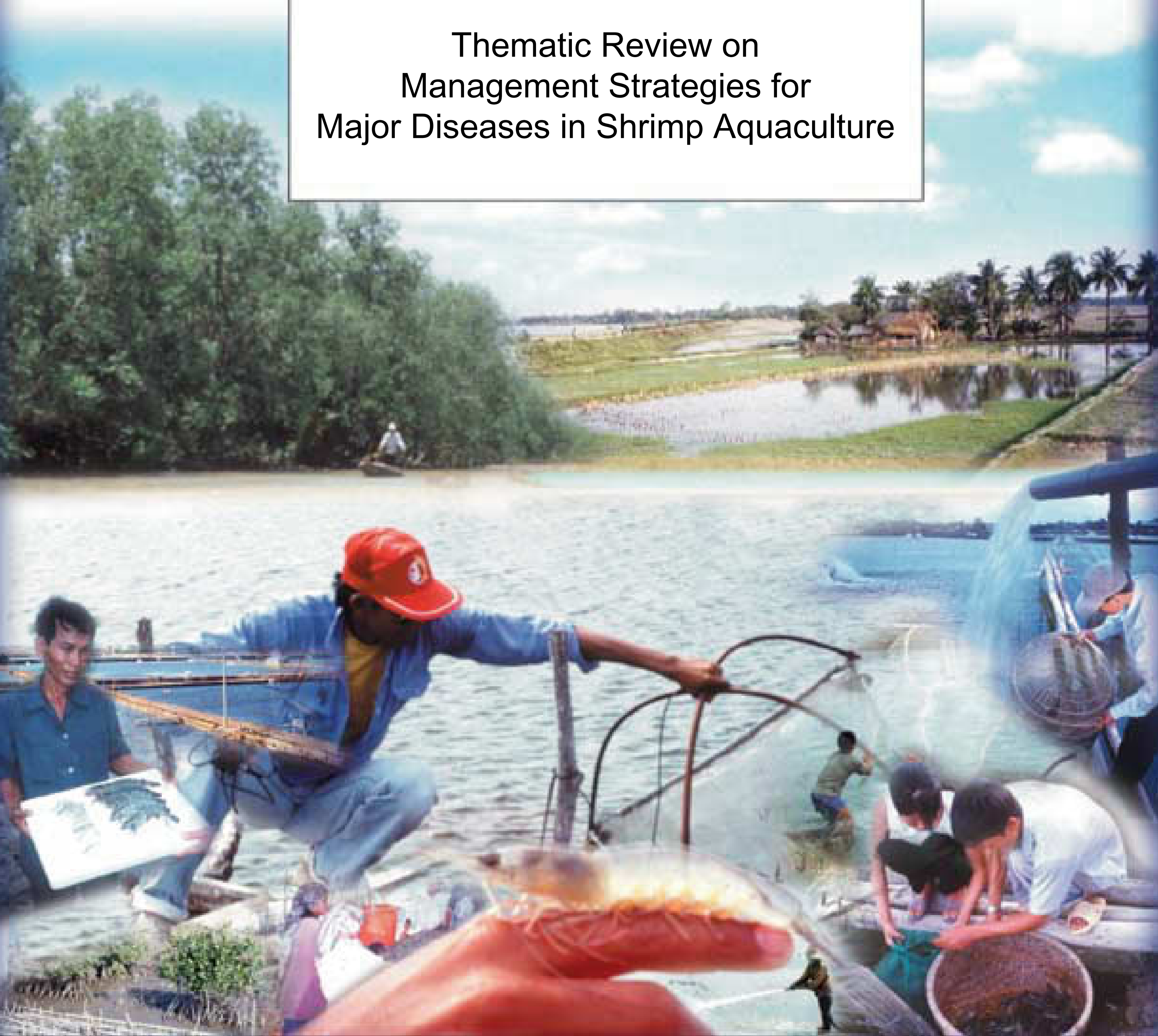
Shrimp Farming and the Environment

Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture



A Consortium Program of:

THEMATIC REVIEW ON MANAGEMENT STRATEGIES FOR MAJOR DISEASES IN SHRIMP AQUACULTURE

Edited by

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Report of a Workshop held in
Cebu, Philippines from
28-30 November 1999

A Report Prepared for the

World Bank, Network of Aquaculture Centres in Asia-Pacific,
World Wildlife Fund and Food and Agriculture Organization of the United Nations
Consortium Program on Shrimp Farming and the Environment

Preparation of this document

The research reported in this paper was prepared under the World Bank/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment. Due to the strong interest globally in shrimp farming and issues that have arisen from its development, the consortium program was initiated to analyze and share experiences on the better management of shrimp aquaculture in coastal areas. It is based on the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture[1], a World Bank review on Shrimp Aquaculture and the Environment[2], and an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. The objectives of the consortium program are: (a) Generate a better understanding of key issues involved in sustainable shrimp aquaculture; (b) Encourage a debate and discussion around these issues that leads to consensus among stakeholders regarding key issues; (c) Identify better management strategies for sustainable shrimp aquaculture; (d) Evaluate the cost for adoption of such strategies as well as other potential barriers to their adoption; (e) Create a framework to review and evaluate successes and failures in sustainable shrimp aquaculture which can inform policy debate on management strategies for sustainable shrimp aquaculture; and (f) Identify future development activities and assistance required for the implementation of better management strategies that would support the development of a more sustainable shrimp culture industry. This paper represents one of the case studies from the Consortium Program.

The program was initiated in August 1999 and comprises complementary case studies on different aspects of shrimp aquaculture. The case studies provide wide geographical coverage of major shrimp producing countries in Asia and Latin America, as well as Africa, and studies and reviews of a global nature. The subject matter is broad, from farm level management practice, poverty issues, integration of shrimp aquaculture into coastal area management, shrimp health management and policy and legal issues. The case studies together provide an unique and important insight into the global status of shrimp aquaculture and management practices. The reports from the Consortium Program are available as web versions (http://www.enaca.org/shrimp) or in a limited number of hard copies.

The funding for the Consortium Program is provided by the World Bank-Netherlands Partnership Program, World Wildlife Fund (WWF), the Network of Aquaculture Centres in Asia-Pacific (NACA) and Food and Agriculture Organization of the United Nations (FAO). The financial assistance of the Netherlands Government, MacArthur and AVINA Foundations in supporting the work are also gratefully acknowledged.

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[1] FAO. 1998. Report of the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture. Bangkok, Thailand, 8-11 December 1997. FAO Fisheries Report No. 572. Rome. 31p.

[2] World Bank. 1998. Report on Shrimp Farming and the Environment – Can Shrimp Farming be Undertaken Sustainability? A Discussion Paper designed to assist in the development of Sustainable Shrimp Aquaculture. World Bank. Draft.

Preface

The World Bank (WB), the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wide Fund for Nature (WWF) and the Food and Agriculture Organization of the United Nations (FAO) are pleased to present this report of the Expert Workshop on Management Strategies for Major Diseases in Shrimp Aquaculture, a component of the WB/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment.

Regional and, more recently, inter-regional spread of several highly pathogenic viral diseases of shrimp, have accompanied the trans-boundary movements (introductions and transfers) of penaeid shrimp for aquaculture development. Recent outbreaks of white spot disease (WSD) (caused by the white spot syndrome virus, WSSV) and yellowhead disease (YHD) (caused by the yellowhead virus, YHV) in several Latin American countries are a direct result of the ill-considered importation of infected shrimp from Asia. These pathogens, and others, such as Taura syndrome virus (TSV), which has been recently transported from Latin America to Asia, have caused enormous economic losses to the aquaculture industry. They have also affected national budgets, through significant losses of export earnings, and have had wide-ranging socioeconomic impacts, including loss of direct and indirect employment associated with shrimp culture. Often these impacts have affected small-scale growers (primarily in Asia) and the poorer segments of society in both hemispheres.

The most serious viral diseases have been seen in Asia since 1992, and have progressively devastated the shrimp culture industries of many countries of East, Southeast and South Asia. However, as Asia has had a longer period of experience with these diseases, aquaculturists have begun to develop a number of strategies for managing them. Similarly, Latin America has been affected by Taura syndrome for a number of years. Thus, sharing of knowledge and experiences between regions may assist the countries of both regions to more effectively reduce losses due to epizootic diseases.

Initial steps were taken by members of the private sector of Latin America, who visited Southeast Asia, and who arranged for Asian experts to assess first-hand the problems occurring in several Latin American countries. This workshop was organized to provide a more formal mechanism for addressing Asian and Latin American shrimp health management problems, by bringing together experts to seek mutually beneficial management strategies for major diseases in shrimp aquaculture. The Expert Workshop is one component of the WB/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment, which seeks to promote sustainable shrimp culture through implementation of the FAO's *Code of Conduct for Responsible Fisheries* (CCRF).

To set the tone for the workshop, four broad thematic reviews were presented dealing with aspects of introductions and transfers of aquatic animals. These included (i) a presentation on the issues surrounding trans-boundary pathogen spread with the movements of fish and shellfish; (ii) a paper dealing with industry perspectives with regard disease outbreaks; (iii) a review of knowledge and experience in trans-boundary movement of aquatic animal pathogens: the roots, impacts and implications for aquaculture and aquatic biodiversity, and options and interventions available for mitigation; and (iv) a presentation on species introductions, international conventions and biodiversity impacts, and the associated prospects and challenges. During the workshop, participants from 15 countries (5 from Latin America and 10 from Asia) presented reviews on the history and current national status of major shrimp diseases, including their socioeconomic impacts and an evaluation of the successes and failures of state and private sector interventions intended to solve them. The countries represented included Equador, Honduras, Nicaragua, Panama, and Peru; and Australia, Bangladesh, India, Indonesia, Malaysia, Philippines, P.R. China, Sri Lanka, Thailand and Vietnam. The report summarizes the major recommendations arising from the Expert Workshop, laying groundwork for a subsequent Latin America/Asia inter-regional meeting on shrimp diseases funded by APEC, held in Puerta Vallarta, Mexico in July of 2000.

The WB, NACA, WWF and FAO thank the experts from government, international and regional organizations and the private sector, and their supporting agencies for their contributions to the success of this Expert Workshop.

Abstract

This document presents the report of the Expert Workshop on Management Strategies for Major Diseases in Shrimp Aquaculture, a component of the WB/NACA/WWF/FAO Consortium Program on Shrimp Farming and the Environment. The Expert Workshop was jointly organized by FAO's Inland Water Resources and Aquaculture Service, the World Bank (WB), the Network of Aquaculture Centres in Asia-Pacific (NACA), and the World Wide Fund for Nature (WWF) and was held from 28-30 November 1999 in Cebu, Philippines. Included are summaries of 15 country review papers (5 countries from the Latin American Region: Eqcuador, Honduras, Nicaragua, Panama, and Peru; and 10 countries from the Asian Region: Australia, Bangladesh, India, Indonesia, Malaysia, Philippines, P.R. China, Sri Lanka, Thailand and Vietnam) on the history and current national status of major shrimp diseases, including their socioeconomic impacts and an evaluation of the successes and failures of state and private sector interventions to solve major disease problems and to develop more sustainable shrimp culture industries. Also included are summaries of the discussions and recommendations arising from four expert working groups dealing with (i) national and regional policies, legislation, and regulatory frameworks for reducing the risks of trans-boundary disease outbreaks in shrimp aquaculture; (ii) industry management and technological requirements for reducing the risks of disease outbreaks and increasing productivity and sustainability; (iii) specific recommendations for the adoption of programs to control the trans-border transmission of shrimp diseases; and (iv) improving responses to disease problems and management of risks of diseases in the small-scale livelihood sector. Summaries of four broad thematic reviews presented at the workshop are also included: (i) movements of fish and shellfish: pathogens, issues and avenues; (ii) dealing with disease outbreaks: an industry perspective; (iii) knowledge and experience in trans-boundary movement of aquatic animal pathogens: the roots, impacts and implications for aquaculture and aquatic biodiversity, and options and interventions available for mitigating such impacts; and (iv) species introductions, international conventions and biodiversity impacts, prospects and challenges. The report summarizes the major recommendations arising from the Expert Workshop, laying groundwork for a subsequent Latin America/Asia inter-regional meeting on shrimp diseases funded by APEC, held in Puerta Vallarta, Mexico on 24-28 July 2000.

Content

Acronyms and Abbreviations

AAHRI	Aquatic Animal Health Research Institute
AAPQIS	Aquatic Animal Pathogen and Quarantine Information System
ACIAR	Australian Centre for International Agriculture Research
ADB	Asian Development Bank
APEC	Asia Pacific Economic Co-operation
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
CIEL	Center for International Environmental Law
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DFID	Department for International Development (United Kingdom)
DIAS	Database on Introductions of Aquatic Species (of FAO)
EIFAC	European Inland Fishery Advisory Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FDC	Fish Disease Commission (of OIE)
GAA	Global Aquaculture Alliance
GEF	Global Environmental Facility
HACCP	Hazard Analysis Critical Control Point
ICES	International Council for Exploration of the Sea
ISO	International Standards Organization
NACA	Network of Aquaculture Centres in Asia-Pacific
OIE	Office International des Épizooties (the World Organisation for Animal Health)
SAARC	South Asian Association for Regional Co-operation
SEAFDEC-AQD	Southeast Asian Fisheries Development Center – Aquaculture Department
SPS	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
TCP	Technical Co-operation Programme
WB	World Bank
WTO	World Trade Organization
WWF	World Wildlife Fund

Background

World aquaculture production continues to grow fast, and is now contributing over 25% to the global supply of aquatic food products. According to official FAO estimates, world production of farmed shrimp in 1996 amounted to more than 0.9 million mt, with a value of more than US$ 6000 million. About 80% of the world's farmed shrimp are produced in Asia, with most of the remainder coming from tropical Latin American countries. Rapid growth in production and the expansion of shrimp farming practices fuelled by high profitability and growing demand by mainly affluent consumers in importing countries, have provided several developing countries in Asia and Latin America with substantial foreign currency earnings.

Small-scale farmers owning less than 5 ha of land located in rural coastal areas undertake most shrimp farming in Asia. In both Asia and Latin America, shrimp farming has emerged as a main source of employment and income for hundreds of thousands of people. Globally, a recent conservative estimate is that the sector employs directly more than one million people. Additional employment and income are generated in supply industries, as well as in the shrimp processing and distribution sectors, including retailing. Returns from shrimp farming continue to be high, benefiting small-scale farmers and communities, as well as larger-scale entrepreneurs. Because earnings from production, export and trade of shrimp products are significant, expansion of shrimp farming continues in Asia and Latin America, and there is a growing interest in Africa, where so far there has been little shrimp culture development.

Controversy over problems associated with shrimp culture in both shrimp-producing and importing countries has been growing, including some well-publicized events in international fora. Public opinion is being influenced by high profile concerns over environmental and social impacts of shrimp culture development, food safety issues involving shrimp products, and, more generally, over the long-term sustainability of shrimp farming.

Major issues raised include the ecological consequences of removal of mangroves for construction of shrimp ponds, salinisation of groundwater and agricultural land, pollution of coastal waters due to pond effluents, biodiversity issues arising from collection of wild seed, and social conflicts between shrimp farmers and other coastal resource users. The sustainability of the sector has also been questioned by some, in view of self-pollution in shrimp growing areas and the introduction of pathogens, which have led to major shrimp disease outbreaks and significant economic losses.

Problems arising in shrimp culture are, in part, due to the rapid expansion of shrimp farming, during which limited consideration may have been given to appropriate farm siting and adoption of sustainable farm-level management systems. Planning and co-ordination of the sector's development and overall planning and management of coastal areas and resources have also generally not kept up with the pace of development.

A Consortium Program on Shrimp Farming and the Environment, consisting several complimentary case studies in a number of shrimp farming countries and a few thematic reviews, which is jointly financed and executed by the WB, NACA, WWF, and FAO, has been developed. The program is based on the outcome of the April 1999 expert meeting in Bangkok, recommendations arising from the WB review on shrimp aquaculture and the environment, and other ongoing initiatives and recommendations, including those of the FAO Bangkok consultation of December 1997. The project activities are directed at the implementation of the FAO *Code of Conduct for Responsible Fisheries* (CCRF), and other key areas of shrimp farm sustainability.

Shrimp disease has emerged as one of the key issues affecting sustainability of shrimp farming worldwide, and is the subject of this thematic review.

Introduction

Infectious disease is considered to be the single most devastating problem in shrimp culture. Over the past decade, significant losses have been experienced by the shrimp aquaculture sector throughout the world. Conventional methods for controlling aquatic animal pathogens, such as chemotherapy, appear less effective in managing newly emerging pathogens, thus, efforts have been made to improve the situation by introducing various management strategies to prevent the occurrence of disease outbreaks. Instead "quick fix" control methods applied by individual farmers, there have been attempts to combat disease outbreaks through the collective efforts of the affected farmers, national and state agencies, private-sector service providers, and other stakeholders. These include: changing management practices, improving research and development efforts, introducing new legislation, initiating dialog among shrimp farmers through development of farmers' societies, and attempting to reduce trans-boundary spread of pathogens. Some of these efforts have been successful, while in some places, such efforts have not realized their full potential. Therefore, this thematic review is designed to examine such efforts, analyze their effectiveness, and try to understand the underlying reasons for their successes or failures.

In this thematic review, emphasis is given to the three most serious viral diseases of shrimp; yellowhead disease (YHD), Taura syndrome (TS) and whitespot disease (WSD). Other diseases of local interest and importance are also addressed, in cases where such diseases have significantly contributed to economic losses within local industries.

SUMMARY OF THEMATIC REVIEWS AND SPECIAL LECTURES

This section gives summaries of the thematic reviews and special lectures given at the workshop in Cebu, Philippines from 28-30 November 1999.

Movements of Fish and Shellfish: Pathogens, Issues and Avenues

by
Rohana P. Subasinghe and J. Richard Arthur

Background

Included among the Guiding Principles of the *FAO/NACA Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals* is the principle that " movement of living aquatic animals within and across national boundaries is a necessity for economic, social and development purposes." The trans-boundary movement of fish, shellfish and molluscs is thus an inherent right of nations. Such movements have often had beneficial social and economic results; however, far too often, poorly conceived introductions of exotic aquatic animals and transfers of native species within their existing ranges have had serious negative socioeconomic and biologic implications. These include unpredicted ecological, genetic and disease risks, along with unforeseen economic losses caused by many factors.

There are many records of pathogens being introduced into new areas along with the movement of their hosts. In addition to obvious effects on aquaculture production and economics, and occasional cases of widely reported mass mortalities in capture fisheries, exotic pathogens may also affect aquatic biodiversity. There is an increasing body of factual evidence and theoretical analysis showing that pathogens may determine aquatic community structure, and regulate host abundance through such mechanisms as altered energetic demands, altered host behavior, increased mortality, decreased fecundity, increased susceptibility to predation, etc. Exotic pathogens may reduce the intra-species genetic variation of new host species, may cause local extirpation of susceptible components of aquatic communities, and, in extreme cases, species extinction.

Instances where pathogens have been spread to new geographic areas and hosts are probably highly under reported. Although exotic pathogens do not always establish themselves when introduced into new habitats, they are usually impossible to eradicate once they become established in natural waters. In general, the potential to introduce exotic pathogens along with the international movement of their hosts is not adequately considered by aquaculturists and fisheries managers. In many cases, their introduction and spread can be avoided if appropriate methods of inspection and quarantine are applied.

With the world-wide increase in aquaculture and the widely held belief within the industry that the international movement of new species and strains of aquatic animals is beneficial, aquaculturists have been responsible for the introduction and spread of some of the most pathogenic and economically important disease agents. This has occurred through stock enhancement and stocking programs, stocking of exotic species, and stocking of hatchery-produced seed obtained internationally. These practices, when not conducted in a responsible manner, have often led to point source contamination by pathogens.

Issues and Avenues

Pathogens are one of several issues that provide ammunition to anti-aquaculture groups in their attempts to discredit the industry and prevent its further expansion. In prawn culture, the irresponsible movement of broodstock and juveniles has been responsible for the wide dissemination of several serious diseases, such as Taura syndrome (TS) and white spot disease (WSD). Although there are often legitimate reasons for international movement of species for aquaculture, many movements have been poorly considered, unnecessary and irresponsibly implemented.

These have involved the use of stock from unscreened sources (wild-caught). Post-larvae (PL) and broodstock are moved over long distances for a number of reasons, including inadequate local supplies, failure to domesticate species, the perception that new species are somehow better, the perception that wild-caught PL are somehow better, and the motivation for quick profits.

There are also socioeconomic and livelihood issues to consider. The lack of control inherent in many aquaculture systems results in increased chemical use, possible depletion of natural stocks, wastage of by-catch and a bad international image for the sector.

Risks can be reduced by such measures as effective screening of PL and broodstock for serious pathogens, full control of the life cycles of cultured species, reduced use of wild-caught PL, etc. However, in many cases there are issues of technical and practical feasibility, and cost-effectiveness. The responsibility for promoting hatchery development, whether state or private sector has yet to be defined in many countries. Developing hatchery standards, whether by state agencies or the private sector, is needed to guarantee "quality assurance" for healthy larvae, promote vendor responsibility, increase farmer confidence, and reduce disease risk.

Broodstock Issues

Aquaculture is the only major animal production sector that depends, for the most part, on wild-caught broodstock or seed. There is an urgent need for self-reliance in resources for seed production. Broodstock development programs will allow full control of the life cycle. Such domestication allows genetic improvement, control of pathogens and prevention of vertical transfer between parent and offspring.

Preventing Pathogen Spread

Using the polymerase chain reaction (PCR) method to enhance and detect pathogen DNA, it is now possible to screen shrimp post-larvae for several of the most important pathogens. However, although many government and private sector diagnostic laboratories are rapidly adopting this technique, there are a number of significant problems, which need to be overcome. These include technical issues related to good technique (avoidance of contaminant DNA), pathogen detection (failure to detect due to small sample size), test specificity, and sensitivity, standardization, reliability, and lack of farmer confidence. An important consideration is the expense of the equipment and reagents. Cost-benefits must be closely examined.

Quality Control Issues

Quality control issues include the need for quality assurance programs for broodstock and seed. National accreditation schemes need to be considered. These could assure specific pathogen-free (SPF) or specific pathogen-resistant (SPR) post-larvae or certify production facilities as free from specific pathogens.

Consideration should be given to the use of Hazard Analysis Critical Control Point (HACCP) procedures in aquaculture production systems. Such methods may be most applicable to closed culture systems, which are yet to be widely practiced.

Other quality control issues include the application of International Standards Organization (ISO) accreditation to aquaculture production. Governments, international organizations and private sector associations have also tried to address issues related to quality control through Codes of Conduct, Codes of Practice, and industry standards and self-regulation.

Zoning, as outlined by the Office International des Epizooties' (OIE) *International Aquatic Animal Health Code*, is another approach, which allows uninfected areas of a country or individual production facilities to have access to international markets even though a serious aquatic animal pathogen is present in some areas of the country. Important quality control issues to be resolved include determining who pays for such programs, and whether there is sufficient consensus and motivation within the private sector to implement them.

Efforts to Minimize Pathogen Introductions

There are a number of important international efforts currently underway to minimize the risks of introducing pathogens into new areas. These include international Codes of Practice, agreements and guidelines. The *International Council for the Exploration of the Sea/European Inland Fisheries Advisory Council (ICES/EIFAC) Code of Practice*, which was developed mainly for introductions of marine aquatic animals, includes protocols for the safe introduction of exotic species. Similarly, the FAO's *Code of Conduct for Responsible Fisheries* (CCRF) recognizes the importance of responsible trans-boundary movement of aquatic species. More specific to pathogen movements, the OIE's *International Aquatic Animal Health Code* and *Diagnostic Manual* provide standards for the quarantine and inspection of aquatic animals for serious pathogens of international significance, while the World Trade Organization (WTO) and the Sanitary and Phyto-sanitary Agreement (SPS Agreement) outline standards for trade in aquatic animals and prevention of disease spread, and give the Fish Disease Commission (FDC) of the OIE the mandate to set the required aquatic animal health standards and arbitrate international trade disputes arising from aquatic animal health issues. Both the Code and the SPS Agreement have far-reaching implications for trade, the aquaculture industry, and capture fisheries.

On a regional basis, the FAO/NACA Asia-Regional Programme on Aquatic Animal Health Management, with the collaboration of the OIE, is assisting national governments with harmonizing policy and procedures for the prevention of aquatic animal diseases within the Asia Region. Components include regional strategy on quarantine and health certification, regional disease reporting, inter-net based information systems and assistance with the development of national strategies on aquatic animal health management which include elements on policy/legislation, quarantine and health certification, diagnostics, disease reporting, import risk analysis, national coordination, institutional resources services, etc.

Conclusions

The impacts of introduced aquatic animal pathogens in new hosts and ecosystems cannot be predicted *a priori*. Species that are well tolerated by their normal hosts may be highly pathogenic to unexposed species. Experience has shown that the socioeconomic costs of inadvertently introducing a pathogen may far exceed the costs of rigorous measures to prevent its introduction. Therefore, aquaculturists, fisheries managers and development agencies must take disease concerns more seriously than has been done in the past. If an intentional introduction or enhancement of a fish, shellfish or mollusc is worth doing from an economic or ecological standpoint, then it is also worth the time, effort and money to adequately address disease concerns both before and after production starts.

Dealing with Disease: An Industry Perspective

by
Daniel Fegan

Any discussion of disease and strategies for dealing with disease in the shrimp industry needs to take account of the diversity of the "industry" and the systems involved in shrimp production in different countries and regions and the local capabilities and priorities for dealing with shrimp disease. There is, in reality, no simple definition for "the" shrimp industry. What is commonly called the shrimp industry consists of a large number of activities and enterprises involved in the production, sale and marketing of shrimp, and what is seen as the "direction" of the industry is the collective outcome of many decisions, good, bad and indifferent, made at all levels, not just of the industry, but of the authorities and other stakeholders affecting its development. Like many modern production industries, shrimp production has a chain of core activities from broodstock fishing, broodstock production, nauplius production, post-larvae (PL) production, farming, processing and export, with ancillary service components, such as feed and other product suppliers. It is also impacted upon by government policies and plans, stakeholders and the market. As with all diverse industry activities, the priorities, objectives and needs of each of these sectors do not necessarily coincide.

Production operations vary from small, stand-alone, family-run operations to large, vertically integrated corporate structures. There are major differences in attitude to disease between groups whose primary involvement is shrimp culture and those for whom shrimp culture is a relatively minor component of a diversified range of business activities. Companies or individuals for whom shrimp represents their main activity are more likely to persist in finding solutions to disease problems than are companies or individuals for whom shrimp represents simply one option in a portfolio of investments.

Shrimp production operations in Asia and Latin America are very different: technically, culturally and as business models. Small-scale producers at the hatchery and farm levels, often operated on a family basis, dominate the Asian shrimp industry. Pond and farm sizes are usually small, with ponds between 0.5 and 2 ha each and farms of less than 10 ha total area. In many Asian countries, the dominant form of production is semi-intensive, averaging approximately 3-5 mt/ha/crop, although in some countries, extensive production is more common. The semi-intensive systems demand a relatively higher level of pond management, and the higher predominance of owner-operated farms increases the direct stake held in the farm and its success by those working on it. Asian governments, recognizing the importance of shrimp aquaculture as an earner of foreign exchange, also provide comparatively high levels of direct and indirect support for the industry.

The Latin American shrimp industry is characterized by a predominance of large-scale producers and more vertically integrated operations. Farm and pond sizes are much larger than in Asia, with farms of several hundred hectares being fairly common and pond sizes generally varying between 5-20 ha. Latin American production is largely extensive, with yields averaging around 0.5-2 mt/ha/crop. Both wild and hatchery-reared PL are used, and progress in domestication of the principal species cultured (*Litopenaeus stylirostris* and *L. vannamei*) is more advanced than in Asia, with greater availability of domesticated, specific pathogen-free (SPF) and specific pathogen-resistant (SPR) stocks. In contrast to the situation in Asia, in Latin America there appears to be a comparatively low level of governmental support for the industry.

How Businesses Perceive Disease

In business terms, disease is not viewed as technical issue. This is because disease is viewed as a cost and a business risk in the same way as inflation, rising raw material prices, market variations and other impacts on financial viability.

There is also a clear difference among people in their attitude to risk. Some people are extremely risk averse and will avoid taking any action which they perceive as increasing their exposure to risk; others are very risk accepting and are willing to take risks with the expectation of higher rewards. As the disease risk is seen to increase, the more risk-averse investors tend to move out, and investors willing to accept higher risks remain or come in.

The focus on economic performance also means that if a disease does not cause unexpected loss of income, it is not generally regarded as a priority. This is despite possible significant costs to the industry due to non-lethal diseases that reduce growth and survival. However, since these costs are regarded as "normal", little attention is paid to these diseases.

In the private sector, the acceptable time frame to develop solutions is short, especially for diseases with severe, acute impact. This is in sharp contrast to the pace of scientific investigation, and this difference is a frequent cause of frustration to both scientists and businessmen.

Finally, perceptions of the importance of diseases change with time depending upon how much of a business risk they represent and their unpredictability. Both yellowhead virus (YHV) and Taura syndrome virus (TSV) have been downgraded as business risks as their impact on shrimp farming has declined to either a background or a more predictable pattern, or as management strategies have been developed.

The Business Cost of Disease

Direct losses due to viruses in the last five years are estimated to be in the region of several billion US dollars. However, the indirect losses to service and ancillary businesses may be as much as two to three times the direct losses.

Direct loss of shrimp production is also evident. Reports from various countries indicate that disease has reduced production by 25-80% over that in the years preceding a major disease outbreak. At the farm level, production losses up to 100% have been experienced, sometimes in several succeeding crops. The decline in production is not simply due to direct loss, as it is also affected by farms being taken out of production, either as a result of losses and bankruptcy, or to avoid risk. This represents a further opportunity loss where the potential for production is not realized.

The adoption of "closed" systems to deal with disease has also impacted on production. These strategies, where as much as 60% of a farm's production area is set aside for reservoir and treatment ponds, reduces the overall yield/unit farm area, giving a significantly reduced yield.

The recent impact of white spot syndrome virus (WSSV) on the Americas has clearly highlighted one of the most important social impacts of shrimp disease. Job losses in farms, hatcheries, processing plants, feed mills and ancillary/service businesses have been high. This is particularly true in the case of processing plants that employ large numbers of women in predominantly rural or low employment areas. National income is also affected, with the loss of direct export revenue affecting "hard currency" income and the loss of tax revenue from exporters and employees in the industry.

Loss of investor confidence is also a significant impact of disease on the business environment of shrimp culture. Apart from reducing direct investment in the industry, it also reduces the money available to upgrade facilities and to take countermeasures against disease. The banks' perception of business risk is also affected, making it more difficult to borrow money.

Market perceptions are also impacted by disease problems. Consumer perception of product safety can be affected by reports of disease in farmed food products. Reports of viral diseases in farmed shrimp can cause concern about impacts on human health, and heavy losses due to disease affect the consumers' perception of shrimp farming as a sustainable activity.

Disease problems will inevitably result in closure of some businesses due to lack of financial resources or loss of desire to maintain investments in the sector, and may also cause other businesses, or even countries, to become uncompetitive or reduce their importance as exporters. In the long-term, however, it is widely believed that the industry will be able to overcome these problems and continue to satisfy the global demand for shrimp. This has to be done, however, in a practical and cost-effective way, which will continue to supply the consumer with a good quality, competitively priced product.

Disease problems influence competitiveness at several levels. On an individual level, those with better financial resources have a distinct advantage, in that they can withstand the economic impact of disease. The competitive position of exporting countries is also affected. Buyers may shift purchases to countries with fewer disease problems, if shrimp supply from affected countries becomes uncertain. At the same time, some strategies for managing disease problems may distort the market, such as the shift to earlier harvesting of small-sized shrimp. International competition for markets can also have an effect on international co-operation, as some countries gain competitive advantages over others.

One other important point regarding competition is where standards are sought through codes of practice, legislation or other mechanisms. This generally leads to increased costs due to the cost of compliance. If such standards are not applied uniformly, they will penalize those who absorb the cost of compliance or whose costs of compliance are higher. This can have an impact on the market, favoring those with the lowest costs of compliance or countries that are, for whatever reason, given some measure of exemption from their application. It is important that mechanisms be sought which encourage the market to recognize and reward those producers that comply with accepted standards.

Relationships between Scientists and Industry

The relationship between the private and public sectors in dealing with disease problems is often discussed with some measure of frustration on both sides. This is frequently due to differing objectives, priorities or time frames in which both groups operate. Some scientists approach a disease problem in a commercial farm as an opportunity for academic study, causing frustration for farmers expecting a quick solution. Others take a more practical approach, working with the farmer to develop solutions. This approach is obviously more appreciated by the farmers, even when it does not prove successful.

Scientists and researchers are generally regarded as providers of information and services to the private sector. However, they are by no means the only, or the major, source of such information. When questioned about their sources of information, farmers generally give the following in order of perceived importance:

- Other farmers, peers
- Salesmen
- Extension workers
- Scientists

This ranking reflects the extent to which farmers has contact with the different groups and the importance of communication. The way in which farmers get information is also quite specific. Word of mouth is usually the most important, followed magazines, articles and sales information. On a more formal basis, local seminars and meetings, often hosted as sales promotions, are useful. Peer-reviewed papers, journals and scientific conferences are generally disregarded, due to their poor availability, cost, highly technical language and the lack of a clear frame of reference for the farmer.

Most farmers are part of an informal network in which the transfer of information is rapid, although of varying reliability. The credibility of this network is high, as farmers feel that they have similar problems, views and experiences. Salesmen generally rank next, as they provide a large measure of close technical support, visit frequently and are aware of the farmer's problems. Farmers are aware that their credibility varies, but since their sales depend upon the farmer's success and ability to purchase their goods or services, they are seen as being generally helpful. Government extension workers are also viewed as useful sources of information, but they tend to visit infrequently and lack sufficient credibility to be effective. Financial constraints on extension services and a lack of direct practical experience in growing shrimp are often cited by farmers as reasons for not following extension workers' advice. Scientists generally come low down, with many farmers having a quite disparaging attitude.

When confronted by a disease outbreak, a producer wants to do something…anything... to solve the problem as quickly and as cost-effectively as possible. Diagnostics are frequently of limited interest, as putting a name to a problem does not solve it. When confronted by a catastrophic disease outbreak affecting his livelihood, a farmer will do anything to try to save the crop. As a result, there is a general tendency towards increased use of "cures" and "miracle treatments."

Communication skills are of paramount importance when dealing with farmers. It is also important, particularly for scientists and extension workers, to realize that technical issues are only one dimension of a producer's business concerns. The most important factor in any business is financial performance, and this must be considered when discussing any producer's business operations. Failure to do so can result in misunderstanding and loss of confidence, especially if proposed actions are financially unsound.

Aquaculture producers, regardless of the scale of operation, are generally focused on their business needs and make decisions on a business basis. How good or bad such decisions are will depend upon the availability of relevant information and how it is considered when the decision is made. One of the major constraints, especially for small farmers, is the availability of such information in a form that is understandable, relevant and, equally important, timely.

Much of shrimp aquaculture decision making is effectively risk management. Producers are continually called upon to make decisions requiring a trade-off between several competing factors. In order to do so requires a good understanding of the risks and rewards of particular strategies or decisions. This requires more information on the relative risks associated with particular strategies, their evaluation and some level of cost-benefit analysis. This kind of information is frequently lacking, and farmers are continually seeking advice and practical assistance on different strategies, their likely outcomes and an appreciation of their individual circumstances in using such strategies.

Producers want reliable information from a trustworthy source, particularly when faced with a disease problem. This is often difficult as, when problems strike, producers are faced with a number of people offering advice and solutions. They find it difficult to turn down offers of assistance at times when they are most vulnerable, and frequently purchase products or solutions, which offer only transient, if any, relief. Scientists, who may have a great deal to offer in terms of information and advice, often expect that their information will somehow filter down to the farmers. Unfortunately, this is seldom the case.

Interventions

Interventions to solve disease problems need to be made at an appropriate point in the production chain should be practical and cost effective. This requires considerable study of the disease and its aetiology, as well as good information on its epidemiology. However, this information is frequently lacking or is not available on a timely enough basis to be useful. The reasons for this lie both with the producer, who may not have sufficient records or may avoid reporting the disease, and with the lack of an effective reporting and monitoring structure for shrimp disease within a country.

The current fragmented nature of the shrimp industry is also a constraint, particularly in Asia, where the different levels of the production sector operate largely independently. This can result in a lack of cost-benefit at the level where the intervention is most appropriate (e.g., the need for PCR testing or PL quality control schemes at the hatchery level to be compensated in the price).

Domestication is frequently highlighted as a way to reduce the industry's exposure to disease resulting from the use of wild stocks in farms and hatcheries. Domestication of *Litopenaeus vannamei* and *L. stylirostris* has developed to the stage where the use of domesticated stocks and the process of genetic selection are relatively well advanced in the Americas. In Asia, marked resistance by the hatchery sector, as well as unreliable reproductive performance of pond-reared broodstock have slowed interest in domestication and selection program. Their development will rely greatly upon demonstrating the economic and management benefits to farmers.

The elimination of carrier, or potential carrier, species for some highly virulent diseases such as WSSV has been identified as an appropriate intervention. However, the apparently successful adoption in the case of WSSV in Asia does not necessarily make it universally appropriate. In the case of large farm systems, such as those in Latin America, the elimination or exclusion of carriers is unlikely to be cost effective due to the vast land areas and water volumes involved. In this case, the decision to spend a great deal of time, money and effort to exclude or remove carriers will depend upon the perceived risk. The costs and likely returns of any disease control or prevention strategy will have to be calculated on a case-by-case basis, as they depend on mainly business factors, such as return on investment needs, loan repayments, shareholders demands, ability to withstand a given period of reduced or negative income, etc.

Diagnostics

The use of diagnostic tests is an interesting case study of industry-scientist interaction, particularly the use of PCR techniques in the diagnosis of shrimp population health. Problems related to interpretation of results and a lack of standardization of methods resulted in confusion among farmers, eroding their confidence in diagnostic capabilities. These problems related to misunderstandings on the part of farmers and diagnosticians of a number of basic epidemiological principles, such as sampling and epidemiological statistics, and the relationship between the presence of a pathogen and the occurrence of clinical disease and mortality. At the same time, farmer's expectations were too high, such that the diagnostic result was regarded as a definitive statement of the health of a batch of PL or a pond. These issues highlight the need to adopt a multidisciplinary approach that includes diagnostic methodology and epidemiology as tools to develop strategies for the management of shrimp population health. The further development of practical and economically effective disease management strategies will require further improvements in these methods and a thorough understanding of the business realities surrounding disease control and health management.

Knowledge and Experience in Trans-Boundary Movement of Aquatic Animal Pathogens: The Roots, Impacts and Implications for Aquaculture and Aquatic Biodiversity, and Options and Interventions Avaliable For Mitigating Such Impacts

by

John D. Humphrey

Globally, disease has become a major limiting factor to the successful aquaculture of finfish, molluscs and crustaceans. A complex global trade exists in living aquatic animals and products. This trade supports the well being and economic viability of many segments of many communities worldwide. Components of the aquaculture industries are dependent on this trade for supply of broodstock, larvae or juvenile animals and feedstuffs. With some exceptions, major deficiencies exist in quarantine, health certification and industry practices for translocations of aquatic animals and their products. These deficiencies encourage and facilitate the on-going movement of pathogens between and within countries. This is primarily the result of unrestricted translocations of infected aquatic animals or their products, with establishment of pathogens in new environments resulting in disease.

The past 25 years has seen enormous advances in the understanding of the nature of aquatic animal disease. These include the development of sophisticated diagnostic tests and procedures, the characterization of pathogens at the genetic level, and the development of a diverse range of chemotherapeutic agents and vaccines, powerful information technology capabilities and state-of-the-art risk analysis procedures. Paradoxically, despite these unprecedented advances, major disease epidemics continue to occur globally in farmed and non-captive aquatic finfish, crustaceans and molluscs.

The spread of serious diseases associated with translocations of living aquatic animals is not a recent phenomenon. Many such events are recorded over the past century and have probably been occurring as long as aquatic animals have been moved from one location to another. The introduction and spread of many of these diseases could have been prevented with the application of basis quarantine and treatment strategies. Regretfully, contemporary aquaculture has learnt little from the lessons of history.

There exists developing and expanding global aquaculture; ongoing and expanding trade in aquatic animals and their products; new and emerging diseases of unprecedented magnitude; a negative image of aquaculture as causing environmental destruction and spreading disease; and disparate legislation, resources and levels of concern regarding disease incursions. There also exists much new information on aquatic animal diseases, recognition of the devastating impacts of trans-boundary movements of disease, major international initiatives for aquatic animal disease control, and recognition of the need to maintain healthy ecosystems if aquaculture is to be successful. Despite these factors, considerable inertia and indifference exist within government and industry to address global aquatic animal disease, with many individuals and organizations abrogating their responsibilities in this regard.

Disease control and health management are well recognized in the scientific community as key contributors to the sustainability of aquaculture. The need for international regulations to minimize disease incursions and the need for health certification accompanying movements of aquatic animals are also well recognized. Many workshops and meetings have been held which specifically address these issues. Codes of practice have been produced which also address the responsible movement of aquatic animal species. Despite this activity, there appears to be a substantial loss of control over global trans-boundary movements of aquatic animal pathogens.

Many examples exist of the trans-boundary movement of aquatic animal pathogens, including a diverse spectrum of viruses, bacteria, fungi, protozoa and metazoa. These have been moved by a number of mechanisms in vectors including living finfish (including ornamental species and baitfish), fertile finfish ova, living crustaceans, living molluscs, transport water and packing, birds and amphibians, ships and shipping, environmental modifications, fish feeds, raw and frozen commodity products, malicious activities, and invertebrate vectors. A number of examples also exist of the trans-boundary movement of aquatic pest species accompanying translocations of aquatic animals. It is likely that the known number of cases represents but a small fraction of the actual trans-boundary movements of aquatic animal pathogens, which has occurred, and which continue to occur unrecognized and unreported.

The causes of trans-boundary movements of aquatic animal pathogens are many, but may be grouped into social, cultural and economic; and biological, microbiological and ecological causes. Social, cultural and economic causes include historic differences in quarantine between aquatic and terrestrial animals; trade imperatives; social and cultural imperatives; legislation, controls and codes of practice; inadequate aquatic animal health services; resource limitations; disparate capabilities and resources; failure to implement risk assessment procedures; high risk activities and illegal activities. Biological, microbiological and ecological causes include the latent or carrier state and reservoir hosts.

Major adverse impacts and implications for aquaculture and biodiversity have accrued as a result of disease incursions. These impacts may be direct or indirect, consequential or "flow-on" impacts, as well as social or cultural, economic, ecological and zoonotic impacts. Little is known regarding the implications for biodiversity, but the study of disease incursions in new ecosystems suggests that ecosystems undergo a typical stress response characterized in part by reduced biodiversity. The need to quantify impacts in social, economic and ecological terms is of major importance as a basis for the justification of quarantine and control measures.

Options and interventions to prevent or mitigate impacts of disease are generally well described. These include early diagnosis, treatment, control or eradication, ecosystem management, advanced breeding programs, restocking programs and quarantine, health certification and movement restrictions. Other possible actions include risk assessments, regional agreements, collaboration and complementary legislation, closed cycle production, specific pathogen-free (SPF) broodstock and hatcheries, specialized diagnostic capabilities, research, development and training in improved diagnostic capabilities, development of disease information systems, a "zoogeographic" approach to quarantine and health certification and development of resources and infrastructure.

An urgent need exists for government and industry to accept responsibility for minimizing trans-boundary movements of aquatic animal pathogens. This responsibility may be manifest as complementary legislation, infrastructure and policies as well as codes of practice and development and implementation of industry standards. International groups and organizations have a major role to play in developing and implementing disease control policies on a regional basis. Trans-boundary movement of aquatic animal pathogens must be controlled in order to sustain aquaculture. As well, protection of the environment and biodiversity from the adverse impacts of introduced pathogens must be a high priority. Given the enormity of the current problem and the length of time over which it has developed, it is likely that the trans-boundary movement of infected aquatic animals will continue to occur until national, international and regional policies and agreements exist which will collectively minimize disease incursions.

Species Introductions, International Conventions, and Biodiversity: Impacts, Prospects, and Challenges

by

Devin M. Bartley

The movement of aquatic species into areas outside of their native range is a proven method of increasing production and is one of the most common types of fishery enhancement practices. The culture of crustaceans involves both the introduction of animals into new areas and their transfer into areas where they already exist. Both practices have implications for biodiversity and the aquaculture industry.

Introduced species can adversely impact local biodiversity through predation, competition, genetic pollution, habitat modification and the spread of pathogens. In Crustacea, the spread of disease has been one of the most serious impacts of introductions and transfers. The introduction of crayfish from North America to Europe also brought the crayfish plague that has decimated European crayfish populations. The Taiwanese shrimp industry collapsed after the introduction of diseased animals, e.g., shrimp containing monodon baculovirus (MBV) and yellowhead virus (YHV). Newly discovered viruses caused financial losses of over a billion US dollars in Asia in the early 1990s. Now, the shrimp industry in Latin America is threatened by the appearance of white spot syndrome virus (WSSV) and YHV, pathogens that were formerly confined to Asia.

The international community is being asked to provide assistance and guidance on the responsible movement of alien species (i.e., introduced or exotic species). Binding legislation has been adopted by the Convention on Biological Diversity (CBD) and the World Trade Organization (WTO), whereas, voluntary guidelines and codes of practice have been developed by FAO, other intergovernmental and professional associations.

The international agreements concerning use and conservation of living resources may be in conflict. The Center for International Environmental Law (CIEL) noted that due to the "interlocking relationships between trade and other issues, including environmental protection, WTO activities now have more extensive ramifications." The WTO and the CBD will need to harmonize policies such that biodiversity is protected and benefits equitably shared, as trade is globalize, promoted and liberalized. Most of the articles of the FAO *Code of Conduct for Responsible Fisheries* (CCRF) and the CBD are extremely complimentary, in that both instruments call for the precautionary approach, maintenance and restoration of ecosystems, monitoring introduced species, and development of information systems to assist in the conservation and sustainable use of biodiversity.

A key aspect of the responsible use of alien species will be improved information systems that document the movement of species and their impact. Both the CBD and the CCFR call for the establishment of improved information systems on biodiversity in general and on alien species specifically. Toward this end, a Database on Introductions of Aquatic Species (DIAS) was created by FAO from earlier work by Robin Welcomme. In order to understand better the status of introductions and transfers of crustaceans, DIAS was queried to provide summary statistics.

Results

Status of international introductions of crustaceans

DIAS records indicated that *Macrobrachium rosenbergii* was the most commonly introduced crustacean. As with other taxa, aquaculture was the most often cited reason for the introduction of crustaceans. Oceania was the region where most introductions of crustaceans occurred. Who is responsible for most introductions is largely unknown or at least unreported, but of those groups identified, governments were responsible for the majority of the introductions.

Impact of the introduction

The overall impression from DIAS is that the introduction of crustaceans has had more positive social and economic benefits than negative ecological impacts. Many of the records citing adverse affects were from introductions that did not become established in the wild.

The ecological literature states that most introductions fail. Of the 191 records of introduced crustaceans, 73 records indicate that the animal became established in nature, 54 report failed establishment and 64 records report that it was unknown whether or not the introduction lead to establishment. However, the introduction of crustaceans is usually for aquaculture and not for establishing natural populations. Examination of two popular shrimp species revealed that, of 13 countries where *Penaeus monodon* has been introduced, only Fiji (60 mt), Italy (<1 mt), and Solomon Islands (10 mt) report any production. From FAO Fishery Statistics, 23 countries reported a total production of 490,195 mt for *P. monodon* in 1997. Therefore, introduced species only accounted for 0.01% of production. Nine countries have introduced *Litopenaeus vannamei*, but of these, only Colombia reports any production, and *L. vannamei* is native there. The record in DIAS represents a transfer from another part of Colombia. According to FAO, 12 countries report production of this species; therefore no production is from an area where it is not native. Introduced crustaceans are responsible for a substantial part of production in areas such as Europe, where native crayfish have been replaced by exotics.

On a cautionary note, DIAS may be a biased account of species introductions. Those introductions that did become established or that did produce some effect may have been preferentially written up in the literature or included in the questionnaires, whereas introductions that immediately failed or had inconsequential impact may have simply been forgotten or were unreported. One would like to think that more well-advised introductions are now being undertaken. Hopefully, the days of experimentally moving any favorite species around the world have given way to the well planned movement of a few species with proven performance. However, the recent problems with spread of disease in Latin America indicate that there is still substantial irresponsible movement underway that threatens to undermine the farmed shrimp industry.

SUMMARY OF LATIN AMERICAN NATIONAL REVIEWS ON MANAGEMENT STRATEGIES FOR MAJOR DISEASES IN SHRIMP AQUACULTURE

This section provides a summary of the reviews made on management strategies for major diseases in shrimp aquaculture for the Latin American countries involved.

Ecuador

by

Victoria Alday de Graindorge and D. Griffith

History of Major Disease Outbreaks

Although there is evidence that the virus has been present in Ecuador since 1997, the current white spot syndrome virus (WSSV) outbreak is generally accepted as having begun towards the end of May 1999. Previous disease outbreaks of importance include Gaviotas syndrome (1989 through 1990) and Taura syndrome (TS) (1993 and 1994).

Negative Economic and Social Impacts of Disease Outbreaks

According to a simple survey conducted by the National Chamber of Aquaculture (CNA), 73% of farmers surveyed indicated that they had suffered some impact of the virus between April and August of 1999, although the rate of response was low. Based on this survey, it was estimated that perhaps 13% of the direct labor force (26,000 people) had been laid off as a result of white spot. The national projections derived from the survey suggest that the lost production attributable to WSSV was around 63,000 mt (141.2 million lbs) valued at US$ 280.5 million, and that up to 42% of the available farm production capacity had not been achieved due to reduction of operations. Hatcheries also closed down as production and demand declined, and an estimated 74% of installed capacity was idle by the end of August 1999.

Feed mills and packing plants also suffered impacts, reporting a 68% reduction in sales and production. The seven major feed manufacturers reported laying off 64% of their work force, while packing plants, which traditionally employ large numbers of unskilled labor, particularly women, were forced to curtail operations and considerably reduce their labor force. One newspaper estimated that by October 1999, some 150,000 people had been made redundant within the shrimp sector, and that direct economic losses may have exceeded US$ 250 million. By year's end, monthly exports approached levels not seen in 13 years.

Response to Major Disease Outbreaks by Different Sectors

Response by the State

Upon the confirmation of WSSV presence in Central America, the Ecuadorian government, based on recommendations made by the private sector, quickly implemented a ban on live animal transport into Ecuador in the hope that the risk of disease transfer from affected areas could be reduced. This move particularly affected shipments of nauplii from Panama for Ecuadorian producers of post-larvae (PL). Given the futility of this action, both Panamanian exporters and Ecuadorian importers have asked that this restriction be lifted, although at the time of writing the ban remains.

Response by the Farmers

The majority of the recommendations made for WSSV management in Ecuador are based on Asian techniques. However, due to the large differences in the two types of farming system, these recommendations are proving difficult to implement with any success. As a result, many types of treatment, from the promising to the simply far-fetched and hopeful, are being tried.

As in Asia, screening of PL using polymerase chain reaction (PCR) tests to avoid infected batches has been quickly adopted. Private laboratories, some offering a paid service, were quickly developed, and at the present time five of these exist.

Only limited success has been achieved with zero water exchange techniques, due to the lack of aeration in the large ponds operated in Ecuador. While the use of fine screens (down to 300 micrometers mesh size) to eliminate potential carriers in incoming water has become common, the effectiveness of this practice for viral management remains open to question.

Water treatments, including the use of ozone, chlorine compounds, pesticides and a host of natural compounds (including garlic, lemon and homeopathic remedies) are being tested. However, there are serious concerns as to the cost/benefit of such treatments, and there are even more worrying concerns as to potential health and environmental risks associated with the use of chlorine compounds and pesticides.

Ecuador has traditionally used wild seed for pond stocking, an activity that has hindered the development of domesticated shrimp stocks. The WSSV outbreak has altered this situation, and the few companies that have developed domesticated stocks are considered to have a distinct advantage over less advanced farmers. At the same time, it is safe to assume that the majority of farmers will stock ponds with wild seed on a trial basis early in the new year.

In the short term, many farms have either closed or scaled down operations to run extensively until the situation improves. Other strategies, which have shown mixed success, are the use of lime, reduction of stocking density, larval/post-larval disinfections and the use of a wide range of feed additives.

When an outbreak hits a farm, early harvesting has also been adopted, leading to a reduction in the average size of the shrimp produced and reduced income for the farm. Thus a small drop in the quantity produced (4.8%) resulted in a 21.8% reduction in income.

Response by Hatchery Owners

The single most significant action taken by hatcheries has been to suspend operations or close down until the demand increases. In those hatcheries remaining open, improved sanitary procedures have been adopted, including disinfection of eggs and nauplii and PCR screening of PL. PCR checking of broodstock has not been widely adopted.

Response by the Service Providers

As previously described, feed manufacturers and processors/exporters have greatly reduced operations as farms stopped producing and demand for feed slowed. The lack of raw material also affected the packing plants and exporters, forcing them to cut costs by reducing staff and, in some cases, sharing facilities.

Research and Development Interventions

The National Aquaculture and Marine Research Center (CENAIM) have given top priority to applied research to reduce the impact of WSSV. Among the studies conducted were trials on the disinfection of eggs and nauplii, a study of the potential for vertical transmission of the virus, monitoring the presence of WSSV on farms, and testing of some of the additives and products used by the farmers.

Just before the outbreak, a new Center for Aquaculture Services (CSA) was formed by CENAIM, the Escuela Politecnica del Litoral (ESPOL) and the CNA, funded by the European Union (EU), to improve the quality of disease diagnosis. Since the outbreak, the CSA has organized seminars and training courses in the diagnosis of WSSV and the use of PCR. One of the activities undertaken was an inter-calibration exercise of PCR labs to ensure consistent results. This showed good agreement between the laboratories and will be conducted periodically to maintain standards.

The Way Forward

There is a strong need for education to increase farmers' awareness of disease and its prevention. Routine surveillance for current and emerging diseases needs to be implemented. Ecuador has many competent and well-trained pathologists, but there is also a need to increase the number of trained epidemiologists working on shrimp diseases.

Regional disease surveillance programs, co-operation and contingency planning should be established, incorporating a network of reference diagnostic laboratories, which in turn need to be capable of supporting health certification efforts, within a standardized protocol and adopted throughout the region. It is difficult to conceive of a national position regarding aquatic animal diseases that does not take into account the policies of bordering nations. The regional nature of the current WSSV disease problem underlines the importance of regional disease management programs.

Finally, within the shrimp farming community, communication needs to be more effective, so that vital management information can be rapidly disseminated. Again, this needs to be addressed at both the national and regional levels within Latin America.

Honduras

by

Hector L. Corrales, C.L. Watson and John Wigglesworth

History of Major Disease Outbreaks

Honduras has suffered from two major shrimp diseases. Taura syndrome virus (TSV) was confirmed in Honduras during August 1994, while white spot syndrome virus (WSSV) was found in February 1999. In the case of TSV, the effects on production were acute and quite dramatic; during the early stages of the history of this disease survivals dropped to as low as 15%. The TSV problem continued through 1995, and stabilized in 1996, with subsequent survivals reaching an average of around 50%.

Following hurricane "Mitch," in January 1999, acute mortality was encountered in *Litopenaeus stylirostris* in wild-stocked and mixed-stock ponds, and these mortalities were subsequently confirmed as caused by WSSV. Ten months after the initial outbreak, some farms have experienced severe problems, while others have not been badly affected. However, the effects of WSSV have not been devastating to the majority of the shrimp industry.

Negative Economic and Social Impacts of Disease Outbreaks

Following record production in 1993, the TSV outbreak reduced total production by 18% in 1994, 31% in 1995 and 25% in 1996. This caused farmers to take serious steps to reduce costs. Labor costs, for example, were reduced by 18% from 1994 to mid-1995.

Foreign currency generation was also affected. Prior to Hurricane Mitch, shrimp was the third most important export crop in the country, providing between 14% and 26% of the country's Gross Domestic Product (GDP). It is difficult to separate the impact of the disease from that of the hurricane, but both have had a significant adverse effect on foreign exchange generation and the financial situation of most farms. It is too early to assess the impact of the WSSV outbreak, but while not as severe as the impact of TSV, it has also taken its toll.

It is difficult to assess the impact of decreased production on the local economy. However, there was a significant down sizing in the transport and processing sectors and an estimated 13% reduction in the labor force during the first quarter of 1999. Activities recovered during the second quarter, with concomitant increases in the workforce, due in part to improved management and supervision activities to minimize the effects of the disease.

Response to Major Disease Outbreaks by Different Sectors

Response by the State

The Government of Honduras recognizes the importance of the industry and has played an important role in its development, creating incentives such as a 20-year tax exemption, duty free importation of equipment, and resources and land concessions. The government has also co-operated with the National Aquaculture Association of Honduras (ANDAH) to assure optimum growing conditions and low impact on the environment, and they have jointly formulated recommendations on farming practices and for the conduct of joint research initiatives.

When TSV was first detected, the government created an ad-hoc committee with the specific task of identifying the actions necessary to guide the industry in dealing with this new disease. The authorities, together with technical personnel, developed laws regulating the import of post-larvae (PL), proposed a moratorium on new farm development, and developed regulations on cultivation practices. It has also recognized the need for a separate agency devoted solely to aquaculture to give more attention to the sector and to strategic planning.

Response by the Farmers

The initial response to TSV was to increase stocking density to compensate for lower survival. This was not entirely successful, as survival reduced further and stocking density eventually stabilized around 100,000/ha. To reduce costs as production declined, water exchange was reduced from 10% to 3-6%. Some companies invested in controlled nursery systems to facilitate treatment with therapeutants and for water treatment, but this was soon abandoned in favor of stocking PL directly into grow-out ponds. Other groups invested in research and development, designing controlled exposure studies aimed at identifying the most appropriate source of seed. This had some success, but did not predict the outcome in the pond environment. In general, the industry went into a dormant period in which costs were reduced and expansion plans were put on hold until conditions improved.

Since outbreaks of TSV tended to occur more frequently during the rainy season, farms adjusted stocking and harvesting to take this into account. The importance of long-term planning was also recognized, and existing breeding programs were adapted to address the long-term security of the business.

Due to the recent arrival of WSSV, short-term actions have been taken while information is gathered. When WSSV occurred, the farm sector mobilized quickly. Visits and contact with Asian experts were made to gather and disseminate information. Based on the information obtained, farmers requested hatcheries to ensure that seed was produced from WSSV-screened nauplii, wild seed collection was suspended, and stocking densities were reduced to more extensive levels. Farms attempted to reduce viral loads by filtering water prior to pond filling. This worked and encouraged more proactive management efforts.

Pond and water management was reviewed to reduce variation and lower stress factors. Tests with different strains showed that no single source of shrimp was superior. Simple monitoring programs were implemented and seed-related risk factors identified (for example, ponds stocked with wild seed were found to be more likely to be affected than ponds stocked with *L. vannamei* of hatchery origin.). Some companies investigated the use of pesticides in pre-stocking water treatment procedures, but this was mostly stopped due to the cost. As with TSV, companies evaluated their financial positions and took appropriate action to reduce financial exposure.

Response by the Hatchery Owners

The advent of TSV precipitated a boom period for hatcheries, as farms increased stocking densities to compensate for lower production. The hatcheries geared up to meet this higher demand without any change in production methods.

The law requiring that imports originate from areas not having TSV removed competition from Ecuadorian hatcheries, closing the import market such that the supply was largely dominated by local hatchery producers. An increase in supply of nauplii and PL from Panama was also noted, as it appeared that the Panamanian strain was more resistant to TSV.

The reduction in stocking density following WSSV led to a reduction in demand for PL. Farmers also requested screening for WSSV using the polymerase chain reaction (PCR) test. Due to a lack of local facilities and expertise, this pre-screening of nauplii was largely carried out prior to shipment to Honduras. Hatcheries buying nauplii requested suppliers to review nauplius washing techniques and completed monitoring visits to suppliers of nauplii.

Medium-term measures for WSSV are still being developed. The hatchery industry in Honduras relies heavily on nauplii from third parties, mainly Panama. Panamanian suppliers will need to adapt to meet the demands of the Honduran hatchery producers and farmers by implementing PCR screening of nauplii destined for Honduras.

Response by the Service Providers

Most Honduran shrimp farmers belong to the National Aquaculture Association of Honduras (ANDAH). ANDAH has emphasized the promotion of responsible shrimp production with its own Code of Conduct as well as adopting the Global Aquaculture Alliance's (GAA) *Code of Practices for Responsible Shrimp Farming*. These activities are promoted in regular workshops and training sessions for shrimp farmers and ANDAH members. The codes and activities also cover social and labor relations and co-operative research activities.

Feed manufacturers have provided some financial assistance for diagnostic services; biotechnology companies have offered private diagnostic services.

The industry association needs funding to develop diagnostic capability, backed up by technology transfer, extension services for producers, and increased research. The industry would benefit from the development of a service and support organization to co-ordinate extension services.

Research and Development Interventions

The disease outbreaks led to increased emphasis on existing research programs, which are mainly undertaken by the companies themselves or promoted by ANDAH. These included the development of domestic broodstock, improved pond management methods and appropriate means to reduce exposure to and risk from viral diseases. In most cases, it is too early to gauge the results of this work.

Effectiveness of Responses

The industry has contributed some direction and response to the problems of both TSV and WSSV. Few changes were made to the hatchery sector as a result of TSV, since the disease had few direct effects upon larval production. However, this may have inadvertently contributed to the spread of the disease. Efforts to find alternative sources of PL were not successful.

The response to WSSV was much more proactive, as hatcheries petitioned for procedures to reduce disease risk. Washing and rinsing of nauplii coupled with PCR testing enabled hatcheries to supply farms with screened PL.

The few hatcheries located in regions free from the disease, such as those in certain areas of the United States, contributed by offering WSSV-negative animals. In the long term, the hatcheries will play a significant role by further addressing issues relating to biosecurity, placing them in a position to supply healthier animals.

The farming side of the business has already progressed in adopting management strategies emphasizing stress reduction and pond stability. These can be expanded through improved training and technology transfer to the producer. Large-scale restructuring of the industry, such as the rebuilding of ponds and modification of farm design is not considered necessary from an economic standpoint and could also have very negative impacts on social and operational structures.

In general, the service sector has not been proactive. The lack of proven treatments has been a major constraint to dealing with disease problems, although the development of association laboratories capable of providing diagnostic services, technology transfer and extension specialists has been effective in no small measure. This side of the industry should be encouraged to develop further.

The state sector has had a great deal of influence and a positive effect upon the industry as a whole, particularly at the operational level. Legislation has been appropriate and applicable to the industry and has been implemented with input and guidance from the industry itself, which has helped promote co-operation and compliance. Unfortunately the Honduran government lacks the financial resources to support the industry at the research and technical levels. This type of support would allow training and research to strengthen the industry in the long term.

Current Status of Health

The Honduran shrimp industry has learned to live with TSV, and it is no longer regarded as a major threat. Although it is too early to comment extensively on WSSV, the Honduran experience is split between farms that can cope with the disease and those experiencing large variations in production. The majority of farms report survivals around 30-50%, and the situation is not regarded as critical. The industry is cautiously optimistic and is adhering to those practices that are applicable and pragmatic, primarily reducing stress and stocking clean PL.

The Way Forward

The single largest factor for the future success of the industry will be to maintain low input, low density, and semi-intensive management. Greater attention will be placed upon production inputs to maintain stability and reduce stress on the shrimp. Management will focus more on economic gain/ha rather than production yields.

Genetic improvement and breeding programs will secure the long-term future of the industry. The development of a selectively bred animal able to thrive in local conditions will increase consistency in production and the ability to respond to new disease challenges.

The state sector will continue to work with the industry to develop appropriate legislation for the future economic success of the industry. In particular, laws are needed that are designed to allow the industry to import PL and nauplii in a manner that will reduce the risk of disease spread.

The local association, ANDAH, will continue in its pivotal role as a cohesive influence for all the producers. Similarly ANDAH will develop its services so that it will be capable of better technology transfer, extension support, research and development, and training, ensuring the long-term future of the industry through education.

Nicaragua

by
Larry Drazba

Nicaragua is located in the heart of Central America with Honduras on its northern border and Costa Rica on the south side. Besides having extensive coastlines on both the Pacific and Atlantic oceans, it shares access to the Gulf of Fonseca with both Honduras and El Salvador. The Estero Real, or Royal Estuary, which empties into the Gulf of Fonseca, is the major shrimp growing area, contributing roughly 95% of the national total. There are also estuaries located on the Pacific coast as well as on the Caribbean, which have shrimp farming potential, but they do not, at present, contribute much to the national total.

Shrimp farming has made tremendous contributions to the national economy, representing in 1998 6% of foreign exchange earnings. The industry contributes a total of 16,500 direct or indirect jobs and, more importantly, is economically active in one of the more depressed areas of the country. In gross economic terms, the Nicaraguan shrimp culture industry may pale compared to other countries, but it has a vital role in the local and national economies. A second important aspect of the Nicaraguan industry is that co-operatively owned farms generate a full 25-30% of production.

Nicaragua only began to develop its shrimp farming resource in earnest in 1993. Over a decade of civil unrest had prevented it from following in the footsteps of Honduras, which by the same year had already developed 11,000 ha. The residues of civil problems, such as deficient primary infrastructure and the lack of basic private and public primary services have hindered progress. The lack of electrification, decent access roads and basic services such as clinical labs and information services, to mention only a few, has retarded development. In many cases, the delayed development of an industry relative to other areas gives increased competitive advantage because proven ideas are implemented in the new country immediately. In Nicaragua, however, due to a general lack of development and a deficient financial situation, that has not been the case, and the industry has developed in a very rudimentary fashion and still maintains that profile.

History of Major Disease Outbreaks

During the first two years of operation, farmers were able to harvest high yields and enjoyed economic success. In 1995, the situation changed dramatically as a result of the introduction of Taura syndrome virus (TSV). The immediate result of TSV was the depression of survival rates, but there were subsequent, more prolonged effects, as well.

Besides a gradually declining survival, seasonal differences in survival have occurred. During the height of the rainy season in September and October of every year, the survival in newly seeded ponds is extremely low, low enough to discourage seeding during this period. Peaks in survival occur during the dry months (January through April), with a gradual decline as the rains intensify.

The same factors that originally promised to guarantee results now threaten the very existence of shrimp farming in Nicaragua. The year-round presence of wild *Litopenaeus vannamei* seed, year-round growing conditions and the examples of the Honduran shrimp culture industry using practically the same water source have contributed to the spread and persistence of the TSV. Once the virus was present in the endemic seed population, it could not be eliminated, and it was necessary to look for other management techniques to work with it or around it.

The introduction of TSV coincided with the advent of the El Niño phenomena, and it is impossible to separate the effects of the two events. For Nicaragua, El Niño meant severe drought for several consecutive years. It also meant that a large bubble of relatively warm water formed off the coast near the mouth of the Gulf of Fonseca. This bubble of warm water had been pushed up from the equator and trapped by the predominant north to south currents. The important effect was the recirculation of water between the bubble, the Gulf of Fonseca and the Estero Real over a prolonged period of time. The general water quality of the three water bodies deteriorated, bacterial counts increased dramatically, and Nicaraguan farms began to experience problems with chronic *Vibrio* infections as well as intermittent NHP problems, depending on the salinity. The fact that wild seed were not as abundant for several years or that the little seed that was available gave poor farm results could be a result of the presence of TSV, the El Niño, or both. The fact remains that survivals during this period did not recuperate except marginally, and that farms suffered important economic losses.

In January of this year white spot syndrome virus (WSSV) was confirmed in samples taken from several farms. Early results were catastrophic, with final survivals averaging only about 5-10%. An industry hard hit by previous diseases and more recently by hurricane Mitch was on the verge of panic. All ponds harvested from late January to late March had poor results and then, dramatically, the results began to improve for most of the remainder of the year. There was a second, less serious, outbreak during late September and early October, involving fewer farms and less substantial losses. Mortalities continue on several farms but not on farms that have taken measures against the virus.

Again, it is almost impossible to separate the effects of climatological conditions from the direct effects of the disease, but this time weather conditions were favorable. The La Niña conditions of increased rainfall and stable and moderate temperatures seemed to dampen the effects of WSSV. Farms that took no precautions, either from ignorance, over confidence or lack of financial capacity, still managed good results, as did those that practiced all the prescribed management changes and managed to keep the virus out of their systems or dramatically limit its influence. The good results enjoyed by producers who used no biosecurity measures may cause negative repercussions in future crops.

Negative Economic and Social Impacts of Disease Outbreaks

The most important effect has been the decreased economic efficiency of the farms i.e., the loss of profitability. Operators had to use more seed and also more expensive seed, greatly distorting the overall cost of production.

Response to Major Disease Outbreaks by Different Sectors

Response by the State

Since TSV was introduced, the government has taken little action. The only concrete measure was to prohibit the importation of seed from countries infected with TSV, such as Ecuador. There were no more general sanitary measures taken regarding the import of seed, despite the fact that Nicaragua had changed from a net exporter of shrimp seed (to Honduras) to a net importer of PL and nauplii (from Panama and Colombia).

In the case of the recent white spot disease outbreak, the only real change enacted by the government was to require all imported nauplii and PL to carry a PCR certificate assuring freedom from WSSV and yellowhead virus (YHV).

Response by the Farmers - Taura Syndrome Virus (TSV)

Producers learned to compensate stock, that is, stock more animals and harvest relatively the same biomass as before, therefore reducing the effect of the lower survival rates.

Differences in survival based on seeding date have caused a shift from continuous production cycles to a more batch-based seeding system.

Once it was discovered that Panamanian strains of *L. vannamei* demonstrated marked increases in survival under the same conditions as other strains, genetic material from Panama was imported in the form of PL and nauplii.

Other technologies, such as food additives and antibiotic treatments, were tried, but nothing conclusive was discovered, and most, if not all the treatments were discarded. PL was treated with beta-glucans previous to stocking and at different intervals during grow-out. Ponds were treated prophylactically with different antibiotic mixes in an attempt to control secondary bacterial infections and, therefore, minimize the viral "hit." All these treatments only increased costs. If a pond had TSV and the animals were not resistant, then they died. As resistance increased so did survival. Because farmers learned to compensate stock, they did not attempt to exclude the virus. In retrospect, this appears to have been a grave error. This omission can be partially explained by the assumption that TSV was airborne, using the water boatman as a host.

Response by the Farmers - White Spot Syndrome Virus (WSSV)

The reaction to WSSV by producers was very different than the reaction to TSV, possibly because Nicaragua was the first country in the Americas to be infected. The producers' association (ANDA) immediately scheduled conferences by experts experienced in the Asian (mainly Thai) shrimp production industries. Possible production strategies were discussed, and there was co-ordination between farms to test as many things as possible without wasting effort.

Members of all industry sectors, as well as representatives of the government, formed an *ad hoc* committee to design a contingency plan for the industry. The producers themselves, with the help of one or two government employees, were the key players

Basic strategies used by producers to deal with WSSV were (1) exclude the virus from the system and (2) maintain as much stability in the water column as possible. This prevented the virus from progressing from a latent to active infection. The most important and successful treatments included seeding the system with disease-free animals. If the virus is present in the system from the start, the odds that some mortality will occur are high and the possibility for disaster is significant. There are several triggers, such as low water temperature and extreme diurnal temperature fluctuation, which seem to set off the virus, even under conditions of very low prevalence.

Checking broodstock for WSSV, washing eggs and nauplii adequately, discarding larval rearing tanks that are infected and avoiding the use of infected wild populations are all steps which appear to limit the prevalence of the virus in grow-out ponds.

The use of PCR analysis has become crucial to successful hatchery operation. Its use is required at the broodstock, nauplii and PL levels, although farmers still have a long way to go before feeling 100% comfortable with the results. There exists a correlation between ponds seeded using PCR-tested WSSV-free animals and relative pond success.

The use of formalin as a stress agent has not been validated in the semi-intensive environment. These measures, except the formalin treatment, are fairly widely accepted. There is much discussion regarding the use of chemical treatments in ponds and the exchange of water during the grow-out cycle.

Sevin®, Dipterex®, and pyrethrum compounds have all been used to kill potential hosts in the ponds before seeding. Although data are still scarce, there is evidence to support the concept that the use of chemicals may not be obligatory and may, in fact, limit survivorship under certain conditions.

Alternative management techniques, such as using the distribution canal as such and not as a reservoir, and requiring that it be empty for significant periods during the grow-out cycle, are very effective in controlling viral transmission from surroundings to the ponds. This is a very site-specific control and depends on the abundance of higher crustaceans, which can cross the pond walls from outside the farm into the ponds themselves. The use of double bag nets (one inside the other, 500 micrometer mesh) is mandatory for the exclusion of possible host organisms.

While we have very successfully used the 0-exchange policy of water exchange, other producers insist on water exchange with a certain level of success. The two fundamentals to water exchange appear to be to maintain a rate sufficient to guarantee water column stability while excluding disease carriers and free virus particles. If these conditions are met, it is possible to harvest successfully. If, however, the virus enters and some trigger such as temperature change does occur, then mass mortalities may occur. Mass mortalities may also occur if incoming water is different from the pond water itself and the virus is present in the shrimp population. Ponds seeded with disease-free animals and held in 0-exchange situations did not experience mortalities even during periods of low temperature (high stress), even when exchange ponds seeded with disease-free animals were severely affected.

Economic and Financial Interventions

The finance system of Nicaragua is small and relatively new, having only recently been privatized. It is very conservative and does not have the confidence of the international community or development banks. It has never been a solid supporter of the shrimp farming industry, and the devastation left by hurricane Mitch only eroded weakened confidence. Some projects were able to re-finance their obligations, but no new funds were available for working capital. As WSSV began to take its toll (post-Mitch), all formal finance was cut off and producers were forced to pull themselves up by their bootstraps. This usually meant using their last resources or relying on informal financing, with a correspondingly exorbitant finance cost. There was a massive drop in the liquidity of the system; everybody owed somebody and the industry was very fortunate to have enjoyed the modicum of success that it did this year.

The future of financing is uncertain. Most projects have only their land, improvements, and inventories as collateral, but local banks do not accept these assets against working capital loans. Local banks require hard guarantees, such as houses, other properties or certificates of deposit. When money is contracted, it carries an 18% annual cost plus commissions. Many projects are financed by buyers looking for interest on the funds, mark-ups on sales of inputs, such as seed and feed, as well as a mark-up on the sale of the final product. Because these buyers are willing to accept the farms as collateral, they have been the principal source of finance.

Current Health Status

If PCR-tested WSSV-free animals are stocked, all possible hosts are eliminated from the canals by monthly clean-outs and use of bag nets, and the 0-exchange management techniques are employed, 120-d cycles can be completed and PCR-tested WSSV-free animals maintained. As with TSV, the fundamental fact remains that if a high titre of virus is present, shrimp cannot be raised in significant numbers unless you are very lucky. The use of additives, such as immune response stimulators, will be much welcomed when titres can be kept down. Systems have to be designed and operated to exclude all viruses and not just the most recent ones. The production paradigm has not worked well since 1990; Nicaragua has not been very lucky.

The Way Forward

Four consecutive years of disease-affected grow-out cycles have brought the Nicaraguan shrimp culture industry to its knees. The current situation lends itself to a major realignment in the upcoming months, as small farmers are unable to finance changes in infrastructure or adjust to the demands of a changing industry in the form of lab seed use. An industry that is now rich in diversity runs the risk of consolidation, as has happened in so many other industries.

There exists a definite need to adjust the management techniques, if not the entire production paradigm. The critical carrying capacity of the system is limiting, but we are now exploring methods to increase it without sacrificing the benefit.

The western hemisphere has traditionally used an extensive or semi-intensive approach to growing shrimp, but modifications of the system are in order, some of which may lead to a gradual increase in intensity of culture. As the cost of infrastructure and farm inputs increases, yields or at least total sales volume will have to increase as well. This may be accomplished simply by re-establishing the financial confidence that has been lost. Basic research as to what really happens in a shrimp pond on a microbial level is still lacking, but at least some of the right questions are being asked.

Zero exchange appears to be effective in limiting the presence of shrimp viruses, if proper precautions are taken with the seed. It also appears to present an opportunity to control the nutrient mass balance equations and enter conditions of stability. Mechanical aeration and probiotics may have roles.

For areas such as Central America, where climatological conditions and subsequently, water quality conditions, are extremely variable, new ways of insuring minimum conditions in the water column must be found.

Several international development agencies have been studying the possibility of programs to demonstrate new and more reliable production techniques to the small- and medium-sized producers, especially the co-operatively owned farms, in the hope maintaining the industry's diversity. The next several years will be critical, especially considering that the government cannot, or will not, take the industry into account, in spite of its contribution to the economy.

Panama

by
R. Morales, L. Becerra and C. Lara

History of Major Disease Outbreaks

Panama has been affected by two major disease outbreaks, Taura syndrome virus (TSV) and white spot syndrome virus (WSSV). Other, minor, problems have been experienced with vibriosis, necrotising hepatopancreatitis (NHP) and infectious hypodermal and hematopoietic necrosis virus (IHHNV), but these were overcome with a combination of chemotherapy and improved farm management. TSV was detected in January 1996, around two years after it caused mortalities in other countries in the region. It caused significant losses to the shrimp sector and led to a 30% decrease in production, despite an increase in the area under cultivation. The disease later subsided and was considered to be manageable. WSSV was first diagnosed in April 1999, and eight months after the outbreak, it continues to cause severe losses, virtually paralyzing the shrimp industry.

Negative Economic and Social Impacts of Disease Outbreaks

The TSV outbreak in 1996 resulted in a 30% reduction in shrimp production, equivalent to 285 mt. Despite this, there was some benefit of the TSV outbreak to Panama, as Panamanian shrimp appeared to be less affected by the virus. This led to an increased market within the region for Panamanian nauplii and post-larvae (PL). The outbreak of WSSV in early 1999 had a massive impact on the Panamanian industry, as the production of shrimp was reduced by almost 4,400 mt, 60% of the volume produced in the corresponding months of 1998 and only 14% of the 15,600 mt projected for 1999. Loss of exports is estimated at $US 40 million compared to the corresponding period in 1998. This affected demand for nauplii and PL from Panamanian farms and from other countries in the region where a big demand for Panamanian nauplii and PL had developed. Although PL production dropped by only 1% (24,505 million PL), nauplius production dropped by 6,576,130 million, a decrease of 45% over the 1998 levels.

A marked preference towards wild PL led to a decrease in demand, leading to the closure of five major hatcheries. This was exacerbated by a decrease in the area of ponds being operated so that, by September 1999 only 29% (2,638 ha) of the production area in Panama was being utilized. As a result, it is estimated that around 1,500 direct employees lost their jobs, while another 3,500 employees were laid off from ancillary services, such as larvae transporters, shrimp harvesters, security guards, mechanics, processing plant workers, feed mill workers and others.

Response to Major Disease Outbreaks by Different Sectors

State Sector Responses

Following the TSV outbreak in 1996, a national plan for health management in shrimp culture and a ministerial resolution on the movement of animals within Panama was put into place. The veterinary diagnostic laboratory "Dr. Gerardo Medina" was strengthened and a Program of Aquaculture Health established to implement programs for the prevention, control and eradication of pathogens. Measures were also developed to allow inspection and monitoring of aquatic animal health and issuing of zoosanitary certificates with the establishment of standards and procedures for a sanitary classification system.

The outbreak of WSSV in Central America led the National Aquaculture Directorate (DINAAC) and the Panamanian Aquaculturists Association (ASPAC) to organize a seminar on "Techniques for the Prevention and Control of WSSV and Yellowhead Virus" with invited experts and attended by shrimp culturists from throughout the region. It was during this meeting that the virus was first detected in Panamanian shrimp. Due to the high risk from this disease, the Ministry of Agricultural Development established a task force comprised of people from the public and private sectors to develop a national emergency plan. The plan included short- and medium-term measures with important recommendations for the management of hatcheries and farms. One sub-commission was established to evaluate and implement the disease control plan and co-ordinate the involvement of other public and private sector groups. A second sub-commission was also set up to establish registration of products used in aquaculture and for the registration of imported and exported aquatic organisms according to national and international standards. Training and capacity building in the public and private sectors were also increased, with specific training on disease detection methods.

Government laboratories also started a series of trials to test proposed methods of prevention, and a disease surveillance program was set up involving DINAAC, ASPAC and the Smithsonian Institute for Tropical Research.

Farmer Responses

The private sector played a key role in the development of the strategy to deal with WSSV. Private sponsorship of visits by leading specialists in marine shrimp diseases made a significant contribution to developing a plan of action for the control of the disease.

Studies with specific pathogen-free (SPF) and specific pathogen-resistant (SPR) lines of shrimp were undertaken, as well as programs for the genetic improvement of existing stocks. Additional studies were undertaken, in conjunction with local universities, into the use of immunostimulants such as beta-glucans, carotenoids and fucoidan.

At the farm level, tests were conducted on the feasibility of more intensive culture with the use of aeration, higher stocking densities, water treatment and certified (PCR-tested) PL. At the same time, semi-intensive farms experimented with reduction of water exchange, supplementary aeration, reduction of stocking densities, use of certified PL and the use of chemicals to control vectors.

Response by Hatchery Owners

Based on the recommendations in the plan of action, nauplius and PL production centers implemented biosecurity measures to control access, disinfect eggs and nauplii before stocking, disinfect water and culture tanks/utensils, and establish quarantine and PCR screening of new broodstock.

Responses by Other Service Providers

Support from the feed and processing sectors focused on assisting the producers with financial plans and special conditions to allow them to implement the methods recommended in the plan of action.

Research and Development Interventions

In addition to the above-mentioned private research initiatives, government-sponsored research was undertaken into the use of chemicals, such as insecticides, to determine their stability and solubility in water, and their toxicity.

A monitoring program of the estuaries indicated a 50% prevalence of the disease in June of 1999, prompting the establishment of a full monitoring program for the disease in wild stocks and the implementation of a national PCR screening program. As part of an effort to exchange knowledge and experiences, much effort has been made by all sectors to take part in national and international fora. Regular meetings are held between all sectors to update and co-ordinate efforts to deal with the disease.

Merits and Demerits of Interventions

Outbreaks of infection in the hatcheries have been controlled by the implementation of the recommendations of the National Emergency Plan. However, interventions at the farm level have been less successful, due to their location, design and management, as well to the administrative and financial situations of individual farms. Most farms could only partially implement the recommendations, and so there were few encouraging results; outbreaks spread quickly in areas with high concentrations of farms, and following water exchange or under stressful environmental conditions.

Due to a lack of confidence within the financial sector, access to sufficient capital for investment to make the necessary technological adjustments has been difficult to obtain. There has also been an increase in the use of wild PL, due to a lack of confidence in the certification process of hatchery-reared PL and some farms focusing on their own individual efforts without taking a more global view.

The Way Forward

Several actions need to be taken to improve the current situation and achieve a more sustainable industry.

Short-term actions include:

- Achieving better co-ordination between the government and private sector in the implementation of the plan of action
- Establishing “micro-regions” for effective application of control methods
- Establishing quarantine units for broodstock and PL
- Continuing studies with local broodstock to close the reproductive cycle
- Emphasizing the use of HACCP in farms
- Defining protocols for actions which are obligatory
- Developing a permanent monitoring program of physic-chemical and biological characteristics to establish the level of contamination of the main estuaries used for shrimp culture
- Defining the main routes of transmission of the virus in the wild

Medium-term activities include:

- Beginning a program of protection and formation of a shrimp gene bank
- Applying biosecurity principles widely under the Environmental Management Plan
- Increasing the capacity of animal health and aquaculture staff in aquatic health

Peru

by

Victor Talavera and Luis Zapata Vargas

Shrimp farming in Peru started in the late 1970s. The production area is small, almost 3,500 ha of ponds distributed among nearly 60 small farms or production units ranging from 10 to 200 ha. Culture activities are included in extensive and semi-intensive systems all year round. *Litopenaeus vannamei* is the preferred species (95%), although *L. stylirostris* is also cultured (5%).

Most farmers rely on wild post-larvae (PL) to stock their ponds, but as there is a great variation in abundance every year, farmers have to look for PL provided by hatcheries, either from Peru or neighboring countries (Ecuador, Colombia). There are three hatcheries that produce almost 60 million PL monthly, working usually between June to November. As the culture area is very scarce, culture activities have passed from low (extensive) to high (semi-intensive) stocking densities, which vary from 6 to 30 shrimp/m^2. Production is 600-2000 kg/ha/crop head-on shrimp, and average weight is 12 to 20 gm. Export revenues reached about US$ 60 million in 1998. As in other countries, a local abundance of wild-caught spawners has encouraged hatchery-based larviculture.

History of Major Disease Outbreaks

A questionnaire following the components of this review was distributed to farmers in order to evaluate the past and present status of major disease outbreaks in shrimp culture since its development back in 1976. Over 25 companies involved in shrimp culture and hatchery production were contacted. The majority of respondents said that they have suffered one or more disease problems. Most of them agreed that the quality and origin of PL are strongly related to the occurrence of disease.

An increase of productivity due to high density along with adverse climatic conditions has triggered several disease outbreaks in the last 20 years. Moreover, environmental stress, ageing pond bottoms, incorrect management and inferior quality seed can cause outbreaks of disease.

The most important losses are due to white spot syndrome virus (WSSV). Other important viral problems have been caused by *Baculovirus penaei* (BP) and infectious hypodermal and hematopoietic necrosis virus (IHHNV) and, on a minor scale, by Taura syndrome virus (TSV). Major diseases outbreaks seem to be associated with use of nauplii and PL imported from other countries.

BP occurred during winter and spring (June to December) of 1988 in shrimp ponds stocked with *L. vannamei* juveniles of 3-4 gm. These originated from PL supplied from laboratory sources and nauplii imported from Ecuador.

In 1993, Dr. Donald Lightner reported TSV and lymphoid organ vacuolisation virus (LOVV) from samples taken from a shrimp farm near the Tumbes River. Contrary to what happened in Ecuador, TSV affected only two farms in Peru, both stocking PL imported from Ecuador. It is not known what economic or production damage has been caused by LOVV.

Since 1985, IHHN has been recognized in seed coming from both wild sources and hatcheries. By the end of 1998, it was perhaps one of the most important viruses present in Peruvian shrimp culture. It is most noticed characteristic is runt deformity syndrome (RDS), and its presence is observed every year in juveniles or sub-adult shrimp.

WSSV was detected in Peru in late August of this year. Since then, outbreaks have continued and are presently affecting some 2400 ha, or two-thirds of the farming area of Peru.

Although bacteria of the genus *Vibrio* are continuously occurring disease organisms, especially during months of high water temperature (January to March), they have caused only a small number of significant losses. Their major impact happened in 1991 and lasted for almost three months. In the summer of 1993, intracellular bacteria causing necrotizing hepatopancreatitis (NHP) affected almost 2/3 of the total shrimp farming area. At the end of 1998 and during the first semester of 1999, shrimp farming activities were hit by *Pseudomonas* sp., which caused heavy mortalities and disappearing shrimp populations in ponds within a two-week period.

Negative Economic and Social Impacts of Disease Outbreaks

Economic damage to the industry produced by diseases has been due to decreased production. Since the introduction of WSSV in August, it seems to have spread to all shrimp farms and has reduced survival in affected ponds to 6-52%, while harvest weight ranges between 7-18 gm. As WSSV outbreaks are present now, some shrimp farms have closed; by the end of October approximately 2800 ha had closed from a total of 3,200 ha. Some shrimp farmers are waiting for virulence to diminish, or seek some kind of remedy. Meanwhile, WSSV brings unemployment and possible further social implications, as the shrimp farming industry is the second job-producing activity in the region.

During the summer of 1993, NHP produced heavy damage, and losses to shrimp production were estimated to be as much as US$ 20 million for that year, almost half of the total annual sales for the shrimp sector of Peru. Another consequence was the closure of five farms totaling around 450 ha.

Also, in 1993, presence of TSV was reported on only two out of 41 shrimp farms, where it caused mortality in several ponds of both farms. These companies stocked PL imported from Ecuador. Estimated economic losses were around US$ 2.5 million.

In 1998, IHHNV accompanied by bacteria of the genus *Pseudomonas* sp. was the mayor disease problem suffered by the local industry. As a consequence of the La Niña phenomena, wild PL become scarce, and farms were supplied almost entirely by hatchery-produced PL. Nauplii came from broodstock captured locally or imported from Ecuador. Shrimp production reported prevalence of RDS as high as 30%, which in turn caused a low quality product that had to be sold in local markets. Revenues from export were low due to increased volumes of small-sized shrimp.

Since 24 August, disease outbreaks, particularly those caused by WSSV, have led to heavy economic losses, posing a major threat to the industry. Values for the second half of this year show a trend towards reduced area for production, shrimp production units and monthly shrimp production.

US$ values for shrimp exports have decreased during the first half of 1999, which is attributed to disease outbreaks produced by *Pseudomonas* sp. and IHHNV.

Response to Major Disease Outbreaks by Different Sectors

State Sector Response

Aside from enactment of regulations and legislation (see below), there have been no state interventions.

Farmer Response

Farmer interventions varied depending on the organism causing the disease outbreak. Bacterial diseases were usually treated using chemotherapeutic products, probably without the knowledge that this practice can cause potential bacterial resistance or impacts to the environment. Early harvesting was undertaken when bacteria or NHP outbreak occurred; changing farm management practices, such as treating ponds and soil to achieve better quality farming conditions, were also practiced. In the case of WSSV, some farmers are using immunostimulants, or applying bacteria to treat pond soil and the water column. Water supplies and reservoirs are not treated with chemicals; only nets of variable mesh size are being used to stop the entrance of viral carriers. Also, a collective response was to establish a domestication program to grow shrimp at certain farms.

Most farmers has have implemented the following individual practices:

- Fumigation of cars at the shrimp farm entrance with chemical products.
- Restricting circulation of cars and personnel on the farm.
- Use of filtration nets at the water gate entrance to ponds (even at 100 micrometer mesh).
- Use of WSSV-free PL to stock ponds (screening by PCR methods).
- Completely filling ponds before stocking and reducing water exchange during the first 60 d, when possible.
- Some farmers are planning to use chemicals to eliminate potential carriers of virus.
- Supplying each pond with its own equipment (boat, cast net, personnel for feeding, etc.)

Response by Hatchery Owners

All three existing hatcheries belong to a group of farmers. Their interventions have been as follows:

- Complete cleaning and chlorination of pipe systems at the hatcheries.
- Use of broodstock or nauplii free from WSSV.
- Water treatment through filtration and chlorination.
- Avoidance of fresh food that could include potential viral carriers (polychaetes, fresh/frozen fish and crustaceans).
- Avoidance of use of waste materials such as bags, boxes, etc.
- Discouraging and prohibiting entrance of personnel not related to the hatchery.
- Changing broodstock origin and avoiding the use of wild-caught spawners.

Response by other Service Providers

Since the disease outbreak in Central America (Honduras, Guatemala, Nicaragua and Panama) in the first semester of this year, much of the effort to build awareness about potential disease outbreaks has come from the private-sector service providers, such as feed manufacturers. Feed manufacturers provide information on WSSV disease, technical assistance, and publication of a technical monthly bulletin and have developed regular workshops and lectures for the local shrimp farming community.

Peruvian farmers made field trips and attended seminars in Thailand and Indonesia as part of an individual action coming from the private sector. This event was promoted by the local shrimp feed manufacturer as a way to acquire knowledge of new culture practices to prevent WSSV disease.

Additionally, farmers have been given a chart outlining some basic topics for evaluation of the critical point process for management of shrimp culture and prevention of WSSV. This chart is a compilation of management alternatives gathered from Asian and American countries that have suffered the disease and are still producing shrimp. This may help shrimp farmers evaluate the risks and decide whether or not to continue in the business.

Legislation and Policy Interventions

Interventions by government through introduction of new regulations and legislation enforced by the Peruvian Ministry of Fisheries have been implemented recently as a response to WSSV. These include:

- Supreme Decree No.009-99.PE (13.06.99): Suspended for a period of 180 calendar days importation of penaeid shrimp nauplii, PL and broodstock, artemia, polychaetes, and other crustaceans in any biological stage or presentation form with aquaculture purposes. Including live or dead crustaceans intended for direct human consumption, with exception of canned seafood; originating from countries where the presence of white spot disease (WSSV) and yellow head (YHV) has been demonstrated.
- Ministry Resolution No. 245-99-PE (05.08.99): Protocol approval to certify, monitor and detect viruses causing "white spot" and "yellow head" diseases of penaeid shrimp.
- Ministry Resolution No. 248-99-PE (18.08.99): To transport into national territory organisms and products (shrimp nauplii, post-larvae and broodstock; artemia, polychaetes and others crustaceans) originating in our country, natural and juridical persons must carry a statement signed by Local Fisheries Regional Direction Office or its dependants.

Research and Development Interventions

No specific research and development programs have been undertaken by the state or private sector to improve the disease situation. Although some private investors have agreed to start a genetic and domestication program for shrimp broodstock, no action has yet been taken.

Economic and Financial Interventions

During the past outbreaks of viral and bacterial diseases, there has not been any government or fisheries sector intervention. The shrimp industry represents only 1.3% of the total value of exportations for gross national product, and most shrimp farmers depend on local bank credits for their operations. As the white spot disease outbreak is still ongoing, there is no estimation of the economic losses. In the future, there will probably be a shortage of bank loans.

Social and Livelihood Interventions

Since the spread of WSSV into Central and South America, the Regional Office of the Ministry of Fisheries and local institutions, such as the Shrimp Farmer's Association, feed producers and local universities have been building awareness of this disease through local workshops, lectures, bulletins, and TV and radio broadcasting. All these activities are intended to avoid illegal introduction of PL or live/fresh crustaceans from other countries.

Effectiveness of Interventions

There is no expectation of positive results based only on insecurity procedures. WSSV is spreading throughout the region, and some control measures, such as the introduction of specific sanitary practices, changing broodstock origin, and use of health certificates for PL need to be implemented.

Interventions and responses need to be evaluated. Most people interviewed felt that public awareness building and programs for the enforcement of biosecurity measures should have been done much earlier, as it was already known that WSSV affected countries in Southeast Asia.

Main problems include the absence of a local seed health certification agency and the unethical practices of the seed trade in the region. Although a ban on importing seed has been imposed, policies to stop contraband trade have not been enforced. Shrimp farmers feel that agreements between countries to stop the illegal transportation of live/fresh aquatic animals that could be potential carriers of disease should be effectively enforced.

People interviewed, both government staff and farmers, commented that good communication and co-ordination is needed to implement a program to control disease outbreaks and to improve farm biosecurity. As most of the measures were just implemented this past August, the cost/benefits of improved management practices cannot be evaluated.

Current Health Status

As one of the measures used to prevent WSSV entrance into the ponds is to reduce water exchange, there are now more stress problems along with *Vibrio* outbreaks, and epicommensal fouling due to the resulting recirculation. Since 24 August, WSSV has spread to almost all Peruvian shrimp farms and has affected almost 2/3 of the total farming area (3200 ha).

Two out of 33 private companies have initiated domestication programs with native *L. vannamei* and shrimp from other countries, such as Ecuador and Colombia. One of them has already been affected by WSSV.

Some shrimp farmers may close their farms in the coming months. However, a few farmers continue to stock ponds with wild PL; others are importing WSSV-free PL from Colombia for stocking.

The Way Forward

Some shrimp farmers are proposing a national crop holiday similar to the one advised in India. If a crop holiday could be practiced, it should be synchronized and observed by all the farmers to avoid any recurrence of the disease.

Another suggestion proposed by farmers is to clean and dig new water distribution channels. This could avoid recycling of wastewater as long as farm activities are concentrated in certain regions. Release of untreated effluent into water sources is one of the major problems facing shrimp farms in Peru. This also leads to the spread of disease.

Probably, after the trip to Southeast Asia, most Peruvian farmers will start to recognize the importance of best management practices, insist on good seed quality (even if it is expensive), carry out more routine health checks, and better understand the need for reservoirs and treatment systems.

Disease threats could be reduced by replacing wild-caught spawners with domesticated (ideally, high health) stock through a successful breeding program. Some attempts have started in our country.

Increased density in shrimp culture causes the spread of bacterial diseases. This problem can be treated with antibiotics, or by applying better management practices to improve water and soil conditions. However, for other organisms such as viruses, there are no effective compounds for treatment. Inmunostimulants provide the means to enhance the shrimp's defense systems and could help recovery from viral disease. Surely the best defense against viruses is prevention and exclusion.

Good interrelations between the private and government sectors, including regional co-operation between countries, need to be developed. More effort should be directed towards communication, research and development, quarantine, and the implementation and enforcement of legislation on the basis that disease is a continental problem implicating the shrimp industries of many countries. Suggestions for local co-operative arrangements that could work best include:

- Continued building of public awareness through workshops and lectures.
- Creation of a task force including government and private sectors to develop strategies to control disease outbreaks and to improve farm biosecurity.
- Creation and implementation of a local laboratory for disease diagnosis.
- Developing a sustainable broodstock supply for hatchery seed production.
- Research on life history and broodstock maturation in captivity.

Other suggestions for regional or interregional co-operative arrangements include:

- Establish R&D stations for disease for countries that lack such facilities.
- Provide training and grants for personnel to attend courses.
- Sponsor expert interchange between countries.
- Establish an inter-regional newsletter, magazine or other communication system.
- Establish a regional task force to determine the aetiology, epidemiology and treatment of new pathogens and diseases.

SUMMARY OF ASIAN NATIONAL REVIEWS ON MANAGEMENT STRATEGIES FOR MAJOR DISEASES IN SHRIMP AQUACULTURE

This section provides a summary of the reviews made on management strategies for major diseases in shrimp aquaculture for the Asian countries involved.

Australia

by

Peter J. Walker

By global standards, the prawn farming industry in Australia is small. Overall production in 1997/98 was 2200 mt valued at US$ 26 million. The major production species are *Penaeus monodon* and *P. japonicus*; *P. esculentus* and *P. merguiensis* have also been farmed in smaller quantities. Approximately 40 farms and 12 hatcheries are located over a wide geographic area in Queensland, New South Wales and the Northern Territory, ranging in latitude from approximately 12^{o} to 30^{o} South. In northern regions, water temperatures allow two crops/yr, but most farmers elect to de-stock during winter. In the south, a single grow-out season operates from September-April. *Penaeus japonicus* is farmed exclusively in the sub-tropical region near Brisbane, where summer water temperatures are suitable. Production of farmed *P. monodon* is to supply the local market, while *P. japonicus* is produced exclusively for live shipment to Japan. Australia also produces some 26,500 mt of prawns annually from the wild fishery, and imports edible prawns, mainly from Thailand.

Although the geographical and climatic conditions in northern Australia are very suitable for prawn farming, there is a view from government and the Australian community that industry expansion should be within a framework of environmental sustainability and appropriate use of land and resources. Many potential aquaculture sites are also in remote locations that will require significant investment in infrastructure development. For these reasons, projections of industry growth in Australia predict that overall production of farmed prawns is unlikely to exceed 6000 mt before 2005.

History of Major Disease Outbreaks

Prior to 1994, the industry was largely free of disease. A number of viruses (including hepatopancreatic parvo-like virus (HPV) and monodon baculovirus (MBV]) had been identified in wild and/or farmed prawns. However, only MBV was seen to have a significant impact on production. MBV was first seen in wild *P. merguiensis* captured near Townsville (northern Queensland) in 1984. It subsequently appeared in hatcheries in 1986 and continued to be a problem in all Australian hatcheries until 1990, when the introduction of double separation and washing procedures largely eliminated it as a significant cause of production losses.

In mid-1994, mass mortalities occurred in northern Queensland on four farms that had been stocked with *P. monodon* post-larvae (PL) in January. Disease occurred in 12-15 gm prawns, and cumulative mortalities in some ponds reached 80%. In the absence of information on the aetiology, the term mid-crop mortality syndrome (MCMS) was used to describe the condition. Mortalities were generally preceded by reduced feeding and congregation of weak prawns at the pond edge. Prawns displayed dark red coloration on the tail and carapace, disoriented swimming, extreme lethargy and red faeces. Viral aetiology of the disease was established experimentally by injection of freeze-thawed, homogenized, filtered tissue to juvenile *P. monodon* in which similar signs of disease were observed.

Disease problems appeared to abate during 1995. In early 1996, a second wave of mortalities commenced in northern Queensland. Most hatcheries reported mortalities in *P. monodon* broodstock during the August stocking and, during the 1996/97 season, there was a high prevalence of disease throughout the industry. Disease problems again abated in 1997/98, and during that season many farms achieved record crops. Ongoing but isolated cases of unusual mortalities of farmed *P. monodon* have continued, but these have not been attributed to an ongoing epidemic of MCMS.

The aetiology of MCMS remains a little unclear. Initially, two viruses were observed in moribund prawns. The first is a 20-25 nm parvo-like virus that infects the mid-gut and other tissues of moribund prawns. Because of similarities in virion morphology, tissue distribution and gross signs of infection, the MCMS parvo-like virus and spawner-isolated mortality virus (SMV), originally identified during a disease outbreak in *P. monodon* spawners in an experimental facility near Townsville in 1993, have been assumed to be the same agent. Subsequent studies have suggested there may be a correlation between SMV infection, post-larval survival in hatcheries and subsequent survival of progeny in grow-out ponds.

The second agent associated with MCMS is an enveloped, rod-shaped RNA virus. Gill-associated virus (GAV) was first isolated from moribund prawns collected in January 1996 at a farm in northern Queensland. The prawns displayed signs of disease that were typical for MCMS. It is now believed that GAV was a major cause of on-farm mortalities, at least in the disease-plagued 1996/97 season. Sequence analysis of the GAV genome indicates that it is closely related to yellowhead virus (YHV) from Thailand, varying by 17.6% in nucleotide sequence and 10.7% in amino acid sequence over a total of 1780 nucleotides of the large replicase gene. GAV causes a highly pathogenic infection similar to yellowhead disease. However, there is no yellowing of the cephalothorax, and histological sections of gills or haemocytes do not usually display the intensely staining, basophilic, cytoplasmic inclusions typical of YHV-infected tissues. YHV and GAV can be regarded as different viruses in the yellowhead complex.

GAV infections may be overt or covert. Covert infection was recognized prior to the isolation of GAV and, because the virus was observed only in lymphoid organ tissue, it was named lymphoid organ virus (LOV). LOV was first detected in healthy juvenile *P. monodon* collected from farms in northern Queensland in March-May 1993. Recent genetic studies have shown that GAV and LOV is the same virus. In the covert form, GAV is transmitted vertically and has a prevalence approaching 100% in healthy wild *P. monodon* spawners in Queensland. Disease occurs when covert infections become pathogenic, probably due to environmental and/or physiological factors which compromise the defensive response of the prawn.

Overall, the evidence suggests that MCMS is not a discrete disease attributable to a single agent, but primarily due to GAV, complicated by co-infections with SMV and possibly other viruses.

Negative Economic and Social Impacts of Disease Outbreaks

The direct impact of disease on Australian farmed prawn production is difficult to assess. Disease information is often regarded by farmers to be commercially sensitive, and so estimates must rely on overall production trends. However, these are influenced by a range of other factors including availability of broodstock, PL quality, weather patterns, and the quality of farm management. In an expanding industry, the overall growth rate is influenced by factors unrelated to disease, including the availability of investment capital, market value of product, the availability of suitable farm sites and evolving environmental regulatory requirements.

In the six years until the 1993/94 season, *P. monodon* production increased at an average annual rate of 38%. In June 1994, mass mortalities attributed to MCMS first occurred and continued through the 1996/97 season. This coincided with a progressive drop in production of farmed *P. monodon* but not of *P. japonicus*, which was not affected by the disease. Projecting at a more modest annual growth rate of 20%, lost value of *P. monodon* production between 1994-1998 is estimated at US$ 32.5 million. Although several factors led to this decline, the impact of disease and a consequent cautionary approach to industry expansion were significant contributing factors. This figure does not discount for production costs that were avoided through failure to stock or by early harvests. It also fails to account for the reduced employment opportunities and flow-on benefits to the community that would have been derived through continued industry expansion.

Response to Major Disease Outbreaks by Different Sectors

Farm and Hatchery Management

The primary response to MCMS at the farm level was the adoption of a single annual production cycle in all regions, with de-stocking and dry-out during winter. Some farms also treat ponds with chlorine or calcium oxide. Farmers are more aware of the need for daily monitoring and maintenance of water quality in ponds and, in the event of unusual mortalities, removal of moribund prawns from pond edges. Disease problems and concerns about the availability of quality broodstock have also led to increased interest in closed-cycle breeding programs.

The Queensland Department of Primary Industries (QDPI) has also responded to industry concerns by appointing additional fish pathologists, extension officers and a policy officer for fish health management. In consultation with farmers, QDPI has also prepared and published *Guidelines for On-farm Health Management Plans for Prawn Farms* to assist farmers in developing individual and local health management plans.

Strategic Development and Emergency Response Planning

During the past several years, disease reporting, contingency planning and emergency response capabilities in the Australian fisheries and aquaculture sectors have also been significantly upgraded through an on-going consultative process involving industry, government, R&D providers, OIE, NACA and other stakeholders. This has been implemented because of an increased awareness of the vulnerability of aquatic species, both to the emergence of unrecognized endemic diseases and to the inadvertent introduction of exotic diseases through international trade. Importation of diseases with potential to infect salmonids, local disease outbreaks in prawns and pilchards, major epidemics in Asia, and concerns about risks associated with imported frozen prawns and salmon have been factors driving these developments.

One of the major initiatives has been the endorsement in April 1999 of a national strategic plan for aquatic animal health, developed jointly by state, territory and commonwealth governments, and the private industry. AQUAPLAN consists of eight key strategic programs, which provide the necessary framework to develop and implement comprehensive operational plans for aquatic animal health issues. Each program consists of specific projects and project components, which have been identified as the most effective means of meeting the objectives of that particular program. Leaders have been selected for individual projects and components, and detailed business plans have been written. The eight programs that define AQUAPLAN between 1998 and 2000 are: international linkages; quarantine; surveillance; monitoring and reporting; preparedness and response arrangements; awareness; research and development; legislation, policies and jurisdiction; and resources and funding.

Within the framework of AQUAPLAN, an aquatic animal disease emergency plan (AQUAVETPLAN) has also been developed. AQUAVETPLAN comprises a series of manuals and procedures, which outline appropriate methods and protocols for managing emergency aquatic disease outbreaks in Australia. AQUAPLAN will also develop effective institutional arrangements for managing aquatic animal disease emergencies. As part of this process, preparedness in Queensland was recently tested in a simulated outbreak of a hypothetical prawn disease. The simulation comprised a series of high level training exercises at the State Disease Emergency Headquarters involving several government departments and agencies, and two field exercises in the north and in the south which involved prawn farmers from the district.

Disease Reporting

Australia has an obligation to notify OIE in the event of confirmation of the presence of the three major prawn pathogens (white spot syndrome virus (WSSV), Taura syndrome virus (TSV) and YHV). Voluntary quarterly reports are also provided to FAO/NACA on the list of pathogens that are of regional concern. In addition, and to assist both the international reporting process and the national response to disease emergencies, state governments are reviewing legislation to ensure responsible action by industry. According to existing law in Queensland, there is an obligation to report known or suspected disease in wild or farmed fish (including crustaceans). Queensland legislation relating to a Declared Disease List is in the process of legislative proposal. The legislation prescribes action in the event of confirmation of a disease or agent included in the list. The composition of the list and other details of the legislation are under negotiation with farmers and other stakeholders. The issue of compensation for farmers who may be required to destroy infected prawns also remains a matter of discussion.

Import Risk Analysis

The Australian Quarantine and Inspection Service (AQIS) is responsible for the development and review of quarantine measures for protection against exotic diseases that are consistent with international obligations intended to promote free trade. These apply particularly to the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). In relation to importation of prawns and prawn products, the first stages of an import risk analysis (IRA) process have commenced. AQIS commissioned independent scientific consultants to report on the following components of the analysis: environmental impact of the establishment of exotic prawn pathogens in Australia, economic impact of establishment of exotic prawn disease, routes for exposure of aquatic animals to aquatic animal products intended for human consumption, crustacean feeds, and product testing.

In November 1998, following submission of these reports, AQIS released a Technical Issues Paper of the IRA for public comment. Seven submissions raised the following technical issues:

- The relationship between overseas and Australian strains of viruses, e.g. YHV and Australian yellowhead-like isolates (GAV and LOV);
- The possibility that environmental factors may explain the differences in virulence between Australian and overseas viruses;
- The taxonomy of disease agents, e.g. fungi were considered at the genus level, whereas viral strains were compared;
- The potential effects of exotic micro-organisms, such as fungi, on Australian crustaceans; and
- State legislation controlling the movement of prawns and prawn products.

The risk analysis panel will consider stakeholders' submissions and the draft IRA will address these issues. AQIS has also held bilateral discussions with the Thai Government on the Technical Issues Paper. It is expected that the draft IRA will be released in 2000.

A conservative position on quarantine issues has been a hallmark of Australian agriculture for many decades and has ensured that most industry sectors have remained free of damaging and costly exotic pathogens. The strict embargo on the importation of live crustaceans has likely been the most significant factor in preventing the incursion of exotic prawn diseases. For this reason, increased international movement of pathogens due to more open international trading policies is a primary concern of all aquaculture sectors in Australia.

Research and Development

As a relatively new industry with recognized potential for future growth, aquaculture in Australia has seen a very significant increase in R&D funding in the past five years. In the case of prawns, disease is the highest research priority. This has largely been in response to production losses caused by MCMS and related concerns about the consequence of importation of major exotic prawn pathogens, particularly WSSV. R&D activities have been conducted by universities, CSIRO and state governments, research institutes and a major government-industry research consortium (Aquaculture CRC Limited), with support from competitive research grants from the federal government and some direct funding from industry. The Australian Prawn Farmers Association (APFA) has recently resolved to pay a research levy which will be contributed in an annual license fee (based on farm area) and through a surcharge on feed. The levy will be supplemented with a 3X multiplier of federal government funds and made available for research grants through the Fisheries Research and Development Corporation (FRDC). The APFA will assist the FRDC in setting R&D priorities and selecting projects for funding.

Research projects initiated in response to MCMS have identified GAV and SMV as associated pathogens. PCR and *in-situ* hybridization tests have been developed. Introduction of SMV screening in hatcheries on a pilot scale is planned. The use of specific pathogen-free (SPF) domesticated stocks for both *P. monodon* and *P. japonicus* is likely to be developed by the industry in the near future. Research has also indicated a high prevalence of covert GAV infections in wild *P. monodon* broodstock. Husbandry techniques that may produce uninfected PL are being investigated.

Effectiveness of Interventions

The dramatic decline in mortalities in cultured prawns in recent seasons may be attributable to the specific interventions taken at farm level and increased awareness of the need for good health management. Winter de-stocking and dry-out appear to have been effective in breaking the disease cycle, but it is not possible to assess the extent to which natural processes have been responsible. Research has been effective in identifying the major pathogens and in developing sensitive and specific detection tests, and there has been progress in understanding their distribution and biology. However, as these tests are yet to be employed by industry for routine screening, infected prawns continue to be supplied to farms. It is evident, therefore, that the decline in MCMS has not been due to a reduction in the prevalence of the pathogens, but rather to control of the factors that have led to the emergence and persistence of disease.

The notable absence of WSSV in Australia is undoubtedly due to effective quarantine policy, and particularly the embargo on importation of live crustaceans. However, illegal use of imported frozen bait prawns and the potential for importation of infected crustaceans in ballast water remain serious concerns. The effectiveness of a relatively conservative approach to import risk management will be revealed in time. As Australia has not yet faced a serious incursion of exotic prawn disease, the effectiveness of emergency response procedures also cannot yet be assessed directly. Because of its wide host range in arthropods, WSSV may be difficult to contain it ever enters Australian fisheries.

Current Health Status

Sporadic outbreaks of disease on farms continue to occur. However, there has been no evidence of severe disease directly attributable to GAV since the 1996/97 season. It remains a concern that covert GAV infections have a very high prevalence in broodstock currently sourced from Queensland coastal waters. The prevalence of SMV in hatcheries is also relatively high. There are efforts underway to introduce hatchery screening for SMV and to obtain GAV-free animals, particularly for domestication purposes.

Australia remains free of white spot syndrome in cultured prawns. However, imported frozen prawns have tested PCR-positive. Although a risk analysis has indicated that prawns destined for human consumption are highly unlikely to contaminate wild broodstock or farmed prawns, there is concern that imported frozen prawns are being used illegally for bait. Exclusion of WSSV remains the most significant single concern of the Australian industry.

Several other viruses and disease conditions are known to occur in cultured Australian prawns. These include HPV, a new bunya-like virus (Cowley and Walker, unpublished data) and a disease of unknown aetiology affecting nervous tissue in *P. monodon* (R. Callinan, pers. comm.). The impact of these on production is presently unknown.

The Way Forward

Closed-cycle breeding programs to produce PL that are certified free of specified endemic and exotic prawn viruses (i.e., SPF) will improve disease security. This, combined with treatment of pond inlet water and good control of water quality on farms, should minimize the risk of disease. Further work is necessary to identify all potential viral pathogens and to develop sensitive and specific tools for their detection. Ultimately, intensive semi-closed farming systems using high quality SPF, domesticated and genetically selected stock will be the future of the Australian industry.

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Bangladesh

by

Md. Masudur Rahman

Bangladesh is one of the most densely populated developing countries, and depends mainly on its natural resources for employment generation, revenue and foreign exchange earnings. About 0.2 million ha of land is suitable for coastal aquaculture. At present, about 0.14 million ha along the coast is under shrimp culture in the districts of Cox's Bazar, Chittagong, Khulna, Satkhira and Bagerhat. Production from coastal aquaculture is about 52,000 mt, or about 68% of total shrimp production. Bangladesh earned about 12 million taka in foreign exchange during 1997-98 by exporting shrimp. The present average production of shrimp from aquaculture is only about 350 kg/ha.

History of Major Disease Outbreaks

The Ministry of Industry initially encouraged semi-intensive shrimp farming by providing credit and input supply. However, in April 1994 there was a sudden outbreak of disease that spread rapidly, affecting almost all semi-intensive farms of the Cox's Bazar region. The first crop in almost all semi-intensive farms was fully damaged, causing great financial losses. In May 1994, another 19 semi-intensive farms were infected, and a total loss of the standing crop was reported. In spite this setback, the farmers restocked the ponds for the second crop, but again they suffered similar losses. Clinical signs of the disease included white spots on the cuticle, yellowish-white hepatopancreas, reddening of the intestine, empty gut, dull-reddish body color, and swollen gills. In most cases, mortality took place between 25 to 90 days. The causative agent was subsequently identified as white spot syndrome virus (WSSV), and the initial source of infection considered being post-larvae (PL) imported from Taiwan and Thailand.

In 1995, WSSV was reported in some semi-intensive farms stocked with imported PL. In 1996, epizootics were reported in both extensive and improved extensive farms in both the Khulna and Cox's Bazar regions during April to June, that is, just at the beginning of the rainy season. In Khulna, the disease affected an estimated 37,400 ha of extensive shrimp culture. During winter (December 1995 to January 1996), infection was reported in juvenile shrimp reared in nurseries. Throughout 1996, almost all the farms in both regions were affected. In 1997, the infection rate was less, but there was still viral infection in some shrimp farms located in high salinity areas. In 1998, infection was very limited, as most farms stocked locally available PL. Also, by this time the government had banned the importation of PL from overseas.

In 1999, some farms in the Khulna region were affected by viral diseases; however, the clinical signs differed from those seen previously (i.e., in 1994-996). The main cause of disease is thought to be poor management, disease outbreaks being due to different types of pathogens (viruses, bacteria, fungi, parasites, etc.).

Although WSSV has been linked to the most serious epizootics in shrimp culture in Bangladesh, it is clear that the causes of disease outbreaks are usually complex. Unfavorable environmental factors and stress make shrimp very susceptible to pathogens. During 1995-1996, most of the extensive shrimp farms were infected because of adverse environmental factors due to poor pond management. Among the pathogens identified from diseased shrimp sampled since September 1994 are white spot syndrome virus (WSSV) (also known as SEMBV (systemic ectodermal and mesodermal baculovirus or "China virus" (CV)), monodon baculovirus (MBV), type-C baculovirus (TCBV), haemocytic enteritis, systemic vibriosis, and gregarine infection.

In 1995, some broodstock collected by commercial trawler showed white spots on the carapace, indicating that white spot disease had spread to wild stocks of *P. monodon.*

Negative Economic and Social Impacts of Disease Outbreaks

Bangladesh has suffered a wide range of negative economic and social impacts due to disease outbreaks in shrimp culture. These include, in semi-intensive shrimp farming, abandonment of farming activity, with associated losses of crops and employment. In 1994, total losses of both first and second crops occurred in the Cox's Bazar area, while in 1995, all semi-intensive farms in both the Khulna and Cox's Bazar regions reported production losses of about 90%. In 1996, disease outbreaks in both regions resulted in semi-intensive farming being almost abandoned. The targeted rate of production for semi-intensive culture is at least 1 mt/ha/crop, so total quantity of shrimp lost was about 3400 mt, valued about Tk. 800 million, excluding investment costs of around Tk. 300 million. This estimate refers to direct financial losses, excluding bank interest, land value, etc. There was no remarkable loss of employment. About 500 trained staff became unemployed; in addition, people directly or indirectly associated with the supply of inputs for the shrimp farms were also affected to some extent.

In extensive shrimp farming systems, both crop and employment losses occurred. There is about 0.129 million ha of land used for extensive farming, of which about 0.1 million ha is in the Khulna zone. During 1995, about 10% of the farming area was affected, and total crop loss estimated as about 80%. During 1996, about 52% of all extensive farms were affected by epizootics during the first half of the culture period.

Based on the loss of stock, the Department of Fisheries (DOF) estimated losses of Tk. 468 million (US$ 10 million, based on US$ 7700/mt) and a production loss of about 13,000 mt. Many farmers re-stocked at lower density immediately after loss of their standing stock and, in most cases, recovered part of their previous losses. Extensive shrimp farming employs both skilled and unskilled manpower. During the disease outbreaks massive unemployment, mainly for part-time laborers, occurred.

Other losses included export losses and social costs. The trend in frozen shrimp exports has been upward in Bangladesh. However, the viral epizootics in the shrimp farms reduced, to some extent, the export quantity. In 1994-1995, 19,224 mt of headless shrimp were exported, while in 1997-98 exports fell to 18,730 mt. As a result of disease, farmers lacked money to pay for leases and essential inputs. Shrimp farming is capital-intensive and, in most cases, farmers must borrow from commercial banks. Any negative effect on the shrimp-farming sector results in corresponding losses in other linked industries. As many farmers purchase fry on credit, their inability to repay these debts in a timely fashion caused adverse law and order situations. In some instances, laborers couldn't get their salaries on time.

Interventions and Responses by Different Sectors

State Sector Responses

Responses to disease problems initiated by the government included:

- Three committees having members from the DOF, the Fisheries Research Institute (BFRI) and university investigated disease problems in shrimp farms.
- Members of the Central Shrimp Cell of the DOF visited affected areas at Cox's Bazar where they met with shrimp farmers, prepared a detailed report based on the causes of disease in semi-intensive culture, suggested management issues and recommended immediate remedial measures.
- Workshops on shrimp disease were held in 1994 in the Cox's Bazar and Khulna regions. Jointly organized by DOF and DFID, they dealt mainly with shrimp disease in semi-intensive culture.
- Arrangements were made for diagnosis of the disease.
- A consultant was appointed for six months under the Second Aquaculture Development Project (ADB) for reporting details on the shrimp disease in Bangladesh.

- A Central Shrimp Cell was established in the DOF HQ having regional shrimp cells at Cox's Bazar and Khulna to train shrimp farmers, provide the industry with necessary information, and co-ordinate agencies involved in shrimp resource development.
- Staff from DOF and BFRI and some shrimp farmers was sent to the Aquatic Animal Health Research Institute (AAHRI), in Bangkok, for shrimp health training.
- DOF implemented a "Shrimp Disease Prevention and Health Management" project through FAO assistance and conducted farm-based training, including farm survey and recommendations for introduction of a quarantine system for aquatic animals.
- Attempts were made to organize an effective shrimp farmers' association.
- Local awareness was increased through workshops, training and public meetings.
- Improvements to the culture system (e.g., introduction of correct timing of stocking, preparation of ponds before stocking, nursery rearing, better water management, and improved productivity of water by adding lime, fertilizer, manure etc.) were introduced.
- Capability of farmers and state-sector personnel was increased through field training, establishment of demonstration farms, monitoring water quality and shrimp health, and surveying the existing farming system.
- Technical assistance is provided to farmers on post-larval screening, PCR demonstration etc.
- The DOF, through its shrimp cell and district and thana-level officers, arranged intensive training on shrimp farming for the farmers. Under development projects of DOF and technical assistance projects of FAO, the DOF has rendered training and extension programs to 748 departmental officers, 73,125 shrimp farms, and fry collectors and shrimp depot operators.
- Under a FAO TCP project, 315 shrimp farmers, 652 fry collectors and 230 DOF field officers were trained, four DOF field officers were trained at AAHRI, and demonstration farms were established in four shrimp producing districts. Fortnightly water quality and shrimp health checks were done for 100 shrimp farms, and 10,224 shrimp farms were surveyed in order to establish a national database.
- Long-term goals include establishment of a laboratory for disease identification at BFRI, a shrimp health laboratory in the shrimp culture area with modern equipment and trained manpower, monitoring of the aquatic environment in and around shrimp farming areas, and development of shrimp hatcheries to supply healthy PL to farmers.

Farmer Responses

Farmers reacted positively to recommendations made in the shrimp disease workshops. Some followed recommendations partially and others almost fully (e.g., conversion of grow-out ponds into reservoirs, removal of bad soils from pond bottoms). Farmers demanded more on-farm workshops to provide practical training in farm management.

A main demand was for the government to establish field-level laboratories for disease identification and water quality testing as early as possible. After the outbreak of disease in the semi-intensive farms, farmers urged assistance from the DOF for identification of the cause and for curative measures. Initially, farmers attempted to control disease by chemotherapy, and in most semi-intensive farms, antibiotics and chemicals were used. Antibiotics, such as tetracycline, which are used for common bacterial chemotherapy, were not effective.

Disinfectants (formalin, potassium permanganate, BKC, malachite green) were used in water during rearing. Other chemicals (copper sulphate, bleaching powder, ascorbic acid, etc.) were also applied. Lime was used in pond preparation and chemical fertilizers were also added. When the cause was identified as a virus, the farmers realized that the use of antibiotics and chemicals was improper. Having no other alternative, semi-intensive farms initiated early harvesting.

Farmers also requested easy availability of equipment and other inputs with tax exemption, exemption from bank interest and re-financing of their farms, easy access to loans at industrial rates, and special rates for electricity.

Immediately after the occurrence of disease, the semi-intensive farms changed their management practices according to recommendations made at workshops and seminars. Changes related to such factors as pond aeration practices, pond shape, addition of water treatment before intake, provision of water reservoirs, use of feed, and water management.

In extensive farms, changes included pond drying, liming and fertilization; reduction of stocking rate, crop alteration with paddy or finfish culture, introduction of a nursery system for PL before stocking, reducing rearing pond size, screening of intake water, liming, and use of chemical fertilizers. In some cases, farm closures occurred. In the southwest, about 5% of the total farming area has been converted to paddy.

Shrimp farmers, fry traders, hatchery operators, fry catchers, and frozen food exporters reorganized their associations to be more active in safeguarding the shrimp industry.

Farmers understand that alternate cropping can be beneficial and may protect against disease outbreaks. A recent trend is to stock fish during the rainy season when salinity drops to 0-5 ppt. The species cultured include Indian major carps, Chinese carps, Thai barb, tilapias, mullets, freshwater prawn, etc. Paddy production alternating with shrimp, a traditional culture system, has again been introduced in brackish water areas, mainly in the southwest.

Farmers also stocked wild-caught seed of brown shrimp (*M. monoceros*), which is less vulnerable to disease.

Hatchery Owner Responses

Hatchery owners were also affected to a great extent. As there was no market in 1996, hatchery-produced seed were released to open waters.

Hatchery owners took measures to improve the health and survival of PL. This included improved sanitation and hygiene in hatcheries. With technical assistance from the DOF, a shrimp fry transportation system by air is being developed to ensure that healthy shrimp reach the farmers. Some hatchery owners have started the nursery rearing of hatchery-produced seed, so that healthier and larger shrimp fry will can be stocked.

Because of the weak financial situations of most shrimp farmers, the hatchery owners are supplying fry on the basis of 70% credit to the farmers. In 1995, one hatchery arranged a seminar with the local and foreign shrimp experts to identify the causative agent. Presently, hatchery owners are organizing to provide technical assistance to the farmers for disease prevention.

Owners very recently organized an association, as there was no collective involvement in the past.

Legislation and Policy Interventions

These include:

- An immediate ban on the importation of PL. Accordingly, an administrative order was issued On Movement of Post-larvae and Brood-Stock.
- Introduction of a system for quarantine and health certification for live aquatic animals is in progress.
- Introduction of a policy to ensure environmentally sustainable shrimp farming.
- A three-tiered shrimp resource development and management committee was formed at the divisional, district and thana levels with representatives from the shrimp farmers, the Frozen Food Exporter's Association and the Environment Department included. The committee, after considering social, economic, environmental and local issues, must recommend registration of a farm. Only registered farms will be eligible for bank loans and will get legal water intake facilities from the Bangladesh Water Development Authority. The local thana-level committee also monitors the culture systems, use of chemicals, nature of inputs used in the shrimp ponds, etc. Land dispute settlements, crop rotations etc also remain under supervision of the local committee.

Research and Development Interventions

Immediately after the appearance of disease in 1994, a number of research programs and foreign-assisted projects were launched. These include:

- Monitoring water and soil quality changes in semi-intensive shrimp farms.
- Shrimp culture in low saline water to control the disease outbreak.
- Diagnosis of pathogens in disease-infected shrimp.
- A project on Shrimp Disease Prevention and Health Management (DOF, with FAO assistance)
- Establishment of a Shrimp Service Center Project (BAFRU/ODA)
- Second Aquaculture Development Project (assisted by the Asian Development Bank)

Economic and Financial Interventions and Responses

Many exporters are helping the farmers financially with some conditions like dictated price.

Social and Livelihood Interventions

As almost all semi-intensive farms ceased operations, their employees became jobless or had to change profession. Non-professional shrimp farmers changed profession, while outsiders stopped farming. As a result, local involvement in shrimp farming increased. Changing culture practices, including use of hatchery-produced fry, new inputs etc. opened new livelihoods, while changes in crop pattern and other activities also led to some changes in local communities. An awareness of the need for environmentally friendly shrimp culture developed. Many shrimp farmers introduced alternate cropping (fish or rice production), creating new economic activities and changes in local food habits. Hatchery owners became more professional. Government intervention through the DOF created awareness and encouraged farmers to introduce new techniques in farm management.

Effectiveness of Interventions

Intervention of the Government of Bangladesh (GOB) through DOF has helped in awareness building and has encouraged farmers to introduce new culture techniques.

Current Health Status

In 1998, white spot disease was very limited, only occurring in some farms stocked in winter. However in 1999, badly managed monoculture shrimp farms in the southwest were affected. Infection was not limited to WSSV, as clinical signs of other infections were seen (e.g., MBV, SV, HE, parasitic infections). The causative agent(s) couldn't be properly identified due to limited diagnostic facilities. Sudden changes in ecological parameters such as temperature, salinity, rain etc. may have influenced the disease outbreak.

Follow-up training of shrimp farmers is going on under a GOB-financed project. Awareness building on disease outbreaks, preventive measures etc. are gradually being developed. The importance of good site selection, good quality feeds and application of appropriate management technology to prevent disease is now accepted by most shrimp farmers.

Some activity is also evident to prevent pollution and to introduce quarantine. Availability of good quality PL is also going to be ensured.

Introduction of regular training, extension and motivation; legislation to protect the industry; mechanisms for farmer co-operation; and an understanding of appropriate management technology are under regular consideration of the GOB. Research is also recognized as essential to increase the scientific and technological base of the industry and to establish sustainable shrimp farming.

Recommendations

The shrimp farmers' associations in Bangladesh are yet to be organized to support the actual needs of farmers. They should act as lobbying groups to articulate industry needs and may provide a range of services to their members. For effective functioning, these associations need a clear legal mandate and regular financial contributions from members.

India

by

C.V. Mohan and H.N. Basavarajappa

Traditional shrimp trapping systems have been in practice in the low-lying brackish water areas of Kerala, West Bengal, Karnataka and Goa for several years. During the dry season, the low-lying fields are used to grow trapped shrimp and fish, and during monsoon the same fields are used to grow salt-resistant paddy. These traditional systems are still in practice and are largely seasonal in nature. Auto stocking aided by tides is practiced, and managerial inputs are minimal. Production from these traditional systems is low, on the order of 300 kg/ha/season for the 10,000 ha of bheries of West Bengal, 450 kg/ha/season for the 4500 ha of pokkali fields of Kerala and the 4000 ha of gazani of Karnataka, and 700 kg/ha/season for the 2000 ha of khar lands of Goa. However, these traditional systems have demonstrated their sustainability and ecological compatibility over the years.

India has 1.2 million ha of coastal brackish water resources with potential for shrimp farming. Realizing the enormous economic potential, the Government of India (GOI) identified shrimp farming as a thrust area for increasing exports and foreign exchange earning. In spite of rapid development between 1989-1994, only a small percentage of the available 1.2 million ha was brought under culture. Between 1989-99 and 1998-1999, the total area under culture rose from 60,235 to 200,00 ha, while production rose from 29,985 to 82,000 mt.

History of Major Disease Outbreaks

Before July 1994, shrimp farms did not experience serious disease problems. In 1994, two epizootics with distinctly different gross signs were associated with mass mortalities of cultured shrimp. The first mass mortality involved tiger shrimp in grow-out ponds in Gudur, Andhra Pradesh, a large area along the east coast, which has many farms. Infected shrimp refused feed, came to pond margins, showed yellowing of the cephalothorax and started to die. Mass mortality of 70-100% occurred within two to three days after clinical signs appeared. Only 50-70-day-old *Penaeus monodon* were affected. White shrimp (*P. indicus*) showed no clinical signs and were apparently unaffected.

This first case of mass mortalities was similar to yellowhead disease (YHD) with regard to clinical signs, host species and size of shrimp affected, but it was histologically atypical. Intranuclear inclusions typical of white spot syndrome virus (WSSV) were present in shrimp showing signs of YHD, suggesting a dual infection. In addition, the hepatopancreas showed pathology consistent with an enteric bacterial disease.

In late 1994, a second epizootic occurred in Nellore, Andhra Pradesh, and has since spread to several farms in different parts of India. *Penaeus monodon* and *P. indicus* of all ages and sizes were affected in all types of rearing systems and stocking densities. Diseased shrimp refused feed, collected at pond margins, had red to pink-red body discoloration, and damaged appendages. White spots were obvious on the inner side of the carapace, especially on the cephalothorax. Mortality began gradually, but within five to seven days from the first gross signs, mass mortality occurred. This second case of mass mortality was clinically and histopathologically typical of WSSV infection. Densely stained, round intracytoplasmic inclusions typical of YHV infection found in the lymphoid organ and haematopoietic tissue of WSSV-infected shrimp indicated a possible dual infection.

Since the initial outbreak in 1994, white spot syndrome has spread too much of India. It occurred almost at the same time in Tamil Nadu, and in February and March 1995, it was reported in farms of Orissa and West Bengal along the east coast. On the west coast, it was first noted in January 1995 in a farm in Goa, and later in May and June of the same year, it was reported from several farms in Karnataka. Almost at the same time, the disease was also reported from farms in Gujarat. All these outbreaks involved typical WSSV infections. WSSV still remains the major problem of the industry as it still occurs at epizootic levels in different parts of the country, causing enormous economic damage.

Negative Economic and Social Impacts of Disease Outbreaks

Economic and social impacts are difficult to quantify. Production losses during 1994-1995 due to the two viral epizootics have been estimated at 10,000-12,000 mt, while the economic loss in 1994 alone was put at US$ 17.6 million. It is estimated that farmers are losing Rs 4000-5000 million annually.

As more than 80% of the operators are small-scale farmers, there has been a significant socioeconomic impact in coastal regions. Continuous crop failures, high initial investments, high lease values and erosion of profits have forced several farm operators to abandon shrimp farms. This poses a significant challenge to the future productive use of coastal areas because of the limited land use prospects for these unused shrimp ponds.

Disease outbreaks have brought about changes in farming practices. Stocking densities have dropped dramatically, and farmers have reduced the number of crops per year. This has a serious impact on hatcheries and feed companies. Crop failures have forced financial institutions to withdraw credit and insurance to the farmers. Continuous crop failures, erosion of profits and lack of capital for initial investment have compelled several corporate houses and farmers to close their operations. Such closures have had major impacts on employment, both at the technical and non-technical levels.

Negative impacts were felt even by traditional farmers, such as the gazani farmers of Karnataka and Goa. Original estuarine and river basin lands (gazani or khar lands) are put to a variety of uses. Through collective farming, small groups of farmers used these lands to grow salt-resistant rice during the rainy season and for natural shrimp trapping during the dry season. With the advent of commercial shrimp farming, gazani farmers, lured by higher returns, leased their lands to commercial shrimp farms. This led to large-scale conversion of gazani lands to shrimp ponds. Failure of shrimp farming meant loss of lease revenue to the gazani landowners. Since 1995-96, large tracts of former gazani lands are lying as abandoned shrimp ponds. The major problem now is that irreversible land development has taken place. Once converted, gazani lands are not easily restored to their original state or function.

Responses to Major Disease Outbreaks by Different Sectors

State Sector Responses

The Ministry of Agriculture, GOI brought out guidelines for sustainable development and management of shrimp culture in 1995. The guidelines suggested effective methods for management of bottom sediment, pond effluent, etc. and prescribed standards for wastewater discharge. They also recommended that state governments enact legislation to regulate aquaculture activity. However, before such legislation was enacted, a public-interest litigation filed in the Supreme Court of India resulted in the laying down of strict guidelines by the court for the protection of the environment and bringing down social tension. The Supreme Court orders and CRZ rules will have an indirect beneficial impact on long-term strategies for shrimp health management.

The Marine Products Export Development Authority (MPEDA) played a vital role in popularizing commercial shrimp farming in India. The first YHD and WSD crisis that hit the industry in 1994 sent shock waves through MPEDA, which lost no time in responding to the situation. In the process, MPEDA has involved state and central fisheries research organizations, farmer organizations, experts from India and abroad, and all stakeholders. MPEDA made arrangements to get the disease diagnosed. It invited experts to visit the affected areas and asked them for suggestions and advice on crisis management. In

January 1995, MPEDA declared a crop holiday, closing all farms in the affected areas of Andhra Pradesh and Tamil Nadu for one cropping season (3-4 months). MPEDA issued guidelines for the start of shrimp farming after the crop holiday. These included pond drying and liming, chlorination, closed and partially closed systems, choice of quality seed, reduced stocking densities, low water exchange, feeding based on survival rates, culturing both *P. monodon* and *P. indicus* and setting up of effluent treatment systems.

MPEDA organized over 100 information dissemination programs for the benefit of farmers and other stakeholders in the form of farmers meeting, seminars, workshops, training programs and demonstrations. The problem of non-availability of finance for shrimp farming was taken up with NABARD and other nationalized banks with the help of the Ministries of Agriculture and Commerce. Consequently, NABARD recently approved refinancing of aquaculture schemes and requested financing institutions to advance loans to farms licensed by the Aquaculture Authority.

MPEDA funded a few projects to develop rapid diagnostic techniques. Diagnostic laboratories have been established in TASPARC and OSSPARC. MPEDA has also set up DNA dot-blot facilities for rapid diagnosis of WSSV at four regional centers along the east and west coasts of India. Recently, it has embarked on an ambitious project to set up six laboratories in different maritime states of India to offer PCR screening to farmers and hatchery operators.

MPEDA held dialogues with hatchery operators to ensure a supply of healthy seed. A code of practices that will help ensure production and supply of healthy seed is under consideration by hatchery operators. MPEDA has also proposed to extend financial assistance to private hatcheries for establishing screening facilities for viruses and bacteria. A broodstock development center in the Andaman and Nicobar islands is being established with the co-operation of the Ministry of Agriculture. It is hoped to maintain pathogen-free lines of tiger shrimp away from the mainland.

Many maritime states have established Brackish water Fish Farmer's Development Agencies (BFDAs) at the district level. These are mainly extension agencies mandated to work for the development of coastal shrimp farming, and are under the respective state fisheries departments. A total of 70 BFDAs have been sanctioned, and 37 are currently in operation. Since the WSD crisis, BFDAs have been actively involved in the organization of workshops on shrimp health management. Under the Aquaculture Authority, all farms must now to be registered with the local BFDA, and applications for license should be routed through them. BFDAs will also assume the role of a local regulatory body. BFDA has been associated with several extension programs in collaboration with MPEDA, farmers associations and research organizations.

Farmer Responses

When YHD struck for the first time in Andhra Pradesh in July 1994, the farmers were taken by surprise. As mass mortalities rapidly occurred, there was little time to think of logical and scientific interventions. Chemicals, used at many farms, were totally unsuccessful. Rapidly increasing mortalities forced many farmers to go for emergency harvest or drain the pond. Since farmers were totally unaware of viral diseases and the likely mode of spread of disease between farms, they did not take steps to prevent the spread of disease. Water from affected ponds was drained into creeks and estuaries without disinfection or notification to other farmers. Dead shrimp were disposed into surrounding waterways. These initial mistakes contributed to the rapid spread of the disease.

The response of the farmers to the first WSSV outbreak in November 1994 was also one of surprise and shock. Farmers attempted various chemical interventions at the first sign of disease, but none were effective. Realizing that total mortalities could occur within 5-10 days, the majority of the farmers resorted to emergency harvest. Unaware of the consequences, farmers drained their ponds with dead shrimp into the surrounding creeks and estuaries, triggering major outbreaks in the area. Since 1995, WSD has been occurred continuously in different shrimp farming areas of the country.

The first thing that comes to light is the fact that most farmers were unaware of the importance of primary health care in shrimp aquaculture. They thus thought only in terms of chemicals, treatments, vaccines, immunostimulants, etc. Chemical companies and consultants pushed chemicals, etc., so that in the last four years, more than 100 preparations have been used by farmers.

Emergency harvesting has become common throughout India. Decisions to opt for emergency harvest depend on shrimp size, efficacy of the chemical treatment adopted and daily mortalities. Rapidly increasing mortalities is increasingly used to decide on emergency harvest. Farmers with ponds in high-risk areas have closed their farms; such examples are common throughout India.

Farmers have realized that only a collective approach can provide long-term management solutions. As a first step, farmers have formed groups, societies and organizations. Financial institutions and insurance companies have been approached. Farmer organizations successfully organized several meetings in collaboration with state and private sectors on sustainable and pathogen-free shrimp farming practices.

The impact of WSD has made farmers rethink the management aspects of shrimp farming. Pond preparation, drying between crops, and reduced stocking densities (presently below $10/m^2$) are being adopted. The number of crops per year has been reduced. A notification system has been developed in many places, so that farmers inform each other regarding WSSV outbreaks and the details of draining. Instances of farmers collectively paying for pond disinfection have come to light. Collective decisions on cut-off dates for commencement of stocking are common in some places. A few farmers have adopted partially closed systems with chlorination for disinfection. Farmers routinely screen PL for WSSV by PCR. They are aware of the potential carriers of WSSV and have made management modifications to keep carriers out. During periods of WSD outbreaks, farmers close the gates and do not resort to water exchange. Farmers are aware of the consequences of seed movement between coasts within India; farmer organizations have attempted to prevent such movements.

Farmers have taken part in several research programs of the state sector. Some farmers in Andhra Pradesh have tried low-salinity or freshwater culture systems for tiger shrimp; however, these systems are not free of WSD outbreaks either. In addition, growth and performance in these systems are poor, thereby affecting economic viability. Some farmers have tried rotating shrimp with freshwater fish. So far, not much head way has been made with regards to the culture of other shrimp or fish species in coastal ponds. The economic viability of these alternative systems needs to be examined.

Hatchery Owner Responses

Availability of seed was a major constraint in the beginning years of shrimp farming. Establishment of two state-of-the-art hatcheries by the MPEDA in 1989 paved the way for development of large numbers of private hatcheries. From less than 13 hatcheries in 1989, the number has grown to around 175 in 1996. Due to an acute shortage of seed in 1993, it is believed that some hatcheries clandestinely imported nauplii from Southeast Asia.

As a direct consequence of WSD, stocking densities have been greatly reduced, and some farmers have reduced the number of crops per year. This has had a major impact on the demand for seed. With increased competition, hatcheries had to cut the price of seed and sell seed on credit. Some hatcheries could not recover the proceeds from seed sales and were forced to close.

Procurement of healthy broodstock from the wild is becoming difficult. Prices as high as Rs 100,000 (US$ 2200) are being paid for a single wild spawner. The majority of wild-caught broodstock are believed to be PCR-positive for WSSV. Farmers increasingly insist on PCR-screened seed from hatcheries. Conflicting PCR results have affected relationships between farmers and hatchery operators. Technical and financial problems have forced many hatcheries to close. Some mega-hatcheries were constructed but could not commence production. Many hatcheries have now become only nauplii rearing centers.

Hatcheries have introduced some sanitary practices aimed at improving the survival and health of seed. These include broodstock handling, disinfection programs, screening seed for MBV and WSSV, etc. Most hatcheries test every batch of PL for WSSV and other problems and make the results available to farmers. More transparency has come into hatchery operations. PCR-positive seed are sold at reduced prices. Domestication programs, change of broodstock origin, use of pond-raised broodstock, creation of nodal nauplii production and supply centers, etc. are some areas that hatcheries have started to consider. MPEDA hatcheries now offer a 60-day guarantee for their seed.

MPEDA has recommended several quality assurance steps for hatcheries. These include PCR/dot blot analysis of broodstock for virus, using only virus-free broodstock for ablation, egg washing in formalin, nauplii testing by PCR/dot blot, using only virus-free nauplii for rearing, PL testing by PCR/dot blot and selling only virus-free seed to farmers.

Other Service Provider Responses

Feed companies have responded very strongly, as they were severely affected by the WSD crisis. Reduced stocking densities and number of crops per year directly impacted feed sales and turnover of these companies. Increased competition added further problems; feed companies started offering credit and other incentives. Some companies tried introducing new brands. Feed companies developed water, feed and health management guidelines and educated their clients. Several companies, in association with state and farmer organizations, conducted workshops on disease management.

Chemical companies saw an opportunity to introduce new chemicals and promote sales. Significant quantities of chemicals and other preparations were used throughout India, but without much success. Chemical companies in association with farmer organizations and the state have conducted several workshops and seminars on viral diseases and their management in shrimp farming. Such meetings were also used as platforms to launch new products.

Technical consultants also saw this crisis as an opportunity. Consultants could have done a meaningful job, but failed because the majority lacked comprehensive knowledge on the importance of primary health care. Instead, they joined hands with companies to promote chemical sales. Now there is an increasing lack of trust between farmers and consultants.

The WSD crisis and the Supreme Court orders dealt a severe blow to the financial sector. Financial institutions could not recover their loans due to repeated crop failures. The insurance sector avoided shrimp farming after the WSD crisis. Small and marginal farmers, who own more than 80% of the area under farming, are suffering due to the non-availability of finance. In spite of a recent refinancing offer by NABARD, banks are still reluctant to finance shrimp culture. Continuous crop failures and lack of financial support and risk coverage caused many operators to abandon shrimp farming.

Recently, private companies are providing diagnostic services such as PCR screening and dot-blot testing for WSSV, and general health screening. With respect to WSSV, there has been series of problems and controversies. There has been no consistent association between PCR status of the seed and the crop outcome in the farm. As a consequence, the need for using PCR-screened seed is being increasingly questioned by the farmers. These service providers also organized meetings on diseases of shrimp, their diagnosis and management and used such occasions to advertise their services.

During periods of emergency harvest of undersized shrimp, processors took advantage in procurement prices, causing additional losses to farmers. Processors did not take any biosafety precautions in their movements between farms and between farming regions of the country.

Research and Development Interventions

Several research projects on shrimp health involving central ICAR fisheries research institutions (CIBA, CMFRI, CIFA, CIFE) and the fisheries colleges of state agricultural universities have been funded in the last four years by national and international funding agencies. A major R&D program on shrimp health under the National Agriculture Technology Project (NATP) funded by the World Bank is underway.

The majority of the projects have very specific objectives, such as the development of rapid diagnostics, PCR, treatments, vaccines, probiotics, immunostimulants, etc. The recently funded DFID project on epidemiological approaches for aquatic disease control is the first of its kind in India.

There are 11 fisheries colleges in the country under 29 state agricultural universities. Many of these institutions are actively engaged in shrimp health research and extension. Research priorities have been restructured to tackle the current shrimp health problems. Many of these institutions have been conducting regular workshops and training programs on various aspects of shrimp health management for extension officers, farmers, hatchery technicians, fisheries officers, etc.

A lot of extension literature has been published in popular journals and newsletters, mainly by scientists and extension workers working in state and central research and teaching institutions. These articles, especially those dealing with health management, have helped in creating awareness and in updating all concerned with the latest scientific information. Several management changes that have come about in the aftermath of viral epizootics can be traced to some of the articles published.

Legislation and Policy Interventions

Parallel to the WSD crisis, the industry also faced criticism for its role in environmental degradation. In response to public interest litigation, the Supreme Court passed a series of court orders and judgments.

The Ministry of Environment and Forests (GOI) issued a notification dated 19 February 1991 declaring that coastal stretches which are influenced by tidal action (on the landward side) up to 500 m from the high tide line and the land between the low tide line (LTL) and the HTL belong in the coastal regulation zone (CRZ). Various restrictions have been imposed in this zone, especially the prohibition of construction and establishment of industry. Expert review committees found violation of CRZ rules by the shrimp farming industry. Therefore, the Supreme Court in an order dated December 12, 1994 directed the states not to permit the setting up of any industry or construction of any type in the area up to 500 m from seawater at the maximum high tide. The states filed written petitions, and the Supreme Court ordered an expert committee to be constituted by the National Environmental Engineering Research Institute (NEERI) to visit farms in the coastal areas. Based on these reports, the court, in its order dated March 9, 1995, directed that no further farms be set up, no agricultural land or salt farms be converted for aquaculture, and no ground water be drawn for aquaculture.

On December 11, 1996, the Supreme Court passed a landmark judgement, the salient features of which include constitution of an Aquaculture Authority by the central government to regulate aquaculture activities, and strict adherence to CRZ rules. All aquaculture units within CRZ were to be demolished by March 31, 1997. Traditional and improved traditional methods of aquaculture were to be permitted; while agricultural lands, saltpans, mangroves, wetlands, etc. are not to be used for aquaculture. Aquaculture development using other than the traditional and improved traditional systems may be constructed outside the CRZ. Compensation is to be paid to the affected people. The Aquaculture Authority is to estimate the losses to ecology and the environment and set compensation to be paid by polluters. All existing and new farms are to get authorization from the Aquaculture Authority. The industry and central and state governments sought a review of the judgment. The Supreme Court extended the date to April 30, 1997. A ruling on the renewed petition of the government is yet to be given.

This judgment, meant to save the livelihoods of over 100 million people, has serious implications for the shrimp industry. The Ministry of Agriculture got an Aquaculture Authority Bill passed by the Rajya Sabha, but further action by the central government and Supreme Court are awaited.

Economic, Financial, Social and Livelihood Interventions

Affected stakeholders of the shrimp industry have not received any beneficial economic, financial, social or livelihood interventions from the state or central governments. In view of the WSD crisis and the Supreme Court order, farmers' organizations have been pleading for loans write offs from the financial institutions. Continuous crop failures and erosion of profits have forced many farms, hatcheries and feed companies to close, forcing many workers out of jobs. No special programs have been designed to assist these displaced workers. Intervention in this area is not likely in the near future. Putting abandoned shrimp farms to alternative use offers some solutions; brackish water fish culture, mangrove forestation, etc. are being discussed.

Merits and Demerits of Interventions

Some interventions were effective in one way or another. Most succeeded in creating stakeholder awareness of the importance of primary health care in aquaculture. Emergency harvesting was effective in containing the rapid spread of disease. In the case of acute mortalities of small-sized shrimp, farmers simply drained the pond with dead and live shrimp, a response that contributed to disease outbreaks in the vicinity of the farm.

Chemical and prophylactic interventions adopted by farmers did not give consistent beneficial impacts. Excessive use of chemicals can only have negative effects. The repercussions of using probiotics and bioremedial preparations are yet to be discovered. A collective approach taken by farmers to tackle the crisis has helped significantly.

Hatchery operators did not respond very positively to the crisis. Temporary closure of hatcheries and discouraging the movement of seed could have increased the effectiveness of the crop holiday enforced by MPEDA. Screening broodstock and seed has become routine, but there are no regulations regarding what should be done with positive animals.

Management interventions (e.g., proper pond preparation, keeping carriers out, reduced stocking densities, use of healthy seed, use of low exchange systems, not exchanging water during periods of outbreak, minimizing feed wastage, pond bottom management, etc.) have not prevented outbreaks, but seem to have helped reduce the impact of disease.

Crop holiday was a very good strategy but was not as effective as expected, as many farmers did not abide by the advice. Also, only farms were closed, while hatcheries continued to provide seed to farmers willing to stock anywhere in India. A lack of regulatory mechanisms at the time of the crisis appears to have damaged the industry.

Information dissemination has created awareness of the importance of primary health in shrimp farming. This can be seen in the improved farming practices that are being adopted by farmers.

Regulations should have been developed and implemented along with the government liberalization policies that were introduced during 1989-1994. The regulations and policy guidelines now being introduced under the Aquaculture Authority will have a positive impact on health management in shrimp farming.

Current Health Status

WSSV still remains the major problem faced by shrimp farming in India. None of the management, chemical or prophylactic interventions attempted have provided a solution to the problem in any part of India. WSSV has become endemic in many shrimp farming areas. The majority of the wild broodstock are believed to be WSSV positive, adding a new problem to the industry.

The Way Forward

Planners, policy makers and the industry must sit face to face to discuss strategies and options and come up with a pragmatic and practical approach to sustainable shrimp farming. Traditional shrimp farming is a case in point. The orders of the Supreme Court permitting only traditional and improved traditional methods of farming in the CRZ appear biologically sensible.

The Aquaculture Authority, with the help of state and district authorities, has taken appropriate steps to regulate shrimp farming through licensing of farms meeting the basic environmental and social criteria laid down by the Supreme Court. On the other hand, governmental agencies like MPEDA, BFDA, ICAR, and the fisheries research institutions are addressing various issues relating to technical and commercial aspects of sustainable shrimp farming. There is an urgent need to formulate a national policy recognizing the role of shrimp farming as a contributor to the economic development of the country. Based on this national policy, a plan for sustainable development of coastal aquaculture should be developed, focusing on a comprehensive health management strategy for shrimp farming.

Indonesia

by

Akhmad Rukyani

Shrimp culture in Indonesia, despite its tremendous potential, is generally not doing very well. Many of the problems, aside from poor management, have their roots in technical matters, such as poor site selection and design of facilities, water quality problems, and unforeseeable disease epidemics.

The total potential area for aquaculture development is estimated to be about 1,313,400 ha, of which about 850,000 ha are coastal mangrove forests. More than 250,000 ha of this area have been utilized for shrimp ponds to produce about 140,000 mt in 1991, making Indonesia's shrimp production the third highest in the world.

Annual production from shrimp has since declined significantly, down to 100,000 mt in 1993, and to less than an estimated 80,000 mt in this year. As shrimp is the most important fisheries export commodity, the government has recently promoted a national program to gain US$ 10 billion in year 2003 from fish production, of which more than 60% is targeted as coming from the shrimp industry.

History of Major Disease Outbreaks

Virus-caused diseases, particularly yellowhead disease (YHD) (caused by yellowhead virus, YHV) and white spot syndrome (WWS) (caused by white spot syndrome virus (WSSV), also known as systemic ectodermal and mesodermal baculovirus (SEMBV)), presently overshadow all other causes of major production losses. YHD was first reported at Tangerang, West Java and Gresik, East Java. YHV seems to be the most virulent and destructive virus detected so far in cultured *Penaeus monodon*, and has caused serious losses in certain areas. The disease is most severe to shrimp at the grow-out stage of 50-70 days; cumulative mortalities may reach 100% within 3-5 days of onset.

WSS occurred in West Java i.e., Tangerang, Serang and Karawang, in mid-1994 and then spread along the north Java coast. The disease occurs in juvenile shrimp of all ages and sizes (3-40 g), but mostly at 1-3 month after stocking in grow-out ponds. WSSV outbreaks occurred in all farming systems and at all stocking densities, regardless of water quality and salinity; however, less disease was reported in low-saline water (0-5 ppt).

Kunang-Kunang disease caused by luminescent *Vibrio harveyi* is the most serious disease threat to the shrimp hatchery industry in Indonesia. The disease affects more than 70% of post-larval (PL) production, with economic losses of approximately Rp 140 billion annually.

A serious mortality in shrimp culture caused by mixed-infection of monodon baculovirus (MBV) and *Vibrio* occurred in 1986. In 1989-1990, the disease affected shrimp culture in Aceh, North Sumatra, Java, and Bali.

Negative Economic and Social Impacts of Disease Outbreaks

In Indonesia, shrimp crop failures have occurred mainly in the many major semi-intensive farms. Total losses due to diseases are estimated to be US$ 300 million.

Indonesian shrimp farmers need about 6 billion PL per year. While hatcheries have the capacity to produce this amount, in 1991, disease caused a shortage. About 90% of the more than 200 big hatcheries are affected by luminescent vibriosis, losses being estimated at US$ 100 million/year.

In evaluating the negative economic impacts of crop failure in shrimp culture, we differentiate between material and non-material (psychological) effects. Negative material impacts include reduced opportunities for hatcheries, commercial feed businesses and associated employment, chemical and drug businesses, gasoline sellers, larval producers, and cold storage and harvesting operations. Negative non-material impacts are mainly loss of confidence in the shrimp business.

Interventions to Disease Outbreaks by Sector

State Sector Interventions

As an immediate measure, a task force under the co-ordination of the Directorate General of Fisheries (DGF) was established to formulate a solution to shrimp production failures. Using an integrated approach involving appropriate personnel from various sectors, the task force set up a national program to prevent losses mainly due to disease outbreaks.

Short-term measures included confirmation of the main cause of mortality as WWSV. By assessing mortality cases and etiological agents throughout the country, the task force was able to formulate temporary guidelines for disease control, which were disseminated to the farmers.

As a mid-term measure, assessments of formulated technology were conducted as a pilot project in several sites, including the development of procedures for diagnosis and monitoring.

Farmer Interventions

Since the outbreak of WSS in 1994, efforts have been made by farmers to combat what is considered the main cause of mass mortalities of penaeid shrimp. Principle interventions include the use commercial drugs and chemicals for chemotherapy (apparently ineffective), and early crop harvest (adopted by most farmers, rather than chemical application). Farmers are generally interested in any new technique for combating disease, such as bioremediation, and the use of vaccines, immunostimulants, and other commercial products. Some farmers switched to crop rotation using other commodities such as milkfish and tilapia in order to improve pond production, or to reduce disease occurrences. However, many farmers had to close their farms for a certain period of cropping or even completely shut down operation due to the continuous crop failures.

A number of farmer groups act collectively to solve problems in shrimp farming through information exchange for mutual benefit. Generally, these groups represent different culture systems in local areas i.e., traditional, semi-intensive, and intensive systems. The most active groups involve the intensive system, such as the Intensive Shrimp Farm Association (ISFA) and South Malang Shrimp Farm Association (SMSFA). These groups organize meetings every three months by inviting shrimp culture specialists from the state government staff and universities. Shrimp health management is the main topic for discussion, such as quick diagnostic techniques, drug treatments, vaccines, and bioremediation.

Hatchery Owner Interventions

Although there are no serious direct effects of disease occurrences in hatcheries, the owners commonly change their management practices for efficient and profitable operation. Recently, some hatcheries have reduced antibiotic use, applied probiotics for water quality improvement and now carefully screen broodstock for production of better quality PL. The period of larval rearing has been reduced to produce younger PL at 15 days.

The Association of Shrimp Hatcheries (ASH), whose membership consists of large hatcheries, was established in the 1990s. It facilitates meetings, workshops, and information exchange, both on hatchery technologies and on business aspects. This seems to be an effective mechanism to transfer technology to hatchery operators. At present, the ASH is in East Java, where most of the large hatcheries still actively conduct collaborative actions.

Because disease in hatcheries is not as serious as in the early 1990s when outbreaks of luminescent vibriosis caused considerable damage to production, hatchery responses to current disease problems have been minimal. Some hatcheries responded to the farm demand to improve larval quality. A few assure quality by treating the larvae with vaccines or immunostimulants, and at the farm level, they may provide probiotics and technical service. To some extent, large hatcheries, such as Bratasena Hatchery in Lampung, are able to supply WSS-free PL by PCR detection.

Other Service-Provider Interventions

In the private sector, mainly feed companies, PL collectors, and shrimp processors have been affected by recent crop failures. They are struggling to promote their products, mainly due to fewer farms being in operation. Therefore, such companies now provide product quality assurance and technical services for better farm management and production. However, these efforts do not help the farmers very much, as there are no assurances for disease control.

Legislation and Policy Interventions

In Indonesia, there are about 10 laws and regulations dealing with the environment, fisheries, conservation, zoning, environmental impact analysis and pollution control. Guidelines for management and monitoring have been established

Research and Development Interventions

Shrimp disease research is conducted by various institutions in Indonesia. However, recent studies have been focused on immunology and on water quality improvement of shrimp ponds. Current research activities of some of the institutions are as follows:

Research Activities	Research Institutions[1]
Diagnostic and epidemiological studies for bacterial and viral diseases	BAU, GRS, RICF
Pathological studies of *Vibrio* sp.	BAU, Biotrop, RIFF
Immunological studies (vaccination and Immunostimulation, i.e., LPS, levamisole, and *Vibrio* polyvalent vaccine)	RIFF[2] BADC, UGM
Bioremediation and probiotics	BADC, GRS, RICF, RIFF

[1]BAU - Bogor Agricultural University, BADC-Brackish water Aquaculture Development Center, GRS - Gondol Research Station, RICF - Research Institute for Coastal Fisheries, RIFF - Research Institute for Freshwater Fisheries, UGM - University of Gajah Mada

[2] A collaborative project with Australia (ACIAR Project PN9411, 1995-1998)

Economic and Financial Interventions

A number of projects to build and operate shrimp farm facilities nation-wide has been implemented since the early 1990s, including manpower development. All these project activities are financed by the government. These include the Shrimp Culture Development Project, implemented since 1992, and, more recently, an OECF project which is establishing a provincial-level shrimp disease laboratory and demonstration ponds in five locations.

There were two collaborative national research projects funded by ACIAR, the Prawn Health Management and Disease Control to Sustain Hatchery and Pond Production System Project and the Study on Integrated Disease Control at Farm Level.

In terms of financial support, these projects have allocated only relatively modest amounts for research and disease control. Similarly, private farms provide only limited funds for such research.

Social and Livelihood Interventions

Shrimp is the most important commodity in Indonesian fisheries production. Thus, declining production has affected all components, such as producers/owners, farm workers, feed and other product suppliers, traders, shrimp processors, and exporters. Continuous crop failures on shrimp farms, particularly during the present economic crisis, caused multiplying and inter-related impacts on social life, mainly of farm workers.

Effectiveness of Interventions

The interventions discussed above have not yet played a significant role in overcoming the comprehensive and interrelated problems occurring in Indonesia at both the farm and state levels. In order to meet targeted production for shrimp from aquaculture, the government still needs sufficient funding, human resources development, and improved management with well-organized interrelated sectors in an integrated approach.

Technological developments, particularly those dealing with many aspects of shrimp health management, cannot be achieved only by a single sector or individual country, since they require a complicated approach and special expertise. Therefore, current practices in shrimp culture are, in most cases, not sustainable due to a lack of reliable technology.

A number of research activities done by institutions and universities under the national program of Integrated Selected Research and through foreign-assisted collaborative research funding provide some technology for combating disease problems. Through these studies, technologies such as vaccination, specific pathogen-free (SPF) PL, bioremediation and early detection of viral infections have been obtained. Shrimp health management now includes screening of PL and the use of improved pond culture management practices. This type of technology may have potential use in disease control, as it does not have negative impacts on the environment or humans.

A national network, Indonesian Fish Health Management (INFHEM), has been recently established whose membership is comprised of the nation's fish disease specialists. It may also contribute to the technical aspects needed to overcome disease problems.

Unsuccessful interventions include the use of conventional guidelines for shrimp health management, as has been commonly applied by BDC Jepara. Also, the indiscriminate use of chemicals and antibiotics for disease control cannot be recommended.

Current Health Status

The economic impact of WSS in Indonesian shrimp farms is hard to assess. Only 30% of shrimp ponds remain in operation. Some 80% of shrimp ponds have switched to milkfish, but most remain non-operational.

MBV, YHD, and WSS still cause considerable damage to shrimp production. While there are no recommended control measures for these diseases, a general procedure based on temporary formulated technology has recently been suggested by the DGF to be disseminated to farmers. The technology includes PL screening, farm disinfection, use of predator fish to control carriers, improved feed nutrition, improved water quality by bioremediation, immunization, commodity rotation, and monitoring and evaluation. This suggested procedure is expected to improve shrimp health conditions, thus reducing mortalities caused primarily by WSS.

The Way Forward

Indonesia, one of the three top shrimp producers and exporters in the world, has recently set up a program to further increase production. However, the unresolved current disease problem threatens the prospects for shrimp culture. The unexpected emergence of new pathogens and diseases should be given more serious attention in anticipating future interventions.

Technology obtained from current pilot projects should be expanded throughout the country. This should be accompanied by the establishment of appropriate control measures, regional laboratories, and training for trainers, and extension services.

Policy that is relevant to environmentally friendly shrimp farm development should be established and disseminated to farmers.

Enforcement of coastal area management regulations that are relevant to shrimp culture is needed, including increased monitoring and law enforcement to maintain environmental quality, development of law authority capacity, extensive dissemination of information on laws and regulations to local communities; increased effectiveness, co-ordination and integration of law enforcement; improvement and completion of regulations that have not been defined in detail, and encouragement of community capability and awareness in implementing regulations.

A comprehensive study should be considered to support the national program of increasing shrimp production toward Year 2003. The following research and development activities cover priority elements to be included:

Assessment of shrimp culture production, including small- and large-scale hatcheries, grow-out ponds, production systems for hatchery, grow-out and pre-harvest.

Identification of a shrimp health management program, including aspects related to pond construction and irrigation systems, water quality management, feed and nutrition, disease and mortalities, disease control and health management, drugs and chemical treatment, and genetics.

Assessment of shrimp health management services, including facilities at individual farms and hatcheries, for disease diagnosis and control, provision of guidance for disease control, national and regional facilities for diagnosis and control, a network system for disease control services, and research and field-testing facilities for disease control.

Allocation of necessary supplies, equipment, and travel required assessing the shrimp health management status.

Overseas and local training in shrimp disease diagnostics and health management, and training for extension specialists, farmers and hatchery operators.

Some actions needed to obtain reliable information on identified shrimp health management problems in order to establish substantial shrimp culture follow:

- Establishment of national diagnostics and disease control systems, to be linked with other countries' networks.
- Establishment of specific laboratory and research activities for shrimp health management.
- Strengthening of training and research capabilities.
- Supporting information systems for research and training via a regional Shrimp Health Management (SHM) unit in NACA.
- Establishment of a website for recent shrimp disease diagnostics and control measures, so that member countries can immediately access needed information.
- Organization of regional annual meetings and workshops on shrimp health management.
- Conducting a collaborative project among member countries on various aspects of disease diagnosis and control.

Malaysia

by

Y.G. Yang, M. Shariff, L.K. Lee and M.D. Hassan

History of Major Disease Outbreaks

Since semi-intensive shrimp farming started in the early 1900s, disease has become one of the major constraints to achieving maximum production. The first major disease problem encountered was monodon baculovirus (MBV), which was first detected in 1988. MBV affected post-larvae (PL) production with mortalities, thought to be associated with stress factors and poor management, reaching 100%.

White spot syndrome virus (WSSV) was first reported in 1994 and by 1996 had spread to affect 80% of farms. The disease has caused severe losses to the industry at all levels. WSSV is more likely to cause mortality in the rainy season; the dry season crop is less likely to be affected.

Yellow head virus (YHV), although having a high prevalence in Malaysia, does not appear to have resulted in large mortalities, although it is possible that this could change.

Recently, a new virus-like agent has been described which has a high prevalence (up to 99% in grow-out animals). Although no major mortalities have been experienced, the high prevalence and the severe cytopathic effects associated with the disease are a cause for concern.

Two new bacterial diseases were reported, namely soft body-white faeces syndrome (SBWFS) and bacterial white spot syndrome (BWSS). SBWFS was first noted in 1996 and had spread rapidly, causing economic losses as significant as those associated with WSSV. BWSS is caused by bacteria forming white spots on the cuticle similar to those caused by WSSV. This has caused confusion among farmers and the scientific community, who are only aware of viral white spot syndrome. Luminous bacterial diseases caused by *Vibrio harveyi*, known for many years, are also regarded as major problems in both hatcheries and farms.

Negative Economic and Social Impacts of Disease Outbreaks

The major disease for which data on economic losses are available is WSSV. Since 1995, losses due to WSSV are estimated to be in the region of US$ 25 million annually.

No information is available on the extent of the social impacts of the disease outbreaks, however a number of farms and hatcheries have closed as a result of losses caused by the disease.

Interventions to Disease Outbreaks by Sector

State Sector Responses

The Department of Fisheries (DOF) issued rules and regulations aimed at preventing and controlling the spread of disease, such as restrictions on the movement of live shrimp within Malaysia and to/from the country. Initially, east Malaysia appeared to be free from WSSV, and restrictions were placed on the movement of live shrimp from west Malaysia to east Malaysia. Although WSSV has since been confirmed in east Malaysia, this ban is still in place.

Farmer Interventions

Farmer responses to the disease outbreaks varied considerably. For some diseases, such as MBV, the impact was small enough that the disease was accepted as a normal consequence of poor management or pond conditions.

The WSSV outbreak led some farmers to cease operations or to switch to fish and *Macrobrachium* culture and wait for the disease problem to subside. Other farmers accepted as normal the risk of WSSV outbreak and tried various strategies, such as crop rotation with other species. As WSSV persisted, farmers realized that good management could still yield a successful crop, even when the virus is present.

Hatchery Owner Interventions

Following the WSSV outbreak, some hatcheries closed down or operated on a reduced basis due to a low demand from farms. Because broodstock from local sources was infected with the virus, hatchery owners started to look for new sources of virus-free broodstock. Farmer demands led to an interest in PL quality and increased attention to hatchery hygiene, nauplius disinfection and PCR-screening of PL for the virus.

Private Sector Interventions

Service providers also responded positively to the disease situation by organizing extension activities, such as seminars and technical support to disseminate information and provide assistance to farmers in disease management.

Legislation and Policy Interventions

Legislation and policy interventions, such as regulations on live animal transfers, appear to have been of limited effect due to a lack of proper implementation and inadequate inspection facilities.

The lack of a clear mandate for the issuance of health certificates (which are not mandatory) has resulted in a number of agencies and private laboratories issuing their own certificates. There is little standardization of methods, and conflicting results have led farmers to question the effectiveness and reliability of diagnostic laboratories.

The Way Forward

There is a need to increase awareness and expertise in shrimp health management in the private and public sectors. This will improve the acceptance and implementation of the existing regulations. Information dissemination needs to be improved through more effective use of newsletters and bulletins.

More intensive research and development programs need to be funded to find ways to combat the threat from disease. Increased public/private sector co-operation should be encouraged.

Financial assistance to help farmers recover from catastrophic losses needs to be provided to speed up the recovery of the farming sector.

The development of an effective shrimp farming association should be encouraged to improve dialogue and co-operation among farmers. This will allow farmers to react more quickly and effectively in the control of disease outbreaks.

Phillippines

by

Juan D. Albaladejo

History of Major Disease Outbreaks

In the Philippines, outbreaks of disease, particularly in intensive systems, have been recorded for the past ten years. Monodon baculovirus (MBV) wreaked havoc in the late 1980s, with the worst cases reported in 1988. Mortalities due to this virus have abated with the routine screening of fry before stocking. Succeeding disease syndromes involving hepatopancreatic parvo-like virus (HPV) and infectious hypodermal and hematopoietic necrosis virus (IHHNV) were contained with the incorporation of tools for early viral detection and the establishment of strict sanitation in culture systems. Hatchery intensification led to mortalities due to luminous vibriosis, and the timely administration of proper sanitation and prophylactic treatment with antibiotics has reduced occurrences. Nutritional deficiencies (i.e., chronic soft-shelling and blue shrimp) have also caused mortalities and reduced market value of product. Incorporation of wet feeding and essential nutrients to pellet diet has likewise reduced the occurrence of this syndrome.

In the 1994, a precipitous decline in production occurred in most areas in the Philippines as shrimp culture was affected by epizootics in grow-out due to luminous vibriosis. This has put the entire disease prevention and control scheme in a quandary. All possible interventions have been tried, but no effective strategy to combat the disease has been devised.

This situation was further compounded in 1995 with the emergence of economically important shrimp viruses. In 1996, a meticulous program of monitoring the occurrence shrimp viruses in selected farms in the Philippines was initiated. Gross manifestations were non-specific for shrimp samples collected from field cases; typical clinical signs associated with known shrimp viral diseases were not observed. Cumulative mortalities ranged from 40-80% and assumed acute to chronic forms. Two syndromes were observed, one noted between 30-45 d of culture with acute mortalities, and another during mid-culture that assumed either acute or chronic forms. Survivors usually showed poor growth performance without a drop in feed demand.

Histopathology revealed a variety of viral inclusion and occlusion bodies in 90% of the samples. Eosinophilic intranuclear occlusion bodies were mainly attributed to MBV. All the inclusion bodies appeared intranuclear and stained either eosinophilic or basophilic. In all samples, intranuclear eosinophilic inclusion bodies present in the midgut caecal cells and apical regions of the hepatopancreatic tubules were the most predominant cell lesion found. Similar cytopathology in the lymphoid organ was observed in some samples. These inclusions did not conform to the pathognomonic viral effects described in published reports of white spot syndrome virus (WSSV).

Moderate infections of gills and cuticular epithelial cells with intranuclear basophilic inclusion bodies dispersed in the cell cytoplasm were also noted from the histological sections. These inclusions were similar to those reported for cells infected with yellowhead virus (YHV).

The described inclusions were seldom observed in mixed infection together with known shrimp viral agents such as HPV and lymphoid organ vacuolation virus (LOVV). On the other hand, most tissue sections showing viral-associated lesions also showed typical lesions attributed to luminous vibriosis.

Combined SDS-Western Blot-EIA yielded positive results for the presence of YHV. Protein analysis of these samples exhibited a band of approximately 135 kDa, which has been reported as the putative G protein for YHV, and which has been associated with rhabdoviruses. Tests with the same samples using polyclonal antibodies against WSSV were negative, and this was confirmed by PCR and nested PCR. However, these results were short-lived, with shrimp sampled for the first quarter of 1999 and examined using both tests yielding positive results. These samples produce high titre but were not associated with mass mortality, being mostly taken from apparently healthy shrimp populations.

This finding is puzzling, as since 1993, the Philippines have banned the importation of penaeid shrimp of all stages via FAO No. 189 Series of 1993. We speculate that shrimp from other countries may have gained entrance to the country illegally. This new twist in emerging viruses in Philippine shrimp culture has potentially serious economic implications, and care must be taken to prevent a possible disease outbreak due the virus.

The inability of molecular biology to detect the virus associated with the eosinophilic intranuclear inclusion bodies in the midgut suggested that we might be dealing with a new WSSV variant or a totally new virus. On the other hand, similar clinical observations reported by shrimp health workers from Australia (Owens pers. comm.) suggest that this Philippine syndrome resembles cases of spawner-isolated mortality virus (SMV). To confirm this, tissue samples sent to Australia were subjected to *in situ* hybridization using a probe for SMV, with 3 of 10 samples producing positive results. However, the RNA makeup of the virus and the typical cytopathology and predilection to epithelial tissue suggested that it should be grouped with the still-to-be-refined YHV complex (GAV, YHV, LOV and SMV). Sequence analysis comparison of the gill-associated virus (GAV) with YHV suggests these viruses are closely related but distinct, sharing approximately 85% nucleotide and 96% amino acid sequence identity. PCR products from a range of LOV and GAV isolates have indicated that LOV is a non-pathogenic variant of GAV. In the case of SMV, the locality, mortality pattern and cytopathology are distinctly similar to that of GAV (Walker, pers. comm.). The complexity involved in the identification of the viruses involved in the YHV complex may be attributed to their RNA structure, which is prone to mutation of its nucleotide sequence.

These results suggested that the virus, along with the luminous bacteria, might be involved in most cases of shrimp mortality in the Philippines. It seems that we are dealing with a moderately virulent viral disease, the expression of which is enhanced by mixed infection with opportunistic bacteria. The combination produces the outward clinical signs and mortality during shrimp culture.

Negative Economic and Social Impacts of Disease Outbreaks

Disease and environmental deterioration due to the intensification of shrimp culture have led to economic woes in the shrimp industry. Hardest hit is the Western Visayas Region, particularly Negros Occidental, the hub of intensive culture in the Philippines. At the height of production, 1,000 mt/mon of marketable shrimp were produced. Production has since declined precipitously to the present level of 100 mt/mon. Sustaining production, even at this level, is doubtful.

Decreased demand for PL has greatly reduced the number of shrimp hatcheries in operation. This is particularly felt in the Iloilo area, where rows of shrimp hatcheries either closed down or suspended operation. Some hatcheries run occasionally for specific fry orders.

Decreased production has greatly affected shrimp exports. In 1991, Philippine shrimp exports reached an all time high of 30,462 mt, but succeeding years have seen a continuous decline in export, with 10,000 mt reported in 1997.

Processors also felt the pinch, as raw materials became scarce. A high of 11 processors operating in Negros Occidental at the height of shrimp production was reduced to nil, a few operating on a per contract basis. This impact was also felt in Luzon and some parts of Mindanao.

Associated industries, such as feedmills, were likewise affected, sales plummeting due successive crop failures. The main production line for pellet feed for aquaculture, usually concentrated on shrimp feed production, has since shifted to finfish feed pellets.

Due to unreliable and inconsistent production, most shrimp farmers have shifted to milkfish production. It is only the recent depreciation of the peso that has encouraged farmers to return to shrimp culture. However, intensification is greatly reduced; the apprehension for stocking in high density prevails, as no reliable innovation to assure increased production is in place.

The Philippine Prawn Industry Policy Study conducted in 1993 listed the following employment figures: hatcheries - 2,200, feed mills - 900, grow-out operations- 31,700, processing plants - 15,000, and support services - 19,000 jobs. With the decline of the shrimp industry, there has been a corresponding drop in these numbers.

Interventions to Disease Outbreaks

Since the Philippine shrimp industry was developed mostly through private-sector initiative, intervention to arrest the decline of production was first attempted by this sector. Specific innovations such as use of antibiotics, disinfectants and microbial preparations were used. Likewise, matured technologies from countries with good production were acquired. The inconsistent application of these innovations was to the detriment of potential benefits which might have resulted.

To effectively implement these interventions, an informal collaborative effort was conceived through the aegis of the Negros Prawn Producers Marketing Cooperative, Inc. (NPPMCI), based in Bacolod City. Researchers from SEAFDEC-AQD, The Bureau of Fisheries and Aquatic Resources (BFAR) and the University of the Philippines in the Visayas (UPV) were invited to extend assistance through suitable interventions, such as establishing standards for quantitative bacteriology, fry quality assessment, water and soil quality standards, disease monitoring and surveillance, and conducting training and seminars on new developments for good shrimp farm practices

To formalize this collaboration, the Department of Agriculture under Special Order No. 471 Series of 1996 created a task force. The task force, named Operation Save the Shrimp (*Oplan Sagip Sugpo*), has the primary aim of rehabilitating shrimp farming in areas where the industry has declined and making the industry sustainable nation-wide through a focused effort to develop sound shrimp health management techniques. Its specific objectives are:

- To tailor culture techniques to specific culture intensities or systems.
- To determine the carrying capacity of a given area for shrimp production and develop practical guidelines on regulating the development and operation of shrimp farms.
- To set in place a monitoring system to ensure compliance with whatever regulations the task force may recommend for implementation.
- To train shrimp farm operators and technicians on sustainable shrimp culture techniques.

Short-term Strategies (1-2 years)

- Obtain baseline information on production levels, local shrimp consumption patterns, production resource base, and present R&D efforts and identify people involved in shrimp health studies.
- Conduct "fire-fighting" operations to come up with practical and effective methods to greatly minimize the risk involved in sugpo farming, and to make it profitable and financially attractive once again by documenting, evaluating and verifying successful practices.
- Develop a "shrimp production index" to monitor success or failure of the task force.

Medium-term Strategies (3-5 years)

- Evaluate research findings with potential to alleviate shrimp disease problems, such as the use of immunostimulants and enzymes, through laboratory and pond experiments.
- Come up with quality standards for shrimp pond discharges that can be submitted to the Department of Environment and Natural Resources (DENR) for implementation.
- Develop the diagnostic capability of the shrimp producing regions of the Philippines.

Long-term Strategies (6-10 years)

- Develop Specific Disease Resistant (SPR) strains of shrimp through genetics, selective breeding and/or biotechnology.
- Develop and beef up technical manpower in diagnostics, management and research.

Research Activities

Formulation of disease control strategies lies in a better understanding of the interaction of virulent pathogens (i.e., *Vibrio harveyi,* virus) and susceptible hosts (i.e., shrimp) under stressful conditions (i.e., intensive culture). Attempts to control disease should be approached in an integrated manner. Research should, therefore, focus on the means to improve the culture environment and achieve a better understanding of the pathogen and host. Thus, the institutions involved in the shrimp culture rehabilitation program agreed to pool expertise and share research activities to address the research needs in the least possible time. Priority research activities are grouped as follows (low, medium and high needs are indicated respectively by one, two and three asterisks):

<u>Primary needs for shrimp</u>

- Selective breeding (SEAFDEC) ***
- Establish a standard quantitative measure of shrimp health status (SEAFDEC) ***
- Defense mechanisms **
- Nutrition (SEAFDEC) *
- Probiotics/immunostimulants (BFAR, University of the Philippines as Los Banos (UPLB), UPV, SEAFDEC) ***

<u>Primary needs for pathogens</u>

- Biology (BFAR, UPLB, UPV, SEAFDEC) ***
- Molecular (UPV, BFAR/UPLB, SEAFDEC) ***
- Virulence mechanisms (UPV, BFAR/UPLB, SEAFDEC) **
- Epizootiology (BFAR, UPLB, SEAFDEC) ***
- Rapid diagnostic tools (UPLB/BFAR, UPV, SEAFDEC) ***
- Resistance patterns (UPV, SEAFDEC) **

Primary needs for the environment

- Role of predisposing factors in causing the disease state *
- Understanding the dynamics of pond environment - computer modeling (UPV) ***
- Define optimal carrying capacity for shrimp culture pond effluent standards (UPV) ***
- Bioaugmentation/bioremediation (UPLB/BFAR, UPV, CBSF) ***
- Other interventions (chemicals, ozonation, crop rotation, etc.) (BFAR, UPLB) ***

Economic and Financial Interventions

The new government of 1998 embarked on its agriculture and fisheries modernization program called "Agriculture for the Masses*" (Agrikulturang MAKAMASA*). The program aims to provide various support services for agriculture and fisheries infrastructure, credit, empowerment of farmers/fishers, and productivity-enhancing technologies. Key to program implementation is the passing of two important laws, the Republic Act 6435, Series 1997 – Agriculture and Fisheries Modernization Act (AFMA), and Republic Act 8550, Series 1998 – Fisheries Code.

The AFMA entails a PHP 120 billion budget over the next seven years, i.e. PHP 20 billion for 1998 and PHP 17 billion for 1999 up to year 2004. These amounts are aside from the Department Agriculture's budget. The PHP 20 billion for the first year is broken down as follows: 4.4 billion for research; 4.4 billion for extension; 5.2 billion for irrigation; 1.75 billion for infrastructure; 2.0 billion for marketing assistance; and 2.0 billion for post-harvest facilities.

Through the program, it is mandated to ensure credit and guarantee programs. Likewise, AFMA also provides for trade and fiscal incentives, including the duty-free importation of agriculture and fisheries production inputs over a period of five years from the date of effectivity of the law.

As for the Fisheries Code, the following provisions assured the endowment of the fisheries sector, particularly the aquaculture subsector, to make it more competitive and sustainable:

- A new incentive and disincentive system for sustainable aquaculture practices;
- Inclusion of inland fishponds, fish cages, and fishpens in the coverage of the Philippine Crop Insurance Corporation's (PCIC) insurance program for losses caused by *force majeure* and fortuitous events;
- Creation of a Comprehensive Post-harvest and Ancillary Industries Plan for, among others, the extension of credit and incentives for post-harvest operations, promotion and strengthening of processing and handling, and development of the domestic fishmeal industry;
- Banning the capture and/or exportation of breeders and spawners of important fishery species as determined by the Department of Agriculture; and
- Various other support services for fisheries, including the different financing (*i.e*. credit and guarantee) facilities mentioned earlier, infrastructure support (i.e., municipal fishing ports and markets, farm to market roads linking the fisheries production sites, coastal landing points, and other post-harvest facilities to major market and arterial roads/highways), extension services and others.

Long overdue, these pump-priming measures to be implemented under the "Agriculture for the Masses" program, should substantially enhance competitiveness and viability of the local agriculture and fisheries sectors, including the shrimp industry. Crucial to the success of the program is the implementation of an Agro-Industry Modernisation Credit and Financing Program (AMCFP) to provide a rationalized intervention in the rural credit market in a period of adjustment. This augments AFMA and the Fisheries Code to provide long-term improved viability of both agriculture and fisheries investments, with the primary aim of ensuring competitiveness to credit funds. However, financial support can only be realized if the industry can improve its efficiency and viability by reducing risk to supporting financial institutions.

Effectiveness of Interventions

Concerted research has led to attainment of the primary goals set in the short-term strategy. Duplication of research activities is minimized, resulting in output generation in the least possible time. Since research lagged during the heyday of shrimp production, the reverse now exists, as the setting up of disease prevention strategies during the recovery assures a more sustainable industry with reduced risk of crop failures. The meeting of stakeholders allowed the threshing out of the technical and financial support needed by the industry to sustain its recovery. The only hindrance we see is the economic woes being felt by country, which have drastically affected capital inflows to the industry and corresponding government financial support.

Appropriate interventions verified in the field gave the shrimp farming entrepreneurs the needed impetus to revive the business. The innovations made are primarily geared to culture techniques, making them more systems-oriented and environmentally sound. The trend is to reduce pond contamination by pathogens and to provide a better pond environment. The following innovations are those that showed promising results when verified in the field:

Long Dry-Out Period

A reduced number of growing cycles for each pond for a given year is apparently compensated by a reduced risk of production failure and increased yield. Some growers find an extended drying period of 2-3 mon beneficial in getting good yield.

Finfish-based Biocontrol Against Vibriosis

Tilapia and milkfish provide conditioned water with consistently reduced luminescent bacterial counts and stable phytoplankton blooms. The water also increases the microbial diversity of the pond. A number of anecdotal and monitored field successes have been reported; shrimp farmer's nation-wide is starting to utilize this technology.

Crop Rotation

Tilapia and milkfish have been successfully rotated with shrimp. This technology has proven its worth in the field of agriculture in preventing successive crop failures. The challenge is finding the suitable crop rotation ratio to make shrimp culture sustainable.

Development of DNA-based Molecular Biological Tools for Detection of Economically Important Viruses
Health management using rapid and accurate diagnostic tools is becoming an essential component of the systems approach. Polymerase Chain Reaction (PCR) techniques specific to the most important shrimp viruses (e.g., WSSV, YHV) are becoming integral procedures for screening spawners, larvae and juveniles.

Current Health Status

WSSV has just been reported in the Philippines. Since the first confirmed detection of the virus in the Province of Cebu, it has spread to most shrimp culture areas in the country. Testing of new samples collected in the first quarter of 1999 showed some positive reaction using Combined Western Blot/EIA protocol, and this was confirmed using PCR. From preliminary observations made by the team, the following assumptions relating to the virus were made:

- At present the virus is still not causing devastating mortalities to shrimp in grow-out ponds.
- The virus is moderately virulent, unlike the case in other countries with WSSV epizootics.
- From its PCR fingerprint, the virus appears to differ from WSSV reported in other areas.

- Although YHV is prevalent in most shrimp producing areas, no confirmed mortalities have been attributed to it.
- A new shrimp virus resembling spawner mortality syndrome (SMV) was found. A molecular probe for *in situ* hybridization developed by Dr. Leigh Owen was used to screen for the virus.
- A viral cause to the disease syndrome cannot be discounted. It appears that this syndrome is different from the disease problem experienced by other shrimp producing countries. It appears to be a moderately virulent viral-caused disease whose outward clinical signs and mortality rate are enhanced by mixed infection with opportunistic bacteria.

The Way Forward

Disease control programs can only be viable if approached in a holistic manner incorporating innovations to correct problems in the environment, animal and pathogen. Application of individual technologies usually fails or cannot be consistently replicated, suggesting that no single technology can claim to solve the prevailing disease problem. The situation is complex and will require a “systems-wide approach“ involving all elements of shrimp culture.

A review of accepted and tested basic principles of shrimp culture is essential. Formulation of an effective disease prevention strategy will rely on taking full advantage of benefits accorded by previous disease prevention strategies combined with new technologies. Applications of combined interventions (old and new) require complementary sustained pro-active research to keep abreast of other emerging disease problems. The active research collaboration of all sectors of the industry should be sustained. Matured and verified interventions and basic research outputs should be packaged on a regular basis. Likewise, dissemination of information using all forms of media should be done to reach a wider targeted audience. To return shrimp culture to its original state of viability, the program outlined in the task force manifesto will be pursued.

P.R. China

by
Jiang Yulin

White spot disease (WSD) is the most serious epidemic disease affecting shrimp culture in China. It has not only reduced shrimp production on such a large scale so that production has still not completely recovered, but has also caused many negative economic and social impacts. The government administrative departments and shrimp raisers have accumulated experience on control measures against this disease, and shrimp culture is now gradually recovering.

Shrimp culture is one of the fastest growing food-producing sectors in China. Large-scale shrimp culture began to develop at the end of the 1970s, and both production and culture area expanded very rapidly in the 1980s. Production rose from 2500 mt in 1980 to 210,000 mt in 1992, while the area under culture expanded from 9000 to 150,000 ha during the same period. The main species cultured are *Penaeus chinensis, P. japonicus,* and *P. monodon. Penaeus chinensis* is raised in north China, *P. monodon* in the south, and *P. japonicus* in both areas. About 70% of the culture area is concentrated in the Bay of Bohai Sea and two peninsulas, where several thousand hectares of shrimp ponds are linked together.

History of the White Spot Disease Outbreak

In 1992, some researchers noticed hidden troubles resulting from the rapid development of shrimp culture in China. There were so many ponds along each kilometer of coastline, especially in north China, that water pollution and poor water quality were certain to occur. Outbreaks of disease were also certain, although we did not know the kind of disease that would appear in the time to come.

In that year, unstable production in north China due to environmental pollution and high mortality of shrimp in a few ponds in south China caught the attention of some researchers, who reported this to the government. However, this did not arouse much concern, as the affected area was very small and a good harvest was in sight.

In 1993, *P. japonicus* was introduced to north China from the south because of its high market value. This provided a chance for the pathogen to contact a new host, *P. chinensis*. Afterwards, acute disease broke out across all of China at almost the same time. In south China (Guangdong and Fujian provinces), the disease began in wintering *P. japonicus* in March. The peak of the epidemic came in April among *P. monodon* (3-4 cm in length), and then the disease spread to the north (Wenzhou) and the south (Xiamen) in June. It affected 85% of the culture area. In east China (Jiangsu and Shanghai), the disease began in mid-June, peaked in July, and then spread to the whole region; 85-90% of shrimp ponds were affected. In north China (Shangdong, Liaoning and Hebei provinces), the disease existed from June to July (1.5 mon), affecting 70-80% of shrimp ponds. The total national production of shrimp was reduced from 210,000 to 87,000 mt, a decline of about 60%.

From these data, we find that:

- The disease broke out in various regions at almost the same time; there was only a short delay in the north because of the low water temperature.
- There is some evidence indicating that pathogens were spread through the introduction of infected shrimp. Usually the introduced *P. japonicus* became sick first, and then the nearby *P. chinensis* were affected. For instance: (1) *P. japonicus* introduced into a farm in Liaoning Province died on 2 July, then disease broke out in *P. chinensis* on 20 July; (2) in Yantai, Shandong Province the *P. japonicus* were sick on 27 July, while the *P. chinensis* began to be sick on 6 August; (3) *P. japonicus* introduced

into another farm in Jiangsu Province died on 13 June, then disease began to break out in *P. chinensis* on 2 July; and (4) in Shanghai, *P. japonicus* became sick on 25 June, and then *P. chinensis* began to be sick on 5 July.

- In 1993, the epidemic did not affect those farms which were isolated from the outside (other ponds) due to factors such as inadequate water supply, no good conditions for water exchange, no introduction of shrimp, etc.

Outbreaks of WWS were still serious in 1994 and have continued every year to the present. The epidemic season is from May to the end of June in south and central China, and from the end of June to the end of July in north China. National production was reduced to 53,000 mt. Afterwards, shrimp production began to gradually recover and reached 120,000 mt in 1998, as the state government allocated a lot of funding for disease control. However present production is still lower than that achieved in 1992.

In recent years, mortalities of infected shrimp have been slightly lower than previously, and the course of disease is prolonged. Some clinical signs have changed; there were some diseased shrimp showing red body coloration and no white spots, but the results of PCR detection still showed the existence of WSSV DNA.

Interventions to Disease Outbreaks by Sector

State Interventions

When the Ministry of Agriculture first became informed of the wide epidemic of WSS, a group of experts was sent to coastal regions for investigation. The results indicated that the situation was much more serious than earlier supposed. This disease took place so acutely and suddenly, and spread so rapidly, that the epidemic had a broad extent with high mortality. By the end of 1993, 150,000 ha of shrimp ponds (about 70% of the total culture area) were infected. In 1993, losses due to WSSV amounted to 120,000 mt, a direct loss to the Chinese shrimp industry of more than US$ 250 million. The disease also impacted the lives of 1 million people and had social implications involving the food industry, refrigeration companies, foreign trade, the food processing industry, etc.

The government began to contact research institutes and universities to ask for help. At the end of 1993, a baculovirus was observed in the tissue of diseased shrimp that was different from monodon baculovirus (MBV) and BMNV.

In December, the first national symposium on disease control and environmental management for cultured shrimp was held in Qingdao. The relationship between disease and the environment, and disease and the movement of live shrimp was more widely realized, and the appropriateness of the actions taken previously was questioned.

In 1994, the Ministry of Agriculture began to organize an emergency plan to tackle key problems. The government allocated more than US$ 1 million each year for disease control, with two main aims: (a) to study the virus, including its pathogenicity, hosts, and mode of infection, and to develop methods for rapid detection etc., and (b) to set up a national pilot area for disease control in shrimp culture and to try to form a model (or models) for healthy management, and then to extend these to the whole of China.

Some pilot areas have achieved success. For example, in the Tianjing Region, the harvest in some farms reached 3.78 mt/ha; the highest was 6.3 mt in one ha in 1997. In the whole of China, about 4000 ha of pilot area obtained good harvest.

At the same time, the Ministry of Agriculture published "The Technical Criteria for *P. chinensis* Farms" and "The Technical Criteria for *P. chinensis* Hatcheries."

In December 1995, a second national symposium on disease control and environmental management for shrimp culture was held. Information on many successful experiences in preventing diseases was exchanged.

Local Government Interventions

In June 1993, the local government did not recognize that there was a very serious epidemic disease. As common response, the government provided loans for farmers to buy again larval shrimp. In July, the government began to take isolation measures to prevent increased prevalence of this disease, such as blocking the outlets of infected ponds to prevent wastewater discharge. They began to look for chemotherapeutic treatments for farmers to cure this disease and to ask local universities and institutes for assistance. These efforts were very limited because we did not have enough knowledge about the virus at that time.

Farmer Interventions

As WSS is an acute epidemic disease and all shrimp in a pond will die in 90-100 hr, farmers have no time to take measures. Some farmers tried to use those chemicals and drugs that they could obtain, but this was, of course, ineffective. Some farmers tried to save shrimp by changing water, reducing culture density, conducting harvest, etc., but these methods were, for the most part, in vain. For example, when disease broke out around a 10 ha shrimp pond in Liaoning Province, the farmer fished out 370 kg of small shrimp (about 3000 pieces) from each ha of pond and disinfected the water with quick lime. The shrimp were cultured for an additional 40 d, and the farmer harvested 900 kg/ha. In such a bad a situation, this could be considered a good harvest; not everyone was so lucky.

Hatchery Owner Interventions

Hatcheries tried to implement some sanitary measures, such as selecting healthy broodstock and disinfecting eggs and water supplies.

Other Sector Interventions

Since there was a large reduction in production, shrimp sales were also reduced in the market. Some factories produced other animal food, while others produced an extended shrimp food with additives.

The shrimp processors began to install some additional disinfecting measures, such as quick lime pools to treat wastes, because viruses were being discharged with waste when diseased shrimp were processed. However, processors showed low enthusiasm in coordinating these efforts, as there were no direct benefits to factories.

Before 1993, insurance agents advised farmers to insure their shrimp culture activities. But after 1993, insurance for shrimp ponds was refused because the risk was considered too high.

The market supply of chemicals and medicines developed rapidly. However, most of the useful chemicals are disinfectants; other drugs did not show distinct effectiveness.

Exporters introduced white shrimp (*Litopenaeus vannamei*) in the hope that it was not susceptible to WSSV. However, results were not so satisfactory.

Legislation and Policy Interventions

On 2th December 1996, the *"Regulations for the implementation of the quarantine law of the People's Republic of China"* was issued. The animal and plant quarantine bureau are responsible for controlling the entry and exit aquatic animals. A key laboratory for aquatic animal diseases was set up in the Shenzhen Bureau.

On 3rd July 1997, the *"People's Republic of China epidemic prevention law for animals"* was approved. The husbandry and veterinary administration departments are the competent authorities to control aquatic animal movement within China. However, the establishment of a domestic aquatic animal quarantine system is still in its initial stage.

Research Interventions

Some research sectors studied the characteristics of the virus and its host distribution, and established various detection methods, such as PCR, DNA probes, monoclonal antibody technique and ELISA, staining of histopathological sections, etc. These methods were used to investigate WSS across the whole of China and for the quarantine of shrimp being moved.

On the basis of this research, wide epidemiological investigations were also made, the roles of different culture patterns and environmental factors in causing epidemic diseases were studied, and various preventative techniques were explored. This work plays a very important role in resisting disease and achieving good harvests in pilot areas.

The Way Forward

The effects of the environment on the prevalence of diseases have gradually become recognized. People began to consider the existing problems resulting from the rapid development of shrimp culture and to improve culture conditions. For example, Tanghai County is a main area of shrimp culture, having 4700 ha of ponds concentrated along 9 km of coastline. The environmental pollution here was very serious. Adjustments to the culture structure began in 1995. Large-scale monoculture shrimp ponds were converted to multispecies culture of fish, shrimp and shellfish, lightening the pressure on the environment. The culture pattern was changed to low-density stocking and polyculture of fish and shrimp or shrimp and algae. In present health management, the policy of "putting prevention first" is maintained. The disinfection of ponds and water and the use of closed or semi-closed culture systems were adopted.

Conclusions

- WSSV is a very strong pathogen; it has a wide variety of hosts and causes serious pathogenicity. It is the most serious shrimp virus we have ever known.
- The frequent introduction of aquatic species and the exchange of cultured species between different regions without quarantine has led to pathogens being spread all over China.
- The improper rapid development of shrimp culture, especially thousands of ponds being linked together in a region, has exceeded the environmental capacity, resulting in very serious consequences.
- There was a lack of necessary measures and technological capacity, including an aquatic animal health information system, and no prompt or effective measures were taken to meet the disaster.
- In the future, the government will be in a position to:
    - Enhance technical research and speed up extension of aquaculture disease prevention technology.
    - Develop a national contingency plan for aquatic animal disease outbreaks.
    - Establish a quarantine system to control aquatic animal movements within China.
    - Strengthen quarantine for the import and export of aquatic animals.

- Set up a regional disease information network and a timely disease reporting system.
- Distribute shrimp ponds to keep a stable environment and sustainable development.
- Strengthen co-operation among Asian countries on information exchange, policy and quarantine.

Sri Lanka

by
P.P.G.S.N. Siriwardena

In Sri Lanka, there was virtually no aquaculture until the beginning of 1980. The industry grew slowly at first, but expanded rapidly during the early part of this decade and presently covers an area of around 3940 ha. Of this total, ponds occupy 2760 ha, providing a water area of 2200 ha under culture. The estimated total number of shrimp culture establishments is 1344, with extents ranging from 0.5 to 200 ha. However, 641 (47.7%) of these establishments are unauthorized. They occupy 39.4% of the farm area, with 82% being less than 2 ha in extent.

Seventy shrimp hatcheries with a capacity of 750 million post-larvae (PL) per annum have been developed to supply the 500 million PL required. There are 12 processors involved in exporting to the main markets of Japan and the USA. Except for a few small-scale farms on the eastern coast, the entire shrimp-farming sector is concentrated in the northwestern and western coastal belts. An estimated 6000 ha has been identified in the north, east and south coasts as potential area for expansion.

History of Major Disease Outbreaks

Three major disease outbreaks have been recorded. The first, in 1988, was due to monodon baculovirus (MBV). The route of infection was thought to be via importation of PL from Thailand.

White spot disease (WSD) was first confirmed in mid 1996 after importation of PL in 1995 by shrimp farmers. Infections were first detected in the northwest, and the disease subsequently spread throughout shrimp farms on the west and northwestern coasts.

A third major disease outbreak, reported in August 1998, was due to a dual infection of yellowhead virus and white spot syndrome virus (WSSV). The moribund shrimp were first observed in the northwest, the disease subsequently spreading throughout the shrimp farms along both the northwestern and western coasts. In early 1999, the disease was reported from farms on the eastern coast, as shrimp farming there depends on PL supplied by hatcheries on the northwestern and west coasts. It is believed that brooders smuggled by hatchery operators from other countries in mid 1997 to early 1998 were the principle routes of introduction of YHV into Sri Lanka. The occurrence of YHV was high during the early phase of the epidemic, while the occurrence WSSV was high at the latter phase. This may be due to the rapid development of tolerance in pond-reared *P. monodon* to YHV. WSSV is now the most serious threat to the shrimp farming in Sri Lanka.

Densely arranged farms with high stocking densities, pH fluctuation in ponds more than one unit within a day and a drop in dissolved oxygen in ponds to 2 mg/L or below favor viral epizootics. WSSV infection in 1996 and the dual infection of WSSV and YHV in 1998 were first reported in areas with densely arranged farms. These infected farms employed stocking densities as high as 40 to 60 PL/m^2. The Dutch Canal, which is the main source of water for shrimp farms, has low carrying capacity for shrimp farming and deteriorated water quality. Increased sediment sulphides, nutrients and suspended solids were reported in the Dutch Canal and may have contributed to the recent disease outbreaks caused by WSSV, YHV and *Vibrio.* The rapid spread of these infections throughout shrimp farms on the west and northwest coasts was facilitated by their geographic situation and the main water sources. The main lagoons that act as water sources and as effluent receiving waters for the shrimp culture industry are interconnected by the Dutch Canal. This forms a network facilitating the easy spread of disease.

Luminescent vibriosis is the most serious disease affecting hatcheries, causing up to 100% mortality from zoea and mysis to PL stages. Luminescent *Vibrio* was implicated in outbreaks of hatchery diseases in the northwest. This disease, however, is seasonal and coincides with the months soon after the rainy season, when increased organic matter loading in the sea occurs.

Negative Economic and Social Impacts of Disease Outbreaks

A drop in production from 5.3 to 1.9 mt/ha causing a reduction of 64% in production and an estimated loss of Rs. 186.62 million in foreign income was observed due to MBV. The WSSV disease outbreak in 1996 caused a production loss valued at one billion Rs in foreign income, as 90% of the farming units were put out of production. The dual infection of WSSV and YHV which occurred in late 1998 and has continued to the present, caused a 68% and 70% drop in shrimp exports in terms of quantity and earned income, respectively, up to August 1999, as compared with those in 1998. As a result of this dual infection, the farming industry came to a stand still in early 1999. Of the estimated 2760 ha of pond area, the operational production area was reduced to 9.5% (264 ha) in mid 1999. Of this production area, 55.5% (146.5 ha) was affected by WSSV and/or YHV.

The total direct employment generated by shrimp culture is between 15,000 to 20,000 jobs. Additional indirect employment has been created in supporting industries, such as lime producers and outlets, fiberglass manufacturers, fed outlets, machinery supply and repair facilities, hardware stores etc., and part-time laborers in shrimp farms. The industry pays Rs 984 million annually as wages to direct employees, and the direct and indirect employment in shrimp culture industry represents 11% of the total employment in the fisheries sector.

The shrimp farming industry is a valuable foreign exchange earner. From 1992 to 1996, it generated Rs 7,447 million in foreign exchange. The industry earned Rs 6,002 million as foreign income from 1997 to 1998, indicating a recovery after the WSSV outbreak in 1996.

The investment of the shrimp farming industry is Rs 7,590 million based on the pond area and current rate of Rs 2.75 million/ha/crop, including working capital for the first crop. Prior to the WSSV outbreak, the industry was lucrative, with a domestic value-added return on domestic investment of 42%. After the 1998 dual infection, the capital balance outstanding of loans provided by the banks is Rs 1,135 million and the accumulated interest payment is Rs 300 million.

Interventions to Major Disease Outbreaks by Sector

State Sector Responses - Legislation and Policy Interventions

In an attempt to restructure the shrimp farming industry and achieve sustainable aquaculture, the national and local governments have implemented a number of policy and legislative initiatives. These include:

- The National Environmental Act, No.47 of 1980, Section 232 was amended by Act No. 56 of 1988 to issue environmental protection licenses to shrimp farming projects exceeding 4 ha.
- To control expansion of the industry, the National Environmental Regulations No. 1 of 1993 was published in gazette extra-ordinary No. 772/22 of 24 June 1993 under the National Environmental Act No. 47 of 1980 describing the procedure for approval of projects.
- To prevent haphazard expansion of farming, the Ministry of Fisheries and Aquatic Resource Development (MFARD) imposed a ban on granting approval for the establishment of new farms and hatcheries. However, these bans were lifted in February and May of 1995.
- The Fisheries and Aquatic Resources Act No. 2 of 1996 proscribes that no person shall engage in, or cause any person to engage in any fishery operation (including aquaculture) without a license issued by the Director of Fisheries and Aquatic Resources.

- The Scoping Committee of the Northwestern Province (NWP), which grants approval for shrimp farming projects, was formed under the Provincial Environmental Act of the Provincial Environmental Authority of NWP to control the expansion of the industry and to prevent impacts on the environment.
- To implement a comprehensive disease prevention and control program in aquaculture, the draft Aquaculture Management (Health) Regulations, 1999 has been prepared.

Short- and Long-term Interventions

In 1996, on the request of the Shrimp Farmers and Exporters Association, a multidisciplinary Task Force was appointed to control the WSSV epidemic. The Task Force took the following actions:

- Launched an immediate awareness program among the shrimp farmers on the disease and its preventive measures.
- Surveyed the farms to assess the extent of the epidemic.
- Held a seminar for the policy makers, extension officers and industry personnel with expert participation to make recommendations for implementation. Recommendations for short-term action included continuing awareness and extension programs, and requesting banks to reschedule loan repayments and forgive interest during a recovery period of eight months. Recommendations for long-term implementation included framing regulations to manage the industry under the Fisheries and Aquatic Resources Act; establishing a technical advisory service with appropriate laboratory facilities; training all small-scale farmers in culture methods; implementing a research program in regard to the industry, with a percentage of export earnings to be levied to fund this program; exploring possibilities of improving the tidal exchange rate in the Dutch Canal and implementing a coastal resources management program; and encouraging farmers to shift to semi-closed or closed systems.

Two studies were undertaken to formulate integrated resource management plans, one in the north-western coast where the shrimp farming industry is extensively developed, and the other in the southern coast where there is much public interest in both the development and prevention of shrimp farms. The National Aquatic Resources Agency (NARA) launched a multidisciplinary project in 1990 to investigate the current state of the resource base in the Puttalam and Mundal estuarine systems and associated coastal waters. This study included management options to mitigate environmental degradation and resource over-exploitation and to address legal and institutional issues.

The MFARD and NARA, in collaboration with the Federation of Prawn Farming and Exporting Industry, prepared a technical guide to prevent diseases. This guide includes maintenance of a reservoir, observation of a fallow period, use of low stocking densities, proper use of liming, discharging water from grow-outs in a disease situation, selection of PL for stocking, production of quality PL and crop rotation as immediate measures.

Economic and Financial Interventions

As per recommendations made by the Task Force, the banks offered the following concessions: deferred installments for up to 15 months, rescheduled loan repayments by a further five years at 8% interest, reduction of interest rates from the original 24% to 5%, and capitalization of accumulated interest. In addition, the government granted a duty tax and turnover tax waiver on feed imports. After the dual infection of WSSV and YHV, the government and the banks agreed to provide further assistance, including provisions for the settlement of interest arrears and future interest.

Additional financial assistance was given by the government and the banks in the form of soft loans and grants to mitigate or prevent negative impacts on the environment and to incorporate treatment systems into shrimp grow-out systems.

Research and Development Interventions

Under an FAO project, personnel have been trained in shrimp health management and PCR technology for detection of WSSV infection. An extension center was established in Chilaw to render advice to farmers, monitor water quality in hatcheries and grow-out, and to monitor the disease situation in the shrimp farming areas. A series of awareness programs on WSS and preventive measures were conducted for farmers. Moreover, a PCR laboratory was established at NARA to facilitate research on shrimp diseases and to monitor PL and shrimp in grow-out for WSSV. Research was carried out to establish the principle sources of disease affecting farmed shrimp production in Sri Lanka. Screening and monitoring of wild and hatchery-reared broodstock, hatchery larvae and shrimp in grow-out were conducted, and water management systems proposed to prevent WSSV infection were evaluated.

A Plan and Implementation Unit (PIU) was established in 1997 at NARA with GIS application facilities under another FAO-assisted project. This unit is preparing zonal plans for coastal aquaculture.

With assistance from SAARC, research on coastal resources and environmental management was initiated in the Northwestern Province. Included is research on ground water (assessment of resources, quality and the impacts of human activities), the bearing capacity of the main waters, development of permissible standards for aquaculture effluents, and development of treatment systems.

Farmer Responses

After the WSSV disease outbreak in 1996, the associations in the shrimp farming industry were brought under one umbrella, the Federation of Prawn Farming and Exporting Industry (FPFEI). The Federation is comprised of four individual associations, the Prawn Farmers and Exporters Association, the Small Business Prawn Farmers and Exporters Association, the Shrimp Breeders Association and the Seafood Exporters Association. The main functions of the federation are to bring shrimp farmers and exporters into one group in order to fulfill their industrial and social needs; to settle problems within the industry, ensuring disciplined growth and development; to obtain financial support to develop and transfer new technology; to look after the interests of the shrimp farmers in national policy and co-ordinate such matters with the relevant authorities; and to represent the industry in various national level committees.

The FPFEI has participated in organizing seminars and workshops in collaboration with the government agencies and foreign experts to disseminate knowledge among farmers on disease prevention and pond management. The large-scale farmers, who are technically competent, voluntarily rendered advice to the small-scale farmers by visiting their farms.

Farmers developed recirculating, closed and semi-closed pond management systems in order to reduce water exchange and dependence on inlet water.

In 1998, the hatchery operators established the Shrimp Breeders Association, with the objective of up-grading hatchery conditions and technology. The association launched a program to educate the hatchery operators on the importance of producing quality PL, quality assurance and up-grading hatchery technology by conducting regular meetings and publishing technical leaflets. At the demand of farmers, many hatchery operators perform PCR checks on their production.

As previously mentioned, farmer organizations canvassed for financial assistance and relief measures from the state to implement mitigatory and preventive measures.

Effectiveness of Interventions and Responses

This exemption of shrimp farming projects below 4 ha from the Environmental Regulations imposed in 1993 has led to over-crowding of small farms and self-pollution. Due to cumbersome procedures and costs involved in obtaining approval, shrimp farms larger than 4 ha have been established by several farmers working together, each applying for land of less than 4 ha. Thus the purpose of these environmental regulations has been lost. If all shrimp farms were required to obtain zonal clearance irrespective of their extent, expansion and over-crowding of farms could be avoided, proper siting ensured, and impacts on the environment reduced.

Only 205 of 1344 shrimp farms have obtained Aquaculture Management Licenses under Fisheries and Aquatic Resources Act No. 2 of 1996. This can mainly be attributed to lack of monitoring. The Fish Product (Export) Regulations are effective, as there is an individual unit assigned for monitoring. Similarly, a panel of inspectors is included under the Aquaculture Management (Health) Regulations, 1999 for monitoring and reporting.

Research carried out by NARA revealed instances of infected PL from the hatcheries, implicating a route of infection at the hatchery stage. Either samples screened by PCR do not adequately represent hatchery-bred populations of PL and/or the route of infection is at the pond-rearing stage. Although the semi-closed system provided better results than did the recirculating or closed systems, these systems can be effective if the culture cycle is restricted to around 90 d.

The present production pond area should be reduced by 30% upon completion of the restructuring of shrimp farms under the government assistance program. Incorporation of treatment systems will reduce dependence on water sources that have a reduced carrying capacity, and will improve the quality of both pond and discharge water. However, regular monitoring is essential to prevent farmers from using treatment ponds for production.

Relief measures given by the government and banks have helped farmers to continue operation. However, it is very unlikely that they provide relief measures to the shrimp farming industry in the event of a future disease crisis. Hence, now is the time for farmers to adopt and observe "best practices" and comply with the laws and regulations.

The Way Forward

Laws and regulations alone cannot prevent overcrowding of farms and improper management practices. The enforcement of regulations to control expansion, observe proper siting and prevent environmental impacts and self-pollution is difficult due to loopholes in the legal framework and lack of monitoring.

There is a need to critically examine the current approval process for farms below 4 ha. This process is too cumbersome and too loose with respect to the Aquaculture Management License, which is required by all sizes and types of aquaculture farms. The adequacy of the approval criteria needs to be examined to ensure that shrimp culture can proceed on a sustainable basis for all types of farms. One possible approach for encouraging small farmers to obtain Aquaculture Management Licenses is to create a single office under the National Aquaculture Development Authority (NAQDA), which will co-ordinate the entire approval process.

Development of "best practices" not only prevents over-crowding, improper siting and self-pollution, but also leads to proper hatchery operations and pond management. This is feasible through a self-management strategy to develop an industry code based on the FAO *Code of Conduct for Responsible Fisheries* (CCRF) and associated guidelines on aquaculture development, and integration of fisheries into coastal area management. The proposed code of practice for shrimp aquaculture that is being developed includes:

- Technical specifications for siting, design, construction and operation of hatcheries and farms.
- Standards for feed quality, chemicals and other additives, and the responsibilities of suppliers to provide truthful information to farmers.
- A commitment by farmers' associations and the industry federation to encourage implementation of the code of best practices and to facilitate monitoring of farming practices and adherence to the code by all farmers through the competent government authorities.
- Commitment by government to raise farmers' awareness about the code and to encourage and actively support its implementation.
- Commitment by government to ensure that farmers adhere to all laws and regulations.
- Commitment by NGOs to assist in the implementation of the code of best practices through awareness creation, education and training, and by monitoring its implementation.

Membership in the associations comprising the federation currently represents only 50% of the industry. The associations should take steps to increase their memberships, as the federation will play a key role in the implementation of the code. The federation plans to form a consortium with the following objectives:

- Assist and in the implementation of the code of best practices.
- Seek better enforcement of existing laws and regulations.
- Establish a self-insurance scheme.
- To erform information-sharing, extension, training and educational functions.
- Establish a self-assessment scheme based largely on the code of best practices.
- Obtain up-to-date information on unauthorized farms in order to determine if and how they can be legalized.
- Protect the restricted zones in shrimp farming areas without displacement of the occupants.
- Protect members from violators of existing regulations.
- Engage in research and development and to raise financial assistance.
- Establish and operate laboratory facilities.

Setting-up of a central databank on all shrimp farms based on a high resolution GIS system is needed for effective regulation, industry self-assessment, up-to-date monitoring and law enforcement.

In conclusion, the sustainability of the industry will largely depend on self-management strategies adopted by the farmers, hatchery operators, processors, feed manufacturers and suppliers.

Thailand

by
P. Chanratchakool, D.F. Fegan and M.J. Phillips

Thailand, the largest shrimp producer in the world since 1991, has faced problems. Disease is the most serious problem, causing losses from low (chronic) levels to acute, almost complete crop loss. Production of shrimp in Thailand reached a peak of 250,000 mt in 1994. Due to a combination of disease and management-related problems, production started to decline, to 220,000 mt in 1995, 205,000 mt in 1996 and another 30% decline to 150,000 mt in 1997. The major viral pathogens causing this dramatic decline were white spot syndrome virus (WSSV) and yellowhead virus (YHV).

WSSV has proved to be the major cause of mortality in Thai shrimp farming. Many attempts have been made to understand this problem and many recommendations made in order to prevent the disease outbreak. This concerted effort by farmers and supporting institutions has resulted in an increase in production to 210,000 mt in 1998. Improved farm management strategies as well as better government policy related to shrimp farming have been partly responsible for this improvement. An important factor in their success has been a good level of co-operation between the private sector and government institutions to develop appropriate techniques and strategies for sustainable shrimp farming.

History of Major Disease Outbreaks

Yellowhead was the first viral disease to cause catastrophic and rapid losses in commercial farms in Asia. The disease was first observed in Thailand in 1990. The causative agent was unknown until 1993 when Thai workers isolated viral particles from infected shrimp and experimental infections were conducted to demonstrate their involvement.

Shrimp infected with YHV abruptly stop feeding and gather at the surface and edges of the pond. Within a day, large numbers of dying shrimp are observed at the pond edge, and mortality is almost complete by the 3rd to 5th day. Affected shrimp usually have a light yellow head, and the hepatopancreas has a distinct pale yellow appearance.

White spot syndrome virus (WSSV) was first reported in Asia in 1992 and 1993 following outbreaks in China and Japan. Some confusion has resulted with the name of the virus, since it was reported in Asia from late 1994 through 1995 under several different names including hypodermal and haematopoietic necrosis baculovirus, rod-shaped nuclear virus, systemic ectodermal and mesodermal baculovirus (SEMBV), and white spot baculovirus. It is now known that it is not a baculovirus and may, in fact, represent an entirely new group of viruses.

Although the virus was present in Thailand in laboratory-reared *Penaeus monodon* in late 1993, it was not found in farmed shrimp until late 1994, when mass mortalities began to be reported. Infected shrimp usually show distinct white spots on the shell, which may be loose. In many cases, they have a reddish coloration. The white spots are the result of abnormal calcium deposition in the shell. Mortalities are usually high, and cumulative mortality can reach 100% in 3-10 days from the onset of clinical signs. Recently, however, there have been increasing reports of populations of shrimp showing good survival despite being infected by the virus. This has led to considerable speculation on the mechanisms of expression of disease in the shrimp. Thai scientists have proposed that shrimp may be able to "tolerate" viruses if they are exposed to them at a sufficiently early age, and the role of the environment in the development of clinical disease has come increasingly to the fore.

WSSV infects a wide variety of penaeids as well as many other crustaceans. In recent years, more information has been obtained on its epidemiology. The disease shows a strong seasonality in both prevalence in wild stocks and in the severity of outbreaks. It has also proved to be closely associated with the source and disease status of the post-larvae (PL), with recent studies demonstrating the benefits of screening of PL for the presence of the virus by PCR.

Negative Economic and Social Impacts of Disease Outbreaks

Direct losses due to YHV in Thailand were estimated at between US$ 30 and 40 million in 1992 and 1993, respectively. Other figures on economic losses include an estimate of US$ 30.6 million from YHV in 1992, and US$ 650 million from all shrimp disease outbreaks in 1994.

Yellowhead was followed by outbreaks of white-spot disease (WSD). Of the two, WSD has proven to be by far the most serious, being estimated to have caused the loss of 70,000 mt of shrimp (around 40% of total production) in 1996. At a rough estimate of $3-5 per kg profit, this represents between US$ 210 and 350 million in lost revenues for Thailand alone.

YHV and WSSV are currently the most serious pathogens threatening the shrimp farming industry in Thailand. Together, these two agents may be responsible for the drop in shrimp production from 250,000 mt in 1994 to 220,000 mt in 1995. At $8 per kg, this represented a shortfall of $240 million. However, this small difference in production is not a true reflection of the full impact of these diseases. At that time, Thai production was rising at 20,000 to 30,000 mt/year, and production for 1996 had been expected to rise. Shrimp disease losses for 1997 reached nearly 50% of total farm output value. Also, these figures do not include losses in related businesses such as in feed production, processing and exporting, feed production, ancillary services (repair shops, farm suppliers etc.) and lost income for laborers.

Socioeconomics and Impacts on Small-scale Farmers

The reduction by 30% of total production in 1997 was estimated to be equivalent to US$ 600 million in total, a figure which excludes losses in related businesses such as feed production, processing plants, feed raw material producers and labor. When the same losses are applied to the smallest farms, 30% production loss is equivalent to around US$ 1,000 per pond per crop. As 65% of farmers were reliant on shrimp as the main source of income, it is not surprising to find that disease was reported to have serious impacts on households involved in shrimp aquaculture.

Interventions to Disease Outbreaks by Sector

State Sector Interventions

Immediate Policy Decisions on Movement of PL and Broodstock
Since 1993, the Department of Fisheries (DOF) has banned the export of live black tiger shrimp regardless of their size. Although this ban was mainly intended to prevent the export of broodstock, it also caused problems for companies exporting live shrimp for consumption. Therefore, the regulation was amended in 1995 to allow the export of juvenile shrimp bigger than 19 gm, excepting broodstock.

To import shrimp into Thailand, there was no quarantine requirement other than the importer requiring permission from the government. However, in April 1999, the DOF banned the importation of live marine shrimp larvae due to the risk of disease transmission.

Introduction of New Rules, Regulations and Legislation
The development of practical health management strategies is a multi-disciplinary activity that requires a high degree of co-operation between farmers and the relevant authorities. The DOF together with the Thai Marine Shrimp Farmers Association, the Thai Frozen Foods Association, the Thai Food Processors

Association and the Aquaculture Business Club have signed an agreement for a "Code of Conduct" to govern the operation of the industry. The Code of Conduct is a set of principles and processes that provides a framework to meet the industry's goal for environmental, social and economic responsibility. The foundation of the Code is the following Mission Statement: *"The marine shrimp farming industry in Thailand is committed to producing high quality, hygienic products in a sustainable manner that provides for environmental, social, and economic benefits to present and future generations."*

Policy Statements have been formulated that outline actions that the industry will undertake to meet its commitments set forth in the Mission Statement. These cover a broad range of topics, including: environmental protection, public consultation, regulatory compliance, location, quality and safety, continual improvement, efficiency, research and development, social responsibility, monitoring and auditing, education and training, and international trade. The Code commits the signatories to specific actions, including the development of a series of Operating Guidelines and Procedures Manuals. These actions will aid the industry in carrying out its operations in a manner consistent with the intent of the Code of Conduct. The objective of the Operating Guidelines and Procedures Manuals is to establish a consistent approach to industry operations through establishment of Good Management Practices (GMP's). It is anticipated that implementation of these GMP's will enable the industry to operate in a sustainable manner.

Master Plan for Improving the Farming Environment

The DOF has provided infrastructure improvements for farming development since 1991. Seawater irrigation systems in over-crowded farming areas have been constructed to provide good water, as well as to reduce impacts on the local environment. One site in eastern and two sites in southern Thailand are currently in operation. In the year 2000, two more sites are planned. Another 48 sites, covering a total production area of 9,150 ha, have been identified and are planned for completion by 2010.

Technical Assistance to Farmers

In 1992, the government, through the National Science and Technology Development Agency (NSTDA) established a National Yellow-Head Task Force whose main objectives were to identify the causes and management recommendations in order to reduce losses and to identify priority areas for research. The task force consisted of representatives from all stakeholders in the shrimp industry. The task force led to the formation of a Shrimp Biotechnology Programme within the National Center for Genetic Engineering and Biotechnology (BIOTEC), to respond to all shrimp-related issues. Many research projects have been conducted with financial and technical support from the division.

Also under the leadership of the NSTDA, a government-industry consortium called the Shrimp Culture Research and Development Company Limited (SCRD) was established in 1996. Its mission is to co-ordinate and support research and development projects that are applicable to both the immediate and long-term needs of the shrimp culture industry. The first priorities are the domestication of shrimp (selective breeding and genetic improvement), shrimp health management, and the development of better and environmentally friendly food management systems. One of the consortium members has successfully domesticated stocks of *P. monodon* and is currently producing an F3 generation of specific pathogen-free (SPF) shrimp screened to exclude major viral pathogens. The company also intends to promote human resource development and technology transfer through training, seminars and workshops, and to develop a shrimp culture research database.

Technical Services

With government support, a mobile service unit was set up in 1993 to provide technical assistance directly to farmers on their own farms. Free services including water quality analysis, disease diagnosis and management recommendations are provided. Mobile unit services are now available in 21 provinces, covering all shrimp culture areas. Over 15,000 samples per year have been tested. In addition, private companies also provide similar services from local laboratories around the country, including PCR analyses.

Twelve DOF laboratories cover the main farming areas to provide PCR analysis for WSSV, and more than 1,000 samples/month are being analyzed by these laboratories. This type of service is also provided by some academic institutions.

Establishment of the Marine Shrimp Research and Development Institute (MSRDI)
The MSRDI was established in 1997 by the DOF to maintain Thailand's position as the world's largest producer. This agency was made responsible for various academic aspects, especially research and development for shrimp culture and technology transfer to the farmers. The MSRDI is comprised of two research centers, the Marine Shrimp Research and Development Center (MSRDC) of the Andaman Sea at Phuket Province and the MSRDC of the Gulf of Thailand at Songkhla Province. The Andaman Centre is responsible mainly for development of aquaculture technology, including disease management and environmental protection, whereas the Gulf of Thailand centre is responsible for genetic improvement, hatchery technology and feed. Both centers are also responsible for technology transfer and training.

Farmer and Private Sector Interventions

Due to the predominance of small-scale farms in Thailand and the rate of development of intensive aquaculture, feed companies and other suppliers have provided a significant source of information to farmers. Shrimp feed companies and other suppliers frequently provide information and technical support as part of their service to customers. As this information is often aimed at increasing sales, this can lead to the widespread recommendation of inappropriate practices, such as overstocking. At the same time, seminars with invited independent experts have been conducted to pass on new information to farmers so that, on balance, the impact of this information transfer has been positive. Most feed companies also provide technical support, including checks on water quality and shrimp health and advice at the farm. A few also offer testing services for shrimp viruses.

Thai farmers have proven to be quite innovative in their approaches to dealing with disease problems. The risks associated with water exchange, which was often reported to result in losses due to WSSV, led to a more widespread adoption of lower water exchange systems, including the use of reservoirs and "closed/recycle" type systems designed to reduce exposure to water-borne viruses and carriers. Water treatment strategies also became more widespread during the yellowhead epidemic, with the use of chlorine both to treat infected ponds to prevent spread of infection and as a means of '"disinfecting" the pond to remove carriers prior to bloom development and stocking of PL. The high cost of chlorine led to a search for cheaper alternatives, and several companies acquired the rights for the sale of trichlorfon, an organophosphate insecticide used in Europe to treat sea lice in salmon, for aquaculture purposes in Asia. This was effectively marketed as a safer, more convenient treatment for elimination of crustacean carriers in ponds prior to stocking.

The use of reservoirs and treatment ponds has resulted in an overall reduction in the production levels of farms using this strategy. Although per pond production has been maintained, the reduction in production area on the farm has reduced the yield per ha total farm area. At the same time, many farmers have reduced stocking densities and levels of intensification in order to reduce their financial exposure. Although this has, in many cases, increased the net profit per unit area, the total income has been reduced.

The discovery that crabs could act as reservoir hosts led to measures designed to eliminate crabs and/or prevent their movement between ponds. Farmers used small fences of cheap netting around the ponds to prevent movement, although this practice has largely ceased as the incidence of WSD has decreased. The use of trichlorfon to control crustaceans around farms has also continued.

Undoubtedly, a large amount of money has been spent by farmers on all manner of potential cures and treatments for disease, most of which have not been productive. A survey of one group of farmers in southern Thailand revealed that the average amount of money that an individual farmer would spend on potential pond treatments as a trial was 15,000 Baht per crop. For the 1,000 ponds in the survey alone, that represents a total market of 30 million Baht annually. As this survey was undertaken before the onset of major disease losses, the amount farmers would be willing to spend to find a potential solution for disease problems is probably much greater.

Hatchery Interventions

For *P. monodon* culture in Asia, it is currently believed that the broodstock and PL used for stocking are a major source of viral infection leading to WSD outbreaks. In Thailand, WSSV is found in captured brooders at very low to up to 100% prevalence, depending upon the location or season of capture. The nature of the viral transfer from brooder to larvae and PL is still under investigation. However, it is likely that most vertical transmission occurs after spawning via egg or larval contact with external viral material in spawning fluids. Since the egg and naupliar membranes are relatively impermeable even to large molecules, they should also be impermeable to viral particles, although this has not yet been proven. By this reasoning, most viral transmission to larvae should occur from the final naupliar stage onwards, after the larvae have a mouth opening. Thus, WSSV prevention strategies are currently based on washing eggs and/or early nauplii stages.

Given the probability of vertical transmission of WSSV, a major focus should be on the development of domesticated broodstock that can be certified as free of WSSV. Such stocks are now commercially available for *Litopenaeus vannamei* and, on a more limited basis, for *P. monodon.* However most of the industry in Asia still depends on PL derived from wild broodstock. This is due to a lack of acceptance by commercial hatcheries, which still prefer to use wild stocks, partly due to their higher fecundity. In this case, preventive measures against WSSV would best begin with a preliminary screening of brooders to exclude infected individuals from the hatchery. Since brooder infections tend to be very light and since assays must be non-destructive, screening is currently done by molecular genetic techniques including DNA dot-blot and PCR assays performed on extracts of haemolymph or clipped appendages.

A recent study in Thailand has shown that thorough washing of eggs from WSSV-PCR positive brooders greatly reduces the probability of viral transfer. It is now recommended that eggs and/or nauplii completely enveloped by the nauplii membrane be thoroughly washed with clean seawater containing disinfectant (concentration adjusted to suit species and life stage) before transfer to larval rearing tanks. If combined with broodstock screening by PCR, discard of positive brooders and subsequent periodic PCR checks of larvae, the probability of WSSV occurrence in hatchery-produced PL can be made extremely low. Unfortunately, since the demand-supply situation for PL in Thailand depends largely on the season and, as most of the operators are small scale, implementation of such a recommendation is, in many cases, impossible.

Many hatcheries have not adopted these practices. The majority of hatcheries are small-scale, relatively unsophisticated and operated on a seasonal basis. When there are major problems, these hatcheries will close down until more favorable conditions prevail. There has been some difficulty in persuading hatcheries to adopt practices designed, in the end, to protect the interests of the farmer rather than that of the hatchery owner. Farmers have increasingly demanded higher standards of PL production, whether it is overall PL quality or the use of PCR screening techniques to eliminate infected batches. However, at the same time they have been highly resistant to price increases, thereby reducing the incentive to hatcheries to produce higher quality PL. In fact, a widespread practice of demanding guarantees from hatcheries in terms of survival developed which placed a greater burden of credit and risk on the hatchery sector. This has tended to drive hatcheries out of the business due to increased risk and diminishing returns. The ability to extract such concessions from hatchery producers depends, to a large extent, on the demand/supply situation for PL. In recent years, as a result of lower production of PL, demand has sometimes exceeded supply, so that hatcheries have been less willing to make such concessions. In addition, a dual market for PL has developed, with some farmers insisting on PL, which have been screened for WSSV and others willing to take unscreened PL despite the risks.

The Way Forward

Training and Education

Training and education of farmers has played a major role in coping with the impacts of disease. Farmers' associations are effective in disseminating information widely, as they provide a forum to reach a large number of farmers with a minimal effort. Government extension services are regarded as useful by most farmers, but budgetary constraints often mean that their coverage and frequency of visits is much lower than the similar extension services provided by suppliers. As a result, the government services are frequently viewed as unbiased but slow and not so advanced as the services provided by private-sector technical support. Transferring information through private-sector sales persons, as well as through government extension officers, is an ideal route. The information provided to these salespeople should be derived from the results of research or activities designed to meet the needs of the industry. With this approach, Thailand has successfully integrated private companies with research institutes to conduct joint research.

Further Development of Rapid, Sensitive Diagnostic Methods

The arsenal of rapid diagnostic methods available to the farmer and to the small laboratory is currently rather small, although progressing rapidly. This progress needs to continue, since rapid and accurate disease diagnosis is fundamental to appropriate response. They are also the key to preventing viral diseases by allowing the early detection and eradication of infected stocks. For example, current methods of testing for WSSV in PL rely on PCR, which can only be carried out in specialized laboratories. However, the development of a fast, simple, cheap and easy to use diagnostic test would increase the likelihood and willingness of hatcheries and farmers to undertake routine testing as a preventative measure.

Increased Application and Dissemination of Research Results

The key to the application of disease research rests with the dissemination of research findings to the farmers who will apply it. Bridging the gap between scientists and farmers is a specialized activity requiring people with a real understanding of the practicalities of farming and a sufficiently good grasp of the scientific benefits of research to be able to effectively develop application of the research findings. This requires not only a good grasp of science and farming, but also a clear knowledge of marketing and training techniques to effectively transfer technology.

Vietnam

by
Le Van Khoa, Nguyen Van Hao and Le Thi Lan Huong

Shrimp culture has been played an important economic role for around two decades of renovation in Vietnam, including significant contributions to poverty alleviation, employment and foreign currency earning. Traditional shrimp farming has rapidly expanded into semi-intensive and intensive farming systems in order to achieve higher production. Increased stocking density (from 100,000 to 450,000 individuals/ha), improved feed quality and quantity, and the application of modern culture techniques including the use antibiotics have also been introduced.

Disease outbreaks have inevitably occurred. In Vietnam, a serious outbreak of viral disease occurred in late 1993. By September 1994, 85,000 out of a total of about 250,000 ha of shrimp farming area were seriously affected, resulting an estimated loss of 5,219 mt of shrimp. Moreover, unplanned development, including development of extensive shrimp farming, has had a serious impact on coastal environments and bio-diversity.

History of Major Disease Outbreaks

Around 1990, shrimp farming bloomed in almost all of the southern provinces of Vietnam. The main cultured species were *Penaeus monodon, P. chinensis, Litopenaeus vannamei and P. merguinensis.* Of these, *P monodon* was most interesting because of its easy growth and attractive price. In 1990, monodon baculovirus (MBV) caused mass mortalities in central hatcheries and during grow-out. However, the most serious viral disease outbreak was first seen in 1993 in shrimp farms of the southern provinces. Studies found that MBV, white spot syndrome virus (WSSV), yellowhead virus (YHV) and vibriosis were important pathogens. Furthermore, luminescent disease, red body disease, appendage agglutination disease, swollen tail disease, and protozoan diseases were also reported. Low seed quality, lower antibodies during grow-out, and low water quality in ponds were reported as non-infectious factors.

In the north, small-scale aquaculture plays an important role in providing livelihoods in rural areas. Freshwater aquaculture has been developed for years, while shrimp farming is quite young. Small-scale shrimp farming is a major aquaculture activity in the coastal provinces and contributes greatly to livelihoods and employment. Diseases are one of the important constraints that reduce shrimp farm productivity. Researchers found that MBV, *Vibrio* spp., *Zoothamnium* and *Epistylis* were infectious pathogens. Other related factors such as low water quality, poor pond management, and long-distance transportation of larvae were also reported.

Since the doi moi renovation in 1980, the government has converted over 500,000 ha of mangrove forest into shrimp aquaculture. In Minh Hai Province, more than 70% of the mangroves have been destroyed for shrimp farming. As the shrimp industry was highly profitable, the farming area was expanded, systems were intensified, and heavy drug use occurred in order achieve high productivity. This led to a subsequent plummet in production and disease outbreaks due to environmental pollution, proliferation of antibiotic-resistant bacteria, etc.

Recent studies in the southern coastal provinces have shown that MBV and vibriosis are frequent pathogens. However, WSSV is the most serious pathogen, causing mass mortalities in affected farms. WSSV occurs year round, especially in June and July. Yellowhead disease (YHD) and a disease of unconfirmed aetiology in hatcheries in the central area are also major constraints. Likewise, WSSV was also found in the northern province of Nghe An last August after 80 days of culture. MBV and vibriosis also occurred with high frequency, particularly during the last month of culture. Although northern shrimp farms are mostly extensive and/or improved extensive types with low investment in both pond practices and management, disease is still one of the major causes of reduced farm production.

Negative Economic and Social Impacts of Disease Outbreaks

Disease outbreaks have caused a great loss to state returns, serious viral diseases accounting for some $100 million in 1993. By early 1994, the disease outbreak in central hatcheries and southern shrimp farms had caused massive damage to householder incomes and the shrimp enterprise economy, accounting for economic losses of 70-80%. Furthermore, disease outbreaks also directly and indirectly damaged society, especially by affecting employment and farmer's interest in shrimp culture. Shrimp culture has contributed greatly to poverty alleviation in the coastal communes, as well as increasing employment and economic inputs. However, disease prevention and treatment methods have not been effective, and therefore, farmers have not been interested to invest in this sector.

Interventions to Disease Outbreak By Sector

Government Interventions

Immediate Responses

Early harvesting was recommended to infected farms as the most immediate response. Restrictions were placed on the outbreak areas to minimize pathogen transmission. The government required that the concerned institutions and local quarantine offices investigate the situation and, if possible, find appropriate solutions. Moreover, health certification and quarantine of broodstock and larvae to be moved were required.

Local extension workers are responsible for most farm activities, including farm practices and management. Local shrimp farms are visited regularly by district and provincial officers. Therefore, in case of a disease outbreak, advice will be given in order to solve farm problems. However, due to a lack of personnel and diagnostic facilities, the availability of this indispensable service is limited.

Short-term Measures

Short-term interventions have been made by both farmers and the government. Actions, for the most part aimed at alleviating the impact of disease, were applied at both the local and state levels. Provision of technical assistance to farmers through short-term training courses and extension material is one of the most important activities of the government. Training farmers and building the capacity of farmers, hatchery owners and government personnel have also been widely tried. In addition, improvement of farm management practices, formation of societies for collective action and the introduction of new species have been recommended.

Long-term Measures

This task is closely related to the development of sustainable aquaculture, in general, and of shrimp farming, in particular. Proper pond design and good management have been recommended for improving yields. Moreover, legislation and policy on the movement of seed have been developed to reduce the transmission of important pathogens. However, seed quality is still considered as one of the most important factors in sustaining farm productivity. Low seed quality is reported to cause unhealthy shrimp during grow-out, particularly in northern shrimp farms where seed is being transported over long distances.

The government has provided technical, environmental, social and economic interventions through farm surveys for the long-term development of shrimp farming. Difficulties to be overcome include a lack of qualified personnel and adequate diagnostic facilities and an absence of effective policy.

Farmer Responses

Responses by farmers in order to find short-term and long-term interventions include early harvesting, treatments, requests for assistance from government, change of farm management practices, collective actions, and introduction of new species and modified culture techniques, including low stocking density and heavy use of antibiotics. Shrimp ponds are carefully reclaimed after harvesting. Closed water supply has been adopted in some farms, and water has been purged by using chlorine, malachite green, potassium permanganate, etc. In some cases, diagnostic facilities were equipped, and some farmers bought pH and salinity meters for monitoring water quality. However, some farms closed due to inefficient financing.

Farmer interventions were quite different between the south and the north. Most of the above mentioned activities occurred in the southern shrimp farms and central hatcheries. In the north, no effort was made when farms were affected.

Hatchery Owner Interventions

Hatchery owners faced a difficult situation because disease outbreaks may cause indebtedness. When serious disease outbreaks occurred, prevention was immediately and strictly applied. This included sanitizing tanks after each breeding, selecting healthy broodstock, and sanitizing parent shrimp and hatchery instruments. Furthermore, some equipment for measuring water quality and disease diagnostic facilities was acquired. Improving water quality has been become important; other techniques have also been gradually improved, for instance, water supplies and feeding tools were sanitized, stocking densities were decreased, and antibiotics were heavily used.

Research and Co-operative Interventions

A number of research activities have been conducted in order to overcome disease outbreaks and to improve shrimp farming returns. Some farms in southern provinces such as Tra Vinh, Ninh Thuan, and Khanh Hoa, have experimented with intensive, semi-intensive and "clearance" shrimp farm trials. In addition, responsible institutions and others with related expertise have co-operated in the effort to find solutions. These have contributed significant ideas, particularly by providing farm models.

Legislation and Policy Interventions

According to Decree 28 TCN Established 24/6/97, live aquatic animal transfer must be accompanied by a health certificate issued by the Department of Fisheries Resources and Environmental Conservation. Importers and exporters not complying with this requirement are fined.

A policy on re-forestation of mangroves in the Mekong Delta has been implemented to promote sustainable shrimp farming. Maintaining appropriate mangrove cover near shrimp ponds has been given attention while shrimp culture is still extensive in the southern provinces. In northern coastal areas, strict regulation of seed trading is applied.

Some revised policies on financial loans have also been circulated in an effort to help farmers overcome disease outbreaks and natural disasters. However, given the large region to be covered, funding has been limited. In some cases, funds have been provided, but no assessment on the success or failure of farm trials has been reported.

Economic, Financial, Social and Livelihood Interventions

The government has tried to provide some financial support to farmers through grants and loans when serious disease outbreaks occurred. However, this is mostly provided through organizing courses on shrimp disease, farm management and by communication programs. In addition, linkages between state organs are not close and therefore, procedures for loans are very complicated.

Shrimp farming in Vietnam is dominated by small-scale systems. It not only earns valuable foreign exchange but also generates jobs and assists in poverty alleviation. Unfortunately, social and livelihood interventions have not been widely implemented. This can be explained by the fact that as the shrimp farming industry was an unplanned development, social impacts were not clearly assessed; also there has been a lack of financial support and trained personnel for this activity.

Effectiveness of Interventions

Recently, legislation on the movement of live aquatic animals has been established so that disease outbreaks and transmission have been rapidly reduced. The government has also been addressing the need to reduce disease impacts, with enormous support from state institutions and international organizations. Some specific research programs have also had high value, in particular, in finding methods for preventing serious disease outbreaks and for managing culture conditions.

Formerly, the effectiveness of government interventions was not evaluated in terms of both economic and social interactions. Lack of funding and qualified personnel was the most important factor. Hence, specific studies on the social and economic consequences of serious disease outbreaks have not been conducted. Moreover, an effective disease surveillance system has not been established.

The Way Forward

Shrimp farming is faced with many difficulties due to disease outbreaks and environmental pollution. Therefore, a case study on shrimp farming in Vietnam should be conducted to analyze serious disease outbreaks and their socioeconomic and environmental impacts. The study should also include the northern provinces, as small-scale shrimp farming plays an important role in poverty alleviation and employment generation in this area, while southern areas should be planned for sustainable and extensive farming systems in order to generate high foreign exchange. Governmental actions that should be undertaken include improving diagnostic facilities, establishing a disease surveillance system, training local extension officers in shrimp health management, strict enforcement of legislation on the movement of live aquatic animals, and developing a clear policy to deal with future disease outbreaks. Also, a national plan for sustainable shrimp aquaculture and coastal environments should be developed.

SUMMARY OF THE WORKING GROUP DISCUSSIONS

The Workshop consisted of 4 working group's disscuing relevant issues on management strategies on major diseases in shrimp aquaculture. This section provides summaries of the working group discussions.

Working Group 1 – National and Regional Policies, Legislation, and Regulatory Frameworks

Members: J. Humphrey (Chair), R. Arthur (Rapporteur), V. Venkatesan, R. Morales, Jiang Yulin, C. Mau, D. Bartley and J. Wigglesworth

The widespread occurrence of disease over the past years in Asia and Latin America is indicative that disease control and preventive measures have been inadequate. Likewise, within the Latin Region disease protection initiatives have not worked.

This Working Group Report is based on the premise that policies and legislation should facilitate trade, support industry and protect livelihoods while minimizing the risk of pathogen transfer. It is recognized that industry has, in many cases, been developed, promoted and supported by government based on unrestricted imports, and that there could be adverse impacts rising from sudden restrictions or bans on movements of live aquatic animals, including negative effects on industry or increased smuggling.

Table 1 provides the responses to certain questions discussed (on the basis of the TOR of the country reviews) by region.

Table 1: Retrospective Responses (G = Government, I = Industry).

Immediate/Short-term Responses	**Effectiveness (0 – not tried, 1 – not effective, 5 most effective)**		
	Latin America	**Cen. America**	**Asia**
Formation of task force/specialist committees to identify disease and recommend actions (G/I)	3	1	2
Banning of imports of PL and broodstock (G)	3	1	2
Extension – Meetings/symposia to advise on disease and control measures (G/I)	1	1	1
Management strategies (G/I)-harvest, crop holidays, crop rotation	1	2	4
Importation of resistant strains (incl. SPF/SPR)	3	3	0
Importation of new species for aquaculture	0	0	1
Screening of PL for virus	2	3	2
Medium to Long-term Responses	**Effectiveness (1 – not effective, 5 - most effective)**		
	Latin America	**Cen. America**	**Asia**
Diagnostic capabilities (PCR etc.) (G/I) -establishment -veracity -application	 3 1 3	 2 1 3	 3 2 3
Developing/strengthening monitoring and surveillance capabilities	2	2	2
Change of farm management practices (construction design, etc.)	2	4	3
National plans for restructuring and remediation -local or restricted plans	 3	 2	 ?
Codes of Practice (industry, government, regional, international)	?	?	?
National legislation -establishment -effectiveness	 3 2	 3 1	 4 1

The following are the major considerations that Working Group 1 identified as appropriate and timely:

Regional Considerations and Requirements

The following are considered important points related to regional issues and requirements:

Legislation and Legal issues

- Legislation should be complementary and harmonized where possible.
- Legislation does not necessarily have to be identical.
- Country legislation should, where feasible, require use of local broodstock.
- Country legislation should require testing of imported broodstock.
- Legislation should recognize the continuum that exists from codes and "soft laws" through to national legislation and international agreements and (WTO) "hard laws."
- There is an onus for liability to be identified; the responsibility for introduction of prohibited species or illegal movements that may be considered a form of pollution (biological pollution) must be determined.
- There is a need for penalties for breaches of legislation and quarantine.
- Penalties should exist for illegal activities, such as smuggling.

Regional Quarantine, Control Plans, Diagnostic Procedures and Guidelines

- Plans for the control of important diseases on a regional basis need to be developed among regional countries.
- A comprehensive disease database is needed for decision-making purposes.
- Codes of practice requiring acquisition of broodstock from low prevalence or disease-free regions or zones are needed.
- Higher levels of quarantine stringency are needed when pathogen-free zones or regions are involved.
- Consistency of policies and legislation for other aquatic animals and aquatic animal diseases is required.
- Illegal movements and smuggling of live animals to avoid costs and quarantine inspection are considered common practices in the Asian Region. Regional intervention to minimize this activity is thus required, as the illegal movement of live shrimp poses a major disease threat, with "spillover" of infected imported stock into natural waters.
- Accreditation of laboratories and participation in quality assurance programs are necessary to achieve uniform testing capabilities and standards.

Inter-Regional Collaboration

- Collaboration between the Latin American and Asian regions should be a priority.

Industry Organizations

- An organizational structure for dealing with national organizations representing aquaculture groups or bodies is needed.
- Industry groups are necessary to act as informed conduits to government and FAO.
- Industry-appointed groups have a major role to play in building industry/producer confidence.
- Industry-appointed groups can serve as a line to academics and research organizations.

Networking

- Opportunities and requirements for national, regional and interregional collaboration and networking need to be identified and defined.

- A framework for networking in relation to disease notification and outbreaks of new diseases should be developed.

Disease Monitoring and Surveillance

- Identification of disease-free regions or zones is necessary.
- Identification of regions or zones of low disease prevalence is required for acquisition of broodstock.
- The origin of important pathogens should be determined.
- Wild populations should be monitored.

Regional Research and Development

- Methods for the detection of the carrier state are needed.
- Methods for the detection of specific pathogens and the identification of specific pathogen-free stocks should be developed.

Role of Non-governmental Agencies

The roles and inputs from NGOs need to be recognized and identified in regions and countries.

Other Considerations

Governments in the region may have other major economic and social considerations which over-ride disease control and quarantine issues (e.g., poverty, civil war, etc.).

Conclusions and Recommendations

In preparing these recommendations for control and prevention of aquatic animal disease, the Working Group recognizes that concerned parties have the obligation to conserve the environment, promote industry, support social equity, and protect aquatic biodiversity. Furthermore, it must be recognized that new conditions will arise (new diseases, new farming areas/species/systems) and that policies and mechanisms to implement them must be flexible enough to deal with the new conditions and general uncertainty.

A. Comprehensive Review of Country Reports

Conclusion
A large body of data and information relating to legislation, national and regional policies and regulatory frameworks for disease control was presented.

Recommendations
A comprehensive review of the data should be undertaken to provide a more in-depth evaluation of country documents to support development and implementation of policies, legislation and regulatory frameworks at the up-coming regional meeting in Mexico.

B. Available Legislation Preceding Disease Incursion

Conclusion
Legislation for the effective control, quarantine, containment or eradication of disease was not present in all countries prior to outbreaks of disease.

Recommendations

- Legislation and policies should be compatible and harmonized between countries and regions and consistent with regional guidelines and international conventions.
- Information on legislation needs to be disseminated to promote awareness among stakeholders.
- Legislation should protect the environment, support industry and promote social equity by preventing the introduction and spread of disease.
- Frameworks for the safe introduction of new species should be developed and adopted.
- The issue of liabilities and penalties should be examined.
- Stakeholder consultation is an essential component in the development of national legislation for quarantine and certification and should be encouraged.

C. Industry Liaison and Producer Organizations

Recommendations

- Government infrastructure and industry liaison should be available as required to manage, share experience, develop policy, promote awareness and identify expertise in relation to control, prevention and eradication of diseases. This may necessitate support for specialist committees, and extension activities.
- Support for effective quarantine service should be provided.
- Support for laboratory capabilities, disease diagnosis and health certification should be provided. These activities should be consistent with regional quality control guidelines, i.e., standardization, nomenclature, technology transfer and monitoring/surveillance programs.

D. Infrastructure and Support

Recommendations

- Support for effective quarantine services is necessary.
- Mechanisms for R&D support, which will include partnerships between government and industry, must be developed.
- Increased capacity must be developed by providing support for training, technology transfer and support, and the institutions that offer them. This may include support from industry and other donors, such as international organizations.

E. Policy Development and Implementation

Recommendations

- National strategies (master plans) for aquatic animal health should be developed in harmony with regional guidelines and policies. Government, industry and other stakeholders should be linked. Where regional guidelines do not exist, they should be developed using appropriate existing guidelines, which may need to be adapted to local/national situations, as models.
- Codes of practice/conduct should be developed and promoted, as appropriate.

F. Inter-regional Collaboration and Co-operation

Recommendations

- The continued development of the AAPQIS-Asia and the initial development of a similar information system, AAPQIS-Latina (Mexico, Central and South America) should be supported.
- It should be recognized that some codes of practice and similar initiatives are mechanisms for interregional collaboration and development.
- Given that some codes (e.g., the ICES/EIFAC code) call for the establishment of advisory bodies, the Mexico consultation may wish to examine the need to establish such a body.

- The applicability of the FAO/NACA/OIE guidelines to Central and South America should be examined.

G. Technical and Financial Assistance

Recommendations
Sources of funding and technical assistance are necessary to support quarantine activities and other environmental protection activities. Funding will become available provided a “responsible approach” is taken (e.g., via FAO, WB, GEF/CBD, etc.). Technical training in various areas will be required. The Mexico meeting should address ways to expedite this process.

Working Group 2 - Industry Management and Technological Requirements

Members: P.P.G.S.N. Siriwardena (Chair), D. Fegan (Rapporteur), M. Shariff, L. Zapata, G. Lio-Po, P. Chanratchakool, Huang Jie and P. Walker

It was generally agreed that the scope of this topic was such that it was not possible to easily summarize the range of interventions in the time available. It was recommended that a more comprehensive review be prepared for the APEC meeting in Mexico to review the range of activities undertaken to deal with disease outbreaks at the farm level.

In general terms, the need for a greater education and awareness on the part of shrimp producers and processors on the risks of disease outbreak was regarded as *the* single most important need. There remains a high level of ignorance in many countries as to the nature of the major diseases and means whereby risk can be reduced.

It was also felt by some members of the group that, for those diseases, which we currently know, there was need for greater emphasis on the epidemiology of the diseases. Epidemiological information will be an essential component in identifying the risks and routes of exposure to these pathogens and the development of practical, effective means to reduce or eliminate them.

There is also a need for a greater dissemination of information at all levels of the production chain from broodstock suppliers to hatcheries, farms and processors to increase their awareness of their interdependence and the impacts each may have on the other and, ultimately themselves.

Where these interventions are not carried out, this may indicate a higher risk of exposure to pathogens, depending upon the overall risk that exists at the time. For example, if WSSV is not present in a country, the use of methods to reduce exposure to this pathogen will not affect exposure or risk from this particular pathogen.

At present, we have very little idea of the relative risks associated with different potential sources or vectors of infection for the major shrimp diseases. The assessment of relative risks associated with inputs and potential sources of infection is an integral part of the development of more appropriate intervention strategies for disease control.

General Recommendations

- A comprehensive review of methods and strategies employed by the industry to combat disease outbreaks and reduce disease risks at the farm level should be prepared for the Mexico meeting.
- Education and awareness-building at all levels of the production chain should be emphasized.
- Training in the epidemiology of major shrimp diseases to improve awareness and develop practical health management schemes at the farm, national and regional levels should be promoted.

Hatchery Interventions

Use of Wild Broodstock

Dependence on wild broodstock is a major constraint to increasing the productivity and sustainability of shrimp production systems. The development of domesticated broodstock selected for desirable production characteristics is regarded as one of the major goals of the industry. Such programs are better developed in the Americas for local species such as *Litopenaeus vannamei* and *L. stylirostris* than for

Penaeus monodon where, although successful domestication has been demonstrated for many years, there has been less demand for domesticated stocks until relatively recently.

Wild broodstock should be treated with an appropriate disinfectant to eliminate external fouling organisms and pathogens prior to entry into the maturation and spawning facilities.

Use of Wild PL

The use of wild PL is inherently risky due to their unknown health status. In general, the use of hatchery-produced PL is preferable to the use of wild PL. However, switching from dependence on wild PL to hatchery PL has implications for sustaining rural livelihoods and employment of wild fry collectors.

Where the use of hatchery PL is not an option, the PL used should be screened for disease by the most appropriate and sensitive method available. For viral diseases, this will be by one of the rapid DNA-based methods such as dot blot or PCR. If these are not available, the minimum should be a simple screening based on obvious gross signs of ill health.

Water Treatment

Water treatment to eliminate pathogens is a standard practice in most hatchery operations. Disinfection, either by chemicals (chlorination, ozonation) or the use of ultra-violet sterilization, is common in hatchery operations. This eliminates external water sources as a potential source of pathogen entry.

The minimal treatment should be sedimentation and filtration to as fine a level as possible. The use of the so-called "micron bags" (in reality very fine mesh fiber bags) which can give an effective filtration rate down to as low as 1-5 micrometers is one simple, relatively cheap method.

Feeds

The use of fresh feeds in the hatchery, especially in maturation facilities, is considered a necessary component of a balanced diet for broodstock. However, their use represents a risk of introducing pathogens through contaminated feeds, particularly those containing crustaceans. The use of crustacean fresh feed components of maturation diets should be discontinued unless appropriate treatments to eliminate viral contamination can be used. Non-crustacean live feeds, although representing a lower risk, need to be regarded as potential sources of contamination and may also need to be treated. This may require some work to identify treatments that will not adversely affect their acceptability as food by the shrimp.

Some hatcheries, especially small-scale hatcheries, have used crustacean components in the PL diet, sometimes mixed in the form of egg-based feeds prepared as required. This practice represents a high risk and should be discontinued. As with broodstock diets, other components may also represent some risk and care should be exercised in their use.

In general terms, the use of fresh feed items, which have a higher risk of exposure to viral pathogens of shrimp, should be avoided (i.e., squid muscle should be used rather than whole squid). Discarding tissues from the alimentary system and gills (which are more likely to be exposed to virus) prior to use of fresh feeds may also be preferable to the use of whole animal items.

Broodstock Survival/Performance

The survival of broodstock after spawning is one indication of broodstock health and the potential for exposure of the eggs/nauplii to viruses by vertical transmission. Batches of eggs/nauplii from broodstock that subsequently die within a short time after spawning can be discarded if the risk is regarded as high.

Recent research has also shown that even highly sensitive methods of viral detection such as PCR are more reliable when carried out after spawning. Thus, disease screening should be conducted post-spawning where possible.

Both of these techniques are more effective where the batches of eggs/nauplii from an individual spawn are maintained separately until the health status of the spawner is known. Therefore, it is recommended that they be kept in individual containers at least until such information is available and a decision made on their acceptance/rejection for use in the hatchery.

Single Spawning

The practice of single spawning of females (i.e., one female per spawning tank) should be encouraged. The use of multiple spawning tanks increases the risk of exposure of eggs and nauplii to virus that may be shed by only one, or a small number, of infected females.

Washing of Eggs/Nauplii

The benefits of washing eggs and nauplii in reducing the risk of vertical transmission of some viruses (e.g., BMN, MBV, BP) have been well established. There is also some evidence to suggest that it may help in reducing vertical transmission of WSSV. Given that washing of eggs and nauplii is a simple, cheap and practical intervention, its use as a "best management practice" in hatcheries and nauplii production facilities should be encouraged.

Selection of Nauplii

Hatcheries should select only the healthiest nauplii by using their strong phototactic behavior. The use of a strong light and selection of only those nauplii that swim toward it is a simple, effective means of selecting only strong, healthy nauplii.

Combining and Discarding of Low Survival Tanks

In many hatcheries, especially small-scale ones, it is common practice to combine larvae of the same ages from tanks that exhibit poor survival. In most cases, the reason for this low survival is not known. This represents a considerable risk of increasing the transmission of pathogens as well as reducing the quality of PL produced. The practice of combining tanks for this reason should be discouraged.

At the same time, the practice of disinfecting tanks of PL prior to draining out should be encouraged to prevent the possibility of draining infected larvae into the environment and to reduce the potential for genetic pollution should survivors from distant areas go on to reproduce.

Post-Larval Screening for Quality and Health Status

Basic PL quality and health status screening should be developed for different levels of sophistication depending upon facilities available to farmers. Obviously, for viral diseases, the use of less sensitive screening methods results in a higher risk of exposure to pathogens, especially viruses. It is, therefore, likely that the more simple, less sophisticated production systems where sensitive screening methods are not available, are inherently more at risk than those which are capable of more sophisticated selection.

The use of any type of quality control system inevitably results in the discard rate from the hatchery increasing. Thus, it is likely to meet with some resistance from the hatchery sector unless there is some incentive for the hatchery in producing PL with a higher quality. Thus, it is important to raise awareness among hatcheries and farmers of the benefits of using higher quality, screened PL and encouraging a pricing system based on equity of benefit.

Recommendations

- Dissemination of information and training in hatchery production methods is required.
- Training in the use of simple diagnostic methods for field use (e.g., rapid staining or dot blot methods) is needed.
- Basic methods of PL quality assessment should be promoted.
- Appropriate use of water treatment systems for hatchery production is required.
- The use of a quarantine period and treatment to eliminate external pathogens of broodstock/spawners prior to entry into maturation/spawning facilities should be encouraged.
- Research into treatment of live feeds to eliminate major pathogens without adversely affecting feed acceptability by broodstock is needed.
- The practice of spawning in single tanks should be encouraged.
- Eggs and nauplii from individual spawns should be kept separate until the health status of the spawner is known.
- The use of egg and/or nauplii washing as a "best management practice" should be encouraged.
- The practice of nauplii selection using light should be encouraged.
- The practice of combining tanks with low survival should be discouraged.
- When hatchery tanks are drained, the water should be treated to kill the shrimp larvae and to disinfect the water prior to draining.
- Encourage the application of PL quality assessment and health screening at the hatchery and farm levels and promote the principle of equity in pricing of quality PL.

Farm Interventions

Post-larval Selection

Other than the use of quality assessment schemes and screening for diseases of concern, farmers can use some treatments that have been shown to eliminate weaker PL which tend to be infected. One of the simplest of these is the formalin stress developed by Chanratchakool and Limsuwan in Thailand. This has the benefit of reducing exposure to infection regardless of any prior screening process, and is cheap and simple to apply. It would be of particular benefit in small-scale, unsophisticated farm systems where sensitive health screening methods are not available.

Water Treatment

The large volume of water used in farms is a major constraint in the treatment of incoming water. Where water is treated, this is usually limited to pre-stocking treatments. Current treatments have been developed largely *ad hoc,* and there is a need to evaluate these for effectiveness. Although such treatments are called "disinfection," it is more appropriate to refer to them as methods of carrier exclusion, as this is their main function, particularly since few of the treatments actually achieve any measure of sterilization due to the high organic loading of most pond and farm systems.

Carrier Exclusion

Simpler, less costly, means of waterborne carrier exclusion have shown to be effective. In particular, the use of 300 micrometer screening to prevent the entry of small waterborne carriers has been demonstrated to reduce potential exposure to WSSV. Since this method is simple, cheap and effective, its use as a standard management practice should be considered.

Exclusion of land-based carriers is more problematic, especially in the large-scale farms common in Latin America. The application and effectiveness of exclusion methods will depend upon their practicality and also the extent of the risk from these land-based carriers. The use of crab fences, for example, may be more practical in the small farms of Southeast Asia than in the large ones of Latin America, but even in Thailand, their use is less common than before, as the perception of risk from land-based carriers such as crabs has reduced. There is a need to find simpler and cheaper means of eliminating potential carriers from farm systems, especially large ones.

Transfer of Items/Equipment Between Ponds

Preventing the transfer of equipment between ponds to prevent contamination is one practice that has been proposed. However, buying multiple sets of equipment for individual pond use is expensive and may not be cost-effective, particularly if this route of exposure is shown to be low-risk. However, small equipment such as nets can be washed and disinfected using chemical disinfectants before being used in other ponds.

Transfer/Mixing of Shrimp from Different Ponds/Tanks

As in the hatchery, if mixing of stocks is undertaken as a result of low survival, this is a high-risk activity. However, it may be justifiable on economic terms, depending upon the age, size and investment of the shrimp and the future prognosis for the pond's performance.

Crop Rotation/Fallowing

The practice of crop rotation or pond/farm fallowing has been suggested many times. However. this will likely only be effective if the disease is horizontally transmitted and sufficient time allowed for any infections in wild stocks near the farm to reduce in prevalence. If the infection is vertically transmitted, on the other hand, such strategies may be of limited use, other than to reduce financial exposure until the situation improves. Also, unless the alternative crop is of equal value to shrimp, there are cost implications of crop rotation strategies.

Reduced Water Use Strategies

There have been many strategies used on farms to reduce water use and therefore, reduce the risk associated with pathogens in water. These will be treated individually, but as a general "best management practice" to reduce resource use, pumping costs and environmental impact, their adoption should be encouraged. The use of reduced water exchange, however, requires much greater attention to control of water quality and more frequent monitoring of water quality parameters, especially ammonia and dissolved oxygen.

Closed Farm System/Recirculating Farms

The use of completely closed or recirculating farm systems reduces exposure to external, waterborne pathogens. In such systems, water is taken in once and then re-used with only minimal water brought in to replace that lost by seepage and evaporation (hence the commonly used term "closed system" is actually a misnomer). Unfortunately, little hard data are available on their effectiveness in reducing exposure to disease risk, but production per unit farm area is generally reduced due to the need for 30-50% of the farm to be devoted to reservoirs and treatment ponds. This imposes costs on the farm due to reduced production levels. There is also the potential for retention of some pathogens in the system (e.g., if fish and shrimp are together, microsporidian disease transmission is a higher risk), but as these pathogens are of much less concern than viruses, this may be regarded as "acceptable risk."

Closed Pond Systems (Partial/Semi- and Full)

Closed pond systems are distinct from closed farm systems, in that the individual ponds are operated in this way rather than the whole farm. They are more common where a farm has only a single pond or a few ponds and cannot afford to devote large areas of the farm to non-production units. As with closed farm systems, the idea is to reduce exposure to external water-borne pathogens and, again, water quality parameters are more critical. There is some indication that the use of such systems results in reduced growth rate and production levels, but once again, there is a dearth of information on the effectiveness of these systems. It is possible also, that there is limits on the length of the culture cycle that can be obtained due to the limited water exchange.

Low Salinity Culture

There have been many suggestions that, for some diseases, there is a relationship with salinity and, particularly, that culture of shrimp in lower salinity gives better survival. Unfortunately there is a lack of consistent, verifiable information on the relationship between salinity and disease outbreaks, even for a single disease, due to the many confounding factors, such as site location and water availability. The evidence for a relationship between salinity and different diseases is also lacking, with some claims that one disease is more virulent in low and another in high salinity. Reports from different countries also appear to be contradictory, even for a single disease. The environmental implications of shrimp farming in low salinity areas should also be taken into account, as these have already been of concern in some countries such as Thailand.

Green Water Culture

In some countries, the use of "green water" culture techniques appears to reduce pathogen-related problems. Green water techniques use water from the culture of fish as the source water for the culture of shrimp. There is some evidence from freshwater systems that some benefits do derive from the application of such systems, especially at the hatchery level. Such systems have considerable promise, and their application deserves further investigation.

Feeds

Feed use on the farm should be restricted to the use of formulated feeds, as fresh feeds, unless appropriately treated to prevent contamination, represent an unacceptably high risk. The feeds should have a formulation appropriate to the species being cultivated, and they should be stored properly to avoid contamination.

The use of crustacean meals, including shrimp meals, as components of shrimp feeds has been the subject of considerable debate and, although there is as yet no evidence to suggest that any of the major viral pathogens can survive the processes of meal production and pelleting, alternatives should be sought.

Emergency Harvest

In the case of rapid, acute mortality, many farmers resort to an emergency harvest to recover as much of their investment as possible. This strategy is appropriate in such cases where there is poor potential for recovery, although there are some constraints in terms of finding buyers and the price, which can be obtained for the product.

The main danger comes from the potential for transmission to other ponds/farms in the harvest effluent water. Ideally, farmers would treat or retain the effluent water for 4-5 days. If this is not practical (and in most cases, it is not, without extensive and costly re-engineering of the farm), the farmer should inform other farmers nearby so that they can stop pumping water for as long as possible.

Slaughter

Slaughter of infected ponds to eradicate and prevent spread of disease between ponds has been used for some diseases. However, it is a drastic and costly measure and is only appropriate for highly virulent, highly transmissible diseases. As a strategy, it is more acceptable in a single-owner farm system and is not so acceptable where many farmers are involved, as the benefits do not accrue to the farmer affected. In such cases, it may only be possible where some form of self-insurance or compensation scheme is in place to encourage co-operation between farmers. This strategy is highly disease-specific and, as with other methods, it is not certain exactly how effective it may be in preventing disease.

Diagnostics

Although in general, there is a need to focus more on epidemiological approaches to disease management, there remains some need to improve diagnostic capability, particularly at the farm level. The development of simpler, faster, low-cost, pond-side diagnostics for real-time decision making is seen as a priority for the industry to reduce the rate of loss to disease.

There is also a need to evaluate the specificity of existing diagnostic tests to ensure accuracy of diagnostic interpretations, improve reliability and ensure appropriate coverage of all potentially pathogenic strains.

The correct interpretation of diagnostic tests by farmers is an essential part of their appropriate use in decision making. Farmer and diagnostician training in the use and interpretation of diagnostic test results are needed to avoid confusion, particularly for the more sensitive DNA-based methods. Standardization and cross-validation of tests between laboratories, as recommended by the expert consultation on DNA-based diagnostics, should be implemented on a regular basis.

Dry-out

Regular drying out of production facilities (farm and hatchery) should be included in production schedules as a component of "best management practice."

Polyculture Strategies

Polyculture of fish and shrimp has been proposed to reduce availability of infected shrimp for cannibalism. This involves stocking fish species, which will consume infected shrimp before cannibalism takes place. Although there is little information on how such systems may be used to reduce the risk of disease transfer within a single pond system, their use and effectiveness should be evaluated.

Seasonal Production Strategies

Many of the diseases of concern demonstrate a clear seasonality of occurrence, or the extent of losses, leading to seasonal variations in risk. Some farmers have begun to reduce their exposure to risk in times of high risk (usually the rainy or cold season) by adopting different stocking strategies. Where clear information is available, risk avoidance strategies during periods of high risk represent a sensible strategy for reducing disease losses.

Processing Plant Waste Disposal

There is increasing anecdotal evidence that untreated waste from processing plants may play an important role in the dispersion of some pathogens into the wild and into farmed stocks. There is a need to raise awareness among processors of the risks associated with the uncontrolled discharge of untreated shrimp and other aquatic animal wastes into the environment and to encourage responsible disposal or treatment of wastes to inactivate viruses. Alternative, more profitable, uses for shrimp wastes need to be promoted, such as processing as meal for non-aquaculture feed uses, and cooking or disinfecting before disposal.

Recommendations

- Farms should implement methods for selection of healthy PL by using screening techniques such as formalin treatment to eliminate weaker, infected individuals.
- Current methods of water treatment need to be evaluated for their worth and effectiveness in reducing disease risk.
- The use of simple waterborne carrier exclusion methods such as 300 micrometer screens should be adopted as a "best management practice."
- There is a need to develop simple and cost-effective means of reducing exposure to land-based carriers of disease.
- More information needs to be obtained on the relative risk associated with farm practices such as the use of equipment in several ponds. Basic disinfection procedures should be implemented to avoid contamination between ponds.
- The risk of disease transfer should be carefully considered before combining shrimp from two or more ponds.
- Crop rotation and fallowing strategies should be based on consideration of the means of transmission of the particular pathogen of concern.
- Reduced water exchange strategies should be encouraged on the basis of reduced exposure to water-borne risk and as a best management practice to reduce environmental impacts.
- The effectiveness of "green water" culture strategies to reduce the impact of disease outbreaks should be investigated.
- Fresh feed use on the farm should be discouraged due to the high risk of disease transfer and environmental degradation.
- In principle, alternatives to the use of crustacean meals in formulated feeds should be encouraged.
- In the event of emergency harvests, farmers should do their best to co-operate and keep each other informed of the disease situation.
- Where a strategy of slaughter is indicated, the possibility of self-insurance or co-operative sharing of costs of slaughter among farmers should be encouraged.
- There remains a need to develop farm-based, real-time diagnostics tests to allow better decision-making at the farm level.
- Training of pathologists and farm technical staff in the use and interpretation of diagnostic test results is still a priority.
- Standardization and cross validation of diagnostic tests should be implemented.
- Regular dry-out of farm and hatchery facilities should be promoted.
- Investigations into appropriate polyculture strategies to reduce disease transmission within the pond need to be conducted.
- Where clear information is available on seasonality, risk avoidance strategies during periods of high risk should be encouraged.
- Processing plant managers and operators should be made aware of the risk of disposal of untreated wastes directly into the environment. Measures for encouraging the responsible disposal of processing wastes and the use of processing wastes for value-added products should be found.

Working Group 3 – Specific Recommendations

Members: H.L. Corrales (Chair), L. Drazba (Rapporteur), R.P. Subasinghe, V. Alday, C. Marte and J. Clay

The control of transborder or interregional transmission of shrimp diseases can only be accomplished if shrimp producers, industry suppliers and governments work together. This collaborative process could involve a variety of programs that either deal with the control of individual events, such as an Import Risk Assessment for a particular species to a particular area, or more comprehensive programs, such as an externally audited certification process. Several such programs were evaluated for the following characteristics; relative effectiveness in controlling the transborder transmission of shrimp diseases, cost and ease of implementation. All programs were evaluated for implementation in the production of broodstock and post-larvae shrimp, the grow-out process, shrimp processing and the sale of goods and services to the production sector. The programs evaluated included: Hazard Analysis and Critical Control Point (HACCP) or quality assurance, Codes of Conduct, Self Evaluated Codes of Practice, Externally Audited Codes of Practice, Import Risk Assessment (IRA) and Environmental Impact Assessment (EIA). The HACCP programs at the broodstock, post-larvae and shrimp grow-out levels did not consider the quality of product from the point of view of food safety but rather from the perspective of the producer who wishes to assure the successful technical outcome or profitability of his operation.

Recommendations

The following recommendations reflect the outcome of this analysis:

- The probable impact of Quality Assurance Programs (QAP) on the control of transborder disease transmission coupled with their low cost and relative ease of implementation deem them the best strategies for immediate incorporation into the procedures manuals for hatcheries, farms and processors. The greatest impact is at the hatchery level and therefore, the greatest emphasis should be placed on implementation of programs aimed at quality assurance with regards to brood animals, nauplii and post-larvae shrimp.
- QAP for diagnostic laboratories is also needed to insure that they are useful tools in the control of disease transmission. Standardization of techniques and training of personnel in molecular biology are the most immediate needs, however, training in all areas of pathology and a general standardization of techniques are recommended.
- There should be a continuous process of development of codes of conduct and codes of practice based on the FAO's *Code Conduct for Responsible Fisheries*, Chapter IX Aquaculture. The most logical sequence would be the low-cost development and implementation of codes of conduct, which serve to raise levels of awareness. Further development would lead to the design and implementation of codes of practice beginning with self-evaluation but leading eventually to externally audited codes. The latter would potentially have greater impact but would require more time and money to implement.
- National reference pathology laboratories should be established to assure the quality of the local private labs in any country. These national reference labs would work with regional reference labs, if available, and with the existing OIE reference laboratories.
- Import Risk Analysis appears to be an important tool in the control of disease transmission, but it is expensive and more difficult to implement than several of the other measures. Work should be initiated to define criteria, trade issues and regional or inter-regional issues related to IRAs now, in order to permit their harmonization across countries and regions and their implementation at the earliest possible opportunity. Workshops should be held to train officials in the concepts of the IRA process, monitoring and contingency planning.

- Environmental Impact Assessments (EIA) are good tools for the prevention of diseases. They are most effective when they take into account the type of culture system used and its specific requirements as they relate to the environment. All EIA's should directly address the disease transmission issue, especially when considering the source of broodstock, nauplii and post-larvae shrimp. Countries that do not currently require EIA’s for hatcheries or shrimp grow-out installations should require them.

Based on the experiences of the Working Group members, estimates of the relative probabilities of success, cost, and implementation for the various measures (quality assurance, codes of conduct, codes of practice, IRA and EIA) were estimated for various activities at the hatchery, farm and processor level. These are given below in Tables 1-3.

Table 1. Relative probability of success of interventions at various production levels. Ranking: 1-low probability to 5-high probability.

Measures		**Quality Assurance (HACCP)**	**Codes of Conduct**	**Codes of Practice - Self Evaluated**	**Codes of Practice - Externally Audited**	**Import Risk Assessment (IRA)**	**Environmental Impact Assessment (EIA)**
Activities							
Hatcheries							
	(Brood, PL)	5	3	3	4	5	4
Farm							
	Intensive	5	4	4	5	5	5
	Extensive	5	4	4	5	5	4
Processor		2	3	4	5	5	5
Total		**17**	**14**	**15**	**19**	**20**	**18**
Supplier							
	Feed	5	4	4	5	5	NA
	Consulting	5	4	4	5	NA	NA
	Chemicals	5	4	4	5	5	NA
	Diagnostic Lab	5	5	4	5	NA	NA
Total		**20**	**17**	**16**	**20**	**10**	**0**

Differences which exist between measures:

- Either an individual event or body of events (process)
- Can guarantee outcome is: safe, innocuous, responsible, efficient, cost effective, good quality
- Product or result
- Self regulated or externally audited
- Pertains to individual, country or industry

Table 2. Relative costs of interventions at various levels of production. Ranking: 1 - high cost to 5 – low cost.

Measures		**Quality Assurance (HACCP)**	**Codes of Conduct**	**Codes of Practice - Self Evaluated**	**Codes of Practice - Externally Audited**	**Import Risk Assessment (IRA)**	**Environmental Impact Assessment (EIA)**
Hatcheries	(Brood, PL)	3	5	4	2	2	1
Farm							
	Intensive	3	5	3	2	2	1
	Extensive	4	5	3	2	2	1
Processor		1	5	3	2	2	2
	Totals	**11**	**20**	**13**	**8**	**8**	**5**
Supplier							
	Feed	1	5	4	3	2	4
	Consulting	-	-	-	-	-	-
	Chemicals	4	5	3	2	2	4
	Diagnostic Lab	1	5	4	2	NA	NA
	Totals	**6**	**15**	**11**	**7**	**4**	**8**

Differences which exist between measures:

- Either an individual event or body of events (process)
- Can guarantee outcome is: safe, innocuous, responsible, efficient, cost effective, good quality
- Product or result
- Self regulated or externally audited
- Pertains to individual, country or industry

Table 3. Relative probability of implementation at various production levels. Ranking: 1 - low probability to 5 -high probability.

Measures		**Quality Assurance (HACCP)**	**Codes of Conduct**	**Codes of Practice - Self Evaluated**	**Codes of Practice - Externally Audited**	**Import Risk Assessment (IRA)**	**Environmental Impact Assessment (EIA)**
Hatcheries	(Brood, PL)	4	5	4	3	3	4
Farm							
	Intensive	3	3	2	1	3	4
	Extensive	2	2	1	1	1	4
Processor		5	5	4	4	4	4
	Totals	**14**	**15**	**11**	**9**	**11**	**16**
Supplier							
	Feed	4	4	4	4	4	4
	Consulting	-	-	-	-	-	-
	Chemicals	4	4	4	4	4	5
	Diagnostic Lab	5	5	4	4	4	5
	Totals	**13**	**13**	**12**	**12**	**12**	**14**

Differences which exist between measures:

- Either an individual event or body of events (process)
- Can guarantee outcome is: safe, innocuous, responsible, efficient, cost effective, good quality
- Product or result
- Self regulated or externally audited
- Pertains to individual, country or industry

Working Group 4: Improving Responses to Disease Problems and Management

Members: R. Callinan (Chair), C.V. Mohan (Rapporteur), J. Albaladejo, M. Phillips, A. Rukyani and Le Van Khoa.

The Working Group posed a number of questions, and then sought the answers:

What Kind of Farmers are We Talking about?

- Farmers with minimal resources and whose livelihoods are dependent on shrimp trapping or traditional farming (e.g., mixed species, integrated systems).
- Fishers living in coastal areas with limited agricultural or employment opportunities.
- Farmers operating low input systems without feeding, aeration and minimal inputs.

Some Examples of Small-scale, Rural Shrimp Culture Systems from the Region.

Vietnam: These include small-scale, self-owned, households living near their pond and raising crabs, or practicing polyculture of shrimp. The systems involve low inputs, tidal exchange, and extensive culture. They may use pelleted feed. Pond areas are very variable; they range from 0.05 ha - 2 ha in the north. Most income is from fishery products; as there has been a reduction of fishery resources, people have become involved in aquaculture.

Examples also include alternate cropping systems (rice-shrimp farming) and polyculture, which are examples of small-scale diversified systems. In the north of Vietnam, there are limited opportunities for another crop. Farmers have lost confidence in the government's support/planning and recommendations.

India: These include holders of small-scale ponds, 0.5-1.5 ha in size, which are local residents. Household incomes may be diversified, mainly from agricultural land. There is variation in farming types, including monoculture, use of bheries (no stocking), and large areas (200 ha) that have been converted to ponds and are a joint resource managed by 200-300 people in a village. Now some of these systems have been converted and are leased to larger people for shrimp culture. A sustainable traditional practice has now been converted and cannot be recovered. This has increased risk for small-scale farmers. Rehabilitation of ponds is required in some locations. It is difficult to generalize regarding small holders. The policy of the government is to involve local people in shrimp aquaculture.

Philippines: There is leasing of pond areas via fishpond lease agreements. There is less direct involvement of small-scale stakeholders than in some other countries. Indirect involvement includes employment of local fishermen for feeding. Some traditional farms have reverted to milkfish because of shrimp disease problems. Over time, low input systems have gradually developed into high input systems.

Indonesia: There are a large number of small-scale farmers in Indonesia. Farmers stock, and then there are increasing productivity as farmers get the benefit. Traditional stocking at 1-2/m^2 and "traditional plus" stocking at up to 5/m^2 are common practices. Stakeholders are landed people, so they are not the poorest of the poor. Examples also exist of nucleus estates e.g., Dipasena, with two ponds of area 2,000-3,000 m^2 per pond. More information is needed on these systems. The government policy is strongly oriented towards poverty alleviation. Farmers facing shrimp disease problems have returned to fish culture (milkfish, tilapia).

What are the Opportunities Provided by Shrimp Culture for These Groups?

The Working Group asked the question "Can shrimp aquaculture contribute to poverty alleviation?" The answer - It is possible. Government policies are changing e.g., in India, where there is more focus on the small-scale sector.

Opportunities include:

- Improving livelihoods - food security, family income, diversified incomes (mixed farms).
- Improving existing farming practices and making productive use of resources.
- Creating employment opportunities,
- Integrating shrimp farming into overall rural development programs.
- Increasing production. The production potential of the small-scale sector is enormous!

Implications of Shrimp Disease for Small-scale Coastal Livelihoods

Disease causes serious risks to livelihoods; there are direct and indirect impacts on small-scale farmer livelihoods. These include increased debt, loss of employment and income opportunities, and lost development opportunities. Control of risks is essential if farmers are to benefit from small-scale shrimp farming.

Risks are direct where farm households are involved in shrimp production, and indirect where they are involved in employment (Ecuador), leasing (Bangladesh, India) or supply of inputs (e.g., seed collectors in Bangladesh, India and Ecuador). Disease problems in the larger-scale commercial sector have direct and indirect implications for small-scale livelihoods. Disease has also impacted both directly and indirectly on coastal rural livelihoods.

In many traditional ponds, health management is very difficult. There is a need to improve the pond environment.

Loss of investment is a concern also, particularly for small farmers who take out short-term loans and then have difficulty making payments because of disease. The summary of a subsequent workshop on shrimp health management in small-scale shrimp farming is given in Annex IV.

What are the Root Causes of These Risks?

The root causes of these risks are:

- Export focus rather than local development focus in the overall planning of development.
- Limited institutional support to the small-scale sector (e.g., extension, information transfer)
- Farm risk factors, including introduction of infected hatchery seed and the possibility that traditional systems may have more risk factors as compared to ‘commercial’ farms, such as reliance on wild seed and water management difficulties.

How to Manage These Risks?

Risks can be managed in a number of ways. These include:

- Rural development planning, i.e., development based on local resources and focused on people’s needs and opportunities.
- Institutional interventions, including transfer of information responding to development needs, effective extension, farmers' groups, access to credit, and crop insurance, on-farm demonstration and farmer-to-farmer information flow. A special issue for small-scale extension is that simple

management recommendations should to be integrated into management recommendations. Long-term investment can be promoted through local ownership. Land rights also encourage longer-term investment.

Interventions at the Production System Level

The following interventions are needed in hatcheries and nurseries:

- Seed quality needs to be assured. There may be a need for a better system of post-larval screening. Commercial sector pressures may help!
- Low-input considerations such as seed quality checks may be needed.
- There is a need to diversify income and risk. Alternate cropping and polyculture should be promoted, where feasible. However, there is limited understanding of these management practices.
- Basic health monitoring and management should be promoted.

Special Constraints to Risk Management in Small-scale Livelihood Farming

The following are constraints specific to small-scale livelihood shrimp culture:

- There is very limited access to resources such as information, credit, and insurance coverage.
- The educational level of traditional farmers is often low.
- There is a lack of farmer associations and groups at this level.
- The perception of health risk among small-scale farmers is limited.
- The nature of the system, with many disease carriers, makes disease management and control difficult.
- There are ownership issues. Ownership may be single, joint, or multiple.

Commercial and Small-scale Linkages

Larger commercial farms are closely linked to the small-scale sector in many ways. The benefits to be derived from working together could be significant. These could include new developments and new approaches, hatchery sector issues, avoidance of pathogen transfers, and sharing of lessons learned in management. Small-scale farmers are also involved in intensive farming (e.g., in Thailand).

How Have These Different Management Strategies Worked?

- There is very limited experience with the development/livelihood approach.
- Policy guidelines are sometimes directed at commercial groups, although there is increasing emphasis on aquaculture and livelihoods.
- For institutional arrangements, there is limited understanding and focus on the small-scale sector (e.g., few workshops, seminars, and extension materials).
- Self-help arrangements, such as farmer groups, are very poorly understood; however, they have good potential.

How These Different Farm-level Management Strategies Worked?

- There is very limited experience with the farm-level approach.
- There are no easy solutions.
- There is some experience in Vietnam, where epidemiological studies suggest the possibility of introducing basic risk management among rice-shrimp farms.
- Formalin tests as applied in Indonesia may have applicability.
- A better understanding of potential intervention strategies vs. risk factors is required.

Opportunities and Requirements for National, Regional and Inter-regional Collaboration

These include:

- Opportunities for small-scale livelihood focused development
- National-level exchange of successful experiences, priorities to support small-scale sector
- Regional and inter-regional exchange of successful experiences – dissemination of successes and information exchange.

Items for the APEC Agenda

The agenda should include an emphasis on:

- The role and potential of small-scale shrimp aquaculture within a rural development perspective.
- Addressing the implications of transboundary movements and health management issues for the small-scale sector. This may require a more detailed analysis of the issues and problems faced by the small-scale sector.
- The action plan proposed should give special attention to initiatives which support the small-scale sector, e.g., regional co-operation on information exchange, capacity building and other ways to reduce risk and improve delivery of health management programs to small-scale shrimp farmers.

SUMMARY OF RECOMMENDATIONS

This section summarizes commonalties in recommendations and general needs identified in the Country Summaries provided by (a) participants from the Latin American Region, and (b) from the Asian Region, and (c) the recommendations of regional significance given in the reports of the four workshop discussion groups.

A. Recommendations for the Latin American Region

I. Infrastructure, Capacity Building and Training

- Promote education to increase farmer's awareness of disease and its prevention.
- Implement routine surveillance for current and emerging diseases.
- Increase the number of trained epidemiologists working on shrimp diseases.
- Increase the capacity of animal health and aquaculture staff in aquatic health.
- Fund and encourage industry to develop diagnostic capability, backed up by technology transfer, extension services, and increased research.
- Increase financial support to national governments to support the industry at the research and technical levels.
- Develop service and support organizations to co-ordinate extension services for industry.

II. Research and Development

- Develop effective treatments to deal with disease problems.
- For some countries, adjust management techniques, if not the entire production paradigm.
- For areas such as Central America, where climatological conditions are extremely variable, find new ways to insure minimum conditions in the water column.
- For some countries, develop monitoring programs for physico-chemical and biological characteristics to establish levels of contamination in the main estuaries used for shrimp culture.
- Define the main routes of viral transmission in the wild.
- Continue studies with local broodstock to close the reproductive cycle, reducing disease threats by replacing wild-caught spawners with domesticated (ideally, high health) stock through successful breeding programs.
- Establish programs for shrimp gene banks.
- Establish quarantine units for broodstock and PL.

III. Legislation, Policy and Planning

- For some countries, formulate laws designed to allow the industry to import PL and nauplii in a manner that will reduce risk of disease spread.
- Achieve better co-ordination between government and the private sector in the implementation of action plans.
- For some countries, establish "micro-regions" for effective application of control methods.
- Emphasize the use of HACCP in farms.
- Define protocols for actions, which are obligatory.
- Apply biosecurity principles widely.

IV. Regional and International Cooperation

- Establish regional programs for disease surveillance and contingency planning.
- Establish a regional network of reference diagnostic laboratories to support health certification, within a standardized protocol.
- Establish R&D stations and local laboratories for disease diagnosis for countries lacking such facilities.
- Improve communication within the shrimp farming community so that vital management information can be rapidly disseminated.
- Establish an inter-regional newsletter, magazine or other communication system.
- Continue to build public awareness through workshops and lectures.

- Provide training and grants for personnel to attend courses.
- Sponsor expert interchange between countries.
- Establish a regional task force to determine the aetiology, epidemiology and treatment of new diseases, to develop strategies to control disease outbreaks and to improve farm biosecurity.
- Undertake co-operative research projects, such as the development of sustainable broodstock supplies for hatchery seed production and research on life histories and broodstock maturation in captivity.

B. Recommendations for the Asian Region

I. Infrastructure, Capacity Building and Training

- Establish laboratories in national lead centers for disease identification, and shrimp health laboratories in shrimp culture areas with modern equipment and trained manpower.
- For some countries, develop shrimp hatcheries to supply healthy Post-larvae to farmers.
- Allocate necessary supplies, equipment, and travel required to assess shrimp health management status.
- For some countries, provide overseas and local training in shrimp health management and disease diagnostics.
- Provide training for extension specialists, farmers and hatchery operators.
- Enhance technical research and speed up extension of aquaculture disease prevention technology.
- For some countries, establish or strengthen quarantine systems to control the import and export of aquatic animals.
- For some countries, set up central databanks on all shrimp farms based on high resolution GIS system for effective regulation, industry self-assessment, monitoring and law enforcement.
- Organize shrimp farmer's associations to act as lobbying groups, articulating industry needs and providing a range of services to members.
- Improve information dissemination and increase pubic awareness through more effective use of newsletters and bulletins.

II. Research and Development

- Fund more intensive R&D programs to find ways to combat disease threats. Encourage increased public/private sector co-operation.
- Establish closed-cycle breeding programs to produce PL that are certified free of specified viruses (i.e., SPF) to improve disease security.
- Identify all potential viral pathogens and develop sensitive and specific tools for their detection.
- Conduct research leading towards farming systems, which are most appropriate to national situations, whether intensive semi-closed farming systems using high quality SPF, domesticated and genetically selected stock (e.g., Australia) or extensive traditional systems (e.g., India).
- Establish programs to monitor aquatic environments in and around shrimp farming areas
- For some countries, evaluate the economic viability of alternative shrimp farming systems (e.g., low-salinity and freshwater culture systems).
- Expand technology obtained from current pilot projects.
- Assess shrimp culture production, including both small- and large-scale hatcheries, grow-out ponds, and production systems for hatchery, grow-out and pre-harvest.
- Identify shrimp health management programs, including aspects related to pond construction and irrigation systems, water quality management, feed and nutrition, disease and mortalities, disease control and health management, drugs and chemical treatment, and genetics.
- For some countries, assess national shrimp health management capabilities, including facilities at individual farms and hatcheries.
- Develop new rapid diagnostic methods for use by farmers and small laboratories.

- For some countries, conduct case studies on shrimp farming to analyze serious disease outbreaks and their socioeconomic and environmental impacts.

III. Legislation, Policy and Planning

- Increase interaction between planners, policy makers and industry to discuss strategies and options for practical approaches to sustainable shrimp farming.
- For some countries, formulate national policies recognizing the role of shrimp farming as a contributor to economic development.
- For some countries, formulate plans for sustainable development of coastal aquaculture, focusing on comprehensive health management strategies for shrimp farming.
- Establish policies that are relevant to the development of environmentally friendly shrimp farming.
- For some countries, provide financial assistance to help farmers recover from catastrophic losses to speed up the recovery of the farming sector.
- Develop disease control programs based on "holistic," systems-wide approaches that incorporate innovations to correct problems in the environment, animal and pathogen.
- Review accepted and tested basic principles of shrimp culture to formulate effective disease prevention strategies that take full advantage of the benefits accorded by existing disease prevention strategies and those offered by new technologies.
- Develop national contingency plans for aquatic animal disease outbreaks.
- Develop codes of "best practices" for industry self-management, based on the FAO *Code of Conduct for Responsible Fisheries* and similar guidelines on aquaculture development.
- For some countries, enforce coastal area management regulations that are relevant to shrimp culture, including increased monitoring and law enforcement to maintain environmental quality, developing law authority capacity, extensive dissemination of information on laws and regulations to local communities; increased effectiveness, co-ordination and integration of law enforcement; improving and completing regulations, and encouraging community capability and awareness in implementing regulations.
- Develop improved legal frameworks, monitoring systems and enforcement capabilities for effective regulation to control expansion of shrimp farming, observe proper siting and prevent environmental impacts and self-pollution.
- For some countries, examine critically the current approval process for shrimp farms.

IV. Regional and International Cooperation

- Support information systems for research and training via a regional Shrimp Health Management unit in NACA.
- Link national diagnostics and disease control systems with other countries' networks.
- Establish a website for recent shrimp disease diagnostics and control measures, so that countries can immediately access needed information.
- Set up a regional disease information network and a timely disease reporting system.
- Strengthen co-operation among Asian countries on information exchange, policy and quarantine.
- Organize regional annual meetings and workshops on shrimp health management.
- Conduct collaborative projects among regional countries on various aspects of disease diagnosis and control.

C. Working Group Recommendations

The following section summarizes the major recommendations arising from the Working Group Discussions which will require further consideration and/or action by FAO, NACA, WWF, WB and other interested donor and implementing agencies, or which should be addressed at the APEC meeting to be held in Puerto Vallarta, Mexico in July 2000. More specific recommendations of a technical or highly specific nature can be found in the summary reports for the individual working groups.

I. Recommendations to be addressed by the APEC Meeting

- A comprehensive review of the data contained in the individual country reports presented at the Cebu Workshop should be undertaken to provide a more in-depth evaluation of country documents to support development and implementation of policy, legislation and regulatory frameworks at the up-coming regional meeting in Mexico.
- A comprehensive review of methods and strategies employed by the industry to combat disease outbreaks and reduce disease risks at the farm level should be prepared for the Mexico meeting.
- Given that some codes (e.g., the ICES/EIFAC code) call for the establishment of advisory bodies, the Mexico consultation may wish to examine the need to establish such a body.
- Sources of funding and technical assistance necessary to support quarantine activities and other environmental protection activities will become available provided a "responsible approach" is taken (e.g., via FAO, WB, GEF/CBD, etc.). Technical training in various areas will be required. The Mexico meeting should address ways to expedite this process.
- With regard to the small-scale sector, the APEC agenda should include an emphasis on:
    - The role and potential of small-scale shrimp aquaculture within a rural development perspective.
    - Addressing the implications of transboundary movements and health management issues for the small-scale sector.
    - Proposing an action plan that will give special attention to initiatives which support the small-scale sector, e.g., regional co-operation on information exchange, capacity building and other ways to reduce risk and improve delivery of health management programs to small-scale shrimp farmers.

II. Other Recommendations of Regional/International Significance

(i) Infrastructure, Capacity Building and Training

- Provide support for effective quarantine services.
- Provide support for laboratory capabilities, disease diagnosis and health certification. These activities should be consistent with regional quality control guidelines, i.e., standardization, nomenclature, technology transfer and monitoring/surveillance programs.
- Develop mechanisms for R&D support, including partnerships between government and industry.
- Increase capacity by providing support for training, technology transfer and support, and the institutions that offer them. This may include support from industry and other donors, such as international organizations.
- Promote training in the epidemiology of major shrimp diseases to improve awareness and develop practical health management schemes at the farm, national and regional levels.
- Emphasize education and awareness-building at all levels of the production chain. In particular, dissemination of information and training in hatchery production methods, the use of simple diagnostic methods for field use (e.g., rapid staining or dot blot methods), and basic methods of PL quality assessment are needed.
- Provide farmer and diagnostician training in the use and interpretation of diagnostic test results to avoid confusion, particularly for the more sensitive DNA-based methods.

(ii) Research and Development

There are many areas in which research is needed to support sustainable shrimp culture. The following areas were highlighted by the Working Groups:

- Develop treatment methods for live feeds to eliminate major pathogens without adversely affecting feed acceptability by broodstock.
- Develop epidemiological approaches to disease management.
- Develop simpler, faster, low-cost, pond-side diagnostics for real-time decision making.
- Evaluate the specificity of existing diagnostic tests to ensure accuracy of diagnostic interpretations, improve reliability and ensure appropriate coverage of all potentially pathogenic strains.
- Evaluate current methods of water treatment for their worth and effectiveness in reducing disease risk.
- Develop simple and cost-effective means of reducing exposure to land-based carriers of disease.
- Develop more information on the relative risk associated with farm practices, such as the use of equipment in several ponds.
- Evaluate the effectiveness of "green water" culture strategies to reduce the impact of disease outbreaks.
- Develop appropriate polyculture strategies to reduce disease transmission within the pond.
- Standardize and cross-validate tests between laboratories, as recommended by the expert consultation on DNA-based diagnostics.

(iii) Legislation, Policy and Planning

- Develop national strategies (master plans) for animal health in harmony with regional guidelines and policies. Government, industry and other stakeholders should be linked. Where regional guidelines do not exist, they should be developed using appropriate existing guidelines, which may need to be adapted to local/national situations, as models.
- Develop and promote codes of practice/conduct, as appropriate.
- Develop government infrastructure and industry liaison, as required, to manage, share experience, develop policy, promote awareness and identify expertise in relation to control, prevention and eradication of diseases.

(iv) Inter-regional Cooperation

- Give priority to collaboration between the Latin American and Asian regions.
- Support continued development of AAPQIS-Asia and initiate development of a similar information system, AAPQIS-Latina (Mexico, Central and South America).
- Recognize that some codes of practice and similar initiatives are mechanisms for interregional collaboration and development. Codes of practice requiring acquisition of broodstock from low prevalence or disease-free regions or zones are needed.
- Examine the applicability of the FAO/NACA guidelines to Central and South America.
- Develop plans for controlling important diseases on a regional basis
- Develop accreditation schemes for laboratories and promote participation in quality assurance programs to achieve uniform testing capabilities and standards.
- Exchange information on opportunities for small-scale livelihood focused development among countries. Successful experiences and priorities to support the small-scale sector should be discussed both regionally and inter-regionally.

III. Recommendations for the Control of Trans-boundary Movement of Shrimp Pathogens

The following are specific recommendations made by the Working Group for the Control of Trans-boundary Movement of Shrimp Pathogens:

- Quality assurance programs (HACCP) are considered the best strategies for immediate incorporation into the procedures manuals for hatcheries, farms and processors. The greatest impact is at the hatchery level and therefore, the greatest emphasis should be placed on implementation of programs aimed at quality assurance with regards to broodstock, nauplii and PL.
- A Quality Assurance Program for diagnostic labs is needed to insure that they are useful tools in the control of disease transmission. Standardization of techniques and training of personnel in molecular biology are the most immediate needs, however, training in all areas of pathology and a general standardization of techniques are recommended.
- There should be a continuous process of development of Codes of Conduct and Codes of Practice based on the FAO *Code of Conduct for Responsible Fisheries*, Chapter IX Aquaculture. The most logical sequence would be the low cost development and implementation of Codes of Conduct, which serve to raise levels of awareness. Further development would lead to the design and implementation of Codes of Practice beginning with self-evaluation but leading eventually to externally audited codes. The latter would potentially have greater impact but would require more time and money to implement.
- National reference pathology labs should be established to assure the quality of the local private labs in any country. These national reference labs would work with regional reference labs, if available, and with the existing OIE reference laboratories.
- Import Risk Analysis (IRA) appears to be an important tool in the control of disease transmission, but it is expensive and more difficult to implement than several of the other measures. Work should be initiated to define criteria, trade issues and regional or inter-regional issues related to IRAs now in order to permit their harmonization across countries and regions and their implementation at the earliest possible opportunity. Workshops should be held to train officials in the concepts of the IRA process, monitoring and contingency planning.
- Environmental Impact Assessments (EIA) are good tools for the prevention of disease. EIA's should directly address disease transmission issues, especially when considering the source of broodstock, nauplii and post-larvae shrimp. Countries that do not currently require EIA's for hatcheries or shrimp grow-out installations should require them.

Annexes I - V

Annex I Workshop Program

Management Strategies for Major Diseases in Shrimp Aquaculture
28-30 November 1999 - Cebu City, Philippines

Date	Time	Activity
28-11-99	08.30 - 09.00	Registration
	09.00 - 09.30	Opening Ceremony
	09.30 - 10.00	Introduction to the Workshop - **Dr. Michael Phillips** Background, objectives, and expected outcome - **Dr. Rohana Subasinghe**
	10.00 - 10.30	Coffee
	10.30 - 11.00	**Thematic Review 1** - Trans-boundary movement of aquatic animal pathogens: implications to aquaculture and biodiversity – **Dr. John Humphrey**
	11.00 - 12.30	Session I – Experience from Latin America
		Ecuador – **Dr. Victoria Alday** Honduras – **Mr. Hector Luis Corrales** and **Dr. John Wigglesworth** Nicaragua - **Mr. Larry Drazba**
	12.30 - 14.00	Lunch
	14.00 - 15.00	Session I continued
		Panama – **Mr. Reynaldo Morales** Peru - **Mr. Luis Zapata**
	15.00 - 15.30	**Special Lecture** - Species introductions, international conventions, and biodiversity: impacts, prospects, and challenges - **Dr. Devin Bartley**
	15.30 - 16.00	Coffee
	16.00 - 18.00	Session II – Experience from Asia
		Australia – **Dr. Peter Walker** Bangladesh – **Mr. Masudur Rahman (presented by Dr. Sunil Siriwardena)** China – **Prof. Jiang Yulin** India - **Dr. C.V. Mohan**
29-11-99	08.30 - 10.30	Session II continued
		Indonesia - **Dr. Akhmed Rukyani** Malaysia – **Prof. Mohd. Shariff** Philippines - **Dr. Juan Albaladejo** Sri Lanka - **Dr. Sunil Siriwardena**
	10.30 - 11.00	Coffee
	11.00 - 12.00	Session II continued
		Thailand – **Dr. Pornlerd Chanratchakool** Vietnam – **Mr. Le Van Khoa**
	12.00 - 12.30	General discussion
	12.30 - 14.00	Lunch
	14.00 - 15.30	**Thematic Review 2** - Aquatic animal pathogen transfers with special reference to point source contamination - **Drs. Rohana Subasinghe and Richard Arthur** **Thematic Review 3** - Viral disease outbreaks and their impacts on the industry: an industry point of view - **Mr. Dan Fegan** **Thematic Review 4** - Shrimp disease management in small-scale aquaculture practices - **Dr. Richard Callinan**
	15.30 - 16.00	Coffee

	16.00 - 18.00	Working group discussions
30-11-99	08.30 - 12.30	Working group discussions
	12.30 - 14.00	Lunch
	14.00 - 16.00	Working group presentations (30 minutes each) - chaired by **Dr. Devin Bartley**
	16.00 - 16.30	Coffee
	16.30 - 18.00	Final discussion, conclusions and way forward - chaired by **Dr. Rohana Subasinghe**

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Annex III Instructions to Reviewers

The review attempts to document the following information for all major disease outbreaks in individual countries included in the study.

- When and how (if known) did the first major outbreaks of disease take place? What is it and how long did the outbreak last in epizootic levels?
- What is the estimated damage to the industry/sector in terms of direct and indirect economic loss, employment, social implications, etc.?
- How did the government and state instruments respond to the disease outbreaks? What short-, medium-, and long-term interventions have been undertaken? The interventions, among many others, may include:
  - Immediate policy decisions on movement of post-larvae and broodstock.
  - Introduction of new rules, regulation, and legislation.
  - Introduction of quarantine, health certification, etc.
  - Financial assistance to farmers through grants, loans, subsidies, etc.
  - Technical assistance to farmers through R&D, post-larvae screening, PCR, domestication attempts, etc.
  - Local awareness building, workshops, public lectures, etc.
  - Training and capacity building within farmers, private sector and state sector personnel.
- How did the farmers respond to the disease outbreaks? What short-, medium-, and long-term interventions have been undertaken? The interventions, among, many others, may include:
  - Individual attempts to control through use of chemotherapy, etc.
  - Early harvesting
  - Requests for assistance from the state sector and financial institutions
  - Change of farm management practices
  - Closure of farms
  - Formation of societies
  - Collective action
  - Introduction of new species
  - New culture practices
  - Research and development programs, including development of diagnostic facilities, broodstock development and domestication programs, etc.
- How did the hatchery operators respond? The interventions, among, many others, may include:
  - Closure of hatcheries
  - Introduction of specific sanitary practices
  - Change of broodstock origin.
  - Provision of incentives to farmers, etc.
- How did the private-sector service providers, such as feed manufacturers/traders, post-larvae collectors and traders, shrimp processors and exporters respond to the situation?
- What specific sanitary procedures have been implemented at hatchery and farm levels?
- What specific research and development programs were undertaken by state and private sector to combat the disease situation? How economically feasible were the implementation of such R&D programs and has any major R&D program really taken off as a result of a major disease outbreak situation?
- The successes and failures of government and farmers interventions and strategies to control the disease outbreak and to improve farm biosafety. Investments made and costs/benefits of improved management practices.
- How effective were the responses?

- If the responses were not effective, what are the possible reasons?
- What lessons can be learned for future interventions, and emergency/contingency response to the inevitable future disease problems, including emergence of new pathogens and outbreaks of diseases?
- What forms of co-operative arrangement could work best? What specific needs could be identified as important to be addressed under co-operative arrangements?
- How effective has regional and inter-regional co-operation been? What type of regional and/or inter-regional co-operation could be effective?

Annex IV Summary of Development and Delivery of Practical Disease Control Programs for Smallholder Shrimp Farmers

During the past decade, recurrent outbreaks of infectious diseases, particularly those caused by viruses, have caused major losses of farmed shrimp across the region. As a result, many smallholders, who comprise the vast majority of shrimp farmers in most Asian countries, have suffered heavy financial losses. For example, in Thailand, in the years 1994-1997, viral diseases are estimated to have caused losses of A$1.1 billion, 400 million, 500 million and 1 billion, respectively.

In response, research groups within the region and elsewhere have worked towards developing effective farm-level control measures for important shrimp diseases. Key components of this work were done in Thailand, notably by AAHRI in collaboration with DFID, as well as by Thai universities and private sector organisations. ACIAR has also contributed substantially by funding several shrimp disease-related projects, including the recently completed FIS97/125 'Disease control programs for prawn farms in Indonesia and Australia : A pilot study'.

This collective regional research effort has resulted in a 'critical mass' of relevant expertise and information now being available for on-farm application and further refinement. However, because of limited capacities in technical implementation and extension in most regional countries, smallholders have generally failed to benefit.

In order to synthesise the available information and to focus in more detail on delivering disease control programs to regional smallholders, ACIAR held a workshop on 'Development And Delivery Of Practical Disease Control Programs For Smallholder Shrimp Farmers' in Jakarta on 6-7 June 2000. The workshop, attended by 21 regional shrimp health and aquaculture extension experts from Australia (AusVet, CSIRO, Fisheries WA, NSW Fisheries, NTDPIF, QDPI, UNSW), India (College of Fisheries, Mangalore), Indonesia (CRIFI, DGF), Philippines (BFAR) and Thailand (AAHRI, NACA) as well as several progressive farmers and ACIAR representatives, reviewed and integrated the findings of FIS97/125 with those of other recent, regional, farm-level, shrimp disease control projects.

Using this information, participants then produced a comprehensive list of best practice disease control and prevention strategies for smallholders, in which they scored the importance and current feasibility of each intervention. Of the 44 identified strategies, 9 were considered 'mandatory', 34 'very important' and the remaining one 'important'. All should therefore be seriously considered for inclusion in best practice disease control programs for smallholders.

In considering the current feasibility of implementing these measures, all but one of 44 strategies were scored as 'feasible, but some difficulties' (25) or 'probably feasible, but not certain' (18). This result suggests that while there are likely to be many practical obstacles to implementing disease control programs for smallholders, these obstacles are probably surmountable. The remaining strategy ('Screen PLs by one-step PCR and reject positive batches') was scored as 'doubtful feasibility'. Screening issues were recognised as one of four high priority areas urgently requiring attention (High Priority Research and Development Activities, see below) if reliable disease control and prevention programs are to be delivered to smallholders.

Participants also considered issues relating to extension of best practice disease control programs to smallholders. They noted that, while large commercial shrimp producers had often benefited from research findings, current extension systems within the region had generally failed to deliver effective programs to smallholders. In addressing this problem, participants agreed that effective extension must involve smallholders and other relevant stakeholders (government, scientists, economists etc) working in partnership to develop practical solutions, based upon the contextual needs of the farming community, to disease control problems. Participants noted that, compared with a top-down extension effort, this approach generally delivers much higher rates and a more sustainable processes for adoption.

A primary outcome of the workshop was production of a list of high priority Research and Development Activities aimed at promoting a coordinated, regional approach to future research and extension efforts on disease control and prevention for smallholder shrimp farmers. Four Key Issues, each with its component Target Areas, requiring action were identified as:

1. On-Farm Health Management
    a) Packaging of current best practice disease control strategies
    b) Disease control program development

2. Extension Services
    a) Packaging of information for farmers and technical services
    b) Delivering information to farmers
    c) Farmer networking

3. Screening Processes
    a) Screening strategy development
    b) Farmer-based PL testing
    c) Reliability/validity of stress testing
    d) Infrastructure development
    e) Training

4. Epidemiology
    a) Epidemiological approaches
    b) Information systems

It was proposed that funding and other support for these high priority R&D activities be sought as necessary from appropriate agencies committed to sustainable agricultural development and poverty reduction in the region. These included research and development funding bodies, World Bank and Asian Development Bank, APEC, NACA, OIE and public and private sector organisations in relevant countries.

Arising from the high priority R&D activities list, a funding application for a project entitled 'Development And Delivery Of Practical Disease Control Programs For Smallholder Shrimp Farmers' has been considered by ACIAR and approved for further development. Research groups from Indonesia, Thailand and Australia will participate in the proposed project.

Further action addressing the other high priority R&D areas is essential if the region's smallholder shrimp farming sector is to develop sustainably in the short to medium term. This requirement will be formally addressed, and support opportunities explored, by Jakarta workshop participants and other appropriate attendees at the FAO/Government of Australia Expert Consultation on Good Management Practices and Good Institutional and Legal Arrangements for Shrimp Culture to be held in Brisbane in December 2000.

Annex V Related Literature

The following presents a list of references refered to in the workshop and other related literature of interest

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