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# Promoting health management of shrimp aquaculture on Guam and Commonwealth of Northern Mariana Islands

**Hui Gong***

College of Natural and Applied Sciences, University of Guam, Mangilao, GU, USA

## Abstract

Shrimp disease outbreaks remain the most profound threat to the fast growing shrimp aquaculture industry, and they have caused billions of dollars in economic losses worldwide. Biosecurity has been applied in aquaculture as a preventive practice for the exclusion of specific pathogens from cultured aquatic species at various levels from facility/farm level to regional and country levels. Isolated in the Western Pacific, the Mariana Islands have a unique geographic advantage and great potential in playing a more significant role in shrimp aquaculture locally, regionally and even globally. Yet, some biosecurity measurements are quite relaxed and the whole region is lacking health monitoring and regulatory control programs. There is a need to increase awareness of biosecurity measurements on the individual farm level, as well as to establish systematic health management to protect the whole region from the introduction of viral pathogens. This will avoid major disease outbreak, reinforce the clean zone image of the region, and eventually lead to long-term sustainable shrimp aquaculture development on Guam and the Commonwealth of the Northern Mariana Islands (CNMI).

This project aimed at promoting the health management of shrimp aquaculture on Guam and CNMI, with three specific objectives: 1) to evaluate current shrimp health management practices in the region by conducting biosecurity audits of all existing shrimp farms and identify the key risk factors; 2) to set up farm-specific bimonthly surveillance program in two major shrimp facilities; 3) to promote the awareness of biosecurity in the region via various means of education, and to prepare and distribute a comprehensive summary report to aquaculture stakeholders and the corresponding government agencies.

Biosecurity audits were conducted for seven shrimp farms/facilities in the region. The strengths and risks of each shrimp facility were evaluated and suggestions were also provided. During the biosecurity audit, shrimp samples were taken and analyzed to identify the presence of any infectious shrimp disease. Based on the information collected from this project, four sessions are covered in this manuscript: 1) introduction and principles of health management; 2) current status of shrimp health management on Guam and CNMI; 3) challenges to improve biosecurity in Guam and CNMI; 4) future outlook and direction.

*Corresponding author. E-mail address: hgong@uguam.uog.edu

The research effort serves as a useful tool for shrimp farmers in the region in terms of improving the health management of shrimp aquaculture.

## Introduction and Principles of Health Management

Since the 1970s, shrimp aquaculture has grown rapidly from 0 to 71% of the total world supply of shrimp, in the past three decades, with a global annual production level that exceeded 3.2 million metric tons in 2006 (Josupeit 2008). Epizootics remain the most catastrophic threat to the industry of shrimp aquaculture, especially viral disease outbreaks. Major viral diseases include white spot syndrome virus (WSSV), yellow head virus (YHV), Taura syndrome virus (TSV), infectious hypodermal and hematopoietic necrosis virus (IHHNV), infectious myonecrosis virus (IMNV) etc (OIE 2009). One good example is that China, the largest shrimp producer in the world, was hit by YHV in 1988, and then WSSV in 1992. As a result, its total production level dropped two thirds, and it took 8 years to recover. Similarly, shrimp aquaculture in Thailand and Ecuador, another two major producers, suffered greatly due to WSSV outbreak as well. It was estimated that the economic losses due to the shrimp disease outbreak have easily surpassed 10 billion US dollars (Lightner 2005). The infectious pathogens have been transferred from facility to facility, country to country and even from one continent to another, and the widespread pandemics could be prevented if proper health management is in place.

The guiding principles for proper health management include:

- ✓ Start with stocks of premium health status
- ✓ Implement biosecurity to protect unit from disease introduction
- ✓ Monitor health/conduct surveillance
- ✓ Have contingency plans in place

Specific pathogens free (SPF) concept was introduced to exclude the pathogens of concern in shrimp stock, with successful development in two peneaid species, *Penaeus stylirostris* and *Penaeus vannamei* (Wyban 1992; Wyban et al. 1992; Pruder et al. 1995; Lightner 2005). *P. vannamei* has become the dominant shrimp species cultured globally because of the availability of SPF stocks and genetic improved stocks through selective breeding.

The application of biosecurity, a concept that is widely used in livestock industries, has been introduced to aquaculture as a preventive practice for exclusion of the specific pathogens from cultured aquatic species at various levels from facility/farm level to regional and country levels (Lee and O'Bryen 2003). Biosecurity may be defined as the sum of procedures used to protect living organisms from contracting, carrying and spreading diseases. In other words, biosecurity is the implementation of measures to avoid the entrance of infection into a unit, control the dissemination of an infection within the unit, and avoid spreading of an infection to other units. Implementation of biosecurity measurements will help to protect the facility from disease introduction, and the biosecurity audit is a useful tool to examine how well those measurements are executed. The priorities of biosecurity audit include categories such as:

- Site location
- Water intake
- Fresh/frozen feed sources
- Introduction of new shrimp sources or genetic materials
- Dispatch & loading procedure
- Personnel and visitors
- Others

The details for each category are specified below.

Other than the biosecurity audit, shrimp health monitoring/surveillance is the essential component of health management program at various levels, such as national, regional, and farm levels. In the current project, we focused on the farm level health monitoring of the shrimp stocks. Both the observations on shrimp clinical signs and disease diagnostics are important elements to assess the health status of the shrimp stocks. The basis of good surveillance programs is observant and skilled people with appropriate support resources, who understand what is normal, are alert to changes and can describe the abnormalities they see (Baldock et al. 2006). Only two of the seven facilities have submitted shrimp samples on their own for disease diagnosis and monitoring regularly in the past.

It is also essential for the aquaculturists to understand that the proper sampling size, tissue and fixation method should be followed so that the diagnosis can be correctly performed. For example, hemolymph or pleopod would be ideal samples for detecting the presence of IHHNV, WSSV, TSV, YHV or IMNV by PCR, but will not be suitable for NHP diagnosis.

Lastly, having the contingency plan in place are also critical so that prompt action can be carried out in controlling disease outbreak and preventing further spreading of disease problem.

# Current Status of Shrimp Health Management on Guam and CNMI

***Current Status***

Guam and Commonwealth of the Northern Mariana Islands (CNMI) have all year round warm climate, the natural seawater range from 27 ºC to 29 ºC, which is suitable for warm-water shrimp aquaculture. Currently, *P. vannamei* is the sole penaeid species cultured in Guam. Isolated in Western Pacific, yet within 4h flight time to major cities in Asia, where the center of world shrimp aquaculture production is located, the Mariana Islands have a unique geographic advantage and great potential in playing a more significant role in shrimp aquaculture locally, regionally and even globally. In addition to the steadily growing consumer's needs of local shrimp meat production, there is increasing demands of specific pathogen-free shrimp broodstocks from the Asian countries. Despite the multiple advantages favoring shrimp aquaculture development in the region, biosecurity is absent in general and the whole region is lacking health monitoring and regulatory control programs. There is a need to increase awareness of biosecurity measures at individual farm level, as well as to establish a systematic health management to protect the whole region from introduction of viral pathogens and avoid major disease outbreak, to reinforce the clean zone image of the region, and to eventually lead to long-term sustainable shrimp aquaculture development on Guam and CNMI.

In the past, a biosecurity audit or similar efforts to collect the information across all the shrimp farms in the region and evaluate the current health status of shrimp facilities in the region has not been done. There is a great need to increase the awareness of biosecurity measures at the farm level, as well as to establish a systematic health management plan to protect the whole region from the introduction of viral pathogens so as to avoid major disease outbreak, to reinforce the clean zone image of the region, and to eventually lead to long-term sustainable shrimp aquaculture development on Guam and CNMI.

Funded by USDA Center of Tropical and Sub-tropical Aquaculture (CTSA), University of Guam (UOG) took the initiatives in conducting the biosecurity audits for the seven current shrimp facilities (which were in operation at the time of biosecurity audits being conducted) across the region, four of which are in Guam, two in Saipan and one in Tinian. All the four facilities in Guam are locatedin the eastern coast of the island, one in Mangilao, one in Talafofo and two in Inajaha. The other three facilities are situated inland of Saipan and Tinian. In addition, shrimp samples were collected on site and then submitted to the Aquaculture Pathology laboratory at the University of Arizona for diagnosis.

### *Biosecurity Priorities*

Detailed illustration of the biosecurity priorities involved in the evaluation process of the biosecurity audits are documented as follows:

#### a. Site Location

Location is the most important factor for biosecurity consideration. Compared to a location close to an estuary, an inland location is considered more biosecure in terms of preventing the aquatic species from intruding to or escaping from the perimeter. But the cost of drilling the wells, pumping the water from a deep well and/or transporting water from the ocean may be significantly higher for the inland site than a coastal location. The total numbers and distribution of shrimp aquaculture facilities in the regions should be an important index for the evaluation of site location.

Guam and CNMI could be categorized as a low density region in terms of shrimp aquaculture activities, with only seven shrimp facilities in operation throughout the region. Among them, there are four coastal shrimp facilities in Guam, two inland facilities in Saipan and one inland facility in Tinian. According to the functionality, there is one hatchery and the rest are mainly for production.

The shrimp compound should be clearly defined and fences are necessary to provide a biosecurity barrier. Fences and gates are essential to control outside traffic of people, vehicles and animals. Gates must remain closed and locked at all times except when in use. “Keep Out” or “No Entry” signs should be placed at the active areas of the perimeter fence. Most of the shrimp facilities in the region are fenced, or partially fenced around the gate at the entrance. Signs were usually present nearby the gate to discourage unauthorized visits. However, not all the facilities were clearly defined and/or locked and tighter control of access should be enforced.

#### b. Water Intake

Water is the medium where shrimp live and grow. It is also the medium for some water borne shrimp pathogens to be transmitted for infecting the shrimp. Water free of shrimp pathogens is critical for the exclusion of shrimp pathogens being in contact withthe shrimp.

Currently, only two shrimp facilities were drawing water from the deep well through gravel filtration. Reservoir tanks were equipped to stock the intake water before putting into the culture system in two facilities. The rest were getting their water from the ocean or nearby estuary without further water treatments, except that primary bag filtration was used by a couple of the facilities. In addition, the intake water was close to the discharge site in three facilities situated nearby the estuary. Four facilities were using flow through or low water exchange during the culture period. Recirculation systems wereused in varying degrees at three facilities.

**c. Shrimp Feed**

Feed comprises approximately 50% of the overall operational cost in shrimp farming. Rising fuel costs have driven shrimp feed to reach record high price, especially in Guam and CNMI where almost all goods are imported. Control of feed ingredients and fresh feed must be exercised to prevent the introduction of disease from the use of contaminated components.

Except for the facilitythat functions as a hatchery, all the rest of the farms used dry pellets.In the hatchery, two kinds of fresh/frozen feeds produced from lower risk areas were used: artemia (cysts) and squid. The term lower risk areas refer to a specific pathogen negative zone. *Artemia franciscana* were harvested from the Great Salt Lake and squid were from clean water region (such as northern California, northern Europe or southern Australia). However, there was no procedure in place to log the date received, type of feed, quantity, source, results of any diagnostic testing (when performed).

Shrimp pellet diets came from various manufacturer sources in US, China, Taiwan and the Philippines. A regular monitoring program of shrimp feed sources, which was lacking, should be implemented before starting its usage in any facility. Feed suppliers have not been evaluated and a feed source audit is recommended to be conducted once a year. Feed delivery was not regulated so that feed trucks did enter the secure perimeter. Trucks that haul shrimp and then feed were often the case.

**d. Introduction of New Shrimp Sources or Genetic Materials**

Currently, *P. vannamei*, the Pacific white shrimp, is the sole marine shrimp species cultured in the region. Only SPF shrimp postlarvae from a reliable hatchery source should be introduced to any aquaculture facilities. In other words, the hatchery should have at least a 3- year history of clean broodstocks free of OIE listed shrimp pathogens and the postlarvae production should be conducted in a biosecure facility where the biosecurity protocols are carefully followed. In addition, the shrimp stocks need to be closely monitored for clinical signs, regularly sampled and diagnosed. The hatchery had a 5-year clean history, free of OIE or USMSF listed shrimp pathogen. The biosecurity audit found that various sources of *P. vannamei* postlarvae had been introduced to the farms in the region, without strict background check, health monitoring and proper quarantine procedures. Most of the imported seed stocks were from Taiwan and Thailand, high density shrimp aquaculture areas, where shrimp disease is much more problematic than Guam and CNMI. There were several reasons for the farmers to choose sources other than the local hatchery, such as lower costs, larger volumes for stocking and business strategies, etc. Regardless of the reasons, this practice posesgreat biosecurity risk to the importing facilities, especially when the proper quarantine procedures are not in place. Recommendations were prepared to be distributed to the farm managers in this respect.

Quarantine/isolation and acclimatization play an important role in preventing any pathogenic introduction to the facilities through the new shrimp stocks.

The role of proper quarantine and disease diagnostics has been greatly overlooked in the region when importing foreign sources of shrimp postlarvae. All movements of shrimp in the region have not been conducted properly through a quarantine/isolation procedure using a quarantine station preferably inspected/run by government agency. A quarantine/isolation period would allow sufficient time to detect the presence of possible significant pathogens in the source unit. Diagnostic sampling should be done during the quarantine. Ideally, the quarantine/isolation should be a minimum of 30 days or up to the time that laboratory results from sampling are back. Before releasing the shrimp from quarantine/isolation, the facility manager should obtain information from the source facility that there was no new disease outbreak and the laboratory reports confirmed that with negative test results. Afterwards, all shrimp should follow a farm-specific acclimatization program. The acclimatization period allows the newly introduced shrimp to adapt to a new environment in the receiving facility.

Actions need to be taken at both farm and regional level for increasing the public awareness of this biosecurity aspect.

**e. Dispatch and Loading**

The most common incoming shipments to the shrimp farms were postlarvae, feed and certain equipments/materials. The outgoing shipments were mostly shrimp harvested for salein the local market. A clear distinction between the clean and dirty side for people, vehicle and shrimp flow should be established and maintained in the facility.Almost all the facilities overlooked this aspect in biosecurity. The postlarvae receiving facility should discard the exterior packing materials or thoroughly disinfect the styrofoam boxes outside the perimeter if keeping them for reuse so that the possibility of the transmission of shrimp pathogenic agents during the transportation can be minimized. Holding tanks and ramps must be power-washed and disinfected after each use. Effluents must be prevented from flowing back into the compound. Once deliveries are made, the facility truck is cleaned and disinfected at a truck wash before the next trip. However, this is not the case in the farms throughout the region. There were cases that some equipments and supplies were loaned to one facility by another without proper disinfection procedures. Thorough disinfection procedures for the equipments and supplies from other farms should be established prior to bringing them into a farm in order to eliminate health risk.

### f. Personnel and Visitors

Production personnel mostly worked and lived routinely in the same facility. Staff contact with other aquaculture species outside the facility should be minimized by the staff. No clothes, footwear, etc. that are used around the other aquaculture farms should be worn in the facility. Depending on the risk tolerance, proper downtime requirement should be established if production staff go to any seafood market, go fishing, visit shrimp laboratories or other facilities and are in contact with fresh/frozen shrimp or crustaceans outside a shrimp facility. In addition to the downtime, shower, changing clothes and footwear should be done prior to reporting to work.

Each shrimp facility should have its own practical visitor policy to avoid the possibility of disease transmission through visitors. Visitors should submit visiting request and meet the requirements set by the farm management. The visiting schedule should be determined by the management. Upon approval of the request, all persons entering any shrimp aquaculture facility should observe the downtime regulations. Overnight means a minimum of 8 h. One more night should be added on the downtime requirement wherever a shower is not available. Each aquaculture facility should have its own sign-in book. All visitors must sign the visitors' book before entering a unit. The sign-in book should include: date, name, reason for visit, date and place of last contact with shrimp/aquaculture species or related materials.

Training on biosecurity was officially provided to the personnel before employment in one of the facilities in the region. No visitor was allowed to visit the facility. Not all the managers educated their employees to understand that they could pass on shrimp pathogens if they do not follow the proper preventive measures. Although sign-in book for visitors were used in two facilities, neither emphasized the importance of downtime nor used a questionnaire about the aquaculture related activities prior to the visit on site.

**g. Others**

Few facilities audited have policies for routine pest and crustacean (crabs) control procedures. Feed spillage needs to be minimized and proper disposal of waste should be practiced to discourage pests. The local environment may be favorable to insect nesting. Therefore, practices to keep the insect population at a low level (inside and around the facility) whenever possible were recommended. Two facilities in Saipan and Tinian were bird proofed, while some ponds in one facility in Saipan were not. Birds were seldom a problem for the aquaculture farms in Guam, as a result of wide predation of birds by the browntree snakes. On the other hand, crabs could be easily found in the shrimp facilities near the ocean. Those farms need to build barriers to block crabs from entering the perimeter.

Water discharge should be in line with the local permits and regulations. It would be better to have a settling pond to separate the suspended particles from the water column before the discharge. This would be an effective way to control eutrophication caused by the nutrient loads in the discharge water, and minimize adverse environmental impacts.

Although there are no related regulations for dead shrimp and molts in Guam and CNMI, their disposal should be done properly. Certain protocols need to be developed based on the farm specific condition. Methods of disposing the dead shrimp include incineration, compost pits, and burial. If a burial system is used, the area must be completely fenced and covered. Proper sanitation procedures for the equipment and materials used in disposal are required. However, there were no rules on shrimp carcass and molt disposal in most facilities, and the general sanitation was poor in a couple of the facilities visited.

***Summary of evaluation***

A site-specific executive report was generated for each individual facility. A brief summary of key components in biosecurity is listed in Table 1.

During the biosecurity audit, shrimp samples were collected from the seven facilities in Guam and the CNMI. Both PCR and histopathogicaldiagnoses were performed by the shrimp pathology laboratory at the University of Arizona. The pathogens tested for are listed in Table 2.

**Table 1**. Summary of key components in biosecurity audits among the facilities.

| Facility | Location | Water treatment | Seed source | Personnel/ visitor | Diagnostic results of the pathogens for SPF stocks | Facility Impact |
|---|---|---|---|---|---|---|
| #1 | Coastal | No | Asia | Some restriction | One pooled sample weak positive IHHNV by PCR, but not confirmed by histopathology | Medium |
| #2 | Coastal | No | Asia | Some restriction | Microsporidian infection detected by histopathology | Medium |
| #3 | Coastal | No | Asia | Little restriction | IHHNV positive by both PCR and histopathology | Medium |
| #4 | Inland | No | UOG | Some restriction | Not detected | Medium |
| #5 | Inland | No | UOG | Little restriction | Not detected | Low |
| #6 | Inland | Gravel filtration | Asia | Highly restricted | Not detected | High |
| #7 | Coastal | Gravel filtration | UOG | Highly restricted | Not detected | Very strong |

**Table 2**. USMSFP Working List of Specific Pathogens for SPF Penaeids in the United States (Lightner 2005 and UAZ lab report).

| Pathogen Type | Pathogen | Pathogen Group | Pathogen Category[1] |
|---|---|---|---|
| Viruses | TSV | dicistrovirus (n.f.) | C-1* |
| | WSSV | nimavirus (n.f.) | C-1* |
| | YHV/GAV/LOV | ronivirus (n.f.) | C-1,2* |
| | IHHNV | parvovirus | C-2* |
| | BP | occluded baculovirus | C-2* |
| | MBV | occluded baculovirus | C-2* |
| | BMN | unclassified nonoccludedbaculovirus | C-2 |
| | HPV | parvovirus | C-2 |
| | IMNV | totivirus | C1,2* |
| Procaryote | NHP | alpha proteobacteria | C-2 |
| Protozoa | Microsporidians | Microsporidia | C-2 |
| | Haplosporidians | Haplosporidia | C-2 |
| | Gregarines | Apicomplexa | C-3 |

* OIE listed diseases as of year 2007. Any of these diseases may be notifiable to OIE (within 48 h of a confirmed diagnosis) if it fulfills any of the following criteria: First occurrence or re-occurrence in a country or zone of a country, if the country or zone of the country was previously considered free of that particular disease; or occurrence in a new host species; or new pathogen strain or new disease manifestation; or potential to spread the disease globally; orzoonotic potential.

[1] Pathogen category (modified from Lotz et al. 1995) with C-1 pathogens defined as excludable pathogens that can potentially cause catastrophic losses in one or more American penaeid species; C-2 pathogens cause economically significant disease and are excludable; and C-3 pathogens cause less serious disease, but should be excluded from breeding centers, hatcheries, and some types of farms.For more information on some of these pathogens and the most appropriate diagnostic methods see: OIE 2006, Diagnostic Manual for Aquatic Animal Diseases, Fifth Edition. Available at:http://www.oie.int/eng/normes/fmanual/A_summry.htm

From the health management point of view, the strengths of having shrimp aquaculture in Guam and CNMI are: 1) the region is in the category of low density shrimp aquaculture area; 2) good isolation and far enough from the high density area of shrimp aquaculture; 3) relatively "clean" area with good source of water; 4) some of the farms have certain appropriate elements of infrastructure which could be utilized to improve the biosecurity measurements; 5) most farm managers have years of experience in commercial shrimp production, which is an asset for practical solution in biosecurity implementation; 6) no major shrimp disease outbreak has been reported in the past 5 years.

Despite the multiple advantages favoring shrimp aquaculture development in the region, the concept of biosecurity is vague and the practice is sporadic. The whole region, Guam in particular, is lacking health monitoring and regulatory control programs. Five major weaknesses with detail illustrations are listed below.

**1) High health risk seedstock imported from Taiwan and Thailand**

There is a hatchery in the region, UOG hatchery, which supplies the local shrimp farms in Guam, two farms in Saipan and one farm in Tinian on a limited basis. Currently, UOG hatchery has limited resources to meet all the postlarvae requirements of the regional shrimp farms in terms of the quantity and price. Several farmers still source some postlarvae from abroad, such as Taiwan and Thailand, which could introduce shrimp diseases into Guam. More reliable and larger scale local SPF postlarvae production is needed to sustain and expand shrimp farming in Guam and CNMI.

**2) No proper quarantine facility and protocols**

As a territory of the United States, the importation and exportation of aquaculture products is jointly regulated by both Guam (or CNMI) and Federal authorities.

The Government of Guam Department of Agriculture requires that the importation of live aquatic animals and plants be permitted and inspected upon arrival. An import permit must accompany aquatic animals from the US, while those from a foreign country require a certificate of origin. In addition, a certificate of health must accompany the animals from a certified agent in the country of origin verifying that the animals are disease free.

Similarly, a declaration for importation or exportation of fish or wildlife must be filed ahead of the shipping and cleared by US Fish and Wildlife Service, Department of Interior, at the port-of-entry or exit.

However for the importation of shrimp postlarvae, a proper quarantine procedure should be included in addition to the appropriate paperwork stated above in order to effectively prevent the intrusion of significant shrimp pathogens to the region. During the quarantine stage, the shrimp from the shipment should be closely monitored and samples need to be collected for diagnosis to confirm the absence of the OIE listed shrimp pathogens. The quarantine could be run either in a government operated facility or a farmer owned facility with sufficient time so that any clinical signs can be observed and diagnostic results become available. In addition, the facility needs to be a closed system isolated from the other shrimp operations and water intake and discharge need to be disinfected and tightly controlled. Meeting these requirements will require the investment in terms of infrastructure, equipments, and personnel, etc. How to fund such a practice is an issue to be resolved.

**3) No proper water treatment for either intake or discharge.**

Although the risk tolerance of most regional shrimp farms is relatively high since their products are for food consumption in the local market, the proper disinfection and/or treatment is necessary to exclude the pathogenic agents and increase the shrimp crop's performance and reduce the adverse environment impact. For example, settling pond would be a practical way to reduce suspended matter from the discharge water. Combined with other treatments, the water can be reused in large scale farms. As for the medium and small scale facility, recirculation systems are more environmentally sustainable. However, it will require substantial effort and investment to make a change in the direction of the long term sustainability.

**4) Relaxed attitude toward biosecurity issues.**

Compared to the other regions conducting aquaculture activities, the regional farmers have been fortunate because no major shrimp disease outbreak has occurred in the past 5 years. Most of the farmers do not want to invest in biosecurity because of a lack of immediate return. They do not understand the biosecurity concept in depth, as well as the importance of its role. But in reality, Guam and CNMI are not immune to shrimp viruses if they are brought in. Therefore, there is a need for being more cautious as new shrimp viruses are emerging and there is no cost effective cure for infections caused by these known pathogens. It will be much more costly or too late to correct the problem if catastrophic disease outbreak occurs. It requires vision and action to protect the investment and regional shrimp health status.

5) **No PCR diagnostic capacity in the region for accurate and fast diagnostic result**

In the past, all the shrimp samples were collected and sent to Dr. Lightner's laboratory at the University of Arizona for diagnosis. It usually takes 2 weeks up to 1 month from sample collection to the delivery of the results. Besides the diagnostic cost, the long turnaround time and high shipping cost make it impractical to conduct the diagnosis during quarantine stage, and make it excusable to exclude the diagnosis as the routine monitoring tool.

University of Guam has recently established a molecular biology laboratory with PCR capability. The laboratory has the potential to be used for shrimp disease diagnosis after the validation by an OIE authorized laboratory.

***Setting up Health Surveillance for Two Facilities***

Based on the geographic location and the levels of impact of the facilities on the aquaculture development in the region, two facilities were selected for health surveillance: one is in Guam and one is in Saipan. Sampling schemes have been tailored to fit the sources and numbers of shrimp stock in the facility. On-site training for sampling shrimp tissues for specific diagnostics was also provided during the health surveillance visit.

## Challenges to Improve Biosecurity in Guam and CNMI

From the information collected by the biosecurity audit and health surveillance, there are three major challenges to improving the biosecurity control measures in Guam and CNMI: the awareness, the resources and the cost related to implementation of biosecurity management. Actions at both farm and regulatory government agencies levels are required for the improvement.

It is fundamental to continuously increase the awareness of biosecurity for shrimp farming in the region. Proper training should be provided to not only the farmers, but also to regulatory government officials. The latter group needs to understand the importance of biosecurity, both principals and practices. Without the correct mindset, it is impossible to do the job properly.

Secondly, it seems that generation of resources to improve the regional biosecurity level for shrimp aquaculture has been low in priority. It would require a well-structured plan, collaborative efforts and legislative support. Government agencies, such as the Department of Agriculture and US Fish and Wildlife Service, should take a leading role in this, especially in the development of a quarantine station and procedure, regional diagnostic laboratory, shrimp health surveillance service, preparation of the contingency plans, etc.

Thirdly, cost is inevitable in implementing the biosecurity measurements. The cost includes manpower costs, investment in infrastructure, equipments and supplies, diagnostics costs, etc. Compare to the potential losses due to disease outbreak, it would be much less expensive to take the preventive approach. It requires both farmers and government to work together in solving this cost issue.

Overall, the greatest risk for some facilities is the seedstocks imported from Asian countries, and no proper quarantine procedure is in place to minimize the disease risk. Fortunately, there has not been any major shrimp disease outbreak in the region in the past decade even though there are indications of the presence of IHHNV in a couple of locations. If such health issues are not being scrutinized and proper solutions being sought at both the facility and regional levels, the adverse effects may magnify and could evolve to a much more serious situation.

## Future Outlook and Direction

Information generated from this health project provided baseline information on health status of shrimp farming in Guam and CNMI. In addition, the project also served as a useful tool in increasing awareness of the need for biosecurity among the regional shrimp aquaculture society and improving the health management of shrimp aquaculture in Guam and CNMI.

In the end, the establishment of a systematic health management regime requiresthe collaborative efforts from all the stakeholders in order to improve the health status of the regional shrimp industry, which will eventually lead to the development of a long-term, sustainable shrimp aquaculture for Guam and the CNMI.

## References

Baldock, F.C., A.R. Cameron and N.R. Perkins. 2006. Aquatic animal health surveillance. In: Aquaculture biosecurity prevention, control and eradication of aquatic animal disease. (ed. A.D. Scarfe, C-S Lee and P.J. O'Bryen), pp. 129-148. Blackwell Publishing, Ames, Iowa, United States.

Josupeit, H. 2008. Towards sustainability in shrimp production, processing and trade. pp. 29. Shrimp 2008 – Technical and trade conference on shrimp, Guangzhou, China. 6 – 7 November 2008.

Lee, C.-S.and P.J. O'Bryen. (ed). 2003. Biosecurity in aquaculture production systems: exclusion of Pathogens and Other Undesirables. pp 275-293. The World Aquaculture Society, Baton Rouge, Louisiana, United States.

Lightner, D.V. 2005. Biosecurity in shrimp farming: pathogen exclusion through use of SPF stock and routine surveillance. Journal of the World Aquaculture Society 36: 229-248.

Lotz, J.M., C.L. Browdy, W.H. Carr, P.F. Frelier and D.V. Lightner. 1995. USMSFP suggested procedures and guidelines for assuring the specific pathogen status of shrimp broodstock and seed. In: Swimming through troubled water, Proceedings of the Special Session on Shrimp Farming, Aquaculture '95, San Diego, California, 1-4 February 1995, (ed. C.L. Browdy, C. L. and J.S. Hopkins), pp 66-75. World Aquaculture Society, Baton Rouge, Louisiana, USA.

OIE (Office International des Epizooties). 2009. Aquatic animal health code, 12th edition. Office International des Epizooties, Paris, France.

Pruder, G.D., C.L. Brown, J.N. Sweeney and W.H. Carr. 1995. High health shrimp systems: seed supply – theory and practice. In: Swimming through troubled waters. Proceedings of the Special Session on Shrimp Farming, Aquaculture '95, San Diego, California, 1-4 February 1995. (ed. C.L. Browdy, C. L. and J.S. Hopkins), pp. 40-52. World Aquaculture Society, Baton Rouge, Louisiana, USA.

Wyban, J.A. 1992. Selective breeding of specific pathogen-free (SPF) shrimp for high health and increased growth. In: Diseases of cultured penaeid shrimp in Asia and the United States. (ed. W. Fulks and K.L. Main), pp 257-268. The Oceanic Institute, Honolulu, Hawaii, USA.

Wyban, J.A., J. Swingle, J.N. Sweeney and G.D. Pruder. 1992. Development and commercial performance of high health shrimp from SPF broodstock *Penaeus vannamei*. In: Proceedings of the ppecial session on shrimp farming, Orlando, Florida, 22-25 May 1992. (ed. J. Wyban), pp. 254-260. World Aquaculture Society, Baton Rouge, Louisiana, USA.