong Delta.

Mortality of stock could occur due to number of reasons, including:

- Disease from infectious pathogens (normally parasitic, bacterial, fungal or viral) when the level of mortality could be high depending on the virulence of the pathogen.
- Nutritional deficiencies, when the mortalities are low at any one time but continues to occur on a regular basis.

- Very poor water quality; in the case of catfish farming the latter is unlikely to be due to oxygen deficiency but could be due to high levels of metabolic wastes (eg. ammonia) and or hydrogen sulphide.

Daily careful observations of the stock will enable farmers to pick up early signs of disease.

Some of the important symptoms to look for are: changes in behaviour, fish congregating near inlets and outlets, not feeding normally or loss of appetite, jumping out of the water, (yellow) discoloration of flesh, ulcers and haemorrhages on body, pale gills, torn fins, fish floating on the surface and loss of balance.

Every attempt should be made to collect sick and moribund fish and to do a preliminary examination either at the pond side or preferably by sending to a nearby disease diagnostic laboratory for testing. In the event of noticing mortality, gather the following information will assist in diagnosis:

- A description of the symptoms observed.
- The number of live fish showing symptoms and the severity of symptoms (very low/high).
- The number of ponds on the farm affected (is it in one pond or several ponds in the area?).
- Size and number of fish that die each day (is it a one-time event or a continuous event?).

If dead fish are noticed, they should be removed and properly disposed of. Dead fish should never be left in the pond as other fish could eat them and become infected.

Many of the pathogens responsible for causing disease may already be present in the pond water. Only when the water quality is poor and fish are stressed do they cause disease in fish. By improving water quality and minimising stress, many of the infectious diseases can be controlled/minimised.

Use of chemicals and drugs to treat diseases may not be useful unless a proper diagnosis is obtained. Only approved chemicals and veterinary drugs should be used. Indiscriminate use of drugs could lead to food safety issues and market rejection of stock.

BMP 1. 15. Fish health management

- **External factors cause negative impact on fish health, including weather changes (e.g. temperature drop, too much rain ...etc), and high fluctuation of water conditions (e.g. water colour changes). Pay attention at all times to the factors given below and take appropriate action as suggested:**
 - **Abnormal fish behaviour:**
 - **Loss of appetite (reduce eating).**
 - **Suddenly jump up.**
 - **Congregation of groups of fish in corners of the pond**
 - **Appearance of common diseases:**
 - **Bacillary Necrosis of *Pangasius* spp. (BNP):**
 - **Symptoms: glassy swim, jump out of the water pond, rotated swim down to the bottom, loss of appetite.**
 - **Treatment: stop feeding and drug/chemical treatments.**
 - **White livers and gills:**
 - **Symptoms: Gills and livers are whitish colour.**
 - **Treatment: Reduce feeding rate and treat water.**
 - **Haemorrhage:**
 - **Symptoms: red anus, red mouth, goggle eyes, red fins. Dark red liver, haemorrhage in intestinal tracts and inside abdomen walls.**
 - **Treatment: treat water and mix appropriate antibiotic with feed.**
 - **Disease prevention:**
 - **Ensure that feed of proper nutritional quality is used**
 - **Monitor water quality on a regular basis.**
 - **When the weather changes, exchange water and/or treat intake water with salt and lime if required.**
 - **It is equally important that the disease in one farm is not transmitted to the adjoining ones, if the sector as a whole is to become sustainable. Therefore when a disease occurs in the farm:**
 - **Immediately inform adjoining/ surrounding farms**
 - **Do not discharge water in to a common source**

Diseased and concurrent dead fish management is crucial to better management. Adoption of timely actions in this regard helps the spread of disease in the farm and to other farms and makes it also easier to treat the disease. Proper actions in respect of the disposal of dead and diseased fish also help to minimise the attraction of terrestrial, arboreal and aquatic scavengers. This minimises the spread of the disease and acts to contain potential 'reservoirs' of further pathogen contamination.

BMP 1. 16. Disease/dead fish management/ disposal

- **Regularly observe fish for abnormal clinical signs and behaviour.**
- **Record carefully all clinical signs and progression of development and size of the affected stock.**
 - **Have dedicated containers (with a lid) to collect dead fish**
 - **Regularly (preferably daily) remove and bury dead fish with lime in a fixed place in the farm isolated from growing ponds, feed sheds and staff quarters.**
 - **Do not sell diseased/dead fish to other grow out farms.**
 - **Where possible, send moribund fish samples to the nearest laboratory for disease diagnosis to confirm appropriate chemical treatment.**
- **Do not use chemicals without understanding the primary aetiology of the disease.**
- **Use treatments very judiciously based on diagnosis results.**
- **When discharging water from diseased ponds, inform other farmers in the area to avoid cross-contamination.**

5.8 Harvesting

Harvesting represents the culmination of a period from stocking to careful husbandry and the final reaping of the rewards of hard labour and financial inputs. In tra catfish farming in the Mekong Delta, harvesting is a relatively difficult process compared to most aquaculture practices as the stock is retained in a pond of average 4-5 m deep and a potential harvest up to 800 t/ ha/ cycle (averaging 400-450 t/ ha/ cycle) (see Figure 5). The average fish size should be around 900 g/fish for a culture period of six-seven months, which would be the most economical operational cost. The average survival rate is >80%

In catfish farming in the Mekong Delta, when the stock is ready for harvesting the farmer will explore the market prices on offer from the processors, and will enter in to a deal that suits him/her best. The processor in turn will test the stock for quality, uniformity in size and chemical residues, after which a final deal is struck and the harvesting date(s) fixed. Harvesting is rarely carried out by the farmer. In the Delta, specialised harvesting and transportation (boat) crews operate and these crews are often sub-contracted by processors.

Harvesting is conducted by these specialised crews over a few days (up to 7 days depending on volume of fish and number of ponds), and is done so in batches as the water level in the pond is depleted. The day's harvest is kept in pens, batch weighed, and often hand carried or by motor bike or vehicle to an anchored boat with facilities for transportation of live fish..

BMP 1. 17. Harvesting

- Stop feeding fish 2-3 days before harvest.
- It is best to complete the harvesting within 4 days, but total harvest time should not be more than 7 days.

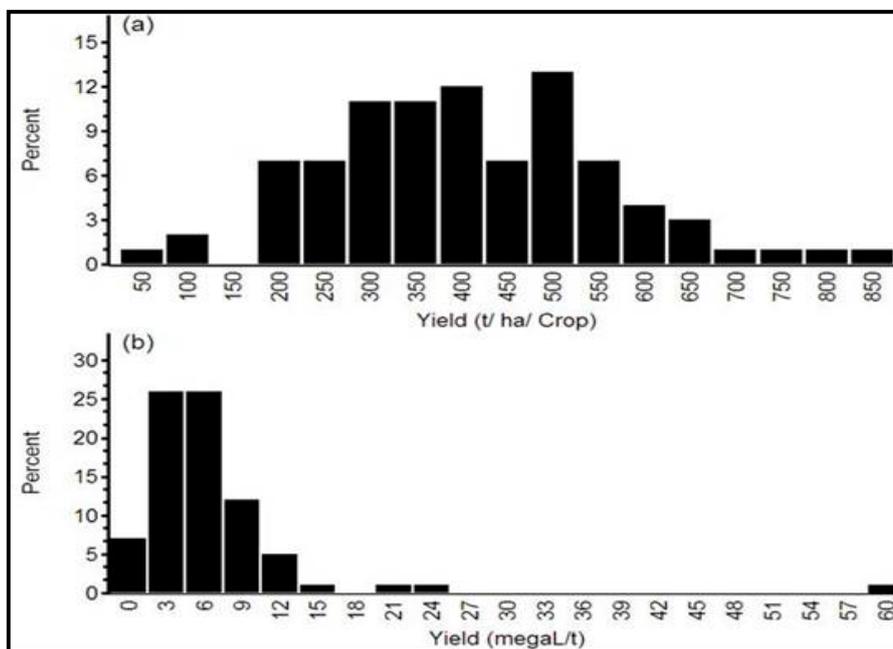


Figure 5. The percent of ponds with different average tonnages at harvesting in relation to a) area and b) the amount of water (from Phan et al., 2009⁴)



Pictures showing a day's harvest being weighed and taken to the boat for transport to the processor

PART C. BMPs FOR HATCHERIES

The Mekong Delta catfish farming sector has hundreds of hatcheries in operation, located mainly in An Giang and Dong Thap provinces. These hatcheries are estimated to have produced 11,807 million fry in 2007, which is 25 fold of that in 2000. Needless to say this is a very important sector, and special attention is needed to ensure the supply of good quality seedstock and in turn the sustainability of catfish farming in the Delta as a whole.

Quality of hatchery seedstock depends on a number of factors affecting different production stages, including pre-spawning broodstock conditioning, spawning and the immediate post-hatch stage (egg incubation, larviculture and post-larval husbandry). Relevant factors for broodstock conditioning include physical status (e.g. size, age, level of maturity, number of spawns per year, appearance and health condition) and genetic integrity of the parent fish.

From an aquaculture perspective, hatcheries in the long-term should aim at providing consistently good quality seed (i.e. fry) to the nursery sector:

- ***Through proper husbandry practices, and***
- ***Ensuring long-term genetic quality of the broodstock with a sound genetic management plan.***

From project survey results, most hatcheries used the river as the main water source. Hatchery farm size ranged between 0.2-15 ha (mean 2.5 ± 0.5 ha), with 0.05-10 ha (mean 1.59 ± 0.3 ha) in pond area. Most farmers (96 %) operate one farm only. Hatchery buildings cover 12-500 m² (122 ± 16 m²). Hatcheries have 1-25 (mean 8) outdoor broodstock ponds ranging in size between 0.02-3.0 ha (mean 0.16 ± 0.05 ha) which are up to 4 m deep, and 1-10 (mean 4) outdoor nursery ponds ranging in size between 0.03-0.8 ha (mean 1.3 ± 0.1 ha) which are up to 3.7 m deep.

1 Husbandry practices

1.1 Broodstock ponds

The Stage 1 project survey included 30 and 15 hatcheries in Dong Thap and An Giang, respectively. Ponds used to hold broodstock ranged between 0.02 - 3 ha, with water depth between 1.2 - 4.0 m. *Ponds over 1 ha in size are probably too large and inconvenient to easily collect broodstock when needed.*

The majority of hatcheries clean the broodstock ponds yearly by removing the sludge, though some hatcheries do so more frequently (from three - four to six - eight months). Pond bottom treatment duration ranged between 1-15 days and the treatments include the application of lime (in a large number of hatcheries) and others such as charcoal, BKC, Zeolite, Yucca and Virkon A. There is no scientific information on the beneficial effects of probiotics and therefore *it is*

recommended to use only lime for pond bottom treatment (see BMP 1.1 and 1.2 for bottom treatment for grow-out ponds).

Broodstock are one of the major resources of a hatchery, and it is important to have a well protected pond area with strong dikes to avoid ponds from being flooded and fish escaping. Broodstock ponds should also be clear from any obstructions for easy netting and transportation during breeding seasons.

BMP 2. 1. Broodstock ponds

- **For minimum farm size: 2 ha, the min. number of broodstock required: 300 fishes.**
- **Broodstock ponds should not be larger than 1 ha in size, with most suitable pond sizes between 500-2,000 m² and 2-2.5 m depth.**
- **Pond dike should be strong and higher than the maximum flood level in the past 5-10 years to prevent broodstock from escaping during floods.**
- **Remove all obstructs from the pond bank for easy netting and transportation of brood fish.**
- **See BMP 1.1 and 1.2 for suggestion on pond bottom treatment with lime.**

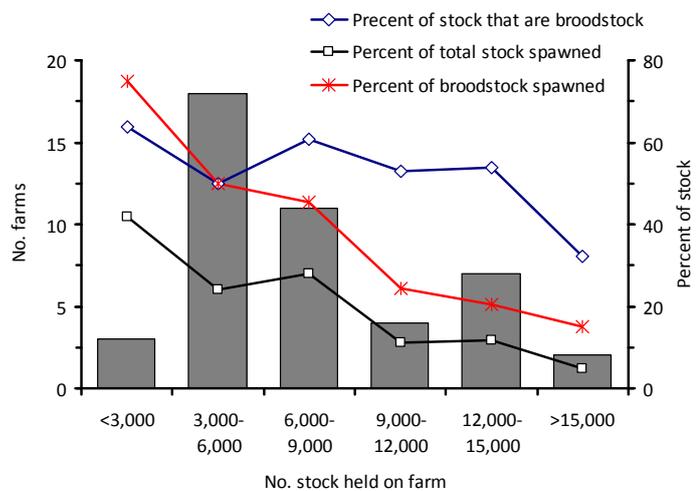
1.2 Broodstock conditioning

According to the project survey results, the tra catfish farming sector in the Mekong Delta is some what unique in hatchery operators maintaining a vary variable, often excessive, number of fish as potential broodstock (Figure 6). Potential broodstock numbers retained by hatcheries range between 240 ->15,000 fish/ha.

Broodstock should be maintained under less crowded conditions than in grow-out.. *Ideally, no more than one fish/ m² (for both males and females) should be held in a 1 ha pond.* In addition, the number of broodstock held should be in accordance with the capacity of the hatchery.

Holding excessively large number of broodstock does not make sense as only a fraction will be used for spawning, and therefore unnecessary expenditure is incurred by maintaining large numbers. Some farmers have the view that the cost involved in maintaining a large number of potential broodstock is secondary to the “insurance” the large number provides in the case of excessive stock loss. Farmers are of also of the view that the large number provides them with a greater choice for spawning purposes.

Figure 6. Number of broodstock held on 45 striped catfish hatcheries in the Mekong Delta, and % of these stock that are broodstock, and % of broodstock that are spawned in 2008.



The survey results suggest that there are no special broodstock diets available for catfish. Some farms (38%) use only farm-made feed to

reduce cost and improve quality of the diet, whereas some farms (49%) used both commercial diet for grow-out in combination with farm-made feed and some (13%) used only commercial feed. Farm-made feed ingredients include fish meal, blood meal, “trash” fish, rice bran, broken rice, cotton seed flour, soybean cake, milk, egg and vegetables (e.g. water spinach and green pea). Feeds are also supplemented with vitamins (C, E), prebiotics (glucan), premix, probiotics and digestive enzymes before feeding.

The survey indicated that broodstock conditioning under current practices is divided into two stages: the gonad developmental stage and the maturation stage. In the former, the majority of farms (up to 60%) feed very high protein diets, and at the latter stage some farms reduced the protein content.

In fact special broodstock diets are not required throughout the year, but only for the 2-3 months immediately before breeding. Broodstock generally require a diet that is used for growout, supplemented with some essential ingredients 2-3 months prior to spawning. It is noted that attempts have been made by farmers to improve protein content in the diet for broodstock. However, 40% protein in catfish broodstock diet is too high and it is more important to increase dietary fatty acid levels as these are equally important to oocyte development. Broodstock need a normal diet that maintains its health and condition, but also enhances oocyte formation and yolk deposition. The latter requirement is not necessarily dependent on very high protein content diets. Two - three months prior to spawning is crucial for effective broodstock conditioning, and during this period changing the diet on a weekly basis is more advantageous than a single special diet throughout the year.

BMP 2. 2. Broodstock conditioning/ management requirements

- **Fish :** body weight >3.0 kg/fish; good shape, no deformity; stocking density: 2-3 kg/m².
- **Management:**
 - **Culture period:**
 - **If the first spawning, the culture period is 12 months (9 months for intensive conditioning and 3 months for maturation).**
 - **If the fish has spawned, the culture period is 2-4 months (1-2 months for intensive conditioning and 1-2 months for maturation).**
 - **Stock male and female separately.**
 - **Pellet feed: about 30% protein, supplement with unsaturated fatty acid at 0.1%, Vitamin C and E at 1%. Feeding rate is 1% of body weight for four - six weeks prior to be used for spawning; supplement the diet with minced ox liver, fresh trash fish to about 1% of the body weight every other day.**
 - **Check the feed quality before use.**
 - **Water exchange: every 10 days at 30% of water volume.**

1.3 Spawning

Catfish spawning season is between February - October. Fish are often selected for spawning based mainly on level of maturity and health condition (uniform size and colour of eggs for females, and running milt for males).

Often catfish reach maturity at about 3 - 3.5 years of age (~3-3.5 kg). However, the project survey indicates that some farms use very young (2 - 2.5 years) or old (7-10 years) broodstock, which may lead to poor quality of seed.

All hatcheries use human chorionic gonadotrophin (HCG) to induce spawning, followed by artificial fertilisation. No anaesthetics are applied during hormone injection and stripping. Fertilised eggs are treated with a tannin solution to remove their stickiness, which facilitates incubation.

The survey results indicate that the sex ratio of male: female in matings ranges from 1:9 to 1:1.

Although the sex ratio does not directly affect the quality of one batch of seedstock for grow-out, care must be taken in case seedstock are selected to become potential broodstock (see Section 2 below for more information on effect of sex ratio on genetic diversity).

Based on the mean weight of females used by each hatchery, and mean fertilisation and hatch rates, spawning females produced 0.003-1.28 million eggs/kg (mean 0.127 ± 0.036 mil. eggs/kg) and 0.0012-0.8 million larvae/kg (mean 0.087 ± 0.024 mil. larvae/kg). Further, egg and larval production was negatively correlated with female weight.

BMP 2. 3. Spawning

- **Do not spawn an individual fish more than twice in a 12 month period, and ideally spawn once only**
- **The best spawning age: 3-6+**
- **Broodstock quality checking:**
 - **Female:**
 - **Egg quality: diameter: >1.1 mm, eggs translucent to transparent, uniform size and brilliant colour.**
 - **Average fecundity: 500 g of eggs for 5 kg of female.**
 - **Male:**
 - **Sperm quality: > 1 ml of fluid, milk white colour and fairly thick.**
- **Fertilisation: 2-5ml sperm for 1 kg of eggs.**

1.4 Hatching/ Care of the hatchlings

The rate of metabolism per unit weight is at a maximum during larval development. Consequently, many metabolic products, such as ammonia, are excreted by larvae in significant quantities, and also at this stage the sensitivity of larvae to chemicals is also at a maximum. As such it is important to ensure that there is continuous exchange of water during egg incubation, and the developing eggs are kept in constant motion to prevent any clumping.

It is also important to maintain a proper record on performance of each of the broodstock based on egg quality as measured by fecundity (total number of eggs produced), % hatching rate and % viability of hatched larvae. Table 3 provides a summary based on project survey results of fertilisation rates, hatch rates, larvae to fry survival rates and fry to fingerling survival rates during the peak and off-season production periods.

Table 3. Fertilisation rates, hatch rates, larvae to fry survival rates and fry to fingerling survival rates during the peak and off-season production periods. Values (in percentages) represent range with mean and s.e. (\pm) in parentheses.

Survival rate (%)	Peak season	Off-season
Fertilisation	10-99 (86 ± 2.2)	28-95 (71 ± 3.3)
Hatch	60-100 (88 ± 1.2)	50-100 (77 ± 2.7)
Larvae-to-fry	15-80 (34 ± 3.9)	5-80 (32 ± 5.8)
Fry-to-fingerling	10-90 (44 ± 8.3)	7-90 (32 ± 8.7)

BMP 2. 4. Egg incubation/ Hatching/ care of hatchlings

- **Ensure that the fertilized eggs are kept in constant motion, in good quality water, with regular monitoring of water quality, and do not use any chemicals**
- **If fecundity is below average (egg mass is <5% of body weight), do not use the eggs from this particular broodfish..**
- **Requirements for egg incubation:**
 - **If it is planned to use the offspring as further broodstock, incubate separately the eggs from each broodstock at spawning.**
 - **If the offspring are to be used for growing out, incubate all eggs at a spawning together.**
 - **Record the spawning performances (fecundity, hatching rates, mortalities, deformities); cross check with the past performance of the female.**

2 Maintaining genetic diversity of broodstock

Genetic quality of the broodstock plays an important role in ensuring the quality of seedstock produced. Hatcheries, apart from day-to-day duty of producing good quality seedstock to support the nursery and ultimately grow-out sector, have also to develop their broodstock by eliminating poorly performing fish and at the same time recruit new ones. This has to be undertaken strategically in order to maximise genetic diversity and to avoid inbreeding effects (see Figure 7).

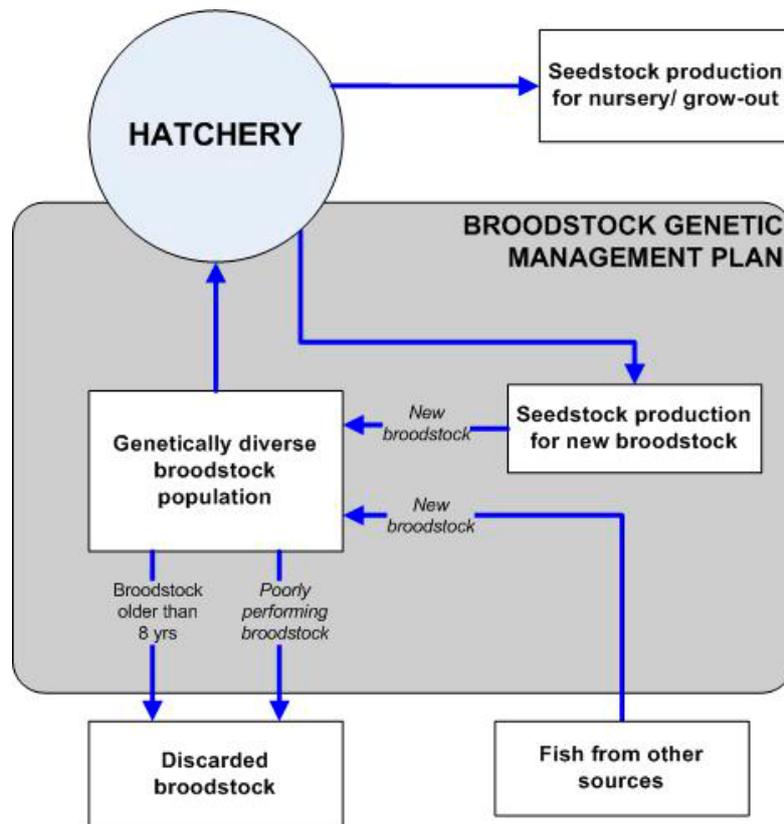


Figure 7. Schematic diagram of a preferred broodstock genetic management plan showing major activities of a catfish hatchery

One of the major problems of poor genetic management of broodstock is “inbreeding”, which is the mating of siblings or relatives, for example between brother and sister, cousins, parents and their offspring etc. In some cases, well planned and directed inbreeding can be beneficial, but unintentional and unplanned inbreeding will cause problems.

When unintentional and/or unplanned inbreeding occurs, performance of fish declines over subsequent generations due to a number of factors including low growth rate, reduced viability and fecundity, increase in incidence of abnormalities and increased susceptibility to diseases.

The negative effects of inbreeding normally do not occur immediately. Inbreeding depression is often delayed (i.e. might not occur until several generations after inbreeding has begun). How quickly inbreeding depression occurs depends on the species, the amount of inbreeding that has occurred and the production trait of interest.

Please note that inbreeding is not always the major reason behind production problems. Many catfish farmers believe that seedstock quality is decreasing because inbreeding has occurred. This could be erroneous because low seedstock quality (deformities and decrease in growth rate) can be the result of a range of factors other than genetic factors, such as developmental errors, toxins, nutritional deficiencies or water quality.

To avoid inbreeding, it is ideal to fit each broodfish with a unique tag so that a full ‘individual’ pedigree can be recorded. However, this can be expensive, and if such tagging is not affordable, hatcheries must manage broodstock ‘populations’ on a pond and/or farm unit basis to minimise the effects of inbreeding.

To minimise inbreeding means to maximise “effective breeding number” (EBN), which is determined by the number of females and males that produce viable offspring, which in turn can reproduce and contribute genetic material to the next generation. EBN can be maximised by:

- Increasing the number of spawning females and males towards the optimal max. number for the farm (see previous), and
- Bringing the sex ratio of spawning broodstock as close to 1:1 as possible.

There is no rule of thumb of how large the value of EBN should be. This depends on the goal of the hatchery i.e. what level of inbreeding is acceptable and for how many generations. For example, if a hatchery would like to maintain levels of inbreeding of less than 5% for 50 generations (i.e. 150 years for catfish), EBN should be kept at least at 500. This is in fact an achievable goal for catfish hatcheries in the Mekong Delta.

It is noted from the project survey that numbers of broodstock held at the hatcheries are highly variable, ranging between 240 - 11,000. The male: female ratio also varied, from a balanced ratio of 1:1 to a highly skewed ratio of 1:9. ***A large broodstock number does not necessarily reduce inbreeding, as what is important is that they can contribute their genetic material to the next generation (i.e. EBN).*** Hatcheries often keep only a small portion of the offspring for broodstock (about 4%) and it is likely that this small portion is only confined to a few families which may perform well at one spawning. In the longer term this is not a good strategy as inbreeding can be accumulated quickly when there are few families contributing to the next generation. ***The more skewed a sex ratio, the least EBN becomes.***

Keeping excessively large number of broodstock is not necessary and it will increase the costs of maintenance. Based on the average number of broodstock used at each spawning and the number of spawning conducted per year, the project survey suggests that a majority of hatcheries are maintaining excessive number (between 800 - 9,000) of broodstock. It was also clear that all hatcheries do not have a strategic plan for broodstock management and in general there is a lack of understanding on genetic aspects of broodstock management. Some hatcheries for example procured adult fish from grow-out farms or from Cambodia.

BMP 2. 5. Genetic management - *Note that this BMP is only applied for spawning batches that produce potential broodstock*

- **Parents should not be relatives.**
- **Efforts should be made to achieve EBN of at least 500.**
- **One or more of the following should be applied to maximise EBN:**
 - **The more number of parents the better, and parent male: female ratio should be 1:1.**
 - **Keeping a small portion of each family of many families.**
 - **Equalise the number of offspring from each family: This requires each family to be raised in a separate unit until family size can be equalised.**
 - **Apply pedigreed mating: i.e. each female leaves one daughter and each male leaves one son as broodstock for the following generation (can be more than one as long as all leave the same number of individuals). This also requires each family be raised in a separate unit to ensure each parent leaves an offspring of the correct sex.**
 - **Milt should not be pooled or added in a sequential manner. These practices cause gametic competition and one male can fertilise most of the eggs, producing EBN smaller than expected.**
 - **Hatcheries can maintain two separate broodstock populations and produce hybrids between them. If more lines are maintained, rotation mating program can be used to prevent inbreeding for a number of generations.**
 - **Procure broodstock from the wild or grow out farms (know the history) to replace 10-25% of new brood fish every year.**
 - **Exchange of broodstock among hatcheries is recommended.**

PART D. BMPs FOR NURSERIES

Background

Based on the vertically integrated organisational structure of the tra catfish farming sector in the Mekong Delta, nursery activities are considered sufficiently specialised to be warranted as a stand alone sector. The interrelationship between the different sectors, including hatchery, nursery and growout, is schematically represented in Figure 8.

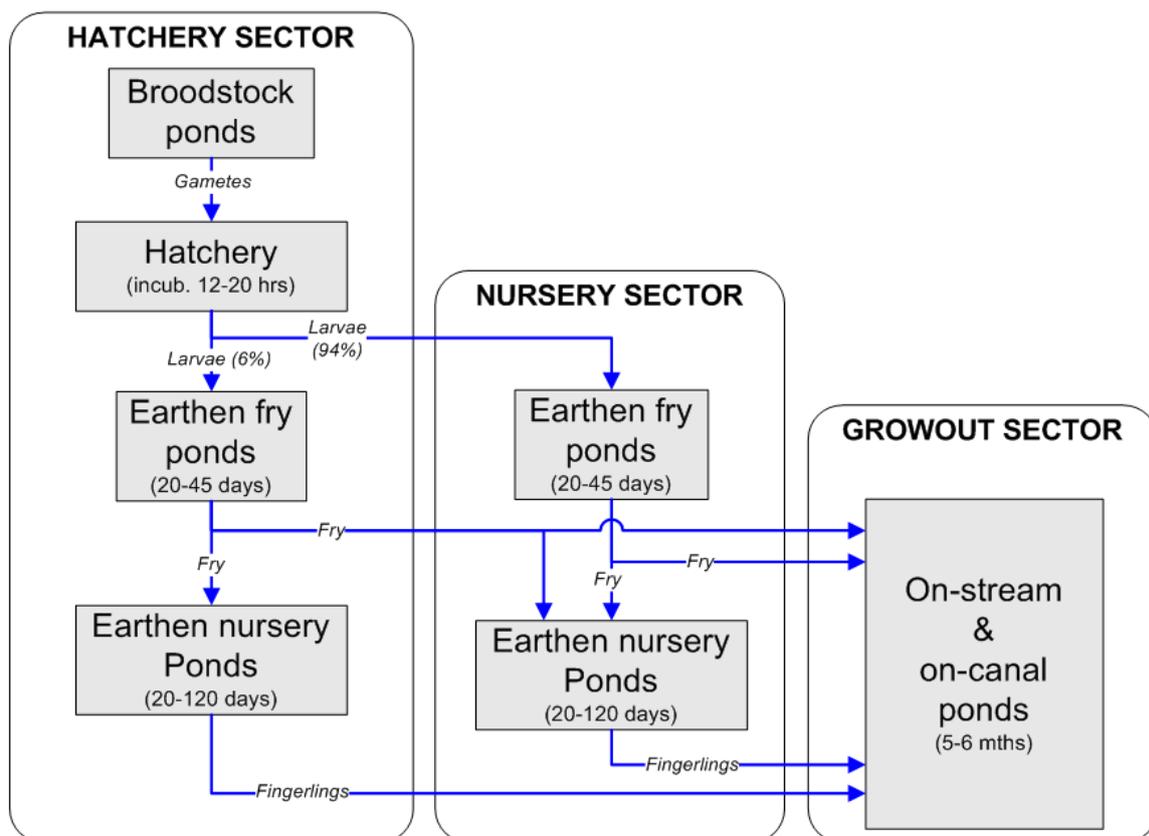


Figure 8. Schematic representation of the interrelationship among hatchery, nursery and grow out sectors of the striped catfish industry of the Mekong delta and movement of stock between each sector.

As evident from the project survey, in some instances the hatcheries themselves will carry out nursing to fingerling stage, albeit to a smaller degree, with the great bulk of nursery production being conducted as a specialised activity in farms dedicated for fry to fingerling rearing (Fig. 8).

Nursery farm size ranged between 0.09-11 ha (mean 1.9 ha), with 0.01-10 ha (mean 1.3 ha) in pond area. Nursery farms have 1-10 (mean 3) ponds for rearing striped catfish. Ponds used for the larvae-to-fry rearing stage were generally smaller and shallower (0.0025-2 ha, mean 0.44 ha,

mean depth 1.8 m) than those used for the fry-to-fingerling rearing stage (0.016-4 ha, mean 0.48 ha, mean depth 2.2 m).

Most nursery farms used the river as the main water source. Ponds are treated before use, mainly by removing sludge, applying lime and salting. Less than 50% of farms screen the inlet, but most farms will treat the water once ponds are filled. Farms mostly dispose of water to a rice field or a garden.

BMP 3.1. Pond preparation

3.1.1. Primary Pond preparation: see BMP 1.1 and 1.2.

- **Ensure that ponds are surrounded by nets.**
- **Consolidate and clean up the pond dikes, pipes.**
- **Pond size should range from 5,000-10,000 m², with water depth between 1.5-2.0 m.**
- **Apply lime CaO for the pond and dike at 10 kg/100 m² for the first time.**
- **Dry the ponds for 1-3 days depending on seasons and soil characteristics. Do not dry acidic soil.**

3.1.3. Water screen and treatment

- **Screen water before filling up the rearing ponds to eliminate trash/predator fish.**
- **Prepare food for larvae**
- **Stocking *Moina* spp. As a supplementary live food before stocking fish fry at 20 kg (wet weight) *Moina* spp./ha (3 milk cans = approx. 1 kg of *Moina*).**
- **Water depth for stocking: ≥ 1.5 m.**

Larval to fry rearing

Larval to fry rearing is conducted in conjunction with hatchery operations and or as a specialist nursery activity, where fertilized eggs and or larval/post-larval hatchlings are purchased from hatcheries.

BMP 3.2. Larval Stocking

- **Stock larvae in early morning or late afternoon after 2-3 days of filling up water at stocking density: 300-350 larvae/m².**
- **Water quality: suitable pH range: 7.5-8.5; do not stock at higher pH.**
- **Larvae quality: not deformed, uniform size, active swimming at bottom of containers.**

BMP 3.3. Feeds and feeding regime

- **In the first two weeks: duck (chicken) egg yolk and soybean meal prepared in the form of a fine emulsion.**
- **Feeding regime: 6 times a day (at least 3 h interval) at 50 duck egg yolks and 2 kg of soybean meal/ha/time.**
- **From the third week on: formulated feed.**
- **The total nursery period should be around 3 weeks.**

BMP 3.4. Feeds and water exchange

- **No exchange water, only fill up water.**
- **Filling water depends on water levels and water colour.**

BMP 3.5. Fish health management

- **Rarely appear in the stage, if disease occurs or outbreak, it could be isolated and completely destroyed.**

BMP 3.6. Harvest

- **Harvest for selling or transfer to second stage.**
- **Harvest size: approximately 3,000 fry/kg.**
- **Desired survival rate from the time of stocking: 30%.**

Fry to fingerling rearing

As for hatchling to fry rearing, the same operations may continue to apply for fry to fingerling rearing, which is mostly undertaken by specialised nursery farms. It is rather rare for hatcheries to be involved in rearing up to fingerling stage, primarily due to constraints on pond space requirements and the fact that hatchery operations are labour intensive and deviation from the practice could be counter productive.

BMP 3.7. Fry stocking

- **Stocking density should be: 100-150 fry/m².**
- **Stocking time: at early morning or late afternoon.**
- **Water quality: suitable pH range: 7.5-8.5, not recommend to stock at higher pH.**
- **Larvae quality checking: should not have deformed fish, stock should be of uniform size and active.**

BMP 3.8. Feeds and feeding

- **Feed: formulated feeds are recommended; feeds of appropriate particle size and nutritionally wholesome should be used.**
- **Feeding regime: 2-3 times/day at 7-10% of body weight**
- **Stock should be observed on a regular basis for activity and feeding.**

BMP 3.9. Water exchange

- **Exchange water: every 7-10 day at 20-30% of water volume.**
- **Ensure that toxic metabolite levels such as ammonia concentration are kept low**

BMP 3.10. Health management

- **Common diseases that occur: parasitic, fungal and bacterial infections.**
- **Chemoprophylaxis and treatment: apply special drugs or chemicals (directly into the ponds or mix with feed), as prescribed and after consultation with a fish health specialist only.**
- **If widely prevalent in the stock consider destroying the stock and disposing in the proper manner**

BMP 3.11. Harvest

- **Most desirable harvest size: 30-70 fingerling/kg, the best size: 1.7 cm in body depth.**
- **Desired survival rate: 50-70%.**
- **Nursing period: 2 months.**
- **To obtain uniform size, fingerlings should be screened after one month of nursing.**

PART E. GENERAL ASPECTS IN RELATION TO BMPs

1 Use of chemicals (also see food safety)

Consumers all over the world are becoming extremely conscious of the quality of the food they consume, and how it is produced. This is an unavoidable and indeed most welcome status, driven by increasing standards of living, improvements to technological advances on testing and detection, increasing advancement and awareness of food related health issues, made easily available to the public through the modern day mass media.

Food quality standards of importing countries could differ from each other. For example, though Britain is a member of the European Community (EU), it has its own food quality standards over and above that imposed by the EU. In the EU standards there is 'zero tolerance' for antibiotic residues, i.e. the food will be rejected if any antibiotic is found in the consignment. In Vietnam, there are regularly updated published lists of banned chemicals, which are brought to the notice of catfish farmers by Ministry of Agriculture and Rural Development (MARD) Such chemicals should not be used under any circumstance.

On the other hand, farming communities the world over, more so in developing countries, are induced to use various forms of chemicals and other substances that are claimed to have a positive impact on production. As an example, in one country it was found that over 1000 'chemical products' were traded, of which, as revealed by later studies, all essentially consisted of less than only 20 active ingredients which were sold under different trade names and claimed to have different impacts.

Bacterial diseases are commonly treated with antimicrobial agents (antibiotics). The project survey indicated antibiotics are widely used by catfish farmers in the Delta. Use of antibiotics to treat diseases should be undertaken with extreme caution as bacteria have the ability to develop and transfer drug resistance. The occurrence of multiple antibiotic resistance by bacterial fish pathogens is becoming more evident in farmed fish, especially in areas where antibiotics are widely and indiscriminately used. Antibiotics must be used cautiously and done under the supervision of a qualified veterinarian. In extreme bacterial disease outbreaks, it may be necessary to destroy infected stock and eliminate the responsible pathogens by sterilisation of ponds, tanks and equipment. In the future, vaccines should be developed for important bacterial diseases of catfish rather than encouraging further use of antibiotics.

Probiotics are a group of substances, primarily bacterial inoculants, that are used in farming practices, based on the belief that these impact positively on water quality and hence productivity. The scientific evidence on the positive impacts on the use of probiotics in aquaculture remains unclear and somewhat controversial. The bacteria used in probiotics are aerobic, and need oxygen to be metabolically active. Such probiotics cannot beneficially impact on water quality when pond sediments are under anaerobic conditions, which is often the case in relatively deep, intensively stocked catfish growout ponds. The balance of evidence suggests that

use of probiotics in grow-out operations in catfish farming is likely to be ineffective, and good pond management and fish husbandry are sufficient to facilitate optimal productivity.

Reducing use of chemicals can contribute significantly to reduced cost of production and therefore increased profits.

BMP 4. 1. Use of chemicals

- **Do not use any banned chemical, at any stage of the farming process**
- **Have regular consultations with authorities with regard to banned substances.**
- **Do not use probiotic chemical and or other similar substances that are claimed to improve water quality**
- **Any chemical usage should be carried out after consultation with qualified personnel and under supervision**
- **Be conversant with the food quality and safety standards guidelines**

2. Community responsibilities

In aquaculture, there is a need to share common natural resources such as water and land. Tra catfish farming is no exception in this regard. Use of common resources when done with social responsibility will only lead to sustainability for all users, bring about minimal environmental perturbations and most of all generate synergies that benefit the broader community stakeholders. Governments have a role to play in ensuring effective governance arrangements are in place to equitably and sustainably allocate common natural resources to industry. Farmers have a responsibility to comply with such governance arrangements at all times.

BMP 4. 2. Community responsibility

- **Property right and regulatory compliance:**
 - **All farms have legal rights for land use, water use, construction, operation and waste disposal (incl. predator control permit, well operation and protection of wetlands and other sensitive habitats).**
- **Community relations:**
 - **All farms should endeavour to establish good community relations and not block access to public areas, common land, fish ground and other traditional resources used by local community.**
- **Worker safety and employee relations:**
 - **All farms shall comply with local and national labour laws to assure adequate worker safety, compensation and on site living conditions.**

Equally, a most crucial element of social responsibility of a farming community also entails a major facet of environmental responsibility. All farming, whether on land and/or in water impacts on the environment. The responsibility of the farming community is to keep such perturbations to a minimum. After all, a degraded environment will ultimately result in a reduction of farm productivity and viability.

BMP 4.3. Environmental responsibility

- **Wetland conservation and biodiversity protection:**
 - **Aquaculture facility shall not be located in mangrove or other sensitive wetland areas. Farm operations shall not damage wetland or reduce the biodiversity of ecosystems.**
- **Effluent management:**
 - **Farms shall monitor and find the appropriate way to treat the effluent before discharging to public water systems, and make all efforts to comply with the BMPs that have been recommended in this regard under the different farming practices (e.g., grow-out, hatchery, nursery rearing).**
- **Fish meal and fish oil conservation:**
 - **Farms shall properly monitor feed input and minimise the use of fish meal and fish oil derived from wild fisheries that are not sustainably managed.**
 - **Farms need to ensure that commercial feeds are manufactured in accordance with accepted regulations and standards, and if in doubt demand from suppliers the nature of ingredients and manufacturing standards.**
- **Soil and water conservation:**
 - **Farm construction/operation should not cause soil and water salinisation or deplete ground water in surrounding areas. Farms shall dispose of sediment in a manner compliant with the recommended BMPs.**
- **Control of escapees:**
 - **Farm shall take measures to minimise escape of stock and comply with governmental regulations regarding the use of native and non-native species.**
- **Storage and disposal of farm supplies:**
 - **Fuel, lubricants and agricultural chemicals shall be stored and disposed in a safe and responsible manner and in accordance with the existing regulations.**
- **Animal welfare:**
 - **All on-farm fish handling operations will be undertaken with animal welfare and well being in mind. Employees shall be trained to provide appropriate levels of husbandry.**

3. Food safety and traceability

In the modern world, food safety and traceability of the produce are crucial elements that reflect consumer needs and facilitate access to export markets. Compliance with internationally recognised and independently certified and traceable food safety standards is a minimum requirement for catfish farmers who wish to sell product to exporters at a profitable price. Adoption of BMPs, as a first step by farmers, is expected to facilitate compliance with various certification standards, including the food safety and traceability requirements of the market place.

BMP 4. 4. Food safety

- **Drug and chemical management:**
 - **Banned antibiotics, drug and other chemical compounds shall not be used.**
 - **Other therapeutic agents shall be used as directed on product labels for control of diagnosed diseases or required pond management, not for prophylactic purposes.**
- **Microbial sanitation:**
 - **Human wastes and untreated animal manures shall not be permitted to contaminate pond water.**
 - **Domestic sewages shall be treated and not allowed to contaminate surrounding areas.**
- **Harvest and transportation:**
 - **Fish shall be harvested and transported to processing plants or other markets in a manner that maintains temperature, as far as possible under minimal minimise stress, physical damages and contamination.**

BMP 4. 5. Traceability

- **To establish product traceability the following data shall be recorded for each culture unit/area and each production cycle, and be made available for inspection and scrutiny at any point of time. The record keeping recommended is:.**
 - **Culture unit identification number.**
 - **Unit area or volume.**
 - **Stocking date.**
 - **Quantity of seed stocked, and origin of seed stock.**
 - **Antibiotics, drugs, herbicides, algicides and other pesticides used, including the brand name, date of purchase and application.**
 - **The dates and amounts used and reasons for use.**
 - **Manufacturers and lot numbers for each feed lot used.**
 - **Harvest date, total production.**
 - **Details on processing plants or purchasers.**

4. Market aspects

Tra catfish mostly caters to the major overseas market for ‘whitefish’, but has had to face many obstacles, starting with the embargo on imported catfish introduced by the US several years ago. Despite initial problems, such obstacles enabled the industry to develop and establish new markets in the EU and neighbouring countries, which subsequently assisted in the stabilisation of world market demand for catfish-based ‘whitefish’. However, this is no matter for complacency as there are many anonymous campaigns that are carried out in the world media, perhaps from competitors, to discourage the consumption of tra catfish. As such it is an ongoing battle to maintain and grow market share for the tra catfish.

Another problem is that from a small, household-scale producer view point, the farm gate price is often dictated by the processors in the Delta, and this may have very marginal bearing on the prevailing export market prices *per se*, making it difficult for the small scale operators to remain economically viable. In many instances, small-scale farmers have no established formal business (contractual) relationship with processors, and therefore little or no bargaining power in relation to farm-gate price.

Perhaps, some of the answers to the above lie in the cross-industry adoption and implementation of BMPs through a cluster-based system i.e. formation of effective and functional Associations

of small producer groups; a lesson to be learnt from the Indian shrimp farming BMP and ‘Aquaclub’ experience. Cluster based adoption of BMPs will help small-scale farmers to obtain certification as a cluster participant, thereby minimising the cost of obtaining certification by individual farmers.

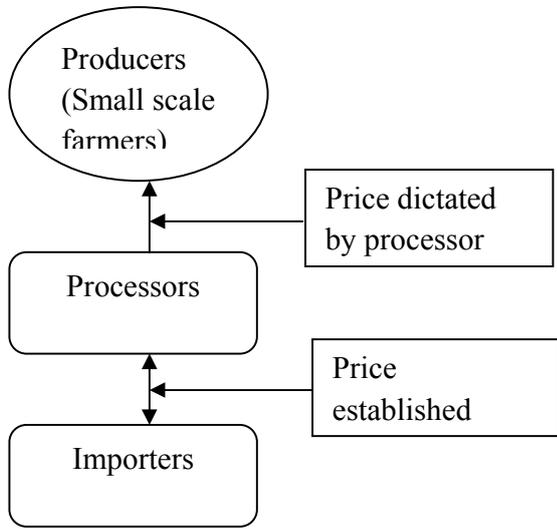
Independent groups are developing certification standards for tra catfish culture, and equally certification of the produce is now needed to access many export markets. In this context, adoption of BMPs by the catfish industry in the Delta, particularly for small-medium household-scale farmers is expected to facilitate the following outcomes:

- The production process will be cleaner and more compliant with certifiable food safety and product quality standards
- Cluster based adoption of BMPs will enable small-scale farmers to more effectively negotiate farm-gate price and to place a premium on product quality, thereby hopefully eliminating the problem of the internal deadlock between farmers and processors, and/or unilateral price determination by processors with regard to the farm gate price. In this instance, the produce will be sold as a ‘cluster product’ and this will give greater bargaining power to all and will enable a more equitable farm gate price to be obtained.

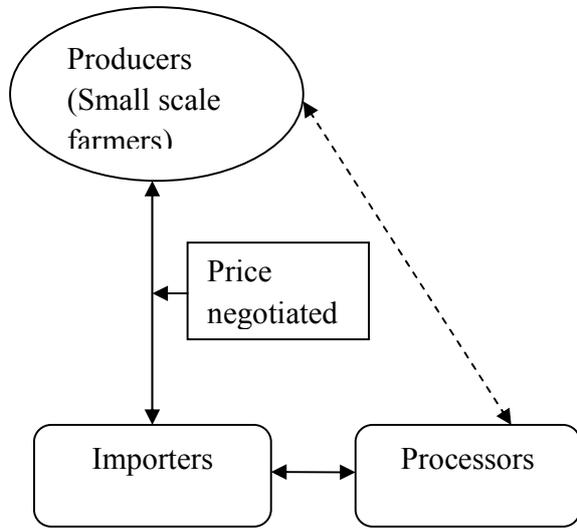
Experience in India clearly showed that all of the above were achieved within a period of two to three years. In fact Indian shrimp farmers are less well off and less forthcoming (in most cases) than tra catfish farmers, who are well informed and are more enterprising in most ways. However, the lack of organizational structure in the catfish industry has hindered the catfish farmers in making better headway, and most of all to facilitate more enterprising, mutually beneficial price agreements between farmers and processors. The Indian experience has demonstrated that adoption of BMPs and cluster formation have attracted major buyers directly to the producing cluster directly and improved prices. This is what the Vietnam catfish farmers need to achieve and there is no doubt that the adoption of BMPs working through a cluster system should facilitate such an outcome.

A similar status has recently been achieved in respect of a rural Thai shrimp farming activity, where premium prices have been agreed upon, through AquaStar, for a well renowned retailer Chain in the UK.

The above is simplified in the diagram below.



Current marketing



BMPs/ Clusters marketing

PART F. THE WAY FORWARD

The BMPS developed in this project provide catfish farmers in the Mekong Delta with an efficient, cost-effective and user-friendly set of technical guidelines designed to standardise practices across all production sectors, independent of scale of operation and total investment. BMPs are a prescriptive means by which farming practices can be optimised within the limitations of available information and resources but consistent with imperatives of ecologically sustainable development. With the dynamic nature of the industry in terms of consumer demands, the emergence of new technologies and the broader impacts of market globalisation and climate change, BMPs also provide farmers with a practical and cost-effective benchmark against which continuous improvement can be evaluated and promoted.

In this context, BMPs act as a catalyst for a suite of direct and indirect benefits applicable at local, national and international levels, which in turn are expected to be achieved in the short-medium term and which are sustainable in the long-term. Full compliance with BMPs has the potential:

- To enhance overall productivity and profitability of farmers by reducing costs (e.g. feed, seed, chemicals etc) and increasing fish growth and survival and product quality
- To reduce environmental impacts of farming through more sustainable management of chemical usage and wastewater and sludge disposal,
- To enhance networking between farmers as they form into associations for cooperative information sharing and training and general support, and
- To facilitate broader social benefits for farmers and local communities through greater transparency of operations and tangible commitment to communication and responsible farming

The recent general downgrading trend which many small and some large household-scale producers are facing due to low market prices and increasing costs, aggravated by the often difficult relationships with processes, highlights the need for more functional and relevant cooperative arrangements between farmers as key future challenges that the industry is facing. Accordingly, BMPs will need to be not only technically informative, but they will need to be more directly communicated to farmers, processors and the broader market place. This will require multi-faceted implementation and communication strategies customized for different scale producers who may have very different economies of scale, needs and expectations, resources and capabilities.

Adoption and implementation of BMPs by farmers must be coordinated with concurrent establishment of farmer associations which act as focal points for industry and government to facilitate industry-wide impacts. At a market chain level, BMPs have the potential:

- To encourage farmer associations to form into functional business units with economies of scale for purchasing agreements with third-party suppliers of good and services,

selling agreements with processors and other buyers, and market development and marketing strategies with buyers and consumers in general

- To harmonise the supply-demand and associated price dynamic between farmers and processors as both parties enter into appropriate agreements underpinned by BMP-based production systems
- To facilitate orderly transition into compliance with certification-based standards and traceability systems consistent with the farmer's own needs and priorities, and ultimately
- To facilitate longer-term development towards a value chain approach to building the Vietnamese catfish brand internationally based on innovation, continuous improvement and excellence in safe, high quality and affordable seafood production, and where the creation of 'through chain' value is equitably and appropriately shared by all players.

Successful outcomes for development and implementation of BMPs at industry-wide scale extend beyond the documentation and communication of relevant SOPs. Compliance with BMP-based SOPs in itself does not guarantee practice change in farmers. If continuous improvement and innovation in farming practices are considered necessary imperatives for small-scale farmers to survive and prosper into the future, then a more comprehensive 'systems' approach to BMP adoption and implementation is required in the medium to longer term. Such a systems approach needs to factor in the requirement for new business models, monitoring of BMP performance and evaluation of impacts, together with an ongoing BMP review process to capture and implement learnings and new technologies, and to address new and emerging risks and opportunities.

Consistent with these considerations, a new, '*BMP System*' conceptual framework is proposed to facilitate effective:

- Communication of BMPs to industry stakeholders (what, why, where, how etc.....)
- adoption and implementation of BMPs by farmers (extension, training and technical support etc), and
- Monitoring and evaluation of BMPs by farmers, government and/or industry stakeholders (including for compliance, performance management, impact assessment etc).

With further development, this framework will also provide preliminary guidelines on processes for formation of clusters and associations, as well as suitable business models for 'commercialisation' of the clusters/associations into functional business enterprises consistent with the 'value chain' approach mentioned previously.

The adoption of the proposed *BMP system* conceptual framework by industry and government, and the formation of farmer associations which operate within the market place as functional business clusters, will facilitate a more strategic approach to industry development going forward. Having said that, the catfish industry has an urgent need for an agreed strategy which encompasses BMP adoption and implementation by farmers and the adoption of a cluster-based,

agribusiness value chain approach to sustain future development. Such value chains will need to be market-driven, internationally competitive, adaptable to change and meet community and consumer expectations.

Industry trends anecdotally at least suggest that influence of the large scale farmers and associated processors in the operational structure and economic performance of the catfish market chain is increasing, and that conversely, the influence of small-scale farmers is declining.

Nonetheless, small-scale farmers are expected to have a significant role to play in ensuring the long-term sustainability of the industry going forward, on the assumption that there is widespread and effective adoption of BMPs. It is further assumed that such BMP adoption by small-scale farmers needs to be cluster (or farmer association) based, along the lines of the successful NACSA shrimp farming BMP experience in the Andhra Pradesh region of India. Such an arrangement will provide practical, cost-effective means of adoption and implementation in the absence of adequate resources for farmers operating individually. The cluster-based approach also provides the potential for individual farmers to establish commercial cooperative or joint venture partnership type agribusiness units with adequate critical mass and capability to participate cost-effectively in existing catfish market chains.

In the longer term, the industry requires a strategic development plan to enable the existing market chains to evolve into more functional value chains in the future. These value chains need to be designed to meet the increased market/consumer expectations on food safety, credence characteristics and associated standards-based certification and traceability systems.

In summary, three key steps define the way forward for catfish farming in the Mekong Delta, and specifically for the role of BMPs:

- Pathway to adoption of BMPs
- Pathway to formation of clusters/ Associations
- Industry development strategy

1 Pathway to adoption of BMPs

- Finalise the BMPs (version 3.0) and associated documentation, including BMP handbooks and data records booklets (hereafter referred to as the ‘BMP package’) with representative industry stakeholders at all levels (farmers, processors and policy makers) at the national BMP workshop in November, 2010 (this document)
- Disseminate the information arising from the BMP demonstration trials to demonstrate the impacts of adoption of BMPs to other stakeholders, such as information related to:
 - disease occurrences,
 - productivity,
 - cost of production,
 - economic viability,
 - market price obtained.
- Initiate an industry-wide *BMP systems* approach to BMP adoption and implementation, with emphasis on introduction of:
 - Dissemination of the *BMP package* to all farmers, via both hard copy and/or on-line downloads (from NACA website)
 - A structured BMP training and extension package targeting farmers with emphasis on compliance, innovation and continuous improvement
 - An ongoing BMP monitoring and evaluation process targeting farmers, processors and selected consumers
 - A BMP communication and public relations strategy targeting both local communities at one level and international consumers at the other end
 - Establishment of a joint stakeholder BMP coordinating body

2 Pathway to the formation of clusters/ Associations

Throughout this document it has been stressed that BMPs will be most effective when adopted and operated through a cluster/ associations system approach. Evidence is cited from other farming systems in other countries that such an approach is advantageous to all stakeholders, and brings about better harmony and well being to the community as well. It was shown that this approach has advantages in meeting food quality and safety requirements, and also facilitates clusters/associations to obtain certification as a unit rather than individual farmers having to pay more and achieve the same objective.

As such the current stakeholder meetings/ consultations will need to make the following decisions through a consensus:

- Do the tra catfish farmers agree that a cluster/ association-based approach to industry-wide BMP adoption and implementation is required to sustain the industry and meet the modern day demands of markets?
- What should be the nature of such clusters/ associations?
 - Should each cluster/ association be restricted to a District/ Sub District/ or a defined number of farms along a pre-determined length of the river
 - How would you make the cluster/ association” functional?
 - Elect by consensus a Chair, Secretary and Treasurer, and five to six Committee Members
 - Prepare guidelines for the conducting the day-to-day affairs of the “Cluster/ Association”
 - Proceed to obtain registration with the appropriate governmental body

It is further suggested that farmer clusters/associations:

- Develop and adopt a new business model and associated administrative plan to act as a formal, legally binding business entity on behalf of farmer participants in the establishment of new market chain relationships with processors and other buyers.
- Such a business model also needs to recognise the role of BMPs as a fundamental business criterion for clusters/associations to participate effectively in the catfish market chain.

3 Industry Development Strategy

- To ensure that the catfish farming sector in Vietnam grows and developments strategically, in a sustainable manner and with an emphasis on adopting and implementing the proposed BMP systems approach, a formal industry development strategy needs to be developed and implemented as a priority. More specifically, the existing catfish market chain inevitably needs to evolve into a more functional value chain, in which there is more effective, efficient through chain delivery of quality assured product into the market place to meet consumers needs and expectations, but in a way that is more equitable to all chain participants and which supports the critical role of smallholders.

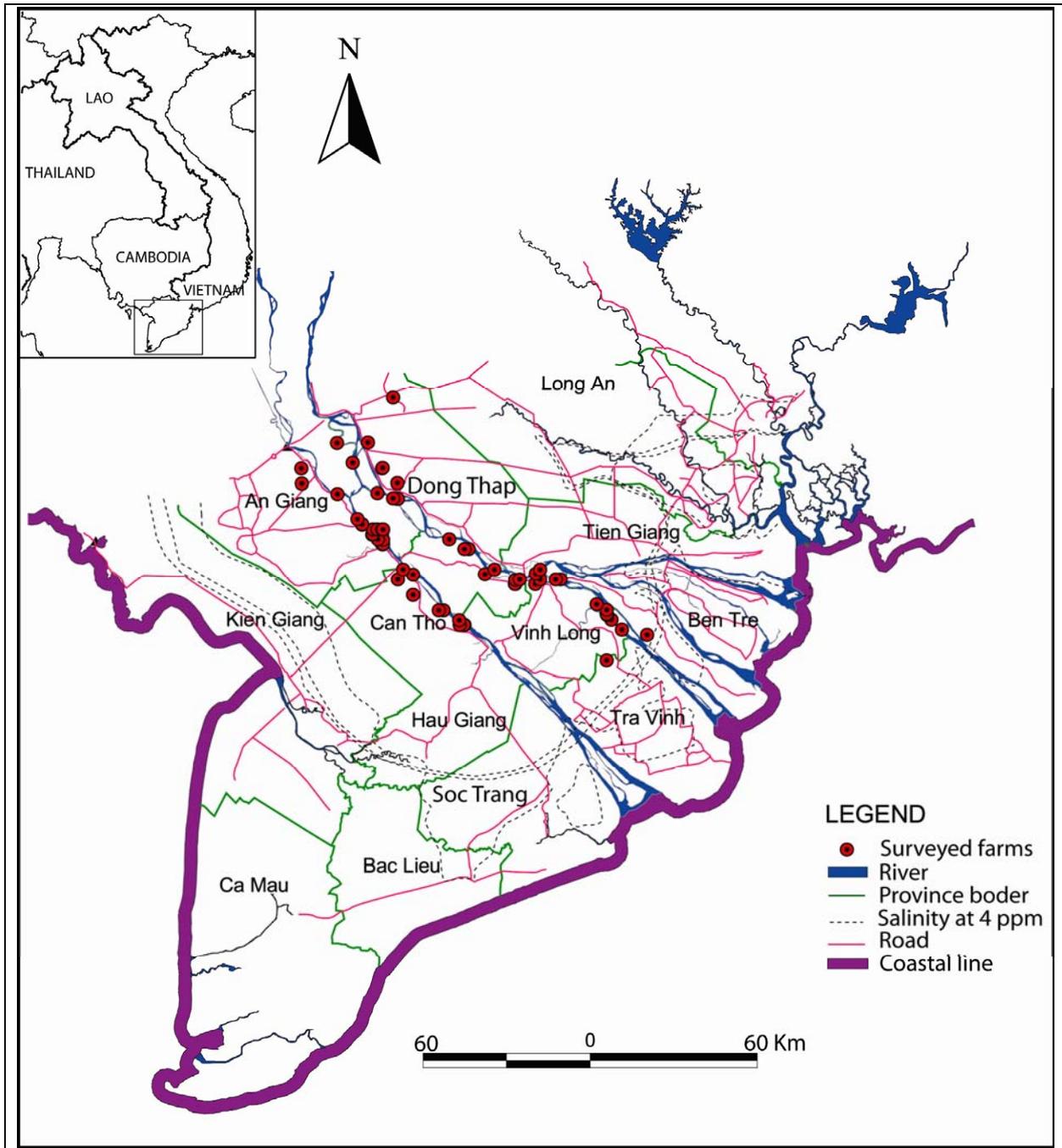
The proposed value chain approach requires:

- more complete, timely and symmetrical sharing of information relating to market demand and pricing
- technical, training and research, development and extension support for farmers to facilitate BMP systems adoption and implementation, and to drive technical innovation and continuous improvement
- new business relationships which recognise farmer clusters/associations as legitimate business units and potential ‘chain champions’
- appropriate governance support from central and provincial governments to ensure orderly and well managed development.

In summary, this strategy should address (but not be limited to):

- Support for industry adoption of the BMP systems approach
- Support for the formation of farmer clusters/associations where appropriate for small-scale farmers and
- The development of new catfish farming value chains highlighting the role of BMP systems and clusters/associations within the industry.

Annex 1. The area surveyed by the CARD project for describing catfish farming practices in the Mekong Delta, Vietnam



Annex 2. List of chemicals/ products used for pond bottom and water treatments (based on project survey results)

Treatments	
Pond bottom	Pond water
Anti-bacteria	Biozyme
BKC	BKA
Chlorine	BKC
CuSO ₄	Caximex
TCCA	Chlorine
Dipterex	Copper sulfate
Ensova	Damexiton
Formalin	Formalin
KMnO ₄	Iodine
NPK fertilizer	KMnO ₄
Saponin	Lime
TCA	Oxytetracycline
TCCA	Probiotics
Thiodan	Protexol
Vimidime	Salt
Virkon	Saponine
Yucca	Super charge
Zeolite	Sytado, eftalo
	TCCA
	Vikon
	Vimmekong
	Yucca
	Zeolite