

Raising Awareness of Aquatic Animal Health Management

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Introduction

A result of unplanned aquaculture is the occurrence of epidemic diseases, which impedes the development of aquaculture and consequently holds back the development of local economy and increases poverty. An important step to take is to promote local people's awareness of animal health management and of the necessity to plan aquacultural development in harmony with other activities such as crop and livestock production. The development of aquaculture has not been well planned although local government and other organizations have made some efforts towards this.

Participatory research methods were applied to raise awareness of local people on the management of animal health aimed at protecting aquatic species. Preliminary conclusions are encouraging and indicate that the results will be applied sustainably by aquaculturists in their community.

The villagers in Trung Lang, Quang Thai commune do various activities to make their living but mainly farming and fishing. They count on the lagoon ecosystem for all their livelihood activities – even agriculture production relies on freshwater macrophytes harvested from the lagoon (Thuan *et al.*, 2000a). Although Quang Thai lagoon, 1100 hectares in size, is rich in aquatic species, fisheries production is rapidly decreasing (Thuan *et al.*, 2000b). Agriculture is also poor in production as a result of poor soils and erratic water supply (Tuyen *et al.*, 2000). As a result, local farmers and fishers are interested in learning more about fish culture in cages.

Aquaculture in Quang Thai began in 1997 when the project recommended and supported the development of fish culture in cages, ponds and low-lying rice fields for villagers in Trung Lang Village. This was aimed at creating more jobs and raising incomes and standard of living. Aquaculture has now developed in many households and the culture area is increasing. Cage culture developed best in Trung Lang village, because it requires less investment and appropriate to local environmental, social and cultural conditions.

The number of households practising cage culture increased from 13 to 70 households since 1997 with a total number of cages of 98 by October, 2000. The culture of fish in cages is an appropriate activity for the local people and has increased the income of nearly 70 households. The culture of grass carp (*Ctenopharyngodon idellus*) has been adopted by the local community as this species does not eat much and feeds on freshwater macrophytes, an abundant resource in this lagoon area. Grass carp is an inexpensive source of protein which could reduce the rate malnourishment, a condition that plagues 40% of Vietnamese women and children due to a lack of protein in their diet (Luu, 1997).

Not only has the number of people practicing aquaculture been significantly increased, but also the culture area (Table 1). Mr. Tran Kien, a fish farmer, has increased the number of his cages to five.

Table 1: Fish culture in Quang Thai lagoon from 1997 to 2000¹

| Data | 1997 | 1998 | 1999 | 2000 |
|-----------------------------------|------|------|------|-------|
| Area of culture (m ²) | 1100 | 1736 | 3424 | 11760 |

¹ This data differs somewhat from Viet (****). Discrepancies may be due to a variable production cycle and different calendars used (Solar vs. Lunar).

| | | | | |
|----------------------------|------|------|------|----|
| Output (kg) | 3400 | 7200 | 7190 | - |
| Yield (kg/m ²) | 3.09 | 4.15 | 2.10 | - |
| Number of cages | 13 | 20 | 42 | 98 |
| Number of hhs | 13 | 20 | 35 | 70 |

The lagoon of Quang Thai is a very unique ecosystem and complicated but rich in both plant and animal species. The thick mass of aquatic plants in the region is the main food source for grass-eating fishes and also the major revenue for many local households. Thuan *et al.* (2000a) reported 7 kinds of water-plants in Quang Thai. *Vallisneria spiralis* is the most common in and around the 900 hectares of water surface and grows year round thus it has become the main food for grass carp culture.

Factors affecting aquaculture

The climate plays an important role in the aquaculture activities of the commune. The northeast monsoon which influences Thua Thien–Hue province brings with it sudden temperature drops which affect the fish. In fact, the temperature of the water in Quang Thai ranges from 14 °C in winter to 37 °C in summer while the optimum temperature for raising grass carp is 22 – 23 °C. Households that raise fish year round are affected by the low temperatures.

Another factor that also affects the development of aquaculture is the changing nature of the lagoon's ecosystem. The recent floods in the region have created more openings between the sea and the lagoon which has changed water currents, salinity, etc.

The number of boats navigating in the lagoon is growing. Boat traffic and fishing activities (particularly raking for eels and freshwater macrophytes) affects the bed of the lagoon. They pollute the environment, increase the hardness of water (the ions Ca²⁺, Mg²⁺, etc.), change the pH and dissolved oxygen content and have many more affects.

Our survey results indicate that the aquatic potential in Quang Thai is great, but production is low as the aquaculture experience of the local community is poor. Other factors include poor economic condition, low awareness and knowledge of technology, and disease. During the first year of cage culture, grass carp developed well. However, recently there has been an increase in the number of diseases that affect the fish. Unfortunately, the relationship between animal health and aquaculture practice is not well understood, especially by the local people who have no experience in aquaculture. It is suspected that bad management has greatly affected animal health. This research aims at further exploring this link by defining the causes of disease, proposing preventive measures to be taken, improving aquaculture techniques and promoting the local people's awareness of the significance of environmental protection.

Research Methodology

It is difficult to describe the exact methodology used in this research as all methods were integrated. Training was interactive and so included a lot of discussion; and discussions and mapping were also used as an opportunity for training. Thus, though this section is divided into separate sections describing different methods used (training, mapping, discussions, culture trials), all activities were integrated.

Training

Training was aimed at informing local fish farmers about possible measures to take for the improvement and benefit of aquaculture. Training was conducted formally during workshops held in the village as well

as informally during meetings, discussions and visits to aquaculture sites. Aquaculturists were educated on the relationship between fish disease and environmental factors, and other factors such as fingerling care and quality, location of fish cages, water depth, size of cage, density, culture period, type of food and management. Appropriate and inappropriate actions were described and discussed in terms of the location of cages, culture areas, the depth of water, and as well as the mesh size of the nets. Much of the training was conducted on disease. The diseases which appeared in previous culture seasons were classified with the help of the fish farmers and trainers cited some of the main causes of disease and identified causes that can be overcome as well as those that are difficult to overcome.

Mapping

Mapping was initiated by a general observation of fish cage culture in the commune: location of cages, waterways and fish corrals, areas of potential for aquaculture and areas affected by agricultural run-off. Fish farmers and researchers mapped the position of the fish cages and marked the locations already affected with epidemic diseases in the previous culture season. The community mapped all lagoon activities including areas where the environment is polluted and which might lead to the occurrence of diseases. All households who were engaged in aquaculture gathered over a basic map of the lagoon area and discussed the following factors:

- Depth
- Navigation
- Currents
- Potentially polluted water areas (from land-based activities).
- Regulations on land and water management.

Participants then marked potential areas for culture and completed the map. One group was assigned to enforce the activities proposed by the mapping exercise. This group consisted of representatives of the 3 production groups (mobile gear fishers, fixed gear fishers and fisher-farmers) which are also indicators of standard of living (poor, medium and better off, respectively), 2 other members elected by community and one representative of the local government. This group was responsible for reminding fishermen to put cages in the regulated places and for solving disputes arising from aquaculture activities.

Discussions

Discussions with local people were generally focussed on identifying appropriate solutions to reduce the causes of disease. Good opportunities were created for the local people to meet, discuss and select the most appropriate options and solutions for fish-cage culture (*ie.* water depth, stocking season and fingerling size). They also discussed appropriate locations for fish cages considering navigation, water current, fish corrals, run-off from nearby rice fields, places of water exchange, etc. Locations were indicated on the map as described above.

A meeting with the local community and representatives of the local government was organized to draw out experiences gained after 3 years of fish cage culture. The researchers presented different issues and options for the fish farmers to discuss (fingerlings, depth of the water, stocking period, feeding and caring for fish, etc.) and pointed out the advantages and disadvantages of each factor. The information and data gathered from the meetings and talks were analysed and printed for the fish farmers. This helped to enrich and update the local fish farmers' aquacultural knowledge. The participants identified inappropriate fish raising techniques and management of aquaculture and, after discussion, the community all came to a conclusion that culturing techniques had not been well applied in making cages, choosing good locations, cleaning cages, stocking densities and feeding.

Culture trials

Researchers met separately with the 3 production groups (mobile gear fishers, fixed gear fishers and fisher-farmers) indicating different economic status: poor, average and better-off. From each group 3 households were selected by the community to participate in culture trials. The households selected were willing to cooperate voluntarily, were previously involved in fish cage culture, were typical of their group, and were willing to share their gained experiences with others in their group.

The selected households were provided with fingerlings and, throughout the culture period, they were technically supported by the researchers and assisted by the local community. They agreed to a standardized method of culture in terms of feeding times, type of food, regular cleaning of cages, stocking density, size of fingerlings, etc. They also agreed to place their fish cages in the recommended areas, distant from rice field run-off and frequent boat travel. The cages maintained by the selected households served as the experimental group, which were later compared with those raised by the rest of the local fishing community. The collaborating households also helped the researchers exchange information with the community and collected data on depth and water colour in and around their cages from June to October (Lunar months V to IX).

Environmental factors were monitored using easy indicators for the fish farmers to assess water quality and fish health. These included water colour, depth, flow, viscosity, and salinity (using taste). Those factors were decided on by the researchers and fishers upon discussion. The 9 households were able to measure these factors every day with the help from the project.

Some factors such as dissolved oxygen (DO), pH, and salinity, measured with metres, which are relatively difficult for the fish farmers to measure, were measured every 15 days by the researchers in the 9 fish cages, in the lagoon near fish culture areas and near the rice fields (see Map 1).

Four focus group discussions were held, one per month, during the culture season between July and October to review and evaluate culture practices. Participants included the 9 households collaborating in culture trials and other interested aquaculturists. Some aspects discussed were the survival rate of fingerlings, food and epidemic diseases. The group also compared the results of the 9 trial cages to those of other households' cages in the community.

Map 1. Location of water sampling areas and fish cages ****

Aquaculture Sites

Site selection is one of the key factors which decides the output. However this is a new concept for aquaculturists – one with which they have little experience. Usually fish farmers care more about locations which enable convenient and quick care and protection, and thus, the majority of cages are placed near boat wharfs, estuaries and along traveling routes. The locations chosen in Quang Thai were not really suitable which accounted for low yield and diseases (Map 2). To deal with this, we organized a workshop on how to select appropriate places fish cage sites in addition to training on appropriate techniques. At the workshop the fishers in Trung Lang agreed on several criteria for locations (see Map 2).

- Distance greater than 100m from the dikes
- Far from sluice gates of irrigation canals for rice fields, and

- In water depth of greater than 1 m in dry season².

Map 2. Map indicating areas for fish culture, transportation and areas affected by field run-off ***.

Originally, aquaculture cages were placed near the shore of the lagoon, close to sluice gates and rice field canals in water depth of around 0.8 m. When the fishers moved their cages further away, around 100m from the shore, and into deeper water of 1.5 m, the results were better perhaps because the water quality had improved. The fish were not affected by diseases. However, an unexpected flood came at the end of the crop in July, 2000 which allowed fish to escape from cages that were not well covered. Some households anticipated the flood and built strong cages with 2 to 3 layers of nets and supported by numerous stakes. These designs, although sturdy, reduced oxygen levels in the cages during the dry season because of too small mesh size or too many layers of nets. This is the probable cause of the deterioration in fish health and provided a favourable environment for the development of diseases.

Cage Design

Fish cages made in Quang Thai are bottomless thus the design of this type of cage makes use of the lagoon bed as its floor (Figure 1***). A cage can be approximately 13 m long by 10 m wide and about 1.6 to 1.7 m high (though the water depth varies not only in location but seasonally as well). The cages are fastened to the bottom by bamboo stakes embedded in 0.3 to 0.4 metre of mud all around and are covered with nets of mesh size 1.0 to 1.2 cm on the 4 sides and on the top. To make this design strong and prevent fish from getting out during floods, some cages are covered with two layers of net. The advantage of using the lagoon bed as the floor of the cage is that it is a good environment for the growth of the fish. However the design of this type has its disadvantage in that it makes moving the cage difficult. Moving is required when the water gets polluted or when the level of water rises.

Cage size varies depending on the economic status of the aquaculturists with the smallest at 50 m² and largest at 150 m². Better-off households (farmer-fishers) often make bigger cages and although all aquaculturists understand that with larger cages, they could stock more fish and earn more income, they can't afford the extra investment.

Depending on design, this type of cage need not cost much and is easy to make. However, many of the cages have shortcomings – the mesh size of nets were small, the stakes were not well located and the net covering was too loose – decreasing the exchange of water and depleting oxygen. The mesh size of nets should increase as the fish grow. A few wealthier fishers invest more money in making cages of different sizes, so as the fish grow they are moved into larger cages with bigger mesh sizes to reduce the density. Mr. Tran Khuyet, one of the 9 collaborating households, was financially assisted by the project to make bigger cages with large meshed nets to transfer and protect the fish as they grew. The results of his work encouraged some households to follow his pattern.

Poor, or mobile gear, fishers, however, did not have extra cages into which to transfer their fish. This, in combination with poor location and other factors caused poor growth of fish and disease which resulted in considerable reduction in productivity and a rapid spread of infection to nearby cages.. Mr. Phap Tan, a mobile fisher, was affected with approximately 80% of his fish infected, resulting in 60% mortality.

Culture Process

²Depths throughout this document refers to the water depth in the dry season, when the lagoon is at its lowest level. In the rainy season, the depth fluctuates – it especially rises and subsides with every flood.

Feeding

Duy (1995) recommends the raising of fish that eat grasses and water plants. The amount of aquatic plants on the bottom of the rivers, ponds, fields and in the lagoon itself is quite large and the productivity of freshwater macrophytes is about 14 -15 kg/m². Regeneration time after harvest is about 10 -15 days (Thuan *et al.*, 2000a). In addition, agricultural by-products (or green material) from corn and peanut are locally abundant and can also be used as food for fish. All of the 50 households interviewed said they had enough food for the cultured fish. They either harvested freshwater macrophytes themselves or payed others to harvest depending on the availability of labour in their households. It is possible that in the future, as aquaculture develops even more, synthetic foods for the culture of special aquatic animals will also be developed in Thua Thien–Hue Province.

When the fish reach a body size of 10-20 cm, they are fed with *Caridina* (a small crustacean) and fishes mixed with mash in addition to water plants. The daily amount of tiny fish and shrimp consumed is as much as 10-20% of their body weight. In well managed cages, the fish are fed 2 times a day, in the morning before the fishers go to work and in the afternoon before they go to harvest the fish corrals and other fish traps. When the fish are about 20 -30 cm, they eat freshwater macrophytes only. In cages of 100 m², 150 to 300 kg of macrophytes should be provided at one time.

Fingerling size and stocking

In the market there are four classifications of fingerlings: 4- 6 cm, 6 -8 cm, 10-15 cm, and 20-25 cm. The size of fingerlings depends on technology level, economic condition, and culture size. As cage culture is an open system, environmental factors can exert their effect upon the fish. When the fish are still young, they are less adaptable to rapid changes in the environment, and consequently they are affected by diseases, and mortality increases. The advantage to stocking larger sizes is that they are less susceptible to disease.

Some fishers have tried using different sizes of fingerlings and, their experience thus far dictates that the best stocking size for inexperienced households is the 10 -15 cm range with low densities at 4 to 5 fingerlings per m². For those families with more aquaculture experience, they felt that they could stock their cages with fingerlings of 4 - 6 cm with a density of 10 to 20 fingerlings per m². Some of the latter households raise the smaller fingerlings to 10 - 15 cm and then decrease the density by either transferring some fingerlings to a second cage or selling them to fishers with less experience.

Density of fish often affects the growth and productivity of fish directly. A survey on stocking density revealed that fingerlings of 4 to 5 cm were stocked at 63 individuals/m³ and fingerlings of 8 to 12 cm were stocked at 13 individuals/m³. However, this varies greatly. Phan Hai stocked fingerlings of 4-5 cm with a density of 150 fish/m³ and, after 3 to 4 months, moved his fish to other cages or harvested to reduce the density.

If fingerlings are not acclimatized prior to stocking, the shock can potentially kill them. Most fishers place the fingerlings into the cages immediately upon purchasing and transporting them without acclimating them first. Thus, the sudden change in environment that they experience as they move from the container or plastic bag in which they were transported to the cages in the lagoon, shocks them, weakens them and makes them more susceptible to disease. Acclimation of fingerlings prior to stocking is essential.

Net Cleaning

The fishers often neglected to clean the nets, and when they did, it was not done regularly and correctly. Although the fishers are aware that a clean net means a healthier environment for the growth of the fish, the nets were not cleaned until they were very dirty. When disease appeared, they did not remove or isolate the diseased fish immediately therefore diseases were transmitted to other fish and cages. The

fishers did however remove waste food out of the nets regularly. Particularly during the dry season when the water level in the lagoon is low, the volume of food can occupy 2/3 of the cage volume which reduces the living space of the fish. The left-over food breaks down and contaminates the environment.

Through training and discussion, the fishers were reminded to clean their nets regularly and remove left-over food before adding new food. These practices were followed by a few households but especially the 9 collaborating households. Those who were feeding fish once a day agreed to change this practice to feed twice per day and this has since become a regular routine for all fishers. Some households had the habit of changing to new cages with bigger mesh size when the fish were big and a second net was added to prevent the food from clinging to the inner nets.

Culture period

In Quang Thai, fish are raised for one season per year. Fish are stocked in late lunar month X and harvested in VI and VII before the flooding season begins. However some households strengthen their cages to avoid losing fish during the flood and they harvest in XII and I of the following year. They then stock late from lunar months II to III but the fingerlings are then vulnerable to disease in the dry season (from lunar months IV to VIII) when the water gets shallow and the weather is hot.

A small flood called *tieu man* occurs in month IV or V, so the local people have to strengthen the cover of the cages to keep the fish from escaping.

Harvesting

The amount of fish harvested depends on market demand and weather. According to local experience, floods begin in lunar month VII and last until the 23rd of month X. Most households harvest all their fish before the floods to avoid losses and as a result the price is low at about 8000 - 10000 VND/kg.

Some households harvested their fish in XII (before *Tet*, the New Year festival), when the price is higher at about 12000 - 15000 VND/kg. These households are able to hold their fish through the flood season by strengthening their cages, covering them with nets to protect the fish and monitoring them very closely. For example, Ha Hop was successful in maintaining his fish in the cages through the flood season and harvested over 200 kilograms of Grass carp at 15000 VND/kg.

Figure 2. Culture work plan in Quang Thai

| Work | Lunar Months | | | | | | | | | | | |
|---------------------------|--------------|---|----|-----|---|----|-----|----|---|----|-----|------|
| | IX | X | XI | XII | I | II | III | IV | V | VI | VII | VIII |
| Prepare cages | | | | | | | | | | | | |
| Pitch cages | | | | | | | | | | | | |
| Buy & stock ¹ | | | | | | | | | | | | |
| Culture | | | | | | | | | | | | |
| Harvest | | | | | | | | | | | | |
| Slack season ² | | | | | | | | | | | | |
| Harvest Rice | | | | | | | | | | | | |
| Disease | | | | | | | | | | | | |

¹ Buy and stock fingerlings

² Slack season in agriculture (*ie.* Period of unemployment)

Environmental Factors

New estuaries were created in Tam Giang lagoon by the Century Flood of November 1999 which affected salinity in the lagoon. Although this was a serious problem for most aquaculture facilities in the lagoon, increased salinity did not reach Quang Thai lagoon in particular. However, fishers in Trung Lang still felt the subject was important and discussed the issues of potential salinity changes. The villagers felt that salinity could increase in the future but had ideas for how to adapt to these changes: either by stocking sooner when salinity was still low or by moving the cages into mouth of the rivers. However, the salt concentration during the survey did not exceed 1‰ (Table 2) and grass carp can live in up to 12 ‰ salinity.

The average chemical oxygen demand (COD) in fish cages was 51.8 mg of O₂/L which was over twice that found in lagoon water (21.5 mg of O₂/L). The water inside the cages gathered a lot of inorganic and organic matter which decreased oxygen. Oxygen levels were much higher in the lagoon (average 6.9 mg/L) than in cages (4.3 mg/L). With a lack of oxygen in the cages, fish health was affected, resulting in illness and death. The measures of environmental factors are summarized in Table 2. Oxygen and COD in the 3 sites over the research period are compared in Figures 3 and 4.****

Table 2. Water quality parameters measured from water samples collected from Lunar months V to IX.

| Factor | Lagoon | | Cage Culture | | Field | |
|---------------|-----------|-------------|--------------|-------------|-----------|-------------|
| | Min – Max | Mean ± s.d. | Min – Max | Mean ± s.d. | Min – Max | Mean ± s.d. |
| Oxygen (mg/L) | 6.5 – 7.5 | 6.9 ± 0.5 | 3.1 – 6.3 | 4.3 ± 1.2 | 3.2 – 6.7 | 4.4 ± 1.3 |
| pH | 6.8 – 7.6 | 7.1 ± 0.3 | 6.2 – 7.4 | 6.8 ± 0.4 | 6.0 – 6.6 | 6.2 ± 0.2 |
| COD (mg/L) | 18 – 29 | 21.5 ± 3.8 | 45 – 58 | 51.8 ± 5.5 | 32 – 75 | 48.5 ± 13.2 |

| | | | | | | |
|-------------------------|-------------|------------|------------|------------|-----------|------------|
| Temperature (°C) | 17 – 34 | 26.5 ± 6.4 | 17 – 34 | 27.5 ± 5.0 | 18 – 36 | 28.5 ± 5.8 |
| Salinity (‰) | 0 – 1 | 0.5 ± 0.5 | 0 | 0 | 0 | 0 |
| Depth | 1 – 2.3 | 1.6 ± 0.3 | 0.9 – 2.0 | 1.5 ± 0.4 | 0.3 – 1.7 | 0.74 ± 0.5 |
| Colour | Light Green | | Dark Green | | Green | |

Diseases in Quang Thai

The following story illustrates the complexities of cage culture and seasonal effects: In 2000, when the flood season came, the fishers strengthened their cages, increased the number of stakes and poles and covered them with nets to prevent fish from escaping. However they did not move the fish to larger cages because they thought it would be too difficult to maintain. At the end of the culture season when the weather was dry and with the high density of fish, fish grew slowly and disease occurred.

The fish showed the following pathological signs and symptoms during and after a health survey:

- Their appetite was reduced or lost and the fish became lethargic.
- The fish floated right beneath the surface or swam with their heads out of the water
- Red spots developed on their skin, heads and fins, which then developed into large necrotic open ulcers on other parts of the body of the fish.
- The fish died after two weeks.

Figure 5. Losses in cage culture due to disease in Trung Lang Village.****

Aquaculture is a new development in Quang Thai but diseases have already developed which affect the survival rate of the fish and reduces the productivity. Figure 5 summarizes the heavy losses incurred by fishers as a result of disease in aquaculture in Trung Lang since it began in 1997. It is difficult to find the disease-causing agents in aquaculture as it requires a lot of time and equipment. However with the participation of fishers, we have speculated on some causes.

Agricultural Run-off

In low-lying fields, the pH of water is low at an average of 6.2 over the research period because they are affected by acid sulfate soil as well as by chemicals applied during the culture of rice. Chemical fertilizers and pesticides used in rice fields are known to affect aquaculture though more studies are required to quantify the extent of the problem in this area. After a heavy rain these substances run into the lagoon water and kill the fish raised in cages near the fields. To prevent this, we advised the fishers to move the cages out of polluted areas. Fishers then noted that the mortality rate was quickly reduced and said that in the coming years, they would all move their cages out of polluted areas for the rainy season.

Electric fishing

When electric fishers fish outside the cages and especially if the electric shock is applied too close to the cage, the grass carp are disturbed and weakened and thus may be more susceptible to disease. Some fish actually die from the shock.

Seasonal causes

Diseases often occur in the summer when the water temperature is high, the water level is low and the

culture area gets polluted. Information from fishers indicates that fish diseases often occur in April and May. Mortality increased to its highest at 65.6% in 1999 due to the unfavourable state of environment in dry season: the temperature was high and the water level was low.

Poor Management

The culture environment is not ideal if, for instance, the fish are overfed and the nets are not cleaned. Poor cage management may pollute the water in fish cages and result in high mortality.

Disease prevention

Local fishers do not use any chemical preventative measures to combat disease other than applying lime or medicinal herbs. However, they have some ideas about how to prevent disease such as moving cages when salinity increases. Since aquaculture is a new activity, villagers felt that they are still learning and had no time yet to think about management or to experiment with various management techniques. Sometimes fish were over-fed or under-fed and villagers did not always take proper care of the cages which increased the risk of diseases. Since fishers have limited experience with technique and with feeding, they were not always sure how to prevent or to deal with a problem. However, techniques will improve with more group discussions and sharing of technical expertise.

Many fishers treated diseased fish with medicinal herbs and lime without much success. These interventions are adequate as preventions but not as treatments. There are many agents through which epizootic ulcerative syndrome (EUS) occur, so prevention is the best method, however these should be applied prior to the appearance of disease. Other preventative measures discussed with fish farmers included:

- Cleaning fish cages regularly.
- Never feeding too much at once.
- Acclimatizing the fingerlings before stocking.
- Ensuring proper density
- Adding vitamin C into the food
- Applying lime and China tree leaves twice a week (5-10 kg of lime/100m² and 4-5 kg of China tree leaves/100 m²) or grinding 2.5-3 kg China tree leaves with 100 kg fish for 3 days' feed.
- Mixing antibiotics such as Furazolidon (5ppm) or Gentamyeine (30ppm) into feed which is given once a day for 7 days and repeat 3 times.

Results from Collaborating Households

Table 3. Results of cage culture from 9 collaborating households.

| Household | | Cage size (m ³) | Stocking Density (fish/m ³) | Total # of fingerlings | Size (cm) | | Mortality (%) |
|------------------------|----------------|--------------------------------|--|---------------------------|-------------|-------------|------------------|
| | | | | | Initial | Harvest | |
| Mobile gear fishers | Pham Chuong | 120 | 3.3 | 400 | 12.4 | 24.1 | 40 |
| | Ha Loc | 100 | 4.5 | 450 | 12 | 24 | 55 |
| | Phan Long | 100 | 3.8 | 380 | 13.7 | 22.4 | 45 |
| | Average | 106.7 | 3.9 | 410 | 12.7 | 23.5 | 46.7 |
| Fixed gear fishers | Phan Xuan Thin | 150 | 2.9 | 440 | 14 | 25.2 | 40 |
| | Phan Danh | 150 | 4 | 600 | 12 | 24.1 | 37 |
| | Hoang Tuan | 130 | 3.1 | 400 | 14 | 24.2 | 30 |

| | | | | | | | |
|----------------|----------------|--------------|------------|------------|-------------|-------------|-------------|
| | Average | 143.3 | 3.3 | 480 | 13.3 | 24.5 | 35.7 |
| Farmer-fishers | Hoang Ngat | 150 | 4.7 | 700 | 12 | 25.3 | 30 |
| | Tran Ung | 150 | 6.7 | 1000 | 14 | 23.4 | 35 |
| | Tran Khuyet | 150 | 4 | 600 | 14.2 | 24.1 | 30 |
| | Average | 150 | 5.1 | 767 | 13.4 | 24.3 | 32.7 |

The 9 experimental households chose to stock fingerlings of 12 to 14 cm. The average survival rate was 62% after 5 months which is quite high. The volume of fish cage, density and mortality were different for the 3 groups with higher volume and density found in farmer-fishers, probably because of higher investment and good management.

Due to lack of resources, mobile gear fishers were not able to afford the larger cages needed for deeper waters, thus kept their cages close to shore, in more polluted areas. It was also more convenient for them to have their cages located near their sampans (or homes). Fisher-farmer and fixed gear fishers put their cages far from the foot of the dikes and the dirty sources of water flowing from the rivers and boat stations.

Conclusions

Fish diseases often appear in April and May and when fishes are ulcerated, it is serious. The major causes leading to the occurrence of diseases are:

- Poor feeding: Feeding once a day; too much food relative to cage size; left over food is not removed and contaminates the environment.
- Poor cage maintenance: Cage cleaning not done regularly; dead fish are not discarded away from the culture areas. In some cases, the dead fish are thrown just outside the cage thus polluting the common aquaculture environment and spreading diseases.
- Poor stocking: Stocking has a great effect upon the survival rate of fish. Smaller stocking sizes suffer greater loss and are more susceptible to disease.
- Location of cages: More successful households chose deeper areas to place their cages, far from boat stations and waste sources so the survival rate was higher.

Through discussions and exchanges of experience, the local fish farmers have become aware of the relationship between aquatic epidemic diseases and management, and between aquacultural development and environmental management. The research was supported by the local people because it enable them to identify causes of the diseases and to minimize or eradicate them. For instance, fishers learned the importance of location of fish cages. Mobile gear fishers, who have earned money from aquaculture, can now afford the extra costs of placing their fish cages in deeper water sites. Having benefited from the research and discussions, they have changed their methods and improved production.

Recommendations

- Aquaculture in Quang Thai has developed later than in other areas of the lagoon. Aquaculture should be carefully planned to develop a sustainable aquaculture industry in the community. In the coming years, the number of households culturing fish in cages will further increase thus planning and zoning is essential. The fishers must select suitable areas that can satisfy technical requirements and polluted areas must be identified and avoided.
- Cages should be located 60 metres from the shore and 100m from the dykes; areas near canal

mouths or sluice gates should be avoided and cages should be spaced at least 5m away from each other.

- The fishers should be entrusted with the management of water areas. They should raise fish that are traditional and are adapted to the local climate such as grass carp and common carp. Most food for fish culture should be prepared or processed locally.
- Electric fishing must be restricted because it has a harmful effect on the environment.
- When fish grow, they should be moved to new cages with bigger volume and mesh sizes to ensure enough room and increase water exchange.
- Fish should be fed 3 times a day to decrease the pollution caused by left-over food and increase the room for fish to live in.
- It is necessary to support technical innovations and improve the management in the community.

References

Tráon **Duy**. 1995. Kyî thuáút nuãi lăõng caĩ năăic ngoüt vaì caĩ biăøn. (Techniques for Cage Fish Culture). NXB Năng nghiăúp.

Le Thanh **Luu**. 1997.***

Le Van **Mien**, Ton That **Phap** and Hoang Nghia **Duyet**. 2000. Aquaculture – Its introduction and development. Pp. 115-133 *In*: V.J. Brzeski and G.F. Newkirk (eds.) Lessons from the Lagoon. Coastal Resources Research Network, Dalhousie University, Halifax, Canada.

Le Thi Nam **Thuan**, Truong Van Tuyen and Nguyen Hong Viet. 2000a. Freshwater macrophytes – their ecology and exploitation. Pp. 145 - 167 *In*: V.J. Brzeski and G.F. Newkirk (eds.) Lessons from the Lagoon. Coastal Resources Research Network, Dalhousie University, Halifax, Canada.

Le Thi Nam **Thuan**, Truong Van Tuyen and Nguyen Hong Viet. 2000b. Fishing in Quang Thai commune. Pp. 168 - 185 *In*: V.J. Brzeski and G.F. Newkirk (eds.) Lessons from the Lagoon. Coastal Resources Research Network, Dalhousie University, Halifax, Canada.

Truong Van **Tuyen**, Tran Van Minh and Le Thi Nam Thuan. 2000. Participatory development of peanut crops. Pp. 99 - 114 *In*: V.J. Brzeski and G.F. Newkirk (eds.) Lessons from the Lagoon. Coastal Resources Research Network, Dalhousie University, Halifax, Canada.