Shrimp Farming and the Environment

A Consortium Program
To Analyse and Share Experiences
on the Better Management of
Shrimp Aquaculture in Coastal Areas

A Consortium Program of:

WWF

SHRIMP FARMING AND THE ENVIRONMENT

A CONSORTIUM PROGRAM

"TO ANALYZE AND SHARE EXPERIENCES ON THE BETTER MANAGEMENT OF SHRIMP AQUACULTURE IN COASTAL AREAS"

DRAFT

Prepared by 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

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Preparation of this document

This report 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 Farming 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 report is a synthesis of the findings from the Consortium Program to March 2002.

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 is also gratefully acknowledged.

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Reference:
World Bank, NACA, WWF and FAO. 2002. Shrimp Farming and the Environment. A World Bank, NACA, WWF and FAO Consortium Program "To analyze and share experiences on the better management of shrimp aquaculture in coastal areas". Synthesis report. Work in Progress for Public Discussion. Published by the Consortium. 119 pages.

[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.

Executive summary

This report provides details of the activities and outcomes of work conducted under the World Bank, NACA, WWF and FAO consortium program on “Shrimp Farming and the Environment”.

Aquaculture is an important economic activity in the coastal area of many countries and offers a number of opportunities to contribute to poverty alleviation, employment, community development, reduction of overexploitation of natural coastal resources, and food security in tropical and sub-tropical regions. Global production of farmed aquatic animals and plants in 1999 reached 42.8 million MT with a value of US$ 53.6 billion. Of this, crustacean farming (shrimp, prawn and other minor crustaceans) accounted for about 3.7% of the total yield and represented 16.5% of the total revenue from aquaculture worldwide. The yield from shrimp farming alone represented about 2.6% of the total aquaculture output that year. In 2000, 1.1 million MT at a value of about US$ 6.9 billion of shrimp was produced, with yields from shrimp aquaculture representing more than 28% of the total shrimp market. The three main cultivated shrimp species (*P. monodon*, *P. vannamei*, and *P. chinensis*) account for more than 82% of total production. While *P. monodon* ranked 20th by weight in terms of global aquaculture production by species weight in 1999, it ranked first by value at US$ 4.05 billion (FAO 2002). The annual average increase in farmed shrimp production was 5-10% in the 1990s. This achievement was driven by the high value and market demand for shrimp that attracted considerable private and public sector investment.

Development of coastal aquaculture, and shrimp farming in particular, has generated debate in recent years over the social and environmental costs and benefits. Rapid expansion of shrimp farming in some countries in Latin America and Asia has focused attention on the need for effective management strategies. Such strategies are needed to enhance the positive contributions that shrimp farming and other forms of coastal aquaculture can make to economic growth and poverty alleviation in coastal areas, while controlling negative environmental and social impacts that may accompany poorly planned and regulated developments.

Recognizing that challenges for better management of shrimp aquaculture around the world are complex, and that improved practices often result from identifying and analyzing lessons learned and exchanging such information, the Consortium Program entitled "Shrimp Farming and the Environment" has been developed. The partners are the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wildlife Fund (WWF) and the Food and Agriculture Organization of the United Nations (FAO). The consortium supported some 35 complementary case studies prepared by more than 100 researchers in more than 20 shrimp farming countries. These cases have been developed through consultation with numerous stakeholders throughout Asia, Africa and the Americas. Cases range from specific interventions within single operations to thematic reviews of key issues in shrimp aquaculture. The overall goal is to document and analyze experience around the world in order to better understand what works, what doesn't and why.

This report synthesizes the major findings of the consortium program from 1999 till March 2002. It includes the outcome from a stakeholder workshop that discussed the program findings, hosted by the World Bank in Washington DC, in March 2002. Individual case study reports are being released in hard copy and via a web site www.enaca.org/shrimp. This synthesis report and the case study reports are intended for use and discussion among stakeholders to ensure that the findings from the Program have broad impact and relevance.

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Abbrevations and Acronyms

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
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DFID	Department for International Development (United Kingdom)
DIAS	Database on Introductions of Aquatic Species (FAO)
EIFAC	European Inland Fishery Advisory Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
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 (of FAO)
WB	World Bank
WTO	World Trade Organization
WWF	World Wildlife Fund

Introduction to the Consortium program

Background

In recent years, aquaculture has become an increasingly important economic activity and is now globally one of the fastest growing food producing sectors. Aquaculture is an important economic activity in rural areas of developing countries, offering opportunities for poverty alleviation, employment, community development, reduction of overexploitation of natural resources, and food security in tropical and sub-tropical regions.

Global production of farmed aquatic animals and plants in 1999 reached 42.8 million MT with a value of US$ 53.6 billion. Of this, crustacean farming (shrimp, prawn and other minor crustaceans) accounted for about 3.7% of the total yield and represented 16.5% of the total revenue from aquaculture worldwide. The yield from shrimp farming alone represented about 2.6% of the total aquaculture output that year or more than 1.1 million MT at a value of about US$ 6.7 billion. In 1999, yields from shrimp aquaculture represented more than 28% of the total shrimp market. The three main cultivated shrimp species (*P. monodon*, *P. vannamei*, and *P. chinensis*) account for more than 82% of total production. While *P. monodon* ranked 20th by weight in terms of global aquaculture production by species weight in 1999, it ranked first by value at US$ 3.6 billion. The annual average increase in farmed shrimp production was 5-10% in the 1990s. This achievement was driven by the high value and market demand for shrimp that attracted considerable private and public sector investment.

About 80% of the world's farmed shrimp comes from Asia, with most of the rest coming from tropical Latin American countries. Rapid growth and expansion of shrimp farming practices, fuelled by high profitability and demand by mainly affluent consumers in importing countries, has provided several developing countries in Asia and Latin America with substantial foreign currency earnings. Most shrimp farming in Asia is undertaken by small-scale farmers owning less than 5 ha of land located in rural coastal areas and in both Asia and Latin America, shrimp farming has emerged as a main source of employment and income for hundreds of thousands of people. Additional employment and income is generated in supply industries as well as in shrimp processing and distribution 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, investment in shrimp farming continues in Asia and Latin America, and there is growing interest in Africa, where there has been only little shrimp culture development to date.

Development of coastal aquaculture, and shrimp in particular has generated debate in recent years over the social and environmental costs and benefits. Rapid expansion in Asia and Latin America has been accompanied by rising concerns over environmental and social impacts of development, and controversy associated with shrimp culture in 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 of shrimp products, and, more generally, over the long-term sustainability of shrimp farming. Major issues raised include the ecological consequences of conversion of natural ecosystem, particularly mangroves, for construction of shrimp ponds, the effects such as salination of groundwater and agricultural land, use of fish meal in shrimp diets, pollution of coastal waters due to pond effluents, biodiversity issues arising from collection of wild seed, and social conflicts in some coastal areas. The sustainability of shrimp aquaculture has been questioned by some in view of self-pollution in shrimp growing areas, combined with the introduction of pathogens, leading to major shrimp disease outbreaks, and significant economic losses.

Rapid expansion and increasing awareness of such problems has focussed attention on the need for better strategies to manage the sector. Such strategies are required to enhance the positive contributions that shrimp farming and other forms of coastal aquaculture can make to economic growth and poverty alleviation in coastal areas, while controlling negative social and environmental impacts that may accompany poorly planned and regulated development.

Recognizing that challenges for better management of shrimp aquaculture around the world are complex, and that improved practices often result from identifying and analyzing lessons learned and exchanging such information, the Consortium Program entitled “Shrimp Farming and the Environment” has been developed. The partners are the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wildlife Fund (WWF) and the Food and Agriculture Organization of the United Nations (FAO). The consortium supported 35 complementary case studies prepared by more than 100 researchers in more than 20 shrimp farming countries. These cases have been developed through consultation with numerous stakeholders throughout Asia, Africa and the Americas. Cases range from specific interventions within single operations to thematic reviews of key issues in shrimp aquaculture. The cases have been presented and discussed at more than 150 meetings and workshops worldwide. The goal of the cases is to document and analyze experience around the world in order to better understand what works, what doesn't and why.

Objectives

The Consortium Program is based on the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture[3], the World Bank review on Shrimp Farming and the Environment[4], and an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. There are six objectives to the Consortium Program:

1. Generate a better understanding of key issues involved in sustainable shrimp aquaculture;
2. Encourage a debate and discussion around these issues that leads to consensus among stakeholders regarding key issues;
3. Identify better management strategies for sustainable shrimp aquaculture;
4. Evaluate the cost for adoption of such strategies as well as other potential barriers to their adoption;
5. Create a framework to review and evaluate successes and failures in shrimp aquaculture which can inform policy debate on management strategies for sustainable shrimp aquaculture; and
6. Identify future development activities and assistance required for the implementation of improved management strategies that would support the development of a more sustainable shrimp aquaculture industry.

The Consortium is giving special attention to poverty, labour and equity issues, and the work will provide an assessment of the use of investments in shrimp farming as a means of alleviating poverty through targeted development interventions in coastal areas.

The Consortium Program was initiated in August 1999, and comprises some 35 complementary case studies on different aspects of shrimp aquaculture (Table 1). The case studies provide wide geographical coverage of major shrimp producing countries in Asia and Latin America, as well as Africa and the Middle East, and studies and reviews of a global nature. The subject matter is also 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 bring together unique and important insights into the global status of shrimp aquaculture and management practices. While there is limited shrimp farm development to date in Africa, that case provides guidance on important issues to consider with a likely future development of shrimp farm development in that region.

[3] 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.
[4] World Bank. 1998. *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.

Methodologies

The program comprises complimentary case studies that have been prepared by more than 100 researchers in more than 20 shrimp farming nations. The subjects to be included are derived from the recommendations of the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture, the World Bank review on Shrimp Farming and the Environment, and particularly an April 1999 meeting on shrimp management practices hosted by NACA and WWF in Bangkok, Thailand. Cases were selected to broadly cover the following issues:

Sustainability

The cases address what are the necessary conditions for sustainable shrimp farming, including:

- Appropriate institutional and legal framework for shrimp aquaculture.
- Integrated management of coastal areas and opportunities/limitations for shrimp aquaculture.
- Appropriate institutional mechanisms, human skills and delivery of information.
- Devolution of management to the appropriate level of responsibility.
- Technical and non-technical aspects of management and their influence on sustainability.
- Shrimp disease/health issues will also be included, as they have been a major sustainability issue.

The cases also explore the role and applicability of the Code of Conduct for Responsible Fisheries (FAO, 1995) that is used as a framework for more detailed analysis at the country level in some studies.

Governance, Legislation and Experience with Existing Regulations and Procedures

Legislation related to shrimp farming has been introduced in some countries, but little is known about the implementation and effects of these rules and regulations. In other aquaculture countries, specific legislation has governed development for many years. The study focuses on legislation related to shrimp farming, while drawing on the experience of other types of aquaculture in countries where legislation has been introduced, and where there is long-term experience with such legislation. The study looks into enforcement instruments, and examines lesson's learned from failures and successes.

Incentives and Disincentives for Investment in Sustainable Shrimp Aquaculture

Tax and other incentives have been used to promote the development of shrimp farming, or aquaculture in general, have been introduced in a number of countries, but information on their positive and negative effects is generally limited. The case studies examine incentives including the results of these incentives in countries where they have been introduced. The case studies also identify potential better management strategies would also provide a basis for the development of incentives promoting sustainable shrimp farm investments.

Social Impacts and Employment in Shrimp Farming

Many authors mention the social impacts of shrimp farming, including both positive and negative aspects. Several cases of social unrest have been reported. However, few, if any, attempts have been made to study the causes and results of these incidents, the degree of success of conflict management strategies, or of the social effects in general. The case studies gather information on the social interactions and employment of shrimp farming in selected countries and identifies examples of where management practices have been adopted that improve the social benefits of shrimp farming.

Some case studies have been chosen to explore conditions under which poverty alleviation on coastal communities might be alleviated through shrimp farm development. The potential applications of shrimp farming/coastal aquaculture targeted for poverty reduction among the coastal poor with few, if any, capital assets, are to be explored. The study investigates if shrimp farming is an appropriate occupation in which coastal poor households should become involved. Such an assessment is done in the light of the track record of risk facing the industry. The study explores the experiences and mechanisms that may ensure success (e.g. joint credit liability schemes, cooperative arrangements, etc.) where shrimp culture is a viable option for development in coastal communities.

Environmental Impacts and Management

The environmental issues related to shrimp aquaculture include the loss of mangroves and wetlands from conversion to shrimp ponds, collection of wild post-larvae and broodstock, the use of fish meal in shrimp diets, shrimp disease spread, and the effects on water quality and salinization, and the use of chemicals substances, as well as impacts of other sectors on water quality for shrimp aquaculture. The cases were chosen to bring together various experiences on the environmental impacts and in successful and unsuccessful environmental management strategies for shrimp aquaculture.

Better Farm Management Practices

Farmers have made progress in the development and implementation of better practice management, although experience suggests that local circumstances and farming systems determine the types and success of different management systems. Several cases were selected to assist further development and understanding of better farm management practices and their application to shrimp aquaculture, including also the practicalities of applying codes of practice. The cases also give special attention to economics and profitability—including particularly the costs and benefits of development and implementation of best practices, as well as the effectiveness and cost-benefit of applying codes of practice.

Implementation Arrangements

The program was implemented through a consortium comprising the World Bank, NACA, WWF and FAO. A small informal steering committee was established for the project, including World Bank, NACA, WWF and FAO personnel. The steering committee approved the Terms of Reference that were prepared for each case study, and provided guidance in implementation of the program. Terms of Reference were additional circulated for peer review and comment before approval.

The implementation of individual case studies involved both international and national experts, and participation of government, non-government and shrimp industry participants. Emphasis was given to national experts in underteking case studies, and over 100 researchers have become involved. In addition to experts contracted for individual case studies, a team of economists from the Institute of Environmental Studies (IvM), Netherlands and Department of Economics (CSUF), USA also provided important inputs.

Funding Arrangements

The case studies supported under the program were jointly funded and executed by the World Bank-Netherlands Partnership program, WWF, NACA and FAO sources. The financial assistance came from the Government of Netherlands and the MacArthur and AVINA Foundations. In all, the budget for the work of the consortium totaled just over US$1 million. However, the work of the consortium benefited considerably, in fact was even made possible at all, due to significant expenditures on primary research from a number of different organizations (multi- and bi-lateral agencies, research institutes, individual researchers, companies, foundations, and NGOs) whose results were generously shared. The sums spent by these agencies totaled, were far greater than the sums directly spent for this work.

Purpose and Organization of the Report

This report summarises accomplishments and findings from the consortium program. The first draft report was prepared for a stakeholder workshop hosted by the World Bank in Washington DC in March 2002 and the current version has been finalized based on comments received at this workshop. This document is now being made available for wider public discussion, and comments received will be incorporated into a final document for publishing by the consortium.

This synthesis report is divided into the following sections:

- **Background section**, providing information on the objectives and activities of the consortium.
- **Brief description of the case studies** on shrimp aquaculture and other activities supported under the World Bank-Netherlands partnership program grant.
- **Global status of shrimp aquaculture** overview.
- **Major findings** and issues arising from the case studies.
- **Draft BMP matrix**, including costs, better/worse practices, costs and impacts and measures required to support implementation of better management practices, including the need for technical guidelines and other support (e.g. institutional requirements) and thresholds – economics, standards, etc.
- **Information on the impacts** of consortium work.
- **Follow up actions** and recommendations.

The Bank requested an update for the Environmental Assessment Sourcebook[5] on shrimp aquaculture. This sourcebook will be prepared and distributed separately.

Acknowledgements

The case studies supported under the program are jointly funded and executed by the World Bank-Netherlands Partnership Program, WWF, NACA and FAO. The financial assistance from the Government of Netherlands and the MacArthur and AVINA Foundations in supporting the work is also gratefully acknowledged.

The contributions of researchers, farmers, government and non-government agencies and others that supported and participated in the case studies are also gratefully acknowledged. The list of stakeholder meetings and workshop given in Annex B gives an indication of the number of people involved. The authors are particularly grateful to all for their valuable insights and contribution to this unique work.

[5]This Environmental Assessment Sourcebook will incorporate the BMP findings from the consortium work

Details of Case Studies and Consortium Program Activities

Case Studies

The work of the program progressed and expanded significantly from the start in August 1999 and during 2000, and by March 2001 comprised of 35 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 of a global nature. The subject matter covers a wide range of topics, from farm level management practice, poverty issues, integration of shrimp aquaculture into coastal area management and policy and legal issues. The case studies together provide unique and important insights into the global status of shrimp aquaculture and management practices. With regard to the Africa case, where there is only limited shrimp farm development to date, the case study document provides guidance on issues to consider in the shrimp farm development process.

The finalization of the case study reports has taken longer than anticipated, due to the large number of cases undertaken, the time taken to gather comments and inputs from different authors and the extended review process involving different stakeholders. A table and executive summaries of all cases are provided in **Annex A.** In Table 1 the different cases are presented.

Table 1. Different case studies undertaken by the Consortium work.

Thematic Reviews

Title of case study
Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture Prepared by: *Donald J. Macintosh, Michael J. Phillips, Robin Lewis III and Barry Clough*
Codes of Practice for Marine Shrimp Farming Prepared by: *Claude Boyd, John Hargreaves and Jason Clay*
Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture Report of the Workshop held in Cebu, Philippines from 28-30 Nov1999
Thematic Overview of Social Equity, benefits and Poverty Alleviation BMP's of the Shrimp Aquaculture Industry Prepared by: *Jason Clay*
An Analysis of Shrimp Aquaculture Legislation Prepared by: *Annick Van Houtte and William Howarth*
Innovation and the Implementation Deficit: Assessing Shrimp Producing Countries Based on Their Effectiveness in Implementing the FAO's Code of Conduct for Responsible Fisheries and Related Guidelines and Standards in the Context of Shrimp Aquaculture Prepared by: *David Barnhizer*
Chemical and Biological Amendments Used in Shrimp Farming Prepared by: *Claude E. Boyd*
Global Review of Feeds Management Practices in Shrimp Aquaculture Prepared by: G J Tacon

Asia-Pacific Countries

Country	Title of case study
Australia	The Environmental Management of Shrimp Farming in Australia Prepared by: *Nigel Preston, Peter Rothlisberg, Michele Burford and Chris Jackson*
Bangladesh	Social Aspects of Shrimp Aquaculture in Bangladesh Prepared by: *Anwara Begum and S.M. Nazmul* Case Studies on Shrimp Aquaculture Management in Bangladesh Prepared by: *Rahman M., P.P.G.S.N. Siriwardena and Wajed Shah*
China	Shrimp Farming in Rushan Country, China Prepared by: *Anantha Kumar Duraiappah*
India	The Role of Small Farmer Groups and Associations in Sustainable Shrimp Aquaculture Management Prepared by: *Kutty, M.N., P. Ravichandran, M. Krishnan, M. Kumaran and C.P. Balasubramanian*
Indonesia	Good Practices for Community-Based Planning and Management of Shrimp Farming in Sumatra, Indonesia Prepared by: *James Tobey, Hermawati Poespitasari and Budy Wiryawan*
Philippines	Mangrove Management and Aquaculture in the Philippines Prepared by: *Dioscoro M. Melana, E.E. Melana, C.E. Yao and Edgar L. Abuan*
Sri Lanka	Report on a Code of Good Management Practices for Shrimp Aquaculture in Sri Lanka Prepared by: *Siriwardena, P.P.G.S.N.*
Thailand	Case Study on Institutional Aspects of Shrimp Aquaculture in Thailand Prepared by: *Nissapa, Ayut and Somsak Boromthaanarat*
Thailand	Assistance and Issues in the Implementation of the Code of Conduct for Shrimp Aquaculture Prepared by: *Siri Tookwinas*

Vietnam	Coastal Shrimp Aquaculture: Searching for Better Management Practices – Some cases from the North and North-Central Vietnam. <u>Prepared by:</u> *Tran Van Nhuong, Raymon van Anrooy and Michael Phillips.* Silvofishery Farming Systems in Ca Mau Province, Vietnam Part a) Background and technical recommendations <u>Prepared by</u>: *Barry Clough, Danielle Johnston, Tran Thanh Xuan and Michael Phillips* Part b) A Socio-economic study <u>Prepared by:</u> *Pednekar, Sunil S, Nguyen Huu Thien, Pham Le Thong and Truong Hoang Dan* Studies on Mixed Rice-Shrimp Aquaculture Systems in the Mekong Delta <u>Prepared by:</u> *Nigel Preston and Donnah Brennan*

Latin American Countries

Country	Title of case study
Belize	Evaluation of Belize Aquaculture, Ltd. - A Super-Intensive Shrimp Aquaculture System in Belize <u>Prepared by:</u> *Claude E. Boyd and Jason Clay*
Brazil	Key Management Challenges for the Development and Growth of a Shrimp Farm in Northeast Brazil -- A Case Study of Camanor Produtos Marinhos Ltd. <u>Prepared by:</u> *Barbara Schwab, Michael Weber and Bernard Lehmann*
Brazil	Barriers to Investing in Shrimp Aquaculture – Lessons from Brazil <u>Prepared by:</u> *Patricia Moles..*
Colombia	The Integration of Mangrove and Shrimp Farming: The Case Study of Agrosoledad on the Caribbean Coast of Colombia <u>Prepared by:</u> *Dominique Gautier*
Colombia	The Adoption of Good Management Practices by the Shrimp Industry on the Caribbean Coast of Colombia <u>Prepared by:</u> *Dominique Gautier*
Ecuador	Case studies on shrimp aquaculture management in Ecuador covering: (I) Use of wild post larvae (II) Composition of shrimp pond soils in former mangrove versus non-mangrove areas (III) Farm management and concentration of potential pollutants in effluents (IV) Water exchange practices (V) Status of mangrove forests <u>Prepared by:</u> *Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd*
Honduras	Science and Society in the Gulf of Fonseca: The Changing History of Mariculture in Honduras <u>Prepared by:</u> *Denise Stanley' Carolina Alduvin and Amanda Cruz*

Honduras	Coastal Water Quality Monitoring in Shrimp Farming Areas with an Example from Honduras Prepared by: *Claude E. Boyd and Bart Green*
Mexico	Shrimp Aquaculture, People and the Environment in Coastal Mexico Prepared by: *Billie R. De Walt, Lorena Noriega, Jaime Renan Ramirez Zavala and Rosa Esthela Gonzalez*

Africa and the Middle East Countries

Country	Title of case study
Regional	Review on Shrimp Farming in Africa and the Middle East Prepared by: *Rafael Rafael and Jason Clay*

Information Dissemination and Participation of Stakeholders

The consortium program approach emphasizes consultation with as many stakeholders as possible throughout the study, at all levels from local to international. The preparation of the case studies has incorporated the views and inputs from a wide range of stakeholders, from local communities to global multilateral organizations. Several cases entailed widespread consultation with local farmers and communities, through community workshops and participatory meetings. In Bangladesh, for example, the researchers consulted stakeholders at all levels; from poor women and landless households involved in shrimp fry collection to senior government officials involved in policy development. The consultations with landless women in particular provided an important insight to the dependence of poor families in coastal Bangladesh on shrimp aquaculture for their livelihood. This type of open and participatory approach to the development of the cases has provided a unique opportunity to gain understanding, generate consensus and identify management experiences from a wide range of stakeholders involved in this complex sector. The case study findings have been presented to stakeholders on many occasions. A special session on the consortium work was organized at the World Aquaculture Society (WAS) meeting in May 2000 at Nice, France. The session included presentations by consortium members on the status and findings of various components of the program. The list of meetings and consultations organized for such purposes are given as **Annex B.** As the reports have been finalized, case study findings are being discussed with a wider audience. This approach is designed to ensure that the findings will be based on widespread consultation and will have widespread impact and relevance. To ensure quality of the case study material, all case studies have also been subject to an expert review process.

A web site on the consortium work and case studies has been developed (http://www.enaca.org/shrimp). The web site provides an opportunity for comments to be received and published on each of the cases, to promote wider public discussions of the findings. The web is increasingly be used as a means of disseminating information arising from the studies. Translations of case study materials into Spanish, Portuguese, Thai and Mandarin Chinese, have been initiated to disseminate findings to non-English speakers. Priority will be given to further translations.

The results from the Bank funded work will also continue to be disseminated through the regular publications, consultations/workshops and policy meetings organized by World Bank, NACA, WWF and FAO, allowing widespread dissemination of the findings and lesson's learned.

A list of publications from the consortium program is also provided in **Annex D**.

Conference on Aquaculture in the Third Millennium

The Conference on Aquaculture in the Third Millennium was held in Bangkok from the 20^{th}-25^{th} February 2000 co-organized by NACA and FAO and hosted by the Government of Thailand. The conference involved some 540 participants from 66 countries, representing a wide range of stakeholders from government, non-government, the private sector and regional and international organizations. The World Bank-Netherlands partnership funds were used to support selected participants from developing countries involved in the shrimp case studies to attend.

The Conference was a landmark assessment of the present status of aquaculture and an important opportunity to discuss and identify strategies for future development of the sector on a global scale. Based on the deliberations at the Conference, the delegates prepared and adopted the Bangkok Declaration and Strategy for Aquaculture Development beyond 2000. This document, published and widely distributed in April 2000, provides a summary of the major issues to be addressed and future development strategies for aquaculture, with a strong emphasis on social, economic and environmental sustainability. Many of the issues discussed are relevant to shrimp aquaculture, and the Conference provided an important opportunity to identify strategies for better management of the sector in the future. The text of the Declaration and Technical Report from the Conference can be found at www.fao.org/fisheries. They together represent also a particularly important and timely synthesis of the present status and future directions for aquaculture development at a global level.

The Conference also made a recommendation for establishment of intergovernmental forum for discussion of global aquaculture issues. FAO convened a meeting immediately following the Conference that considered the recommendations of the Bangkok Declaration and Strategy and proposed constitution of a sub-committee on aquaculture within the FAO Committee on Fisheries (COFI) to facilitate implementation of the recommendations, particularly those of global and inter-regional nature. This proposal was subsequently adopted by the 24th COFI meeting held in Rome on 26th February to 2nd March 2001 and the First Session of the sub-committee will be held in Beijing China during April 2002. The Conference, and the support provided to the Conference from World Bank-Netherlands partnership, therefore contributed to the establishment of this new forum on major aquaculture issues.

FAO / Government of Australia Expert Consultation

The findings from the shrimp case studies likewise represent a globally unique and important collection of information on better management of shrimp culture and some were also discussed at a FAO/Australia expert consultation on shrimp aquaculture management, held in Brisbane during December 2000[4] (FAO/AFFA. 2001) This meeting reached initial agreement on a set of objectives and operating principles for sustainable shrimp aquaculture management. These and other relevant information will soon be presented to an intergovernmental forum for formal agreement. FAO is facilitating this process. Related issues were also discussed during the first meeting of the COFI Sub-Committee on Aquaculture held in Beijing, China P.R. in April 2002. This meeting recognized the outcome from the Consortium studies and recommended continuation of such work. The Program has therefore provided an important basis for consensus building for better management of shrimp aquaculture.

The issues identified during the Brisbane meeting provides a useful general framework for better management in the sector and are given as **Annex C**.

This co-operative approach provides an important platform for gaining understanding and sharing experiences globally on shrimp aquaculture management. The next stage of work must focus on support to implement the findings. This reflects a key concern among consortium partners to translate the information generated into improved capacity and better management practice from the pond level to the ecosystem, national and international levels. As aquaculture continues to expand globally, and becomes more diverse and complex, the need to promote co-operation, capture lessons learned, and share learning and experiences will increase. The Consortium's partnership approach shows that such co-operation is not only fruitful in the short-term but also provides a platform upon which such cooperation can be further extended in the future.

An Overview of Shrimp Aquaculture and its Global Status

Production Trends

Global production of farmed aquatic animals and plants in 1999 reached 42.8 million MT with a value of US$ 53.6 billion. Of this, crustacean farming (shrimp, prawn and other minor crustaceans) accounted for about 3.7% of the total yield and represented 16.5% of the total revenue from aquaculture worldwide. The yield from shrimp farming alone represented about 2.6% of the total aquaculture output that year.

In 2000, 1.1 million MT at a value of about US$ 6.9 billion of shrimp was produced, with yields from shrimp aquaculture representing more than 28% of the total shrimp market. The three main cultivated shrimp species (*P. monodon*, *P. vannamei*, and *P. chinensis*) account for more than 82% of total production. While *P. monodon* ranked 20th by weight in terms of global aquaculture production by species weight in 1999, it ranked first by value at US$ 4.05 billion (FAO 2002). The annual average increase in farmed shrimp production was 5-10% in the 1990s. This achievement was driven by the high value and market demand for shrimp that attracted considerable private and public sector investment.

Table 1. Total world production of farmed shrimp in 2000, by weight and value. Source: FAO (2002).

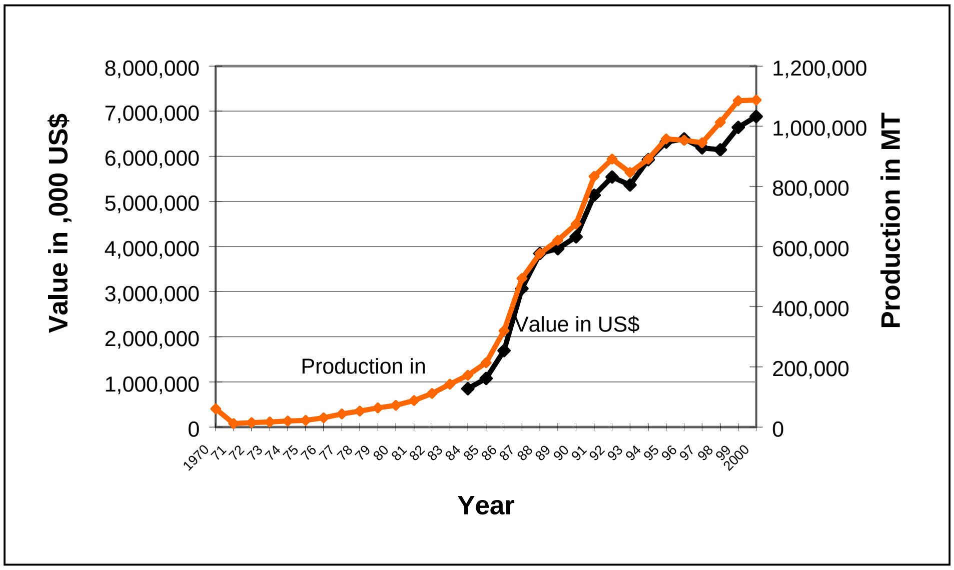
Shrimp species	Production (MT)	Production (,000 US$)
Giant tiger prawn *Penaeus monodon*	571,499	4,032,044
Fleshy prawn *Penaeus chinensis*	219,152	1,324,969
Whiteleg shrimp *Penaeus vannamei*	140,785	861,774
Penaeid shrimp *Penaeus* spp (spp not given)	74,694	312,971
Banana prawn *Penaeus merguiensis*	45.718	179,933
Metapenaeid shrimp *Metapenaeus* spp	21,149	78,263
Kuruma prawn *Penaeus japonicus*	3,184	24,497
Indian white prawn *Penaeus indicus*	4,371	23,094
Southern white shrimp *Penaeus schmitti*	1,350	4,725
Natantian decapods *Natantia*	540	3,529
Blue shrimp *Penaeus stylirostris*	503	2,017
Akiami paste shrimp *Acetes japonicus*	544	408
Redtail prawn *Penaeus penicillatus*	44	275
Palaemonid shrimp, spp not given	110	330
Total	**1,083,641**	**6,863,537**

Table 2. Global trends in farmed shrimp production quantity (MT) and value (US$)

Year	Production (MT)	Production (,000 US$)
1989	621,254	3,955,472
1990	674,949	4,219,418
1991	833,770	5,139,097
1992	890,283	5,544,184
1993	845,825	5,360,677
1994	890,724	5,924,019
1995	957,766	6,310,477
1996	953,018	6,385,411
1997	945,069	6,184,755
1998	1,013,063	6,143,522
1999	1,084,875	6,640,551
2000	1,083,641	6,863,537

Asia dominates shrimp production. In 2000, seven of the top ten shrimp producing countries were Asian, accounting for 75 % of the global production. The giant tiger shrimp (*P. monodon*) is the major farmed shrimp species making up around 52% of total global shrimp production. Asia makes up the bulk of the 571,499 tonnes of *P. monodon* cultured (Table 1). Other crustacean species cultured include *P. merguiensis*, *P. indicus* and *Metapenaeus* spp.

In Latin America, the western white shrimp (*P. vannamei*) dominates, accounting for more than 90% of production. Other species include the western blue shrimp (*P. stylirostris*).



Globally, smaller amounts of shrimp are farmed in the Pacific (mainly New Caledonia, that produced around 1,723 tonnes in 2000), the Middle East (Iran, Saudi Arabia) and in Africa. The African east coast countries of Egypt and Madagascar also have a small but increasing production of farmed shrimp. The main species in these new shrimp producing countries in Africa and the Middle East is *P. monodon*, a species that occurs naturally in the region. The major shrimp producing nations are Thailand (an estimated unofficial production around 300,000 tonnes in 2001) followed by China, Vietnam and Ecuador. A list of the 25 largest farmed shrimp producers is given in Table 3.

Table 3. The top 25 producers of farmed shrimp in 2000 by weight and value. Source: FAO (2002).

Country/Territory	Production(MT)	Production (,000 US$)
Thailand	299,700	2,125,384
China	217,994	1,307,964
Indonesia	138,023	847,429
India	52,771	393,938
Vietnam	69,433	319,392
Ecuador	50,110	300,660
Philippines	41,811	271,385
Bangladesh	58,183	199,901
Mexico	33,480	194,184
Brazil	25,000	175,000
Malaysia	15,895	124,577
Colombia	11,390	91,120
Sri Lanka	6,970	78,342
Taiwan, Province of China	7,237	60,483
Honduras	8,500	59,500
Venezuela	8,200	34,030
Australia	2,799	27,557
Madagascar	4,800	24,000
Nicaragua	5,411	17,423
USA	2,163	14,513
Belize	2,648	12,710
New Caledonia	1,723	12,061
Costa Rica	1.350	11,475
Panama	1,212	6,399
Peru	512	3,741

On the three maps below the development on the most important shrimp farming Regions and countries can be seen:

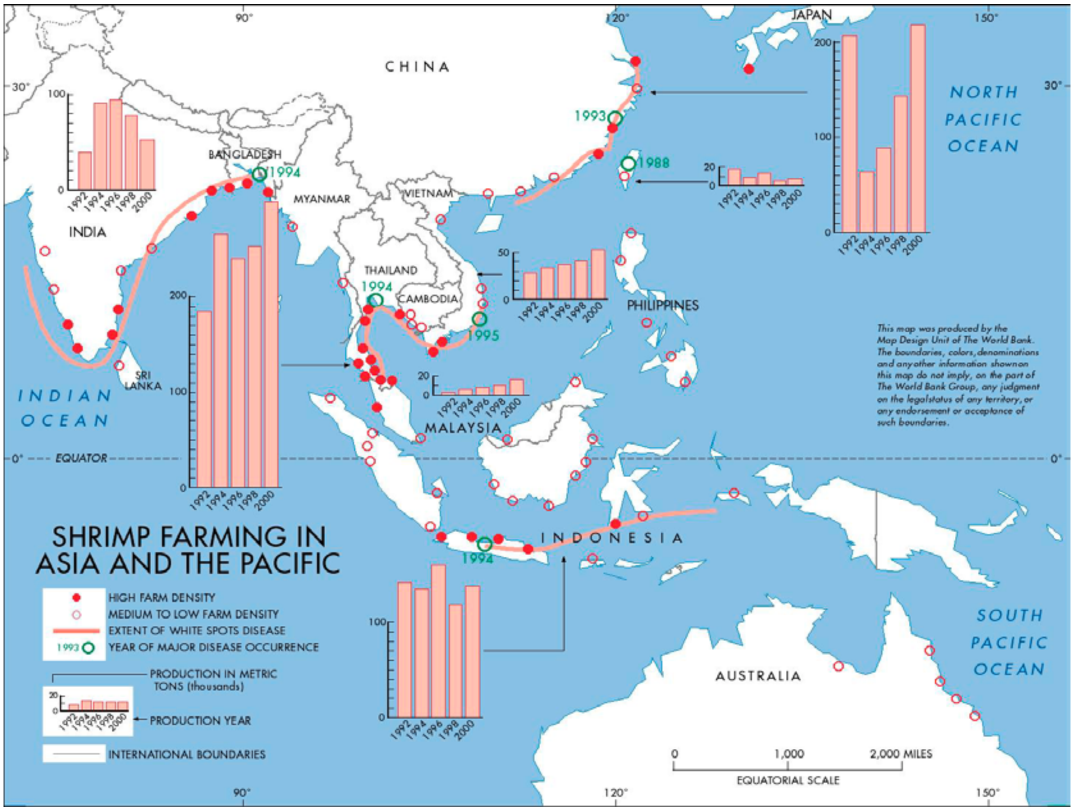


Figure 1. Map showing the more important shrimp farming areas in the Asian Pacific Region and the extend of White Spot Syndrome Virus (WSSV) (FAO 2002;Rosenberry 2001)

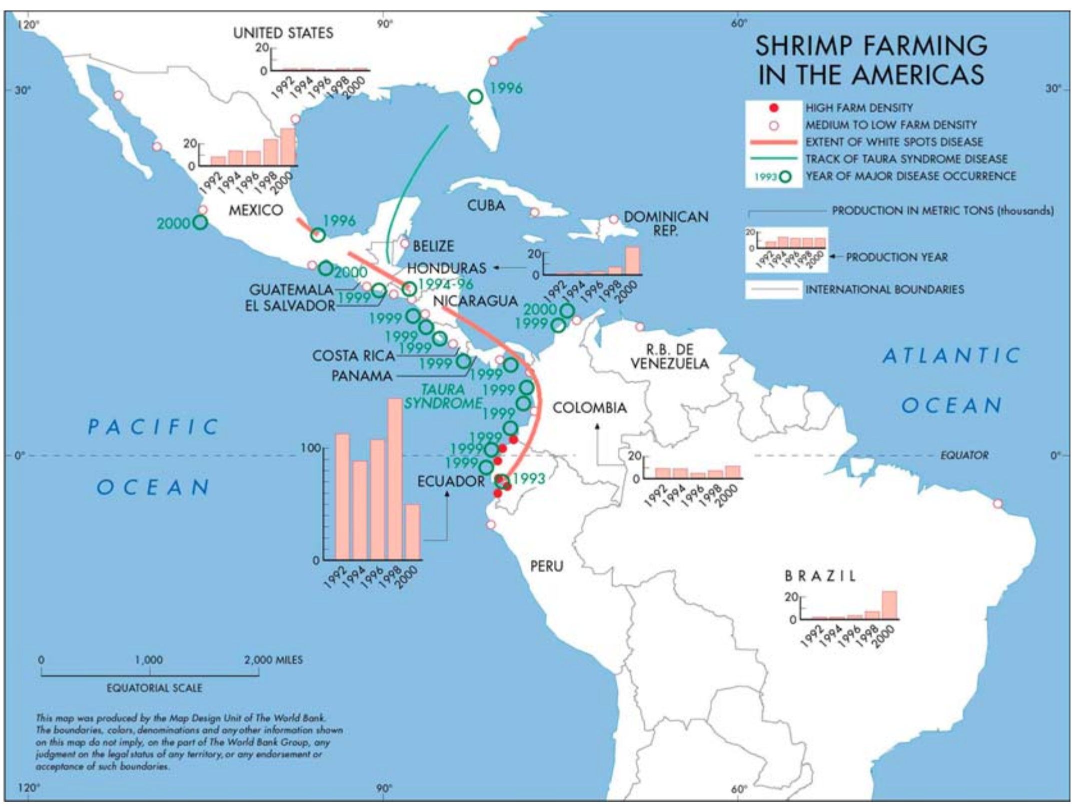


Figure 2. Map showing the more important shrimp farming areas in the Americas and the extend of White Spot Syndrome Virus and Taura Virus (FAO 2002;Rosenberry 2001)

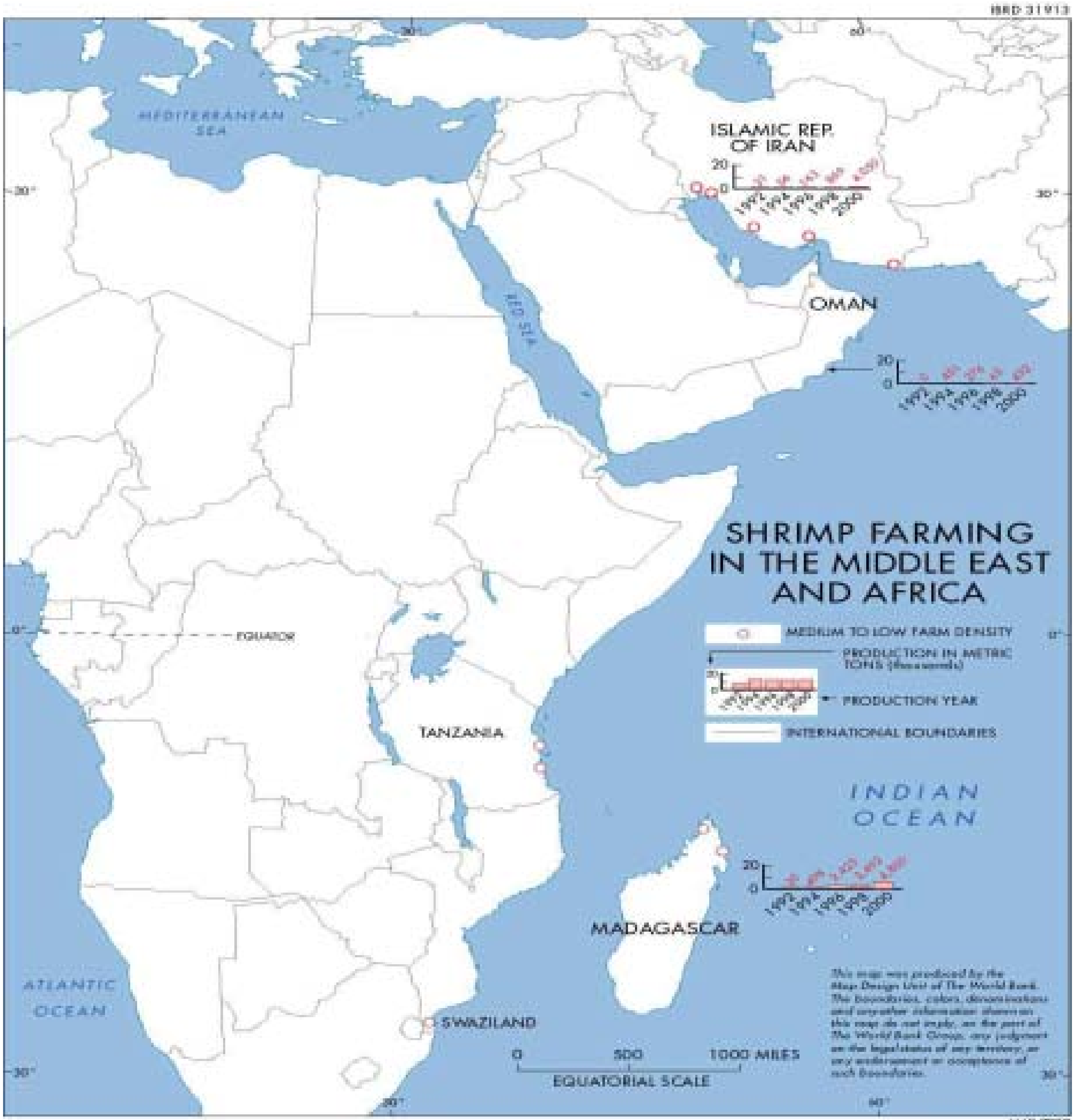


Figure 3. Map showing the more important shrimp farming areas in the Middle East and Africa (FAO 2002; Rosenberry 2001)

Diversity of Farming Systems

The farming of all shrimp species is similar, involving the stocking of juvenile shrimp in coastal ponds, where they are grown over 3 to 6 months until they reach a market size. The shrimp juveniles in the majority of nations now come from hatcheries. In Asia, mature adults are collected from the wild fishery and spawned in hatcheries to produce juveniles. In Latin America, there is increasing use of domesticated shrimp to produce juveniles. A small proportion of farms stock wild juveniles collected directly from nature, usually by poor coastal fishers, but the majority (probably greater than 95% of farms) use shrimp juveniles from shrimp hatcheries.

Grow out of the juvenile shrimp takes place in ponds, usually located in coastal areas. The type and size of ponds, the location, and management systems are extremely diverse. Shrimp farms are commonly classified by stocking density into extensive or traditional systems (low stocking density), semi-intensive (medium stocking density) and intensive (high stocking density); however, this simple classification system hides a wide diversity of farming systems.

The extensive farms are low input farms, characterized by low stocking densities, tidal water exchange and shrimp yields of less than 500 kg/ha/yr. In Asia, such farms are common in **Vietnam, India, Indonesia** and **Bangladesh.** These ponds tend to be located in intertidal areas because they need tidal water exchange. Farms may culture one species (monoculture) or more commonly a mix of species. Extensive systems are also commonly operated in several countries as "mixed" systems (e.g. shrimp and mangrove farms) or part of an alternate cropping system, that may involve one crop of shrimp followed by a harvest of another species or crop. For example, farmers living in the coastal deltas of the Ganges, Krishna and Mekong river systems in Asia practice alternate cropping of rice and shrimp; a crop of shrimp in the brackish dry season followed by a crop of rice in the rainy season. Extensive farms are of variable size, but generally extensive farms tend to cover large areas, in some countries (but rarely) up to several 100 ha in area.

Semi-intensive farms involve more inputs, supplemental feeding, intermediate stocking levels, power to pump water and investment, and consequently have higher output yields, generally of 0.5-2 MT/ha/yr. Such farms are found in many nations of Asia and Latin America, including **Ecuador**. Shrimp pond sizes are variable, but specialized semi-intensive shrimp ponds average from 2 to 30 ha. Most Latin American nations practice some form of semi-intensive shrimp culture.

Intensive shrimp farming involves smaller ponds (0.1 – 2 ha) with higher inputs, higher stocking density, formulated feeds, aeration, water pumping and more investment, with yields of more than 2 MT/ha/yr. Intensive systems are common in South East and East Asian nations, particularly Thailand. In Latin America, there are few intensive farms, except in **Belize** where a new intensive farming system produces up to a whopping 28 MT/ha/yr (Boyd and Clay 2002).

Shrimp farming has also been classified by some as 'traditional' or 'industrial' shrimp farming, but such terms do not describe the extreme variation in shrimp farming systems. An important consideration when discussing shrimp farming, and its social and environmental interactions, is the diversity of farming systems in operation as well as their location, size, management and the people involved. The case studies also bring to light an important divergence in shrimp farming – from small-scale farms often with low investment and involving poor coastal dwellers, to more intensive farms with high investment. It should be noted that although much recent investment in shrimp farms tend to be more intensive or semi-intensive, extensive farms still contribute significantly to the world's farmed shrimp production.

The shrimp-farming sector undergoes rapid change. The occurrence of shrimp viral disease in particular has had a significant impact in the past 5 years, and in Latin America, this has led to major changes in management and farm types. The trend in this region is from large extensive and semi-intensive farm ponds towards much smaller ponds that can better managed and made more secure from the risks of introduction of viruses ("biosecure"). The global trend is towards smaller ponds, that probably make more efficient use of land area, and towards more biosecure farm operations, although achieving biosecurity on many extensive farms, and with poorer producer groups, remains a major constraint.

The shrimp farm sector also supports a large number of associated "industries", such as input suppliers (hatchery operators, manufacturers and suppliers of feeds, equipment, chemicals, consultants *etc.*) and people and businesses dealing with post-harvest handling and processing, distribution, marketing and trade. This diverse and sometimes fragmented industry structure has to be considered in assessments of the nature of shrimp farming and in the implementation of better management practices.

Market Chain

The following information on market chains is based on "best guess" estimates totaled from information gathered throughout the 3-year process of gathering information and impressions for the work of the consortium. This information is not intended to be authoritative only indicative and relative. There is clearly a need for this type of information and hopefully these estimates, crude as they may be, will elicit the kind of discussion and debate that will allow better estimates to be generated over time.

Production

Some 1.5 to 2 million hectares of ponds are in production at any time. There may be as much as 10 or 20 percent of the total pond areas that are fallow for any given crop cycle. Most of the existing ponds produce 2+ crops per year. The exceptions to this are found in the areas on the edges of the tropics where cold weather allows for only one, albeit a longer, crop.

Globally, there are a few hundred thousand producers, perhaps some 300,000 more or less. The value of the crop is estimated by FAO as $6.9 billion at the farm gate (and as more than $7-$8 billion after processing). There is increasing vertical integration of production, with both buyers and input suppliers providing credit in the form of inputs and agreeing to buy the harvest. Given that the cost of feed and PL are the two main production costs around the world, this form of credit "in-kind" provides much of the needed working capital. Increasingly, buyers are attempting to place conditions on their purchases that are based on product health and safety concerns (e.g. use of chemicals and medicines).

Several global trends are affecting shrimp market chains. Three important factors are the costs and uncertainty of production, the declining price for shrimp, and the growing concern about product quality in consuming countries. These factors have generated considerable interest on the part of many in the market to find ways to reduce costs, increase efficiency and increase accountability in the market chain. Increasingly, this results in the development of various forms of "contract farming" to insure product quality, to address chain of custody concerns and to reduce transaction costs. Overall, these efforts make the market chain more transparent.

Shrimp aquaculture has had a positive impact on employment and worker income in many parts of the world, particularly in areas that are more isolated and less connected to national societies through infrastructure. Data from around the world suggests that some 1.2 to 1.5 million full time equivalent jobs are created directly in shrimp aquaculture production. While the multiplier effect is not known for shrimp aquaculture and will likely vary considerably from one country to another, it is safe to suggest that 3 to 6 times as many jobs are created indirectly as directly by the industry. This would be an addition 3.6 to 9 million jobs. If average family size is 5 people, then some 6-7 million people are supported directly by the industry and another 18 to 45 million people could be supported by the industry. Of course the number of people affected is much greater because a number of the positions in and associated with the industry are part time positions.

Post Larvae and Feed Providers

Shrimp aquaculture producers either buy their PL from hatcheries or from consolidators that work with individuals who collect the PL from the wild. The overwhelming trend is toward the use of hatchery provided PL and away from the use of wild-caught PL. While precise data does not exist globally, a reasonable estimate would suggest that 65-75 percent of all PL at this time used by the industry are produced in hatcheries. There are more than 1,000 hatcheries globally, and they probably employ fewer than 100,000 people. In Asia, smaller hatcheries are more common. In Latin America, much larger hatchery and captive breeding programs are more common. Increasingly, broodstock in Latin America are produced in hatcheries breaking even the dependence of the industry on wild caught broodstock. The total value of the hatchery produced PL is probably less than $1 billion per year, but the price can vary tremendously from country to country as well as year to year.

Wild caught PL are a declining source of seed for shrimp producers, but they can be a significant source in some countries (e.g. Bangladesh) or for smaller, poorer producers. Globally, there are more than 1 million people engaged on a part time basis collecting wild PL. There are thousands of bundlers who combine the catch of many and either sell directly to producers or to another layer of consolidators. Globally, some 25-35% of PL demand is supplied with wild caught PL. The final value for the wild PL is perhaps some $400 million, but the original collectors receive a much lower price for the PL they collect.

In many parts of the world, the wild caught PL traditionally sell for a higher price per thousand PL, but that situation is now changing. Many countries have prohibited the collection of wild PL because they are concerned that that seed can inadvertantly bring disease into the ponds. In addition, breeding programs in Latin America are now demonstrating that hatchery PL have higher survival rates as well as higher production rates. This is even the case in Ecuador where the use of wild caught PL was the most significant in Latin America.

Feed is the single largest input cost for shrimp producers. The total cost of feed used by the industry is probably about US$1.5 billion per year. Globally some 50 companies produce the vast majority of feed. Five to ten companies probably account for 70% of total feed production. CP in Thailand, for example, produces two-thirds of all the feed in that country, and the company is a major supplier of feed in China, Indonesia, India, Bangladesh, Malaysia and the Philippines. Actual employment in feed plants is relatively small, however, as most manufacturing plants are highly mechanized. Globally, perhaps a few thousand people are involved in the production of shrimp feed.

Processor to Port

Most shrimp around the world is sold into independent processing plants. Only the largest producers have sufficient production to justify a processing plant. In Latin America, a higher percentage of producers have their own processing plants, but even in that system a total pond area on the order of 250-300 ha of semi-extensive production is required to keep a plant occupied.

In Asia, many farmers sell their product to independent buyers who consolidate it and sell it own to processing plants. Some of these buyers are connected with specific processing plants; others are independent and supply different processors depending on the price they will pay or the volume to be processed they already have in hand. In Thailand, most shrimp are sold through a consolidator system rather than directly to processing plants. In general, the chain of custody issue is quite difficult to address in most producing countries.

Globally, there are thousands of processing plants, but probably no more than 100 dominate the market because of their volume. These are located in only 5-10 countries. The value of the product, depending on the value added processing, is perhaps $7-$8 billion. Basic processing creates a considerable amount of product differentiation (e.g. whole, headed, pealed, de-veined, etc.). More sophisticated processors can also butterfly, bread, or even add product to pre-cooked soups, egg rolls or other dishes. The degree of value added processing depends primarily on the cost of labor locally.

While some processing is undertaken to satisfy specific consumer markets (e.g. the US market prefers headed and even peeled product), a significant proportion of processing is undertaken to “improve” product quality by removing or disguising evidence of disease.

Once the shrimp is processed, it is very easy to trace product back to the processing plant. Most shrimp is packed in either 2 kg or smaller packages. Each package has a bar code which not only indicates the country of origin but also the processing plant and time of processing. In Latin America, processing plants include the shrimp farm and even the specific pond information within the bar code. Processors do this as a way to limit their liability. This model will probably tend to become more common in Asia as consuming countries insist on higher quality products without chemical and medical residues.

The current bar code system, which is a series of parallel lines, is limited to a 15-20 bits of information. There are, however, two dimension bar codes with cross hatched lines that allow for as much as 2,500 bits of information. To date, these bar codes are used more for product management in warehouses. In the future, they could be used to document a tremendous amount of production information including better practices for production, handling, and processing. The potential for this information to be used is still unrealized, but it could provide a useful basis for consuming companies interested in greening their supply chains or for companies interested in selling products with some form of certification.

Once processed, most aquaculture product is exported. There are a few notable exceptions, however. For example, China consumes a significant portion of its aquaculture production. For the most part, aquaculture production is exported. Some processors export their own product but most do not. There are perhaps 1,000 companies that export or import shrimp aquaculture products. As few as a few dozen companies dominate the markets. The CIF value of imported shrimp products is probably in the range of US$8-US$10 billion with the US accounting for US$3 billion or more of these imports.

Exporters and importers can either take legal/physical possession of the product, or they can act as brokers and work on a commission. In the case of brokers, the commission is usually on the order of 1-2 percent. Importers may make a margin of 3% or more. They make their money on volumes of trades and turnover of product. Importers do not want to hold product; they want to sell it immediately to keep their money working.

For developing countries, the major contribution of shrimp farming is foreign exchange earnings (for importing companies/countries there is substantial profit arising from trade, marketing). Exports of fresh and frozen aquaculture shrimp are within the top foreign exchange earners in major shrimp producing countries in Asia. In Thailand, fresh and frozen shrimp export value was estimated as over US$2.0 billion in 2000, the fourth most important export by value. In India, marine product exports reached record levels of US$1.4 billion in 2000, of which shrimp accounts for 71% of the value. In Ecuador, exports of shrimp (the major part of which are farmed shrimp) reached over US$500 million per year (Olsen and Coello 1995), although exports have been severely hit in 1999 and 2000 as a result of shrimp disease outbreaks.

Importing Countries

Once the product enters the importing country and clears customs it is handled by distributors. Some of these companies are vertically integrated as importers, exporters from the producing countries and even processing. Others are integrated into the market within the importing companies as wholesalers.

Globally, there are a few thousand distributors. There are a few dozen that dominate markets in the main consuming countries. They operate on 3-7% markups making their profits on volume and rapid turnover. Forward contracting is practiced in some countries by some of the larger users in order to guarantee future supplies and prices. Many distributors have important relationships with large retailers or restaurant chains who do not want to get involved in the export/import business but who want to reduce their risk of not having product available to them on a timely way. Most large buyers do not want to tie up a lot of capital in warehouses until they use it. They prefer just in time delivery and are willing to pay a somewhat higher price for this. The higher price, however, is often offset because they expect to negotiate a volume discount. The trend at this time is for the number of players in the distribution and wholesale level to be reduced as a way of reducing overall transaction costs and the time of finding new sources of product from a number of different sellers.

There are several thousand wholesalers in the major consumer countries. They tend to hold product longer and to deal in smaller quantities, so their overall costs are higher. Depending on their volume of trade and the number of retail clients they have, their markups can be as much as 5-12%. The number of wholesalers is being reduced in most consumer countries, and the margins are also declining as market chains become more efficient.

There are hundreds of thousands of retailers (e.g. fishmongers, grocery stores, restaurants) who sell shrimp produced from aquaculture. They generally have markups of 15-100% on the shrimp they sell. Retailers tend not to pass on savings to consumers in declining markets, but quickly pass on price increases.

There are 1 billion or so consumers who purchase shrimp produced by aquaculture. By the time the shrimp is actually purchased at the consumer level, the total value may be as high as $50-$60 billion. Overall, shrimp consumption seems to be income-dependent rather than price dependent, at least in the US. That means that consumption tends to depend on the overall level of income of the consumer and the general health of the economy rather than the price per se.

Market Trends of Note

There are several factors that are shaping the overall markets for shrimp produced from aquaculture.

There are increasing concerns regarding chemical residues found in shrimp. Shrimp from China and Vietnam have been confiscated and destroyed in the EC due to the discovery of chloramphenocal. As a consequence, shrimp shipments are under increasing scrutiny in the EC and other importing countries (e.g. Japan and the US) and for a wider range of contaminants (e.g. PCBs, dioxins, and furazolidone).

The price of shrimp has steadily declined on the global market, with a few exceptions, for more than a year. There has been considerable speculation on shrimp and as a consequence, prices continue to decline and stockpiles increase. This will affect markets for at least the coming year.

For nearly a decade, the consumption of shrimp has been in decline in Japan. In part, this appears to be related to the overall economic situation, but it also appears to be related in part to decreasing interest in shrimp.

There is increasing consumer interest in certification and eco-label systems. While the interest in certified products is perhaps more pronounced in Europe, it is also common in the US as well.

Increasingly, consumers are concerned about how the product they consume is produced. Most broadly the issue is whether the products are produced from aquaculture or are wild caught. However, it is increasingly of concern how the aquaculture production takes place as well. Furthermore, as consumers become more aware of social and environmental impacts, it is likely that this issue will drive consumer preference even more.

Major Issues and Management Responses

The information generated through the case studies, and the various workshops and other participatory consultations held with a wide range of stakeholders (**Annex B**) provide a better understanding of the key issues that have to be addressed, and better management practices for shrimp aquaculture that can be adopted. The case study material has been used to encourage a debate and discussion around these issues with the hope of achieving more consensus among stakeholders regarding key issues. The case study findings now provide a basis of moving forward towards better management of shrimp aquaculture.

The key issues emerging from the cases and discussions are summarized below, together with examples of management responses. Reference to individual case studies is given where appropriate. Additionally, reference is given of the role and applicability of the Code of Conduct for Responsible Fisheries.

Overview of Major Issues

Environmental Issues

Environmental interactions of shrimp aquaculture in general arise from a wide range of interrelated factors including availability, amount and quality of resources utilized, type of species cultured, size of farm, farming systems management, and environmental characteristics at the location of the farm. The interactions arise because shrimp aquaculture relies heavily on environmental "goods" (e.g. water, feed ingredients, seed *etc*) and "services" (e.g. coastal ecosystems for pond water discharge).

Three issues arise from these interactions: (a) Aquaculture in general, and shrimp farming in particular, is highly sensitive to adverse environmental changes (*e.g.*, water quality, seed quality), and can be seriously affected by aquatic pollution. (b) Aquaculture inevitably interacts with non-aquaculturists that rely on similar "common" resources such as water and public land and conflicts may arise where formal and informal institutional/legal/social structures are inadequate for conflict resolution and allocation of resources among competing groups. (c) It is in the long-term interests of aquaculturists to work towards protection and enhancement of environmental quality. The latter raises interesting possibilities for shrimp farmers to work in partnership with communities and other groups with a mutual interest in protection of aquatic environments. Examples of this trend can be found in several case studies, in Ecuador and Thailand, where producer associations are working with government to protect and manage mangrove and in Madagasgar, where farmers are working with government to establish industry regulator frameworks.

The main environmental interactions of coastal shrimp culture are now well known – relating mainly to the habitat and resources required for shrimp aquaculture. Environmental impacts may arise through impacts of environmental change ***on*** aquaculture; ***of*** aquaculture on the environment; and impacts ***of*** aquaculture ***on*** aquaculture. Major environmental issues include:

- Ecological consequences of conversion and changes in natural habitats, such as mangroves, associated with construction of shrimp ponds and associated infrastructure.
- Discharge of pond effluent leading to water pollution in farming and coastal areas.
- Seepage and discharge of saline pond water that may cause salinity changes in of groundwater and surrounding agricultural land.
- Use of fish meal and fish oil in shrimp diets.
- Improper use of chemicals raising health and environmental concerns.
- Spread of shrimp diseases.
- Trans-boundary movements concerning spread of genetic materials, exotic species and disease.
- Biodiversity issues primarily arising from collection of wild seed.

An important issue also relates to the *efficiency* of use of resources in shrimp aquaculture, compared to other alternate or competing resource users.

As will be seen below, the extent and significance of environmental interactions is highly variable, depending on farming system, location, economic and social factors and other incentives and disincentives. Although this makes it difficult to generalize, the cases do provide examples of better management and farming systems that have reduced environmental impact and better efficiency. One of the features of this diverse sector appears to be the opportunity to considerably improve farming practice to address environmental impacts, in ways that are profitable.

Employment and Social Impacts

The case study work confirms that shrimp farming is an important source of employment in many developing countries and the investment and economic output from shrimp generates considerable employment in developing (but also developed) countries from input suppliers (e.g. hatchery operations, feed sales), producers (farmers and farm workers) and in post-harvest and processing, including employment for women. Shrimp farming is often conducted in remote coastal areas, with little alternate employment, and indeed can become a very significant source of employment. There are also a diversity of people involved in shrimp farming, from various backgrounds, social groups and traditions. The employment generated in distribution, marketing and trade is also significant, and stretches through a global market chain from the local farmer in coastal area of a developing country to consumers in western countries.

On the other hand, social conflicts have arisen in some coastal areas as a result of introduction of shrimp aquaculture. The case studies therefore explore some of the causes of these conflicts and means of addressing them. Particular attention is also given to poverty issues and shrimp aquaculture development, through studies in Bangladesh and Vietnam (Begun and Nazmul 2002).

In many ways, the global expansion of shrimp farming, generated by demand from western consumers, epitomizes many of the challenges faced in making globalisation work for the poor.

Management Responses

The management responses to the environmental, social and economic issues that have emerged in shrimp aquaculture can be seen at different levels, at the level of the farm and its immediate surroundings, at the level of local coastal communities and the local coastal areas, at national and regional and international levels.

The FAO Code of Conduct for Responsible Fisheries (CCRF) (FAO 1995) and associated Technical Guidelines (FAO 1997) in very broad terms identify these management strategies, focusing on level of the producer and State. The Code provides a range of provisions that address important issues relevant to shrimp aquaculture. In addition to Article 9 "Aquaculture Development", which explicitly covers major aspects of aquaculture, there are also significant provisions in other sections of the Code having an important bearing on aquaculture and its general development context. The case studies explore different management options in relation to the CCRF.

Various commentators have emphasized the importance of implementation of the Code of Conduct, and other global or regional documents. The cases therefore examine issues concerning implementation of what is already known about better management practices.

Environmental Issues

Mangroves and Coastal Wetland Habitats

Major Issues

The sites selected for shrimp aquaculture and the habitat at the farm location play one of the most important roles in the environmental and social interactions of shrimp aquaculture. There are numerous examples of farms located in suitable areas, which cause few or no environmental problems. Conversely, it there are examples of poorly sited farms, for example located in mangrove areas that have clearly damaged mangroves, mud flats, salt marshes and other forms of coastal wetland.

Site selection for shrimp aquaculture is governed by many factors, including climate, elevation, water quality, type of soils and vegetation, infrastructure, legislative aspects and land availability among other factors. The result is that shrimp ponds are found on many different types of land in coastal areas, including inter-tidal land (mangroves, mud flats and salt pans) and land above the high tide mark (rice fields, other agricultural land and saline areas). The sites above the tide are much more suitable for semi-intensive and (particularly) intensive aquaculture because they allow for easy drainage of ponds and drying of the pond bottom between crops, thus improving bio-security and reducing disease risks. Recent trends in some countries, in both hemispheres, are towards use of land above the intertidal area.

The pattern of coastal land use differs considerably between countries, and even withing countries. In countries with little mangrove forest, such as China, Japan and South Korea, ponds are constructed on agricultural land of low productivity, or under-utilized saline land, and in these countries shrimp farming has had virtually no impact on mangroves, but may impact tidal marshes. In countries with significant mangrove resources, farms may be constructed on various types of land, depending on such factors as government policy, availability of non-mangrove land, population pressures and infrastructure development (e.g. road access).

Land use patterns also change with time. In Ecuador, for example, the favored sites for shrimp farms were originally salt pans, or "salinas". Once these sites were used up, the industry moved to less favorable areas, including mangrove habitats (Sonnenholzner et al. 2002). The results of a 1994 survey in Asia show the diversity of land use types and that extensive shrimp farms in particular were greatest 'consumers' of mangrove land (see Table 4). The conversion of mangrove habitats to shrimp aquaculture has dominated much discussion of the debate on environmental interactions of shrimp aquaculture, and the issue is directly addressed in the mangrove thematic review. However, conversion of other land, including tidal marshes and salt pans, is also important and should be considered (Machintosh et al. 2002).

Major Findings and Lesson's Learned

The Conversion of Mangrove Habitats

It is increasingly recognized that mangroves do not make good sites for semi-intensive and intensive shrimp farms and in several countries more recent shrimp pond expansion has tended to be on higher land behind or away from mangrove areas. In Thailand, extensive shrimp farms were traditionally located in low lying (inter-tidal) coastal wetlands, but this preference has changed to towards supra-tidal land (above the maximum tide level), where ponds are cheaper to construct, drainable and soils are normally more suitable for intensive culture (Menasveta 1997). The major loss of mangroves in Thailand occurred from extensive shrimp farming during the 1980's when 64,992 ha of mangroves were converted to shrimp ponds. Menasveta (1997). An unknown amount of that conversion has been converted to temporarily disused or abandoned ponds in need of restoration (Stevenson et al. 1999) (**Don Sak Thailand Case Study**). Menaveta (1997) concluded that the recent trend towards intensive shrimp farming located behind mangroves in Thailand has tended to reduce further damage to mangroves and this trend provides an example of a better management practice, and is a management trend that should be encouraged.

Table 4. Estimated land use type for shrimp farming in 12 Asian countries, based on a farm level survey of ~5,000 farms conducted during 1995 * (ADB/NACA 1997).

Land use type (prior to shrimp farming)	**Intensive farms**		**Semi-intensive farms**		**Extensive farms**	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Intertidal land						
Ex-mangrove	14,142	19.0	24,786	18.6	359,118	41.9
Non forested wetland	8,669	11.6	25,206	19.0	136,121	15.9
Salt pan	7,496	10.0	4,242	3.2	20,649	2.4
Other-intertidal	6,470	8.7	14,603	11.0	195,948	22.9
Supra-tidal land						
Rice farm	22,515	30.2	19,397	14.6	122,087	14.3
Other agriculture	8,432	11.3	4,603	3.5	8,215	0.9
Non-agriculture	7,397	9.9	36,278	27.3	25,601	3.0
Estimated total farm area	74,600	100	133,000	100	856,300	100

* Includes Bangladesh, Cambodia, P.R. China, India, Indonesia, R. O. Korea, Malaysia, Philippines, Sri Lanka, Taiwan, Thailand and Vietnam. The total shrimp farming area was estimated to be 1,063,900 ha in 1994.

A number of studies attempt to quantify the country loss from conversion of mangroves to shrimp ponds.

In Indonesia, studies carried out using satellite imagery during the early 1990’s showed that 56% of shrimp ponds in North Sumatra were built on what had been (in 1977) primary forest areas, 15% in secondary areas and 29% in fringe areas without forest cover (McPadden 1993). In Java, traditional mangrove *tambak* ponds have been constructed for centuries, providing important sources of income and food for coastal people on a sustainable basis (Schuster 1952). Although mangroves have been converted to shrimp ponds traditionally throughout Indonesia, current estimates suggest that 5% of the total Indonesian mangrove resource has been used for coastal aquaculture ponds for the farming of shrimp and milkfish (Spalding et al. 1997). Sammut and Hanafi (**Indonesia case study on soils, within the mangrove thematic review**) however, have estimated that 128,420 ha of abandoned shrimp ponds, due to acid sulfate soil problems, exist in Indonesia.

The amount of conversion of mangrove to shrimp farms in Ecuador can be obtained from statistics showing that mangrove forest reserves declined from about 204,000 ha in 1969 to 162,000 ha by 1992 (CLIRSEN 1992). There were about 120,000 ha of shrimp ponds in Ecuador in 1992, none of which were constructed until the early 1970’s. Thus, if the entire loss of mangrove had resulted from shrimp farm construction, 35% of shrimp farms could have been constructed in mangrove areas. It is known that mangroves were converted to other uses in Ecuador (e.g. for urban expansion, timber – see Ecuador case study report), so the figure of 35% is an overestimate. Local level studies indicate that in some estuaries losses from shrimp pond construction may be higher, such as the Bolivar-Chamanga-Cojimies and Rio Chone. Mangroves in Taura and Estero Salado have also been reduced significantly by the urban expansion around Guayaquil (Bodero and Robadue 1995). Since 1995, the land use situation appears to has stabilized and the **mangrove thematic review** indicates there may have been a small (2%) net gain in mangrove area overall in Ecuador.

The **mangrove thematic review** concludes that shrimp farming has contributed to loss of mangroves, particularly within the last 20 years. The review notes that greatest losses have arisen from extensive culture systems that occupy large areas of intertidal land, but due to the variability and general unreliability of available data, particularly on the status and quality of mangrove forests involved, it is impossible to assign a reliable global figure for the mangrove losses from shrimp culture. Nevertheless, some estimates have been made in the review.

The total global mangrove resource has been estimated at 181,077 km^2 (18,107,700 ha) based largely on data collected in the 1980’s. In Asia, if 37% of shrimp farm area is on ex-mangrove land, the 402,199 ha, this represents is 5.3% of the existing mangrove resource area of 7,517,300 ha. On the other hand, pond area figures do not always include ponds that have been abandoned so the figure may be an underestimate.

As the historical mangrove coverage is higher than this figure, the total regional loss from shrimp farming is estimated as less than 5%. In South and Central America, shrimp farming occupied around 185,100 ha in 1995 that represents around 3.8% of the existing American mangrove resource. There are no data from which to estimate the percentage loss in most other Latin American nations, but the evidence suggests that the percentage loss of mangrove to shrimp farming in the other countries probably does not exceed 10% of the total mangrove loss that has occurred since the 1960s.

Globally, if it is assumed that all of the 12,855 km^2 (1,285,550 ha[6]) of ponds reported by Rosenberry (1999) were converted from mangrove land, then shrimp ponds would account for 7.6% of the present resource, representing less than 5% of the total historical resource. An analysis undertaken for the World Wide Fund for Nature (Clay 1996) also concluded that "... the extent of mangrove destruction world-wide resulting from shrimp farming is only a tiny fraction of the total lost to date… ". The same report estimated that "Globally, shrimp farming is not responsible for even a quarter (perhaps even as little as 10%) of the mangrove clearings that have taken place since 1960." These figures are essentially confirmed by the analysis of the **mangrove thematic review**. Extensive shrimp farming has made by far the most significant contribution to the mangrove losses from shrimp aquaculture, and the recent trend away from large pond areas to smaller more intensive ponds has implications for more efficient land use and ecological implications. However, it should be noted that locally, such conversions can result in severe habitat loss.

Major Factors Contributing to Conversion of Mangrove to Shrimp Aquaculture

- Extensive shrimp farming.
- Uncertain land ownership and rules governing access to mangrove areas
- Governance and institutional failure to effectively manage coastal mangrove resources.
- Environmental changes and shrimp disease, leading to shifting practice.
- Poor planning of coastal land use and implementation of development plans
- Difficulties in enforcement, unrealistic modes of implementation of legislation (e.g. zonation schemes)
- Lack of participation of communities in decision making and management (development of legislation, enforcement).
- Institutional responsibilities poorly defined and lack of co-ordination between different levels and different sectors of government
- Market forces and perceptions of high profitability versus risk from shrimp culture, based on short-term financial considerations rather than long term economic ones.
- Major land use changes and infrastructure development in coastal areas.

The mangrove thematic review emphasizes that shrimp culture is but one of the many causes of mangrove losses, along with population pressures, pollution, logging and conversion to agriculture, industrial and urban areas. Taking an example from Thailand, the largest producer of farmed shrimp in the world, forestry scientists (**Thailand case study in mangrove thematic review;** Aksornkoae, 1996) records that there have been several reasons for loss of mangroves in Thailand, including agriculture, salt production, mining, resettlement programs and industrial and other infrastructure developments, as well as extensive shrimp farming. There are clearly areas where mangroves have been denuded by shrimp farming, but this loss also has to be seen in the perspective of the overall pressure on coastal resource. While better management of shrimp aquaculture can avoid siting of shrimp farms in mangrove areas, the findings imply that better management of mangroves requires understanding and management of the multiple uses and pressures on coastal mangrove resources. Some of factors contributing to conversion of mangrove to shrimp farms based on the thematic review findings are noted in the above box.

Other impacts on coastal areas include those on inter-tidal mudflats, salt pans, and salt marshes. Again, most problems relate extensive farming and could be solved by locating farms out of the inter-tidal area.

[6] These figures do not consider the question of "abandoned" ponds.

Major driving forces, such as those noted in the box, play a similarly important influence in the conversion of such lands to ponds.

The Impacts of Conversion of Mangroves and Coastal Wetlands

The impacts of conversion of mangrove to shrimp aquaculture ponds, and mangrove habitat in general are well known, although there is considerable variation between sites. These impacts may derive from loss of habitat due to direct replacement or through off-site impacts such as hydrological change, effects caused by removal of habitat and fragmenting of remaining habitat. Individual effects of farms may be minor, but as farm numbers and area increase the impacts can increase dramatically as they accumulate over time and space. Unfortunately, the thresholds in this process are still very poorly understood. These impacts can by addressed by adopting effective site selection in ways that do not replace habitat, or cause hydrological change or fragmentation of remaining habitat and restoring ponds back to wetlands when no longer in use

The case studies provide some examples where loss of mangroves has led to localized decline in fish stocks, other ecological changes and loss of livelihood opportunities for coastal people. However, it emphasizes that such changes are highly site dependent, and notes that such problems can be effectively eliminated with better management. An important issue raised is that more intensive farming practices have a more limited demand for land, that may be a major advantage over extensive farms, where large areas of land may be required for profitable enterprises. As the requirement for land increases, so do the potential impacts on habitats, and the people dependant on those habitats, particularly where coastal populations are high.

The social impacts of land use changes may also be significant. There have been trends in some countries, and this is documented in the Bangladesh study, towards loss of access to traditional common property resources, for grazing of livestock, fishing and access to canals and water bodies. Often, such changes impact most significantly on the livelihoods of poorer people living in coastal areas.

Shrimp Aquaculture and Other Coastal Land Types

The development of shrimp farms on other land types (that actually comprise the majority) has not raised the same level of concern as the development in mangrove wetland habitats. Here, again the emphasis on more effective local management arrangements for making decisions on resource use appears to be critical. The management interventions are similar to those that can be applied to mangroves.

In two country case studies, Bangladesh and Vietnam, shrimp has been developed extensively on rice farming land in coastal deltas, covering 10’s of thousands of hectares. Shrimp has often been cultured as a dry season crop in traditional farming systems in these coastal areas (salinity enters the delta waterways during the dry season; during the rainy season large freshwater discharges drive out the salinity and allow rice culture). Shrimp has emerged as an important source of income for coastal farmers in these two countries. The examples provided by these traditional systems show that shrimp culture can be an alternate crop, rather than as a replacement crop.

Management Strategies

Major factors contribute to conversion of mangroves to shrimp aquaculture as shown in the box above, and all of these factors may need to be addressed for effective mangrove management. Only a few of the causes in the box relate specifically to aquaculture – most relate more generally to the current patterns of resource use in coastal areas which has been beyond a sustainable level in many countries, compounded by weak policy and poor resource management capacity. Thus, problems related to shrimp aquaculture are in many cases a symptom of underlying weak planning processes, legislative implementation mechanisms and institutions for coastal resources management. While considerable improvements are required in coastal resource management (from which aquaculture will benefit), it is clear there are better management practices that can be promoted within the shrimp aquaculture sector to reduce or eliminate mangrove impacts and perhaps restore truly abandoned ponds formerly constructed in wetlands

There is increasing recognition of the need to protect mangrove resources and the **mangrove thematic review** finds positive efforts being taken to mitigate negative impacts caused by shrimp culture. The shrimp farming industry is showing some responsibility and several initiatives have been taken in advocating for a more enlightened approach to the issues concerning shrimp farming, mangroves and the environment. As a single sector with reasonably good organizational capacity in many countries, the potential for concerted action by shrimp farmers in support of the environment is strong and should be recognized and encouraged.

The management interventions for eliminating impacts of shrimp aquaculture on mangroves basically revolve around siting and operational management of shrimp farms and the development of infrastructure, such as roads and drainage/water supply systems in ways that do not damage or fragment mangrove ecosystems. The siting of farms needs to be supported by policy, planning and development process associated with the location of shrimp aquaculture projects. Finally, an important issue is that restoration or rehabilitation may also be required, after shrimp aquaculture has stopped, either because of shrimp disease or other causes, such as reclassification of the land area for other uses (see the **Don Sak mangrove forest reserve case study**).

Shrimp Farm Siting and Project Planning

The most effective interventions are associated with the siting of shrimp aquaculture farms to be addressed during project planning and development phase prior to the introduction or further development of shrimp aquaculture. Essentially this involves effective planning of coastal land use, balanced planning of aquaculture in relation to wetland habitat, aquaculture zoning behind mangroves, farm design and consideration of alternatives – polyculture, aqua-silviculture, other land uses, and community involvement in land use planning and management.

The simplest method to eliminate impacts on mangroves and wetlands, and one that is increasingly being followed, is to locate new farms behind the intertidal wetland area. Provided care is taken not adversely affect hydrology (water supply to mangroves or other habitats), this method can effectively eliminate impacts on mangrove ecosystems. This policy is now being actively promoted in several SE Asian countries, including Thailand, the world's largest shrimp producer. The thematic review emphasizes it is an important and simple management practice that can have very significant positive benefits.

Property rights and land tenure have profound consequences for the patterns of resource use and management in coastal area, and land tenure is a critical factor in how people use and manage mangrove and wetland habitats. Short or insecure tenure provides little incentive for long-term sustainable use of coastal land resources, and making long term investments in soundly engineered ponds and infrastructure. Property rights and tenure have to be addressed in the context of sustainable aquaculture development in coastal areas.

Changes in land use over time, and willingness to participate in rehabilitation efforts are commonly related to land use. In Vietnam (Machintosh et al. 2002), for example, local people's interest in participating in mangrove reforestation has been constrained severely by the lack of land ownership conveyed on the local people. As tenants with limited ownership rights, poor farmers were unwilling to invest in mangrove management, or crop diversification, and opted instead for short-term economic benefits from shrimp aquaculture. In south Sumatra, the case study shows there has been resistance among local people to the replanting of mangroves, the reason being that the status of the trees would revert the land to the government Forestry Service once the trees become productive – this seems unacceptable to community members who are currently making a living in these areas (Tobey et al. 2002). In the **Philippines,** the lack of clear ownership is also one of the factors that is constraining rehabilitation of disused aquaculture ponds to mangroves or other productive uses.

The policy, legal and institutional framework play an important part in land use changes in coastal areas, including those related to the development of shrimp and other forms of aquaculture. In general, such issues are largely ignored in many analyses. Institutional responsibilities and policies may suffer from conflicting mandates, often caused by a narrow and rigid sectoral approach to coastal resources management and development. The **mangrove thematic review** provides several examples of more effective planning strategies being implemented in some countries. However, it also stresses the point that most aquaculture planning to date has been focused on resources – and rarely focused or been driven by local people's needs.

Partnerships – an example in Ecuador

In Ecuador, there has been a project partnership between the National Chamber of Aquaculture and the Natura Foundation-Guayaquil chapter, known as the "Control and Surveillance System for the Mangrove Deforestation in the Continental Coast of Ecuador". The purpose of this initiative is to control the indiscriminate mangrove deforestation and identify the persons and companies that commit this infraction over a test period of two years.

According to the annual report presented by the Natura Foundation, during the first year of execution (November 1/98 – October 31/99) the project organised 44 aerial monitoring surveys in the mangroves located in the Estuary of the Guayaquil Gulf (the Jambelí Gulf included), the Estuary of the Chone River – Portoviejo River, the Estuary of Esmeraldas – Muisne – Cojimíes and the Estuary of San Lorenzo.

The monitoring flights tried to include deforestation sites detected earlier allowing the technical personal of the project and delegates of the competent authorities to ensure proper follow up. By now, 88 % of the cases of infringement have been attended to by on the ground inspections between the UCV (Unit of Conservation and Control) and the Natura Foundation.

In eleven months of follow ups of established cases and as a product of ten administrative resolutions executed by the Forest Provincial District of Guayas, it sentenced violators have been required to reforest 80.09 hectares of mangrove in the Gulf of Guayaquil.

Likewise, eight cases has been sentenced through the administrative resolution in the Forest Provincial District of Guayas, and six cases detected before the initiation of the project were also sentenced through the administrative resolution to the same organism; four dislodges to informal violators of mangrove deforestation were executed by the Port Captain of Guayaquil.

A particular problem for shrimp farming is that high profitability combined with uncertain ownership can lead to rapid conversion of habitat to shrimp ponds, that can be very difficult to enforce as change can occur very quickly. This seems only likely to work with more emphasis on local management arrangements. The **case study in Indonesia** provides an example of how a more local participatory planning process might work in the face of rapid development of shrimp aquaculture. More effective local coastal management arrangements and participation will not only benefit aquaculture, but lead to better management of coastal resources (Toeby et al. 2002.)

Shrimp Farm Construction and Project Implementation

The second level of intervention iinvolves the operation and management phase of shrimp aquaculture projects. It may involve the application of more effective management practices (e.g. through applying Codes of Practice); intensification of production, use of closed culture systems, effluent management, bioremediation and other environmentally friendly options. These actions are mainly considered at the farm level, in terms of siting, construction and operational management. The case studies provide several good examples of siting and farm management where shrimp aquaculture and mangroves have a mutually beneficial co-existence. For example, one farm studied in the **Colombia case study** provides a good example of where mangroves help clean up effluent from shrimp farms and local people benefit from maintaining mangrove stands. Such mutually beneficial arrangements need to be promoted as they can capture the positive social and economic benefits from shrimp aquaculture whilst conserving mangroves and contributing to coastal rehabilitation. One of the critical factors driving this successful case was the presence of an effluent tax that provided the incentive to develop a mangrove filter for cleaning up pond effluent (Gautier 2002a).

Restoration and Rehabilitation

There is increasing emphasis on restoration or rehabilitation of mangrove habitats. This final intervention is concerned mainly with land use changes and may involve a restoration or rehabilitation phase after shrimp aquaculture has stopped; for example, because of disease problems, or after reclassification of the land area for other uses. There are considerable efforts now going into restoration of mangroves, at both the farm level and coastal zone scale (Stevenson et al., 1999; Lewis 1999) It should be noted that many of these efforts have failed to successfully establish mangroves due to hydrologic issues discussed in detail in Lewis (1999) and Lewis and Streever (2000).

Rehabilitation and Building Resource Value in Extensive Ponds

Extensive shrimp and fish ponds constructed in mangrove areas are often characterized by low biological and economic yields that are less than original intact habitat. The rehabilitation of ponds in such areas can contribute to improved biological and economic yields. The options include:

- Mangrove restoration - restoring the habitat to as far as possible original mangrove habitat.
- Mixed silvofishery integrated farming systems, as practiced in **Vietnam** and **Indonesia.** This provides the option of providing income and food from aquaculture, whilst seeking to enhance mangrove conservation (Nhuong et al 2002; Tobey et al. 2002).
- Redesign of extensive farms leading to intensification of better areas and restoration of mangroves in suitable areas, as practiced in several **Latin American** countries.

Large areas land in Asia and Latin America areas under still extensive farming – when these involve replacement of habitat – are not good use of habitat. In Asia, conversion of mangrove forests to extensive shrimp farming clearly has caused the most significant impact from aquaculture on mangrove ecosystems. The previous section suggests that extensive farming systems - and particularly those that involve 100% clearance of mangroves – do not make ecological or economic sense, either in the long or short-term. Menasveta (1997) already pointed out the dangers to mangroves from further expansion of extensive farming and emphasizes that development efforts should be directed towards the intensification and diversification of existing systems rather than further expansion of extensive shrimp farming areas. This opinion is confirmed by the **mangrove thematic review**. In some cases, partial or complete restoration of mangrove forests may be the most appropriate action in extensive farming areas, as is happening in some parts of **Ecuador, Indonesia** and **Thailand**. Restoration of unused ponds to mangroves within such intensification areas could also produce great benefits where water pollution is a problem, by providing pond effluent clean, up as previously noted.

It should also be borne in mind that, particularly in Asia, many poor coastal inhabitants are involved in extensive shrimp farming - one of the (several) reasons why extensive farms are built is because of the lack of capital investment. Some countries, such as Vietnam, have encouraged extensive farming as part of the traditional practice of 'reclaiming' coastal land in accretion areas. Given the importance of extensive farming to coastal shrimp production in many countries, and to the communities involved, efforts should also be made to improve economic productivity from such systems. Integrated aquaculture-mangrove forestry (silvo-fisheries) offers one approach to conservation and utilization of the mangrove resource which if properly designed may maintain integrity with the mangrove area while capitalizing on the economic benefits and poverty alleviation potential of brackishwater aquaculture. Indeed, silvo-fisheries have been used in mangrove rehabilitation projects being undertaken in **Vietnam, Indonesia** and **Philippines**. Such integrated systems show promise in meeting rehabilitation objectives, as well as providing food and income for the people involved. However, mangroves isolated from regular tidal flow inside a pond, as in most silvoculture operations, such as those I have seen in Vietnam do not represent a high level of integrity with the mangrove area.

Building Partnerships for Better Management

As emphasized above an alternative strategy that is now gaining more support among both governmental agencies and the public sector is the development of action on mangrove management that promotes a diversity of sustainable activities organized and administered at the local level. Many schemes have been introduced and various names are used to describe them, such as partnerships, stewardship schemes, multi-lateral cooperation schemes or concerted actions, and negotiated agreements for local area management (e.g. covering a particular lagoon, estuary or bay area). Local area initiatives depend primarily on strong local community organization and participation, which is the subject of the following section. These examples suggest that shrimp aquaculture should occur within the context of local integrated coastal area management.

In Thailand, one example is a partnership between the Surat Thani shrimp farm association and an international NGO (Wetlands International) that has been successful in working together in restoration of a small area of mangroves in old extensive shrimp farming areas in southern Thailand. In Ecuador, NGOs have been working with the National shrimp farmers association to identify and bring to prosecution mangrove encroachment by shrimp farms, as noted in the box above.

Conclusions

As pressures increase along many coastlines, ways to sustainably integrate economic activities such as aquaculture are needed. Pressures on wetland areas, including mangrove forests, will increase and management strategies to avoid adverse impacts are required.

Some small-scale aquaculture can be conducted in mangrove areas, with minimal impacts, but shrimp farming requires land and therefore cannot be integrated into mangrove areas without some clearance of mangroves. Such problems can be avoided by siting shrimp farms outside of mangrove areas. In some cases, canals may be necessary through mangrove areas. Where such clearance is required, careful assessment is necessary, and mitigation measures should be taken.

An important condition for the sustainable use of mangroves, whether for aquaculture, timber production or other uses, should require no net loss of the area of mangroves in existence prior to the “sustainable” activity being begun (through restoration or creation of equivalent habitat), and the restoration back to former conditions of mangrove areas temporarily used for a defined sustainable activity. This approach now seems to be gaining more widespread acceptance, and has been adopted by a global shrimp industry organization (GAA 1997). If implemented, it is an important step forward in terms of improving the environmental performance of the shrimp aquaculture industry.

The impacts on mangroves can be effectively controlled through better management practices, effectively siting of farms behind or out of mangrove areas. Such practices have been adopted by some nations, but experience suggests that awareness building and incentives that promote such practices are also required.

In other coastal wetlands, adverse impacts can be avoided also by siting farms away from the inter-tidal area. A special case exists though in large delta areas in Asia, India and Bangladesh. Here, shrimp aquaculture is practiced over large areas (sometimes 10’s of thousands of hectares) of inter-tidal habitat, sometimes replacing or alternate cropping with rice. In such situations special emphasis is required on the management strategies that integrate shrimp aquaculture in ways that enhance land productivity and habitat values.

Source of Shrimp Seed - Post Larvae and Broodstock

Major Issues

Shrimp farming globally relies almost entirely on wild shrimp resources at the present time. Most shrimp post-larvae stocked into ponds come from hatchery-reared animals, although the adult or mature shrimp are collected from the wild for breeding in captivity. There are some innovations using domesticated shrimp in the Americas (*P. stylirostris*) and in Asia (P. *monodon)* but globally the wild source is still most important. Asia so far lags behind the Americas in genetics and domesticated breeding of shrimp.

Major Findings and Lesson's Learned

Trends in Use of Wild Shrimp Stocks
The majority of shrimp seed globally now comes from hatcheries and nurseries (probably 2% or less comes from stocking of wild seed [7]). In a small number of countries, mainly Ecuador and Bangladesh, shrimp seed are harvested directly from the wild and there are concerns over the effects of such collection of post-larvae on wild shrimp stocks, and also the impacts on biodiversity of collecting and discarding other species caught along with the shrimp. Wild seed (usually lower value shrimp species) also enters many extensive ponds, and contributes to the total pond yields.

The driving force for wild PL preference over hatchery PL in Ecuador in the past, and in Bangladesh is the belief among shrimp farmers that wild fry outperform hatchery larvae in grow out ponds. In Bangladesh, farmers in 2000 still preferred wild seed, but the Ecuador case study showed that there was no difference in performance, and farmers are now shifting to hatchery reared seed because they are perceived to contain less disease. This trend seems likely to continue, and with farmer concerns and awareness over the health status of shrimp captured from the wild, stocking of wild seed will soon become a thing of the past.

The replacement of wild shrimp seed with hatchery seed has positive environmental implications, although there may be some significant social implications. The collection methods used for wild seed are implicated in damage to non-target species, although quantitative information on impacts on non-target species is lacking. The Bangladesh case study shows that over 400,000 people – commonly women and children from the poorest groups living in coastal areas – earn income from the collection of wild post-larvae. The transition to hatchery-reared stocks has important implications for these people.

Impacts of Harvesting of Wild Stocks
The effect of harvesting of wild shrimp on wild stocks of *P. monodon* is explored in the **Bangladesh case study** (Begum and Nazmul 2002), where farmers are strongly dependent on the stocking of wild postlarvae (PL) harvested from coastal waters. The sustainability of the practice of harvesting wild PL has been questioned, in particular as the aquaculture industry has expanded and the demand for postlarvae has increased ten-fold over the past 15 years. In aquatic populations, the impact of harvesting early life stages on yield and spawning stock biomass is dependent on details of the recruitment process that for shrimp are poorly understood. Although overall survival from the egg stage to recruitment is highly density-dependent, the crucial question with respect to PL harvesting is whether density-dependence occurs primarily before or after the PL stage. If density-dependence occurs after the PL stage, then the harvesting of PL would have little effect on recruitment unless spawning stocks are at a very low level. If, on the other hand, density-dependence occurs mainly before the PL stage and survival from PL to recruitment is density-independent, then PL harvesting would have a direct and proportional effect on recruitment and fishery yield.

[7]Estimated shrimp farm production derived from wild seed is 16,000 tonnes - 90% of production in Bangladesh, 10% in Ecuador, 5% in India, 10% in Vietnam.

This question has been addressed in detail by Begum and Nazmul in the **Bangladesh post-larval case study** that indicates that the demand for PL in the aquaculture sector is now similar to, or possibly larger than the number required to support capture fisheries. PL harvesting has therefore become a major factor in the exploitation of shrimp resources. However, the case suggests that PL harvested for aquaculture make a greater *direct* contribution to yield (6 vs. 0.38 g/PL) and value (0.01 vs 0.0025 US$/PL) than PL left *in situ* to be exploited by the capture fisheries. This argument does not account for the contribution made by the PL left *in situ* to future recruitment, but it indicates that PL harvesting is not intrinsically irrational or wasteful. The conclusions from the case are summarised in the box below.

Conclusions on the Effects of Shrimp Post Larval Collection on *Penaeus monodon* Fishery in Bangladesh

- Current levels of PL harvesting to satisfy demand from the aquaculture industry are similar to the numbers of PL required to support capture fisheries. Hence PL harvesting is now a major factor in the exploitation of *P. monodon* stocks.
- Whether or not this level of PL exploitation has significant effects on *P. monodon* capture fisheries and spawning stocks is dependent on the *degree to which density-dependent regulatory mechanisms act beyond the PL stage*. If such mechanisms are strong, then even the current high level of PL harvesting may have little effect on stocks. If regulatory mechanisms are weak, then effects on stocks may be very significant. At present this question remains unresolved and therefore, the possibility of significant impacts can not be discounted. A careful examination of *P. monodon* catch data should be carried out to obtain better impact information.
- In the short-term, and at present exploitation patterns and market conditions, PL harvested for aquaculture may make a larger contribution to the economy than those left *in situ*. Hence PL harvesting is not intrinsically a wasteful use of resources. If sufficient spawning stocks can be maintained, it may be rational to allocate a share of PL production to harvesting for aquaculture. The trade-offs between harvesting levels in different phases of the lifecycle, stock levels and economic benefits should be investigated by bio-economic modelling.

The questions of whether the current levels of post-larval exploitation are significant, and the impacts on aquatic biodiversity remain to be answered, as insufficient information exists on the species collected and the biology of these species.

Social and Economic Importance of Wild Fry Collection

In the few countries still practicing collection of wild post-larvae, collectors are often among the poorest of the poor people in coastal areas. In Bangladesh, the livelihoods of at least 400,000 people are dependant on shrimp PL collection, including women and children, of which the largest group are landless. Although shrimp seed collection offers only part-time employment, and is seasonal, the Bangladesh case study shows that this is an important source of income for many poor coastal households, who have few other options for income generation.

Ths social and economic importance emphasizes that particular care is needed to ensure that any negative impacts on poor people are also mitigated in the ongoing transition to hatchery reared and domesticated stocks. The Government of Bangladesh in 2000 banned collection[8] of wild shrimp seed – the effects of this ban on coastal households are likely to be severe unless alternative means of employment are found.

Management Strategies

The practice of collection of wild broodstock and post larvae is changing, particularly because farmers are increasingly concerned over the health status of stocks collected from the wild. Wild broodstock for hatchery breeding are routinely collected, but considerable investments are being made in domestication programs to produce shrimp that can be guaranteed from a health perspective. The domestication of shrimp will also allow strains to be developed with characteristics suited to farming.

To reduce the impacts of "accidental" collection of other species of fish and shrimp during post-larval collection, programs underway in **Bangladesh** and in **Guatemala** and **Ecuador** to support the development of better catching methods. These include the sorting of shrimp in the water and release of

[8] This major policy change represents an important research opportunity.

by catch, emptying nets at regular intervals, sorting of PLs in shade, and other measures to reduce mortalities of by-catch shrimp post-larvae.

Conclusions

It is likely that further developments in hatcheries and eventually domestication of shrimp, a trend driven by disease concerns and shortages of wild shrimp broodstock in some countries, is a way forward to remove the effects of direct collection on the wild stocks. Already farmers in most countries prefer hatchery reared stock, and it seems likely that the move towards hatchery and domesticated stocks will continue as farmers become more aware of the need to control disease.

Finally, introduction of measures to improve quality of post larvae will have implications for the spread of disease through poor quality, infected, seed. The movement of domesticated stocks of shrimp may also have genetic implications, that are at present poorly understood.

Feeds and Feed Management

Major Issues

Feed is the major operational cost of semi-intensive and intensive shrimp farming. It is less important in extensive farming, where shrimp food cpmes from natural pond productivity. The amount of feed used, the protein content (and particularly fishmeal) of feed and consumption efficiency are important in farm economics and environmental interactions. Environmental issues relate primarily to the use of fishmeal and fish oils in shrimp diets and the effects of fish feed on water quality and pond effluent.

Major Findings and Lesson's Learned

The **shrimp feed review** farming sector currently consumes 470,386 MT of fish meal and 36,184 MT of fish oil within compound aquafeeds (dry basis) or the equivalent of 2,351,930 MT of fish (pelagic fish live weight equivalent) for the total global production of 1,130,737 MT of farmed shrimp in 1999; this is equivalent to the consumption of 2.08 kg of fish for every 1.0 kg of shrimp produced (Tacon 2002).

The mean fish meal and fish oil content of shrimp aquafeeds in 1999 was estimated to be 26% and 2%, respectively. The use of fish meal in shrimp diets varies between shrimp species – carnivores and omnivores – *P. vannamei*, *P. monodon* and *P. japonicus* and there are large differences in the conversion of fish meal to shrimp also varies considerably between species and farming systems (Tacon 2002).

The mean food conversion efficiency of shrimp aquafeeds was 2.0 in 1999, with 2.0 kg of shrimp feed (dry basis) being consumed for each 1.0 kg of shrimp biomass harvested (wet basis). This feed efficiency is equivalent to a shrimp nutrient utilization efficiency of about 25% the remainder being lost to the surrounding aquatic environment (Tacon 2002).

At present the majority of shrimp aquafeeds used by farmers are nutritionally over-formulated as complete diets irrespective of the farming system and shrimp stocking density employed and natural food available.

Management Strategies

There are a number of management options for reducing the use of fish meal and oils in shrimp diets including. The **feed thematic review** concludes there is an urgent need to turn the shrimp farming sector from a net consumer of fishery resources into a net producer of much needed food-grade aquatic produce. These include the replacement of fish meal and fish oil in shrimp aquafeeds with alternative more sustainable feed-grade plant/animal protein and lipid sources. Replacement of fresh food organisms in aquafeeds with processed feed materials and processed agricultural by-products.

There is a need to develop improved shrimp feed formulation programs and on-farm feed management practices that take advantage of natural food availability, and by so doing reduce existing dietary nutrient levels and consequent feed wastage. Development of improved feed manufacturing technology to produce more water-stable shrimp feeds, and minimizes nutrient loss through leaching and feed disintegration. Development of technical guidelines for good on-farm feed manufacturing practices and feed management practices for use by small-scale and large-scale producers.

The replacement of fish meal and fish oil within shrimp aquafeeds with alternative protein and lipid sources can only be achieved if changes are made in the basic shrimp culturing practice, such as closing the farming system through water recycling or zero-water exchange, and by maximizing in-situ "floc" and natural food production within the culture system. The upshot of such production systems is that imports of high quality feed ingredients and aquafeeds can eventually be eliminated, and the utilization of locally available agricultural waste streams and by-products greatly improved and maximized.

The **Belize case study** also reveals the potential for reducing the use of fishmeal used in shrimp production, in this case *P. vannamei*. The highest yield of 27,200 kg/ha was achieved in 650-m^2 ponds aerated at 60 hp/ha and containing 1,350 m^2 of vertical surfaces created with "AquaMats" that appear to increase production by providing surface areas on which food can grow. This approach reduces the overall feed conversion ratio from 2 to 1 to 1.4 to 1. The result is a 30 percent reduction in feed costs per animal produced and a reduction in the overall cost of producing shrimp byUS$.27/kilogram. It also causes an overall reduction in the amount of wild fish used to make the fish in the fishmeal used to manufacture the shrimp feed. Given the fishmeal content of the feed used in Belize and the feed conversion ratio, one kilogram of shrimp is produced with less than one kilogram of wild fish converted to the fishmeal in the shrimp diets they were fed (Boyd and Clay 2002).

The promotion of closed shrimp production systems would greatly reduce water use and increase shrimp production per unit area, but would necessitate the continuous provision of an electricity for aeration during production. Alternative energy sources such as solar and resource-poor farming communities should also explore wind energy for use.

The figures below show the amount of wild fish (weight wet) at each FCR level with a given percentage (%) contain of fish mean in shrimp feed.

25% fish meal diet – farm FCR 2.0 – pelagics required 2.5 kg (calculated (0.25 x 5) x 2)
25% fish meal diet – farm FCR 1.8 – pelagics required 2.25 kg
25% fish meal diet – farm FCR 1.6 – pelagics required 2.00 kg
25% fish meal diet – farm FCR 1.4 – pelagics required 1.75 kg
25% fish meal diet – farm FCR 1.2 – pelagics required 1.50 kg
25% fish meal diet – farm FCR 1.0 – pelagics required 1.25 kg
25% fish meal diet – farm FCR 0.8 – pelagics required 1.00 kg (break point)
15% fish meal diet – farm FCR 2.0 – pelagics required 1.50 kg
15% fish meal diet – farm FCR 1.8 – pelagics required 1.35 kg
15% fish meal diet – farm FCR 1.6 – pelagics required 1.20 kg
15% fish meal diet – farm FCR 1.4 – pelagics required 1.05 kg (break point)
10% fish meal diet – farm FCR 2.0 – pelagics required 1.00 kg (break point)

The major incentive to make efficient use of feed is the cost savings and improved profitability associated with lower Food Conversion Ratios (FCRs). There is a strong financial incentive to improve FCR. The amount of feed wastage can be significantly reduced by improved feeding practices, such as carefully controlled feeding and use of feeding trays. The case studies in **Vietnam, Thailand** and elsewhere indicate that there are few constraints to adoption of better feeding practice by farmers, except knowledge of better practice. Interestingly, past surveys in Thailand have also shown that FCR is less on small family operated farms than on larger-scale farms (CP News 1994). These findings are confirmed by some of the case study work during the present studies. However, more research on efficiency of feed use on small versus large scale farms would be extremely useful (Nhoung et al. 2002; Tookwinas In press).

The use of moist and fresh diets are known to be more polluting and wasteful of resources and tend to be less used on intensive farms in Asia, because of concerns over water pollution and introduction of shrimp pathogens. It can be expected that improved feeds (such as with more appropriate protein content) and feeding systems will be adopted by the shrimp industry over the next five years a move that could further reduce loadings of pond effluent and efficient use of fish meal.

Case studies also show that improvements in the design of shrimp farming systems can be made to recycle excess nutrients and organic matter in effluent into secondary aquaculture products (e.g. fish, mollusk) or even agricultural crops and can help improve the efficiency of resource use and make additional contributions to local food supplies (as well as reducing effluent loads to local coastal waters).

Conclusions
Feed is the major operational cost of semi-intensive and intensive shrimp farming and a key environmental concern. The case studies show that the nutrient loads and use of fish meal can be substantially reduced with better feeding practices, shrimp feed formulations, and developments in farming system design. The economic incentives for better feed management are also significant, in terms of reduced operational costs. There are also some innovative management and farm design strategies now evolving that can be used to significantly reduce fish meal demand for shrimp feeds, although applying such measures in small-scale farm ponds will likely be constrained by lack of investment.

Water Use and Pond Effluent

Major Issues
The major water quality concerns are the risks of water quality problems created by shrimp pond effluent and the effects of water pollution from non-aquaculture sources on shrimp farm water supplies. Although minor local water pollution has been related to indiscriminate discharge of wastewater from hatcheries most environmental concerns relate to the discharge of water from ponds. In general, extensive shrimp culture systems with low stocking densities and little or no fertilization or supplementary feeding do effluent of concern. Indeed, extensive systems tend to be net removers of nutrients and organic matter. The major issues are release of organic material, nutrients, and (in some locations) salinity. Chemicals are also a concern and considered separately below.

Major Findings and Lesson's Learned
The intensification of shrimp farming to semi-intensive and intensive levels is characterized by increasing inputs of fertilizers and supplementary feeds, and increased potential for nutrients, organic matter and other wastes to affect water quality in ponds and effluent. Supplementary feed is the most important input contributing to the waste nutrients and organic matter from more intensive culture systems, indicating that feed management can be a major contributor to control of effluent loads as emphasized above.

Effluent discharged from ponds reflects the internal processes of the pond and farm management practices. The effluent quality during normal operation is basically similar to the quality of water in the pond, which if managed effectively will tend to be well mixed with water quality within acceptable ranges for shrimp. The effluent discharged during harvest and during cleaning of intensive ponds tends to be of poorer quality, as indicated in **case study reports in Ecuador and Thailand.** There are considerable opportunities to reduce any negative effects of shrimp pond effluent, and the management lesson's arising from the case studies are discussed below.

Impacts of Effluent
Effects of shrimp farming on local water quality are very variable, depending on factors such as amount and quality of effluent discharged, farming system and management and assimilative capacity of the receiving water. The main water quality parameters of concern are dissolved oxygen, BOD (that can lead to reduced DO in receiving waters) and release of the nutrients nitrogen and phosphorus (that carry risks of hypernutrification (nutrient enrichment) and eutrophication, with increased primary productivity and

possible phytoplankton blooms). Most studies show that effluent impacts, where they occur, are localized. This is confirmed by case studies in **Australia and Honduras**. Location of the farm site and water management practices, particularly in relation to the flushing rate of receiving waters is critical. The **Honduras case study**, for example, that farms placed further upstream in an estuary will most likely have significant impacts on dissolved oxygen in the estuary, although effects can be ameliorated by limiting farm water exchange during the dry season. The study in **Australia** emphasizes that nutrient loads from shrimp farms need to be seen within the perspective of the total loads to coastal waters arising from watersheds – the case argues strongly for a watershed approach to pollution control and water quality management (Preston et al. 2001; Boyd and Green 2002).

Watershed Approach

To assess the contribution of shrimp and other aquaculture effluent to nutrient enrichment and occurrence of algal blooms in coastal waters, it is necessary to compare the relative contribution of nutrients in shrimp pond effluent with other sources of nutrients in coastal areas (agriculture, industrial, urban sources). The water quality monitoring program described by the **Honduras case study** has not shown any clear cut negative impacts of shrimp farming on coastal water quality. However, there are other activities that also influence water quality in the area, water quality problems do exist, and shrimp farming must be considered as a contributor of pollutants to the coastal waters (Boyd and Green 2002).

Other published studies, whilst rare, show that the total contribution of shrimp pond effluent to coastal nutrient and organic loadings is small compared to other agricultural, urban and industrial loads (e.g., studies in the Gulf of Thailand; see NACA 1996; studies in the Bohai sea, China; see FAO/NACA 1995). Further research work is necessary to assess the contribution of shrimp pond effluent to changes in overall coastal water quality, and to put the contribution by shrimp farms within the overall context of coastal environmental protection and management.

Salinity in Agricultural Areas

Salinity can be a problem where there is saline discharge into freshwater areas. This can be addressed be better siting and pond design that reduces risk of saline water discharge. For example, in **Thailand**, the ditches can be built around ponds to minimize seepage. Soils are also important factors. Seepage is less of a problem on clay soils, than on sandy soils. For example, salinity problems reported from some coastal areas in **India** appear to be associated particularly with location of farms on sandy soils, and with contamination of freshwater supplies of nearby villages.

Management Stategies

Water Exchange and Quality Management

There are considerable better management measures that can be taken to reduce effluent problems, and indeed there appears to be good potential to move towards zero net discharge of nutrients and organic material from farms. At the farm level, there are various options for control of effluent loads in shrimp ponds that can be applied to reduce any impacts of effluents on surrounding waters, and keep any discharge within assimilative capacities of recipient water bodies. These essentially involve reduced water exchange, better feed management practices and treatment of effluent.

The recent trends in Southeast Asia and elsewhere towards low (and some zero) water exchange systems, systems with very low water discharges could become a reality within a few years. In **Ecuador**, relatively high pond water exchange rates have been considered the most viable and economic management tool to correct water quality and oxygen problems in large (10 hectare average) ponds. Location of farms in rural areas with limited electrical power supply, continuous and almost unlimited source of water from natural waterways in estuaries or open sea, and the absence of clear regulations on water use and effluent discharge have contributed to this practice. A survey conducted during the **Ecuador case study** revealed however a decrease in exchange rates in last two years from 10-15% pond volume/day to 1-3% or no water exchange. Reduction of disease risks by restricting water inlet into ponds was given as primary explanation for current water exchange practices by interviewed farmers (Sonnenholzer et al. 2002). These practices have been shown to dramatically reduce effluent loads through increased settlement of nutrients and organic matter within ponds (Hopkins et al. 1992).

If reductions in nutrient or organic loads from land-based effluent are necessary, then various treatment strategies are available. There are two measures: (a) removal of suspended solids and disposal of pond sludge using various techniques; and (b) biotreatment, including the use of artificial wetlands.

Sediments
In most shrimp culture ponds (the new systems designed in Belize being and exception), the bul of nutrients and organic material is locked away in sediments. The management of these sediments at the end of the culture crop has important implications for effluent loads to the environment. Where sediment is "cleaned" by hosing or other wet methods, use of settlement ponds to capture pond sediment is essential.

Use of Settlement Ponds
The **case study in Australia** characterized and quantified shrimp pond effluent over the entire production season at three shrimp farms. The study demonstrated that untreated shrimp pond discharges contain elevated levels of total suspended solids (TSS), nitrogen and phosphorus compared to intake (Preston et al. 2000). However, farms using settlement ponds reduced TSS loads by 60%, total phosphorus by 30% and total nitrogen by 20%. One of the major achievements noted in this case study has been in developing and promoting the use of settlement ponds to treat pond effluent prior to either recirculation or discharge to adjacent waterways. All new farms, or expansions of existing farms in **Australia**, now require the use of effluent treatment systems to meet effluent discharge standards. Many existing farms are also exploring the use of treatment ponds for reducing discharge loads and recapturing otherwise wasted nutrients.

The management strategies for effluent need also to be carefully balanced against discharge targets, to avoid unnecessary costs. Nutrient and organic matter concentrations in effluent are highest during shrimp harvesting and subsequent cleaning of ponds, when effluent quality can be very poor due to disturbance and release of material previously bound to the sediment. Effluent targets could be met in some circumstances by concentrating management efforts on treating harvest water and sediment.

Biofiltration
Field studies and tank trials have already demonstrated that effluent nutrients can be successfully recaptured using secondary cash crops such as seaweeds, bivalves and fish (Lin 1995; Jones & Preston 1999; Jones et al. 2001). There is increasing interest in the use of biofiltration, including wetland-mangrove habitats in appropriately located sites on the farms (**Colombia and Australia cases studies in thematic review**). The use of mangroves in particular is attractive. The **case study in Colombia** was also instructive as the water quality regulations (that taxed effluent discharge) provided a strong incentive for the shrimp farm to plant mangroves for effluent clean up.

There are also numerous other options for biofiltration, including use of mollusks, seaweeds, finfish ponds, and recent studies have been done on the use of halophytes for treatment of saline aquaculture effluent, such as *Suaeda* and *Salicorna* which are succulent marsh species which can be used as fodder for some livestock. Halopytes are being used for effluent treatment in Eritrea (see www.seawaterfarms.com).

Whilst various researchers are focussing efforts on different aspects of intensive pond effluent treatment, it is also becoming clearer that controlling effluent loads to coastal environments requires a 'holistic' type approach. This should be based on understanding of local farming systems, properly defining problems (if any), and development of locally appropriate solutions depending on individual farming systems or location specific environmental concerns.

The research in Australia for example demonstrated that most of the nitrogen, the nutrient of key environmental concern in coastal ecosystems, is added in the form of formulated feed (Preston et al.

2000). Further, most of the nitrogen is not retained by the shrimp but enters the pond system where it is rapidly cycled (Burford & Glibert 1999). Pond sediments play a key role in this (Burford 2000). In addition, the type, positioning and number of pond aerators deployed in ponds affects both sediment and pond water quality (Peterson 1999a,b; Peterson et al. 2000). This research has important implications for attempts to reduce waste production within ponds and highlights the importance of an integrated approach to waste reduction involving the disciplines of nutrition, health, genetics and ecology.

It should also be emphasized that there may be limits to what can be done at the individual farm level – more cooperation among farmers may be necessary in crowded farming areas.

Problems of Farm Clustering

Local problems caused by increased nutrient, organic and microbial loads can arise in enclosed waters or where there is a very high density of ponds. These changes can have a severe influence on the sustainability of shrimp farming, because such crowding inevitably leads to shrimp disease outbreaks. Reports on 'self-pollution' of shrimp culture areas by pond effluent have occurred from many parts of Asia, in Taiwan (Liao 1992), Thailand (Lin 1992), the Philippines, Indonesia and China. This is a particular problem addressed in the **Sri Lanka case study** where special management measures to encourage cooperation among farmers are being proposed to deal with the issues. Such cooperative management arrangements seem to be the only viable way to deal with such problems. However, there are few examples of successful implementation of management of farm clusters (Siriwardena In press).

Water Quality Standards and Discharge Permits

Some countries have introduced water quality standards and discharge permits for shrimp farms and different approaches have been tried. One of the key environmental concerns in **Australia**, and elsewhere, is that untreated pond effluent could contribute to the turbidity and eutrophication of coastal regions. In Australia the regions of greatest concern are those adjacent to unique and environmentally sensitive areas such as the Great Barrier Reef and other marine parks. From an aquaculture industry perspective, many existing farmers, and those seeking to enter the industry, feel that environmental regulators compared to traditional agriculture are targeting them unfairly. Permitted discharge loads of suspended solids and nutrients are very stringent, and the associated financial costs of both upstream and downstream monitoring programs are high. A number of other countries have adopted various environmental quality standards to control environmental effects of shrimp aquaculture, including the effects of pond effluent on receiving waters. Such standards are notoriously difficult to monitor and enforce (one of the reasons being the large number of farms, often spread over large geographical areas, and limited capacity for monitoring). In any event, to be ecologically effective, water quality standards for effluent should be set based on the farm type and environmental quality objectives for receiving waters.

This issue is emphasized in the **Australia and Honduras** case studies. In Thailand, a legal regulation for intensive shrimp aquaculture includes elements of both effluent monitoring and "best management practices". (see box).

Shrimp Farm Regulation from Thailand

- Shrimp farmers must register with the local district office of the Department of Fisheries.
- Shrimp farms over 8 ha must have a wastewater treatment (sedimentation) pond equal to 10% of farm area.
- Saltwater must not be discharged into public freshwater resources or agricultural areas.
- Sludge and pond bottom sediment must be confined and not pumped into public areas or canals.
- BOD of discharge water must be less than 10 mg/l.

The **thematic review on codes of practice** also emphasise the potential for a series of best management practices to reduce discharge of nutrients and organic materials (Boyd et al. 2002).

Shrimp culture often suffers from water pollution caused by other industries (FAO/NACA 1995) and this is emphasised in several case studies. Thus, attention should be given to water pollution controls in other sectors, rather than concentrating on shrimp culture alone. Water quality management should therefore be part of a comprehensive integrated approach to environmental management in coastal areas. Whilst adoption of more integrated approaches would greatly benefit the protection of environmental quality and coastal aquaculture also, unfortunately, such approaches are globally rare.

Carrying Capacity

Similarly, understanding of the carrying capacity of coastal areas for shrimp aquaculture is also still limited, although there are ongoing studies in **Australia, Thailand, Vietnam** and elsewhere that may provide practical guidelines on this issue.

Water Quality Monitoring

Water quality monitoring of the coastal areas where shrimp farms are located establishes the present status of water quality in a specific area and determines if changes in water quality occur in the future. One review explores in detail the subject of water quality monitoring, with an example from **Honduras**.

The sampling stations for a water quality monitoring program to evaluate shrimp farm impacts should include stations near shrimp farm outfalls, near the inflows of selected streams, near pumping stations, and in the larger body of the estuary and the seashore. Some stations should be well removed from farm outfalls, and there should be a gradient from farm outfalls to remote stations. Stations should be marked clearly so that samples are always taken from an exact location. The sampling frequency should be weekly or more often, and reflect seasonal and tidal fluctuations. The most important variables to be measured are as follows: water temperature, dissolved oxygen, pH, total ammonia nitrogen, nitrite nitrogen, total phosphorus, total nitrogen, chlorophyll a, total suspended solids, biochemical oxygen demand, salinity and Secchi disk visibility. Standard analytical protocol should be used, and the same methods should be employed throughout the program. A good record-keeping protocol is essential, and the laboratory personnel should design and maintain a system of quality control. The benefits of a water quality monitoring program are discussed in the **Honduras** case study, where such a program was established to assess impacts of water quality on coastal waters. The program has been implemented under the auspices of the Honduran National Association of Aquaculturists.

Conclusions

The discharge of effluent from shrimp aquaculture ponds can lead to localized water quality problems. These case studies demonstrate that such problems can be effectively managed through combinations of better farm design and on-farm management practices. There are also emerging opportunities for zero discharge farming systems that can effectively eliminated water quality impacts, although there applicability for poor, small-scale coastal farmers may be constrained.

Chemicals

Major Issues

The use of chemicals is widespread in semi-intensive and intensive farming, but only a few products such as fertilizers, liming materials, probiotics, and zeolite are routinely used. When a disease problem occurs in an area, farmers are more likely to use other chemicals. Chemicals are used in shrimp aquaculture, but more widely used in intensive shrimp farming, for various purposes such as water quality control, pond conditioning, shrimp disease control and predator eradication, among others. Concern over contamination of shrimp product with chloramphenicol and nitrofurans has become an issue in international markets.

Major Findings and Lesson's Learned

There are some differences in chemical use between Asia and the Americas (Claude Boyd 2002) but these differences are quickly disappearing because of increasing ease with which shrimp farmers can communicate with each other. However, chemicals did not prove to be effective for controlling recent shrimp diseases and the current tendency is to rely less on treatment and to apply preventative means that involve disease-free post larvae and better management. Fertilizers are sources of nutrients, so excessive use of fertilizers should be avoided to prevent eutrophication of natural water by nutrients in shrimp pond effluents. Nitrate fertilizers are potential fire or explosion hazards if not stored properly, but otherwise, fertilizers do not pose hazards.

Some aquaculture chemicals may be irritants or toxins to workers who apply them to ponds, and diesel fuel is flammable or explosive. Even when shrimp farmers are aware of the human dangers encountered when handling chemicals, they often overlook the potential impact of substances on the surrounding environment and on the quality of aquatic food products. Because of increasing concern over the potential harm of aquaculture effluents on receiving water bodies, worries over the contamination of aquatic food products with bioaccumulative and potentially harmful chemicals, and human risks associated with storing and handling some chemicals used in aquaculture, farmers should carefully considered the consequences of using biological and chemical agents in shrimp culture. It is evident from the extensive literature on insecticides that their use should be discouraged in aquaculture because of their bioaccumulative properties and the high risk of contaminating the environment. Most bactericides are probably degraded by natural processes, but there is a possibility for the development of resistant strains of bacteria through repeated use of bactericides. Also, some bactericides may accumulate in shrimp tissue and pose a food safety problem. Fortunately, most substances used to improve water quality or to stimulate the immune system of shrimp present little or no risk to the environment or food safety.

BMPs for chemicals (prepared by Boyd 2002)

- Fertilizers should be applied only as needed to enhance phytoplankton blooms.
- Fertilizers should be stored under a roof in a dry place. They should not be exposed to oil or electrical spark.
- Agricultural limestone should not be applied to ponds except where it is desired to disinfect pond soils between crops. Burnt or hydrated lime should be used only as bottom soil disinfectants.
- Liming materials should be stored to prevent them from washing into natural water after storm events.
- Shrimp health management at hatcheries and farms should focus on disease prevention through good nutrition, sound pond management, and overall stress reduction rather than disease treatment.
- Where countries have approved lists of chemicals and chemical uses, only approved chemicals should be used in ponds and only for the use approved.
- Where such lists are not available, the shrimp industry and individual producers should work with governments to prepare such lists.
- Strong chemical treatments that can stress shrimp should not be employed.
- Medicated feed should be used only if necessary for the control of a specific disease for which the medication is thought to be effective.
- When practical, antibiograms should be used to select the best antibiotic for use in a particular case, and the minimum inhibitory concentration (MIC) should be used.
- Shrimp farmers should follow information on product labels regarding
- dosage, withdrawal period, proper use, storage, disposal, and other constraints on the use of a chemical including environmental and human safety precautions.
- When potentially toxic or bioaccumulative chemicals are used in hatcheries and ponds, water should not be discharged until compounds have naturally decomposed to non-toxic form.
- Careful records should be maintained regarding use of chemicals in ponds as suggested by the Hazard Analysis and Critical Control Point (HACCP) method.
- Store therapeutants in a cool place and in a secure manner where they will be inaccessible to unauthorized personnel, children, and animals, and dispose of unused compounds by methods that prevent environmental contamination.
- The shrimp-farming industry should work with governments to develop regulations for labeling the content and percentage of active ingredients in all chemicals including liming materials and fertilizers.
- Processing plants should regularly monitor shrimp for residues of antibiotics commonly used in the area.

Management Strategies

Adequate guidelines and regulations regarding chemicals and other agents have not been formulated in most countries. Shrimp farmers who use these substances should follow product labels regarding dosage, withdrawal period, proper use, storage, disposal, and other constraints, including environmental and human safety precautions. Also, careful records should be maintained regarding use of chemicals in ponds, as suggested by the Hazard Analysis and Critical Control Point (HACCP) method. A greater effort must be made to prepare lists of acceptable chemicals and recommendations for the use of these chemicals. Some chemicals are necessary in aquaculture, and a system for using them in a safe and publicly acceptable manner must be developed and implemented by the aquaculture industry worldwide. One way of minimizing the risks of aquaculture chemicals is to develop BMPs for their use. The Global Aquaculture Alliance (Boyd 1999; and Boyd 2002) made a list of BMPs for chemical and biological amendments used in shrimp farming.

Conclusions

The amounts and type of chemicals used in shrimp culture vary depending on the type of shrimp farming system. They are used principally for disease control, but may also be used in various ways as disinfectants, water conditioners and treatment, for sediments and for other purposes. The main concern relates to a few chemicals that have potential to influence human health and the environment. These can be eliminated through better management practices. It seems likely that much more attention will be given to the presence of residues in shrimp flesh, and farmers will have to be increasingly aware of this problem and adopt management measures to reduce or avoid use of chemicals in shrimp farming.

Shrimp Health and Disease Control

Major Issues

Infectious diseases, particularly those caused by viruses, are consistently identified as the major threat to the long term viability of the shrimp farming industry in the Asia-Pacific region and Latin America.

Over the past decade, pandemics caused by 'new' viruses have struck all levels of shrimp farming in Asia, from intensive farms in Thailand to simple extensive systems in Bangladesh and Vietnam. For individual smallholder farmers, who make up the vast bulk of producers in almost all Asian countries, the associated crop losses have been catastrophic, leaving many burdened with debt and unable to finance a subsequent crop. Shrimp disease has caused serious economic and social impact to shrimp farms globally and a major threat to its economic sustainability (**shrimp disease thematic review**). There is no information that shrimp farming has caused disease in wild stock, although there are some ongoing studies on this issue and concern over such hazards and impacts on biodiversity. The white spot syndrome virus (WSSV) in particular has impacted shrimp aquaculture globally, in Asia and the Americas. An example of the social and economic impacts from Ecuador is given in the box.

WSSV - Social and Economic Impacts in Ecuador

According to a 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 labour 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.

Many of the factors leading to shrimp disease – poor water quality, poor quality of seed stock, location of farms on sub-optimal sites – are also related to poor environmental performance. This creates a potentially important “win-win” situation creating an incentive for farmers to reduce environmental and shrimp disease problems. Shrimp disease has been an “entry point” in many countries for improving the environmental performance of shrimp aquaculture (see also 1997 World Bank review on shrimp diseases).

Major Findings and Lessons Learned

The WSSV is now considered as the single most serious shrimp pathogen worldwide, which appeared to have caused a cumulative global loss of production in the order of 1 million metric tons or more by the end of the year 2001. As with the international spread of diseases and pathogens of other aquaculture species, the highest risk of introducing shrimp pathogens, especially viruses, appears to be through the movement of live animals (broodstock and post-larvae) from infected areas. This risk can be significantly reduced by using specific pathogen-free (SPF) and specific pathogen-resistant (SPR) stocks. Even with SPF or SPR shrimp, first importation should involve co-habitation tests with local species and varieties to guard against introduction of unknown pathogens. Importation of cooked, dried and salted shrimp pose no threat of pathogen introduction, as the conditions used in their processing regime would inactivate the viruses. Green shrimp are fresh/frozen raw shrimp and careful assessment shows that the possible risks from green shrimp vary greatly with product target use and the likelihood that viable viral particles present in frozen carcasses will reach a susceptible host. Pathogen viability can be affected by factors such as processing time, freezing and thawing after processing. The risk of introduction and spread of pathogens could be reduced through responsible movement (introductions and transfers) of live shrimp following appropriate protocols. However, there is still a need to develop more practical and applied protocols specific to shrimp with due consideration to the specific requirements of the shrimp aquaculture sector. In addition, local initiatives can be taken such as the Asia Regional Guidelines for Responsible Movement of Live Aquatic Animals formulated through a collaborative project of the Network of Aquaculture Centers in Asia Pacific, the United Nations Food and Agriculture Organization (FAO) and the Office International des Epizooties (OIE). These guidelines will form a basis for responsible and safe movement of live aquatic animals.

Management Strategies

The shrimp disease case study provides a detailed analysis of the actions taken by the private sector, governments and international agencies and their success in dealing with the problems.

Farm Level Management Practices
The management practices for control of shrimp disease can be taken at hatchery and farm level, and at the supporting level of government. There is growing experience in shrimp disease control within the private sector of many countries. Some disease risk factors are within the control of the farmer, others are more difficult to control and require cooperation between farmers, and between farmers and the government. The shrimp disease thematic review provides detailed information on risk factors and the success of different control measures.

Government Level Management
Government level actions are also required for shrimp disease control, at national level to control the spread of outbreaks and at regional and international levels to promote cooperation in management of major epizootics. Recent work on development of “National Strategies” for aquatic animal disease control have been prepared in 20 Asian countries with FAO and NACA assistance (FAO/NACA, 2000). The most effective national aquatic animal disease control strategy can be found in the “AQUAPLAN” strategy in Australia.

AQUAPLAN is comprised of eight programs, with appropriate program activities, forming a comprehensive integrated national approach to aquatic animal health. The programs and activities are shown in the box below.

A similar outline has been prepared by Asian regional governments, including Australia, that are strongly linked to, and fully compatible with, the OIE's International Aquatic Animal Health Code and Diagnostic Manual (OIE 1997a, 1997b), and the provisions of membership in the World Trade Organization and the SPS Agreement. This type of management framework provides a useful framework for effective government response and support to shrimp (and other aquatic animal) disease control. References of relevant FAO, NACA and APEC reports are provided in the reference list.

PROGRAM 1 – International Linkages

- *Development of regional technical guidelines for aquatic animal quarantine and health certification (FAO/NACA/OIE Regional Program)*
- *Aquatic Animal Pathogen and Quarantine Information System (AAPQIS)*
- *OIE's aquatic animal disease categorization, and disease lists*
- *International and regional disease status reports*

PROGRAM 2 – Quarantine

- *Import risk analysis (IRA)*
- *Review and regulation of post-arrival quarantine procedures for live fish*
- *Training of quarantine officers in aquatic animal quarantine*
- *Random sampling of imported fish and fish products*
- *Dissemination of quarantine information on fish and fish products*
- *Health certification*

PROGRAM 3 – Surveillance, Monotoring and Reporting

- *Surveillance and monitoring strategies*
- *Diagnostic capability*
- *Standard Diagnostics Techniques and Standard Operating Procedures*
- *Reporting and disease status*
- *Zoning programs for aquatic animal diseases*

PROGRAM 4 – Prepardness and Responce

- *Institutional arrangements for aquatic animal disease emergency management*
- *Disease simulation exercises*

PROGRAM 5 – Awareness

- *Australian Aquatic Animal Disease Identification Field Guide*
- *Inclusion of aquatic animal health in veterinary curricula and other tertiary education*

PROGRAM 6 – Research and Development

- *Inventory of aquatic animal health research projects in Australia*
- *Strategic prioritization of research projects*

PROGRAM 7 – Legislation, Policies and Jurisdiction

- *Identify and work towards necessary legislative and jurisdictional outcomes*
- *Control of exotic/emerging disease on Commonwealth land an in Commonwealth places*

PROGRAM 8 – Resources and Funding

Complementarity Between Shrimp Aquaculture and the Environment

Major Issues

The findings of the case studies emphasize in several instances the complementarities between shrimp aquaculture and the environment. The reason is that aquaculture relies heavily on environmental "goods" (e.g. water, feed ingredients, seed *etc*) and "services" (e.g. coastal ecosystems for pond water discharge) from coastal ecosystems. Thus, aquaculture in general, and shrimp farming in particular, is highly sensitive to adverse environmental changes (*e.g.*, water quality, seed quality), and can be seriously affected by aquatic pollution. It is in the long-term interests of aquaculturists to work towards protection and enhancement of environmental quality.

Major Findings and Lesson's Learned

The **mangrove thematic review** emphasizes some of the mutual benefits from shrimp aquaculture and mangrove conservation, including water quality improvement through mangroves, mangroves as shelters from storms, and for stabilization of canal banks and coastal land. Shrimp aquaculture can be a monitor of environmental conditions in coastal areas. The attention given to shrimp aquaculture and mangroves has probably been responsible for highlighting the importance of mangrove ecosystems, and has led to a lot of positive mangrove conservation effort.

Similarly, the economic analysis suggested that good environmental performance makes economic sense (see later Section).

Conclusions

This mutual benefit raises interesting possibilities for aqua-farmers to work in partnership with communities and other groups with a mutual interest in protection of aquatic environments. This partnership evident in several case studies and is clearly a move in an important direction that should be further encouraged.

Employment and Social Issues

Rural Employment and Social Impacts

Major Issues
Economic development is often assumed to lead to increased social benefits for entire populations. Unfortunately, as so many cases around the world have demonstrated, development often brings benefits for a few while leaving the majority of the population behind. Increasingly, social equity, benefits and poverty alleviation are being given a higher priority by governments, aid agencies, local communities, and societies.

With a relatively new industry like shrimp aquaculture, it makes sense to determine what the social and welfare effects have been. The goal of the consortium was to generate more comprehensive data about innovative and exemplary practices that are present in some countries, regions and/or farms with the idea of encouraging better practices throughout the industry. The goal was to identify and document a broad range of practices and structures that increase profits and benefits simultaneously. Put simply, one of the goals of this work was to identify social BMPs that would speed up the learning curve. If shrimp producers are able to read about practices that are both socially beneficial and enhance profits, they will be more open to the possibility of trying them themselves.

The shrimp farming industry has changed substantially in recent years, largely in response to declining prices, increased costs of inputs, criticisms by environmentalists, and serious disease problems. The industry has adopted the rhetoric of sustainable development, but they have applied the concept primarily in a technical manner to the ‘environment’ of a shrimp pond. The focus has been in terms of the factors that make a farm *operationally sustainable* as a business investment activity (Barnhizer 2000). A far more difficult task involves the development of mechanisms that reflect the larger social, community-oriented, and ecosystem concerns that are integral aspects of sustainable development.

Major Findings and Lesson’s Learned

Direct Employment and Benefits
There has been considerable discussion about employment in the shrimp industry. However, much of the available information is anecdotal and not terribly reliable. Several questions need to be answered.

- How many jobs has the industry created?
- What part of the industry creates them?
- Which are for men? Which for women?
- How does this compare on an annual basis with other industries?
- How do the wages paid in the shrimp industry compare to other sources of employment (e.g. cash crop production, subsistence production, or rural day wages)?

- What other compensation or benefits do workers receive (health, education, pensions, etc.)?
- What is the average length of time employees work in the industry compared to other industries? Are there ways in which employers are trying to reduce turnover of employees?
- Is housing provided for employees? What about their families? How does this housing compare to local housing (e.g. roofs, floors, size, electricity, tv)?
- Do employees get any direct training or education that increases their skills, marketability? Do their families?

Some estimate that globally the shrimp farming industry employs more than 1 million people directly (Phillips and Barg 1999). The industry generates as much as ten times the revenue as traditional agricultural crops and about 3 times the amount of export agricultural crops. It is speculated that increased revenues allow for the purchase of less expensive foods and even proteins.

Shrimp aquaculture is often located in areas that have not had dynamic economies. In Honduras, shrimp farming generates some .5 jobs per hectare of ponds and anywhere from 3 to 6 times that many indirect jobs (Stanley et al. 2000). Even so, the area is still a net exporter of labor to other regions in the country and to the US.

Schwab, Weber and Lehmann (2000) reported that the unemployment rate in rural areas of the northeast of Brazil is about 50% and the rate of illiteracy or near illiteracy is about 60 to 70%. Employment on the farm they studied in this region increased from 38 in 1993 to 221 in 2000. At the same time, the turnover rate of employees on the farm was reduced from an annual rate of more than 30% to 13.6%. They attribute these and other improvements (including productivity) on the farm to better management. Until 1993, there was a great deal of theft and mis-reporting that negatively affected profits. A professional manager employed in 1993 replaced almost all the employees and implemented stricter management controls that resulted in the farm showing positive financial results for the first time (Schwab, Weber and Lehmann 2000). This case demonstrates that honest managers can help generate employment opportunities and greater profits.

Gautier (2002b) documented that Agrosoledad in Colombia dedicates resources to economic and conservation activities that are not directly related to shrimp aquaculture. Some 200,000 hardwood trees were planted on more than 200 hectares and a 50-ha native dry forest has been preserved. Part of its property is dedicated to sheep and cattle ranching, and thatch palm and fruit production. Those activities generate about 130 permanent jobs, plus about 50 occasional daily workers. The operations also provide about 30 additional workers for harvesting shrimp.

One of the major problems for many shrimp farms relates to the costs associated with conflict and security. Stanley, Alduvin and Cruz (2000) suggest that the cost of security guards is 26% of the annual permanent labor budget and 5% of the total budget on small shrimp farms in Honduras. In addition, companies spend money on barbed wire, watch towers, weapons, lawyers, publicity and lobbying. All these are costs that directly relate to the cost of conflict. One $20 million investment in Malaysia went bankrupt as a result of protracted legal conflicts with its neighbors.

Indirect Benefits from the Industry

The work of the consortium only scratched the surface of this issue. Many of the cases, however, can point future researchers in the right direction concerning the kinds of data that should be developed for each country concerning indirect benefits from the industry. Among the most important questions that should be asked are the following:

- What types of taxes are paid by the industry to the state?
- What is the impact of the industry on local, regional and national infrastructure (e.g. ports, highways, export facilities, health care, education, energy, communication)?
- Who pays for the infrastructure, the industry or the state?

- What positive impacts are there on local or neighboring villages?
- What are the foreign exchange impacts of the industry?
- What are the net earnings?
- Are there any indicators to measure the multiplier effects of the industry on the rest of the economy? For example, how many jobs are created in other industries for every job in the shrimp industry?

Agrosoledad in Colombia has developed social programs to help the surrounding population. The company supports six schoolteachers and assists the schools with funding for course materials on ecology and conservation. Agrosoledad also employs a healthcare worker to promote health programs locally and supports specific projects such as an agricultural cooperative, horticulture and freshwater aquaculture units, infrastructure constructions, etc. (Gautier 2002a; 2002b).

Better Practices for Social and Equity Issues

There are a lot of innovative approaches employed by the shrimp aquaculture industry around the world. What is acceptable or "normal" will vary tremendously from culture to culture. There are several important areas that need more systematic investigation. However, the work of the consortium gives some insights.

Shrimp producers tend to pay better wages than other employers in their areas. They pay considerably more (1.5 to 3 times) than those who employ agricultural day labor and temporary workers. They pay 50% or more than other commercial producers in the same area. Increasingly, however, at least in Latin America, a number of employers have found that worker incentive programs actually increase the productivity of workers on farms. In the past such programs focussed on senior management, foremen and administrators. Today, owners are finding that incentives even for entry level positions actually increase profits and increase the income of even the lowest level employees. Employees are also finding that the more they create worker incentives for innovation, not just performing the normal work load, workers actually help identify more efficient practices that can lead to increased productivity.

A number of shrimp producers in Latin America are using incentive systems with workers and not just administrators also people working directly in the ponds. People get base salaries and then they get bonuses based on productivity and net profits. This has been seen to increase production, reduce feed use, increase FCR and increase net profits. For example, some companies give bonuses for people who invent or discover better ways to do things. In one case from Brazil, this included making feeding trays by recycling bicycle tires. There are other examples as well.

Many companies, in an effort to focus on their primary businesses, are spinning off industries or businesses and turning them over to workers' associations, unions, communities or cooperatives. This is true of worker transportation systems, laundries for uniforms, cafeterias, security services, transportation systems, even harvesting. These spin-offs not only benefit workers, they often benefit nearby communities as well.

A number of spin-off businesses have been created by companies and handed over to workers associations, unions or cooperatives. Some may have been handed to local communities, but I am not aware of any specific examples. The focus of these companies is not the direct mandate of the company, e.g. produce shrimp. They are, rather, ancillary businesses. These include worker transport companies, companies to run the cafeterias for the workers, and laundries to clean the uniforms on farms and in processing plants.

One shrimp producer in Colombia uses mangroves on his property as a biofilter to process the effluents from the shrimp ponds. The biofilter cost approximately US$100,000 to construct and in the year 2000 it directly saved the company approximately US$95,500 in environmental taxes it would have had to pay if it had released its effluents into the nearby lagoon (Gautier 2002a). Indirect benefits may be even larger. Gautier reports that the biofilter reduces the risk of polluted water in ponds that produce off-flavor shrimp that brings much lower prices on the world market. The mangroves also attract a large number of birds, creating the potential for ecotourism in the region. Finally, to assimilate more nutrients, mangroves need to be selectively cut. By turning the rights to harvest from the mangroves over to workers and neighbors the company can save labor costs and also provide significant financial benefits to others.

In Mexico, communities own more than 80 percent of all shrimp operations collectively. These communities are now entering into joint ventures with commercial producers. Some communities sell rights outright. Some rent out their land for annual payments and some receive a percentage of production. Some communities use a combination of these approaches. In short, there are several ways that shrimp aquaculture can be structured that generate benefits for local populations (DeWalt et al. 2002).

Organizational Efforts to Improve Social Benefits

The creation and dissemination of best practices will be region and country specific. For this reason, the establishment of shrimp producer organizations can be a critical to the promotion of better practices. Factors that affect the effectiveness of such associations is the percentage of farmers that belong, the active involvement of ancillary input industries, and whether the associations promote practices or invest in activities that lead to greater social sustainability of the operations.

Schwab, Weber and Lehmann (2000) document some of the positive effects resulting from the formation of the Brazilian Shrimp Farmers Association (ABCC) in 1984. Initially the organization argued for political, financial and technological support for the industry. It also promoted communication among its members and thus helped to facilitate development of a feed and hatchery industry in the country. More recently, the ABCC initiated a means to support research to improve the productivity of the industry. These programs are financed out of a “feed fund” created at the beginning of 2000. Every kg of feed purchased by a producer is taxed 2 centavos. The projects supported are mainly at universities.

Similarly, shrimp farmers association in Honduras, ANDAH, has helped to promote better technological practices among its members and sponsored several social programs. For example, ANDAH is promoting ISO 9000 and ISO 14,000 standards and a voluntary Code of Conduct with ten ethical points to promote responsible production. ANDAH has encouraged members to stop using chemical fertilizers and to comply with requirements for concessions and environmental impact statements. The association also sponsors aquaculture high school training programs at a regional vocational school, a regional reforestation program, and annual stocking of shrimp larva in the Gulf of Fonseca (Stanley, Alduvin and Cruz 2000).

Outside the Box Innovations

There are some ways that shrimp companies are approaching their businesses that are extraordinarily innovative, but they also make a sense in terms of generating a more sustainable and profitable industry. These practices need further documentation. However, initial findings are intriguing.

In Belize, a shrimp producer needed a processing plant to reduce his dependence on very distant plants. He did not have enough product to keep the plant open all the time. This made it difficult to staff, and it made it even more difficult to retain trained staff who were constantly laid off. The producer proposed that it would be cheaper for him to help local communities learn how to run and operate their own fishponds. This would give local populations food, income, and training in aquaculture. In return the shrimp farmer would have a better-trained local work force as well as additional product to put through his processing plant.

In Colombia, there is a proposal being developed to help a group of small farmers collectively purchase a larger farm and convert it to shrimp aquaculture. This operation would border an existing shrimp operation. The existing operation would manage the new farm with its existing staff and proven management practices. This would lower the existing company's production costs yet insure the startup of professional management. Furthermore, between these two operations, it would be possible to operate a processing plant to add value to the shrimp. This would increase the profits of both operations.

Conclusions

As all these examples suggest, there are many positive developments with regard to the social impact of shrimp aquaculture throughout the world. This in no way should be seen as an effort to minimize some of the negative impacts of the industry. However, there are several examples of efforts being made to develop solutions that are economically remunerative, environmentally sound and socially beneficial. The hope is that by highlighting these positive examples, other examples will be brought forth as well and shrimp producers will be able to build on these examples.

Social Impacts and Poverty Alleviation

Major Issues

The case studies provide some evidence and have been chosen to explore conditions under which poverty alleviation on coastal communities might be alleviated through shrimp farm development. The potential applications of shrimp farming/coastal aquaculture targeted for poverty reduction among the coastal poor with few, if any, capital assets, have been explored in Bangladesh and Vietnam. The study explores the experiences and mechanisms that may ensure success where shrimp culture is a viable option for development in coastal communities.

In Asia, small-scale farmers make up major proportion of the shrimp farming population, although there is a considerable variation between countries. Studies in Thailand demonstrate that the production sector is dominated by small-scale producers, many previously rice farmers or fishermen. In such cases, shrimp aquaculture can contribute to diversification of employment opportunities in coastal areas. In **Vietnam**, the case studies also show that nearly all shrimp farmers are local farmers or fishermen who have switched to shrimp farming to earn extra income. Poverty is particularly endemic in rice farming areas of Vietnam, and coastal rice farmers have readily taken to shrimp farming to improve incomes, under a recent policy shift from the government. Here there are few reported social conflicts (Nissapa et al. 2002; Nhoung et al. 2002).

By contrast, shrimp farming in Bangladesh has reported to lead to several cases of significant local conflict. The picture that emerges from the **social case study in Bangladesh** is that encouraging participation of local people in shrimp aquaculture can considerably reduce such problems. The previous reported conflicts appear to have been the result of renting of land for shrimp farming by mainly outsiders. The case studies demonstrate that shrimp farming can – if practiced in the appropriate way with the involvement of local people – can significantly reduce conflicts, and contribute both to alternative income generating for marginalized coastal inhabitants, some of whom may also be involved in environmental damaging practices. NGOs in northern Vietnam for example are promoting coastal aquaculture, including shrimp, crab and seaweed culture, as components of mangrove replanting projects, and as income generating alternatives to mangrove destruction. In these projects, shrimp provides income whilst other crops also provide more direct food for consumption (Begun and Nazmul 2002).

These positive contributions to employment and income diversification possible through shrimp aquaculture in coastal areas, need to be set against the risk associated with calamities such as for example floods or shrimp disease, which when they occur can make such employment gains and other benefits short-lived. Thus, risk reducing management strategies are required.

The **social study case in Bangladesh** provides a more detailed understanding of the importance of shrimp aquaculture to the livelihoods of poor people living in coastal areas. It suggests that the ownership and management of shrimp farms by local people (rather than absent landowners - a major source of conflict) can lead to substantial reduction in conflict. As such, the participation of the local community in shrimp aquaculture appears to have contributed to a reduction in social conflicts, more timely alternate cropping between shrimp and rice, and consequent reductions in salinity problems in some areas. This approach offers a very important direction to alleviate social conflicts and for shrimp aquaculture to contribute more effectively to coastal poverty alleviation. The approach to conflict resolution in Bangladesh is basically reflecting a shift to social objectives for development (not just directed at shrimp yields).

Major Findings and Lesson's Learned

Management Approaches that Might Work for Poor People

There is a dilemma associated with shrimp aquaculture in coastal areas. In some locations, the development of shrimp aquaculture has contributed significantly to the wealth of local communities and poverty alleviation - **Vietnam** provides several good examples. On the other hand, in some locations shrimp aquaculture has been associated with increased social conflict, equity problems and serious local unrest.

Lessons From Oxfam PRAs in Tra Vinh on Extension to Poor Shrimp Farmers, Compounding Problems of Risk

- Accessibility is a problem. Better off men were most likely to be invited to attend extension classes.
- Extension officers not available at the same time as the loans were available for stocking of shrimp ponds.
- Gearing of shrimp extension courses towards "larger or commercial scale" farming, that was suited to farmers with limited education, landholdings or limited resources.
- Instruction materials complex and require high degree of literacy.
- Remoteness of farms from extension services

Recommendations to Improve Extension Services to Poor People

- Create incentives to increase willingness of extension staff to work in remote areas.
- Develop extension programs that teach methods feasible given the economic conditions of farmers.
- Develop programs that are relevant to the knowledge and education of farmers.
- Develop programs to ensure they are available to poor farmers.

Oxfam (1999) Tra Vinh: A participatory poverty assessment)

This raises questions of whether shrimp aquaculture is appropriate for poor people, both directly and indirectly in employment or businesses providing inputs (e.g. fry trading in Andhra Pradesh) or involvement in post-harvest processing (e.g. women in Bangladesh). It is clear that there is a need for further research on these topics, however, at the present time one can start to identify examples of ways in which employment and also preconditions which should be met for poor people to benefit from shrimp aquaculture.

An important issue is not to develop or site shrimp farms can be done in ways that affect poor people's access to resources, or livelihoods. This is also emphasized in the Code of Conduct for Responsible Fisheries. Several examples can be found – for example, in India, leaving a corridor for local people to access the seashore. This is a simple social BMP that can and should be incorporated into better practice guidelines.

The case studies also show that there are also risks associated with the participation of poor people in shrimp aquaculture. In Vietnam, though, local farmers appear willing to accept the risk because of the potentially significant returns. As one farmer in Ca Mau, Vietnam put it "my family can earn more from one crop of shrimp than six crops of rice". Indeed, in the coastal areas of Asia, shrimp and other forms of aquaculture remain an important, and one of the few sources of income and potential for poverty alleviation. There is also no doubt that participation of poor people in shrimp aquaculture does involve risks to poor people's fragile livelihoods that must be properly considered. For example in Vietnam poor ethnic Khmer in Tra Vinh province suffered repeated losses of shrimp, and eventually sold land to pay for debts.

Oxfam's' livelihood analyses of poor people in Tra Vinh province showed that the Khmer were often left out of traditional extension meetings, and in any event found it difficult to understand the extension messages. In other words, special attention is needed to focus support on poor people if poor people are to be targeted. Such considerations have been rarely considered in the past. The same situation also occurs in Bangladesh, although here the situation is less well studied.

Unfortunately, much coastal aquaculture development has been resource driven –planning based on biophysical resources. This approach has almost certainly missed the main target – people. There needs to be a re-emphasis in several countries, and more focus on people as a starting point in planning for coastal resource use and a shift towards for more people centered development, with mechanisms in place to support the participation of poor people in resource planning and management. If such approaches are allowed to work, with supporting institutions, then poor people may be in a position to benefit from shrimp and other forms of coastal aquaculture.

Institutions to Support Poor People

Some case studies are being chosen to explore conditions under which poverty alleviation on coastal communities might be alleviated through shrimp farm development. The potential applications of shrimp farming/coastal aquaculture targeted for poverty reduction among the coastal poor with few, if any, capital assets, are explored in the case studies in **Bangladesh** and **Vietnam**. The special conditions as expressed by farmers in Mekong delta of Vietnam include the need for access to credit, better farmer-to-farmer cooperation, technical support, and a means of diversification of farming. Some institutional problems facing poor shrimp farmers in Tra Vinh are provided in the box above.

Conclusions

The case studies in several show that shrimp farm development has had significant implications for poor people living in coastal areas. The impacts have been both positive and negative. Recent work in Bangladesh, one of the poorest countries studied, suggests that on balance the incomes of poor people has increased, but that shrimp farming has also been accompanied by increased income inequality. Whilst more work remains to be done, implementation of better management within the shrimp farming sector provides opportunities to contribute to poverty alleviation in coastal areas. One of the key follow up actions should be more focused analysis of the opportunities and conditions for development of shrimp culture in ways that contribute to social development in coastal areas.

Economics and Cost of Management and Barriers to Adoption of Better Practice

Major Issues

Every use of resources has an impact. The question for society is which impacts are acceptable. The environmental and social costs of production in many industries are often passed on to society. With many commodities, the lowest cost producers are often the most polluting. This issue takes on even more importance within the context of globalization and international trade.

Shrimp aquaculture is a global industry. It, too, has had impacts. Reducing the impacts of the shrimp aquaculture industry will cost money. One of the tasks of the consortium was to attempt to understand which of the costs could be paid back relatively quickly and which do not pay for themselves, even in the medium term, through improved efficiency. For these latter costs, the obvious question is who will pay. The prior question, however, is how many of the BMPs actually pay for themselves in the short to medium term.

On this issue, the research results of the consortium are somewhat surprising. While there may be a hundred different activities in shrimp aquaculture have impacts, the majority of the impacts in any single operation arise from only a few activities, perhaps only 3 or 4. Some 6-10 activities appear to account for most of the impacts of the entire industry around the world. The research of the consortium suggests that in two-thirds to three-quarters of these instances, mitigation measures pay for themselves in 2-3 years. However, the practices to address impacts will be different for large producers vs. small ones, for extensive vs. intensive ones, and for producers with more cash or more labor to invest.

The work supported by the consortium does not provide enough detail to know in each instance how one should move forward with all the different types of shrimp producers to reduce their impacts. The approach was to document examples of production practices from around the world rather than to focus on a representative sample of producers by type. Consequently, the work is not definitive, but it does provide a window on the issue and a good indication of followup work to increase the adoption of BMPs.

Major Findings and Lesson's Learned

There are few if any "best" practices at this time. Even so, better practices have significantly lower impacts than worse ones. Most BMPs were discovered by producers trying to solve problems, reduce input costs or wastes, and/or increase profits. They were not generally the result of regulation although that is not always the case. The conditions that increase BMP adoption or that produce new ones (e.g. price of land, labor or other inputs, incidences of disease, decreasing prices for shrimp, etc.) are intensifying. There will be no "one-size fits all" approach to reducing the impacts of shrimp aquaculture, however. What is appropriate to one country, region or even producer, most likely will not be for another. In short, the issue is not what to think but, rather, how to think.

The learning curve in aquaculture is steep, however. Not everyone learns at the same rate. Innovators are always ahead of the curve with the majority of producers holding back until innovations prove themselves or until there is a crisis in their operation. As much as most shrimp producers want to improve their own production, few want to teach others how to do so. Yet, learning is essential if the industry is to remain competitive. Many in the industry have come to realize that it is important to share their knowledge because the poor performance of others can affect shrimp aquaculture's reputation as a whole as well as a government's will to regulate it.

There are a few clusters of activities that have impacts and that also reduce the profits of producers. Siting and construction are cases in point. Some analysts suggest that 90 % of all subsequent impacts result from where a shrimp aquaculture operation is built. This is true of single operations, but impacts are often compounded through the cumulative impacts of many operations in the same area.

An increasing body of data suggests that where one builds shrimp ponds directly affect operating costs and life expectancy. For example, building ponds on acid-sulfate soils tends to increase the need of lime to neutralize the soil, increase the stress on PL in the pond, susceptibility to disease, and generally result in poorer performance. Such ponds often are abandoned or at least left fallow for a number of growing seasons. Given that the average cost of building shrimp ponds is $5,000 to $20,000 per hectare, most farmers want the investment not only to be productive every grow-out cycle, but also to last indefinitely with only minor maintenance.

Building shrimp aquaculture ponds in the wrong place reduces their life expectancy. They require more inputs (e.g. lime and labor), they have lower survival rates, and they require more down time between cycles. They require higher water exchange rates to flush away actual or potential problems. Even small producers who substitute labor for capital and build their own ponds, "invest" even more of their resources in their operations than larger farmers. While land was cheap and readily available and the price of shrimp was high, margins were large and producers did not care about being more efficient. It was too easy to make money even with poor practices. Today, all that has changed.

Not having intake and effluent canals sufficiently separated can cause self-pollution, poor water quality and the spread of disease. These factors can, in turn, cause tremendous losses for producers. Building below high-tide marks makes harvesting more difficult and makes it virtually impossible to dry the bottoms of shrimp ponds. This, too, can lead to deterioration of water quality and, ultimately, reduced profits.

Many shrimp farmers around the world are beginning to experiment with the use of artificially created bio-filters to clean their discharge. In some cases, as in Colombia, this is due to the imposition of a pollution tax which is based on the quality of the effluent. In other instances, farmers see this as a way to treat water so as not to overload the nearby in-shore areas. This is a way to maintain relations with other stakeholders in the area. And, the costs of resulting conflict can be quite high when such issues are ignored.

How farms are constructed also affects profitability. For example, if farmers do not save and replace topsoil, reestablish ground cover, and use proper grading for slopes, they will have to spend money repeatedly to fix their ponds. It might cost US$3,000 to US$5,000 more per hectare to protect ponds and earth works from erosion than to simply slap them together to begin with. Repairing earthworks is not just about the cost of the actual repairs, however. Often it means that ponds may need to dry out for up to 20 days to be able to bring machinery in to fix the damage. This represents some 15% of the average crop cycle or maybe as much as 25% of a crop over the course of a year. In short, cutting corners initially can cost much more over time. It is usually cheaper to simply have done a better job from the outset.

Many of the better practices are linked. For example, feeding multiple times a day and using feeding trays or other reliable means to insure that only as much feed is used as animals eat tends improves FCRs as well as maintains water quality. In the past as much as 30% of feed might not even have been eaten by shrimp. This is clearly a waste of feed, but it has other costs as well. Today feed is better utilized. This means that less water must be exchanged (down from 10-15% per day to 2-3%). Less pumping means lower costs. Better water, in turn, means reduced stress, increased survival rates, less chance of disease, and fewer and less nutrient-laden effluents. Finally, it means that shrimp can be left in the ponds longer to grow to larger sizes that are worth far more.

Effluents are another area where management reduces impacts and can increase profits. Settlement canals and ponds are increasingly used to treat effluents. However, well-managed ponds have fewer effluents to treat and less land must be set aside for these activities. In addition, many farmers are beginning to realize that exchanging water can bring diseases into ponds. Some producers are now thinking that once water is good for growing shrimp it is wasteful to simply release it off the farm. Instead it should be reused. To the extent that this can happen between crops, farmers can reduce by 10-20 days the time it takes to condition the water for the next crop.

While it appears that many if not most BMPs pay for themselves, there may be other ways than immediate financial self-interest to accelerate their adoption. Adoption of BMPs, for example, can be linked to investment or purchase screens or even to government permits or licenses. In the final analysis, however, if producers see a financial advantage in adopting BMPs they will, but only if they have been exposed to them first hand in their own region.

Conclusions

The consensus emerging from the cases is that some practices pay considerable dividends. Others, less so. For example, in Colombia, the survey of best practice showed little adoption. In Bangladesh, a survey of best practice that was primarily based on improving yields, showed a good uptake, provided farmers had resources to invest. In Thailand, the study on the implementation of the Thai "Code of Conduct" suggests better financial returns from several, but not all, management measures. In general, perhaps, the more "advanced" the farm, then the more difficult it may be to obtain returns on investment in better practices. This issue needs to be further looked into when all the case study findings are available.

While tax and other incentives to promote the development of shrimp farming, or aquaculture in general, have been introduced in a number of countries, information on their positive and negative effects is generally limited. The case studies examine incentives including the results of these incentives in the countries where they have been introduced. The identification of better management strategies through the case studies provides a basis for the development of incentives promoting sustainable shrimp farm investments.

Institutional and Policy Issues

The case studies explore the institutional and policy support required for is addressing negative environmental impacts and promoting better practice.

Experience With Integrated Coastal Area Management

Major Issues
There is a need for effective planning of shrimp aquaculture development in coastal areas, which allows for balanced use of coastal resources and optimizes social and economic benefits. An important limitation is that shrimp farming expansion in many countries due to the profitability of shrimp farming can lead to large increases in the number of entrants, in some cases leading to large numbers of farms in areas with limited capacity. Many of the developments of shrimp farming have moved very fast, and beyond the capacity of governments to control or institutionally support development. The case studies bring together some experiences that provide address what are the necessary conditions and limitations for integration of shrimp aquaculture into integrated management of coastal areas. The Indonesia and African case studies in particular explore these issues.

Integrated coastal area management (ICAM) is a process that addresses the use, sustainable development and protection of coastal areas, and according to GESAMP (1996) "comprehensive area-specific marine management and planning is essential for maintaining the long-term ecological integrity and productivity and economic benefit of coastal regions". There have already been considerable efforts within countries as well as internationally to address economic, social and environmental problems being experienced in wide range of coastal areas. Few of these efforts address shrimp aquaculture specifically, however, ICAM may represent an opportunity to capture the benefits from shrimp aquaculture and a means of avoiding *ad hoc* development and crowding of farming areas beyond carrying capacity.

Major Findings and Lesson's Learned
ICAM involves a participatory and strategic planning process that spans issue identification and assessment; public education and stakeholder consultation; selection of issues to be addressed; geographic focus and activities to address issues; formulation and adoption of a management plan; and capacity building within the public sector for implementation. Roles and responsibilities for planning and implementation of ICM need to be clearly delineated. An institutional structure for ICM typically contains distinct but clearly linked mechanisms for: (i) achieving interagency coordination at the national or regional level (e.g. through an interministerial commission, authority of executive council); and (ii) providing for conflict resolution, planning and decision-making at the local level (Tobey and Clay 1997). The practical experience in implementation for aquaculture is limited, which is in large measure because of the absence of adequate policies and legislation and institutional problems, such as the lack of unitary authorities with sufficiently broad powers and responsibilities.

An important principle of ICAM is adoption of participatory approaches and involvement of local community stakeholders. Within Asia, as indicated in the **Indonesia and Thailand case studies**, there is growing experience on community-based coastal resource management efforts addressing sustainable shrimp aquaculture. The general findings with respect to contextual factors that are important for community-based efforts in sustainable shrimp aquaculture, based on the experiences with the Pematang Pasir case in Indonesia, that are broadly relevant include:

- If the community perceives a crisis in the impacts of shrimp farming and in the health of the industry it will be more willing to take action to reverse such trends.
- Natural resource stewardship is only likely to occur if the landholder is aware of the problem, and is motivated to do something about it.
- A community with experience working together or with a tendency for participatory processes and decision-making is more predisposed to developing broad-based consensus and proactively solving resource use issues.

- The more important shrimp culture is to the community, the more interested and committed it will likely be in adopting better practices.
- Farmers are motivated to adopt sustainable management practices where there are economic benefits associated with the practices.
- The legal system relating to land tenure, use and management matters greatly to landholders' freedom of action.

The key findings of the Pematang Pasir case in Indonesia with respect to better practices for community-based management of shrimp aquaculture that are broadly relevant include:

- Awareness raising, education and training help build community understanding concerning environmentally sustainable aquaculture practice.
- A core community planning group that involves important formal and informal community leaders is influential in developing widespread community support for better shrimp farm practice and coastal resource management.
- External advice to the community is important to help highlight and solve on-going problem areas. Small communities typically do not have adequate technical and planning capacity to resolve new issues.
- NGOs can play an important catalytic and supportive role in promoting good practices in communities, especially where government capacity is low. Features that make NGOs especially appropriate partners for local-level coastal management activities are small size, internal flexibility, community and participatory orientation, local-level knowledge, autonomy and creativity, quick response and adaptability, and cost-effectiveness.
- Many of the wider problems in coastal resource management and sustainable aquaculture at the community level must be addressed through complementary legal and institutional strengthening at the regional and national level. Unless there are effective mechanisms to connect local resource management with governance arrangements at higher levels, a coherent nested program of environmental and natural resource management cannot be achieved.

Zoning is a means of making integrated coastal management operational. Such schemes have long been a feature in the management of nature reserves, Marine Parks and other protected areas allowing certain habitats to be completely conserved for their ecological and scientific value, while others are set aside for public use, but on a controlled basis to minimize human impacts on the natural environment. Zonation in this way allows for the separation of potentially conflicting human activities in particular areas. The general principles developed through the **mangrove thematic review** may be applied to coastal zoning schemes for existing shrimp farming in or adjacent to mangrove areas as follows:

- Reclassify the seaward zone and critical hydrological/habitat zones (e.g. along the banks of estuaries and creeks) for mangrove conservation, and have provision to carry out mangrove restoration in such areas, as necessary.
- Redevelop and improve the remaining shrimp culture zone to promote (i) intensification in smaller ponds, and (ii) more sustainable production systems.
- In addition to the zoning scheme itself, there should be enabling mechanisms to ensure that the scheme can be implemented, monitored for effectiveness, and improved where necessary. These steps require enabling mechanisms as follows:
  a) supporting legislation to uphold the conditions stipulated for the management of each zone;
  b) a monitoring system, including environmental indicators for each zone;
  c) mechanisms for consultation with and feedback from the main stakeholders involved.

Conclusions

The integration of shrimp aquaculture into coastal area management represents an important direction for future development of shrimp aquaculture. The case studies provide some experiences and factors that may apply. Participation of local people in the planning process appears to be an important condition for success. However, wider problems in coastal resource management and sustainable shrimp aquaculture at the community level must be addressed through complementary legal and institutional strengthening at the regional and national level. Effective mechanisms to connect local resource management with governance arrangements at higher levels, through a coherent nested program of actions, to support local shrimp aquaculture management is essential.

Codes of Practice and Industry Progress (non-regulatory measures)

Farmers have made progress in the development and implementation of better practice management, although experience suggests that local circumstances and farming systems determine the types and success of different management systems. Several cases were selected to assist further development and understanding of better farm management practices and their application to shrimp aquaculture.

The industry is starting to integrate these practices into "Codes of Practice" or "Codes of Conduct" as analyses in one **Codes of Practice thematic review**. Most are mainly at the development stage, but are increasingly being prepared both driven by industry and governments. Codes of conduct and other forms of guidance on management practice in shrimp farming fulfil a useful role in identifying various aspects of better practice and encouraging adherence to this. The scope of such guidance may of a general or specific kind and its status may be greatly influenced by the standing of the body propounding it. Nonetheless, non-mandatory guidance mechanisms to encourage the improvement of performance fulfil a useful function either as a support to legislative measures or to address matters that are not provided for in legislation. There is a tendency, as one reviewer put it "to regroup technical advice under a so-called "code of conduct" rather than develop realistic strategies that address problems". This point emphasizes that practical measures are essentiual to support implementation.

Whilst Codes of Practice and Conduct are a welcome move forward, particularly when they have strong ownership among industry, clearly much more needs to be done to facilitate their implementation. Further, a question remains of the relevance and ownership of some of the codes to farmers in many developing countries, as their appears to have been a lack of participation by a broad participation by farmers in their development in several nations. Generally, the **thematic review on codes of practice** found good coverage of technical issues, and many environmental concerns, but limited coverage of social issues.

There are other examples of the industry taking action on regulation. In Madagasgar, the shrimp industry is working with government to establish a regulatory structure based on implementation of agreed best management practice.

Legislation and Experience with Existing Regulations and Procedures

Major Issues
What is an appropriate institutional and legal framework for shrimp aquaculture? Several individual case studies explore this aspect and a comprehensive review covering legislation in twenty countries of Asia, East Africa and Latin America is provided in the **legislation thematic reviews** (Barnheizer In press).

One **thematic review** provides information about the present state of the law concerning shrimp, giving particular emphasis upon legal requirements that relate to the environmental impacts of shrimp aquaculture. Such impacts are, broadly, of two kinds. The first relates to the initial impacts of establishing a shrimp farm at a particular location, and potential adverse effects upon the environment and potential conflicts raised with other competing uses of the land and water. The second relates to potential continuing impacts upon environmental quality, which may arise through the actual operation of a shrimp farm once established at a particular location or, indeed, after the cessation of its activities. Alongside these matters are a diverse range of associated issues that relate to the efficiency of the shrimp farming industry and the quality of the products that it produces, and which often reflect underlying environmental concerns. There is also a need for legislation to protect shrimp farming from adverse environmental impacts that are capable of causing significant damage to the viability of shrimp farms or the quality of their products. In particular, industrial and other sources of water pollution should be regulated to ensure that damage is prevented.

Major Findings and Lesson's Learned

National legislation has been enacted in some jurisdictions to address the key environmental concerns and the range of regulatory control techniques in use are noted below.

- The use of environmental impact assessment procedures for individual farm siting, design and operation.
- The implementation of coastal land use zoning techniques, buffer zones and authorizations.
- The application of mangrove management and conservation techniques.
- The formulation of environmental quality objectives, environmental quality standards and effluent standards.
- The limitation of access and use rights for water and seed (capture of post larvae shrimp) and the imposition of restrictions upon introductions of exotic species.
- The use of pond effluent control techniques involving feed control restrictions, settling ponds, limited use of drugs, antibiotics and other chemicals.
- The use of trade-related techniques such as product certification schemes.
- The establishment of user groups agreements, to avoid use conflicts and to allow for effective area management.
- The development of best management practices through codes of conduct and practice.
- The application of controls over disease transmission.

The key issues that may be considered in legislation as related to shrimp aquaculture include the following:

- Status of acquisition of land rights.
- Development licensing for establishment of shrimp farms.
- Continuing controls upon shrimp farming activities.
- Fresh water use licensing.
- Wastewater discharge licensing.
- Shrimp movement licensing.
- Chemical use.
- Food sources and utilization.
- Product quality controls.
- The need to comply with international standards.
- Support for technical guidance and producers' organizations.
- Enforcement.

The evidence from the survey indicates that relatively little use has been made of specialized shrimp farming legislation and in almost all instances the activity is largely governed by legislation which is concerned with fishery resources in general. The practical explanation for this is that, in most countries, shrimp farming has only become established over a relatively recent period of time and, frequently, since the enactment of more general fisheries legislation. It has also been noted that, in some jurisdictions, a considerable amount of environmental legislation has recently been enacted, often following technical assistance projects. By comparison, the development of aquaculture and shrimp farming law has lagged behind and failed to keep pace with developments in practice.

For almost all the countries surveyed, the review concludes that the pressing issue for the future is that of modernizing or replacing outdated fisheries legislation to recognize the distinctive nature of shrimp farming activities and better to facilitate the development of the industry and to improve the standards to which it operates. In many instances, this might be best achieved through the enactment of specialized and comprehensive legislation to bring about some degree of consolidation of, and consistency between, the different legal controls that are needed. The FAO *Code of Conduct on Responsible Fisheries* should become influential in determining the scope and content of national legislation and, as soon as the opportunity arises, countries should give careful consideration to need to amend national legislation to give effect to the Code and, particularly where shrimp culture is concerned, those provisions which have specific application to this activity.

By itself, the existence of legislation on any of the preceding matters is no guarantee that actual practice will be changed without some mechanism for implementing and enforcing regulatory requirements on the ground. Arguably, legislation is only as good as its enforcement, since, where legislation is not enforced, its capacity to secure improvements in practice will be greatly undermined.

Institutional Responsibilities and Capacity

Major Issues

The general picture emerging from the case studies and **legislation thematic reviews** is of policy making, legislative, administrative and enforcement responsibilities spread across a fairly wide range of bodies and institutions. In itself, the dispersal of responsibilities that is commonly found may not be problematic, however an important issue is to ensure that the responsible bodies for each aspect of shrimp farming are clearly identified and the boundaries of the different bodies are clearly defined to avoid overlaps of responsibility or matters that fall outside the responsibilities of any of the responsible bodies. Various case studies provide better understanding of the institutional experiences and conditions necessary for sustainable shrimp aquaculture.

Major Findings and Lesson's Learned

Devolution of Powers

The devolution of policy making, legislative, administrative and enforcement powers is increasingly practiced in several countries and appear to serve a useful purpose insofar as it allows these matters to be determined at a level which is close as possible to those upon whom they impact. Indeed, some nations, for example Thailand, there is increasing devolution of responsibilities of natural resource management. The desirability of local communities having control over their circumstances is strongly emphasized in several case studies, including in **Indonesia** and **Thailand.** A key issue that must be addressed in the allocation of powers and duties to local bodies and authorities is providing the expertise and resources to discharge these functions effectively to ensure the planned and responsible development of shrimp farming.

Public and Private Sector Roles

The public and private sectors work together in various ways in the countries studied. In some, a degree of cooperation has been established to work together in formulation of legislation and policy. In Madagasgar, the government and private sector are working to establish a legal framework for industry development, at the prompting of the industry, that was concerned over the impact of large scale developments on its future sustainability. In Thailand, industry and government have worked together on the development of a Code of Conduct. In some, such as Thailand, producers associations are playing increasingly important roles in interacting with government. The precise roles and responsibilities of public and private sectors varies in different countries.

Institutional Capacity

The case studies emphasize the importance of building local capacity for planning and management of shrimp farming. For example in Tra Vinh, Vietnam, the income generating ability of poor people was hindered by the lack of strong and effective local extension services. Some of the problems faced by poor farmers (and not just shrimp farmers) are noted in a previous section. In **Bangladesh, India and Thailand** the importance of building capacity in local institutions to provide extension support and an institutional structure for management of development has been strongly emphasized. This key issue is of major significance in supporting effective local level coastal management and poverty alleviation - institutions that have the resources; capacity and motivation to respond to local development needs are urgently required.

Institutional capacity has to be built depending on the specific needs, and must be based on local people's needs. There is a need to build policy, institutions and legislation that work at a local level. The experiences suggest that management responsibility should be devolved as far as possible to government institutions and local people in the local area. This raises the importance of integrated coastal area management approach as emphasized in the Indonesia case study.

Human Skills and Delivery of Information

The importance of delivery of knowledge and skills to people for planning and management of shrimp aquaculture is emphasized in the **Indonesia, Vietnam** and **Thailand** case studies. For the most part, government-run extension services do not appear to operate that efficiently. In many cases, they are behind the private sector and delivering technical "textbook" messages that are often not relevant to the local situation. The sheer number of farmers relative to extension services is also a problem. For example in Dam Doi district in the Mekong delta of Vietnam, there are around 100,000 farmers, but serviced by only 4 extension officers. In such cases, it is important to pursue other or parallel means to bring know how and better practices to farmers.

Experiences are mixed in delivery of information. Important directions are towards farmer groups, as Vietnam and Thailand are moving in this direction. Lessons learned from the agriculture sectors, such as "farmer field schools" may also be applied. Self help farmer groups embody the advantage that they are self-motivated to provide extension services and they can use networks among growers, seed suppliers and produce buyers. Another approach that warrants closer scrutiny is harnessing the private sector in extension. In Thailand, for example, some government staff involved in extension are working closely with feed and chemical salesmen to disseminate basic shrimp health messages based on using better management practices. In Bangladesh, NGOs have also proved useful in extending messages on aquaculture, although they may suffer weaknesses from lack of technical expertise.

Some Activities of the Surat Thani (Thailand) Shrimp Farmers Association in 1999 and 2000

<u>Shrimp production</u>

- Participation in government Code of Conduct implementation programme
- Conduct of research and seminars
- Assistance to farmers in government negotiation.

<u>International trade:</u>

- Cooperation with national govt and private sector institutions concerned with trade
- Affiliation with international agencies (e.g. GAA)
- Provision of information to improve image
- Participation in international conferences.

<u>Environmental conservation:</u>

- Participation with NGOs, government departments (Forestry and Fishery) and private enterprises in mangrove planting.
- Creation of awareness among members on environmentally friendly practices.
- Assistance to shrimp farmers in negotiation on environmental laws and regulations.

Role of Farmer Associations and Cooperation

Farmer associations, if democratically run and fairly representative of the interests of their members, can provide a valuable function in influencing the formulation of shrimp farming policy and legislation and bringing educational and training benefits to members, as well as facilitating collective initiatives on common issues, such as disease control, purchase of inputs and marketing. In addition, for example, with the Surat Thani shrimp farmers association in Thailand, a respected association is capable of exerting considerable influence over its members to secure environmental improvements and enhancement of product standards.

There are various ways in which governments may encourage, and provide incentives for, shrimp farming associations that are likely to enhance their membership and usefulness. Financial incentives such as 'start-up' funding might be provided to assist fledgling associations with initial costs and to publicize their activities. Financial support for individual shrimp farmers might be made conditional upon membership of an appropriate association. Education and training provision might be supported through public funding and delivered through associations. Perhaps most importantly, governments should recognize relevant associations as providing a collective voice for the industry in negotiations on matters of national or local shrimp farming policy. Therefore, a general duty upon governments to *encourage* the establishment of shrimp farming associations, supported by tangible measures of this kind, should be a means of improving practice, productivity and environmental performance across the industry.

Several case studies incorporate lessons on shrimp farmer associations and their potential role in improving environmental performance. For example, farmers in the Surat Thani shrimp farmers association and in Chantaburi in Thailand (Tookwinas In press) coordinate the timing of pond intake and discharge, thus avoiding some of the problems associated with self-pollution of water supplies. The association is also now active in replanting of mangroves in coastal areas, and organizes regular meetings that serve an important means of extension as noted in the box above.

Toward Better Management Practices in Shrimp Aquaculture

The case studies show the diversity of shrimp aquaculture – in terms of people involved, farming systems, environments and management activities, as well as environmental and social impacts. The findings support the consensus reached in the Bangkok FAO Technical Consultation on Policies for Sustainable Shrimp Culture (8^{th}- 11^{th} December 1997) **"that sustainable shrimp culture is practiced and is a desirable and achievable goal which should be pursued".** The case studies provide examples of better management practices and strategies to be followed for better management of the sector.

In this section, the information from the case studies on "better management" has been synthesized into a preliminary set of "better management practices" (BMPs) for shrimp aquaculture, taking into account important environmental and social issues. This section will be further developed during 2002, as more information becomes available and comments on the findings and BMP list are received from different stakeholders.

BMPs generally refer to best management practices. The term is used in several ways. It has been used to refer to the best-known way to undertake any activity at a given time. In this sense, it probably refers to the practice or practices of only 1 or a very few producers. A second way, best management practices can be used is to define a few, often different, practices that increase efficiency and productivity and/or reduce or mitigate impacts. Finally, best practices are often required by government or others to encourage a minimally acceptable level of performance (and eliminate bad practices) with regard to a specific activity. In this sense, the term is used in opposition to unacceptable practices. This latter meaning, however, may be quite distant from "best" practice in any real sense.

During the course of the Consortium's work, a number of individual best practices relating to different activities on farm and off as well as varying by intensity, scale and species have been identified. These practices were then analyzed both to understand how they were developed (e.g. what problem did they solve and what result did they achieve), how they work, and what it would take for them to be adopted by other producers. In the process of undertaking these studies, it has become clear that "best" practices today still fall short both of what is needed and what appears to be possible. In all likelihood, today's best practices will be tomorrow's norm and the day after that an unacceptable practice because it has been superceded. In reality, best practices are often employed only by one or a handful of producers. The challenge is to encourage their further adoption while at the same time pushing even further to find better practices still.

In short, the goal must be to constantly seek out better practices, not just because they reduce impacts, but also because they are more efficient and more profitable. The goal is to improve the norm rather than to simply establish a bar and declare everything above it to be best or good practice and everything below to be bad or unacceptable. From the Consortium's work, we know that we may not have any "best" practices at this time. We have, however, identified a number of better practices, and these practices are far better than the worse ones. Their impact on resource use efficiency can be many fold better than worse practices. Their impact on productivity, and more importantly on profitability, can be similarly striking when compared to worse practices.

The Consortium has come to realize that the industry norm may be best moved not by focussing on incremental increases by the middle range of producers, but rather by redefining the limits of what is thought possible, knowing full well that this is a process that will never be finished. It is a process of relative improvement in efficiency that will continue so long as the shrimp aquaculture industry continues. For that reason, we think that conceptually it is more effective to think about better management practices rather than best management practices even if the latter is the more common useage.

Issues to be Addressed

The studies show that there are a number of key issues to be addressed through better management practices and these are summarized below.

- Locating shrimp farms in areas that make efficient use of land and water suitable for shrimp production and conserves ecologically sensitive habitats and ecosystem functions.
- Shrimp farm designs and construction practices that reduce or limit off-site ecological damage.
- Water exchange practices that minimize impacts on water resources.
- Efficient use of shrimp post-larvae and reduced demand on wild stocks.
- Feed types and feed management practices make efficient use of feed resources, and ideally do not contribute to net loss of aquatic animal products.
- Controlling off-site impacts associated with discharge of effluent and sold wastes.
- Minimizing risks of disease affecting farmed and wild stocks.
- Reduce risks to ecosystems and human health from chemical use.
- Development and operation of farms in a socially responsible and way that benefits local communities and the country.
- Shrimp aquaculture that contributes effectively to rural development, and particularly poverty alleviation in coastal areas.

The following questions are also important in implementation of better management practices:

- What are the benefits and costs to farmers for implementation of the better practice?
- What are the positive social and environmental impacts and synergies from their implementation?
- What are the constraints to implementation, and how might these be overcome?
- How can solutions be planned, implemented and enforced both at the national and local levels?

A Draft BMP Matrix

The first draft of a "better management practice" matrix is given in draft form below. The matrix is organized in to give information on:

- Key issue being addressed.
- Identified worse and better practices.
- Benefits and costs of implementation.
- Impacts and synergies from implementation.

- Key constraints

Sector governance issues are included where appropriate, being concerned with the potential institutional, legal and economic solutions that can be developed to support the implementation of better practice. Public and private sector governance are included. A further section on “indicators” will be added based on further analysis.

Shrimp Farm Siting

Worse practice	■ Shrimp farms siting that cause direct and indirect damage to critical habitats including mangroves, that affect coastal ecosystems functioning, local hydrology and cause saltwater intrusion. ■ Such farms may require more production inputs and pond downtime, result in more shrimp stress and disease and lead to negative water quality impacts through discharge of effluent into intake zones for other shrimp farms. ■ Social impacts from blocking of access.
Better practice	■ Siting farms with significant technical, environmental and social problems are notn likely through use of rigorous site evaluation process. More specifically: ■ Build new shrimp ponds beyond the inter-tidal zone. ■ Ensure no net loss of mangroves or other sensitive wetland habitats ■ Intake and effluent canals separated ■ Do not build in areas with existing concentrations of shrimp ponds. ■ Dykes, canals and infrastructure located in ways that do not adversely affect hydrology ■ Retain buffer zones and habitat corridors between farms and other users and habitat ■ Site farms on suitable soils reducing seepage and salinity problems. ■ Where existing extensive shrimp farms are located in mangrove areas, replanting of mangrove forests, retiring of unproductive ponds, intensification of remaining areas of the farm, and mixed mangrove-aquaculture systems can be considered.
Financial/production impacts	■ Economic and social benefits from implementation of better siting practices are considerable. ■ Site selection practices may be time consuming and costly in the short term but in the long run, are cost effective and efficient in term of farm operation. ■ Retrofitting of existing farms may prove very difficult and costly.
Environmental and social impacts	■ There are significant positive social and environmental impacts from implementation of better siting practices. Site selection practices can be used to avoid negative environmental impacts on sensitive ecosystems, such as mangroves, and agricultural land.
Key constraints	■ Lack of access to or ownership of suitable sites (especially relevant for small farmers in developing countries) ■ Lack of time and resources to undertake detailed studies of site characteristics (especially relevant to small farmers) ■ Site selection criteria not adequately defined or communicated ■ Perverse incentives for short-term profit over long-term sustainability goals ■ Availability and cost of professional engineering and design support ■ Political will to ensure participation of stakeholders ■ Lack of an integrated management framework within which to balance and integrate stakeholder interests.
Public sector governance	■ Pursue a preventative approach ■ Support integrated coastal area management, including zoning, and participatory planning. ■ Support devolution of planning for shrimp aquaculture development at local level and provide capacity building to support local level participatory planning. ■ Ensure that use and property rights are clearly defined in the coastal zone. ■ Seek coherence of multi-sectoral development objectives among sectoral agencies. ■ Environmental assessment procedures (that also include social assessments) integrated into the planning process and enforced by governments or agencies supporting investment in shrimp aquaculture
Private sector governance	■ Awareness building ■ Participation in coastal ecosystem and mangrove replanting ■ Contribute as a stakeholder in coastal resource management and planning ■ Participate in development and enforcement of local standards adhering to better management principles ■ Support small-scale farmer participation in efforts to implement better management practices

Shrimp Farm Design and Construction

Worse practice	▪ Poor farm design and construction (ponds, infrastructure) that leads to erosion problems, may affect local problems related to flood levels, storms, seepage, water intake and discharge points and encroachment on mangroves and wetlands. ▪ Such farms usually require continuous investment in maintenance and leave soil piles and borrow pits.

Better practice	▪ Farm design incorporating buffer areas and techniques and engineering practices that minimize erosion and salinization during construction and operation.
	▪ More specifically:
	  ▪ Minimize disturbance of acid-sulfate soils during construction and operation.
	  ▪ Minimize creation of degraded areas such as unused soil piles and borrow pits
	  ▪ Save and replace top soil
	  ▪ Re-establishment of ground cover after construction is complete
	  ▪ Proper grading for slopes
	  ▪ Avoid sandy soils, unless using pond liners to avoid seepage
	▪ Farming system design that conserve biodiversity and mangrove replanting

Financial/production impacts	▪ Shrimp farm with good and proper design and construction will directly reduce operating costs due to less energy input, for example gravity feeding of all production ponds with water from reservoir rather then using water pump for water exchange. ▪ While operating cost is reduced the profit margin may be higher.
Environmental and social impacts	▪ Good farm design and construction will limit impact on environment at the construction period and also during the operating season. ▪ Erosion problems, seepage and drawing of water from unwanted catchments can be avoided. ▪ Farm design which incorporate features such as buffer zones, sediment traps and correctly situated outfalls will protect and maintain sensitive habitats in and around farm areas. ▪ Siltation of natural waters reduced. ▪ Salinity problems on surrounding areas can be eliminated.
Key constraints	▪ Small holder or extensive shrimp farmers may find it difficult to allocate sufficient funds for proper farm design and construction, which may be an insignificant amount to the medium or big farms. ▪ Lack of ownership and tenure may inhibit willingness of farmers to invest. ▪ Lack of longer-term credit restricts capacity of farmers for longer-term investment. ▪ Lack of farmer knowledge, skills.

Public sector governance	▪ Incentives for longer term investment, e.g. land tenure
	  ▪ Ensure that use and property rights are clearly defined in the coastal zone.
	  ▪ Pursue a preventative approach

Private sector governance	▪ Awareness building ▪ Participate in development and enforcement of local standards adhering to better management principles ▪ Support and participate in farmer cooperative arrangements

Reducing Impacts of Water Use and Effluent Discharge on Local Water Resource

Worse practice	▪ Excessive use of ground freshwater for reducing salinity in pond creates risks of lowering water table level or causing saltwater intrusion. ▪ Release of brackishwater into freshwater systems has the same effects. ▪ High water exchange may be inappropriate in areas where tidal range is limited and with a high density of shrimp farms. ▪ Water inlet and outlet located in the same area creating self-pollution.
Better practice	▪ Minimize discharge of nutrients, organic matter and suspended solids through wastewater treatment systems, and appropriate management of pond sediments at the time of harvest. ▪ Appropriate waste water treatment options such as low water exchange strategies, for example semi-close or close system are ways to reduce releasing high nutrients waste water into the natural water. ▪ Minimize used of ground freshwater for salinity control. ▪ Closing the farming system and water reuse ▪ Less than 5% per day for traditional systems ▪ Less than 100% water exchange per cycle in closed systems ▪ Water exchange rate based on objective reasons ▪ Separate discharge point from inflow canal
Financial/production impacts	▪ Low water exchange strategies reduce energy cost, which make operation more economically sound.
Environmental and social impacts	▪ Risk of introducing pathogens and disease outbreak decreased (chemical pollution reduced) ▪ No discharge of high nutrient waste waters hence less water pollution to nearby areas. ▪ Reduce or eliminate effects of shrimp farms and other resources users.
Key constraints	▪ Allocation of sufficient area for waste treatment systems may be a limitation for small farmers ▪ Tidal flow and water supply system may limit water management options
Public sector governance	▪ Develop water quality standards for local water users. ▪ Develop and implement a strategy to maintain these standards. ▪ Move towards a watershed area approach to maintaining water quality in coastal areas.
Private sector governance	▪ Participate in setting of water quality standards and implementation strategy ▪

Shrimp PLs Used for Production

Worse practice	▪ No minimum PLs selection criteria being adopted when purchasing PLs. ▪ Obtain poor quality PLs from problematic hatcheries, due to limited availability of PLs in the market. ▪ High stocking density with the perception of maintaining minimum production level. ▪ Poor packaging and transportation methods. ▪ Wild caught PLs, by-catch and disease issues ▪ Survival rates of less than 15% ▪ No quarantine or on-farm biosecurity measures ▪ Introduced species through escapes
Better practice	▪ Adopting a set of PL quality selection criteria and use quality evaluation process such as freshwater shock test. ▪ Using good quality hatchery produced PLs ▪ Maintaining high survival rate should be greater than 50% ▪ Acclimatize the PLs before released into the pond. ▪ On-farm quarantine and biosecurity measures ▪ Precautions to prevent escapes – screening of inlet and outlet ▪ Use of local species ▪ Use of domesticated stocks to enhance culture performance and health
Financial/production impacts	▪ Cost of screening the inlet and outlet are minimum, and timely for quality test, however stocked PLs are quality assured. Survival rate may be higher thus higher production level can be maintained.
Environmental and social impacts	▪ Industry wide production will be more stable and less disease outbreak in the farming areas. ▪ In the long run the industry will be less dependence on wild PLs, and the quality of the hatchery produced PLs can be improved and assured.
Key constraints	▪ Available of good quality PLs may be limited due to broodstocks condition and seasonal availability. ▪ Availability of hatchery produced PLs in certain countries. ▪ Limited choice and ability to select for quality PLs. ▪ Social impacts may arise from shifting to hatchery reared stock in some countries (e.g. Bangladesh).
Public sector governance	▪ Contribute and conform to national and international protocols on the transfer and introduction of alien species ▪ Where alien species or non-native strains are used, take maximum precautions to prevent escape of introduced stocks. ▪ Transgenics should only be used where such use has official approval and after appropriate safeguards have been put in place to avoid adverse environmental effects
Private sector governance	▪ Farmers associations to conform with national and international protocols on the transfer and introduction of alien species

Responsible Use of Chemicals

Worse practice	■ Excessive use of chemical or antibiotic in farming shrimp. ■ Treatment of farm problem (disease or not) with inappropriate chemical/antibiotic without proper diagnosis of the problem.
Better practice	■ Chemicals used as little as possible, consistent with the need to maintain pond environment and shrimp health ■ Records maintained regarding use of chemicals in ponds and hatcheries ■ Training of farm staff provided in safe handling of chemicals ■ Ensure that chemicals used are effective for the purpose and are used in accordance with standard techniques or manufacturers' instructions regarding dosage, withdrawal period, proper use, storage, disposal, and other constraints on the use of a chemical including environmental, human and food safety precautions.
Financial/production impacts	■ Appropriate and reducing usage of chemical products on farming activities will bring down the operating costs.
Environmental and social impacts	■ No residue problems in markets ■ Reduced risk from environmental and health impacts on workers.
Key constraints	■ Training and awareness ■ Active and widespread promotion of chemicals by salesmen
Public sector governance	■ Chemical legislation, lists of approved chemicals, support to training and awareness campaigns. ■ Legislation or other measures to ensure manufacturers' provide instructions regarding dosage, withdrawal period, proper use, storage, disposal, and other constraints on the use of a chemical including environmental, human and food safety precautions. ■ Prohibit the unrestricted sale of antibiotics whose unregulated use could undermine their effectiveness in the treatment of human diseases.
Private sector governance	■ Farmer associations and/or industry provide information, training and facilities on disease diagnosis and correct treatment protocols, and in relation to other uses of chemicals.

Feed and Feed Management

Worse practice	▪ Dumping feed in one location. ▪ No monitoring system for feed consumption. ▪ Use of poor quality feed (e.g. raw fish, shellfish, fines). ▪ Feed more than can be eaten. ▪ Feed one time per day (up to 30% wasted). ▪ Feed conversion ratio > 3:1. ▪ 3.5 kg of wild fish to produce 1 kg of shrimp.
Better practice	▪ Use of commercially available shrimp feed of high quality. ▪ Feeding more frequently to tailor with feeding habit. ▪ Using feeding tray to monitor feed consumption. ▪ Spreading feed widely to increase the availability of feed to shrimps in all areas of the pond. ▪ Record keeping on daily feed consumption. ▪ Use formulated (extruded?) feeds. ▪ Feed multiple times with feeding tray to reduce waste. ▪ FCR of less than 1.5:1. ▪ Less than 1 kg of wild fish (in fish meal) for 1 kg of shrimp. ▪ Promote pond productivity (water column, bottom) to produce shrimp feed. ▪ Use of worker incentives to reduce feed wastage.
Financial/production impacts	▪ Good quality feed may be expensive but the FCR tends to be lower and shrimp tends to grow faster and healthier. ▪ Feeding tray monitoring may be time consuming but the benefits of feed wastage reduction are significant. ▪ Record keeping allows management to use this information for adjustment and improvement if necessary.
Environmental and social impacts	▪ Less nutrients load to receiving water bodies. ▪ Less on-farm water and soil quality problems. ▪ Use of fishmeal resources in ways that contribute to net aquatic animal food production.
Key constraints	▪ High cost of formulated high quality feed, may be a limited factor for small and extensive shrimp farmers. ▪ Some farmers may have very low level of education, and may be difficult for them to adopt to record keeping practices. ▪ Training and awareness.
Public sector governance	▪ Promote the use of management systems and technologies that make efficient use of feed. ▪ Promote the supply of safe, high quality feeds for shrimp aquaculture in line with guidelines for good practice for manufacturing and use. ▪ Encourage companies to provide information on nutrition and ingredients on feed labels. ▪ Encourage the use of settlement facilities and bioremediation to reduce waste outputs and encourage the creation of marketable by products. ▪ Extension services promote farming systems, which are compatible with the use of local resources. ▪ Encourage the development of markets for waste-based by-products (e.g. sludge, shrimp processing wastes) and/or share information on viable markets.
Private sector governance	▪ Producer associations promote the use of management systems and technologies that make efficient use of resources, such as shrimp PLs, water, chemicals, land, energy and labor. ▪ Farmer organizations should monitor and evaluate feed use and performance amongst their members, and provide periodic reports on these issues to their members, feed manufacturers and relevant government agencies.

Effluent and Solid Waste Management

Worse practice	■ Effluents discharged untreated into the natural water ways. ■ Release of pond and hatchery effluent into waters with low exchange rate. ■ Solid wastes flushed directly into natural water body. ■ Solid wastes accumulated in pond bottom without removal, sundry or oxidation treatments. ■ Release of pond effluent and solid waste directly into intake water supply. ■ Excessive velocity of discharge causes erosion.
Better practice	■ Allocate area for solid wastes from pond bottom for sun drying and oxidation treatments. ■ Use settlement ponds or canals to settle solids (settlement time at least 3 days). ■ Settlement pond volume sufficient to capture and treat effluent discharged during and after harvest (60% of solids and nutrients discharged at this time). ■ Return better quality water to ecosystem than taken out. ■ Use natural or artificial biofilters to remove excess nutrients, such as fish, bivalve or seaweeds in settlement pond to take up the solid waste and nutrients. ■ Use polyculture to remove solids and nutrients.
Financial/production impacts	■ Pond environment can be improved, and shrimp will grow better and faster. ■ Bi-products from treatment ponds can be consumed by farm workers or sold as secondary products. ■ Polyculture and alternate cropping allows for risk reduction among small-farmers, while providing off-season food and income.
Environmental and social impacts	■ Better quality waters, either within the farm or in surrounding water sources, due to less nutrients and solid waste discharge. ■ Reduced eutrophication risks.
Key constraints	■ Solid waste removal and oxidation may be costly as it requires considerable area for storing these wastes. ■ More time consuming if compare with flushing system. ■ Need to identify suitable polyculture species. ■ Small farmers with one pond may face particular difficulties in finding areas for waste treatment.
Public sector governance	■ Create incentives (e.g. effluent tax) for waste treatment and biofiltration and reuse of water. ■ Establish standards for water quality and effluent treatment.
Private sector governance	■ Participate in setting of effluent quality standards and implementation strategy.

Shrimp Health Management Practices

Worse practice	■ Stocking without reference to seasonal risk factors. ■ PLs are bought and stocked without proper quality check. ■ Absence of daily checking of shrimp health via observation of pond dike, and feeding tray. ■ Lack of weekly monitoring of shrimp health. ■ Lack of checking or diagnosis of unhealthy shrimps.

Better practice	■ Implement technologies (health management protocols) that reduce stress and focus on prevention.
	■ Daily routine monitoring of shrimp health and record keeping.
	■ Dead shrimp removed and disposed of in a sanitary manner.
	■ Farm workers acquainted with major diseases and syndrome of shrimp and means of prevention and treatment.
	■ Maintain biosecurity.
	■ Ensuring good quality standards of shrimp post-larvae.
	■ Responsible trans-boundary movement of live shrimp.
	■ Implement management strategies to avoid spread of shrimp disease off farm:
	  ■ quarantine of infected ponds.
	  ■ notification of farm neighbor.
	  ■ treatment of before water discharge from diseased ponds.
	■ Pond preparation through drying between crops.

Financial/production impacts	■ Time consuming and costly for diagnosis. ■ Daily routine health monitoring and record keeping takes time, however, benefits of time invested are substantial in allowing immediate action to be taken and reduction in losses. ■ Record keeping is beneficial for future study and self-analysis for improvement.
Environmental and social impacts	■ Good quality product, safe for consumers and trade. ■ Reduction of social and economic impacts of disease on farms and in nearby areas. ■ Reduction of risks to wild stocks
Key constraints	■ Timing and expense of diagnosis. ■ When immediate action needed, farmers will try everything just to save their crop. ■ Lack of awareness, training, self-help supporting mechanisms for farmers for preventative health measures and to cope with emergency disease problems.

Public sector governance	■ National quarantine/biosecurity framework/legislation to protect national aquaculture industries.
	  ■ Quarantine and certification protocols in line with WTO/OIE standards
	  ■ Risk analysis procedures.
	  ■ Diagnostic support.
	  ■ Training programs.
	■ Establish aquatic animal health management program

Private sector governance	■ Farmers association to support cooperation in local and national disease control measures.

Social Impacts

Worse practice	▪ Reduces resources used by local people ▪ Reduces access to critical resources by local people ▪ High costs associated with guards, fences etc ▪ Legal costs and business failures
Better practice	▪ Participation of local people in production ▪ Be a good neighbor ▪ Regular consultation with local people ▪ Ensure health and safety, rights and welfare, of staff in farm operations ▪ Spin-off businesses or joint venture ▪ Shrimp aquaculture as a cornerstone for local development and poverty alleviation (see below).
Financial/production impacts	▪ Potential reduction in costs of conflicts ▪ More effective poverty alleviation from shrimp aquaculture
Environmental and social impacts	▪ Improved social performance of the industry.
Key constraints	▪
Public sector governance	▪ Governments should implement plans for integrated coastal area management and rural development planning. ▪ Develop shrimp farms within the confines of integrated coastal area management and rural development planning ▪ Shrimp aquaculture should be integrated into rural development planning, as it has potential for poverty alleviation through direct involvement of rural people in aquaculture production, as well as through employment and or involvement in off-farm activities. ▪ Governments should develop and implement appropriate labor regulations for shrimp farm activities ▪ Sectoral convergence to support local development.
Private sector governance	▪ Being socially responsible within community standards and values ▪ Encourage participation of local people in shrimp aquaculture ▪ Conduct shrimp farm operations to minimize impacts on surrounding resource users ▪ Producer associations should work together to ensure that producers obey all laws relating to their operations. ▪ Producer associations should work together to ensure the rights of individuals and communities who choose to pursue their traditional use of resources. ▪ Producer associations recognize the social and environmental impacts of operational failures and take reasonable steps to reduce the rate of failure in shrimp farming. ▪ Work with Governments to maximize the social benefits of shrimp aquaculture to the wider community through the development of such initiatives as public or joint venture operations, value-added processing, and infrastructure development.

Worse practice	▪ Poor people excluded from the planning process leading to lost development opportunities and social conflicts.

Better practice	▪ Encourage participation of local people in the planning and implementation of shrimp aquaculture projects. People-centered planning process.
	▪ Conduct shrimp farm operations to minimize impacts on surrounding resource users
	▪ Participatory planning process that involves poor people
	▪ Mechanisms to reduce risk when poor people are involved in shrimp aquaculture such as
	  ▪ Joint credit schemes, to support longer term investment (>1 yr)
	  ▪ Tenure to land resources allowing longer-term investment.
	  ▪ Farmer groups for self-help. Technical support directed towards addressing poor farmers needs
	  ▪ Technical support and extension directed at poorer farmers and their needs.
	  ▪ Local institutional and co-management arrangements that support poor people's participation.

Financial/production impacts	▪ Potentially significant positive socio-economic benefits on local development
Environmental and social impacts	▪ Positive environmental and social impacts.
Key constraints	▪ Institutional weaknesses, ▪ Central, top-down driven development process
Public sector governance	▪ Shrimp aquaculture should be integrated into rural development planning, as it has potential for poverty alleviation through direct involvement of rural people in aquaculture production, as well as through employment and or involvement in off-farm activities. ▪ Governments to support implement plans for integrated coastal area management and rural development planning and planning process driven by understanding of poor people's livelihoods. ▪ Governments to support building of local institutions that are responsive to the needs of poor people.
Private sector governance	▪ Support development among local communities ▪ Participate as stakeholder in local development

Implementation Issues

The information synthesized above will when complete provide an initial set of better management practices. The emphasis now needs to shift towards implementation of these measures. The implementation involves consideration of various factors, including overcoming the constraints identified in the tables above. The following provides some examples of more general actions that might be taken to support implementation.

- The need for effective communication of findings to industry and government.
- The need to develop thresholds and standards that can provide a basic direction for improvement of management.
- The need for significant capacity building efforts, such as through in-country training/workshops, consultation with farmer groups and participatory meetings on implementation of BMPs and their adaptation to local levels.
- The need to support to training and extension – including some extension materials in local languages, perhaps some teaching materials etc.
- The need for technical guidelines that support implementation of better practices, and particularly their implementation at local and national levels.
- The need to develop manuals, which could be developed through consultation, at national, or regional level, and in local languages, to support implementation.
- The need to continue dialogue and consensus building on the major issues identified through the case studies and the development of effective measures to support BMP implementation.
- The need for investment to support implementation of better management practice.

The adaptation to local levels also needs to be based on careful consideration of the local circumstances and fully involve local stakeholders. In practice, considerable local differences in implementation may occur. Farmers should be allowed to adopt and adapt better management practices following general principles but suited according to local conditions.

Impacts of the Consortium Program

There are indications already that the consortium approach and case study findings are having positive impacts. A few are highlighted in this report to indicate the types of impacts that can be expected.

In Mexico, the findings from the case study have resulted in some change in the ways NGOs and foundations view and engage the shrimp aquaculture industry to work together to reduce agro-chemical runoff from commercial agriculture farms.

In Brazil, the case studies are providing the basis for putting in place policies and investment screens for supporting more sustainable shrimp aquaculture management practices.

The outcome the multi-country, thematic analysis of shrimp disease issues has helped promote regional cooperation on the movement of animals in Latin America both among governments and shrimp producers, and south-south cooperation between Asia and Latin America. The thematic review has ahas also raised awareness of the importance of aquatic animal disease control within the Asia-Pacific Economic Cooperation (APEC) forum and provided a base for a new FAO/TCP project to assist Latin American countries that was initiated in 2001.

The case study in the north-central coastal areas in Vietnam has explored the role of shrimp aquaculture in coastal community development. The information has contributed to raising awareness in the country about the potential connection between shrimp aquaculture and poverty alleviation. The findings and approach adopted have contributed to the development a new government policy orientation within the Ministry of Fisheries towards poverty focussed aquaculture development.

Shrimp aquaculture in Bangladesh has been marked by significant local social conflict and confrontation between NGOs, government and private sectors. The case has provided an important, basis for dialogue between NGOs and the government and led to wider appreciation of social issues in shrimp culture development, and means for addressing the social problems through encouraging local farmer participation in shrimp aquaculture. The case also contributed to the development of management strategies for a World Bank supported project in coastal areas.

The case from Colombia explores the use of an artificially extended natural mangrove as a biofilter used to treat effluent from a shrimp farm. There is considerable interest in the incorporation of natural biofilters in shrimp operations as a way to avoid pollution and, in the case of Colombia, the pollution taxes they generate.

A consortium case is also being developed that looks at the production and market implications of third-party certification systems for shrimp aquaculture. The goal of this work is not to create a certification system but rather to identify what the major issues and implications are for such work. There is tremendous interest in this issue both on the part of producers and retailers, but few have thought through the issues carefully. The case will provide further guidance on these issues.

One future case will also explore the potential of investment and buyer "screens" that could be used to send signals to producers regarding more sustainable shrimp aquaculture on the part of investors and consumers.

The consortium program has clearly generated considerable interest in further support and cooperation in promoting better management in shrimp aquaculture. A number of agencies have also expressed interest to work together in the future.

Follow-up Activities and Recommendations

The consortium program has created a framework for review and evaluating successes and failures in shrimp aquaculture, which can now be used to inform policy debate and movement towards implementation of better management practices for shrimp aquaculture. The findings have come from a consultative process that has involved cooperation and inputs from a wide range of groups, including government, non-government and industry inputs. The work has started to identify future development activities and assistance required for the implementation of better management strategies that would support moves toward a more sustainable shrimp culture industry. The consortium members agree that the cooperative approach provides an important platform for gaining understanding and sharing experiences globally on shrimp aquaculture management and should be continued.

The following recommendations were discussed and agreed by a stakeholder consultation that was hosted by the World Bank in Washington DC, USA on 27th-28th March 2002.

Communications and Dissemination

The present synthesis document is to be circulated and will continue to be developed based on comments received during 2002 from a wider range of stakeholders. Selected documents will continue to be translated into major languages. Case study reports will be reproduced in hard copy on an as needed basis but the internet will be the major medium for publishing and dissemination of case studies. The electronic versions of the cases will continue to be made available on a web site (www.enaca.org/shrimp), and World Bank, WWF and FAO web sites as appropriate.

The initial priority will continue to be given to communicating findings from the consortium work to date. This may be supported through such activities as:

- partnership with farmers associations and other key “information providers”;
- further development of the web site, including putting links on the web site to other relevant sites and reports on shrimp aquaculture, and loading other relevant papers/reports in the site;
- translations where possible, through cooperation with national partners;
- innovative mechanisms for dissemination. This may include a CD ROM – that would include presentations, interactive material, good maps, links to photos of BMPs, and possibly simple comic like materials; and
- creating links with SIFR and other relevant web sites involved with aquaculture and fisheries.

Training activities could also be organized around a BMP manual and support provided to facilitate preparation of extension materials as part of awareness building programs.

Investments will be required to support implementation of better practice in shrimp culture. Several activities may be pursued by the consortium, including development of investment screens possibly moving towards establishment of a revolving loan fund (or a loan guarantee funding mechanism) that would support investments in better shrimp farm practices, including small-scale producers, as well as efforts to retrofit existing operations. There is a need for investigations into the respective roles of private and public sector investment in the sector. The Stakeholder consultation in Washington also identified the need to reach out to regional development banks for investment, such as the Asian Development Bank (that perhaps may be a source of investment for “retrofitting” of existing farms) and Africa Development Bank for new farms.

There is a particular need to make sure the products of the previous work of the consortium are made widely available through the web site as well as linked to the sites of others. Opportunities include the FAO and UN Ocean Atlas web sites, and other ventures, such as the Knowledge Environment (Island Press, AAAS, Stanford, High Wire), and others.

The consortium members will continue to promote the consortium work, and particularly the findings, at meetings with various stakeholders. The participants at the FAO/Australia Brisbane meeting requested NACA to assist Asian farmers in organizing a meeting to discuss and disseminate of the findings from the consortium work to producers. Therefore, special attention will be given to dissemination of the findings at meetings of farmers associations. Upcoming meetings and workshops where there are opportunities to disseminate findings include WAS meetings, APEC meetings, COFI/Aquaculture Sub-committee meetings, the Australian Farmers Association and others.

Follow up actions

The key concern of the consortium partners is to support implementation of better management practices, and follow up work should be focused primarily towards implementation of better management practices and support to farm level and community level actions. This reflects the need to translate the information generated into improved capacity and better management practice from the pond level to the ecosystem, national and international levels. For the consortium’s effort to provide the basis for improving farm management and environmental and social sustainability of shrimp aquaculture, better practices must be adopted. Therefore, an organized program to encourage and assist adoption of BMPs at the farm level in as many shrimp farming nations as possible is required. The following recommendations were also discussed and agreed by a stakeholder consultation that was hosted by the World Bank in Washington DC, USA on 27th-28th March 2002.

Discussion and Agreement on Core BMP Principles

There is a need to initiate discussions through workshops and other means aimed at gaining agreement among stakeholders (industry, government, civil society/NGOs) on a set of “core” BMP principles that could be widely adopted throughout the shrimp industry. These should focus on key issues and BMPs with potentially most significant benefit. There is a need to develop indicators and monitoring for BMPs.

Such principles, if developed through a transparent and consultative process, might eventually form the basis for development of a shrimp aquaculture certification system. As there is increasing international interest in certificiation, other necessary studies on shrimp aquaculture and certification, including market chain analysis, and also implications and support required for smaller-scale producers and poverty should be undertaken.

Government, Investor, Purchaser Screens

There is a need to undertake studies and consultations to support development of government, investor and purchaser screens based around the core BMP principles including such issues as certification; financial incentives for implementing BMPs; and tax incentives to support BMP implementation.

Studies should also consider socially responsible issues and differentiation between farmed and wild shrimp in certification systems.

In general BMP-based approaches to reducing the impacts of shrimp aquaculture should be mutially reinforcing. For example, government BMP-based regulatory systems or permits and licenses should compliment or reinforce those for investors. Likewise both of these should compliment any BMP-based purchase screen or certification program.

Country Cooperation

There are opportunities to initiate activities that support implementation of BMPs in selected countries and provide wider experiences for the consortium program. Bangladesh, Vietnam, Madagascar, Thailand and Brazil have all expressed interest, but specific selection criteria are to be developed, and other countries may become involved as opportunities and needs arise.

Studies on Gaps and Issues

There is a need to implement studies to address key gaps in the consortium program. The following were identified by the Stakeholder workshop in Washington:

- Globalisation and impacts of WTO and services agreement (including extension services) on shrimp aquaculture, producing countries and trade
- Mangroves, coastal wetlands and options for restoration of abandoned shrimp farm land (Thailand has expressed a particular interest in developing a project on this topic)
- Aquaculture parks
- Social dimensions of BMPs and small-scale producers, including poverty impacts (positive and negative) of BMP implementation.
- Economics of BMP implementation and cost reduction studies (including studies on reducing energy costs).
- Legislation studies, including examples of where is it working, and minimal legal requirements to support implementation of core BMP principles.
- Chemicals and shrimp quality and residues, with a focus on anti-microbials, including understanding of background levels.
- Genetics, immunology and biodiversity. A review on major current and future issues should be implemented.
- GMO/LMO's and shrimp aquaculture
- Shrimp ponds as a vector for water borne diseases
- Inland shrimp farming and better management practices in inland farming systems
- Effluent water quality standards and capacity to conduct effluent analyses
- BMPs and coastal polyculture aquaculture systems

Other Points Regarding Existing Work

One of the best ways to disseminate the findings, for example, will be through an expanding list of insitutions who want to be part of the work—e.g. existing producer associations, governments, NGOs, bi-laterals and multi-laterals, among others. There is therefore a need to encourage further partnerships and cooperation, national and international. One way would be to establish a "consultative group" composed of individuals from industry, NGOs, government and international/multilateral agencies to be consulted on implementation of the consortium program, discussion of core principles and to support fund raising.

Future Cooperation

As aquaculture continues to expand globally and becomes more diverse and complex, the need to promote cooperation, capture lessons learned, and share learning and experiences will increase as well. Similarly, the cooperation extended through the consortium's work on shrimp aquaculture might be extended towards other commodities or other forms of aquaculture. For example, there is clearly an urgent need to share learning experiences and support directed poverty alleviation efforts, in line with international poverty alleviation targets. The possibility of the consortium expanding its cooperative approach to looking at other aquaculture commodities should also be explored.

There are opportunities for more distinct partnerships with interested countries or other organizations to be established for knowledge dissemination and work towards the establishment of better practices, including farm level, and institutional and legislative support. While the members of the consortium are quite happy with the internal workings of the existing consortium, we are also aware that other organizations and even governments may want to be more directly involved in the work. The overall goal is to include as many institutions as possible in this work but to maintain, at the same time, the flexibility that allowed the first phase of the work to proceed so smoothly. The consortium is committed to exploring ways to involve other interested organizations in the second phase of the work.

The consortium's partnership approach shows that such cooperation is not only fruitful in the short-term but also provides a platform upon which such cooperation can be further extended in the future to address other major international issues affecting aquaculture development.

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Annex A: Abstracts of Shrimp Aquaculture Case Studies

Thematic Reviews

Mangroves

Donald J. Macintosh, Michael J. Phillips, Robin Lewis III and Barry Clough. **Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture.** 2002.

Abstract: The interactions between coastal wetland habitats, particularly mangroves, and shrimp aquaculture, have received considerable attention in recent years. This thematic review begins by documenting the status of shrimp aquaculture in relation to coastal wetland habitats, especially mangroves. The environmental, social and economic interactions of shrimp farming in mangrove areas are discussed, with examples included illustrating both the positive and negative aspects of the sector's development in coastal mangrove areas. In discussing the overall objectives of the Thematic Review, it was agreed that the management strategies to be discussed in the review, and the overall thrust regarding better practices for shrimp aquaculture development, should be directed towards the following developmental objective, or 'guiding principle': *"To promote coastal aquaculture in an environmentally responsible manner, adopting the principles of co-existence of mangroves and aquaculture, of supporting the livelihood needs of local communities, and of promoting a net increase in mangrove area where this is a policy of the country concerned."*

The main section of the review considers interventions and other activities to improve the sustainability of shrimp farming in the context of better management of aquaculture and mangrove ecosystems. Over the past decade, understanding of the relationship between shrimp farming and the environment have led to various efforts to mitigate the impacts of aquaculture on coastal habitats. These include: zoning schemes to confine aquaculture outside wetland conservation areas, changes in farm management practices, introduction of new legislation to protect the environment (e.g. controls on farm effluent discharge), initiation of dialog among shrimp farmers through development of farmers societies, and dialogues with non-governmental sectors, and increased research and development efforts. The effectiveness of these interventions is considered in the light of experience based on 15 mangrove-shrimp case studies, from Asia-Pacific and Latin America.

The individual case studies highlight the effectiveness of efforts made, the underlying reasons for successes or failure, their strengths and weaknesses, and identify where research and other future efforts are most required. The case studies used to support this synthesis were initially identified at a workshop held in Bangkok, Thailand on 14th-16th February 2000. The expert group invited to the workshop, that included mangrove scientists, representatives of NGOs, shrimp producers and government agencies also agreed on the major issues to be considered for the thematic review and how information from each case study should be incorporated into the synthesis. Some of the case studies are based on country level experiences, others are more specific to a particular locality where there is a record of experience regarding environmental management related to shrimp farming.

Codes of Practice

Claude Boyd, John Hargreaves and Jason Clay, **Codes of Practice for Marine Shrimp Farming.** 2002.

Abstract: The main objective of this case study was to document the status of existing Codes of Conduct for shrimp farming and to compare the contents of the different codes. The focus was on environmental management because the Codes of Conduct provide guidelines for development of voluntary systems of environmental management. Other objectives were to provide suggestions for improving existing codes, to give recommendations on how new codes should be prepared, and to consider the status of code implementation.

Shrimp farming Codes of Conduct from the following organizations were considered in this case study: Australian Prawn Farmers Association, Shrimp Farming Industry of Belize, Global Aquaculture Alliance, Marine Shrimp Culture Industry of Thailand, Malaysia Department of Fisheries, and the University of Rhode Island. The codes are rated based on authors' opinions in the following table where the higher the number (0 to 3) the more positive the opinion:

	Australia	Belize	GAA[1]	Thailand	Malaysia	URI[2]
Coverage of issues:						
Production methods	3	2	3	2	1	3
Environment	3	3	3	2	1	3
Socioeconomic	0	2	2	1	0	1
Involvement of stakeholders	3	1	1	1	?	2
Appropriateness of BMPs	3	2	3	2	1	3
Detail of BMPs	2	1	2	1	1	2
Discussion of purpose of Program	2	2	3	1	0	2
Plans for implementation	?	?	3	2	?	1
Self-evaluation procedure	0	0	2	2	0	2
[1]GAA = Global Aquaculture Alliance [2]URI = University of Rhode Island						

The codes were remarkably similar in their content of best management practices (BMPs) to improve environmental performance. However, the level of detail on BMPs vary considerably among the codes. The codes were all weaker on social considerations than upon environmental ones. In addition, there was a general lack of stakeholder involvement in preparation of the codes. The Global Aquaculture Alliance (GAA) is preparing a plan for implementation of their Codes of Practice, and there is an effort to implement the codes of the Marine Shrimp Farming Industry of Thailand. There were no clear plans for implementation of other codes. Thus, at present, Codes of Conduct and Codes of Practice are simply "pieces of paper" that have not been implemented. However, there is much interest in codes by the shrimp farming industry, and implementation of some codes will probably occur very soon. The GAA code will probably be the first one.

Codes should have greater stakeholder involvement, contain more detail for installation of BMPs, provide more social BMPs, and provide clear plans for implementation and verification of use. We think that Codes of Conduct can be instruments to greatly improve the environmental and social performance of shrimp farming. However, for this to occur, the industry must dedicate itself to environmental and social responsibility.

<u>Shrimp Diseases and Health Management</u>

FAO, NACA, World Bank and WWF. **Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture.** 2002.

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: Ecuador, 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.

Thematic Overviews of Social Equity, Benefits and Poverty Alleviation BMPs of the Shrimp Aquaculture Industry.

Four separate case studies have been prepared on BMPs for shrimp aquaculture to address social and equity issues. These cases have been drafted, but they will be rewritten as a single thematic review by mid-2002. The intention is that this case will be structured so that new information about examples of social BMPs can be added at any time. The four reviews are as follows:

Connor Bailey, **Improving the Social Impact of Shrimp Aquaculture in Asia: Best Management Practices to Improve Employment, Benefits, and Equity within the Industry.** 2002.

Billie R. de Walt, **Social Best Management Practices in Latin America.** 2002.

Catherine Michielsens, **Socio-Economic Analysis of Shrimp Aquaculture in Coastal Areas of Asia.** 2002.

Emanuel Mike Polioudakis, **Synopsis of Results of Research on Southern Thai Shrimp Farming: Some Recommendations.** 2002.

Abstract: The reviews are intended to identify examples of better management strategies for improving the positive social impacts of shrimp aquaculture, and of avoiding potential negative impacts. Better management practices are identified in the following categories: (a) being a good neighbor; (b) promoting regular consultation with local people; (c) having a reliable, long-term workforce; (d) reducing costs of conflicts; (e) spin-off businesses or joint ventures with local people; and (f) using shrimp aquaculture as cornerstone for local development, including poverty alleviation. There are different experiences on social BMPs between Asia and Latin America, but considerable opportunities exist for adopting better management strategies for creating positive social benefits from shrimp aquaculture, whilst at the same time improving economic performance of the industry. These case studies are the first to examine such issues, and will be developed as a single thematic review by mid-2001, adding information as new examples of social BMPs become available.

Legislation and Shrimp Aquaculture
There are two detailed studies that have been prepared on the legal aspects of shrimp aquaculture, one funded by FAO and one supported by WWF. The two reviews are as follows:

Annick Van Houtte and William Howarth. **An Analysis of Shrimp Aquaculture Legislation.** 2002.

Abstract: The purpose of the study is to pursue the research objectives indicated by the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture, in 1997 by gathering information about the present state of the law concerning shrimp farming in those developing countries most heavily involved in the activity. The initial objective of the survey, therefore, is to provide a comparative account of legal provisions concerned with shrimp farming which are in force in different countries engaged in the activity. A further objective of the study is to provide commentary upon the national legislation and to offer suggestions as to what measures are appropriate in encouraging good legal and administrative practice in the regulation of shrimp farming.

Particular emphasis is placed upon legal requirements which relate to the environmental impacts of shrimp aquaculture. Such impacts are, broadly, of two kinds. The first relates to the initial impacts of establishing a shrimp farm at a particular location, and the potential adverse effects that this may have upon biodiversity and the potential conflicts that may be raised with other competing uses of the land and water. The second relates to the continuing environmental impacts, upon environmental and ecological quality, which may arise through the actual operation of a shrimp farm when once it is established at a particular location or, indeed, after the cessation of its activities. Alongside these matters are a diverse range of associated concerns, which relate to the efficiency of the shrimp farming industry and the quality of the products which it produces, and which often reflect underlying environmental concerns.

Preliminary indications were that national legislation had been enacted in some jurisdictions to address key environmental concerns and had made use of a range of regulatory control techniques: a key purpose of the survey was to ascertain the extent to which approaches of this kind have been used in different jurisdictions within the scope of the survey.

The countries within the scope of the survey are those that are thought to have experienced shrimp aquaculture developments, whether at a rapid growth or still at an initial stage. Information was sought on shrimp farming legislation in Asia (Bangladesh, China, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, Vietnam, East Africa (Madagascar, Mozambique and Tanzania) as well as in Latin America (Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico and Nicaragua)
Guatemala).

The comparative study is structured around the following headings:

1. Background
2. Objectives of the Survey
3. Sustainable Development
4. Legislation
5. Institutional Responsibilities
6. Devolution of Controls
7. Acquisition of Land Rights
8. Location Licensing for the Establishment of Shrimp Farms
9. Continuing Controls upon Shrimp Farming Activities
10. Fresh Water Use Licensing
11. Wastewater Discharge Licensing
12. Shrimp Movement Licensing
13. Genetically Modified Organisms
14. Chemical Use Restrictions
15. Food Sources and Utilization
16. Product Quality Controls
17. The Internationalization of Standards
18. Guidance and Producers' Organizations
19. Enforcement
20. Other Issues

David Barnhizer, Esq. **Innovation and the Implementation Deficit: Assessing Shrimp Producing Countries Based on Their Effectiveness in Implementing the FAO's Code of Cnduct for Responsible Fisheries and Related Guidelines and Standards in the context of Shrimp Aquaculture.**

These reviews provide a rich source of information on the legal aspects of shrimp aquaculture and it is planned to prepare a synthesis document on legislation and shrimp aquaculture based on the materials during 2001.

<u>Chemicals and Biological Amendments</u>
Claude E. Boyd. **Chemical and Biological Amendments Used in Shrimp Farming.** 2002

Abstract: This case study compares the use of chemical and biological amendments in shrimp farming in Asia and the Americas. The information comes mainly from the author's experience in Thailand and Ecuador, as well as from the literature. The amendments are discussed according to three major categories: (1) water and soil quality management products, (2) biocides, and (3) feed additives.

There is relatively little use of fertilizers in Asia compared to the Americas. The main chemical fertilizers used in Asia are urea and triple superphosphate; fertilization with animal manures is not common. In the Americas, by contrast, a wide range of chemical fertilizers are promoted by vendors, and animal manures and other organic fertilizers are often applied to ponds. Agricultural limestone is used widely in both Asia and the Americas, but larger quantities of burnt and hydrated lime are applied to shrimp ponds in Asia.

Overall, liming is practiced more widely and more intensively in Asia than in the Americas. Probiotics (bacteria, enzymes, and plant extracts) are used widely in both Asia and the Americas. Zeolite is commonly applied to ponds in Asia but is seldom used in the Americas. There is some use of sodium bicarbonate and carbonate, peroxides, and aluminum compounds in Asia, but once again these products are seldom used in the Americas. The most likely environmental impact from the use of these water and soil quality management products is eutrophication of coastal water from fertilizer nutrients. However, aquatic organisms can be exposed to toxicity if burnt or hydrated lime, peroxides, or aluminum compounds are accidentally spilled into natural waters. Aside from the possibility that shrimp flesh can be contaminated with antibiotic residues from animal manures, no other food safety hazards exist from applying water or soil management products. Safety issues arise when workers handle burnt and hydrated lime and peroxides, however.

Biocides are made up of a wide range of substances, including chlorine compounds, formalin, providone-iodine, quarternary ammonia compounds, furazolidone, malachite green, glutaraldehyde, potassium permanganate, peroxides, copper sulfate, various insecticides, treflan, and lime. These products have long been used in hatcheries to disinfect water and equipment and to control diseases in culture tanks. Viral diseases became a serious problem during shrimp grow-out in China in 1993/94 and in Thailand in 1995/96. At those times, farmers began to apply biocides to ponds. The potential for environmental, worker safety, and food safety problems related to biocides is much greater when biocides are put in ponds than when they are applied in hatcheries, mainly because ponds require larger amounts of biocides. The shrimp in ponds treated with biocides might also be contaminated with residues. There was little use of biocides in the Americas until the late 1990s, when White Spot Syndrome Virus disease became a serious threat. Shrimp producers there tried all the products that had been used in Asia in attempts to control white spot virus. Because biocides are proving to be ineffective in preventing shrimp diseases in ponds, their use is declining in favor of disease prevention measures such as disease-free post-larvae, less water exchange, and better pond management to reduce stress. Nevertheless, biocides continue to be used in Asia and in the Americas, and programs to educate farmers on the safe and effective uses of chemicals are badly needed.

Feed additives—vitamins, minerals, binders, attractants, chitin, immunostimulants, and therapeutic agents—are included in shrimp feed throughout the world. Two possible hazards can result from using feed additives: phosphorus added to feed can cause eutrophication of natural waters, and antibiotic agents in medicated feed might result in antibiotic-resistant strains of micro organisms.

Certain chemical and biological agents, while necessary to successful shrimp farming, should be used only when needed and in a safe and responsible manner. Following better management practices (BMPs) for responsible use of chemical and biological amendments in shrimp farming is essential.

<u>Feed</u>
G.J. Tacon. **Global Review of Feeds Management Practices in Shrimp Aquaculture.** 2002.

Abstract: The aim of this paper is to undertake a review of feeds and feed management practice in shrimp aquaculture. The main points to be addressed are: Assess the environmental implications and trends of feed use in shrimp aquaculture, particularly the use of fish meal and water pollution caused by feeds; The paper also identify practices at farm, manufacturing and ecosystem levels that can reduce environmental impacts associated with the use of shrimp aquafeeds, giving special attention to fish meal and effluent management, and practical measures that can promote efficient use of feed resources; Analyze the constraints and opportunities for promoting such practices, including costs and benefits for their adoption and identify follow up activities to support efficient use of feed resources, including nutrition and feed management research, information exchanges, and others as appropriate.

Further focus is given on: Assertions that shrimp aquaculture is literally “feeding on world fisheries” and that the production of shrimp contributes to net loss of wild caught fish; Trends in the use of alternative ingredients as fish meal replacers, including soybean meal, and other agricultural byproducts; Short and long-term strategies for improving the efficiency of feed resource use in shrimp aquaculture and provision of a comprehensive set of references for further reading on the subjects.

A number of recommendations are given in the paper to identify good feed management practices and there are furthermore some suggested follow-up activities.

Asia-Pacific Region

Australia

The study in Australia was coordinated by a research team from the CSIRO Marine Research.

Nigel Preston, Peter Rothlisberg, Michele Burford and Chris Jackson. **The Environmental Management of Shrimp Farming in Australia.** 2002.

Abstract: In Australia, strict Commonwealth and state environmental regulations have constrained uncontrolled development of shrimp farming. A high level of resources, relative to the size and value of the industry, has been devoted to collaborative research on the environmental management of shrimp farming in Australia. This research has quantified nutrient processes in shrimp ponds, determined whole farm nutrient budgets, analyzed effluent composition, determined the effects of different effluent treatment strategies, and traced the fate of effluent in receiving waters. The research findings are being used to provide a scientific basis for discharge license requirements for shrimp farming. These data are also being incorporated into an advanced geographic information and decision support system in order to improve site selection and aquaculture planning. Despite these improvements, however, public concerns persist about the environmental management of shrimp farms.

One potential avenue for providing a more logical and systematic basis for this debate is through the establishment of environmentally sustainable development (ESD) performance criteria for the industry. The current study begins this process with an initial focus on the Queensland shrimp farming industry. A central finding of this study is that environmental management of shrimp farms needs to be incorporated into environmental management of the water body and catchments adjacent to shrimp farms. By this means, aquaculture can be compared to other forms of agriculture, particularly in relation to permitted discharge loads. This concept is not unique to Queensland or Australia but has rarely been addressed for any location. We anticipate that this study will provide an opportunity to determine more effective ways of broadening the environmental planning and licensing of shrimp farming to include environmental standards for the whole catchment.

Bangladesh

The two case studies in Bangladesh were prepared with contributions from the Department of Fisheries, the International Centre for Living Aquatic Resources Management (ICLARM) and CARITAS (an NGO active in coastal areas).

Anwara Begum and S.M.Nazmul **Social Aspects of Shrimp Aquaculture in Bangladesh,** 2002.

Rahman, M., P.P.G.S.N. Siriwardena and W. Shah. **Case Studies on Shrimp Aquaculture Management in Bangladesh,** 2002.

Abstract: The shrimp farming in Bangladesh is mainly low input and extensive and many of the farms are located in rice farming areas and operated as alternate crops between shrimp and rice. There is also a high degree of social conflict in some coastal areas, and concern over the effects of shrimp farming on salinization of rice farming areas. The two case studies in Bangladesh provide a comprehensive analysis of the history and present state of shrimp aquaculture development, shrimp post-larvae collection, hatcheries, farm management practices and social impacts and management practices to alleviate impacts.

The social study case provide a detailed understanding of the importance of shrimp aquaculture to the livelihoods of poor people living in coastal areas. There is some experience in ownership and management of shrimp farms by local people (rather than absent landowners), and such participation of the local community in shrimp aquaculture appears to have contributed to a reduction in social conflicts, more timely alternate cropping between shrimp and rice, and consequent reductions in salinity problems in some areas. This approach offers a very important direction to alleviate social conflicts and for shrimp aquaculture to contribute more effectively to coastal poverty alleviation. There was an agreement at the final policy workshop that this policy objectives – emphasizing the participation of local people in shrimp aquaculture production – should be pursued.

The second case study looks more broadly at different parts of the shrimp sector – hatcheries, fry collectors and distribution systems, and on-farm management practices. The study also provides an analysis of implementation strategies for the FAO Code of Conduct and recommends a number of strategies for better shrimp aquaculture management. Finally, the recommendations arising from the case studies were presented and discussed at a national workshop attended by senior government policy makers, farmers and NGO representatives and a consensus reached on policy directions and issues to be addressed in the future development of the sector in Bangladesh.

China
The study in China was carried out by the Yellow Seas Fisheries Research Institute (YSFRI) in cooperation with IVM.

Anantha Duriappah, **Shrimp Farming in Rushan County, China**. 2002. Available in Chinese and English.

Abstract: This case study explores the rehabilitation of a shrimp farm area in Shandong province (Wehai Municipality, Rushan County) in north-east China in areas supported under a World Bank coastal resources investment project. The project supports the rehabilitation of an extensive, traditional, shrimp culture area that was badly affected by shrimp disease. The case examines the management practices adopted for rehabilitation, environmental impacts, control of shrimp diseases and water quality management. An economic analysis also looks into the economic costs and benefits of the rehabilitation. The case study also includes regulatory aspects, including the ability of farmers to use regulations to control the impacts of water pollution from other sectors on shrimp production.

The findings show that because of risk associated with shrimp disease, farmers are reluctant to adopt rehabilitated farming systems, because of the high investment costs compared to traditional, more extensive farming systems. A break-even analysis to compute the time period credit limits to make rehabilitated systems competitive with traditional systems suggests the breakeven point occurs at about the 11-year mark. In other words, farmers can be persuaded to adopt rehabilitated farming systems if: (1) credit is extended to farmers to cover their fixed costs; and (2) the time period allowed for them to repay these loans should be 11 years at the minimum. Although rehabilitated farms have a higher NPV when the labor costs are taken out, the lower fixed cost to net benefit ratio suggests caution on the part of farmers if they face capital constraints. Therefore, if rehabilitated farms are to be encouraged and assuming that labor costs are negligible, then governmental support in the form of capital credits will need to be extended to the farmers to induce them to adopt rehabilitated farming systems. Thus, while rehabilitated farms make more efficient use of land, and probably water resources, financial incentives are required for farmers to adopt such practices.

In conclusion, farmers will be reluctant to adopt rehabilitated farming systems if no governmental support in the form of capital credits is provided. But the positive externalities of rehabilitated systems in the form of lower probability of disease outbreaks and a cleaner marine environment are not captured in the cost-benefit analysis presented in this paper. A counter-argument can be made that a majority of farmers do not perceive these positive benefits in their decision making framework and the variables that matter are the ones analyzed in this paper. If this is the case, then governmental support and financial incentives are a necessary condition if rehabilitated farms are to be encouraged.

India
The study in India was prepared by M. N. Kutty and assisted by a team from the Central Institute of Brackishwater Aquaculture (CIBA): Dr. P. Ravichandran, Team Leader & Senior Scientist (Shrimp Breeding & Culture), Dr. M. Krishnan, Senior Scientist (Fisheries Economics) Dr. M. Kumaran, Scientist (Fisheries Extension), and Dr. C.P. Balasubramanian, Scientist-in-charge (Puri Center, Orissa).

Kutty, M.N., P. Ravichandran, M. Krishnan and C.P. Balasubramanian. **The Role of Small Farmer Groups and Associations in Sustainable Shrimp Aquaculture Management.** 2001.

Abstract: The case study in India covered three shrimp farming sites: (1) Kandaleru Creek cluster, situated on the banks of a narrow creek in Andhra Pradesh State; (2) Dhigirpar World Bank aided project site, situated on the banks of the estuarine portion of the wide Matla River in West Bengal; and (3) Brahmagiri ERRP site, situated in the periphery of Chilka Lake (a lagoon connected to the Bay of Bengal) in Orissa. Information on the background profiles of the shrimp farming areas, as well as the socio-economic profiles of stakeholders and key issues at each site were gathered using PRA methods.

The shrimp farmers at all the sites were predominantly small farm holders (88% having <2 ha at Kandaleru, and all at Dhigirpar and Brahmagiri, <1 ha), several of whom were from socially deprived groups, who have received Government support to participate in shrimp farming, but still face serious livelihood constraints. Two common features have affected almost all the shrimp farmers – one is the crop failure and losses owing to disease (WSSV) and the other is the new GoI regulation which restricts shrimp farming to traditional systems only in the coastal regulatory zone (CRZ) and all the existing or new shrimp farms have to be licensed to operate by the newly set up Aquaculture Authority (AA) of the GoI – most are in the process of obtaining their licenses.

As a consequence, all shrimp farmers are motivated to adopt low input, and likely more sustainable shrimp farm practices. To achieve this they have invariably adopted low intensity methods beginning with low stocking density (<5-10 Pl/m^2, majority <5), in consonance with the AA guidelines for "improved extensive" shrimp farming, which also help maintain a healthier pond environment, discouraging WSSV outbreaks, as the farmers have learned themselves from their experience. The most positive developments in this direction are discernible at Kandaleru Creek, where the farmers are more experienced, motivated and self-reliant. But unfortunately except for the cooperative association already built into the project among the Dhigirpar farmers, and the apex level shrimp farmer associations (as in Kandaleru), there was no field level cooperative efforts, as informal groups even, to get over the various difficulties encountered by the small farmers, as indicated by the key issues identified in the present study.

To improve farm performance at the sites the following recommendations are made – the common issues for all sites are indicated first in each case and site–specific remarks are given in parenthesis:

1.Siting/infra-structure: Improvements in water supply and disposal – it is imperative that all farmers in specific sites/sub sites work in tandem in a cooperative effort to ensure adequate quantity and quality of water for pond filling and also for maintaining effluent quality standards. [This can be achieved with some structural modifications (detailed separately) in the cooperative set up already available and also improved power supply at Dhigirpar; as new addition of one or more effluent treatment ponds for each sub site and pumping facilities to enable those who need to pump out water in the case of final harvest or for pumping out water from any pond, closed due to diseases and consequent crop failure at Brahmagiri - otherwise, the ponds here are normally "confined" to rain water filling with no discharge as the pond dry up after the second crop, and hence most eco-friendly; and for Kandaleru cluster, major structural changes as carving out common inflow reservoirs/treatment ponds as well as effluent treatment pond facilities, with the cooperative understanding and rearrangement of ponds, through the initially in a small sub site area of about 100 ha – socio-economic issues will have to be sorted out with possible intervention of NGOs].

2.Low input shrimp farming: Continue the low-density stocking (5-10/m^2), as now practiced, and other concomitant sustainable procedures as outlined in the Guidelines of GoI-AA.

3. Improve extension set up: The existing DoF set up should be strengthened and involvement of NGOs (having requisite technical know-how and commitment) has to be increased. [This need is fairly well met at Dhigirpar, both through the DoF and one NGO, actively involved, but not at the two sites; considerable new extension effort to induce especially the most backward group (SC/ST cluster) at Dhigirpar to take up sound shrimp pond management is needed. There is some need for training (trainers' training) the existing and the newly recruited extension personnel (in DoF and NGOs) to enable them to function effectively].

4.Provision of field facilities for monitoring shrimp health and water quality.

5.Provision of quality seeds and feeds: The present set up at all sites is not able to assure either, either due to lack of adequate screening facilities or due to lack of purchasing capacity/ lack of credit. [The Dhigirpar

farmers are yet to harvest a successful/profitable crop, and at Brahmagiri, especially, the poorer section is under the grips of private moneylenders] (See also # 7 below).

6.Training needs: Most asked for training was in shrimp health management and water quality monitoring. Other training need expressed: Improved SF practices; pond management including use of chemicals.
7.Provision of adequate financing/credit/insurance mechanisms: Non-availability of adequate financing facilities and need for credit were common problems at all sites. The farmers also expressed the need for some insurance cover for the crops and their willingness to pay the premium.

8.Provision of cooperative input supply and marketing facilities: [These facilities exists in Dhigirpar, but not in other sites. The Brahmagiri farmers are in considerable difficulty, as at present the local fish/shrimp processors who do not allow the shrimps to be sold to any one else dictate their harvested shrimp prices]

9.Organization of farmer cooperative groups and associations **-** primarily at the field level and later at the apex level, so as to have a common platform/s for tackling issues arising in the field such as disease outbreaks and their control as well as keeping a healthy pond environment (water and soil quality) through adopting synchronized farming procedures; to organize better financing/credit/insurance systems; for arranging purchase of farm inputs and marketing of harvested shrimps. This would need DoF intervention and also assistance through rural cooperative banks and NGOs. [Except for the arrangements available through the project at Dhigirpar (which have to be streamlined) and the Apex cooperative SF Associations in Kandaleru/Nellore, there is none operating at this level. We got very positive response from the farmers through our PRAs, to the queries concerning the establishment of the cooperative groups, the successful operation of which could solve several of the problems indicated above]**.**

Indonesia
The study is carried out by the Indonesian Coastal Resources Management Project (Proyek Pesisir) and the Coastal Resources Center of the University of Rhode Island.

James Tobey and Hermawati Poespitasari and Budy Wiryawan, **Good Practices for Community-Based Planning and Management of Shrimp Farming in Sumatra, Indonesia.** 2002.

Abstract: The case study for this report was conducted in the coastal village, Pematang Pasir in Lampung Province, Sumatra, Indonesia. Pematang Pasir hosts a pilot project promoting environmentally and responsible shrimp aquaculture implemented by the Indonesian Coastal Resources Management Project (Proyek Pesisir). Most of the shrimp farming techniques in Pematang Pasir are either semi-intensive or traditional extensive small-scale farms, with 10% of the production coming from the extensive systems. The hatcheries in the area are typically small 'backyard' hatcheries with a total production of around 190 million PL_{12} per month.

This paper describes the lessons learned to date in Pematang Pasir and offers strategies and tools of community-based coastal resource management. The lessons learnt are based on findings from Pematang Pasir but can be used in a broader perspective as more general guidelines for community-based and participatory development of shrimp aquaculture in marginalized coastal areas.

The findings are not only based on natural and physical conditions but also on socio-economic aspects and impacts for the individual farmer and the whole community. The chances for sustainable development of shrimp aquaculture are connected to the communities' involvement in the planning. The more important shrimp culture is to the community, the more interested and committed it will likely be in adopting better practices. The management and the planning should involve stakeholders from NGOs as well as from the different governmental levels to ensure a good development. Also inputs from external sources are important since the technical knowledge can be limited in the more remote areas.

Philippines
The case study was conducted by mangrove and coastal resources specialists from the Coastal Resources Management Project, Department of Environment and Natural Resources and private researcher from EY Consultancy and Services (Philippines).

Dioscoro M. Melana, E. E. Melana, C.E.Yao and Edgar L. Abuan, **Mangrove Management and Aquaculture in the Philippines.** 2002.

Abstract: The conversion of mangroves to brackishwater aquaculture ponds contributed to the loss of mangroves in the Philippines. There have been several phases of coastal aquaculture development in the country, from extensive expansion for milkfish farming in the 1970's, a period of growth and conversion to shrimp aquaculture in the 1980's, followed by widespread shrimp disease outbreaks, and more recent reclamation of abandoned ponds to milkfish farming again, and some mangrove rehabilitation. The case study presented here documents what happened, factors influencing the various changes that occurred, what is happening with shrimp disease affected areas, conversion to milkfish, other cultures, and other uses. The various mangrove management strategies, and interactions between aquaculture and mangroves are documented, and the role of aquaculture discussed within the broad picture of mangrove restoration, coastal resource management and improvements in the livelihoods of coastal people. The lesson's from this case emphasize the importance of community based management of aquatic resources, and particularly the participation of local communities in successful mangrove rehabilitation.

<u>Sri Lanka</u>
The study was conducted by a team of eight researchers coordinated by the National Aquatic Resources Agency (NARA) of Sri Lanka.

Siriwardena, P.P.G.S.N., **Report on a Code of Good Management Practices for Shrimp Aquaculture in Sri Lanka**. 2002.

Abstract: The present shrimp aquaculture industry in Sri Lanka is confined to northwestern and eastern coasts and covers a farm area of around 3940 ha and 70 hatcheries. The shrimp aquaculture industry grew slowly towards the latter part of 1980's and expanded rapidly during the first half of 1990's. This expansion was slowed considerably by serious outbreaks of shrimp disease during the 1990's. Recent studies show that improving the management of the sector needs to address: (a) increasing the know how of farmers and their ability to change their practices; (b) adoption of better practices by small-scale farmers; (c) improving farmers' access to technology and finance; (d) improving the ability and capacity of local, provincial and national governments to apply better regulatory practices and strengthened law enforcement. Recognizing these constraints, the private sector, government, and NGOs have collaborated on the development of a Code of Best Practice for Shrimp Aquaculture in Sri Lanka.

The case study report explores the history of shrimp farm development, the reasons for preparing a Code, identifies management practices for the Code and responsibilities for its implementation. The management practices identified give special attention to the larger numbers of small-scale farms in Sri Lanka. Experiences suggest that better management strategies require more effective coordination and cooperation among groups of farmers.

<u>Thailand</u>
The two case studies in Thailand were implemented by researchers at the Coastal Resources Institute (CORIN) of the Prince of Sonkhla University and a team of researchers at the Department of Fisheries, working closely with Thai shrimp producers.

Nissapa, Ayut and Somsak Boromthaanarat, **A Case Study on Institutional Aspects of Shrimp Aquaculture in Thailand.** 2002.

Abstract: There are several examples in Thailand where (formal and non-formal) farmers associations and local government have worked together to facilitate the development and adoption of better management practices. The Coastal Resources Institute (CORIN) has been particularly active in working on participatory solutions to local environmental problems caused by shrimp farming. This case study documents the success and lesson's learnt from such local co-management approaches involving farmers associations and local government. The case study also shows the linkages and relationships of institutions operating at different levels of administration from farm to national levels and their effect on management.

Siri Tookwinas, **Assistance and Issues in the Implementation of the Code of Conduct for Shrimp Aquaculture**. In Thai and English.

Abstract: The case study focuses on the implementation of the Thai Code of Conduct for Responsible Shrimp Farming, which has being developed under World Bank funding, and is now undergoing 'testing' at farm level. The case study assists in monitoring the uptake of the Code by farmers and farmer groups, constraints and the costs and benefits from application of the code. The study provides an analysis of the benefits and constraints in the adoption of this new code, and a basis for assistance in identifying opportunities and removing constraints for more widespread adoption of the code among Thai shrimp farmers.

The case concludes that most of the better management practices promoted in the Code of Conduct can be adopted by farmers, without significant cost, and with potential short and longer term financial benefits. However, care needs in adapting the generic principles of the Code of Conduct to fit the local farming situation. Selected articles of the Code of Conduct, and particularly those requiring an effluent treatment pond may be more problematic and costly to implement, and particularly for small-scale farmers with only one or two ponds. Here, cooperation between farmers may be necessary to implement effective water treatment measures, or modifications may be required to the existing pond systems. Finally, the case emphasizes that significant extension work and time will be required to ensure the Code of Conduct is adopted by farmers. As an incentive, the Department of Fisheries is planning to link adoption of the Code to a national shrimp certification scheme.

<u>Vietnam</u>
The studies in Vietnam were carried out by researchers in the north, central and southern coasts, giving a broad coverage of the coastal environments, social conditions and shrimp farming systems found within the country.

Tran Van Nhuong, Raymon van Anrooy and Michael John Phillips. **Coastal Shrimp Aquaculture: Searching for Better Management Strategies—Case Studies From the North and North-Central Coastal Area of Vietnam.** 2002.

Abstract: This case study coastal aquaculture management was carried out in the North and North Central of Vietnam. The study was based on primary and secondary data collected through participatory discussions and structured interviews aqua-farmers, agriculture farmers, extension officers, commune key persons, and local, provincial and national level officials. The objectives of the study were to describe the current coastal aquaculture practices, the impact on the livelihood of the coastal inhabitants (aqua-farmers and non-aqua-farmers) and on the environment, to discuss the current situation in relation to the respective articles in the Code of Conduct for Responsible Fisheries (CCRF), and identify BMPs.

Coastal aquaculture activity in Bang La, Quang Thuan and Quynh Bang (the North and North Central of Vietnam) showed an increase after 1990 under the influence of the Doi Moi economic reform in Vietnam but is currently still characterized by extensive and improved extensive culture systems of small-scale farmers with low input use and leading to low productivity levels, but the transition to semi-extensive culture systems is beginning and being strongly promoted by government. The cultured species are mainly tiger shrimp although farmers also culture mud crab. Aqua-farmers are showing a tendency to specialize into tiger shrimp monoculture, which offers higher net benefits but is very prone to diseases and therefore implies higher risks. Negative environmental impact of the coastal aquaculture development in the 3 communes is low because the expansion of aquaculture did not result in the destruction of large areas of mangroves (instead marshland, swamps and salt fields were converted into ponds) and the present mode of production (improved extensive) has limited effluent impact.

Coastal aquaculture activities in the 3 investigated communes is currently changing rapidly from (improved) extensive to semi-intensive. Rapidly increasing population in the coastal areas is a major incentive in this process. To generate more employment and income coastal aquaculture needs to change to smaller ponds per household and higher uses of inputs leading to a higher productivity per hectare, and hopefully higher net benefits per hectare. Productivity of small ponds (around 0.2 ha) appeared to be tenfold higher than of large

ponds (>1 ha). However, this study showed that pond sizes of 0.2 ha are probably too small for a household to make a living only from coastal aquaculture, considering the economies of scale related to labor inputs, stocking densities, costs and benefits of the currently used system. Further investigations into the current and more intensive production systems (pond size, stocking density, input use, marketing, etc.) are therefore needed to support the coastal aquaculture development planning processes and policies.

Coastal aquaculture development benefited many farming households in the villages studied, and has clearly generated wealth to the community. In addition it supported also directly the livelihoods of poorer people that are involved in seed collection, trash fish commercialization, feed production, processing and small scale marketing, via new employment opportunities and incomes. For each 3 aqua-farming households one household is active in services provision (seed collection, processing, marketing) in the sector. Incomes in these aquaculture services sub-sector are often better paid than in the production itself, e.g. incomes from seed supply and in the marketing of the product were on average respectively 30% and 100% higher than from aquaculture. Another advantage of coastal aquaculture is more indirectly for the local economy, due to the increased expenditures of aqua-farming households, the alternatives it offered to fisherfolk to become employed in aquaculture, and the migration (knowledge drain) to the urban centers. The accessibility of coastal aquaculture production itself for the poorest of the poor is restricted by the decreasing availability of suitable land, the structure of the land markets, lack of technical know-how, lack of investment resources, regulations in favor of those with assets, prejudice of officials towards the capacities of the poor and the competitors in other layers in society. Especially the current land distribution practices under the Land Law increase inequality and limit the access of the poor to aquaculture. Land use contracts in many cases are given only for 5 years and the price of the land rent increases every time when renewal is needed, in this way decreasing the opportunities for the poor to get involved and discouraging sustainable investments in aquaculture. Some government and local level policies are slowly trying to change this situation, but a more positive pro-poor policy implementation is required. Moreover, in the 3 communes there were some efforts made by local people such as the introduction of group management strategies, in which poor farmers together manage and reap the benefits of a common property pond. Initiatives of this kind show that the poor can benefit from shrimp aquaculture, but support and training in pond management, planning and incentives to invest are definitely needed to get more poor actively involved in aquaculture development.

Though the Vietnamese Government established a strong institutional systems in theory to support aquaculture development, current institutions in the fields of aquaculture as well as fisheries are weak. This weakness in institutions governing aquaculture is recognized in terms of laws and regulation enforcement, and disharmony in supporting policies. The Sustainable Aquaculture for Poverty Alleviation (SAPA) strategy, the national aquaculture development plan for the next 10 years and the elaboration of the new Fisheries Law are therefore important initiatives and steps taken by the Ministry of Fisheries. Present major weaknesses in the system are the lack of financial and human resources (especially professional skills) and the planning of aquaculture development, what is currently slow and presents sometimes externalities like the negative impact on the environment.

Silvofishery Farming Systems in Ca Mau Province, Vietnam. 2002

The case study is divided into two parts:

Background and Technical Recommendations
Prepared by: *Barry Clough, Danielle Johnston, Tran Thanh Xuan and Michael Phillips*

Socio-economic Studies
Prepared by: *Pednekar, Sunil S. (NACA, Bangkok), Nguyen Huu Thien, Pham Le Thong, Truong Hoang Dan (Can Tho University, Vietnam)*

Abstract: This case study looks at the mixed mangrove-shrimp farming systems in ca Mau province of Vietnam. The case study provides a background to the origin of the mixed farming systems, and identifies better management practices identified by an ACIAR/RIA-2/NACA Project “Mixed shrimp farming-mangrove forestry models in the Mekong delta”. The project was carried out in two State Fishery-Forestry Enterprises (SFFEs), viz., Tam Giang III (TGIII) and 184, both located in the Ngoc Hien District, Ca Mau

Province, Vietnam. The project identified the main factors limiting shrimp and wood production, and better management practices for these mixed farming systems.

The socio-economic study was carried out to assess the benefits and constraints relating to the implementation of the better management recommendations by farmers, and to recommend appropriate institutional framework that would enable effective adoption of these recommendations. In addition, the information on socio-economic conditions of farmers practicing silvo-aquaculture, gathered through this study, may be of use to the upcoming World Bank-funded project for the Rehabilitation and Development of Wetlands and the Rehabilitation of Mangrove Forest Project (E-RMFP; now in the extended phase), funded by the Dutch government.

The results reveal a vicious circle of poverty, indebtedness, shrimp production failure and more indebtedness, which affects a significant number of farming households in the State Fishery-Forestry Enterprises. The poorest are obviously the less successful farmers with low technical know-how or experience in shrimp farming, but also those with few alternative income sources and no access to capital. The lack of technical know-how often leads to ineffective or wasteful use of resources (e.g., stocking shrimp at high densities). Lack of capital and access to formal, low-interest credit, on the other hand, forces farmers to purchase capital inputs such as shrimp post-larvae on credit from informal sources at exorbitantly high interest rates. With fluctuating production, repeated crop failures, and a lack of alternative income sources, the end result is growing indebtedness and more poverty. Uncertain land tenure, unavailability of marketing channels and lack of incentives for diversification, as well as uncertain income from mangrove plantation, together with low community bonds due to a relatively recent settlement history, only add up to the larger problem of poverty and indebtedness.

Regarding the better management recommendations from the ACIAR project, there is a reluctance of farmers to incorporate all of the project technical recommendations, partly due to lack of know-how and experience in shrimp farming, and partly due to a lack of capital. Simply providing capital access may lead to its ineffective use in the absence of proper technical know-how, causing further indebtedness. Implementing most recommendations would require small financial support, where capital is the major constraint (e.g., digging the pond, good quality post-larvae, etc.), and training and extension. Institutional reforms are necessary both at the Enterprise levels as well as provincial or national government levels.

The case study shows that shrimp aquaculture can contribute to poverty alleviation among poor people in mangrove rehabilitation projects – however, effective risk management strategies and institutional support oriented towards poor people’s needs are essential. The issues to be considered to support poor farmers in implementing better practice include: (a) basic institutional support to extension at farmer level and the need for giving special attention to poor people in such extension efforts is emphasized; (b) mechanisms for advancing small, short-term loans should be devised; (c) income diversification to spread risk; (d) mechanisms to improve market access, including farmer cooperation; (d) the need for a profit sharing arrangements be reviewed as well as more incentives be provided for mangrove conservation.

Nigel Preston, **Studies on Mixed Rice-Shrimp Aquaculture Systems in the Mekong Delta.** 2002.

Abstract: Integrated rice-aquaculture systems are expanding rapidly in the Mekong delta in southern Vietnam. The short rice growing season caused by saline water intrusion in some areas has meant that returns from rice are limited and adoption of shrimp as a second crop in the dry season has resulted in significant income gains, and contributed to poverty alleviation among some local farmers. However, the practice of shrimp farming is risky, due to disease problems that can lead to loss of investment. As the region has become more experienced with shrimp, environmental problems have emerged including salinity in rice fields and waterways and siltation of fields and canals. This case study contains the results and management lesson’s learned from a three year study of these mixed shrimp-rice farming systems in the Mekong delta.

Latin American region

Belize

Claude Boyd and Jason Clay, **Evaluation of Belize Aquaculture, Ltd.—A Super-Intensive Shrimp Aquaculture System in Belize.** 2002.

Abstract: Belize Aquaculture, Ltd., has developed a super-intensive shrimp aquaculture system operating in lined ponds with heavy mechanical aeration and water recirculation (Mcintosh 1999; Mcintosh et al. 1999). The pilot study of the operation has been in progress for two years, and several different trials have been conducted in ponds of 0.065 to 1.6 ha in size. Shrimp production has ranged from less than 8,000 kg/ha to more than 20,000 kg/ha per crop.

Such high production per unit area without water exchange presents several advantages over conventional shrimp aquaculture. These include greater potential for mechanization, reduced use of land and water, fewer logistical problems in pond operations, and less effluent. If this system works as efficiently as the early data suggest, and if it is suitable for general adoption by shrimp farmers around the world, it could provide a more environmentally responsible method of shrimp production.

Because the Belize Aquaculture, Ltd., production system appears to address a number of the environmental impacts of traditional shrimp aquaculture systems, a case study of this unique system was conducted. The case study was also intended to evaluate the potential of the system for replication throughout the world. The specific objectives of the case study were to:

1. Describe the production system.
2. Present a summary of its performance.
3. Discuss the unique aspects of the system.
4. Compare the system with conventional shrimp production systems.
5. Identify potential areas of concern with the current Belize Aquaculture system.
6. Discuss the implications of expanding the current system in Belize.
7. Assess the socioeconomic factors and effects of shrimp culture by this method..

<u>Brazil</u>

Barbara Schwab, Michael Weber and Bernard Lehmann, **Key Management Challenges for the Development and Growth of a Shrimp Farm in Northeast Brazil—A Case Study of Camanor Produtos Marinhos Ltd.** 2002.

Abstract: This case study discusses the main lessons for management practices learned at the shrimp farm Camanor, in Rio Grande do Norte (RN), Brazil. Since it was founded in 1982, the Camanor farm has yielded data that allow the knowledgeable observer to draw lessons and make insights. The lessons learned should be considered when addressing future development potential and the challenges of the shrimp aquaculture industry. This process is extremely important in Brazil and elsewhere, as new producers are likely to repeat the mistakes of others rather than learn from them unless the lessons learned are documented. This case thus attempts to document the most important lessons by Camanor during the past 18 years. The most important challenges before the shrimp aquaculture industry involve developing better practices and implementing industry wide standards that are more sustainable.

The case study is divided in two main parts: The first part is based on data available from the farm and on the experience of the owner and manager, Werner Jost. The second part is also based on Camanor data but includes projections of results from implementing certain sustainable management practices.

Camanor, like other shrimp producers in Brazil, is increasing its production rapidly. Besides the current operation, three more farms are under construction, some of which are beginning production. This expansion leads to new challenges in processing, administration, and overall management of the farm. The description and analysis of the past development of Camanor give some idea of the preconditions needed to support the current expansion.

Patricia Moles.**Barriers to Investing in Shrimp Aquaculture**. Terra Capital Fund, Banco Axial, Sao Paulo, Brazil. 2002.

Abstract: The purpose of this study is to assess the development of the shrimp farming industry in Brazil, identifying past obstacles and key incentives for its expansion. The shrimp industry has taken longer to develop in Brazil than in other countries. Despite favorable conditions, it is only recently that successful

efforts are consolidating. This report analyzes the main factors that have inhibited the development of the industry and describes the sector's current characteristics.

The shrimp farming industry is developing rapidly today. The stability of the Brazilian economy since 1994, together with the establishment of commercial shrimp hatcheries and aquafeed companies from Taiwan and the US, has provided further incentives for new investments in the sector. Most farms have implemented semi-intensive methods with *P. vannamei* and *P. subtilis* and adopted innovative management techniques

At the moment, there is an absolute absence of any scientific research from Brazilian governmental bodies concerning PL production in hatcheries or raising shrimp in ponds. All the progress made to date has come from producers' own on-site research or the expertise of international consultants. The members of the producers' association (ABCC) agreed to pay a "research tax" levied on the feed sold to farmers. These private funds support research projects proposed by ABCC's members that have industrywide relevance. It is odd that on the one hand the public sector in Brazil is highly effective in taxing all kinds of economic activities, and on the other hand incapable of building a public research infrastructure that would strengthen the industry.

One issue to be resolved is the use of marine land as collateral for credit, since most farms are situated on marine land. Normally the actual land where a shrimp farm is built represents the highest-value component of the farm. Banks or other lenders will demand additional collateral if the owners lack the land's title, since they consider "occupancy of marine land" not equivalent to having a definitive title to the real estate. It would greatly enhance the borrowing capacity of shrimp farmers if the federal government can resolve this issue.

Colombia

Dominique Gautier, **The Integration of Mangrove and Shrimp Farming: The Case Study on the Caribbean Coast of Colombia.** 2002.

Abstract: Shrimp aquaculture has been accused of threatening mangrove forests worldwide. In response, the shrimp industry is developing the concept of integrated mangrove–shrimp farm systems. Mangrove and shrimp ponds are known to have mutually supportive functions. Mangrove wetlands can treat effluents from shrimp ponds effectively by removing suspended solids and nutrients. This activity can be expected, in turn, to enhance mangrove productivity. This report describes an integrated mangrove wetland–shrimp farm operating in Colombia since 1996. At this site, shrimp farm effluent is recirculated through an 120 ha mangrove area. Suspended solids are considerably reduced in the effluent, and nutrient concentrations in the adjacent lagoon decrease. Mangrove growth and regeneration in the biofilter are very high, but nutrient cycling in the biofilter is poorly understood. Moreover, the long-term impact of effluents on mangrove ecosystem has to be assessed. This case provides a positive example of responsible aquaculture development in coastal areas, but at the same time reveals the need for further research to develop sustainable practices within the shrimp industry.

Dominique Gautier, **The Adoption of Better Management Practices (BMPs) by the Shrimp Industry on the Caribbean Coast of Colombia.** 2002.

Abstract: This report discusses the recent history of shrimp aquaculture along the Caribbean coast of Colombia, with a focus on effective management practices that have been implemented since the mid-1990s. While the primary reason for using different practices has been preventing outbreaks of shrimp diseases, many such practices provide environmental benefits as well. Examples include reducing the use of water (and other resources) as well as ensuring that effluent entering natural water bodies is at least as clean as the intake water.

Strong growth prevailed in Colombian shrimp production from the early 1980s to 1993, when Taura Syndrome hit the industry and spread throughout coastal shrimp farms. Many farms closed, some of these never reopened; other farms have bounced back, and total production has been growing again since 1997. Since the Taura outbreak, research efforts led by the nation's industry association, Acuanal, have produced an ample domestic supply of broodstock and seedstock from animals selected for growth rates and resistance to disease. In addition to avoiding importation of shrimp and other marine animals that could carry disease, other elements of a biosecurity plan were implemented, including systematic disinfection of equipment, thorough testing, and certification that any animals to be moved from a facility are free of the viruses that cause White Spot Syndrome and Taura Syndrome, as well as the pathogens Baculovirus, Yellow-Head Virus (YHV), Infectious Hypodermal and Hematopoietic Necrosis Virus (IHHNV), and Necrotizing Hepatopancreatitis (NHP). Vibriosis occurs more commonly than any of the major diseases and is usually treated with antibiotics.

Biosecurity procedures are strict at hatcheries and nurseries, resulting in higher survival rates and healthier nauplii provided to the industry. The elements of ensuring biosecurity strive to prevent pathogen introduction or circulation, to diagnose quickly any disease that does appear and eliminate it, and to protect the genetic stock that is aquaculture's foundation. So far, these preventive actions have protected the industry on the Caribbean coast, but farms on the Pacific coast were hit with WSSV in 1999, and most in that area were closed in 2000. Fortunately, all shrimp-related facilities in the Caribbean coastal area that were closed from disease outbreaks have reopened and resumed their activities.

After surveying many facilities (seven shrimp hatcheries and nurseries, six companies that own and manage nine farms, and two processing plants), the author reports on common practices in place in 2000. These practices are contrasted with those used in 1997, when an earlier survey was conducted, and numerous inputs and outputs are compared between the two years. The six aquaculture companies operate farms that account for 88% of the area in production on the Caribbean coast, and the two processing companies process about 90% of that coast's total production. For each type of facility, the following topics are addressed: production methods, resource use, biosecurity measures, employment, efficiency, and economic aspects.

Shrimp farms in this area of Colombia have displaced undeveloped land or agricultural/ cattle farms that provided fewer jobs, rather than communities or communal resources. Destroying mangrove ecosystems has not been an issue for these farms; the small mangrove areas within farms have been preserved, as required by law. The farms as well as hatcheries, nurseries, and processing plants provide much-needed employment, and these jobs pay better and provide better benefits than the few other local options. Social services including schools, housing, and health care are often provided for local communities. Personnel turnover is very low. However, some workers, particularly those in processing plants, suffer from respiratory irritation and illnesses due to exposure to sodium metabisulfite, or skin irritation and infection from constant exposure to moisture.

The use of chlorine (increased since 1997) and sodium metabisulfite necessitates letting these residues dissipate in a tank or pond before discharging water, but not all farms have this equipment. Organic fertilizer use has diminished, but fertilizers (including inorganic ones) still pose risks of contaminating shrimp ponds and eutrophying natural water bodies. Hazardous waste collection and treatment methods have been improved at shrimp farms. Water use in shrimp farms has decreased since 1997, lowering energy costs and reducing total production costs. New legislation that levies a tax based on measured differences between intake and discharge water now provides facilities, especially processing plants, with the incentive to further reduce costs by eliminating contaminants from effluent.

In 2000, the average survival rate at the shrimp farms surveyed was 65 percent, a notable increase over 1997. Many factors contribute to the higher survival rates, including lower stocking densities and greater use of chlorine, as well as the improved health of post-larvae and screening for disease mentioned above. The costs of nauplii and PL have both been substantially reduced. Stocking densities have decreased since 1997 by 35% on average. In sum, the higher yields and survival rates that stem from the selective breeding program have increased production and profits as well as supported other changes that improve environmental impacts.

Challenges that remain for the Colombian shrimp industry include implementing comprehensive environmental management systems; finding less expensive (and domestic) sources of shrimp food, especially for brooders; further improving the biosecurity of facilities (investing in costly recirculation equipment); and discovering and addressing the factors that reduce pond productivity during the dry months, so the whole year can be used for production. Environmental management should be further improved, perhaps by adopting a generally accepted certification program. Acuanal, the industry association, is central to providing training and information to producers as well as representing their interests in negotiations with government agencies.

Ecuador
There are five case studies conducted in Ecuador under the authorship of Jorge Calderon and Stanislaus Sonnenholzner (CENAIM) and Claude E. Boyd (Auburn University). All of these case studies are published in one document

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Case Studies on Shrimp Aquaculture Management in Ecuador**. 2002

Abstract: Shrimp farming in Ecuador has grown steadily since its inception in the early 70s to an extent of becoming the largest shrimp producer of the western hemisphere today. The relative rapid expansion of this activity has raised environmental and social concerns regarding contamination and eutrophication of natural waters by farm effluents, use of wild-caught post-larvae, destruction of mangrove forests and consequent negative effects on native fisheries and biodiversity. To address these environmental and social issues, a series of case studies on shrimp farming were conducted in Ecuador by Foundation CENAIM-ESPOL to document the practices used in shrimp farming in the past five years. Results here presented will contribute to assess objectively the environmental and socioeconomic status of shrimp farming in Ecuador.

Shrimp farming in Ecuador is characterized by extensive and semi-intensive production systems. Stocking densities range between 8 to 14 PL per sq. m. and yields after 90-120 production days average 1,200 kg per hectare per year. During the 70s and 80s the industry relied almost entirely on wild seed. However, unpredictability of wild supply and disease outbreaks has forced the industry to use hatchery post-larvae. Records of larvae source obtained from 12 commercial shrimp farms for the period 1995-2000 indicate a decrease in number of ponds stocked with wild seed from 58% in 1995 to 7% in 2000. The driving force for wild PL preference over hatchery PL in the past, besides lower prices due to high supply during warm months and El Niño years, is the believe among farm managers that wild larvae outperforms hatchery larvae during grow-out in ponds. Analysis of production data from commercial farms showed no difference in yields per hectare and growth among ponds stocked with wild and hatchery larvae. Currently there are 308 registered shrimp hatcheries with an installed production capacity of 46 billion post-larvae per year, enough to supply estimated yearly demand of 38 to 45 billion larvae.

Relatively high pond water exchange rates have been considered the most viable and economic management tool to correct water quality and oxygen problems in large (10 hectare average) ponds. Location of farms in rural areas with limited electrical power supply, continuous and almost unlimited source of water from natural waterways in estuaries or open sea, and the absence of clear regulations on water use and effluent discharge have contributed to this practice. A survey conducted in this study to 14 shrimp farmers revealed however a decrease in exchange rates in last two years from 10-15% pond volume/day to 1-3% or no water exchange. Reduction of disease risks by restricting water inlet into ponds was given as primary explanation for current water exchange practices by interviewed farmers.

The shrimp farming industry has been accused of threatening mangrove forests, and is sometimes pointed out by environmentalist groups as the major cause of their degradation in certain regions. Although, it can be said that shrimp aquaculture contributed to mangrove loss in certain cases, aquaculture is but one activity that has impacted mangrove resources. A lack of effective regulation of these resources, as well as a combination of exemptions for small-scale exploitation and lack of enforcement, often lead to the wrong impression that mangrove forests are essentially free resources. It is interesting to see that data from satellite pictures presented by CLIRSEN (Center of Integrated Readings of Natural Resources by Remote Sensor) in 1999 show a stabilization in mangrove coverage. The previous survey of 1995 confirmed the decline from 204,000 ha in 1984 to 150,000 ha in 1995, but the total surface area reported for 1999 is again of 150,000 ha. It is thought to be the result of a better awareness of the Ecuadorian public for mangrove value and of several small-scale projects directed towards conservation and restoration efforts. In this last aspect, it is encouraging to see that shrimp farmers out of their own initiative are reforesting small areas adjacent to their farms.

Shrimp farming started in tidal flats that included mangrove areas. Tide action for pond filling was considered one of the most important criteria for site selection. This criterion has changed over the years, as more knowledge on soil and water quality parameters for sustainable aquaculture has been acquired. However, many ponds constructed on mangrove soils are still in production today. Soils of ponds constructed on former mangrove areas have been found to be more acidic and contain more carbon and sulfur. However, production data of 7 farms having ponds on different soil types including former mangrove areas revealed no difference in growth, survival and yields among mangrove and non-mangrove soil in the last five years.

Honduras

Denise Stanley, Carolina Alduvin and Amanda Cruz, **Science and Society in the Gulf of Fonseca: The Changing History of Mariculture in Honduras.** 2000.

Abstract: Shrimp farming in southern Honduras has generated considerable controversy around the issues of natural resource access and management. This case study reviews the reasons for and history of that controversy. The early disorderly growth of the industry is seen as having created both public and private costs and benefits in these early years. But the shrimp industry's proactive stance and sustainability ethic after 1994 are factors that led to more cooperation among stakeholders in the zone. Additionally, international research efforts, vertical integration, and the pressure of environmentalists have considerably changed the dynamics in the Gulf of Fonseca. The new protected areas legislation offers lessons of sustainable coastal management strategies available to other countries with mariculture programs. However, the case study concludes that additional data is needed to assess the actual social and environmental effects of mariculture on local communities.

Claude Boyd and Bart Green, **Coastal Water Quality Monitoring in Shrimp Farming Areas with an Example from Honduras.** 2002.

Abstract: This case study was prepared with the objectives of describing how to conduct a coastal water quality monitoring program and to present such a program in Honduras as an example.
Coastal water quality monitoring establishes the present status of water quality in a specific area and determines if changes in water quality occur in the future. The sampling stations for a water quality monitoring program to evaluate shrimp farm impacts should include stations near shrimp farm outfalls, near the inflows of selected streams, near pumping stations, and in the larger body of the estuary and the seashore. Some stations should be well removed from farm outfalls, and there should be a gradient from farm outfalls to remote stations. Stations should be marked clearly so that samples are always taken from an exact location. The sampling frequency should be weekly or more often. The most important variables to be measured are as follows: water temperature, dissolved oxygen, pH, total ammonia nitrogen, nitrite nitrogen, total phosphorus, total nitrogen, chlorophyll a, total suspended solids, biochemical oxygen demand, salinity, and Secchi disk visibility. Standard analytical protocol should be used, and the same methods should be employed throughout the program. A good record-keeping protocol is essential, and the laboratory personnel should design and maintain a system of quality control. Estimates of the costs of a water quality monitoring program are provided, and the public and private benefits of coastal water quality monitoring are discussed.

Auburn University and the United States Agency for International Development, Pond Dynamics/Aquaculture Cooperative Research Support Program (PD/A CRSP) cooperated with several Honduran organizations (General Directorate of Fisheries and Aquaculture, Honduran National Association of Aquaculturists, Pan American Agricultural School and Federation of Producers and Exporters of Honduras) to develop coastal water quality monitoring in the estuaries and Gulf of Fonseca in the Choluteca region. This program was initiated in 1993. Auburn University and the PD/A CRSP involvement in the program ended in 1998, but the program has continued under the auspices of the Honduran National Association of Aquaculturists.

The water quality program involved establishing and equipping a water quality laboratory and hiring a capable analyst. A sampling network was established and shrimp farmers assumed the responsibility for providing the samples on a regular schedule. There have been no problems associated with acquisition of samples, as the farmers are very interested in the results of the program.

The monitoring program has not shown any clear cut negative impacts of shrimp farming on coastal water quality. However, there are other activities that also influence water quality in the area, water quality problems do exist, and shrimp farming must be considered as a contributor of pollutants to the coastal waters. The monitoring program has allowed data to be complied on the shrimp farm configurations, exchange rates, and effluent chemistry. Temperature/salinity/dissolved oxygen profiles have been measured in the estuary channels in both rainy and dry seasons. Physiographic hydrographic and meteorological data have been obtained to supplement the estuary data. The assimilative capacity of these estuaries with respect to dissolved oxygen (DO) have been examined. The oxygen demand of organics is measured by biochemical oxygen demand (BOD). Shrimp farm BOD loadings were estimated from effluent data and exchange. A transport model for salinity and DO in the estuaries was applied to predict the tidal-mean, section-mean concentrations of salinity and DO. The model predictions of DO given 1995 BOD loadings were satisfactory. Future loadings based upon full shrimp farm development along these two estuaries were then input to determine the resulting DO under these conditions. It was found that the 1995 configuration is already pressing the carrying capacity of both systems, and the DO will be worsened at full development. Shrimp farms placed farther upstream than about 20 km from the mouth will most likely have excessive impact on the DO in the estuary. The impact is exacerbated under dry season conditions. Negative impacts of a specific farm can be ameliorated by reducing or eliminating pond discharges during the dry season, and by reducing the level of water exchange employed. This work needs to be extended to address additional water-quality parameters, and to incorporate larger spatial scales, especially to establish the interaction between different estuaries draining into Fonseca.

Mexico

Billie R. DeWalt, Lorena Noriega, Jaime Renan Ramirez Zavala, and Rosa Esthela Gonzalez, **Shrimp Aquaculture, People and the Environment in Coastal Mexico**. 2002.

Abstract: The shrimp aquaculture sector in Mexico has experienced a boom, particularly following 1992 revisions to Article 27 of the Constitution (agrarian reform legislation) and the Fisheries Law. This case study documents the social and environmental effects of aquaculture, the effectiveness of government in regulating the industry, the interaction between new producers and long-term residents of coastal areas, and the sources of investments in the industry. Individuals from many different stakeholder groups were consulted to insure that their concerns and issues are adequately reflected in the analysis. The report identifies the most important interventions needed to make shrimp aquaculture economically and environmentally sustainable.

Approximately 90% of operating shrimp aquaculture farms are located in the three states of Sonora, Sinaloa, and Nayarít, accounting for 95% of production of farmed shrimp in the country. A summary of the current situation is that: (a) the number of producers nearly doubled in the period between 1993 and 1998 to nearly 400 farms; (b) there are now nearly 21,000 hectares of shrimp aquaculture ponds in the country; (c) average yields are approximately 1.34 tons per hectare; (d) shrimp aquaculture production generated a value of approximately 128 million dollars in 1998; and (e) shrimp farming has generated approximately 8,000 direct jobs (and perhaps twice as many indirect and part-time jobs) in regions of the country that offer few other economic options. Aquaculture now contributes approximately 25% of total shrimp production in Mexico, about the same as near shore fisheries, but still lagging the high seas fishery that provides about 50%. Of Mexico's total production of 71,609 tons of shrimp in 1998, it exported about 53% of the total (38,221 tons) with 98% of this going to the United States. There is an excellent domestic market for shrimp in Mexico and competition for product keeps prices to producers relatively high.

Because of the historical legacy of the agrarian reform, about 80% of the shrimp aquaculture farms are still held by the cooperative/ejido sector; these producers still account for about 48% of the farm-raised shrimp in the country. In cases in which individuals from ejidos decide to sell or lease their lands, they receive good prices. Associations of Participation are being formed in some areas. In these situations, the private sector develops an aquaculture park in which a portion remains in the hands of the cooperative/ejido sector that has traditionally held the property rights to the land. In Mexico, the issue of coastal property rights is quite complicated with federal zones, sub-divided ejido lands, communal ejido lands, private property, and areas in which cooperatives have been granted fishing rights all overlapping or existing in close proximity. Disputes among these stakeholders are common.

All producers in both the cooperative/ejido and private sector are quite concerned about disease problems. Mexico's use of hatchery PL is extensive, with about 90% of production using this source of PL. This may help in preventing further disease problems. Approximately 23% of shrimp farms in Mexico were not producing in 1998 primarily because of disease problems, poor choice of site for the farm, or lack of capital.

Shrimp aquaculture in Mexico has thus far developed largely without the major detrimental environmental effects seen in other countries of the world. Little evidence of mangrove destruction was discovered. The most serious potential threat from shrimp aquaculture is probably its potential effects on water quality.

Capital to invest in shrimp farming comes from a diversity of sources. Private capital, national banks, and financial institutions have provided most of the money invested. Input suppliers (for feed and PL) and marketers also are providing extended credit and/or loans to farmers. Some foreign investment is present but most of the capital being invested is national. Substantial progress has been made within SEMARNAP, the main development, regulatory, and enforcement organization. In terms of legal requirements, regulations, and norms, a reasonable structure now exists. Enforcement is still a problem, with PROFEPA (the Attorney General for Protection of the Environment) suffering from a lack of funding, but the situation appears to be improving.

Overall, the state of aquaculture in Mexico appears to be evolving in a very positive direction. Because of the historical legacy of the Revolution, Mexico may be the only place in Latin America in which the resource-poor sector will play a big role in production of farmed shrimp. Regulation and monitoring of the industry are still in their infancy, but SEMARNAP is putting in place a system that may be able to insure that aquaculture will be sustainable. The presence of a strong system of universities and applied research institutes should help in the development and monitoring of the industry. A stronger presence of the NGO community involvement in the aquaculture sector may also help with monitoring and in insuring compliance with environmental regulations.

Africa and the Middle East Region

The case studies on East Africa and the Middle East are to be prepared as a single thematic review. The titles of the individual cases as they were prepared under the direction of SEACAM in Maputo, Mozambique are as follows:

Rafael Rafael and Jason Clay. **The Current Status of Shrimp Aquaculture Systems in Africa and the Middle East.** 2002.

Abstract: This case study summarize existing experiences with shrimp aquaculture in Africa and the middle East region through consultation with people involved in shrimp aquaculture development (private and government) and analysis of major issues. The reports also provide lessons that Africa and the Middle East might learn from the management experiences documented in Asia and Latin America.

Annex B: List of Meetings and Stakeholder Consultations

Location	**Appendix A--Meetings Held or Attended in 1999-2002 to further the Work of the Consortium.**	Participants	Producers	Govt. officials	Multi-lateral orgs.	Bi-lateral orgs.	NGOs	Researchers/ universities	Community groups	Investors/ Funders	Buyers	Certifiers	Trade associationsC	Consultants
Vinh, Nghe Anh, Vietnam	Provincial level stakeholders workshop on shrimp aquaculture management in Nghe An province, Vietnam (NGOs in the Vietnam context = Women's union, Youth Union and non-aquaculture farming and community groups) (one day workshop, March 2000)	30	✓	✓			✓	✓	✓					
District and Villages in Nghe Anh, Hai Phong and Quangh Binh provinces, Vietnam	Stakeholder workshops in districts of Quynh Luu, Quang Thuan, Bang La, Quang Thuan, Quynh Bang, Quang Binh and Do Son, covering livelihood analyses, wealth ranking, social impacts of shrimp aquaculture and poverty. (7 workshops in total, in March-April 2000)	140	✓	✓			✓	✓	✓					
Hanoi, Vietnam	Scoping workshop on "Sustainable Aquaculture for Poverty Alleviation" ("SAPA"). National level workshop to present findings of research and broadly discuss the role of aquaculture in poverty alleviation in Vietnam. (23rd-25th May 2000).	60	✓	✓	✓	✓	✓	✓	✓					✓
Hanoi, Vietnam	Follow up workshop to approve a government policy document on "Sustainable Aquaculture for Poverty Alleviation" ("SAPA") (14th September 2000).	40	✓	✓	✓	✓	✓	✓	✓					✓
Khulna district, Bangladesh	Primary stakeholder workshops (women, shrimp cultivators, agriculture farmers, landless) in three "polders" in Khulna district (March 2000)	182	✓				✓	✓	✓					
Khulna district, Bangladesh	District, upazilla secondary stakeholders workshop on shrimp aquaculture in Khulna district (4 one day workshops, March 2000)	87	✓	✓			✓	✓	✓	✓	✓			
Dhaka, Bangladesh	Workshop on shrimp aquaculture case studies in Bangladesh (presentations of draft case study findings) (3rd July 2000)	51	✓	✓	✓	✓	✓	✓						✓

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Nice, France	World Aquaculture Society meeting	2,50 0	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Thailand	Local workshops on the Thai Code of Conduct for Responsible Shrimp Aquaculture (Rayong and Hat Yai) (June/July 2000)	15	✓	✓			✓							
Bangkok, Thailand	Workshop to prepare the thematic review on coastal wetland habitats and shrimp aquaculture (14th-16th February 2000)	25	✓	✓			✓	✓						✓
Bangkok, Thailand	NACA/FAO/Government of Thailand Conference on Aquaculture in the Third Millenium. (20th-25th February 2000)	550	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Negombo, Sri Lanka	Sri Lanka consultations on development of a Code of Practice (March 2000)	50	✓	✓			✓							
Various locations, the Philippines	Local workshops held at 4 coastal locations in the Philippines	60+	✓	✓		✓	✓		✓					
Cebu, Philippines	Management strategies for major diseases in shrimp aquaculture. (28th-30th November 1999)	40	✓	✓	✓		✓	✓					✓	✓
Puerto Vallarta, Mexico	Trans-boundary aquatic animal pathogen transfer and the development of harmonized standards on aquaculture aquaculture health management (joint APEC/FAO/NACA consultation) (24th-28th July 2000)	49	✓	✓	✓		✓							✓
Brisbane, Australia	FAO/Australia consultation on management practice and institutional and legal arrangements for shrimp aquaculture (4th-7th December 2000)	65	✓	✓	✓	✓	✓	✓				✓	✓	✓
Beijing, China	Final workshop on Asia Regional Health Management for the Responsible Transboundary movement of live aquatic animals (27th-30th June 2000)	45		✓	✓	✓								
Dhaka, Bangladesh	Regional workshop on "Primary aquatic animal health care in rural, small-scale, aquaculture development" (27th-30th September 1999) (participants from 12 countries)	48	✓	✓	✓	✓	✓	✓						✓
Hanoi, Vietnam	Meeting on a potential Code of Practice for shrimp aquaculture in Vietnam (December 2000)	17	✓	✓		✓		✓						✓

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Hanoi, Vietnam	Workshop for drafting of EIA guidelines for government on coastal aquaculture developments in Vietnam (13th December 2000)	10		✓		✓	✓	✓						✓
London, UK	Meeting with the Marine Stewardship Council, December 1998	7										✓		
Guayaquil, Ecuador	Annual meeting of ISANet. December 1998	30					✓	✓	✓					✓
Guayaquil, Ecuador	Meeting with the Ecuadorian Shrimp Industry. January 1999	20	✓				✓	✓			✓		✓	✓
Washington, DC	Meeting with Oceanographic Institute and World Bank, 24 May 1999	5			✓			✓						
Washington, DC	Meeting with US-based NGOs on Shrimp Aquaculture, 25 May 1999	5					✓	✓						
Washington, DC	Meeting on Economic Analysis of Shrimp BMPs	3					✓	✓						
Caracas, Venezuela	Meeting with WWF Latin American Marine Program staff to discuss shrimp aquaculture. May 1999	20					✓							✓
Auburn University, USA	Presentation to Auburn U. Aquaculture Staff. June 2, 1999.	26						✓						✓
Los Altos, CA, USA	Met with Packard Foundation to advise on the priorities for their expanded marine program	15						✓		✓				✓
San Diego, CA, USA	Spoke about consortium's work at Coastal 99 meeting sponsored by Sustainable Resources Division of NOAA in light of US goal to increase aquaculture output 5-fold in 20 years. July 1999	125	✓	✓			✓	✓	✓		✓		✓	✓
Washington, DC, USA	NOAA meeting to discuss implications of reaching goal of increasing aquaculture production 5-fold in 20 years. August 1999.	250	✓	✓			✓	✓	✓				✓	✓
Salzburg, Austria	Salzburg Seminar on sustainable development in the humid tropics. Aquaculture featured. Clay gave keynote. August 1999.	90			✓	✓	✓	✓		✓				✓
Guayaquil, Ecuador	Bi-Annual Meeting of the National Shrimp Producers Association. October 26-31.	500	✓	✓			✓	✓			✓	✓	✓	✓

Location	**Appendix A--Meetings Held or Attended in 1999-2002 to further the Work of the Consortium.**	Participants	Producers	Govt. officials	Multi-lateral orgs.	Bi-lateral orgs.	NGOs	Researchers/ universities	Community groups	Investors/ Funders	Buyers	Certifiers	Trade associationsC	Consultants
San Francisco, CA, USA	Meeting of the Marine Program of the Packard Foundation on fisheries (including shrimp) market chain analysis. November 18-19, 1999.	10					✓	✓			✓			✓
Belize	Met with Belize Aquaculture and other producers to tour operations and discuss BMPs for shrimp aquaculture. December 12-15, 1999.	12	✓				✓	✓						✓
Bangkok, Thailand	NACA/WWF/WB/FAO meeting to discuss BMP work and the role of the consortium. April 20-23, 1999.	40	✓	✓	✓		✓	✓	✓					✓
Sydney, Australia	World Aquaculture Society Meetings. Session on shrimp aquaculture and the environment. April 27-30, 1999.	150	✓	✓			✓	✓						✓
Maputo, Mozambique	Meeting on Threats to the East African Marine Ecoregion. Discussion on shrimp aquaculture. January 14-21, 2000.	25			✓		✓	✓	✓					✓
New Orleans, LA, USA	Aquaculture America 2000. Talk on NGOs and Aquaculture and the identification and use of BMPs to improve performance. February 4, 2000.	125	✓	✓			✓	✓	✓					✓
New Orleans, LA, USA	Aquaculture America 2000. Session on Environmentally Sound Aquaculture. February 3, 2000.	150	✓	✓			✓	✓						✓
San Francisco, CA, USA	Marine Working Group, Consultative Group on Biodiversity. Talk on Promoting Sustainability through Certification, Marketing and Consumer Awareness. February 10, 2000.	45					✓	✓		✓		✓		✓
San Francisco, CA, USA	Marine Working Group, Consultative Group on Biodiversity. Talk on the Consortium's work on BMPs for shrimp aquaculture. February 10, 2000.	50					✓	✓		✓		✓		✓
Bangkok, Thailand	ISANet Annual Meeting. February 19, 2000.	40					✓	✓	✓	✓				✓
Bangkok, Thailand	Meeting with ISANet to discuss the work of the consortium. February 20, 2000.	12					✓	✓	✓					✓
Bangkok, Thailand	Meeting on Organic Shrimp Certification with Agro-Eco. February 24, 2000.	7	✓	✓			✓	✓				✓		

Location	**Appendix A--Meetings Held or Attended in 1999-2002 to further the Work of the Consortium.**	Participants	Producers	Govt. officials	Multi-lateral orgs.	Bi-lateral orgs.	NGOs	Researchers/ universities	Community groups	Investors/ Funders	Buyers	Certifiers	Trade associationsC	Consultants
Bangkok, Thailand	Expert consultation on the Proposed Sub-Committee on Aquaculture of the Committee of Fisheries to advise the FAO on the mandate of an aquaculture subcommittee. February 28-29, 2000.	35	✓	✓	✓	✓	✓	✓						✓
Washington, DC, USA	Gulf of Mexico shrimp fishery modeling session. March 4-5, 2000.	20		✓			✓	✓						✓
London, UK	Chatham House session on Business and Biodiversity. Discussed BMPs and shrimp aquaculture. April 3, 2000.	140	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
Mohonk, NY, USA	Social Venture Network Meeting on sustainability. Discussed BMPs using shrimp aquaculture as an example. April 13-16, 2000.	350	✓				✓	✓		✓	✓	✓	✓	✓
Monterey, CA, USA	SeaWeb/Packard Foundation Seafood Consumer Initiative Workshop. April 26-27, 2000.	55					✓	✓			✓	✓	✓	✓
Recife, Brazil	Meeting at Instituto Josue de Castro on shrimp aquaculture. May 22, 2000.	60	✓	✓			✓	✓	✓					✓
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on the work of the consortium. May 23, 2000.	250	✓	✓			✓	✓	✓					✓
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on BMPs and shrimp aquaculture development in Brazil. May 24, 2000.	200	✓	✓			✓	✓	✓					✓
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on the Mexican case study of the consortium. May 24, 2000.	150	✓	✓			✓	✓	✓					✓
New London, NH, USA.	Second International Industrial Ecology Conference: Engineering Global Systems. Gordon Conference. Talk comparing the environmental impacts of aquaculture and fisheries. June 11-16, 2000.	130		✓			✓	✓						✓
Washington DC, USA	World Wildlife Fund staff meeting. Presented the work of the consortium. July 14, 2000.	75					✓	✓						✓
Georgetown, Guyana	Addressed the President and Members of Parliament regarding natural resource management, BMPs and marketing. September 11, 2000.	150		✓		✓	✓	✓						✓

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Zurich, Switzerland	Addressed WWF-Switzerland Conference on the identification and use of BMPs. October 18-19, 2000.	80					✓	✓						✓
Washington, DC, USA	Addressed ISANet Board on preliminary findings of the consortium's work. October 22-23, 2000.	12					✓	✓						✓
Panama City, Panama	Fourth Latin American Aquaculture Congress and Exhibition. October 25-28, 2000.	300	✓	✓	✓		✓	✓		✓	✓		x	✓
London, UK	Addressed Ford Foundation Environmental Staff about the use of BMPs to improve environmental performance, natural resource management and marketing. November 2, 2000.	25					✓	✓		✓				✓
Baja, Mexico	Pew Fellows' Fifth Anniversary Meeting of Marine Fellows. November 5, 2000.	75					✓	✓		✓				✓
Washington DC, USA	Met with Marine Aquarium Council to discuss differences between certifying aquaculture and wild caught products. November 20, 2000.	4					✓							
Washington DC, USA	Addressed the IFC's agriculture and sustainability divisions on BMPs with reference to shrimp aquaculture and agriculture. November 21, 2000.	35			✓		✓							
Washington DC, USA	Met with Inter-American Development Bank's Multi-Lateral Investment Fund to discuss shrimp aquaculture, the use of BMP screens for their investments, and the establishment of a trading company to handle third-party certified production. November 20, 2000.	3			✓		✓							
Washington DC, USA	Met with the International Finance Committee of the World Bank Group to discuss the use of BMPs for investment screens for shrimp aquaculture, January 2001	50			✓		✓							
Boston, MA, USA	Stakeholder meeting on aquaculture development in New England, USA, January 2001	150	✓	✓		✓	✓	✓	✓	✓	✓			✓
Vancouver, BC, Canada	Multi-stakeholder meeting on aquaculture development with particular emphasis on VC, Colombia, January 2001	120	✓	✓			✓	✓	✓	✓	✓		✓	✓
San Francisco, CA, USA	Session on Aquaculture at the AAAS annual meeting. February 2001	125		✓			✓	✓						✓

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Orlando, FL, USA	Session on the work of the consortium at the World Aquaculture Society annual meeting. January 2001	75	✓	✓	✓	✓	✓	✓			✓		✓	✓
Tana, Madagascar	Preliminary meeting with shrimp producers, consultants, NGOs and government officials regarding the potential of creating BMP-based regulations, permits and licenses for the shrimp industry. April 2001.	8	✓	✓	✓		✓							✓
Cartejena, Colombia	Meeting on certification potential of shrimp aquaculture with the Colombian Shrimp association. May 2001	30	✓	✓			✓	✓			✓			✓
Philadelphia, PA, USA	WWF sponsored meeting on the development of a certification program for shrimp aquaculture. July 2001	20	✓		✓		✓	✓		✓	✓	✓		✓
Rome, Italy	FAO meeting to develop indicators for sustainable shrimp aquaculture. September 2001	20	✓	✓	✓		✓	✓						✓
Shepardstown, WV, USA	Keynote address on shrimp aquaculture BMPs to the annual meeting of the Aquacultural Engineering Society. October 2001	125	✓	✓			✓	✓						✓
Madison, WI, USA	Meeting of Protected Harvest (third party certifier) to discuss certification principles, criteria, and standards with relevance to shrimp aquaculture	12					✓					✓		
Sevilla, Spain	Meeting with WWF's Mediterranean Program Office to discuss aquaculture and marketing strategies. November 2001	17					✓							
Kota Kintabala, Sabah, Malaysia	Meeting with WWF staff in Malaysia and Indonesia to discuss BMPs for shrimp aquaculture. November 2001	10					✓							
Brussels, Belgium	Meeting with WWF's agriculture and aquaculture staff to discuss strategies for identifying and adopting BMPs to reduce the impacts of production. December 2001	25					✓							
Bangkok, Thailand	Meeting in NACA to discuss potential follow-up work of the consortium on certification of shrimp aquaculture. December 2001	4			✓		✓							
Bangkok, Thailand	Meeting with GEF to discuss possible follow-up work on shrimp aquaculture and mangroves in SE Asia. December 2001	4			✓		✓							

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Bangkok, Thailand	Meeting with private company possible roll-out of BMP work on shrimp aquaculture. December 2001	3			✓		✓							
Washington, DC, USA	Meeting of the Seafood Choices Alliance to discuss possible strategies to influence seafood consumption in the US. January 2002	50					✓					✓		✓
Washington, DC, USA	Meeting with a certifier and industry analyst to discuss problems and opportunities for BMP-based shrimp aquaculture certification. January 2002	3					✓					✓		✓
Washington, DC, USA	Meeting with the IFC to discuss the development of a BMP-based investment screen and also a larger investor round table. January 2002	12			✓		✓							
Washington, DC, USA	Meeting with Island Press to discuss putting the consortium's shrimp aquaculture work into the Knowledge Environment. January 2002	3												
Monterey, CA, USA	Meeting with donors and researchers regarding trends in aquaculture and shrimp aquaculture in particular. January 2002	15		✓			✓	✓		✓				✓
San Diego, CA, USA	World Aquaculture Session on the Potential Uses of BMPs to improve aquaculture performance. January 2002	75	✓	✓	✓	✓	✓	✓		✓			✓	✓
San Diego, CA, USA	Meeting with the Global Aquaculture Alliance. January 2002	2					✓						✓	
San Diego, CA, USA	Meeting with seafood industry analyst to target those companies most likely to purchase certified shrimp. January 2002	2					✓							✓
San Diego, CA, USA	Meeting with Monterey Bay Aquarium and COMPASS to discuss seafood rankings, aquaculture experts, and strategic interventions needed to improve the performance of aquaculture. January 2002	5					✓							
Beijing, China	Committee on Fisheries, Sub-committee on aquaculture. First session. Beijing, China, 18th-22nd April 2002.	100		✓	✓		✓	✓						
Totals	Total of All Consortium Meetings	7925	35	36	18	14	58	54	20	13	10	11	12	49

Annex C: Draft Objectives and Operating Principles Adopted in Brisbane

The following gives the objectives and operating principles for sustainable shrimp farm management, and recommendations, developed and adopted by participants at the FAO/Government Australia Expert Consultation on "Good Management Practices and Institutional and Legal Arrangements for the Sustainable Shrimp Culture", held in Brisbane, Australia, 4-7 December 2000.

A draft document on legal and institutional arrangements to support implementation of these management practices was also developed during the consultation, but will be made available in the consultation report. Other substantive issues discussed during the consultation, such as performance criteria, the process of development and implementation of good management practices, are not reported here, but will be included in the consultation report being prepared by FAO.

Objectives and Operating Principles for Shrimp Sustainable Shrimp Aquaculture

Use Land and Water Which is Suitable for Sustained Shrimp Production

Operational Principles for Farm Management

- Farmers should construct new ponds after following a rigorous site selection process (components of the site selection process need to be elaborated as part of a system of GMPs)
- Existing farms should plan expansions, modifications and operation to comply with agreed criteria (criteria could be either described in a system of GMPs or mandated by regulations)

Operating Principles for Sectoral Management

- Governments should promote shrimp farm development through selected integrated coastal area planning and management procedures, as applicable to local circumstances, with special emphasis on:
  - Protection of critical habitats
  - Assimilative capacity of water bodies exposed to farm effluent
  - Encouraging collective action in farm clusters, i.e. large areas covered by many farms. This may include collective approaches to multiple effluent management, joint liability schemes for cooperative management or even redevelopment of cluster areas.
- Government should ensure that use and property rights are clearly defined in the coastal zone, and that these are compatible with Objectives below.
- Government should make information available on suitable site selection criteria for shrimp farming, and identify locations and possibly zones suitable for shrimp farm development. In identifying such criteria, locations and zones, government should take account of:
  - The range of site conditions suited to different kinds of shrimp culture.
  - The potential of sites for alternative activities.
  - The interests of other resource users.
  - The practical issues of land ownership and access.
  - The location and functioning of valuable habitat and physical ecosystem functions.
  - Desirability of transparency in planning and approval processes.

Conserve Sensitive Aquatic Habitats and Important Ecosystem Functions

Operating Principles for On-farm Management

- Farmers should construct new ponds after following a rigorous site selection process (components of the site selection process need to be elaborated as part of a system of GMPs)

- Existing farms should plan expansions, modifications and operation to comply with agreed criteria (criteria could be either described in a system of GMPs or mandated by regulations)

Operating Principles for Sectoral Management
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  - Protection of critical habitats
  - Assimilative capacity of water bodies exposed to farm effluent
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  - The potential of sites for alternative activities.
  - The interests of other resource users.
  - The practical issues of land ownership and access.
  - The location and functioning of valuable habitat and physical ecosystem functions.
  - Desirability of transparency in planning and approval processes.

Manage Soil Resources and Earthworks to Minimize Impacts on Surrounding Environments

Operational Principles for On-farm Management
- Employ techniques and engineering practices to minimize erosion and salinization during construction and operation.
- Employ techniques to minimize disturbance of acid-sulfate soils during construction and operation
- Minimize creation of degraded areas such as unused soil piles and borrow pits

Operating Principles for Sectoral Management
- Zoning and site selection should include consideration of soil characteristics, suitability and appropriate use.
- In granting permits or licenses proponents should be required to demonstrate how the following issues will be addressed (for example):
  - Land clearing/vegetation management
  - Avoidance or management of potential acid sulfate soils (PASS) or acid sulfate soils (ASS) during construction.
  - Stormwater management during construction and operation.
  - Contingency plans for failure of environmental control measures.
  - Rehabilitation measures in the event of a failed or abandoned venture (e.g. lodging an environmental bond).
  - Design to minimize erosion.
- Environmental performance criteria, standards and type of assessment, for new and existing farms, for example.

- Annual performance audit by licensing authority or certified third party. Incentive based, poor performance results in increased level of inspection (with increased costs). Good performance rewarded with reduced audit frequency (reduced costs).
- Random or scheduled compliance monitoring.
- Inspection in response to self reported emergency.
- Inspection in response to complaint.

Minimize Impacts on Local Water Resources

<u>Operational Principles for On-farm Management</u>
- Optimize quality of discharge into natural water systems
- Minimize impacts of water use on hydraulics of natural water systems
- Minimize physical and chemical impacts on ground water resources

<u>Operational Principles for Sectoral Management</u>
- Government and/or farmer associations, in collaboration with other water users, should agree on appropriate quality standards for local water users.
- Government and/or farmer associations should develop and implement a strategy to maintain these standards.

Avoid Release or Escape of Exotic Species and Transgenics Into the Environment

<u>Operational Principles for On-farm Management</u>
- Farmers should undertake to work with local species except where introductions have been made responsibly and following appropriate protocols and safeguards
- Conform with national and international protocols on the transfer and introduction of alien species
- Where alien species or non-native strains are used, take maximum precautions to prevent escape of introduced stocks.
- Transgenics should only be used where such use has official approval and after appropriate safeguards have been put in place to avoid adverse environmental effects

<u>Operational Principles for Sectoral Management</u>
- Translocation has two components, genetics and diseases. Issues to be considered include:
  - Displacement of loss of native species.
  - Habitat modification, destruction or loss.
  - Changes to or loss of genetic diversity.
- Translocation issues should be considered as part of an Import Risk Assessment.
- Governments should enforce internationally and nationally agreed protocols in respect of release of exotic species or genetically modified organisms.
- Develop regulatory mechanisms for the safe introduction of exotic species.
- Develop capacity for the safe introduction of exotic species where these are approved.
- Where suitable native species are available, they should be used in preference to the introduction of exotic species.

Responsible Use of Chemicals That May Impact Adversely on Ecosystems and Human Health

Operating Principles for On-farm Management

- Chemicals should be used as little as possible, consistent with the need to maintain pond environment and shrimp health
- Records should be maintained regarding use of chemicals in ponds and hatcheries
- Train farm staff in safe handling of chemicals
- Ensure that chemicals used are effective for the purpose and are used in accordance with standard techniques or manufacturers' instructions regarding dosage, withdrawal period, proper use, storage, disposal, and other constraints on the use of a chemical including environmental, human and food safety precautions.

Operating Principles for Sectoral Management

- Governments should establish regulations relating to the safe use and handling of chemicals for use in aquaculture and other activities.
- Government and/or farmer associations and/or industry should provide information, training and facilities on disease diagnosis and correct treatment protocols, and in relation to other uses of chemicals.
- Government should prohibit the unrestricted sale of antibiotics whose unregulated use could undermine their effectiveness in the treatment of human diseases.

Maximize Efficiency of Resource Use and Minimize Waste Outputs

Operating Principles for On-farm Management

- Carefully monitor use of essential resources on the farm and adopt a strategy for maximizing efficiency in their use.

Operating Principles for Sectoral Management

- Governments and producer associations should promote the use of management systems and technologies that make efficient use of resources, such as shrimp PLs, water, chemicals, land, energy and labor.
- Governments should promote the supply of safe, high quality feeds for shrimp aquaculture in line with guidelines for good practice for manufacturing and use. Governments should encourage companies to provide information on nutrition and ingredients on feed labels.
- Governments and producer associations should encourage the use of settlement facilities and bioremediation to reduce waste outputs and encourage the creation of marketable by products.
- Farmer organizations should monitor and evaluate feed use and performance amongst their members, and provide periodic reports on these issues to their members, feed manufacturers and relevant government agencies.
- Government extension services should promote farming systems, which are compatible with the use of local resources.
- Government and producer associations should encourage the development of markets for waste-based by-products (e.g. sludge, shrimp processing wastes) and/or share information on viable markets.

Reduce Dependence on Wild Stocks for Farmed Shrimp Production

Operating Principles for On-farm Management
- Preserve genetic diversity of natural stocks
- Use hatchery-reared postlarvae and domestication to enhance culture performance and health

Operating Principles for Sectoral Management
- None provided

Implement Shrimp Health Practices to Reduce Risks of Disease in Farmed and Wild Stocks

Operating Principles for On-farm Management
- Maintain biosecurity.
- Implement technologies (health management protocols) that reduce stress.
- Ensuring good quality standards of shrimp post-larvae.
- Responsible trans-boundary movement of live shrimp.
- Implement management strategies to avoid spread of shrimp disease off farm.

Operating Principles for Sectoral Management
- Key among these would be commitment to development and implementation of a Shrimp Health Plan within the National Aquatic Animal Health Program. The plan should be implemented in a phased manner consistent with capability, resources and priority, in particular capacity building and development of infrastructure.
- Development of protocols on movement and compliance should be consistent with existing protocols and agreements, namely the "Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals" and the International Aquatic Animal Health Code, which are designed to address the requirements of the WTO SPS.
- Key components of a Shrimp Health Plan within the National Aquatic Animal Health Program should consider:
    - Health certification and quarantine measures including methods for screening and diagnostics.
    - Disease surveillance and reporting.
    - Zoning.
    - Import risk analysis.
    - Adequate data for epidemiological analysis.
- Regional cooperation should be extended to support:
    - Development of regional identification and resource centers servicing a number of countries.
    - Development of regional shrimp health plans for zoning, movement, surveillance and quarantine.
    - Accreditation of hatchery practices for production of good quality post larvae or extending to production of 'high health' or specific pathogen free (SPF) post-larvae.
    - Development of regional disease diagnostic capability levels 1-3 as appropriate.
    - Carry out farm trials of disease management practices and disseminate validated programs through extension.

Optimize Social and Economic Benefits to the Wider Community and Country

<u>Operating Principles for On-farm Management</u>

- Being socially responsible within community standards and values
- Encourage participation of local people in shrimp aquaculture
- Conduct shrimp farm operations to minimize impacts on surrounding resource users

<u>Operating Principles for Sectoral Management</u>

- Government and producer associations should work together to ensure that producers obey all laws relating to their operations.
- Government and producer associations should work together to ensure the rights of individuals and communities who choose to pursue their traditional use of resources.
- Government and producer associations should recognize the social and environmental impacts of operational failures and take all reasonable steps to reduce the rate of failure in shrimp farming.
- Governments should facilitate the ability of all resource users to address resource conflict issues.
- Governments should work with the industry to maximize the social benefits of shrimp aquaculture to the wider community through the development of such initiatives as public or joint venture operations, value-added processing, and infrastructure development.

Conduct Shrimp Farm Operations to Minimize Impacts on Surrounding Resource Users

<u>Operating Principles for Sectoral Management</u>

- Government should ensure that zoning and access to resources is transparent and that all interested parties are consulted in the process.
- Governments should ensure that resource use and rights are clearly defined and compatible for all resource users in the coastal zone.
- Governments should identify suitable zones for shrimp farming. The identification of such zones should take into account:
    - The potential of sites for other activities.
    - The interests of other resource owners/users.
    - The location of critical ecosystems.
    - Ensure the health and safety, rights and welfare, of staff in farm operations

<u>Operating Principles for On-farm Management</u>

- Governments should develop and implement appropriate labor regulations for shrimp farm activities.
- Conform to all relevant national labor regulations.
- Maintain healthy and safe living and working conditions.
- Provide appropriate channels to address staff grievances.

<u>Operating Principles for Sectoral Management</u>

- Governments in consultation with industry should develop and enforce standards compatible with international standards in relation to health and safety specifically relating to aquaculture.
- Government and farmer associations to raise awareness o standards and promote compliance.
- Development of shrimp farming within integrated coastal area management and rural development planning

Operating Principles for On-farm Management

- Governments should implement plans for integrated coastal area management and rural development planning.
- Develop shrimp farms within the confines of integrated coastal area management and rural development planning.
- Shrimp aquaculture should be integrated into rural development planning, as it has potential for poverty alleviation through direct involvement of rural people in aquaculture production, as well as through employment and or involvement in off-farm activities.

Operating Principles for Sectoral Management

- See Objective 1.

Note: These objectives and operating principles should not be considered in isolation although priorities and implementation may vary between farms and countries. They are also a "work in progress" and not for dissemination.

Expert Consultation Recommendations

1. There is a need for a consultative **follow up process** after the Expert Consultation (EC).

2. This process should initially involve finalizing the EC report, including revision of the working group reports, taking account of the issues raised during plenary discussions and particularly to ensure conformity and links between objectives, on- and off-farm operating principles for shrimp aquaculture and the legal and institutional arrangements.

3. The process should then provide more detail and supporting material on practical examples of shrimp farm management practices for implementation of the agreed operating principles, and identify mechanisms to support their implementation. The following were suggested:

- Identification of good management practices and good legal and institutional arrangements required to support implementation of the operating principles. The case studies and other material from the WB/NACA/WWF/FAO consortium should be used more extensively for such analyses.
- Estimation of qualitative and quantitative costs and benefits of implementation of good management practices. Financial and economic analyses of best compared to worst practices were recommended; the analyses should take into account the applicability of different shrimp aquaculture management practices at different levels from generic to site-specific farm levels.
- Identification of performance criteria to monitor the effectiveness of implementation of the operating principles, good management practices and good legal and institutional arrangements for shrimp aquaculture, taking into account the need for cost-effective monitoring based on a limited number of key indicators.
- Attention to identification of good management practices and good legal and institutional arrangements for "retrofitting" of existing farms and mobilization of required technical and financial support.

4. FAO and other agencies should produce and share information on development and implementation of good management practices and legal and institutional arrangements. The World Bank/NACA/WWF/FAO Consortium is requested to take responsibility for collating information on management practices as identified above, making further extensive use of the existing case materials from the Consortium work and other relevant sources.

5. In the process of compiling the documentation on development and implementation of good management practices recommended by the EC, linkage and exchange of experiences with farmers associations, governments, academic and research institutions, professional associations, non-government organizations and other organizations with experience and insight should be strongly encouraged.

6. The EC recommends that a document on the objectives and operating principles, and the legal and institutional arrangements to support implementation, be prepared for presentation to an intergovernmental forum for **formal agreement.** The EC requests FAO to facilitate this process.

7. The EC considered that two issues in particular have to be addressed in the process of further development and implementation of good management practices in shrimp aquaculture: (a) that **farmers associations** have a particularly important role to play, especially for small-scale farmers; and (b) **dialogue and cooperation** between farmers associations, government organizations, seafood

export associations, and other stakeholders is required in the development and implementation of good management practices. In this regard, the EC made the following recommendations:

- Preparation of a review of **farmers associations**, identifying the factors for success, to provide practical guidance on development and operation of successful farmers associations.
- Promotion of meetings of **farmers associations** to review and develop good management practices in co-operation with relevant government agencies, where desirable.
- Promotion of **dialogue and cooperation** between farmers associations, , government organizations, seafood export associations and other stakeholders in development and implementation of good management practices.
- More effective **networking among shrimp farmers associations** is required, and a regional shrimp farmers network may be particularly useful in Asia. The EC requested NACA to facilitate a meeting of shrimp farmers association in Asia. The farmers associations should drive the agenda for the meeting.

8. The EC recommended the following additional measures be promoted to facilitate the development and implementation of good management practices and good legal and institutional arrangements in shrimp aquaculture:

- Preparation of a review that will bring together experiences in success and failure in **management of farm clusters** and nucleus estates. Such a document can provide guidelines on how such nucleus estates might work best.
- Preparation of an evaluation of the potential use of the operating principles as basis for **investment and buyer screens**, providing an incentive for investments in farms operating according to good management practices.
- Elaboration of best practices for government–farmer consultation and cooperation at various levels (i.e. central, provincial and local levels) in the development and implementation of good management practices and good legal and institutional arrangements.
- **Financial and technical assistance** be directed to support development and implementation of good management practices and good legal and institutional arrangements, with special attention to small-scale farmers and farmers associations.
- Further evaluation of existing Codes of Conduct and implementation plans be carried out to assess their universal application.

Annex D: List of publications prepared by the Consortium Program

NACA/FAO. 2000. *Bangkok Declaration and Strategy for Aquaculture Development Beyond 2000*. Conference on Aquaculture in the Third Millenium, 20-25 February 2000. Bangkok, Thailand. NACA, Bangkok and FAO, Rome.

NACA/FAO. 2000. *Report on the Conference on Aquaculture in the Third Millenium*, Conference on Aquaculture in the Third Millenium, 20-25 February 2000. Bangkok, Thailand. NACA, Bangkok and FAO, Rome. 120 p.

NACA/FAO. 2001. *Technical Proceedings of the Conference on Aquaculture in the Third Millenium*. Conference on Aquaculture in the Third Millenium, 20-25 February 2000. Bangkok, Thailand, 20-25 February 2000. Bangkok, Thailand. NACA, Bangkok and FAO, Rome. CD version (available from rohana.subasinghe@fao.org).

Phillips, M.J., J. Clay, R. Zweig, C. G. Lundin and R. Subasinghe. 2001. Shrimp Farming and the Environment. A World Bank, NACA, WWF and FAO consortium program to analyze and share experiences on the better management of shrimp aquaculture in coastal areas. *InterCoast* #39, Spring 2001, "Across Portfolio Learning for Enhancing the Impacts of Integrated Coastal Management.

Individual case study reports are available on www.enaca.org/shrimp

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