# Health management practices for cage aquaculture in Asia - a key component for sustainability

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## ABSTRACT

The intensification of aquaculture and globalization of the seafood trade have led to remarkable developments in the aquaculture industry. Nevertheless, the industry, particularly Asian aquaculture (> 90% of world production), is paying a price for this unprecedented growth in terms of deterioration in environmental and health conditions. The industry has been plagued with disease problems caused by viral, bacterial, fungal and parasitic pathogens. In recent years, disease outbreaks are becoming more frequent in the region and the associated mortality and morbidity have caused substantial economic losses.

Asian aquaculture is characterized by an enormous diversity of species, with several dozen marine species being farmed. Consequently, more resources are needed to understand the basic epidemiology of diseases in the various species. In Asia, some disease-causing agents have been described but comparative studies between isolates from different geographical locations and fish species are generally not available. Epidemiology data are scarce, as are basic data on the immune systems of Asian fish species. This hampers development of effective strategies for disease control. Also, most farming is operated on a small scale and technical support, including disease diagnosis and training, is often lacking at farm level.

Increased trade of live aquatic animals and the introduction of new species for farming, without proper quarantine and risk analysis in place, result in the further spread of diseases. In Asia, most individual fish farms produce several species of fish. Trash fish are widely used as feed. Fry are often wild caught or derived from wild-caught broodstock. Furthermore, legislation for and implementation of farming licenses and zoning policies are not in place in most Asian countries. Coupled with a ‘gold rush’ mentality, this often results in too many fish and too many farms in a concentrated area, which in turn promotes disease transmission. The combination of all these factors, together with the diversity of organisms in tropical waters, leads to a truly challenging disease situation.

At present, many farmers still focus more on treatment than prevention. Irresponsible use of antibiotics and chemicals in aquaculture can lead to residue problems, an increasing consumer concern, and to the development of drug resistance among the bacterial pathogens. In Asia, with the exception of Japan, few fish vaccines are yet commercially available. The major advantages of prophylactic vaccination over therapeutic treatment are that vaccines provide long-lasting protection and leave no problematic residues in the product or environment.

Asian aquaculture will continue to grow at a fast pace due to both area expansion and production intensification. Under these conditions, the prevalence and spread of infectious diseases will unavoidably increase as a result of higher infection pressure, deterioration of environmental conditions and movement of aquatic animals. Accordingly, the effective control of infectious diseases has become more and more important in the cultivation of aquatic animals. Good health management is the “silver bullet” for disease control. Collectively, this includes the use of healthy fry, quarantine measures, optimized feeding, good husbandry techniques, disease monitoring (surveillance and reporting), sanitation and

vaccination, and proper control and biosecurity measures when diseases do occur. Overall, the emphasis must be on prevention rather than treatment. Remember, ‘one gram of prevention is better than a kilogram of cure’.

## INTRODUCTION

Today, aquaculture is the fastest growing food-producing sector in the world compared with terrestrial animals and 90% of world aquaculture production is in Asia. However, from the time man started to culture fish, fish diseases have changed from being an interesting phenomenon to an important socio-economic problem. Infectious disease is considered to be the industry’s single most important cause of mass mortalities and economic losses. Health problems have two fiscal consequences on the industry: loss of productivity due to animal mortality and morbidity, and loss of trade due to food safety issues.

Estimates from various organisations have indicated that approximately a third to a half of all fish and shrimp put into cages or ponds are lost due to diseases before they reach marketable size. The actual economic losses in the aquaculture industry worldwide are estimated to be in excess of US$9 billion per year, which is roughly 15% of the value of world farmed fish and shellfish production. Despite being long established, diseases and associated economic losses in aquaculture are a huge problem in the Asia (Bonadad-Reantaso *et al*., 2005). According to Wei (2002), outbreaks of bacterial diseases caused losses of over US$120 million to the fish aquaculture industry in China between 1990 and 1992. In 1994, marine fish diseases caused industry losses of US$114.4 million in Japan alone (Arthur and Ogawa, 1996). In addition, within a 3-month period, Koi herpes virus (KHV) infection of common carp led to losses of approximately US$5.5 million for Indonesian farmers in one area alone (Bondad-Reantaso, 2004). IntraFish Media reported in 2004 that, “the FAO recently sent out an alert in a press release about the dangers some of these diseases can pose not only for human health but they can also paralyze regional food producing sectors and leave thousands of farmers and producers out of work and with no income. Asia has particularly been mentioned where millions of people live off fishing or aquaculture or both”. Thus, disease is undoubtedly one of the major constraints to production, profitability and sustainability of the aquaculture industry.

The aquaculture industry in Asia is characterized by an enormous diversity of fish species and most Asian farms operate on a small scale where technical support, including disease diagnosis and training, is lacking. Consequently, treatment is generally decided without proper disease diagnosis and antibiotics are often improperly used. This has led to residue problems and the development of bacterial drug resistance. Moreover, poor husbandry methods are still in practice in many places, e.g., the use of trash fish as feed, or fry sourced from the wild or derived from wild-caught broodstock. These practices open a door for pathogen infections. In addition, the increased trade of live aquatic animals and the introduction of new species for farming, without proper quarantine and risk analysis in place, have resulted in the spread of diseases within and between countries. The combination of all these factors has led to a truly challenging disease situation in Asian aquaculture where disease prevention is difficult (Tan and Grisez, 2004).

Norwegian salmon farming is often taken as an example of how things should or could progress in aquaculture. However, the production of fish in tropical and subtropical areas is quite different. Differences involve not only the species cultured, but also (and mainly) the scientific knowledge that is available on reproduction, husbandry, feed requirements, diseases and immunology specific to the farmed species. Taking these differences into account, the knowledge that has been gathered in salmon health management can be used to more efficiently advance the relevant science in this region.

As Asian aquaculture will continue to grow at a fast pace due to both area expansion and production intensification, the prevalence and spread of infectious diseases will unavoidably increase as a result of higher infection pressure. In order to become sustainable, the industry must undergo changes and pay more attention to health management strategies.

In this paper, an overview is given about the current situation regarding health management practices in Asia. Recommendations for improvement are discussed.

## CURRENT STATUS OF ASIAN AQUACULTURE AND CHALLENGES

### Characteristics of Asian aquaculture – enormous diversity of cultured species

Aquaculture in Asia has a rich history of more than 2,500 years and is recognized as the leading aquaculture region in the world, contributing to 90% of total world aquaculture production. FAO statistics show that there are over a hundred species of finfish cultured in the region (FAO Fishstat Plus). With such species diversity, a significant amount of resources is needed to understand basic disease epidemiology, genetics/breeding and nutritional requirements for all these species. However, a more realistic approach could be to focus on a lesser number of species, as is the case in the coldwater finfish aquaculture industry. The origin of the species diversification in Asia can be attributed to historical, environmental and social factors (Liao, 1996). Importantly, because of the large number of species, when one is severely affected by an unknown and therefore uncontrollable disease, most farmers will opt for the most (apparently) economical way-out, i.e., stop farming the problematic species and start farming a new one. For instance, KHV has severely affected the carp farming industry of several Asian countries during the last few years. In Indonesia, where the disease has wiped out entire fish populations in certain areas of Sumatra, previous carp farmers are now looking at farming alternative species, such as tilapia. Another example can be seen in Thailand where between 2003 and 2006, the majority of shrimp farmers have switched from farming *Penaeus monodon* to *Litopenaeus vannamei*. At the time, *Litopenaeus vannamei* was considered stronger and more resistant to diseases such as WSSV. However, after several years of culture, disease and other health issues have also appeared in the latter species.

Switching species is only a temporary solution to an on-going problem, disease. This is a consequence of intensive farming conditions and poor health management practices. Even a species such as tilapia, which was initially considered as “hardy“, can be threatened by economically devastating diseases when farmed under intensive conditions. The huge diversity of farmed species in Asia, with sometimes more than one dozen species farmed in the same location, is a huge challenge in terms of disease management.

### Diversity of culture system and environment

Different species might require different culture systems. This is another challenge for Asian fish farmers. Currently the two major culture systems used to raise fish are cages and ponds. In both environments, water quality is a critical factor. In a pond, water quality management is crucial in order to avoid problems such as nitrite toxicity, plankton crash and bloom of blue green algae (causing off-flavour of the meat). In a cage environment, water quality is much less controllable. Due to their crowded condition, fish raised in cages are therefore more vulnerable to a rapid change in temperature or drop in oxygen. In addition, because of a lack of natural food sources in cage culture, fish are more dependent on a nutritionally complete diet. When farming in open water, fish are exposed to wild species therefore with greater risk for disease transmission and outbreak.

Cage farming is practiced in both freshwater and marine environments, but disease problems differ. Simple parameters such as salinity and temperature can dictate the epidemiology of disease outbreaks. For example, Columnaris disease due to *Flavobacterium columnare* is a common skin disease of freshwater fish. This disease is not present in seawater or even brackish water as the bacteria involved can not grow in the presence of salt. In contrast, *Tenacibaculum maritimum*, a common bacterium causing skin lesions in marine fish (Labrie *et al*., 2005b), is not a problem in freshwater as it is incapable of growing without salinity. Therefore, fish reared in environments where salinity fluctuates because of seasonal variations or water availability may encounter different disease problems depending on the salinity of the water. Another example is in tilapia reared in brackish water. These fish will be susceptible to the parasite ciliate *Amyloodinium* spp. (Leong *et al*., 2006). However this susceptibility disappears when salinity decreases as the parasite is not adapted to freshwater.

The temperature of the environment is an additional parameter that influences the complexity of disease epidemiology. In order to infect a fish species, it is necessary that the pathogen must be able to multiply optimally within the temperature range that the fish species is farmed. For example, *Lactococcus garvieae* is a pathogen of fish raised in temperate waters. Therefore, it is commonly found in yellowtail and amberjack farmed in Japan but not in warm water fish raised in South East Asia, such as grouper, Asian seabass and tilapia. Another example can be found in Thailand where the tilapia industry is affected each year with outbreaks of streptococcosis during the summertime when water temperature exceeds 30 °C. This temperature window coincides with the preferential temperature window of *Streptococcus agalactiae*, a pathogen involved in the disease. When water temperature is under 30 $^{o}$C, the mortality associated with this pathogen is low.

**Comparison with salmon farming**

Salmon has been considered as the model species of modern aquaculture, especially for cage farming. In the last 20 years, this industry has developed dramatically and now produces nearly 1.5 million tonnes annually (FAO Fishstat Plus). Produced largely by two countries (Norway and Chile), salmon products can be seen in virtually every supermarket in the world. In marine cage culture in coldwater countries (Northern Europe, Canada and Chile), the focus is on only one family of cultured fish (Salmonids). Therefore, most resources available are used for the optimization (including disease control) of the culture of this one family of fish. This is in stark contrast to the above-mentioned situation in Asia. A survival rate lower than 95% in salmon is a sign of a disease outbreak whereas a survival rate of 50% is often considered acceptable in Asia. It is therefore useful to highlight the main characteristics of these two very different aquaculture regional situations. Table 1 illustrates the differences.

The intensification of salmon production has led to the separation of fry production (hatcheries) and on-growing sites, optimized feed and feeding strategies, good quality fingerlings (that are virtually disease free) and good farm management. In Asia, most farms produce different species of fish at the same site. No segregation in year classes is made, something that is obligatory for salmon in Europe. Trash fish are widely used as feed, fry are often wild caught or derived from wild-caught broodstock and the culture techniques per species are not yet established. Furthermore, legislation and implementation regarding farm licenses and zoning policy are not in place in most Asian countries. With the so-called “gold rush” mentality, this often results in too many fish and too many farms in a concentrated area that promotes the spread of diseases. The combination of all those factors, together with the diversity of organisms in tropical waters, leads to a truly challenging disease situation with a variety of entry points for pathogens.

Table 1: Differences between farming of salmonid and Asian marine fish

| | Salmonids | Asian species |
|---|---|---|
| Farming system and practice | • mainly salmonid family<br>• integrated industry<br>• single species per farm<br>• all-in, all-out approach, with fallowing<br>• hatchery fry<br>• optimal stocking density<br>• zoning policy<br>• established market | • about 100 species<br>• “backyard farming”<br>• mixed species<br>• mixed age groups<br>• no fallowing<br>• many wild-caught fry<br>• high stocking density<br>• no zoning and licensing<br>• fluctuating market |
| Feed technology | • knowledge on nutrition<br>• optimized dry feed<br>• good FCR | • little knowledge on feed<br>• largely using trash fish<br>• generally poor FCR |
| Health management | • knowledge on diseases<br>• acceptable survival 95%<br>• focus on prevention<br>• biosecurity and sanitation<br>• documentation<br>• vaccination | • lack of proper diagnosis<br>• “normal” survival < 50%<br>• focus on treatment<br>• lack of biosecurity<br>• poor record keeping & analyses<br>• few vaccines |

## Disease status in Asian aquaculture

Disease is undoubtedly recognized as one of the biggest constraints to the production, development and sustainable expansion of aquaculture in the Asian region. As most farms operate on a small scale and with limited technical support, disease diagnosis and training is usually lacking at the farm level. Even if fish suffer from disease and overall survival is low, epidemiology data are rarely collected, reported and analyzed.

In past few years, more and more attention has been given to the identification of etiological agents involved in fish disease epidemics. Pathogens can be classified into bacterial, viral, parasitic and fungal groups. Table 2 shows major pathogens affecting the fish farming industry in Asia (Bondad-Reantaso *et al*., 2005; Komar *et al*., 2005; Labrie *et al*., 2005a; Leong *et al*., 2005; Leong *et al*., 2006; Tan *et al*., 2003).

Because of the scale of resource expertise and infrastructure required for disease diagnostics of such a variety of pathogens, FAO/NACA (Bondad-Reantaso *et al*., 2001) recommended the use of three levels of diagnostics:

1) Level I: field observation of the animal and the environment, clinical examination;
2) Level II: laboratory observations using parasitology, bacteriology, mycology and histopathology;
3) Level III: laboratory observations using virology, electron microscopy, molecular biology and immunology.

In fish, clinical signs of disease are rarely obvious and it is difficult to base a diagnosis solely on field observation. Unfortunately, this is very often the only way Asian farmers “guess” the cause of disease as they do not have access to a laboratory. The consequence is that a treatment is generally decided upon without proper disease diagnosis. Accurate disease prevention is therefore difficult. A general improvement of disease management should come from a general improvement of husbandry practises and knowledge on disease health management.

Table 2: Major fish pathogens in Asia

| Temperature zone/species | Pathogens | | | |
|---|---|---|---|---|
| | Bacteria | Virus | Parasites | Fungi |
| Temperate marine species (yellowtail, amberjack, red sea bream, etc.) | *Aeromonas salmonicida*<br>*Edwardsiella tarda*<br>*Lactococcus garvieae*<br>*Listonella (Vibrio) anguillarum*<br>*Mycobacterium* spp.<br>*Nocardia seriolae*<br>*Photobacterium damsela* ssp*. piscicida*<br>*Rickettsia* spp.<br>*Tenacibaculum maritimum* | Iridovirus<br>Lymphocystis virus<br>Nodavirus (Nervous necrosis virus)<br>Rhabdovirus (viral haemorrhagic septicaemia)<br>Yellowtail ascites virus (YAV) | *Benedenia* spp.<br>*Caligus* spp.<br>*Cryptocaryon irritans*<br>*Heteraxine* spp.<br>*Kudoa* spp.<br>*Microsporidium* spp.<br>*Myxobolus* spp.<br>*Neobenedenia* spp.<br>*Paradeontacylix* spp.<br>*Philasterides dicentrachi*<br>*Trichodina* spp. | |
| Warmwater marine species (Asian seabass, groupers, snappers, etc.) | *Nocardia* spp.<br>*Vibrio* sp. (big belly disease)<br>*Streptococcus agalactiae*<br>*S. iniae*<br>*T. maritimum* | Iridovirus<br>Nodavirus | *Amyloodinium* spp.<br>*Brookynella* spp.<br>*Benedenia* spp.<br>*Caligus* spp.<br>*Cryptocaryon irritans*<br>*Dactylogyrus* spp.<br>*Glugea* spp.<br>*Neobenedenia* spp.<br>*Sphaerospora* spp.<br>*Trichodina* spp. | *Ichthyophonus* sp. |
| Freshwater species (tilapia, catfish, carp, etc.) | *A. hydrophila*<br>*E. ictaluri*<br>*E. tarda*<br>*Flavobacterium columnare*<br>*Francisella*-like organism<br>*Nocardia* spp.<br>*S. agalactiae*<br>*S. iniae* | Aquareovirus (grass carp hemorrhage virus; GCHV)<br>Iridovirus<br>Koi herpes virus (KHV)<br>Spring viraemia of carp virus (SVCV) | *Argulus* spp.<br>*Dactylogyrus* spp.<br>*Diplostomum* spp.<br>*Eimeria* spp.<br>*Ichthyophthirius* spp.<br>*Lernea* spp.<br>*Myxobolus* spp.<br>*Piscicola geometrica*<br>*Sanguinicola* spp.<br>*Sphaerospora* spp.<br>*Trichodina* spp. | *Aphanomyces invadans*<br>*Branchiomyces* spp.<br>*Saprolegnia* spp. |

**Irresponsible use of chemicals/antibiotics**

Due to lack of diagnosis, farmers often apply antibiotic treatments when mortality rises, without knowing the cause of the disease and assuming that it is caused by a bacterial pathogen. Some farmers even use antibiotics as a form of “preventative measure”, where antibiotics are administered in anticipation of an expected disease outbreak. This has resulted in a heavy use of chemicals and drugs (Choo, 2000). While under certain circumstances antibiotics can provide a useful means of reducing the adverse effects of bacterial diseases, there are many problems associated with their use. An important side effect of the use of antibacterial drugs in aquaculture is the development of drug resistance among the fish and shellfish bacterial pathogens (Huovinen, 1999; MacMillan, 2001; Smith *et al*., 1994; Tendencia and de la Pena, 2001).

Many bacterial species multiply rapidly enough to quickly adapt to changes in the environment and survive in unfavourable conditions. The heavy use of drugs could results in the development of mutations in some bacteria. These mutations can lead to antibiotic resistance where an antibiotic is no longer capable of either killing (bactericidal effect) or preventing growth (bacteriostatic effect) of the bacteria. Emerging antimicrobial resistance, due to overuse and incorrect use of antimicrobials, is a human as well as an animal health concern worldwide.

For example, in 2004, an Asian fish farm suffered from several bacterial disease outbreaks. The primary pathogen was *Edwardsiella tarda*. The farm began to use a series of consecutive antibiotic treatments in the hope of stopping the on-going mortality as indicated in Figure 1 (personal communication). Antibiotic sensitivity tests were done on *E. tarda* isolated before and after the treatments. As indicated, the bacterium became resistant to two (trimethoprim-sulfamethoxazole and florfenicol, the latter belongs to the same class of chloramphenicol) out of the three antibiotics used. This demonstrates the dangers of excessive usage of antibiotics in aquaculture.

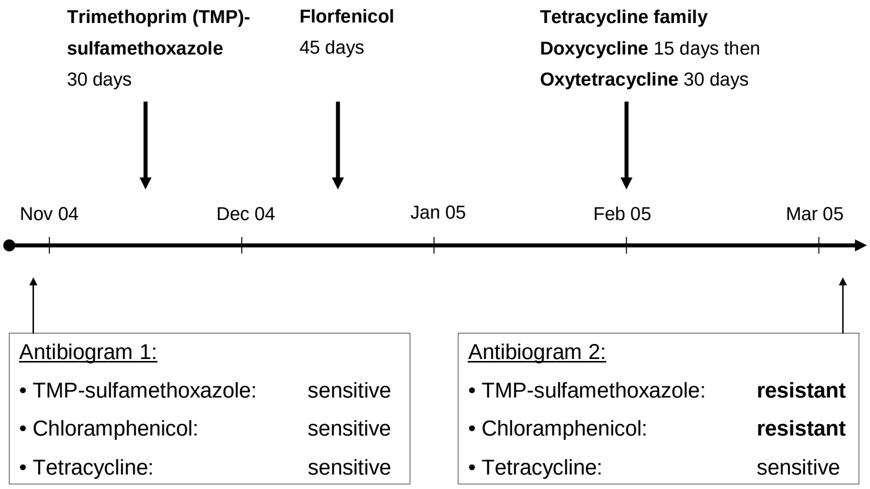


Figure 1. A real case on induction of antibiotic resistance in a fish farm

Undoubtedly, trade restrictions imposed on some Asian aquaculture products, increasing public awareness and concern for residues in fish and crustacean products, and the development of multiple antibiotic resistant bacterial strains will lead to a shift from disease treatment through antibiotics to disease prevention by other means, such as vaccination and biosecurity.

**Inadequate health management practice**

In Asia, good farming and health management practices are still to be implemented. For example, the use of trash fish as feed is a common practise in small scale marine fish farming. From a health management perspective, the use of trash fish opens the door to a variety of potential pathogens and infections and it is one of the major causes of fish disease in Asia.

Fry are often sourced from the wild or derived from wild-caught broodstock. Under these conditions, the quality is inconsistent. Weak or diseased juveniles are one of the failures in Asian aquaculture.

Due to the development of the aquaculture industry and the increased globalization of commercial trade, there is more and more movement of broodstock, fry and fingerlings between countries or regions. KHV is a recent example of disease dissemination due to translocation of fish. The disease has spread to many countries within a few years. (Crane *et al*., 2004)

**Challenge to sustainability**

The challenge we are facing is enormous. In tropical areas, the water temperature is relatively high which facilitates the multiplication of micro-organisms and some of these can be very harmful to aquatic animals. The combination of this with all other factors mentioned above has lead to a truly challenging disease situation with a variety of entry points for pathogens in Asian aquaculture.

Figure 2 illustrates how diseases are threatening the sustainability of the industry in the region.  A disease causes mortality and morbidity. When antibiotics or chemicals are not used properly for treatment, there are negative consequences. One of the problems is residues in aquatic products, which in turn give food safety concerns and trigger trade barriers. In the last several years, residue problems have created a negative image for the whole aquaculture industry in Asia. Farmers in Asia tend to stock more fish or put in more cages to compensate for mortality. The low production efficiency not only increases production costs, it also wastes our natural resources and creates unnecessary pollution. This has caused huge concern by consumer activists or environmental groups (New, 2003). Clearly, something must be done to keep the industry sustainable.

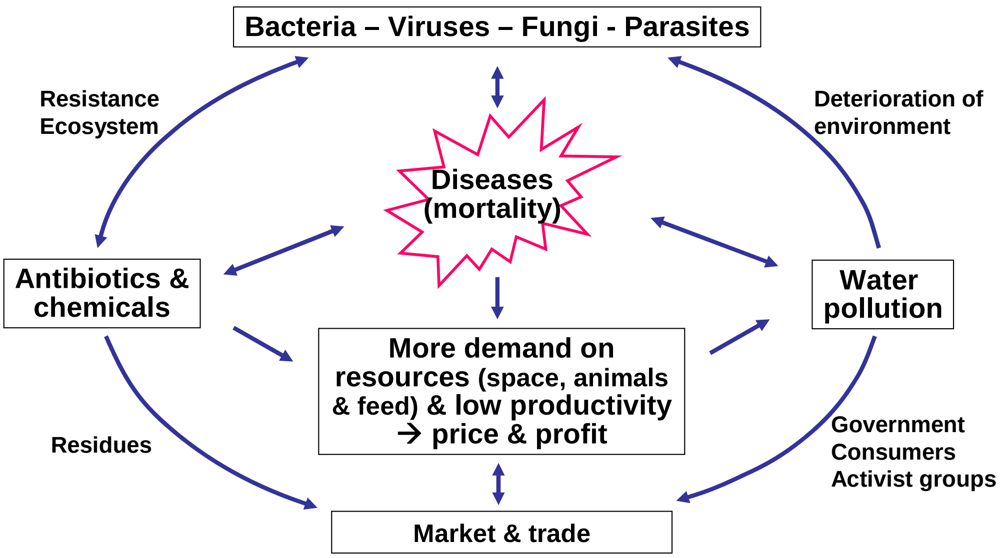


Figure 2. The negative impacts of infectious diseases on sustainability of the aquaculture industry.

## REQUIRED HEALTH MANAGEMENT PRACTICES

The objective of health management is to maintain a good health status, assuring optimum productivity and the avoidance of diseases. In aquaculture, the economic risk associated with diseases is high. It represents a potential loss in production through mortality and morbidity, and might decrease investor confidence. Moreover, the cost to treat diseases when they are already well established is high and treatments are often initiated too late and are therefore rarely effective. Thus, aquatic animal health management must be a global strategy that aims to prevent diseases before they occur.

**Proper disease diagnosis – a prerequisite for effective health management**

As aquatic animal health management is about implementation of control measures to prevent the incidence of diseases, it is a prerequisite to have a good understanding of diseases that might occur in a particular fish species. Therefore, adequate attention should be given to disease diagnosis and epidemiology studies.

As an example, a disease investigation and epidemiology study over the last past 5 years in Asian seabass have allowed us to identify the most critical pathogens in this species (Grisez *et al*., 2005; Komar *et al*., 2005; Labrie *et al*., 2005a). The presence of different pathogens during the production cycle is illustrated in Figure 3.

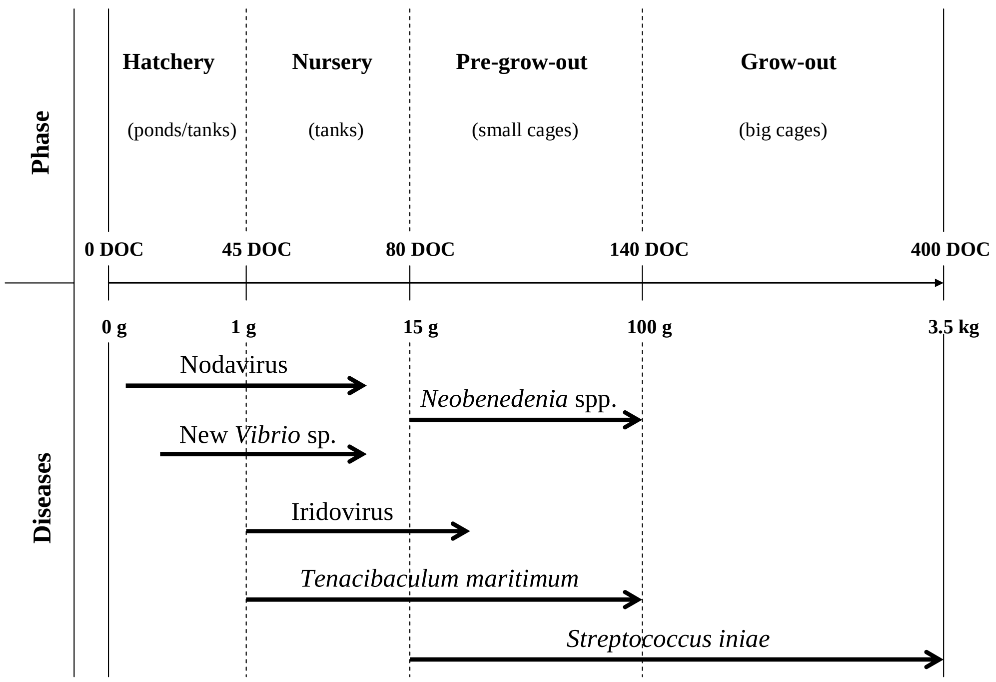


Figure 3: Major diseases affecting Asian seabass during the production cycle.

During the hatchery and nursery phases, two major viral diseases were identified. Viral nervous necrosis (VNN) was encountered in fry as young as 10 days old, causing mortality up to 100%. From 25 days of age onwards, a new *Vibrio* species responsible for acute mortality associated with severe clumping of internal organs, abdominal distension and muscular atrophy, was diagnosed. Subsequently, an iridovirus infection (previously never described in this species) responsible for an acute hemorrhagic syndrome was identified in fingerlings as small as 1 g. Associated mortality could reach up to 90%. In addition, *T. maritimum* was able to induce severe skin lesions in fish after handling and/or stocking. Mortality could reach up to 30% in fish from 1 g to 100 g. During the first month of cage farming, Asian sea bass were most susceptible to monogenean parasites such as

*Neobenedenia* spp. *S. iniae* was a major cause of fish mortality during the grow-out phase, right up to market size. Associated cumulative mortality could vary from 30 to 80% and the suddenness of the onset of the outbreak made antibiotic treatment ineffective.

Once a good understanding of the disease epidemiology is available, adequate treatment, control measures and prophylactic actions can be effectively formulated (Komar *et al*., 2005). An example of appropriate health management measures for Asian seabass farming could be portrayed as follows (Table 3):

Table 3: Control measures for major diseases in Asian seabass farming

| **Pathogens** | | **Treatment** | **Prevention** |
|---|---|---|---|
| Parasites | *Neobenedenia* spp. | • Freshwater bath<br>• Formalin bath<br>• Oral anti-monogenean drugs | • Regular prophylactic bath treatment |
| Viruses | Nodavirus | • None | • Egg ozone treatment<br>• Breeder selection<br>• Future broodstock vaccination |
| | Iridovirus | • None | • Future vaccination |
| Bacteria | *Vibrio* sp. (big belly syndrome) | • None | • Strict hygiene<br>• Improved weaning diet<br>• Regular dry-out of tanks |
| | *T. maritimum* | • Formalin bath with benzalkonium chloride if applied very early | • Reduce stress<br>• Reduce fish handling<br>• Future vaccination |
| | *S. iniae* | • None | • Vaccination |

General approaches to health management are described below.

**Aspects of health management practices – to improve fish health and survival**

<u>Responsible movement of live aquatic animals</u>:
Increased trade of live aquatic animals and the introduction of new species for farming, without proper quarantine and risk analysis in place, result in the further spread of diseases. A scientific process should be undertaken to assist decision making regarding the risks versus the benefits for the species intended to be imported. Such an import risk analysis includes hazard identification, risk assessment, risk management and risk communication (Bonadad-Reantaso *et al*., 2005; Mohan, 2003).

<u>Hygiene, disinfection and biosecurity:</u>
Hygiene and biosecurity aims at preventing the introduction of any disease agent into the farm and should limit the spread of disease. Good sanitation practices in cage-farming systems are difficult to implement as there are no filters or barrier between the cage environment and its surroundings (where pathogens can be found). However, it is necessary to reduce the risk of contamination by simple management practices aimed at reducing the pathogen pressure in the environment. Such practices include proper system maintenance by removing excess suspended particles and uneaten food which is a potential substrate for pathogens. Moreover, their presence reduces water flow and therefore the available dissolved oxygen for the fish. The frequency of net cleaning depends on the severity of the fouling. The removal of dead or moribund fish on a daily basis is an important sanitary measure, as well as important for record keeping. Dead fish, especially in temperate and warm water, decay quickly and can be a critical source of horizontal disease transmission as the remaining live fish will tend to eat the dead fish.

To minimize disease transmission, species should not be mixed in the same farm or even the same water area. An all-in, all-out approach, ideally with a period of fallowing in between, should be considered as a way to break the cycle of infectious disease. Zoning policy should be developed and implemented for disease control. While the above have been practiced in the livestock sector and salmon industry, it is far from the reality in Asian aquaculture.

Selection of hatchery-raised fingerlings:
The overall health status of fry and fingerlings is a critical factor for a successful production cycle. When choosing a species to be farmed, preference should be given to species that are already available from hatcheries. The attention given to fish in the hatchery, and the availability of specific larval diets required to obtain strong juveniles, will allow for a constant supply of good quality fingerlings. Presently, the availability of hatchery-raised fingerlings is still limited. However, somel government-owned high-tech hatcheries have been built in order to provide better quality SPF fry for stocking. The availability of hatchery-raised fingerlings should certainly increase in the near future.

Record keeping and disease monitoring:
Often, in small scale operations, recording of farming parameters such as daily mortality, feed consumption, growth rate and water quality parameters is not standard. Record keeping is crucial in understanding the epidemiology of diseases and can also allow us to identify critical management points in the production cycle. The collection of this historical data will help us take early action in the case of disease outbreaks.

Good husbandry practices:
Choosing the optimal fish density is important. Depending on the fish species and water quality conditions (especially the oxygen saturation of the water), there is a certain fish density that should not be exceeded. A common mistake is to increase the stocking density to compensate for a decrease in survival rate. This is a source of stress for the fish that can lead to skin injuries, low performance and a higher susceptibility to disease. In contrast, stocking fish optimally will allow fish to grow to their best potential and decrease the risk of disease outbreaks.

Good feed management:
Fish should be fed with a balanced diet as nutritional deficiency can have an adverse impact on immunity and disease resistance. Dry pelleted feed adapted to each farmed species is preferred over trash fish as it gives a consistent supply of nutrients free from pathogens. Some international feed companies have invested a considerable amount of resources in the development and supply of nutritionally-balanced pelleted feed for marine and freshwater fish. A wider usage of pelleted diet should contribute to an increase of the overall health status of the fish, thereby reducing nutrition deficiencies and the risk of disease. At the farm, dry feed should be appropriately stored in a cool and ventilated environment to avoid moulding that could lead to mycotoxicity problems.

To minimize stress:
Stress can be defined as any stimulus (physical, chemical or environmental) which tends to disrupt homeostasis in an animal. Under stressful conditions, fish must expend more energy to maintain homeostasis and less energy to combat disease. Aquatic organisms are fundamentally different from terrestrial animals: they are immersed in their environment and can not go somewhere else. Some disease agents are almost always present in the water (ubiquitous). These opportunistic pathogens will invade fish when they become stressed. Some good practices to reduce stress include:

a) Starvation before handling of fish: handling is a source of stress as it puts fish under extreme conditions (overcrowding, manipulation outside the water, etc.). Starving the fish for 24 - 48 hours prior to handling will reduce stress and will avoid the deterioration of water quality when fish are overcrowded.

b) Sedation during handling and transportation: in situations such as handling or transportation, fish are overcrowded. Therefore, there is a higher risk of skin injuries. To avoid such damage, sedation using approved fish anaesthetics/sedatives is recommended as it decreases the level of stress and possible skin injuries.
c) Grading of fish to give a homogeneous population: when size variation increases in a cage, it often creates competition between the larger and the smaller fish. This can result in stress, especially for the smaller fish. In addition, when feeding, the bigger fish are stronger and get more feed. As a consequence, the smaller fish get weaker and more susceptible to disease. As they get sick, they will also become a source of infection for bigger fish as size variation is also a source of cannibalism (leading to horizontal disease transmission).
d) To maintain good water quality: water quality should be monitored on a regular basis and be maintained at optimal conditions.
e) To avoid over-feeding: over-feeding can induce stress and unconsumed feed will pollute the water.

<u>The pitfalls of using chemicals/antibiotics:</u>
While under certain circumstances antibiotics can help to control some bacterial diseases, there are many problems associated with their use (see earlier). Also, as sick fish do not eat, the efficiency of delivering antibiotics orally is often questionable.

Most countries have strict regulations on the use of antibiotics and chemicals. For example, malachite green, chloramphenicol and furazolidone are actually banned from use in most countries (including the major fish-importing countries) and severe measures are taken against exporters of fish and shellfish that contain residues. Regulations on acceptable withdrawal periods must be adhered to.

Between species, differences exist in drug disposition and metabolite formation. Moreover, temperature and composition of the water (fresh/salt water, pH value, hardness, organic material content, etc.) may affect the absorption, distribution, metabolism and excretion of drugs. Per species, relevant pharmacokinetic data are often lacking. Therefore, extrapolation of data from one species to another is difficult (Intervet, 2003).

Changes in the taste of water caused by the addition of antibiotics can influence the intake of medicated feed negatively. Also, chemotherapeutics can negatively influence the immune system of fish (e.g., tetracyclines). Added to the water in recirculation systems (e.g., for eel, catfish and turbot), antibiotics may disturb the biological clearing systems and (bio)filters. Especially in aquaria, there is a risk of serious disturbance when antibiotics/biocides are not used properly. Added to the water, antibiotics can rapidly lead to induction of resistant bacterial strains. The following attention should be paid regarding the use of <u>chemicals/antibiotics:</u>

- Antibiotics should be used only as a last resort.
- Definite disease diagnosis, including antibiotic sensitivity, should be made before administering antibiotics.
- Observe the regulations on banned chemotherapeutants. Maximum residue limits and withdrawal periods should be considered before harvesting the fish.
- The tolerance of the species should be known. For safety reasons, always first try the chemical/antibiotic at a given dose and treatment time with a small number of fish. Fish of different species and sizes under different water conditions (salinity, alkalinity and temperature) may well react differently. In general, lower water temperature requires a longer treatment duration and *vice versa*.

- Follow the correct dose and treatment time. Pay close attention to concentration of the active ingredient and adjust the dose accordingly if the chemical is not pure (< 100% active).
- If using an immersion approach, add the chemical/antibiotic to a small portion of the water in a small container and make sure it is dissolved completely before use. Then pour this ‘concentrate’ into a tank/container to reach the desired final concentration and mix well before placing the fish into it.
- Withhold feed for 8-24 hours depending on the fish size.
- Treat during the coolest part of the day.
- Monitor water oxygen levels before, during and after treatment; if necessary, aerate as required.
- Keep a close watch on the fish during treatment and be prepared to stop treatment immediately if adverse reactions (e.g., gasping for air, strange swimming behaviour, etc.) are noted.
- In some cases, such as the occurrence of a serious disease problem, eradication should be considered. Eradication includes removal of all susceptible species followed by thorough cleaning and disinfection of the cages/nets or ponds.

**Vaccination, a powerful tool that complements other health management practices**

As mentioned above, there are many problems associated with the use of antibiotics. In addition to developing antibiotic resistance, sick fish often do not eat and the efficiency of delivering antibiotics orally is often questionable. Two key technical comments should be made regarding antibiotics: 1) by nature they are active mainly against bacterial pathogens and have no direct effect against viral and other pathogens and 2) antibiotics work only as long as they are present in the appropriate concentration in the target organ.

Whereas the use of antibiotics is a curative measure to treat an existing infection, in contrast, vaccination is a preventative measure, dependent on the immune system of the animal. Vaccines can act against bacterial, viral and, at least experimentally, parasitic infections and they will usually act only against the targeted pathogens. The duration of protection obtained with vaccines normally largely exceeds that of antibiotics. Figure 4 clearly indicates that the introduction of vaccines has greatly reduced the use of antibiotics in Norwegian salmon production.

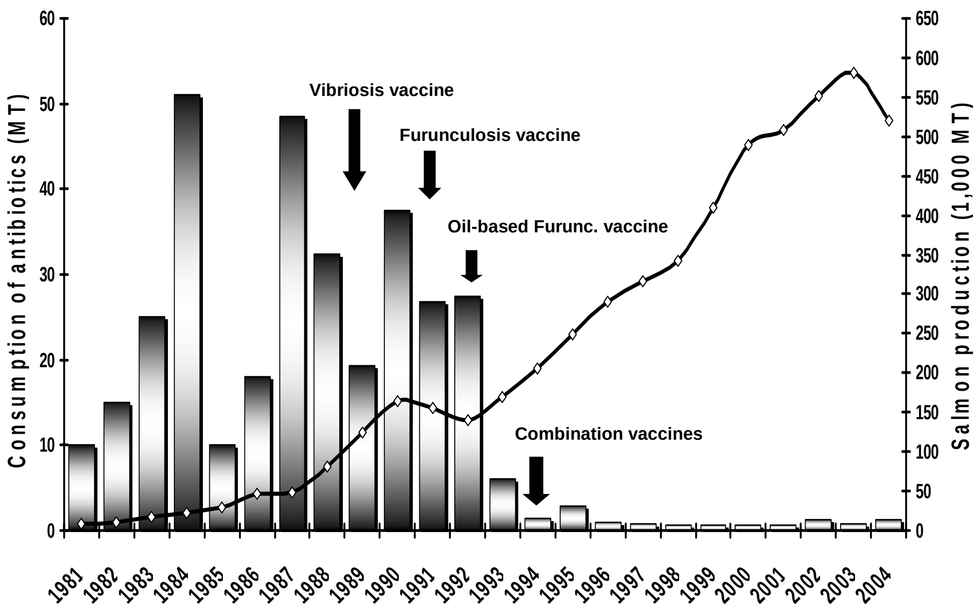


Figure 4: Norwegian salmon production, consumption of pure antibiotics and the effect of vaccines.

Vaccines are various preparations of antigens derived from specific pathogenic organisms that are rendered non-pathogenic. They stimulate the immune system and increase the resistance to disease from subsequent infection by the specific pathogen(s).

Vaccination can be compared with an insurance policy - it is worth paying a basic fee for a policy that would later cover the costs of a more expensive disease that may occur. Similarly, vaccination is a preventive measure that protects fish against a future disease and the associated costs due to morbidity, mortality and therapeutic treatment. However, just as an insurance policy will cover the costs of an accident only if this fits the clauses of the insurance contract, a vaccine (generally) only protects against specific diseases. For example, a vaccine against *S. iniae* infection will protect the vaccinated fish against this specific species of *Streptococcus* but not against another streptococcal species such as *S. agalactiae*.

In the past, fish vaccines were only available for salmonid species. But the situation is changing with new vaccines being registered in Asia for Asian species (Grisez and Tan, 2005). However, it must be remembered that vaccination is only one of the tools for good health management and it is not sufficient on its own to guarantee high survival and profitability. All the measures mentioned previously are needed to sustain a successful aquaculture industry in Asia.

In summary, some of the practices recommended for the fish farming industry for disease control are given in Table 4.

**Table 4. Some practical recommendations to fish farmers in Asia**

| DOs | DON'Ts |
|---|---|
| 1. Use healthy (not necessary cheap) fry | 1. Place your farm too close to others |
| 2. Quarantine incoming animals | 2. Have several species in one farm |
| 3. Use formulated pelleted feed | 3. Use fingerlings from unknown source |
| 4. Grade fish periodically | 4. Overstock (to overcome low survival) |
| 5. Monitor water quality | 5. Use trash fish |
| 6. Record diseases and feeding | 6. Overfeeding |
| 7. Observe withdrawal period of drugs | 7. Use drugs without diagnosis |
| 8. Remove dead fish at least once a day | 8. Leave or throw dead fish in the water |
| 9. Clean and disinfect equipment | 9. Restock fish without cleaning the cages |
| 10. Vaccination if available | 10. Ignore diseases until heavy mortality occurs |

## CONCLUSIONS AND THE WAY FORWARD

Aquaculture production in Asia greatly exceeds that of the rest of the world. However, many examples show that rapid expansion of the industry has been at the cost of deteriorations in health and environmental conditions. In general, production efficiency is low with high mortality due to disease, good health management practice is lacking, and few specific disease preventative measures or products are available. Several factors underline the present problems. The wide variety of species cultured in Asia results in the thin spread of resources across the species, resulting in sporadic and fragmented knowledge on each individual species and limiting the optimization of culture of any given species. In Northern Europe, salmon farming has been the only focus for decades and the production process is therefore fully optimized. In Asia, proper disease diagnosis and systematic collection of pathogen strains is limited. Farmers often use antibiotics without knowing the disease agent because of the lack of diagnostic support and alternatives for disease control. The use of wild fingerlings, over stocking, mixing species, generations over-lapping and the ubiquitous use of trash fish as the principal source of feed further, complicate the issue.

In recent years, an increased focus on diagnostic techniques is apparent. Furthermore, several government-owned high-tech hatcheries are being erected in order to provide better quality fry for stocking. Some international feed companies are investing a considerable amount of resources in the development and supply of nutritionally-balanced eco-friendly pelleted feed for marine fish and shrimp. Significant progress has been made in the field of vaccine research and development (Grisez and Tan, 2005). Besides yellowtail in Japan and grass carp in China, a commercial vaccine has recently been launched for use in Asian seabass, tilapia and other species in some Southeast Asian countries (Komar *et al*., 2005).

Sustainability is a shared responsibility. It rests with all stakeholders concerned directly and indirectly with aquaculture (Figure 5). Collaborative efforts from governments, non-governmental agencies, academia and the private sector are on-going in order to standardize aquaculture practices (codes of practice) and to promote good health management for disease control.

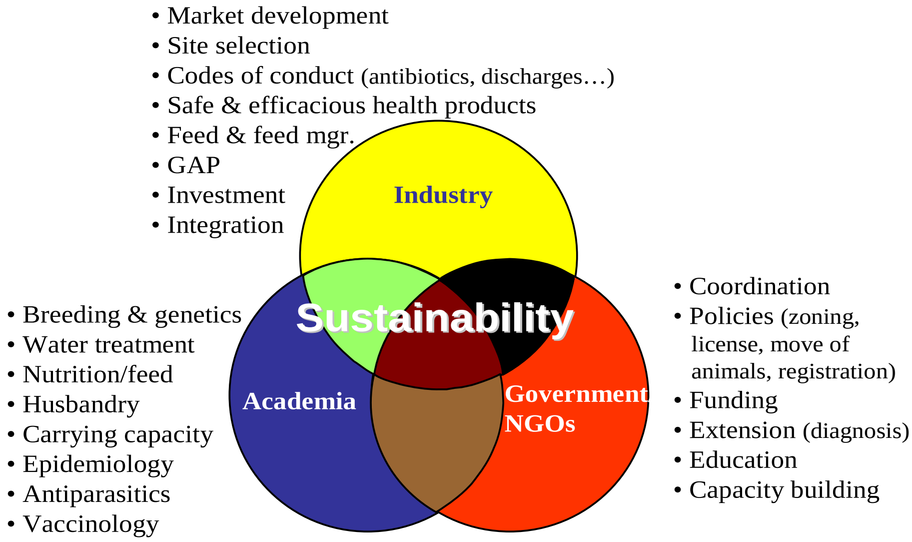


Figure 5. Sustainability is the shared responsibility of all stakeholders, including the private sector, governments and academia.

As Asian aquaculture continues to grow, disease problems will inevitably become worse unless key steps are taken. Under the threat of disease epidemics and the vigilance of governments and consumers regarding food safety, the industry must undergo changes. Therefore, disease research and the implementation of new disease control concepts are inevitable. Collectively, this includes the use of healthy fry, quarantine measures, optimized feeding, good husbandry techniques, disease monitoring (surveillance and reporting), sanitation, vaccination, and the responsible use of chemicals and antibiotics when diseases occur. Overall, the emphasis must be on prevention rather than cure (treatment). This is the only way to sustain a responsible yet profitable Asian aquaculture industry.

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