Strategic alliance for sustainable aquaculture

PANGASIUS FARMING PRACTICES IN VIETNAM

A study in view of sustainability issues

A GTZ / Binca PPP program

Designed by Gregoire Poisson and collaborators

Background:

GTZ has engaged over the last years in various development projects, improving sustainability through Market Chain exercises and the introduction of organic certification schemes for catfish in An Giang.

In 2004, GTZ decided to widen the scope of their action beyond the niche market of organic products and to develop an action influencing the whole industry by initiating a strategic alliance for sustainable aquaculture.

This Alliance should bring together major German and European importers of aquaculture products, business organizations and companies in the producing countries, governmental bodies, NGO and others to jointly develop a common code for responsible aquaculture: minimum set of standards regarding quality, environmental and social issues.

A first study was conducted between November 2004 and January 2005 to assess the situation of the aquaculture sector as a whole and determine the willingness of the stakeholders to join such initiative. After a first workshop in Can Tho in the beginning of 2005, it appeared that the pangasius industry would be most interested in such an approach.

Pangasius is the main aquatic product exported by Vietnam to Europe (100 million USD in 2004). Export of this product is getting off fast (+215% in 2004) and the trend will most likely continue in the future. Pangasius is a white fish, and as such a good replacement for other industrial fishes like cod and haddock, whose sustainability and mere production is threatened by over-fishing.
Sustainability is needed as intensification is underway and will have a direct impact on the success of the industry as European buyers, still deterred by safety issues in Vietnam, will most probably buy en masse as soon as they can get some assurance on the product.
It should also be noted that the environmental and social conditions in the catfish industry are closer to a sustainable approach than in other aquaculture products (e.g, shrimps) and hence situation is less controversial, which will allow for better implementation on a large part of the Vietnamese Industry.
Finally, a code for Pangasius could be easily translated to other tropical fishes (tilapia…) as techniques and conditions of cultivation are very similar.

Therefore it was decided to conduct a study of the current farming system of Pangasius in Vietnam, with the concrete field analysis to be carried out in An Giang province, in view of future implementation of Good Aquaculture Practices. This is undertaken in order to:

- Bring a concrete and detailed understanding of the current farming system of conventional Pangasius.
- Identify problematic areas that need to be changed in order to implement a controlled “safe Pangasius” farming system.

The study will be the basis for proposing the introduction and application of a controlled farming system that meets the minimum requirements of international to local stakeholders and international buyers.

Sustainable Aquaculture of pangasius in Vietnam: An introduction

P. hypophthalmus is native to the Mekong river and delta. It has been farmed for centuries in ponds and cage systems. Commercial aquaculture production of catfish has rapidly increased in recent years and has contributed significantly to food security and economic development. It is well adapted to low oxygen water and can survive on a diet low in fishmeal. Commercial aquaculture for finfish in Viet Nam remains relatively low technology. Many operations are simple earthen ponds and use home made feeds, while others incorporate housing above the floating cages. River catfish has a strong potential to be a sustainable aquaculture species, but the current intensive practices combined with poor management raises serious concerns about future sustainability of aquaculture operations for river catfish. In particular the following dimensions of sustainable production need to be scrutinized and improved:

- Social issues: Employees have right to fair treatment. Disputes and conflicts should be avoided between different users of resources.

- Health and Safety Issues: The use of disease-control drugs and chemicals should be minimal to ensure the safety and quality of aquaculture products. Microbial sanitation should be maximal.

- Environmental impact: Genetic diversity should be conserved and negative environmental effects of aquaculture minimized should be minimized. In addition, care should be taken to monitor and minimize the types of feed and fertilizer used in farming fish, and to reduce waste discharges. In particular, Fish feed should come from renewable sources.

Keeping these diverse dimensions of sustainability in mind, the present study gives an overview of the current status of Pangasius production and of the actual practices along the production line.

I - Status of pangasius aquaculture in Vietnam

1.1 Basic biology of Pangasianodon hypophthalmus

Family: Pangasiidae (Shark catfishes)
English: Sutchi River Catfish
Vietnamese: Ca tra song
World Distribution: Mekong, and Chao Phraya System, Thailand.
Mekong Distribution: occurs throughout the lower Mekong Basin, possibly extending into China. Normally found in large rivers (Rainboth 1996), but can live in both standing and running water.
Feeding: omnivorous – feeds mainly on crustaceans, fish, fruits, debris and forest vegetation.
Size: up to 150 cm.

There are 28 species in the Pangasiidae family, divided into four genera, with the majority of species in the Pangasius genera. The species are found primarily in freshwater to countries surrounding the Indian Ocean basin, with the largest concentration of diversity in southeast Asia (Roberts and Vidthayanon 1991; Gustiano 2003). In Vietnam, two species are predominant in aquaculture activities: *P. bocourti* and *P. hypophthalmus.* Both are native to Cambodia, Laos, Thailand, Vietnam (www.fishbase.org), and *P. hypopthalmus* has been introduced to freshwater systems for aquaculture throughout the region (China, Philippines, Taiwan, Indonesia, Malaysia, Guam, Bangladesh and India). There is no evidence of self sustaining populations or negative ecological impacts, thus far (FIGIS http://www.fao.org/figis/).

Knowledge of biology and ecology of these species in wild is scarce. Both species are omnivorous, feeding primarily on plant matter, fruits and some mollusks, with P. bocourti consuming more fish and crustaceans than P. hypophthalmus.

1.1.1 Population structure

At least two distinct populations are thought to occur. An upper Mekong population extends approximately from the mouth of the Loei River and upstream toward the border with Myanmar/ China. A lower Mekong population is larger, and supports important fisheries throughout its distribution range. It extends from the Mekong delta in Viet Nam, into the Tonle Sap / Great Lake system and as far upstream as the Khone Falls. There may also be a small population in the middle Mekong with a distribution range from below the Khone Falls and upstream to the confluences of some of the major tributaries such as the Mun River, Xe Bang Fai River and Songkhram River. This population may partly overlap with the lower migration, both spatially and genetically. Finally, there may be a distinct population, partially overlapping with the downstream population. It extends into the Sesan tributary system, including the Sesan, Srepok and Sekong rivers, and has been reported as far upstream in the Sekong River as Ban La Vi in Lao PDR.

1.1.2 Critical Habitats

Spawning habitats: Pangasius hypophthalmus spawns in the Mekong mainstream at the beginning of the flood season. The sticky eggs are deposited on root systems of the rheophilic tree species, *Gimenila asiatica* (Touch, 2000). The lower population spawns along the stretch from Kratie to Stung Treng in Northern Cambodia. The spawning grounds of the other populations are not known.
Feeding habitats: juveniles and sub-adults of *Pangasianodon hypophthalmus* feed in floodplain habitats.
The main feeding habitat for the lower population of the species, and possibly also the Sesan population, is the extensive floodplains in the Tonle Sap / Great lake system, Southern Cambodia and the Mekong delta in Viet Nam. The feeding habitats of the upper population are mainly associated with floodplains of major tributaries, such as the Songkhram River1. The feeding grounds of the early juvenile stages of this population may be less dependent on floodplain habitats.
Refuge habitats: during the dry season, *Pangasianodon hypophthalmus* lives in deep pool habitats in the Mekong River. The lower population spends the dry season in deep pools along the stretch from Kratie to Stung Treng in Northern Cambodia, whereas the upper population is concentrated along the stretch from the mouth of the Loei River to Luang Prabang.
Hypophtalmus is able to breath air through the swim bladder which allows the fish to stand in water with low level of dissolved oxygen.

1.1.3 Life Cycle

Sexual maturity in captivity occurs at around 3 years. Females produce about 100,000 eggs/kg body weight and spawn up to four times per year. After spawning, the early larval stage drifts downstream with the water current and eventually enters its rearing and feeding habitats on the floodplains.
At the onset of the dry season in October, the falling water levels trigger fish to move out of floodplain areas and into main river channels. Eventually, they end up in the Mekong River, where they start upstream migrations towards dry season refuge habitats. The movements are also under lunar influence, since they mainly occur just before, and during, the full moon period. The movements continue until February, but peak in November- December1.
The next monsoon season (May-June) triggers mature members of the species to undertake upstream spawning migrations. Individuals, which are not yet mature, migrate back downstream towards floodplain habitats (lower population).
In general, the fish from the Mekong delta are below 50 cm, with the majority being below 30 cm.
Larvae of the lower population drift downstream from spawning sites between Kratie and the Khone Falls at the beginning of the flood season4. When they reach southern Cambodia and Viet Nam, they are swept into floodplain areas. The reversal of the Tonle Sap flow at this time ensures that the larvae are also able to enter floodplains associated with this system, including the Great Lake.

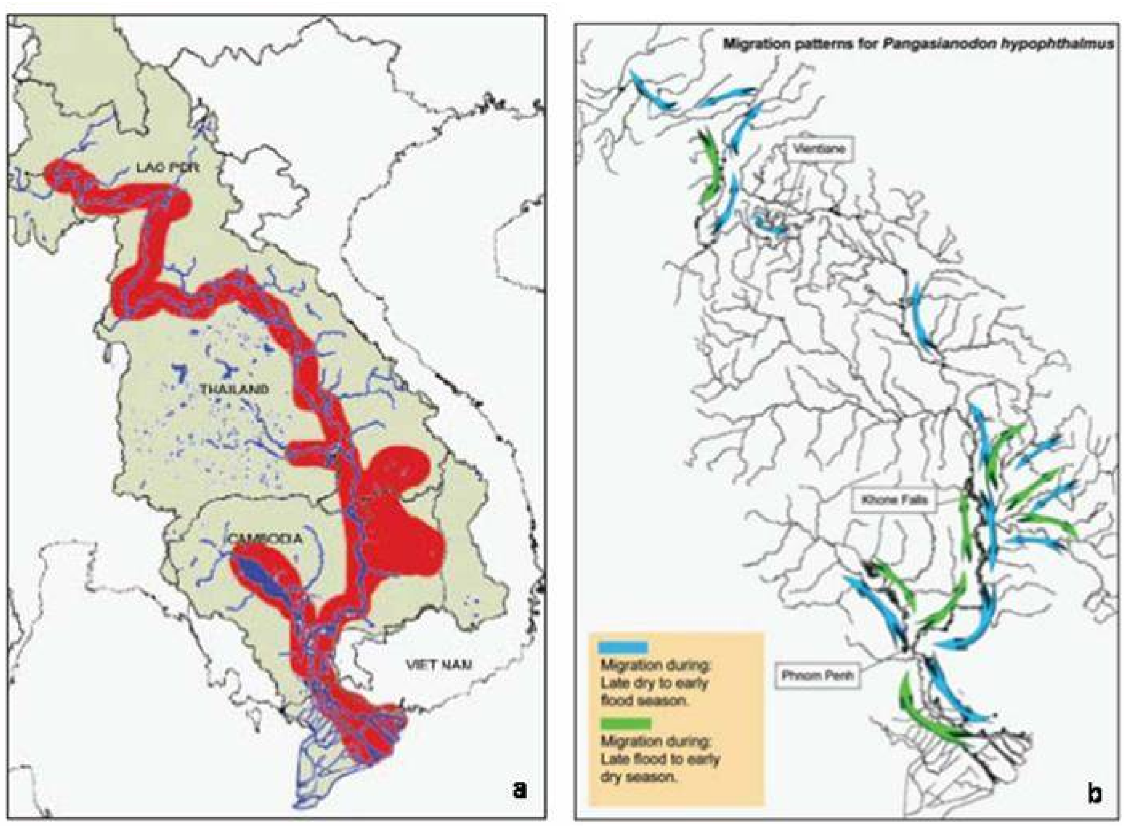
1.1.4 Fisheries

Pangasianodon hypophthalmus is an important aquaculture species. Until recently, the basis for its use in aquaculture in the Mekong delta in Viet Nam was the capture of larvae from the Mekong and Bassac rivers.

For instance, in An Giang and Dong Thap provinces of Viet Nam, large numbers of larvae were caught every year in June-July during their downstream drift from upstream spawning sites in Cambodia. Until recently, large numbers were also caught in Southern Cambodia.

Throughout its lower range, *Pangasianodon hypophthalmus* is an important species in fisheries. It is caught in large amounts in the Tonle Sap and Great Lake fisheries, for instance in the arrow-shaped trap fishery. At the Khone Falls, it is caught during its migration over the falls during the period from May to July, although less consistently compared to other pangasiids.

It is also caught sporadically in the middle and upper sections of the Mekong, particularly in the early monsoon period from May to July.



(a) Range of *P. hypophtlamus*. (b) Migration routes of *P. hypophtalmus*. from Poulsen et al. 2002

1.1.5 Wild larvae commercial fishery

Commercial fisheries exist for *P. hypophthalmus* with no effective regulation. For both species the, now illegal, fishery for larvae are still an important source of fishing mortality, although declining drastically. Because Viet Nam seems to be a sink, the fisheries supplying Viet Nam with fry are concentrated in Cambodia, although there are small fisheries in both the Mekong and Bassac Rivers in two provinces of Viet Nam. This fishery has been banned in Cambodia since 1994, and in Viet Nam since March 2000.

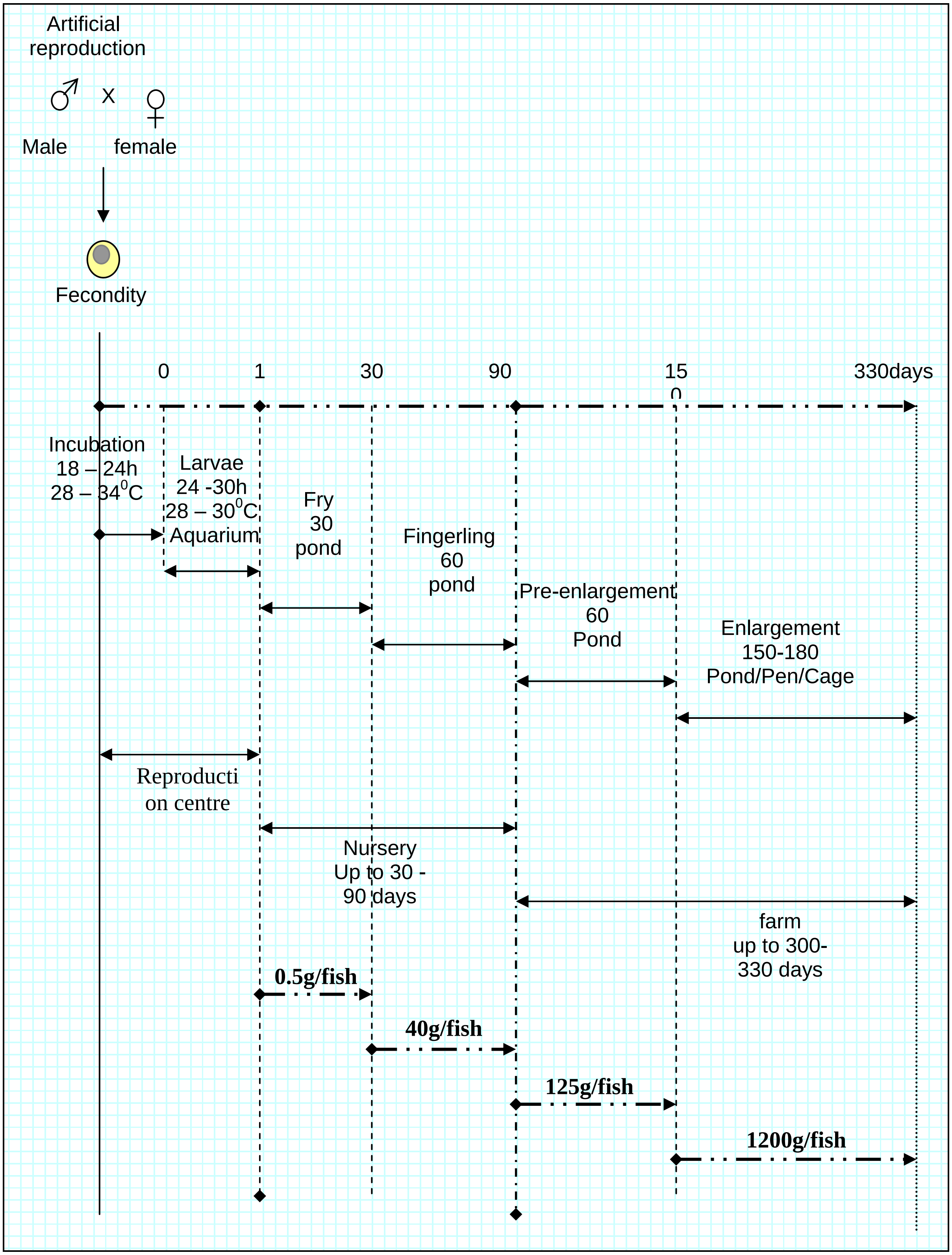
The first artificial propagation or Pangasius catfish occurred in Thailand in 1959 and has since expanded throughout southeast Asia. In Vietnam, production of fry by artificial propagation was developed between 1992 and 1996 (Cacot). In 1999, more than 270 million fry and fingerlings were produced by a number of state and private hatcheries (Van Zalinge et al. 2002).

However, in both countries, the fishery continues to a small degree. There is a general thought that wild caught fry are better quality than farmed fry (Trong et al. 2002).

1.2 Aquaculture Systems

Aquaculture has a long history in the Lower Mekong Delta (Lazard and Cacot 1997). There are more than 30 fish and prawn species cultured in the Lower Mekong Basin comprised of both introduced and native species (Phillips 2002). Methods of culture vary widely from simple subsistence ponds to large, industrialized shrimp ponds. Commercial production for Pangasisus catfish occurs either in earthen ponds or cages and pens in natural water bodies.

Pangasius Hypophtalmus is the top fin-fish produced in the Mekong Delta-region and replaced Bocourti as favourite cultured specie due to the fact that it is less hearty and grows slower and is more expensive to produce. The fecundity of Bocourti is also up to 10 times lower than that of Pangasius Hypophtalmus and Bocourti has a much lower tolerance for poor water quality than tra. As well as a lower production cost, tra also had a higher dress out weight than basa, with 3.1 and 3.7–3.8 kg fish (respectively) required to produce 1 kg fillet. Production *P. hypophthalmus* can be unpredictable, mostly due to the lack of control of the quality and quantity of farm-made feeds. Bocourti was, at one time, the primary fish for export into Asian markets, as hypophthalmus was thought to be dirty and of poor quality – considered as a latrine fish due to the direct positioning of latrines over the rearing ponds. Due to the ease of production, hypophthalmus production was cleaned up and exporting has picked up. True bocourti is still preferred locally, and will sell for one third more than hypophthalmus.



Life cycle of Pangasius hypophthalmus

1.2.1 Source of seed stock

Wild seeds

Seed supply has traditionally been dependent on collection of wild Pangasius seed and fry from rivers (Cacot et al. 2003; Edwards et al. 2004). Most of the spawning grounds for *P. hypophthalmus* are located within the borders of Cambodia (Poulsen et al. 2004). The wild capture fishery is often unable to identify larvae down to species, even though tra larvae are targeted, and some fish farmers have reported a mixture of Pangasius species in their ponds. In the wild fishery, non-Pangasius species are thrown back or used as fish feed (Bun 1999; Van Zalinge et al. 2002). An estimated 5-10 kg of other fish species were killed for each kilogram of river catfish fry caught (Phuong 1998). By-catch of non-target larvae is much higher in Viet Nam than Cambodia, most likely due to the lower numbers of larvae within Viet Nam's waters. Furthermore, the average size of the fry in Viet Nam is larger than in Cambodia (Van Zalinge et al. 2002).

The fishery for fry was outlawed in 1994 (Edwards (2004) reports collection occurring before 1998) in Cambodia and 2000 in Viet Nam, but continues illegally, still supplying larvae to aquaculture (Bun 1999; Van Zalinge et al. 2002). It is unclear the extent to which this practice still is in used, however the increase in hatchery production and increased enforcement indicates that wild capture is declining, including a 1000 fold decrease in wild caught fry in the An Giang province (Van Zalinge et al. 2002). The number of wild caught fry has dropped to almost zero, with hatchery fry dominating the supply.

Artificial breeding

Artificial propagation of river catfish was first achieved in Thailand in 1959 (Boonbrahm 1959, cited by Cacot 1999). Since then it has been done in Indonesia (Hardjamulia *et al.* 1981; cited by Cacot 19 99) and in Malaysia (Thalathiah *et al.* 1983; cited by Cacot 1999).

Since 1978, research on artificial propagation of river catfish in Viet Nam has been undertaken by various institutions. These include the Fisheries Faculty, University of Agriculture No. 4, Thu Duc, Ho Chi Minh City, in cooperation with Long Dinh Agriculture Vocational School, Tien Giang province. The first fry were produced in 1979 and greater quantities of fry and fingerlings were produced over time. The Research Institute for Aquaculture No.2 (RIA 2) and Can Tho University, both began induced spawning trials with river catfish in 1981. The successful development of artificial propagation techniques for river catfish was finalized thanks to the efforts of Legendre and Cacot around 1996.

The development of the technique to remove ovocytes by intra-ovarian canulation and diameter measurement using a binocular microscope, in order to assess readiness of females for spawning, as well as hormonal treatment was vital to successful induced spawning of Pangasiids, and especially of *P. hypophthalmus* (Cacot 1999).

There are many small scale nursery hatcheries in Vietnam (< 1ha in area) that now provide seed supply. These produce enough for the local market and for export to Cambodia. (Edwards et al. 2004). In 1999, more than 270 million fry and fingerlings were produced by a number of state and private hatcheries (Van Zalinge et al. 2002).

Estimated numbers of P. hypophthalmus fry caught in the dai fishery in Viet Nam, An Giang province from Van Zalinge et al .

Year	Number of fry caught	Hatchery fry produdtion	References
1977	200 –800 million	-	Khanh, 1996
1994	62 million	-	Tung *et al.* 2001b
1995	60 million	-	"
1996	56 million	-	"
1997	48 million	6.8 million	"
1998	36 million	25.6 million	"
1999	27 million	90.0 million	"
2000	0.4 million	99.7 million	"

***P. hypophthalmus* seed production in Dong Thap province, 1998 -2000 from Trong 2002**

Year	Number of producers	Broodstock		Fry (million)	Fingerlings (million)
		Number	Tonnes	Number	Number
1998	1	378	2.0	6	2.2
1999	17	3,000	12.0	350	150.0
2000	50	20,500	102.5	750	250.0

Although Chau Thanh was the first (1997-98) major induced spawning area for *P. hypophthalmus* in
Dong Thap province, spawning has since expanded rapidly. It supplies *P. hypophthalmus* seed for intensive cage culture systems. Increasing numbers of hatcheries and nurseries supplying *Pangasiid* seed led to over-supply in 2000. The seed production network can now guarantee sufficient hatchery produced seed to meet the needs of the river catfish culture in the Mekong delta area of Viet Nam.

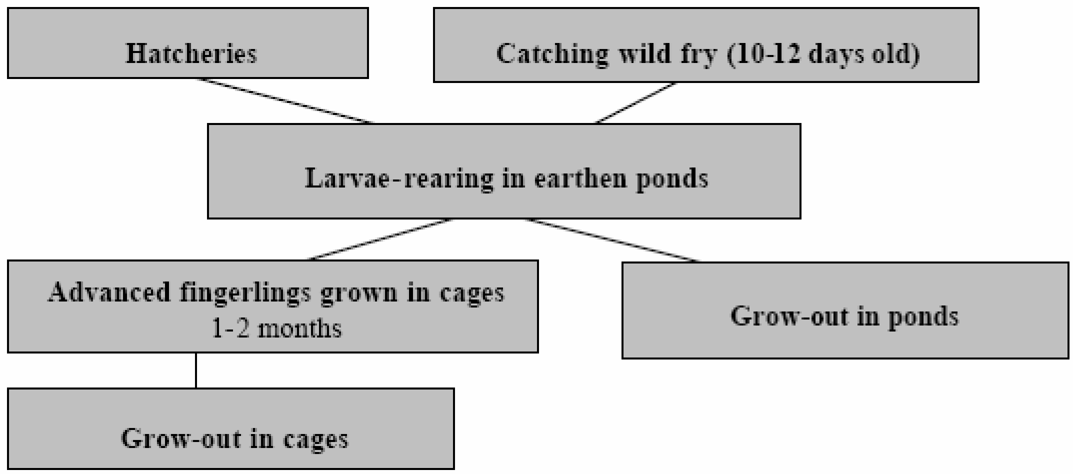
1.2.2 Nursing stage

High mortality rates were caused by cannibalism and bacterial infection (*Aeromonas hydrophila*) – problems caused by rearing hatchlings at densities which were too high. However, hatchling river catfish have mouths large enough to take live feed such as *Cladocera* (*Moina* and *Daphnia*). Nursery survival rates were significantly improved by using such feed and by releasing hatchlings into earthen ponds within 20- 24 hours of hatching. Today it is normal practice to stock hatchlings into properly-prepared earthen ponds just prior to yolk sac absorption. Thus natural feeds are immediately available when yolk sac absorption is complete. Also fry have enough space to avoid cannibalism. High variations are observed for fry survival rates – from 30 up to 60-80 percent.

1.2.3 Grow-out

Cage and pond aquaculture systems are the main production techniques. Fry are mostly hatchery raised, and kept in ponds until the grow-out stage. Fish reach marketable size at 1-1.5kg, after about 8 months of culture from fingerling size (approx. 2 months old). Manufactured feed has been making some way and is slowly is at least equivalent to home made feed in South Viet Nam in cages, ponds, and pens

.



Source: Hung and Cacot 2000.

Aquaculture timeline for both cage and pond production. From Trong (2002).

Pond culture is the predominant method for producing *P. hypophthalmus* by nearly ten-fold (by area in 1999), followed by enclosure culture, cage culture. Most farms in the Lower Mekong delta are small scale, while farms in Bassac River in the Mekong Delta, are large cage-culture farms. In 2002, it was estimated that 6,809 cages and 2,917 ha of pond were engaged in Pangasius catfish culture. This is a two-fold increase over figures for 1995

Pond Culture

There are several hundred years of pond culture tradition in the Mekong Delta, including VAC (Vietnamese acronym for garden, pond, and livestock quarters) systems followed by a second wave of more technologically advanced methods in the 20th century (Edwards et al. 2004). Pond culture tends to be lower technology, with high use of homemade feeds, dependence on natural feeds in ponds. These practices tend to give the meat a muddy flavor and yellowish color, not favored by the export market, thus cage aquaculture is the preferred method of operation for export. Despite the higher risks (from high stocking densities or poor water flow) of characteristics unfavorable to export markets (e.g. yellow flesh) pond culture still constitute 50% of total pangasiid culture (Cacot 2004).

Cage Culture

Modern cage culture uses drums as floats, wood or steel frames, nylon mesh (near Ho Chi Minh City) or inox screen for the cages placed in natural water bodies. Cage sizes in the Mekong Delta ranged from 50 to 1600 m^3 in size, with larger cages commonly including living quarters on top and the submerged cage portion below. At one time, cage culture consisted mostly of bocourti, despite hypophtalmus dominating production. In the last few years, the representation of hypophtalmus in cage culture has increased to surpass cage culture of bocourti.
However, in 2005, pangasius tends to be replaced inside the cages by other fish of higher market value such as Tilapia, Colossoma Brachypomum (Ca Chim, an imported specie close to the piranha) as the market price of hypophtalmus no longer covers the expenses of the cage rearing system.

Cage culture is an intensive culture system since fish are stocked at very high densities (100 kg/cu m) and
artificial feed is provided as the only nutrient source for fish growth. *P. hypophthalmus* is an omnivore that will feed on rice bran, broken rice and corn, cassava flour, trash fish, fish-meal and vegetables in culture systems. In Viet Nam, rice bran usually contributes two thirds of the diet during grow -out of *P. hypophthalmus.* Home-made feeds normally consist mainly of rice bran, broken rice, trash fish and vegetables. In Viet Nam, cage feeds are prepared, mixed and cooked at site, with the feed being presented as wet sticky balls.

Cage culture development is concentrated in An Giang and Dong Thap provinces in areas with suitable water currents and locally available supplies of seed and feed. Good infrastructure (roads and waterways), credit systems and processing factories are also advantageous.

Pen Culture

The pen is a fixed enclosure built on the river embankment, in which the bottom is the bed of the water body. There are several common points between the two systems of culture especially in the environmental set-up of both systems, affecting site selection and culture operations. However, there is economy of material in the pen for the bottom and river side material is saved and therefore pens are much bigger. Another reason for the cost-saving aspect of the pen compared to cages is lower food losses: Part of the feed is likely to be lost uneaten, and drifted away in the current, but the loss here would be less than in floating cages, as much of it sinks to the bottom of the river, and can be eaten by the pangasius which is a bottom feeder..

Because of these characteristics, pens are now a popular alternative to cages for Pangasius culture.

II Practices and analysis of critical points:

This section analyzes practices at each stage and emphasizes critical points observed during the field study. Some critical points are common to several stages For the sake of concision, these critical points have been treated in the grow-out chapter of the section. This reflect the fact that grow-out is decisive in the production process for the final sustainability and safety of the product.

2.1 Hatchery:

River catfish seed production has increased since artificial propagation became routine and both An Giang and Dong Thap provinces have banned the fishery for wild river catfish fry. As shown by our research, private seed producers have recently entered the river catfish seed market, and beside state and large scale private hatcheries, many small-scale hatcheries are to be found in An Giang and Dong Thap (Hong Ngu district), selling at competitive price. Today the private sector plays an important role in river catfish seed production.

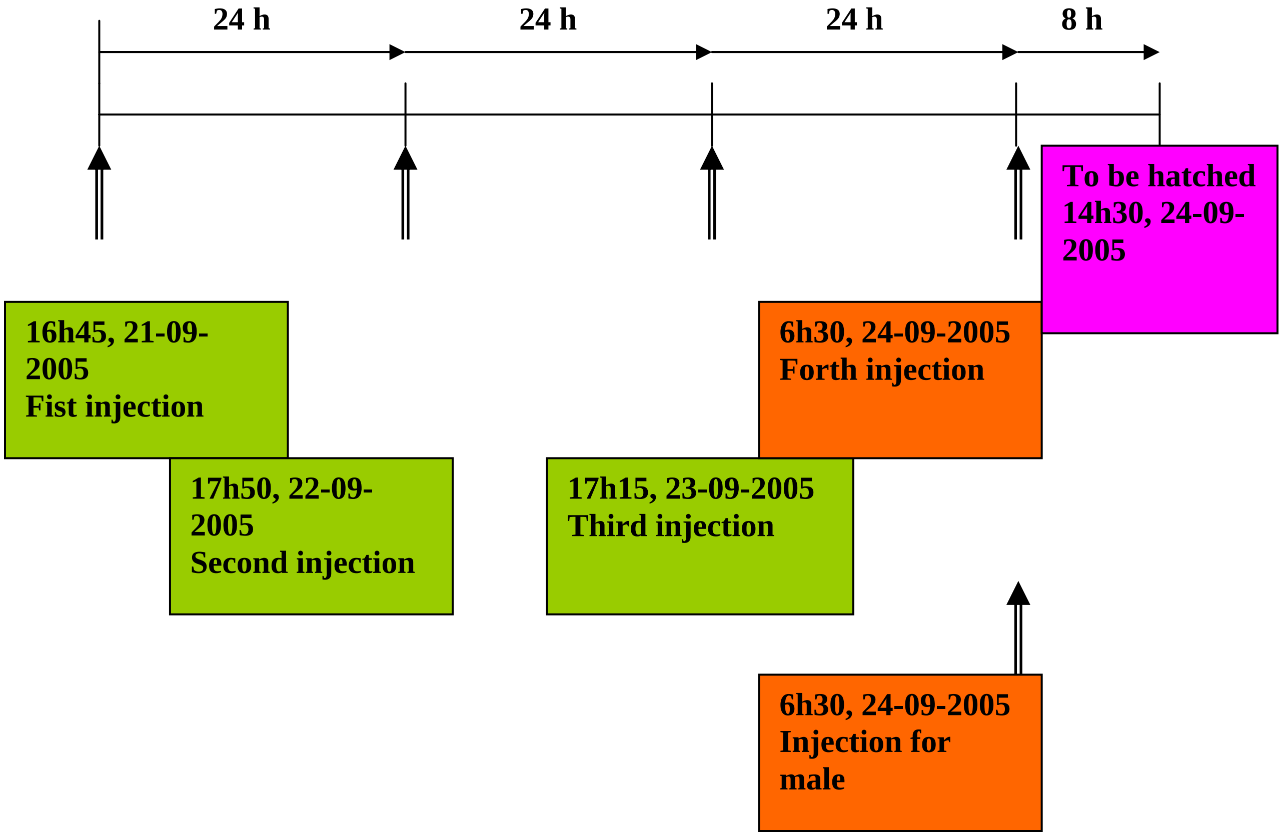
The typical hatchery includes a few earthen ponds in which breeders are stocked and the necessary material to hatch the fish – a few tanks and zugger jars. Large scale hatcheries have a dedicated building for hatching but smaller units simply use the house during hatching, and store their equipment when it is not used. Among the hatcheries visited, Ba Tho’s one was the biggest with 5000 breeders.

Parentals are selected for their size (exceptional individuals, around two kg) in the raising cages. Parental fish are chose from different sources to prevent cross breed, although they are all sourced from cage and not the wild. Sexual maturation of *P. hypophthalmus* takes more than three years, so that broodstock are raised in ponds at least two more years to become fertile and can reproduce up to 10 years. Hatcheries typically breed 2 females for one male.

They are fed with industrial (Ba Tho) or home-made (An Giang research center) feed supplemented by vitamins and nutrition liquid (VIME – squid liver oil) prior to breeding. Interestingly, small scale hatcheries reduce feeding when there is no demand for fries (at the time of our visit, Thanh’s hatchery was feeding once every 3 days).

Breeding is usually induced by HCG injections, although GnRH can also be used. The hormonal treatment (3 to 4 injections for the female, 1 for the male) induce oocyte maturation and ovulation, around 8 hours after last injection.

Time scale for injection of HCG to parental fish in the Research Centre of An Giang



The eggs collected by stripping from females are fecundated with the male's sperm and put in zugger jars with circulating water and supplied in oxygen. The water used at this stage has to be of good quality (water from the Mekong is used with sedimentation and chemical treatment) and warmed to an optimal temperature of 32 - 34^{o}C to accelerate hatching and improve the survival rate of larvae. The eggs start to hatch 20 – 30 hours later, and are then transferred to nursing tanks. The water is also sedimented and cleaned with the same chemicals - Jin Di, a chemical of unknown composition, and PAC (Poly Aluminum Chloride). Oxygen was applied throughout the whole process by air-compressors.
Post larvae develop in nursing tanks from 24 to 30 hours. At that stage they don't need to be fed as they get their energy from their yolk sacks. Finally they can be transferred to ponds. Mortality rates at this early stage can be very high and hatcheries usually treat the transporting water with oxytetracycline. During larval rearing, and especially during the 2-3 first days, antibiotics and disinfectant (such as Chloramin-T, formalin and Malachite Green!) have been proved beneficial to survival rates (Subagja 1999).

Zug jars hatching system (left) and Nursing tank at Ba Tho (right)

Sediments left at the bottom after water treatment (left) and an Air-compressor (right)

Critical points:

Impact on the environment
Source of stock for the farmed species used to be unsustainable (see previous section) and deplete the wild fish stock. However, the reproduction of Hypophtalmus has been mastered and the needs for seeds are now fully covered by hatcheries. Hence there is no impact on the stock from wild collection.

Health treatments
Hatchery have few critical points. Parentals are strong individuals and live on low inputs in terms of both feed and health treatment even though treatment is used when the fish is ill. However this has probably little influence on the final product (the larvae).

The incubation process is itself very short – a maximum of two days before larvae can be released into the ponds and principally requires clean water – no feed being necessary at this stage.

However, the high rates of mortality at this stage makes it very tempting for the farmers to use disinfectant: in all but one hatchery (An Giang Research Center) a Chinese product (Jin Gi) of unknown composition was used to “purify the water”. In itself, this practice – using an unspecified product – is unacceptable. Furthermore the green – bluish colour of the product may indicate that this product contains banned products like malachite green, methylene blue or copper sulfate. Analysis will have to be conducted for further information.
At the transportation level, the use of oxytetracyclin is also an issue.

2.2 Nursery:

Because of its characteristics – quick turnover and critical stage in the growth cycle - nursing is mostly a specialized activity. However, hatcheries usually have some nursing ponds to stock unsold larvae. Some farmers also have a smaller pond for nursery beside their grow-out ponds/pens.

At this stage the fry is small enough to be raised at very high density – 2 to 5.000.000 pieces/ha or up to 500 pc/m2, which allows for the use of small ponds: 2000 m2 to 1 ha for the biggest (Mr Ke and Ba Liep have bigger nursing area, but these ponds are also used for grow-out). Hence beside large producers like Mr Thuan, many nursery owners are small scale ones.

When using up the yolk sack, post larvae turns to fry. At this stage, the fries are transferred to pond and fed. In the first 10 days, they are fed with a mixture of soya powder, egg yolk and nutrition powder (e.g. *Nutri–Fish*, composition: milk powder, lactose, digested enzyme, amino acid, vitamin…), or fed with live feed such as moina, a phytoplankton collected in ponds by filtration of the water. Research showed that during the first 3-4 days, moina is best in terms of growth and survival rate, as the digestive tube of tract is still under development. Moina is produced routinely in hatching/nursing areas such as Hong Ngu district in Dong Thap (see Ba Lanh hatchery and nursery).

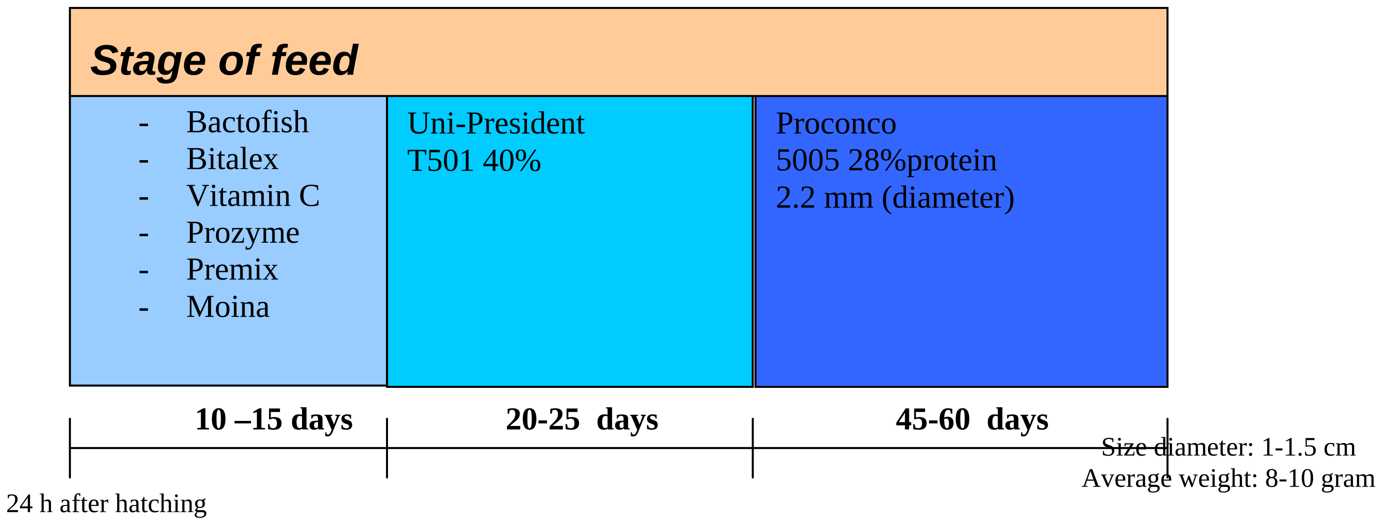
Industrial feed (*Nutri-Fish* and *Premix*) used for fries at first stage – up to 10 days

After 10 days the fish mouth is large enough to ingest extra-small pellets. The number one producer of this starter, Uni–President, has a high protein commercial feed (40% protein) which matches the need of the fish at this stage... However, there is a number of cheaper alternative feeds (Proconco, Ocialis, CP…) with a lower protein content. At this stage, home-made pellets are too large to be used.

After 30 days, the fries reach 0.5-1 g. They can be sold to grow-out farms and raised to mature stage. However, the total length of nursery raising depends mainly on the market: if the price is to low or if there is no buyer, the fish will be kept up to 2 months, 3 months in some cases, when the fish is meant to be sold in cages for instance.

In 60 days time, the weight of fingerlings tops 8 to 10 g for a body height of 1.5 cm and in 90 days time, they can reach 2.5–3cm in height and 30 to 50g in weight. At this stage, they can be sold to farmers who have enclosures or cages. The mesh size of the net used to cover the enclosures and cages are 2 cm to prevent escape.

Feed distribution for fries during 2 months



The mortality rate at this stage is very high: 60 to 80% during the first month. Hence, water treatment - such as copper sulfate - and antibiotic use are common. The nursery stage is by far the most chemical intensive.

- Fallow period: between two cycles, the pond is dried, sediment is removed and lime is applied. All farmers visited seemed to apply these sanitation measures before restocking.
- Stocking of the pond: Some farms prepare the pond's water with such treatment as Copper sulfate and Oxy tetracycline.
- Nursing: Some of the farms visited were using a long list of health treatment at high doses and without any knowledge of the used chemicals. In particular the use of chemicals which were not registered for aquaculture was observed: Human (Ba Liep, Huynh Van Ke) and livestock (Mr. Thuan) antibiotics sold at cheaper price. Observed practices and records showed that chemicals were applied almost daily, particularly in large nurseries. Only small-scale nurseries (such as Huynh Van Thien's) seemed not to use health treatments. According to them, the current selling price of fingerlings (around 80VND/pc compared to 140 the previous year) is too low for them to apply such expensive treatments. On the state nursery of Binh Thanh, the antibiotic treatments applied were much less than in private nurseries, however, the management was quite reluctant to give any information and products may have been hidden during visits. We nevertheless managed to get hold of some unlabelled chemicals for further analysis.

Fingerlings feeding

Critical points:

Nursery is probably the most critical stage in the culture process of Pangasius.

Health treatments
To lower mortality rates, farmers are intensively using chemicals, number of which are banned (copper sulfate), or not registered for aquaculture.
Contrary to the final grow-out where the processors often come and test the fish prior to buying, there is no residue control on the fish at this stage, hence the nurseries do not bear the responsibility or the final product.

Use of resources – feeding
Feed is less problematic as it comes from sustainable sources like moina or industrial feed – there is no home-made feed at this stage.
Although the percentage of protein is the highest (around 40%) at this stage, this does not represent a real threat to the sustainability as in most cases the amount of feed is kept at a low level because nurseries sell the fingerlings by the piece and not at weight.

2.3 Grow-out:

After 2 months, the fish have an average weight of 8-10g. They can be transferred to grow-out pond until they reach the mature stage and are ready for harvesting. Fish stocked in cages and enclosures are usually bigger, weighting between 50 and 120g – i.e. 3 to 5 months old – to match net's mesh size and so that they can stand the strong flow of the Mekong River. At 8-9 months, the fish will reach marketable size – 800g to 1kg, and will be sold to processing companies.

Pond Culture

Earth pond is the most common system for pangasius grow-out rearing. Ponds area can reach between 500 and 10.000 m^2, with larger farms using up to 25 (Ba Tho grow-out farm) to alternate the production. Typical depth will be around 3 to 4m, and density can reach up to 25kg per cubic meter (i.e. 100t/ha) at harvest. Density mainly depends on water exchange. In a well managed pond, a third of the water is renewed everyday. However, this type of rate is only possible for bigger farms which can afford pumping water on a daily basis. Backyard ponds (see cottage farmer) will usually change water once a week or less, which allows for lower density (4 kg/ m^3 in the visited farm) and quality of the fish meat (muddy flavor and yellowish color).

Cage Culture

Most cage visited ranged from 500 to 1000 m^3 in size. Cages commonly include living quarters, storage and feeding facilities (mixer, cooker, pelleting and distribution machines) on top of the submerged cage portion.
Cage culture is an open water system and as such allows intensive culture in which fish are stocked at very high densities (100-200 kg/ m^3) and good meat quality.
Most of the cages visited had produced Tra at one point of time, but had shifted to other, higher value fish as price of hypophtalmus had declined and no longer covered the expenses of the cage rearing system.

Pen Culture

Enclosures typically reach 5000 m^2 for 3m depth. Like cages they are intensive systems and can hold high densities of fish (up to 250kg/ m^3 , see Nguyen Ngoc Duyen). Because they are sited on embankments, storage and other facilities can be built on the bank rather than above the water (TTAgr farm). However, for practical reasons, it is not always the case.
Pen system is now developing in the surveyed area.

Feed:

During grow-out, the fish are mostly fed with home-made food to reduce costs. Most of the farms visited, be it ponds, pens or cages, used homemade feeds at least for part of the cycle. Only one pond was using exclusively industrial pellets, but the pond shareholder was also the owner of A Chau, a local feedmill. However, in a number of farms that used homemade feeds, pellets were supplemented at the beginning of crop when fishes were of small size.

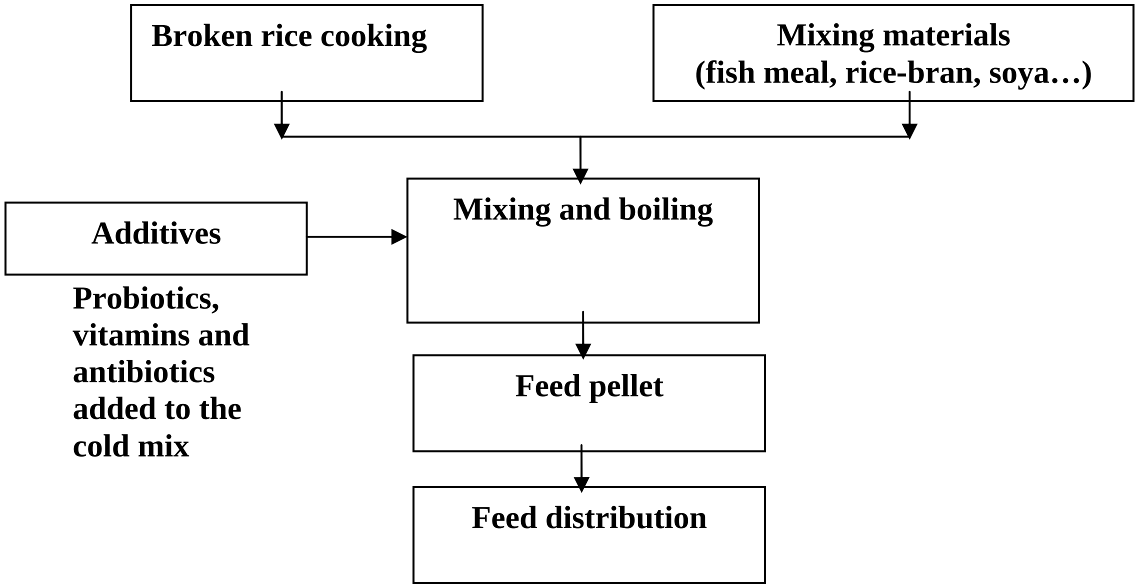
Home-made feeds composition observed during this survey were a combination of rice bran, broken rice, fish meal or trash fish and soy bean. Farmers use an integrated fisheries/aquaculture system that uses low-value fish species (trash fish), either from bycatch or targeted low-value species, taken from marine –anchovy mostly *stolephorus spp*.- or freshwater systems – Ca Linh (small cyprinids, *Cirrhinus siamensis* and *Cirrhinus lobatus)* when it is available i.e. during raining season/ sea fish from Kien Giang (the closest fishery producing 25.1% of the total trash fish in Vietnam) and Binh Thuan (the main fishery for Vietnam with 66.3% of the total production) otherwise.

Homemade feeds, the most widely used feed due to low cost, vary widely in their ingredients and nutritional value according to each farmer, market price of the components and of the Pangasius. Feed cost for Pangasius catfish culture is one important parameter affecting profit of production, as it usually occupies a high proportion (65 to 80%) of total operating costs. Therefore, selection of appropriate feeds is of primary concern to farmers.

Farmers tend to include more rice and less fish meal when pangasius price is falling. Similarly, they will include ca linh – a fresh water trash fish found in the Mekong - during the flooding season when its price is lower, and trash fish from the sea during the rest of the year. This strategy can lead to period of underfeeding when the farmer prefers to have a slower growth to wait for better prices.
Farmers can change the ingredients of homemade feed according to the needs of the fish. Feeding is divided into two stages. The first stage uses feed containing a high level of protein and minerals to help fishes gain maximum length. In the second stage (last three months), farmers usually increase the carbohydrate concentration of homemade feed for fattening fishes before harvest.

Today, the main ingredients of homemade feeds are trash fish (20 to 40%), and rice bran / broken rice (60 to 80%) depending on the size of fishes and investment capacity of farmers. Homemade feeds are also supplemented with vitamins, minerals, and vegetables. In better managed farms, part of the protein are provided by soya meal and lower the fish meal level.

Mixing, cooking and pelleting, sometimes even distribution machines are used on the spot, being on the ponds or the cages.



Home made feed procedure as observed during the survey

Home made feed. *Left :* cooking, *Middle :* mixing, *Right :* pelleting

Health treatments:

Health and growth treatments are applied throughout the cycle. Addition of vitamin, amino-acid (Methyonin, Lysin) and probiotics – enzymes are common practices on Vietnamese farms. Use of antibiotic is recurrent and largely uncontrolled. Farmers have no knowledge of diseases nor of the products they are using. When asked why and when to use a product, they give vague answers. One symptom may correspond to different treatments or a treatment to different symptoms. It appears that most of the farmers use antibiotic following the advice of treatments salespersons. Only very well managed large scale farms as TTAgr. or Mr Ngoc use veterinary advice. Hence the misuse and overdosing of antibiotics and the use of banned antibiotics: Fluoroquinolones (such as Ciprofloxacin and Enrofloxacin) are commonly used although this product's family is banned in the US… But also in Vietnam since February 2005. Furthermore, most farmers do not know the composition of the products, nor do they understand the concept of withdrawal period. In many cases, products are not in their original packaging and are sold in a transparent plastic bag which may – or may not – be hand-labeled. During visits to the health treatment retailers, retailers told our interviewer that he could sell us medicine but not disclose its content, for fear that other retailers would copy their mix.

Some premix, probiotic and antibiotics found during the survey – in their original packaging (left) and hand-labelled (right)

.

Mortality:

Mortality at this stage is limited and usually doesn't add up to more than 20%. In ponds, most of the surveyed farmers declared mortality rates under 10%, and sometimes as low as 2%, but this is probably an underestimation due to a lack of monitoring. In pens and cages, mortality rates are higher. Peaks of mortality especially occur during the flood season when the quality of the Mekong water deteriorates under the influence of agriculture effluents. Spread of disease is also more likely in open aquaculture systems.

Management, monitoring and records:

Type of management varies from one farm to another. All surveyed farms were private owned – indeed 98% of the farms in Mekong Delta are private – and run by the owner. Most of the owners have no academical background in aquaculture. Some of the bigger farms (TTAgr) hire competent technical managers but most learned through experience. Hence, most farms are poorly managed and lack basic monitoring and planning of their operation on such critical criteria as mortality and fish stock, inventory, inputs such as feed and medication or disease and pest. Very few farms actually consider these elements, let alone record them on a daily basis. On 18 grow-out farms visited, only 2 (Mr. Ngoc and Nguyen Ngoc Duyen) could present us with a good recording book of inputs.

Critical points:

Grow-out is a critical stage because of its intensive nature. If nursery use more inputs in relation to the final output, grow-out is using larger net volumes of both feed and treatments to improve yields. Furthermore, it is the last production stage before processing and consumption. The final impact on both environment and safety needs therefore to be monitored carefully.

- **Environmental impact:**
Pangasius farming has multiple impacts on natural resources. Some are the direct result of the farming activity, such as pollution and impact on the wild stock and some are indirect repercussions, such as use of marine resources or energy.

Effluents and waste:
Pollution in aquaculture is primarily linked to effluent management. At this point in time, effluents are not treated before discharge. Moreover, if this would theoretically be possible in pond systems, it will not be possible for cages and pens, which are essentially open net pens within the Mekong River Delta. Open systems like cage and pens can stand much higher densities – up to 10 times - than ponds. Hence they also produce much more waste both in terms of lost food and excreta. It should be noted than home-made feed is less stable and has worse FCRs than manufactured feed, which also leads to increased pollution.

Concern for pollution from cage effluent, deterioration of water quality and fish disease outbreaks exists. Ammonia, nitrates, and organic matter released in fecal wastes could be absorbed at fairly high levels due to high water temperatures, thus fast growth of primary consumers. The Mekong River Delta however is less at risk than reservoirs or coastal areas. A study by the university of Can Tho in the Mekong River waters showed that there was no significant change in the water composition before Chau Doc and after Can Tho, despite the presence of more than 5000 cages – most of the cage production of catfish in Vietnam. The waste is diluted in the flow of the Mekong. However, the impact could be felt soon as the intensification of farming continues.

Location Effects
Siting and locations for cages and pens in the Mekong Delta is relatively benign. Ponds, which are digged have more of an impact. However, the environment in this region is already partly degraded from non-aquaculture sources, and the area is heavily populated. In areas which are not directly adjacent to the river, ponds might divert water from other use – e.g. rice cultivation.

Sediment management is an issue in both ponds and pens. However, most of the surveyed farms use the sediment removed after each cycle to reinforce their banks – a good practice against erosion and floods. Only cages release organic waste in open water.

Waste:

Energy Use:
Most of the operation of Pangasius aquaculture are low-technology and have low energetic demand. Pelleting and pumping are the two main energy activities with high energetic use. Pumping is especially important for ponds which are not directly located on the river's bank so that gravitation cannot play a role for water exchange.

Risk of Escapes, Disease/Parasite Transfer to Wild Stocks
Escape of fish sometimes occurs during floods, if the water level reaches the height of the pond's banks. In the case of Hypophtalmus aquaculture in Vietnam, the impact of escapes is minimal, as the fish are native to the region. In addition, the early stages of artificial hatcheries means that fish produced are still ecologically and genetically similar to wild stocks since artificial selection is used minimally. That being said, as husbandry techniques improve, and hatcheries begin selecting for traits favorable to aquaculture, escapes may become a concern.

Due to the open culture system, risk of disease and parasite transfer to wild stocks would be possible. Recently, the bacteria Edwardsiella ictaluri, a disease native to North America and ictalurid catfish, was identified in farmed tra cultured in the Mekong River Delta. This is the first instance of this disease being observed in pangasiids. It remains unclear as to whether the bacteria are introduced or local but previously unknown, however transmission of pest could be an issue in the future.

Use of Marine Resources
The use of marine resources in the aquaculture systems for tra is moderate. Feed conversion in these omnivorous species is relatively high, and the inclusion of fish is moderate. The high use of homemade feed, while resulting in a worse feed conversion ratio, results in an equivalent or lower input of wild fish to farmed fish because the whole fish doesn't have to be converted to fishmeal. In the case fishmeal is used to produce home-made feed, the ratio is a bit higher. We can estimate that FCR is around 2.5-2.8 for home-made feed (high variation exist due to difference in composition) and 1.5 for manufactured feed (Hung 2002). Inclusion of fish in home-made feed will be around 30%. In manufactured feed, inclusion rates of marine products will be around 4% fishmeal and 2% fishoil or 36% fish at a processing rate of 1kg of fishmeal for 6kg of fish and 20% (1 for 10 in fish oil). Hence the amount of wild fish needed to produce one kg of farmed fish will be 0.79 for home-made feed and 0.84 for manufactured feed, which is a relatively low amount.
It has to be noted that FCR varies according to systems of culture. Ponds and pens incur lower food losses than cages. Part of the feed is likely to be lost uneaten, and sinks to the bottom of the river, but the loss in pens would be less than in floating cages, as much of it can be eaten by the pangasius which is a bottom feeder. This is part of the reason for the higher profitability of ponds and pens.

Sustainability of the trash fishery
However, some concerns exist about the source of the trash fish in home-made feed. Primarily composed of by-catch, trash fish used as feed comes from the nearshore and riverine fisheries, which are considered fully exploited. Uses for trash fish includes direct human uses, mainly as fish sauce, livestock feed, and aquaculture feed. Competition for the use, and overexploitation

is reflected by raising prices. In the future, it is likely that only high value aquaculture use like grouper or shrimp will be able to afford trash fish.
Imported manufactured feeds source from a number of fisheries, but mainly from Peru, which is considered a fairly sustainable fishery.

- **Health and Safety Issues:**

Product contamination containment and hygiene / microbial sanitation, as well as use of disease-control drugs and chemicals must ensure the safety and quality of aquaculture products.

Product contamination and hygiene:

Chemical contamination
In the Mekong delta, the water is polluted already by activities other than aquaculture activities and even though the carrying capacity of the river is high, factories and processors discharging effluents into the river, as well as agricultural activities contributes significantly to the degradation of water quality. Peaks of mortality are regularly observed during flood season probably because of run-offs from agriculture and urban waste water. This affects mostly cages and enclosures which are directly impacted by these sudden changes of water quality. To avoid such hazards, a GAP cages and pens should be sited in a suitable area, far enough from urban centers and intensive agricultural activities. One of the farms visited in My Hoa Hung was situated next to an oil factory processing catfish fat – which represent as much a risk in terms of chemical than biological contamination. But no monitoring had been done on the quality of water.
Other sources of chemical pollution are farm originated, empty feed bags, paper, cardboard, plastic, human waste, oil, fuel, wastewater, machines and disinfectant rinsing.
Disposal of litter and especially empty antibiotic and disinfectant containers is deficient, and garbage has been repeatedly noticed during visits on the farms and their surroundings. Machines are not properly maintained and oil leakage is a rule on all farms. This is a major concern in farms which locates machines above the fish holding area. In this respect, cages, with their home-made feed equipment and living quarters – and sewage from kitchen and workers -on top of the water are especially problematical.

Biological / Microbial contamination
The farm is also the source of biological contamination such as diseased and dead fish. In the muddy water of the Mekong, most of the dead fish can not be seen and removed. However, a daily removal of the dead fish through diving should be conducted in order to avoid the spread of diseases. All the farms surveyed remove dead fish floating on the surface, but very few of them were actually diving to remove the fish.
Disposal of dead fish should be done safely to avoid contamination, i.e. not released in open waters. Preferably the fish should be incinerated and/or buried but the dead fish are actually… eaten by the staff, when decay is not too advanced.
Feed can also be a vector of disease: contrary to what is practiced on the farms, uneaten feed should not be re-fed to the fish. Damp feed is a receptacle for mould and disease.
For those using trash fish in their feed mix, the quality of trash fish is a major concern. Even though it has a high protein content and quality when caught, the quality declines rapidly as only ice or chilled water is used to preserve it on board ship. Storage of trash fish is a problem, especially in offshore fisheries, as boats may be at sea from 1–4 weeks. It is then trans-boarded and transported from Kien Giang to the farms in smaller boats without any icing. On the farm of

Mr Ba Liep, the boat was delivering 3 tons of fish, which would stay during 3 days under the heat. This type of trash fish has been proved to bear pathogens such as *Vibrio spp*.

Although situation is now much better than a few years ago, when tra was considered a latrine fish because latrines were usually hung above the pond to feed the fish, human wastes from toilets are still released into nature. In cages in particular, toilets are situated beside the cage and sewage water contaminate the fish holding area. This unacceptable situation has been regulated and it is now compulsory to have a sceptic tank but all the cages visited still lacked such equipment. In the case of cages, the same would be true of kitchen and laundry sewage.

Containments of pest and rodents
Farms lack pest and rodents containment. Birds, rats and domestic animals are at large on the farm area, be it around the pond or in the building – rats have been found during visits in the feed and medication storage area as well as around the mixer…

Hygiene and maintenance of the building and equipment
Disease are transmitted through poor hygiene and maintenance on the farm. Basic rules of hygiene such as hand washing are not observed. Staff and visitors who go from one farm to the other may spread diseases because of this lack of elementary precautions.
Equipments, especially those in contact with feed (machines and basket) and fish (nets) are not cleaned on a regular basis.
Feed Storage(be it manufactured or feed components) are too often exposed to humidity and contamination from therapeutic agents, oil etc…

Fish welfare
Density is often pushed at extreme limits (200kg/m3), especially in cages. This is detrimental to both the fish health and well-being and to the final quality of the product (which will ultimately contain more fat).

<u>Health treatments</u>

Fish health is primarily the result of good physical, nutritional and environmental conditions. It goes through good monitoring of the fish to assess average weight, size and stocking density, for grading and feeding purposes. Only the better managed farms have such follow-up.
For fish health, farmers mostly resort to the use of health treatments.

Chemical use
The use of probiotics, vitamins and amino-acids is common in Vietnam and this is good practice. However, use of antibiotic is recurrent and largely uncontrolled. Farmers have no knowledge of diseases nor of the products they are using. As most of them do not conduct a proper monitoring of the biomass, they can not apply the right doses for the products. Furthermore, application of drugs, antibiotics, chemical treatments and other therapeutics are not properly prescribed. From all farms visited, only two had a contracted veterinary. Farmers information comes from drug retailers. A GAP farm will need visits to take place regularly – e.g. on each product cycle and on case of major disease or mortality outbreak.
Only such competent person could provide the farm with such vital information as disease prevention strategies, major diseases known or thought to be present, treatments to be administered for regularly encountered conditions, recommended parasite controls and the requirement for feed / water medication.

Medicines banned on the international markets or which are not approved or registered for aquaculture in Vietnam (human and livestock medicine) are used. Regulations for therapeutants such as antibiotics, including their release into the environment, do exist but their implementation is difficult as proven by the common use of fluoroquinolones 8 months after their ban in Vietnam.
Except the tests performed by the buyers (mostly Malachite, Chloramphenicols and Nitrofurans), there are no regular sample tests for the use of permitted and non-permitted substances… National residue surveillance and control program (performed by NAFIQUAVED) are conducted at the level of the processing but not – or rarely – at the level of the farm. Monitoring would be necessary to react to possible maximum residue level (MRL).
Indeed, even allowed substances have MRL and withdrawal period. During the last weeks of grow-out this is an important issue for the safety of the final consumer. But the farmers seemed not to be aware of such restrictions.

Chemical Storage
Chemical storage is generally neither sound (humidity) nor secure (locked facility). They are often found on the fish holding area without containment or anti-spillage facilities, which is a direct threat to the fish.
Label instructions should be followed but more often than not, chemicals are not stored in their original packaging. Measuring equipment, e.g. plastic jugs, scales etc., are missing in many farms.

- **Social issues and management:**

Workers' welfare and safety
Welfare situation in Vietnam and in aquaculture in particular is rather good. Aquaculture in Vietnam is not associated with particular child rights abuse. Children might help on the family farm but rarely on a full-time basis. On all the farms visited no worker under 16 was noticed. The workers living quarters on the fish farm were habitable and sound, with basic services such as toilet and kitchen. Wages seem to be higher than in other sectors, however it remains to be seen if farms comply with all legal requirements, including use of contract for permanent workers.
Safety standards on the farm are quite poor. In particular, of all visited farms, only one, TTagr, had a first-aid kit – which was actually not complete. First-aid training, safety and emergency regulation were missing.

Resource access
No major disputes and conflicts seem associated with the practice of pangasius aquaculture. Farmers usually grant poor fishermen access to the surrounding of the cages and enclosure, where the abundance of feed attracts wild fish. Part of this is ca linh – the fresh water trash fish used as feed – which can sometime be sold for 15.000 VND/kg. Hence conflicts with the traditional users of the river and the embankment are avoided.

Management
Management of the farms is poor. There are no requirements for starting an aquaculture system nor siting, or discharge consent regulation, hence minimum management standard do not exist and have to be voluntarily implemented.

Training and competence of the staff is low. Even at management level, technical or academical background is lacking. This translates into poor management tools. No records of monitoring or activities are kept. For instance, only two of the visited farms had mortality records.
Hence, feed ratio and FCR can not be accurately calculated by most of the farmers, who simply feed according to experience and observed behavior of the fish. This results in waste and inefficient feeding practices. Feed input was however recorded in a few (bigger) farms, usually when the owner did not manage the farm (pointing to financial control rather than good farming practice) .
Similarly, no medicine administration records were kept in all but the same two farms. Some farmers did keep purchase records but none had chemical product inventory.

Finally, precise recordings and documentation, combined with good traceability is the only way to ensure the control of the production and gain the trust of the buyer.
Good Documentation is instrumental to good management. Operating in accordance with documented procedures and work instructions and monitoring of the farm's activities is key to cover all processes critical to the product safety, legality and quality.

2.4 Transport

Between each stage of the production, the fish has to be transported. Each manipulation of the fish is a risk to its health and welfare. Hence, this operation requires careful control to maintain the fish in the best conditions.

Transportation of larvae:
At this early stage the fish is especially vulnerable. The larvae are transported from the hatchery to the hatchery in plastic bags whether by boat or truck. Water is purified through sedimentation in tank and purified with chemicals Jin Di (Chinese product). Fish are transported whether by boat or truck in plastic bags containing 10 liters of water, 10 liters of oxygen and 50-60 000 fish. Transportation time usually does not exceed 5 hours – 3 hours during inspection, however transfer to the bags can last a few hours – 3 hours for 280 bags during the visit (transportation from Ba Lanh's hatchery) .

Transportation of fingerling
Fingerlings are more robust than fries. Transportation at this stage does not necessitate oxygenation or special preparation of water, as the fish is now used to the water of the Mekong. Fish is transferred to a well boat containing Mekong water, generally treated with oxytetracycline to prevent infections. Density during transport is low, under 1kg /m^3
At arrival, the fish is transferred into the pond in plastic basket without water but with low density (6-8kg/basket).
Time during transport is short, generally less than 3h – ½ an hour during the visit, and transfer from and to the pond only last a few seconds.

Transportation of harvested fish:
To be processed, the fish is transported in open boat. Prior to harvest, the fish is fasted for 2 days. The fish is netted and gathered then transported to the boat in bamboo baskets at a density of 80-100kg/basket, without water. This operation lasts a few seconds.
Duration of transport can be up to 15h at a transport density of 100-150 kg/m^3 (Volume of the boat is 120 m^3 and usual fish quantity is 15 tons).
For the local market, e.g. Saigon, the fish can whether be transported alive or dead, usually by truck.


Fish transportation and arrival at processing factory

Critical points:

Hygiene
In all transport operation surveyed, the whole operation was lacking basic hygiene. Transport means – be it truck or boat – are not cleaned before transportation. The same was observed of other equipments like plastic and bamboo basket. This is a vector of disease and infection for the fish. Boats are also a living unit for the workers who eat and smoke above the fish holding area. Oil leakages from secondary pumps were also noticed.

Welfare of fish
After harvest, the fish is transferred to the boat without water and transport duration between farm and processing site is sometime long at high densities. These do not contribute to the fish welfare.
At the other stage, more care is given to the fish to prevent mortality episodes.

Safety – antibiotic use
The use of antibiotic or disinfectant in larvae and fingerling transport should be investigated. Usually, preventive use of antibiotic is not considered a good practice.

2.5 Processing

Most of the processing companies in Vietnam are working under ISO 9000 and HACCP, some like Agifish being certified under BRC, one of the strictest standards for processing. The analysis and control of critical points inside the processing is covered by these standards. Our analysis of processing consequently focuses on the product prior to the entrance in the processing line itself.

The fish are brought to the factory in tanker boats at ambient temperature. Fish are then taken out of the tank by means of small nets, put into crates without water and transported by small trucks to the raw material receiving area of the processing factory. The fish is out of water in 80kg buckets during loading of the car. This operation last between 8 and 10 mn (16 to 25 baskets). It then takes one minute for the car to reach the receiving area and 1-3 more minute for the fish to be weighted. Hence total time between boat and slaughtering of the fish is 10-15 mn. The fish is then put back into water into tanks before to be killed by bleeding.

Bleeding of the fish

Critical points:

Welfare of the fish
The fish is bled alive which is not an acceptable practice. The fish must be rendered into a state of unconsciousness that persists until death has occurred, i.e. it has to be stunned or anaesthetized prior to bleeding.
Although time outside of water is quite long, the practice should be acceptable in a GAP.

Impact on the environment
All visited processors have a waste treatment facility. However, it seems that these treatment stations are adequate for the amount of waste to be treated daily. A large part of the untreated waste is still released in the river.

2.6 Feed mill

Feed industry in Vietnam is booming, although even in the Mekong Delta, feed is largely home-made. However, industrial feed is quickly gaining momentum as the farming activities are professionalizing. Some large player control most of the market but high demand induced production of 2nd rate industrial feed by small producers. This sometimes brings some concern over quality, especially in cases where fishmeal comes from offal from the same species… In the case of catfish especially. As was demonstrated by the study, local manufacturers, which sell their product at a lower price, conduct very few quality tests.
The three feedmills visited were interested by the concept of implementing a GAP.
- Viet Thang, a local feedmiller specialized in Catfish – seemed to be very far from such implementation. This feedmill produces low cost pellets and only controls regularly the humidity content of the feed. Monitoring of the supplies is not done yet. Finally, a general lack of hygiene in the mill (especially in the storage) would make it difficult to implement a GAP.
- The director of Cargill was interested but very secretive on the kind of Quality Control he was conducting. Cargill is probably to big to be involved in such approach at this stage.
- Ocialis, a small (2000t/month) fish feed producer could be a good candidate. They have a good Quality control department, and even if they are not fully ready yet, the involvement of the Quality Manager, a biologist who worked on catfish with CIRAD, could give a good impulsion to the project. The smaller size of Ocialis and its policy of targetting of a quality market, will probably make it a reliable partner.

Critical points

Microbial and chemical contamination
Few tests are done on unwanted contaminants or pesticides or toxins such as mycotoxins. They shall be monitored to serve GAP clients.

Antibiotic use
No antibiotics are added to the feed according to the feedmillers.

Sustainability of the source fishery
Part of the supply – all for Viet Thang – of the feedmills come from local fisheries, which are unsustainable.

3. Conclusions and Recommendations:

Implementation of Good Aquaculture Practices on Pangasius Farming in Vietnam

A summary of critical points and control measures

The following points should be implemented on the hatchery, nursery, and farm stage to ensure the safety and minimum environmental sustainability and social responsibility of the operation.

- **Environmental impact:**

Environmental Management needs be set-up to minimize the impact of farming on environmental resources. In particular, pollution and excess use of natural resources or energy should be avoided.
Environmental policy, including wildlife and conservation policy should be implemented and based on an environmental risk assessment taking into account the prior use of the land or site and all potential environmental impacts, such as those listed below.

Effluents and waste:

- It will not be possible to control the effluents in open systems such as cages and pens. However, this could be acceptable in the Mekong if farms can prove that they have no significant effect on the river eco-system, which seems to be the case.
In all cases, water quality shall be monitored on intake and/or outlet for oxygen, pH and carbon dioxide parameters and ammonia.
- Farm originated waste such as empty feed bags, paper, cardboard, plastic, human waste, oil, fuel, wastewater, machines and disinfectant rinsing shall be contained and properly disposed of. In particular, disposal of litter and especially empty antibiotic will have to be implemented and containment facilities for oil should be built.

Location Effects

- Pond chosen must be directly adjacent to the river, so as to not divert water from other use.
- Sediment should be removed and used to reinforce the banks of the farm – never released in the river.

Energy Use:

- Pelleting could be avoided through the systematic use of manufactured feed all along the cycle.
- To avoid extensive use of pumping, ponds should be located on the river's bank so that gravitation can play its role for water exchange. Pens and cages will of course qualify.

Risk of Escapes, Disease/Parasite Transfer to Wild Stocks

- Banks and nets should be monitored and maintained to avoid rupture. The height of the pond's banks should be higher than the highest recorded water level in the area so as to prevent escape of fish during floods.
-Spread of disease should be monitored by a veterinary.

Use of Marine Resources

The use of marine resources to produce hypophtalmus is moderate. Feed conversion in these omnivorous species is relatively high, and the inclusion of fish is moderate. However, ways to reduce inclusion of fish should be considered. Higher level of Soybean, but also of amino-acid which improve the protein use in both home-made and manufactured feed will probably be the

solution both in terms of environmental and economical sustainability, as the price of fishmeal is raising fast.
Higher FCR should be sought, and ponds and pens, which incur lower food losses than cages, should be preferred. As the cost of feed represent most of the production cost of pangasius, higher FCR will also impact on the farm economics.

Sustainability of the trash fishery
- No trash fish from the nearshore and riverine fisheries, which are considered fully exploited should be used in the fish feed. Sustainable fisheries should be selected by the feed mills.

- **Health and Safety Issues:**

The use of disease-control drugs and chemicals, as well as product contamination containment hygiene / microbial sanitation must ensure the safety and quality of aquaculture products.

Product contamination and hygiene:

Chemical contamination
Site selection should consider run-offs from agriculture and urban waste water. To avoid such hazards, a GAP cages and pens should be sited in a suitable area, far enough from urban centers and intensive agricultural activities.

Chemical pollution of the fish holding area should be avoided – through an efficient waste disposal system – see *effluents and waste* above.
Machines should be properly maintained and have anti-leakage facilities.
In general, farms should not locate machines above the fish holding area. Pelleting / Distribution systems should not be used and the use of manufactured feed, which avoid use of machines will be preferred.

Biological / Microbial contamination
- Daily removal of the dead fish – preferably by divers should be conducted in order to avoid the spread of diseases. Preferably dead fish should then be incinerated and/or buried.
- Damp uneaten feed should not be re-fed to the fish.
- The direct use of trash fish in the feed should be avoided to counter the spread of pathogens such as *Vibrio spp*.
- Sewage from toilets, kitchen and laundry should not contaminate the water. All farms should have sceptic tanks – a legal requirements for aquaculture farms in Vietnam.

Containments of pest and rodents
- Domestic animals should be remained in specific parts of the farm – and not have access to storages, equipment and fish holding areas.
- Rats should be contained outside of fish holding area, equipment and storages. Use of traps is recommended.

Hygiene and maintenance of the building and equipment
- Basic rules of hygiene shall be implemented.
- Cleaning procedure and schedule will have to be established for premises and equipments, especially those in contact with feed (machines and basket) and fish (nets).

- Feed Storage in particular should be clean and sound – feed should not exposed to humidity and contamination from therapeutic agents, oil etc…

Health treatments

Fish health should be the consequence of good general conditions of the fish than the use of chemical treatments. Better monitoring of the fish will be needed to follow up on this issue.

Chemical use

- The use of probiotics, vitamins and amino-acids should be encouraged.
- Use of antibiotic should be strictly controlled. GAP farms should have a contracted veterinary to visit them regularly – e.g. on each product cycle - and on case of major disease or mortality outbreak.

They will provide a competent advice on disease prevention strategies, major diseases present, treatments to be administered for regularly encountered conditions, recommended parasite controls and the requirement for feed / water medication. Farmers should follow strictly the advice of the veterinary or consult the veterinary before taking any action outside the given instructions.

- Products used should be allowed by both National and International markets regulation – i.e. not include banned substances. Alternative should be given to banned substances used (malachite, copper sulfate, ciprofloxacine and other fluoroquinolones).
- Regular sample tests should be performed for the use of permitted and non-permitted substances and the respect of maximum residue level (MRL) for the used substances.
- Withdrawal period should be respected and the product should not be sold during this period.
- Doses for the treatment should respect product label or veterinary instructions; hence the farmer should keep accurate monitoring of the mortality and average weight in order to assess bio-mass at any time.
- Recording of the treatment application – including Date of administration; batch of fish treated; bio-mass of fish treated; quantity of medicine used - should be kept for Control and history of the treatments purposes.

Chemical Storage

- Chemical storage should be sound (humidity),secure (locked facility) and have containment and anti-spillage facilities.
- No chemicals should be stored outside of their original packaging.
- Measuring equipment, e.g. plastic jugs, scales etc., should be used to adequately measure the amount of chemical administered.
- Inventory records should be kept.

Fish welfare

Density should be kept at an acceptable level.

- **Social/Legal issues and management:**

Workers' welfare and safety
Workers are key to the efficient operation of the farm. All staff should understand and are competent to perform their duties; They should also be provided with proper equipment to allow them to work safely. Minimum rights of the workers should be met.
- Farms have to comply comply with all legal requirements, including use of contract for permanent workers.
- The workers living quarters on the fish farm must be habitable.
- Safety should be ensured on the farm. A complete first-aid kit and First-aid training, safety and emergency procedures should be provided for workers in each farm.

Resource access
- Public access should be granted to the surrounding of the cages and enclosure.

Legislative Framework
GAP farms must as a minimum comply with all aspect of legislation esp. Ownership, Food Safety, Registration and licence…

Management
- Decision-maker and workers handling and/or administering medicines, chemicals, disinfectants or other hazardous substances and all workers operating critical or dangerous operations should be have the right competence – through academical background, training.or adequate instructions.
- Documented procedures and work instructions should cover all processes critical to the product safety, legality and quality
- Monitoring, documentation and recording practices (inputs such as feed and treatments, mortality, inventories, invoices and accounting) have to be implemented.
- Finally, management should be able to react to all issues concerning the safety of their product and have a system to handle and react to complaints from clients.

Traceability
Farms must ensure all necessary data are recorded for identification and traceability of the stock from the hatchery (up to the parents or group of parents) to the buyer?
All along the cycle, each fish must be identifiable to a batch with treatments records and other attached).
Traceability of harvest pen must be maintained up to slaughter and process line.

- Processing in factory

Welfare of the fish
Time outside the water should be minimized.
The fish must be stunned or anaesthetized with ice prior to bleeding.

Impact on the environment
No untreated waste should be released in the river.

- Harvest and transport

Hygiene
Cleaning procedure and schedule should be implemented in vehicles and boats used for transporting fish or inputs (feed…): All bins and boxes should be disinfected before use. Contamination on the boat from workers living areas and oil leakage should be avoided. In case fishes are transported dead they should be iced with a 1/1 ratio

Welfare of fish
Transport duration should be minimized, especially without water. Transport duration between farms and processsing site should not be longer than 12 hours. .
In case fishes are transported alive by trucks ice should be added in the water.

Safety – antibiotic use
The use of antibiotic or disinfectant in larvae and fingerling transport should be monitored and advice from a veterinary should be sought.

- Manufactured Feed:

Monitoring of supplies
Feed Producers must obtain from their supplier a declaration of constituents for each compound diet and supplement.

Microbial and chemical contamination
Regular testing on unwanted contaminants pesticides or toxins such as mycotoxins in both inputs and final product should be conducted.

Antibiotic use
Feed Producers should have a list of all colorants, antioxidants, immune stimulants, probiotics and other additives utilized in feed?
No antibiotics should be added to the feed.

Hygiene
All feed stores, receptacles, bins and lorries should be cleaned regularly to remove feed and any mould.
Pests treatments should be scheduled and controlled.

Sustainability of the source fishery
Supply should come from sustainable fisheries.

References

Cacot, P. 1999. Étude du cycle sexuel et maitrise se la reproduction de *Pangasius bocourti* (Sauvage, 1880) et *Pangasius hypophthalmus* (Sauvage, 1878) dans le delta du Mekong au Viet-Nam, l'Institut National Agronomique Paris-Grignon, Paris. (Ph.D. thesis)

Cacot, P., P. Eeckhoutte, D. T. Muon, N. V. Trieu, M. Legendre, C. Mariojouls and J. m. Lazard (2003). "Induced spermiation and milt management in *Pangasius bocourti* (Sauvage, 1880)." Aquaculture **215**: 67-77.

Cacot, P., M. Legendre, T. Q. Dan, L. T. Tung, P. T. Liem, C. Mariojouls and J. Lazard (2002). "Induced ovulation of *Pangasius bocourti* (Sauvage, 1880) with a progressive hCG treatment." Aquaculture **213**(1-4): 199-206.

Cohen, M. and M. Hiebert (2001). "Muddying the waters." Far Eastern Economic Review **164**(48): 67-69.

Edwards, P. (2004). Review of Feeds and Feeding in Mekong Countries. Feeds and feeding for inland aquaculture in Mekong region countries. P. Edwards and G. L. Allan. Canberra, Australia, ACIAR Technical Reports**:** 136.

Edwards, P., L. A. Tuan and G. Allen (2004). A survey of marine trash fish and fish meal as aquaculture feed ingredients in Vietnam. canberra, australia, ACIAR © Australian Centre for International Agricultural Research**:** 56.

Gustiano, R. (2003). Taxonomy and Phylogeny of Pangasiidae Catfish from Asia (Ostariophysi, Siluriformes). Department of Biology, Section of Ecology and Systematics, Laboratory of Comparative Anatomy and Biodiversity, B-3000. Leuven, Belgium, Katholieke Universieit Leuven**:** 300 from Philippe Cacot, Pers. Comm.

Hung, L. T., B. M. Tam, P. Cacot and J. Lazard (1999). "Larval rearing of the Mekong catfish, *Pangasius bocourti* (Pangasiidae, Siluroidei): Substitution of Artemia nauplii with live and artificial feed." Aquatic Living Resources **12**(3): 229-232.

Lazard, J. m. and P. Cacot (1997). "Aquaculture systems in Vietnam: an overview, challenges and prospects for the future." Cahiers Agricultures **6**(5): 127-136.

Phillips, M. (2002). Fresh water aquaculture in the Lower Mekong Basin. Phnom Penh, Mekong River Commission**:** 62.

Phu, T. Q. and T. T. T. Hien (2003). "Changes in Types of Feeds for Pangasius Catfish Culture Improve Production in the Mekong Delta." Aquanews **18**(3).

Poulsen, A. F., K. G. Hortle, J. Valbo-Jorgensen, S. Chan, C.K.Chhuon, S. Viravong, K. Bouakhamvongsa, U. Suntornratana, N. Yoorong, T. T. Nguyen and B. Q. Tran. (2004). Distribution and Ecology of Some Important Riverine Fish Species of the Mekong River Basin. Phnom Phen, Mekong River Commission.

Subagia, J. Slembrouck, J. Hung, LT, et al. (1999) "Larval rearing of an Asian catfish Pangasius hypophthalmus (Siluroidei, Pangasiidae): Analysis of precocious mortality and proposition of appropriate treatments", Aquatic Living Resources, **12** (1)

Trong, T. Q., N. V. Hao and D. Griffiths (2002). Status of Pangasiid aquaculture in Viet Nam. Phnom Penh, Mekong River Commission**:** 16 pp.

Van Zalinge, N., L. Sopha, N. P. Bun, H. Kong and J. V. Jorgensen (2002). Status of the Mekong *Pangasianodon hypophthalmus* resources, with special references to the stock shared between Cambodia and Viet Nam. Phnom Penh, Mekong River Commission**:** 29.

Annex 1: Visited production units: hatchery, nurseries, farms, processing, transport, feedmills, health treatment retailers
Annex 2: List of chemicals found on the farm
Annex 3: Draft of Pangasius Guidelines presented at Eurepgap