Frontiers in Aquaculture, Pages 19–34
Edited by: Sundaray, Sukham, Mohanty and Otta

2

Bio-Security in Aquaculture

P. Nila Rekha

Central Institute of Brackishwater Aquaculture 75, Santhome High Road, R.A. Puram, Chennai-600028

INTRODUCTION

Aquaculture is the fastest growing food producing sector in the world. Besides providing food, it generated employment and income, and supports livelihoods of many millions of people all over the world. Diseases and epizootics are considered to be major concerns for increasing production through aquaculture and for the sectoral development. Most diseases threats have so far resulted from unregulated movement of live aquatic animals and associated introductions and/or transfers of pathogens. Over the years, many attempts have been made to prevent to control disease emergencies in aquaculture, both with documented successes and failures. Controlling diseases in small-scale production systems, which are the core of most global production, is particularly challenging as implementation of control measures is difficult, and resources for prevention are limited. It has been realized that the best approach to managing aquatic animal heath is to improve bio-security at all levels. Bio-security provides a strategic framework and integrated approach to assess and manage the risk that threaten food safety, animal life and health, plant life and health, and associated environmental perils.

Health maintenance in aquaculture is now considered to be one of the most important aspects of aquaculture development and management.

The poultry industry is used as a cornerstone or point of departure for application of bio-security is a vital activity, it is one of several vital activities that are interactive and interdependent. These other activities are genetics, nutrition, health and improved production systems.

Although aquaculture is the fastest growing food-production sector, diseases are a primary constraint to the growth of aquaculture in many parts of the world. A multitude of factors has contributed to the health problems currently faced by aquaculture. Over the past three decades, aquaculture has expanded, intensified, and diversified, based heavily on movements of live aquatic animals and animal products (broodstock, seed and feed). Changing circumstances and perspectives, and especially, world trade liberalization have triggered this trend. New outlooks and directions have accelerated the accidental spread and incursion of diseases into new populations and geographic regions, for example, through movements of hatchery produced stocks, new species for culture, and enhancement and development of the ornamental fish trade.

Factors such as food security, protection of the natural environment, biodiversity conservation, societal demands for healthy products, and the general socio-economic development and work-being of a nation have driven the improvement of biosecurity practices.

In aquaculture, bio-security is a collective terms that refers to the concept of applying appropriate measures (e.g., proactive disease risk analysis) to reduce the probability of a biological organism or agent spreading to an individual, population or ecosystem, and to mitigate the adverse impact that may result (Arthur *et al.*, 2004). This analysis is done in a way that incorporates the best information available on aspects of husbandry, epidemiology, and sound science. The goal can be thought of as minimizing both exposure to and economic loss form disease-related causes, physico-chemical impacts, ecological impacts, nutritional parameters, predation, and more. Bio-security stresses the development of a series of protocols to respond to disease exposure risk that have been assessed through a careful on-site audit, usually by an aquatic animal veterinarian or a qualified aquatic animal health expert.

Biosecurity in aquaculture is the protection of shellfish from infectious agents (viruses, bacteria, fungi or parasites). It is a set of practices that will reduce the probability of a pathogen introduction and its subsequent spread from one place to another. It is the measures and methods adopted to secure a disease free environment in all production phases for improved quality. The shrimp aquaculture has been experiencing severe setbacks due to the devastating viral diseases. These diseases are believed to be transferred between regions through the transportation of hatchery brood stock, post-larvae and shrimp products. Once new pathogens are imported to an area, infection of wild stock appears to be inevitable, eliminating future possibilities of using uncontaminated wild stock to culture. Mortality due to diseases and decreased production due to infections are major factors for economic loss but also a serious food safety concern for the consumers. In addition, as the density of shrimp in intensive farming becomes more concentrated and actively managed, the probability of individuals coming into contact or becoming a source of potential pathogen is much greater. Thus, it is critical to implement appropriate safeguards in production facilities to protect the health of aquatic animals. These safeguards include diagnostics, disease prevention, disease control etc., which are imperative and should be enforced through Ecologically Sustainable Development (ESD) strategies.

The basic elements of bio-security programme in shrimp hatchery include the physical, chemical and biological methods necessary to protect the hatchery from the consequences of all disease that represent high risk. Designing an effective bio-security program requires an understanding of the aquaculture operation, general principles of disease transmission, and knowledge of the shellfish maintained in the facility.

Components of Bio-security

The components of bio-security in an aquaculture facility comprises (i) prevention, which means protection of the cultured/managed organisms from the harmful biological effects of undesirable organisms (especially pathogens) and the protection of humans and ecosystem from the adverse of the introduced culture system, and its targeted and non-targeted organisms. (ii) Control means control of the culture system, the movement of organisms, risk related activities and monitoring and recording of actions taken and (iii) contingency planning is planning for all possible eventualities.

Bio Security Protocols in Shrimp Hatchery

The categories of bio-security issues in shrimp hatcheries may be either internal concerning the introduction and transfer of pathogens within the facility, or External concerning the introduction and transfer of pathogens from outside sources to the facility or vice versa.

Within aquaculture facilities, if diseases do occur, there are several options including: viz., treatment, containment and elimination. The treatment means application of methods that reduce the effects of the diseases. Containment means restriction of the diseases from spreading to other tanks/facilities and elimination means the total elimination of the diseases from the vicinity.

Implementation of a bio-security for a shrimp hatchery should include the following elements:

- Use of specific pathogens free (SPF) or high health (HH) shrimp stocks
- The use of quarantine areas for all incoming stock
- The analysis for disease of all incoming stock (i.e. through PCR or other immunodiagnostic technology)
- Treatment of all incoming water sources to eliminate pathogens
- Sterilization and maintenance of clean equipment and materials
- Personal hygiene measures including washing of hands and feet and clothing
- Knowledge of the potential pathogenic diseases and the sources of risk and methods and techniques for their control and/ or eradication
- The development and use of stock that are resistant to specific pathogens (SPR)
- Maintenance of optimum environmental conditions within all phases of the facility
- Application of immune enhances and probiotics in order to enhance the ability of the stock to resist or tolerate diseases.

APPROACHES FOR THE IMPLEMENTATION OF THE BIOSECURITY PROGRAMME

Standard Operating Procedure (SOPs)

Each hatchery should develop its own set of Standard Operating Procedures (SOPs). Standard Operating Procedures (SOPs) outlining the control protocols for the hatchery should be desired in a comprehensive document that covers each stage or process of the production cycle. The document should include details of all of the critical control points (CCP) and describe how to perform each task to control the associated risk. Once the protocol for hatchery operation is documented, the SOPs should be given to all personnel, and a copy should be available for all workers. It is advisable to have a group of people with higher technical who can supervise and train workers in the execution of each step of the SOPs training or experience.

Training in Bio-security maintenance should be an important competent of the hatchery process. The bio-security risk posed by each area of the hatchery should be determined. Different areas of the hatchery may be classified according to the level of risk of disease introduction or transfer.

Experts have described four classifications:

- Quarantine areas where a pathogen of concern is potentially present or suspected;
- High sensitivity areas requiring minimum exposure to avoid potential pathogen introduction or transfer;
- Medium sensitivity areas with lower risk of pathogen introduction or transfer; and
- Low sensitivity areas in which risks of pathogen introduction or transfer are unlikely.

These classifications can be modified if required and the changes reflected in an updated version of the SOPs. Specific protocols and restrictions may be adopted for each of these bio-security levels of prevents pathogen entry or transfer.

The FAO Technical Guidelines on Aquaculture Development for the Code of Conduct for Responsible Fisheries outlines a number of areas where SOPs should be developed. These will be specific for each type of facility management practices.

- Responsible aquaculture management practices
- Improved selection and use of feeds, additions and fertilizers
- Safe, effective and minimal use of therapeutants, drug, hormones and other chemicals
- Effective operation and health management promotion
- Regulated use of chemical inputs
- Disposal of wastes

- Food safety of aquaculture products
- Establishment of appropriate mechanisms for the collection and dissemination information
- Appropriate procedures for broodstock selection and the production of eggs and larvae.

This document will suggests SOPs for each of these areas, suitable for Indian black tiger shrimp (*P. monodon*) hatcheries. However, each hatchery may modify the SOPs to suit the own conditions and situations without compromising the concept and objective of the SOP.

Hazard Analysis Critical Control Point (HACCP) Approach

Development and implementation of bio-security protocols can be made easier by a Hazard analysis critical point (HACCP) approach. The HACCP approach is a preventive risk management system based upon a hazard analysis and has been widely used to identify and control risks to human health in food-processing systems. Critical limits are set at critical control points (CCPs) in the system where controls must be applied to prevent, eliminate or reduce a hazard. Monitoring and corrective actions are then implemented. HACCP principles have been applied as a risk management tool at control viral pathogens at shrimp research and production facilities.

Application of HACCP principle includes:

- Perform a systematic hazards analysis
- Determine critical control points
- Establish critical limits
- Determine appropriate corrective measures
- Establish monitoring procedures
- Develop verification procedures and
- Design record keeping systems

Stages of Bio-security for Shrimp Seed Production

Shrimp hatcheries should be designed (or modified, in the case of existing hatcheries to ensure good bio-security, efficiency cost effectiveness and the implementation of hatchery operating procedures. To mange health and maintain bio-security in shrimp hatcheries the basic hatchery production process starting from broodstock options through transportation of post-larvae out of the facility has been divided into two broad categories viz.,

Pre-spawning bio-security

Post-spawning bio-security

Pre-spawning Bio-security

The pre-spawning process includes procedures for broodstock collection/production, landing and holding, selection, transport, utilization, quarantine, health screening, maturation and nutrition. Also covered are spawning, egg/nauplius hatching, selection, disinfection and washing, and holding and disease testing of nauplii and their transportation.

Post-spawning Bio-security

The post-spawning bio-security process includes: Larval rearing unit preparation, Larval rearing management, Health management, Larval nutrition and feed management, Important larval diseases, General assessment of larval condition, Quality testing/ selection of PL for stocking, PL harvest and transportation, Nursery rearing, Timing of PL stocking, Use of multiple species in shrimp hatcheries, Documentation and record keeping; and Research and development and extension requirements and equipments should be thoroughly cleaned on a regular basis, cleaned and disinfected after use, and cleaned and disinfected again starting a new production cycle

In general all the bio security aspects to be followed in a hatchery for the shrimp seed production has been narrated hereunder

Infrastructure Requirements

Shrimp hatcheries should be designed (or modified, in the case of existing hatcheries) to ensure good bio-security, efficiency, cost-effectiveness and the implementation of the hatchery standard operating procedures (NACA, 2005). A well-designed shrimp hatchery will consist of separate facilities for quarantine, acclimatization, maturation, spawning and hatching, larval and nursery rearing, indoor and outdoor algal culture, and for the hatching of *Artemia*. Additionally, there will be supporting infrastructure for the handling of water (facilities for abstraction, storage, filtration, aeration, heating and distribution), and feed (laboratories for analysis and preparation and storage facilities) as well as maintenance areas, packing areas for nauplii and PL, offices storerooms and staff living quarters. The physical separation or isolation of the different production facilities is a feature of good hatchery design and should be incorporated into the construction of new hatcheries. In existing hatcheries with no physical separation, effective isolation may also be achieved through the construction of barriers and implementation of fence around the flow controls. The hatchery facility should have a wall or fence around the periphery of the property, with enough height to stop the entrance of animals and unauthorized persons. This will help to reduce the risk of pathogen introduction by this route, as well as increase overall security.

Water Quality and Treatment

Water for the hatchery be filtered and treated to prevent entry of vectors and any pathogens that may be present in the source water. This may be achieved by initial filtering through sub-sand well points, sand filters (gravity or pressure), or mesh bag filters into the first reservoir or settling tanks. Following primary disinfection by chlorination, and after settlement, the water should be filtered again with a finer filter and then disinfected using ultraviolet light (UV) and /or ozone. The use of activated carbon filters, the addition of ethylene diamine tetra acetic acid (EDTA) and temperature and salinity regulation may also be features of the water supply system.

Each functional unit of the hatchery should have independent water treatment facility and it should be isolated from other water supply systems for other areas. Separate recirculation systems may be used for part or the entire hatchery to reduce water usage and further enhance bio-security, especially in high-risk areas.

The discharged water from the hatchery, particularly that is known or suspected to be contaminated (for example, water originating from the quarantine areas) should be held temporarily and treated with hypochlorite solution (>20 ppm active chlorine for not less than 60 min) or another effective disinfectant prior to discharge. This is particularly crucial where the water is to be discharged to the same location as the abstraction point.

Brood Stock Selection

Healthy brood stock that are not carriers of serious pathogens must be selected in order to achieve successful hatchery production. When using domesticated shrimp ,it is essential to obtain adequate background information on the origin of the stocks and their past performance.

Brood Stock Quarantine

The brood stock quarantine facility should be completely isolated from the rest of the maturation and hatchery facilities since it is an area of high risk for disease transmission

The quarantine unit should have the following characteristics

- It should be adequately isolated from all rearing and production areas to avoid cross contamination
- It should be in an enclosed and covered building with no direct access to the outside
- There should be means provided for disinfection of feet (foot path containing hypo chlorite solution at > 50 ppm active ingredient) and hands (bottles containing iodine PVP (20 ppm and /or 70% alcohol) to be used upon entering the unit
- Entrance to the quarantine area should be restricted to the personnel assigned to work exclusively in this area.
- Quarantine unit staff should enter through a dressing room, where they remove their street clothes and take a shower before going to another dressing room to put on working clothes and boots. At the end of the working shift, the sequence is reversed.

- An adequate number of plastic buckets and /or similar containers should be available in the quarantine room to facilitate effective daily routine movement of shrimp in and out of the facility.
- The quarantine facility should have an independent supply of water and air with separate treatment and disinfection systems and a system for the treatment of effluents to prevent the potential escape of pathogens into the environment.
- The seawater to be used in the facility must enter a storage tank where it will be treated with hypochlorite solution (20ppm active ingredient for not less than 30 minutes) before inactivating with sodium thiosulfate or vitamin C (1ppm for every 1ppm of residual chlorine) and strong aeration.
- All wastewater must be collected into another tank for chlorination (1ppm for not less than 60 minutes) and dechlorination before release to the environment.
- All mortalities or infected animals must be incinerated or disposed of in another approved manner.
- Used plastic containers and hoses must be washed and disinfected with hypochlorite solution (20ppm) before reuse.
- All the implements used in the quarantine unit must be clearly marked and should remain in the quarantine area. Facilities form disinfection of all equipments at the end of each day should be available.

Brood Stock Maturation

Selected disease free and acclimatized shrimp brood stock should be held in maturation area for at least four days before ablation, so that the shrimp have fully recovered from transportation stress. The females for ablation should be above 100 gram in size to ensure good numbers of high quality eggs and nauplii. Males can be any size with a minimum of 70 gram.

Brood Stock Nutrition

The feed area should be adjacent to but separated from the maturation room. A good quality diet and feeding protocol for brood stock are key factors in the production of good quality nauplii. An optimum diet in appropriate manner to maintain the nutritional status and fitness of the brood stock nauplli should be provided. When using fresh feeds such as squid, artemia, mussel, oyster, clams etc efforts must be to ensure that the materials is as fresh as possible. The feeds may be sterilized pasteurized to inactivate any virus as long as this does not affect the acceptability or nutritional quality of the feed. Ideally different types of frozen feeds should be stored in separate freezers.

Spawning and Hatching

Spawning should be taken place in dedicated room separated from the maturation area in order to keep the spawing area clean and to be able to carry out daily washing and disinfection of tanks without disturbing the brood stock. Water- purification steps should be taken including UV light treatment and passage through activated carbon and cartridge filtration to < 1um. The eggs should be collected and washed with adequately treated sea water (filtered and sterilized) and then disinfected using iodine – PVP (50-100 ppm / 10-60 sec) before rinsing again.

Hatching should also be done in a separate room. The nauplii should be collected and washed with adequately treated seawater (filtered and sterlised) and then disinfected using iodine – PVP (50-100 ppm / 10-0 sec).

Nauplii should be harvested using a light to attract them to the water surface.The activity and colour of the nauplii should be evaluated and the percentage of deformities estimated.Harvested nauplii must be held under optimal conditions until they are stocked. The nauplii should be transported at appropriate density.

Larval Rearing and Maintenance

Larval rearing should produce the best quality , high-health post-larvae possible, entrance to the larval rearing area(s) should be restricted, each room should have a complete complement of materials for routine operation, All materials and equipments should be for the exclusive use in each room, and should not leave the room or be used elsewhere, Larvae and post-larvae should be routinely checked for quality. The infrastructure for larval culture should include of one or more units of conical or "V"-shaped larval rearing tanks

Larval Nutrition and Feed Management

High standards of feed preparation must be maintained and the entry to the algal culture and *Artemia* culture rooms must be restricted to unauthorized personnel.

Algae

An extremely high standard of hygiene must be maintained for microalgal cultures. Pure cultures of algae must be maintained using appropriate sanitary and microbiological procedures. All algal culture tanks must be washed and disinfected with calcium hypchlorite solution (10 ppm active ingredient) after each harvesting

Artemia

Measures should be taken to ensure that *Artemia* do not pose a risk of disease introduction, *Artemia* cyst and nauplii should be disinfected and decapsulated. *Artemia* should be hatched at 1-2kg cysts/1000 L of seawater under constant light and vigorous aeration for 24 hours or until fully hatched. After harvesting the *Artemia*, the hatching tanks should be thoroughly cleaned

Artificial Feeds

Although artificial feeds generally do not pose a health risk, they must be properly used and stored.

Larval Health Management

If good numbers of high quality larvae are to be produced, tight control must been maintained on the many factors involved in managing larval health in the hatchery. The stocking density at which nauplii are stocked should not be excessive. Good water quality must be maintained. Water exchange should be carefully handled. Hatcheries should also consider the use of probiotics and bacterial enzyme. Each separate unit of larval rearing tanks within a hatchery or, preferably, the whole hatchery should be stocked with nauplii in as short a time period as possible. The quantity, quality & management of feed should be closed monitored. For the majority of the larval feed requirements, reliance should still be placed on high quality live feeds, including algae and *Artemia*. Assessment of larval condition should be one of the main activities carried out in the hatchery. Good hatchery management should be practiced to ensure high post-larval quality. A table summarizing the three levels of post-larval quality and the points system should be used to determine the fate of the PL. The risk of stocking a given batch of post-larvae must be carefully assessed. Post-larvae must be carefully and appropriately packed for shipping to grow-out facilities. A comprehensive and up-to-date system of documentation and record keeping should be established.

Maintenance of the Facilities

After each cycle, sanitary dry out (for larval rearing) for at least every three to four months (for maturation facilities), with a minimum dry period following cleaning of seven days should be practiced. This will help prevent the transmission of disease agents from one cycle to the next. Concrete tanks painted with marine epoxy or plastic-lined tanks are easier to clean and maintain than bare cement tanks. Tanks used for broodstock spawning, egg hatching and holding of nauplii and post-larvae should be thoroughly cleaned after each use. The procedures used for cleaning and disinfection are basically the same for all tanks and equipment. They include scrubbing with clean water and detergent to loosen all dirt and debris, disinfecting with hypochlorite solution (20-30 ppm active ingredient) and/or a 10% solution of muriatic acid (pH 2-3), rinsing with abundant clean water to remove all traces of chlorine and/or acid, and then drying. The walls of tanks may also be wiped down with muriatic acid; outdoor tanks and small tanks can be sterilized by sun drying. All equipment and other material used in the room (filters, hoses, beakers, water and air lines etc) can be placed in one of the tanks containing hypochlorite solution after first cleaning with a 10% muriatic acid solution. All hatchery buildings (floors and walls) should be periodically disinfected. Before stocking tanks for a new cycle, they should once again be washed with detergent, rinsed with clean water, wiped down with 10% muriatic acid and once more rinsed with treated water before filling. Disinfection procedures may require adjustment according to the special needs of the facility. Appropriate safety measures must be taken when handling the chemicals used for disinfection.

Bio-securities in Shrimp Farms

A practical example of bio-security program is demonstrated by a shrimp disease control project in southern India implemented in 2000 by the Marine Products Export Development Authority (MPEDA) of India, Ministry of Commerce and Industry, with technical assistance from the Network of Aquaculture Centers in Asia-Pacific (NACA) (Padiyar *et al.*, 2003).

An epidemiological approach may be made to identify the key risk factors for white spot disease (WSD) and to better understand the role of these factors in disease outbreaks and low pond production. The outcomes of this study led to the development of better management practices (BMPs) to reduce the identified risks, followed by wide consultation with farmers and other agencies to gather consensus on the study finding and their practical application to improve performance of shrimp farming systems.

The BMPs include three main management strategies focusing on: (a) pond bottom preparation and water management prior to stocking, (b) seed selection and stocking, and (c) Post-stocking management. On-farm testing of BMPs followed, using a few selected farms. The process was monitored and evaluated to understand benefits and constraints. Information on risk management strategies was widely disseminated or farmers. Improve pond level risk management practices reduced incidence of disease and led to improvements in profits and productivity.

Village demonstrations were expanded to 256 ponds covering over 125ha of land belonging to 98 farmers. The farmers voluntarily worked with the study team and formed an "Aquaclub" to implement the BMPs through this local networking approach. The "Aquaclub" met regularly, promoted widespread adoption of BMPs gained significant benefits from this cooperative approach.

The details of the BMPs developed and implemented from the above project are presented below.

a. Pond bottom preparation and water management prior to stocking

- Sludge removal and disposal away from the pond site.
- Plowing on wet soil if the sludge has not been removed completely

- Water filtration fusing twin bag filters of 300μ mesh size
- Water depth of at least 80cm at the shallowest part of pond
- Water conditioning for 10-15days before stocking

b Seed selection and stocking

- Uniform size and color post-larvae (PLs), actively swimming against the water current.
- Nested polymerase chain reaction negative PLs for WSD (using batchers of 59PLs pooled together), If the test turns negative, it indicated that the prevalence of WSD infected PLs is less than5% in that population at 95% confidence.
- Weak PL elimination before sticking using formalin (100ppm) stress for 15-20 minutes in continuously aerated water.
- On farm nursery rearing PLs for 15-20 days
- Stocking during the first week of February to the second week of March
- Stocking into green water and avoiding transparent water during stocking.

c Post stocking management

- Use of water reservoirs, and 10-15 days aging before use in grow out ponds.
- Regular use of agricultural lime, especially after water exchange and rain
- No use of any harmful/banned chemicals
- Use of feed check trays to endure feeding based on shrimp demand
- Feeding across the pond using boat/floating device to avoid local waste accumulation
- Regular removal of benthic algae
- Water exchange only during critical periods
- Weekly checking of pond bottom mud for brakishwater organic waste accumulation and unpleasant odor.
- Regular shrimp health checks, and weekly health and growth monitoring using a cast net.
- Removal and sage disposal of sick or dead shrimp
- Emergency harvesting after proper decision-making
- No draining or abandoning of disease-affected stocks,.

The farm level biosecurity experience in India suggests a need to carefully develop situation-specific BMPs with farmers (based in general BMP principles)n tailored to the faring systems (based in stocking densities, ability to maintain water reservoirs, source, water quality, etc.) and investment capacity of individual farmers.

Educating farmers about the risks, engaging them in assessing and managing the risks through a cooperative approach via networking and self-help programs are important components of a bio-security program.

The FAO has provided technical and financial assistance for expanding and widely applying the concept and developing moiré situation-specific BMPs.

The issue of application of BMPs and the management of clusters of shrimp farms and farmers-cluster management in small-scale shrimp aquaculture–taking into consideration the lessons learned and addressing broader environmental, social, and economic sustainability of the sector, based on an epidemiological approach to health management.

Bio-security Awareness at the Farm Level

The above two examples show how important bio-security awareness at the farm level is and how such awareness, or lack thereof, can impact on the economic viability and profitability of an enterprise. The following outlines a process that is designed to ensure a high level of awareness in farm staff, irrespective of the size of the farm.

Start with the Right People

Sometimes, one has to make do with what one has, if possible, employing people who are keen, willing to learn, and motivated can significantly help the process. Disgruntled employees can seriously jeopardize the process.

Instill a Sense of Pride in What Farm Staff do and in the Venture/Company

Farm staff who are proud of their farm and proud of the company they work for are far more willing to do what it takes to protect the health of the aquatic animals they are farming than unhappy or disgruntled staff. Creating this sense of pride and caring for employees will pay dividends in the process. This is often not easy, requiring the creation of a positive company or enterprise culture in which staffs are made to feel important and valued.

Train Farm Staff in the Skills of Fish Health (Including an Understanding of the Concept of Bio-security)

Education is at the heart of creating bio-security awareness. It instills in the farm staff an understanding of potential sources of healthy risks and importantly, how to maintain optimum health in the aquatic animals under their care. Maintaining optimum health is a corner stone of bio-security; having healthy stock decreases the overall risk of disease.

Having farm staff take training courses at a college or institution can expedite the teaching process, but it must go further than this. Farm staff needs to understand how the training relates to their own farm and make sure a significant portion of this learning is farm based. Applied training at the farm site itself will ensure this understanding.

Let Farm Staff Improve on What Theory have been Taught, i.e., give them Some Ownership of the Process

It is important to have standard operating procedures (SOPs) and systems in place to minimize the fish health risk on a farm. The implementation of such systems and procedures can help ensure consistency throughout different operations within a company or enterprise and is necessary and worthwhile. Enrolment of the farm staff themselves, however, in the development and creation of these SOPs and systems is sometimes overlooked. Allowing them to contribute encourages ownership and increased commitment and can make a significant contribution to the effectiveness of the farm or organization.

Ensure Farm Staffs use the Skills they have been Taught to Benefit the Enterprise

A good example is the recording of mortalities. Motivated farm staffs want to learn about what they are growing. From an operations perspective, it is extremely useful to have staffs who are knowledgeable about what a "normal" fish/crustacean/mollusc looks like, both inside and out, and to be able to identify what does not look normal. A mortality recording system can be designed so that is encourages farm staff to look at mortalities and categorize their causes. This greatly assists in record keeping and aquatic animal health monitoring, and also maintains and improves the farm staff's skills in early recognition of disease.

Database that are custom designed for documenting mortality numbers and rates and for classifying mortalities based on what the farmer is seeing (e.g., "internal swelling", skin/fin erosion") are useful tools in maintaining bio-security awareness at the farm level. Even small enterprise can benefit by adopting such databases, especially if substantial growth of the enterprise is expected.

Keep Staff Up-to-date with Industry Knowledge

There is often a failure of top management to ensure farm staffs are kept informed of important health development in their own industry. For example, knowledge that there has been a fish health problem on a neighboring farm or in the local area is critical information for the farm staff, especially if there is any indication that the cause of the problem may be infections. Fortunately, it is quite common for farmers from different farms and companies to talk among themselves, but this "grapevine" should not be relied on as a substitute for factual information being provided by the top management in a timely manner.

Maintain Good Communication Channels

It is absolutely critical to encourage bio-security awareness, and minimize risk for the enterprise. Farm staff like talk about what theory is doing; and to varying degrees, they are the eyes and wars of the enterprise. They are constantly observing the fish or other cultured species and what is happening in and around their farm. They often have concerns. Being able to discuss such concerns may assist in the early identification of potential bio-security problems, and allow prompt action to be taken to ensure the problems are dealt with so as to have minimal impact on the enterprise.

Importantly, it is also helps if the farm staff can discuss such concerns at an informal level with a professional who is knowledgeable on aquatic animal health and bio-security and whom they trust and respect. Such a relationship can take time to develop but it is well worth the effort.

Aquaculture Bio-security Policies

Aquaculture bio-security policies vary from farm-level to the international level, and between areas at each of these levels, but several characteristics are essential if aquaculture bio-security policies are to be successfully implemented. These common characteristics include: a) science-based decision making, b) economical and sociopolitical rationales, c) standardized and uniform methods, d) relative ease of application, e) wide recognition, f) vertical and horizontal integration, application, and agreement, g) consistent enforcement, and h) a primary focus on prevention, but with contingencies in place for control and management, or eradication

Conclusion

Bio-security awareness at the farm level is not simply about having footbaths at the entrance to a facility. Bio-security awareness is the creation of a state to mind in farm staff such that there is constant vigilance at the farm level, on fish health issues that may impact the profitability and sustainability of the enterprise. It is not created overnight, but requires effort and resources. Finally though, the cost benefit associated with that effort will be positive and significant.

Bio-security can be applied to aquaculture production systems through a variety of management strategies and by following internationally agreed upon policies and guidelines. In addition, there are a variety of risk assessments that can be used for aquatic animal diseases of finfish, molluscs, and crustaceans. The key elements of bio-security can be summarized as reliable sources of stock, adequate diagnostic and detection methods for excludable diseases, disinfection and pathogen eradication methods, best management practices, and practical and acceptable legislation. Nevertheless, it is almost impossible to determine the economic benefits of a bio-security program if there is no disease outbreak, and aquaculture producers may be reluctant to adopt biosecurity measures that appear to be an additional cost. A disease outbreak in one area, however, in addition to its economic consequences in that area, may cause unintended consequences in other parts of the world.

REFERENCES

FAO (Food and Agricultural Organization of the United Nations), 2003. Committee on Agricultural Seventeenth Rome, 31 March - 4 April 2003, Biosecurity in Food and Agriculture. Item 9 of the Provisional Agenda. On-line version, http://www.fao.org/DOCREP/MEETING/006/Y8453E.HTM#P35_2595.

FAO, 2003. Health management and biosecurity maintenance in white shrimp (Penaeus vannamei) hatcheries in Latin America. FAO Fish Tech. Pap. No. 450. Publ. Rome, Italy, 62 pp.

FAO, 2005. Improving Penaeus monodon hatchery biosecurity: an Indian experience. FAO Fisheries Technical Paper XXX 128 pp.

Fegan, D.F., Arthur, J.R., Subasinghe, R.P., Reantaso, M.B., Alday de Graindorge, V., Phillips. M.J., 2001. Consultant Report: A review of trans-boundary aquatic animal pathogen introductions and transfers. Trans-boundary Aquatic Animal Pathogen Transfer and the Development of Harmonized Standards on Aquaculture Health Management. Report of the joint APEC/FAO/NACA/SEMARNAP Workshop, Puerto Vallarta, Jalisco, Mexico, 24-28 July 2000. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. pp. 132-174.

Fegan, D.F., Clifford, H.C., 2001. Health management for viral disease in shrimp farms. In: The New Wave: Proceedings of the Specical Session on Sustainable Shrimp Farming. (Browdy, C.L., Jory, D.E., Eds.) The World Aquaculture Society, Baton Rogue. LA. Pp. 168-198.

Lotz, J.M.,1997. Diseases control and pathogen status assurance in an SPF-based shrimp aquaculture industry, with particular reference to the United States. Pages 243-254 in T.W. Flegal and I.H. MacRae, editors. Disease in Asian Aquaculture III. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Padiyar, P.A., Philips, M.J., Primphon, M., Mohan, C.V., Bhat, B.V., Rao, V.S., Ravi, G., 2003. Extension in shrimp health management: experiences form an MPEDA/NACA program in Andhra Pradesh, India. *Aquaculture Asia*, July-September 2003, 7-13.

OIE (Office International des Epizooties). 2003. Manual of Diagnostic Tests for Aquatic Animals 3rd edition. Office International des Epizooties, Paris, France. 358 pp.

OIE (Office International des Epizooties). 2004. Aquatic Animal Health Code, 7th edition. Office International des Epizooties, Paris, France. 167 pp.