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 to the World Bank

Draft – 20th April 2001

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1 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". This report synthesizes the information from activities supported under the World Bank-Netherlands partnership program. As consortium research work is still ongoing during 2001 under different funding sources, this report will be updated during 2001 as further results are obtained. The present document is therefore a working draft of the findings at the time of writing in April 2001.

The major issues:

The findings:

The way forward:

Acronym and glossary section to be added from Hempel report.

2 Introduction to the Consortium program

2.1 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 a particularly important economic activity in rural areas of developing countries and offers one of the few viable opportunities for poverty alleviation, community development and food security in the coastal tropical regions of many tropical regions. The development of coastal aquaculture has, however, not been without its controversies. Shrimp farming in particular has generated considerable debate in recent years over its social and environmental costs and benefits.

The farming of shrimp usually takes place in ponds located in coastal areas, and the past decade has seen a major expansion of this activity in Asia and Latin America.

Insert diagrams and maps

The global trend in shrimp aquaculture has been towards increasing production. According to official FAO estimates, world production of farmed shrimp in 1998 amounted to more than 1.11 million tonnes, with a value of US$ 6.86 billion. About 80% of the world's farmed shrimp is produced in Asia, with most of the rest coming from tropical Latin American countries. Rapid growth in production and the 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 so far there has been only little shrimp culture development to date.

The expansion of shrimp culture in coastal areas of Asia and Latin America however 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.

The interactions between shrimp aquaculture and the environment though are complex and diverse and the rapid expansion of shrimp farming in some countries in Latin America and Asia but such problems

have focused attention on the need for better strategies to manage the sector. Such strategies should tap the potential of the sector for economic growth and poverty alleviation, whilst controlling the negative environmental and social impacts that can 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, a consortium program entitled "Shrimp Farming and the Environment" was developed in August 1999. 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 funding from the World Bank-Netherlands partnership program was used to support the work of this consortium. This report describes the results of work conducted by the consortium from August 1999 until March 2001.

2.2 Objectives

The consortium program is based on the recommendations of the World Bank review on shrimp aquaculture and the environment (1998), a 1999 NACA/WWF meeting in Bangkok, Thailand on shrimp management practices, and an FAO Bangkok technical consultation on policies for sustainable shrimp aquaculture (12/1997). There are six main objectives to this 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 sustainable 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 culture industry.

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

2.3 Methodologies

The program comprises complimentary case studies that have been prepared by more than 100 researchers in more than 20 shrimp farming nations. The cases range from specific interventions within single shrimp farm operations to thematic reviews that cover globally important issues in shrimp aquaculture. The goal of these cases is to document and analyze experience around the world in order to better understand what works, what doesn't and why.

The 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*** and are used as a framework for more detailed discussions and 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 lessons 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
The social impact of shrimp farming is mentioned by many authors, 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.

2.4 Implementation arrangements

The program is being coordinated by NACA, in close cooperation with WWF, the World Bank and FAO. NACA appointed an environment expert (Michael Phillips) as the focal point for the management of the study, who is also providing some technical backstopping as appropriate for some of the studies. With regard to the individual case study components:

- Case studies in Asia are coordinated by NACA (Michael Phillips), jointly with FAO (Rohana Subasinghe and Rolf Willmann) in some instances.
- Case studies in Latin America coordinated through WWF (Jason Clay) and Auburn University (Claude Boyd), who provided technical backstopping to the work and was involved directly in the implementation of some of the studies.
- Case studies in Africa and the Middle East coordinated by WWF (Jason Clay).

As envisaged in the initial program proposal document, 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. E-mail was used for correspondence among members, and occasional meetings were also held. The last meeting was held in Brisbane, Australia, on the 8th of December 2000 at which the status, future plans and activities of the program were discussed and agreed, including some of the key points in this report.

The implementation of individual case studies involves both international and national experts, and involvement of government, non-government and shrimp industry participants. Emphasis has been given to national experts in the 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 are also providing important inputs.

2.5 Contractual and funding arrangements

The funds to implement the case studies came from the Bank-Netherlands Partnership programmed, with supplementary funds from other WWF, NACA and FAO sources. The Bank funds were used to support individual case studies in selected countries, thematic reviews, travel, editing and publications and attendance at the Conference on Aquaculture in the Third Millenium held in Bangkok in February 2000. Table # below provides an approximate breakdown of the partner contributions.

Table #: Financial contributions of partners to the consortium program

Partner	**US$**
World Bank-Netherlands Partnership program	
WWF	
NACA	
FAO	

This table on the $ contributions of the collaborating institutions will be completed pending some outstanding information.

2.6 Purpose and organization of the report

This report summaries accomplishments and findings from the consortium program to date. The report to the Bank has been prepared by NACA in March 2001, in line with the final reporting requirements of the Netherlands funding body (Bank-Netherlands partnership programmed). The full report on consortium work will be prepared later in 2001 incorporating the result of consultations and other data collected subsequent to March 2001. It is expected that this document will be published and made available for input to an intergovernmental Technical Consultation on Shrimp Aquaculture being planned by FAO (see below).

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, including a proposal outlining funding required in 2001.

The Bank requested an update for the Environmental Assessment Sourcebook[1] on shrimp aquaculture. The drafting of this sourcebook will be completed during 2001 after the case studies have been finalized. NACA will take the lead in initial drafting of the document, and (pending funds available) may organize a small meeting of experts during 2001 to finalize the document.

2.7 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 of 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 who supported and participated in the case studies are also gratefully acknowledged. The list of stakeholder

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

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 work.

3 Details of case studies and consortium program activities

3.1 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 33[2] 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 a unique and important insight into the present 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 fieldwork has been completed for nearly all case studies and reports are being finalized. 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, that is still ongoing. A table and executive summaries of all cases are provided in **Annex A.** A short brief on the case studies in each of the major regions and the thematic reviews is below.

3.1.1 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, **The Current State of Shrimp Culture Systems in Madagascar**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in South Africa**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Tanzania**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Mozambique**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Egypt**. 2000.
Mehdi Shakouri, **The Status of Shrimp Culture in I. R. Iran**. 2000.

3.1.2 Asia-Pacific region

There are 13 case studies in the Asia-Pacific region that provide a broad geographical coverage and issues related to shrimp aquaculture, from studies at the implementation of better management practice at farm level to studies that explore experiences in integration of shrimp aquaculture into coastal area management planning. Poverty and shrimp aquaculture issues are explored in several cases.

3.1.2.1 Australia

Nigel Preston, Peter Rothlisberg, Michele Burford and Chris Jackson. **The environmental management of shrimp farming in Australia.** 2001

[2] Africa and Middle East (6), Asia-Pacific (13), Latin America (9), Thematic reviews (5)

3.1.2.2 Bangladesh

Anwara Begum and S.M.Nazmul **Social Aspects of Shrimp Aquaculture in Bangladesh**. 2000

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

3.1.2.3 China

Jie Huang and Anantha Duriappah, **Shrimp Culture Renovation in Rushan County, Weihai, Shandong Province, China**. 2000. Available in Chinese and English.

3.1.2.4 India

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.

3.1.2.5 Indonesia

James Tobey and Hermawati Poespitasari and Budy Wiryawan, **Good Practices for Community-Based Planning and Management of Shrimp Farming in Sumatra, Indonesia.** 2000.

3.1.2.6 The Philippines

Dioscoro M. Melana, E. E. Melana, C.E.Yao and Edgar L. Abuan, **Mangrove Management and Aquaculture in the Philippines.** 2000.

3.1.2.7 Sri Lanka

Siriwardena, P.P.G.S.N., **Report on a Code of Best Practices for Shrimp Aquaculture in Sri Lanka**. 2000.

3.1.2.8 Thailand

Nissapa, Ayut and Somsak Boromthaanarat, **Case Study on Institutional Aspects of Shrimp Aquaculture in Thailand.** 2000.

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

3.1.2.9 Vietnam

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.** 2000.

Silvofishery Farming Systems in Ca Mau Province, Vietnam. 2000

Part a) background and technical recommendations

Prepared by: *Barry Clough, Danielle Johnston, Tran Thanh Xuan, Michael Phillips*

Part b) Socio-economic studies

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

Nigel Preston, **Studies on Mixed Rice-Shrimp Aquaculture Systems in the Mekong Delta.** 2000.

3.1.3 Latin America

The following case studies from Latin America provide a broad geographical coverage, major issues and management strategies for shrimp aquaculture in this region.

3.1.3.1 Belize

Claude Boyd and Jason Clay, **Evaluation of Belize Aquaculture, Ltd.—A Super-Intensive Shrimp Aquaculture System in Belize.** 2000.

3.1.3.2 Brazil

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.** 2000.

Patricia Moles, et al. **Barriers to Investing in Shrimp Aquaculture—Lessons from Brazil**. Terra Capital Fund, Banco Axial, Sao Paulo, Brazil. 2000.

3.1.3.3 Colombia

Dominique Gautier, **The Integration of Mangrove and Shrimp Farming: A Case Study on the Caribbean Coast of Colombia.** 1999.

Dominique Gautier, **The Adoption of Better Management Practices (BMPs) by the Shrimp Industry on the Caribbean Coast of Colombia.** 2000.

3.1.3.4 Ecuador

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Use of wild post larvae in past five years.**

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd.**Composition of shrimp pond soils areas versus non- mangrove areas**

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Farm management and concentration of potential pollutants in Ecuador**

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Water exchange practices in past five years**

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Review of coastal wetland habitats and shrimp aquaculture.**

3.1.3.5 Honduras

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

Claude Boyd and Bart Green, **Coastal Water Quality Monitoring in Shrimp Farming Areas with an Example from Honduras.** 2000.

3.1.3.6 Mexico

Billie R. Dewalt, Lorena Noriega, Jaime Renan Ramirez Zavala, and Rosa Esthela Gonzalez, **Shrimp Aquaculture, People and the Environment in Coastal Mexico**. 2000.

3.1.4 Thematic Reviews

These thematic reviews synthesize information on major topics of global relevance to shrimp aquaculture development, bringing together numerous case study material from major shrimp producing countries in both Asia and Latin America. The following thematic reviews have been implemented.

3.1.4.1 Mangroves

Donald J. Macintosh, Michael J. Phillips, Robin Lewis III and Barry Clough. **Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture.** 2000.

The review brings together experiences of the impacts and management of shrimp aquaculture development in coastal wetlands and mangrove habitats.

3.1.4.2 Codes of Practice

Claude Boyd, John Hargreaves and Jason Clay, **Codes of Practice for Marine Shrimp Farming.** 2000.
The case study brings together experiences in the development and implementation of Codes of Practice.

3.1.4.3 Shrimp diseases and health management

FAO, NACA, World Bank and WWF. **Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture.** 2000.
The case analyses the social and economic impacts and effectiveness of interventions to control shrimp disease outbreaks that have affected shrimp aquaculture globally.

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

There are four separate case studies prepared on management practices 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-2001. 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.** 2000.
Billie R. de Walt, **Social Best Management Practices in Latin America.** 2000.
Catherine Michielsens, **Socio-Economic Analysis of Shrimp Aquaculture in Coastal Areas of Asia.** 1999.
Emanuel Mike Polioudakis, **Synopsis of Results of Research on Southern Thai Shrimp Farming: Some Recommendations.** 2000.

3.1.4.5 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.** 2001.
This review provides the results of a global survey of the legal aspects of shrimp aquaculture covering 20 countries involved in shrimp aquaculture.

David Barnheizer, Esq. **Confusion, Conflict, and Corruption: The On-Going Struggle to Achieve Effective Legal and Regulatory Systems in Responsible Shrimp Aquaculture.** 2000.

3.2 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 list of meetings and consultations organized for such purposes are given as **Annex B.**

To ensure quality of the case study material, all case studies are being subject to an expert review process.

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. A special WAS session is also planned for 2002.

As the reports are drafted and then finalized, findings from case studies 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. A web site giving information on the case studies has been developed (http://www.enaca.org) and a web publishing company has shown interest in publishing the cases on line. The web will 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 translation and dissemination in 2001.

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

3.3 Conference on Aquaculture in the Third Millenium

The Conference on Aquaculture in the Third Millenium was held in Bangkok from the 20th-25th 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 can be found at www.fao.org/fisheries.

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 a sub-committee will be established in 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.

The other outputs from this Conference include the Technical Proceedings of the Conference on Aquaculture in the Third Millennium (to be published in May 2001) and the Report of the Conference, published in December 2000. The publications will be made available in the websites of NACA and FAO. They together represent also a particularly important and timely synthesis of the present status and future directions for aquaculture development at a global level.

3.4 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 the recent FAO/Australia expert consultation on shrimp aquaculture management, held in Brisbane during December 2000. The World Bank-Netherlands partnership funds were used support the preparation of the background papers for the consultation. Some of the case study researchers also participated in the meeting, under separate funding support.

During the consultation, an agreement was reached on a set of broad guiding principles for sustainable shrimp aquaculture management. FAO plans to take these guiding principles for sustainable shrimp culture management forward to obtain formal government consensus at an FAO Technical Consultation in 2002. FAO also envisions to table these guiding principles at the first COFI (Committee on Fisheries) Sub Committee on Aquaculture (2002 in China), mentioned above. The consortium will prepare documentation and reports together for this possible intergovernmental meeting. Apart from the guiding principles document, the consortium will provide syntheses of consortium work. The consortium work will therefore potentially have significant impact at intergovernmental level for reaching broader consensus on guiding principles for future management of shrimp aquaculture.

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

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

4 An overview of shrimp aquaculture and its global status

4.1 Production trends

The quantity and value of shrimp produced by aquaculture has increased significantly in recent years. Between 1988 and 1997 reported shrimp and prawn production increased at 5.8 % per year, and according to official FAO statistics in 1998 around 1.11 million tonnes of shrimps valued at US$ 6.86 billion dollars were cultured (FAO, 2000) (Table 1).

Table 4.1: Global trends in shrimp production quantity (tonnes) and value (US$)

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Tonnes (mt)	620 502	671 993	832 176	889 678	847 697	890 685	951 593	960 054	1 000 565	1 113 857
Value ($)	3 953 404	4 208 245	5 134 387	5 543 368	5 370 777	5 922 463	6 271 281	6 400 586	6 445 427	6 857 257

Asia dominates shrimp production. In 1997, seven of the top ten shrimp producing countries were Asian, accounting for 75 % of the global production. The giant tiger prawn (*Penaeus monodon*) is the major farmed shrimp species making up around 52% of total global shrimp production. In 1997, Asia produced 0.485 million tonnes of *Penaeus monodon*, 99 % share of the total world production (FAO, 1999). Other crustacean species cultured include *P. merguiensis*, *P. indicus* and *Metapenaeus* spp.

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

Globally, smaller amounts of shrimp are farmed in the Pacific (mainly New Caledonia, that produced around 1,800 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 farmer shrimp. The main species in these new shrimp producing countries in Africa and the Middle East is *Penaeus monodon*, a species that occurs naturally in the region.

The major shrimp producing nations are Thailand (an estimated 300,000 tonnes in 2000) followed by ## (insert data).

4.2 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.

The 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 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 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 tonnes/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 tonnes/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 tonnes/ha/yr.

Shrimp farming has also been classified by some as 'traditional' or 'industrial' shrimp farming, but these terms do not describe the extreme diversity of shrimp farming. Thus, 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, much of the world's production still comes from extensive farms. A further important point is that the shrimp farming sector undergoes rapid change. The occurrence of shrimp viral disease has had a significant impact in the past 5 years, and particularly 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 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 (Fegan, 1996) and in the implementation of better management practices.

4.3 Economic significance

Shrimp farms generate considerable economic returns and globally earn more than US$ 6 billion yearly at farm gate prices with value increasing substantially as shrimp moves up the market chain to the consumer. For example, for Ecuadorian shrimps the value from farm to consumer increases by a factor of 4: i.e. from $7.80 (producer to FOB) to $30.00 (FOB to consumer) (Clay, 1996). The industry is worth considerably more, with estimates suggesting an industry valued at US$ 20 billion in Asia, with infrastructure investment in ponds alone probably around US$ 11.5 billion (ADB/NACA, 1997).

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). The amount of shrimp consumed in producing countries is not known, but there is certainly increasing consumption in Asia (Ferdouse, 1996), or exports to Asia (for example, Ecuador increased its export share to Asia (mainly Taiwan, Japan, China [including HongKong], Korea) from 1,8% in 1994 to 12,6% in 1997 (Camara Nacional de Acuacultura -CNA, 1997). In addition, mixed, extensive alternate cropping or

polyculture farms, which may farm fish, crabs and other aquatic products, can also provide food direct for local consumption.

Exports of fresh and frozen aquaculture shrimp are within the top foreign exchange earners in major shrimp producing countries in Asia. The total worth of Asian exports has increased from US$ 1.3 billion in 1984 to an estimated $4.26 billion in 1993. In Thailand, fresh and frozen shrimp export value was estimated as over $2.0 billion in 2000, the fourth most important export by value. In India, marine product exports reached record levels of $ 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) produced 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.

5 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 of shrimp aquaculture. 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 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 management responses. Reference to individual cases studies is given where appropriate. Additionally, reference is given of the role and applicability of the ***Code of Conduct for Responsible Fisheries.***

5.1 Overview of major issues

This section provides a general overview that summarizes the major issues.

5.1.1 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 aqua-farmers to work in partnership with communities and other groups with a mutual interest in protection of aquatic environments.

The key environmental interactions of coastal shrimp culture are now well known – relating mainly to the habitat and aquatic resources in the areas where shrimp aquaculture takes place. Environmental impacts may arise through impacts ***on*** aquaculture; ***of*** aquaculture on the environment; and impacts ***of*** aquaculture ***on*** aquaculture. The major environmental issues are:

- ecological consequences of conversion of natural habitats, such as mangroves, for construction of shrimp ponds;
- discharge of pond effluent leading to water pollution in farming and coastal areas;
- seepage and discharge of saline pond water may cause salinity changes in of groundwater and surrounding agricultural land;
- use of fish meal in shrimp diets;
- shrimp disease problems;
- the use of chemicals to treat diseases; and
- biodiversity issues primarily arising from collection of wild seed.

However, as will be seen below, the extent and significance of environmental interactions is highly variable, making it difficult to generalize.

5.1.2 Employment and social issues

The case study work also 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. There is 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.

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.

5.1.3 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 globally accepted 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 these different management options.

5.2 Environmental issues

5.2.1 Mangroves and coastal wetlands

5.2.1.1 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 is possible to find examples of poorly sited farms, for example located in mangrove areas, that have clearly damaged mangroves and coastal ecosystems.

The selection of sites 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 reducing disease risks.

The pattern of coastal land use differs considerably between countries. In countries with little mangrove forest, such as China, Japan and South Korea, ponds are constructed on low productivity agricultural land of low productivity, or under-utilized saline land, and in these countries shrimp farming has had virtually no impact on mangroves. 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 varies from country to country, however, and even within countries, making it difficult to generalize.

Land use also changes with time. In Ecuador, for example, the favored sites for shrimp farms were originally saltpans, or "salinas". Once these sites were used up, the industry moved to less favorable areas, including mangrove habitats. 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 5.1). 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**.

5.2.1.2 Major findings and lesson's learned

a) 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

Table 5.1: 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
Saltpan	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.*

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. Menasveta (1997) concluded that the trend towards intensive shrimp farming located behind mangroves in Thailand has tended to reduce further damage to mangroves and is an example of a better management practice.

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 only 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).

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, only 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 has stabilized and the thematic review shows there has been a small (2%) net gain in mangrove area overall in Ecuador.

The **mangrove thematic review** finds that shrimp farming has contributed to loss of mangroves, particularly within the last 20 years. It 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, this 402,199 ha, this represents 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. 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, which 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^3) 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**. It also notes that extensive shrimp farming has made by far the most significant contribution to the losses from aquaculture.

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, Aksornkoae (1993) records that there have been many other 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 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.

b) The impacts of mangrove conversion

The impacts of conversion of mangrove to shrimp aquaculture ponds, and mangrove habitat in particular are well known, although there is considerable variation between sites. These may derive from loss of nursery habitat impacts be 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 addressed through siting of shrimp farms in ways that do not replace habitat, or cause hydrological change or fragmentation of remaining habitat.

Major factors contributing to conversion of mangrove to shrimp aquaculture:

- Major coastal land use changes
- Extensive shrimp farming (in some countries)
- 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
- Issues related to enforcement, unrealistic modes of implementation of legislation (e.g. zonation schemes)
- Lack of involvement of communities in decision making (management, development of legislation, enforcement) Lack of understanding of why zonation is required.
- Co-ordination between different levels and different sectors of government
- Compatibility issues, sustainability- time frame?, for whom, ecological versus economic (no benefit to local people)
- Market forces and perceptions of high profitability versus risk from shrimp culture, based on short-term financial considerations,. rather than long term economic ones.

[3] These figures need to be checked, as they do not consider the question of "abandoned" ponds.

The case studies provide several 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 dependant, and such problems can be effectively eliminated with better management.

c) Management interventions

Major factors contributing 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 throughout much of the tropics, 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 that there are a better management practices that can be promoted within the shrimp aquaculture sector to reduce or eliminate mangrove impacts.

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.

d) 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), this method can effectively eliminate impacts on mangrove ecosystems. This policy is now being actively promoted in several SEAsian countries, including Thailand, the world's largest shrimp producer. The thematic review emphasizes it is an important management practice that can have significant positive benefits.

The property rights and land tenure have profound consequences for the patterns of resource use and management, and land tenure is a critical factor in how people use and manage mangrove resources. The changes in land use over time, and willingness to participate in rehabilitation efforts are commonly related to land use. In Vietnam (**mangrove thematic review**), for example, local people's interest in participating in mangrove reforestation was 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, also 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 (**Indonesia case study**).

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. A particular problem is that conversion to shrimp ponds 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 Sumatra** 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 also lead to better management of coastal resources.

e) Shrimp farm construction and project implementation

The second level of intervention is mainly concerned with 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.

f) 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.

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**.

Rehabilitation and building resource value in extensive ponds:
Extensive shrimp and fish ponds in mangrove areas are characterised by low biological and economic yields often less than that of intact habitat. The options for rehabilitation of such ponds include:

- Mangrove restoration.
- Mixed silvofishery integrated farming systems, as practiced in **Vietnam, Indonesia**
- Redesign of the farm leading to intensification of better areas and restoration of mangroves in suitable areas, as practiced in several **Latin American** countries.

It should also be borne in mind that, particularly in Asia, many poor coastal inhabitants are involved in extensive shrimp farming - one of the reasons why extensive farms are built is because of the lack of capital for investment. Some countries, such as Vietnam, also encourage 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

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 realise the 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 was achieved that the the 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.

which allows for maintaining a relatively high level of integrity with the mangrove area while capitalizing on the economic benefits and poverty alleviation potential of brackish water aquaculture (Fitzgerald, 1997). Indeed, silvo-fisheries have been used effectively in mangrove rehabilitation projects being undertaken in **Vietnam, Indonesia** and **Philippines**. Such integrated systems can help meet rehabilitation objectives, as well as providing food and income for the people involved.

g) 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, a partnership between the Surat Thani shrimp farm association and an international NGO (Wetlands International) has been successful in working together in restoration of mangroves in old extensive shrimp farming areas in southern Thailand. In Ecuador, NGO's 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.

5.2.1.3 Conclusions

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 has been adopted by a global shrimp industry body (GAA, 1997) and now seems to be gaining more widespread acceptance. If implemented, then this approach is a major step forward in terms of improving the environmental sustainability of the shrimp aquaculture sector.

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.

5.2.2 Shrimp aquaculture and other coastal land types

The developments of shrimp farms on other land types (that actually comprise the majority) have 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.

Make a brief description of rice-shrimp integrated farming systems, noting examples from Vietnam, India and Bangladesh.

5.2.3 Source of shrimp seed - post larvae and broodstock

5.2.3.1 Major issues

Shrimp farming globally relies almost entirely on wild shrimp resources at the present time. The bulk of 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 (*Penaeus stylirostris*) and in Asia (*Penaeus monodon)* but globally the wild source is still most important. Asia so far lags behind the Americas in genetics and domesticated breeding of shrimp.

5.2.3.2 Major findings and lesson's learned

a) 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 [4]). 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. 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 over the health status of shrimp captured from the wild, one can anticipate that wild seed stocking will soon become a thing of the past.

The replacement of wild shrimp seed with hatchery seed has positive environmental 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.

a) Impacts of harvesting of wild stocks

The effect of harvesting of wild shrimp on wild stocks of *Penaeus monodon* is explored in the Bangladesh case study, where farmers are strongly dependent on the stocking of wild post larvae (PL) harvested from coastal waters. The sustainability of the practice of harvesting wild PL has been questioned, in particular as the aquaculture industry and therefore the demand for post larvae 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.

This question has been addressed in detail 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

[4] 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.

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.

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. Regarding the collection of wild shrimp post-larvae from the wild, and the impacts of by-catch collection, programs underway in **Bangladesh** and in **Guatemala** and **Ecuador** to support the development better catching methods. These include the sorting of shrimp in the water and release of 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 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.

b) Social and economic importance of wild fry collection

In the few countries still practicing collection of wild post-larvae, the collectors are often among the poorest of the poor people in coastal areas. In Bangladesh, the livelihoods of an estimated 600,000 people are dependant on shrimp PL collection, including women and children, of which the largest group is landless. Although shrimp seed collection part-time employment, and 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.

This 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[5] of wild shrimp seed – the effects of this ban on coastal households are likely to be severe unless alternative means of employment are found.

[5] This major policy change represents and important research opportunity.

5.2.3.3 Conclusions

It seems 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.

5.2.4 Feeds and feed management

5.2.4.1 Major issues

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

5.2.4.2 Major findings and lesson's learned

a) The use of fish meal

The use of fish meal in shrimp diets varies between shrimp species – carnivores and omnivores – *Penaeus vannamei*, *Penaeus monodon* and *Penaeus japonicus* and there are large differences in the conversion of fish meal to shrimp also varies considerably between species and farming systems. This issue will be explored in detail in an ongoing case study on feeds and feed management (due for completion in May/June 2001). The case will explore the conversion of wild fish equivalent, wet weight to shrimp, and the range of fishmeal conversion rates is, as well as the weight along the continuum, and the difference between shrimp species.

The effect of dietary fish meal content and FCR on the conversion rates for wild fish to shrimp (wet weight equivalents).
This table is being completed as part of an ongoing case study.

a) Management practices

The major incentive to make efficient use of feed is the cost savings and improved profitability associated with lower Food Conversion Ratios (FCRs). 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, 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.

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.

The 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). The **Belize case study** also reveals the potential for reducing the use of fishmeal used in shrimp production, in this case *Penaeus 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 by $.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.

5.2.4.3 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 fishmeal 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.

5.2.5 Water use and pond effluent

5.2.5.1 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 waste water 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.

5.2.5.2 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 is discussed below.

a) 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.

a) 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 programmed 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.

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.

b) 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.

c) Management practices

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, which 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 in 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. 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.

d) 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.

e) 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.

Useful functions of mangrove-wetland habitats:

- They are sediment sinks. The roots and pneumatophores not only slow the water flow, but they act as sediment binders.
- Walls of effluent canals can be stabilised by roots of mangrove-wetland plants, so erosion of sediments is greatly reduced.
- Nutrients in the effluent are taken up by the mangrove plants, juncus, rushes and algal epiphytes.
- Bacteria contribute to breakdown of organic matter, ammonium and nitrite.
- Bacteria and microalgae are removed by filter-feeding organisms (ie copepods, polychaetes, molluscs).
- Mangroves have the added ecological advantage of attracting juvenile fish and birds. The pneumatophores, prop roots and overhanging branches increase structural heterogeneity, complexity of the habitat, providing shelter, food and refuge, thus contributing to environmental improvement.
- These habitats require almost no maintenance by the farmers, and are not prone to mechanical failure or fatigue. In fact, they should improve with age.

There are also numerous other options for biofiltration, including use of molluscs, 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 (Swingle, et al 1996). Whilst various researchers are focusing 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 (Smith and Masters, 1996; Boyd, 1997) 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 & Gilbert, 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.

f) 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.

g) 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" that appears to have been successful in controlling impacts from water pollution (see box above).

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 waste water 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.

Shrimp culture often suffers from water pollution caused by other industries (FAO/NACA, 1995) ands this is clear from 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 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.

h) 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.

i) 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.

5.2.5.3 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.

5.2.6 Chemicals

5.2.6.1 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.

5.2.6.2 Major findings and lesson's learned

There are some differences in chemical use between Asia and the Americas (Claude Boyd **case study on chemicals**) 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. Natural processes probably degrade most bactericides, 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, 2001):

- 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.

5.2.6.3 Conclusions

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 best management practices (BMPs) for their use. The Global Aquaculture Alliance (Boyd 1999) made a list of BMPs for shrimp farming that included BMPS for use of chemical and biological amendments. The BMP list prepared by Prof. Boyd is given in the Box above.

5.2.7 Shrimp health and disease control

5.2.7.1 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 below.

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 labour, particularly women, were forced to curtail operations and considerably reduce their labour 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.

5.2.7.2 Major findings and lesson's learned

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.

a) 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. A set of 'on-farm' management practices derived from a study of risk factors on Asian shrimp farms is provided in the box below.

Risk factors associated with white spot outbreaks on Asian shrimp farms and potential management measures

Awaiting document

b) 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. 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 as follows:

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, MONITORING 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 RESPONSE
- *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

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.

5.2.8 Complementarity's between shrimp aquaculture and the environment

5.2.8.1 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.

5.2.8.2 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.

5.2.8.3 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.

5.3 Social and employment issues

5.3.1 Rural employment

5.3.1.1 Major issues

Shrimp farming has emerged as a major employer in many developing countries. Most Asian counties are characterised by a fast growing population and workforce and finding employment for these workers is one of the main challenges of the next century (FAO, 1998). The rapid growth of aquaculture in Asia has offered employment opportunities, especially in coastal areas. Further information on employment was generated through an analysis of farm data from 13[6] different countries in Asia as part of the **social BMPs thematic review**.

Note that the following section will be expanded when findings from the social thematic reviews are fully available. The present write up reports some initial findings from Asia.

5.3.1.2 Major findings and lesson's learned

Table 5.2: Amount of family or permanent labour in different shrimp farm systems

Shrimp farm system	labour (no/ha)	25-75 percentile	labour (days/ha/yr)	25-75 percentile
Super intensive	3.2	1.9-5	1025	587-1624
Intensive family	4	2.5-8.3	1359	679-2752
Semi-intensive specialised	1.3	0.7-2.5	368	182-720
Semi-extensive	3	2-5	1133	600-1800
Extensive	0.6	0.2-1.5	194	63-505

Source: Calculated from farm survey data. Note that shrimp farming system classification is different.

The review shows that most shrimp farms in Asia are operated by owners, with labor can be classified as family, permanent and casual labor. Shrimp production labor mainly involves men – however, there are regional differences and the employment of women is important as family labor on shrimp farms in Vietnam and Thailand. The employment of women in the post-harvest of shrimp is also an important feature in a number of countries.

[6] Insert country names

The employment generated from shrimp farming varies with farming system and by country. Table 5.2 shows the total amount of family or permanent labour in the different shrimp farm systems in Asia. Other studies (Muluk and Bailey, 1996) show intensive shrimp farms in Indonesia employ 1-1.6 workers/ha, semi-intensive shrimp farms 1.8 workers/ha and extensive shrimp farms 0.4 workers/ha. ADB/NACA (1999) noted intensive and semi-intensive shrimp farms provide 560 days of labour/ha/year while extensive shrimp farms provide labour for only 190 days /ha/year. The consensus from these figures is that intensive or semi-intensive farms generate more direct employment per ha than extensive farming systems. As the direct employment generated in intensive and semi-intensive shrimp aquaculture is more than traditional forms of agriculture (including rice farming) shrimp production can clearly contribute to employment generation in coastal areas. Employment figures for rice are commonly 200-250 person-days/ha/yr.

The study also shows that labor productivity is highest in Malaysia (3275 kg/laborer/year), followed by Thailand (2171 kg/year/year) and Taiwan Province of China (1333 kg/year/year) (Table 5.3). Although the labor productivity of shrimp farmers in Taiwan is much lower, their yearly labor profitability is much higher (9812 $/laborer compared to 7547 and 5367 $/laborer). Similarly, the productivity of Philippine shrimp farmers (388 kg/year/year) is about half those of shrimp farmers in Sri Lanka, but the labor profitability is about the same (1645 and 1627 $/year/year respectively). Shrimp farmers in Vietnam and Myanmar have a very low productivity (67 and 64 kg/year/year respectively).

Table 5.3: Labour productivity and profitability on aquaculture shrimp farms in different Asian countries

Country	Labour productivity		Labour profitability	
	(kg/labourer/year)	(kg/labourer/ha/year)	($/labourer/year)*	($/labourer/year)
Malaysia	3275	2093	7547	5847
Thailand	2171	2188	5367	4403
Taiwan Province of China	1333	572	9812	7407
Sri Lanka	738	813	1627	1121
Indonesia	405	169	1588	1254
Philippines	388	46	1645	1385
India	283	257	575	196
Bangladesh	189	51	753	422
Cambodia	120	30	153	-420

The different shrimp farming systems differ according to the amount of employment that can be generated through the promotion of each system. The investment of 1000 US$ in intensive family farms generates employment opportunities for 1.56 people, while 1000 US$ invested in super intensive systems generates employment opportunities for only 0.1 people (**Social BMP thematic review case study**). The difference becomes even greater when the employment opportunities per ha are examined. Intensive family shrimp farms generate employment for 4.5 people on one ha. This characteristic of intensive family shrimp farms is especially important in highly populated coastal areas where there is a high competition for land. In general, the investment in shrimp farms operated by families allows more people to be employed.

The survey also showed that investments for the promotion of shrimp aquaculture have the biggest impact on employment in Vietnam (Table 5.4). An investment of 2000 $ in shrimp farms in Vietnam generates employment for 3 people. In India, Bangladesh and the Philippines about 5000 $ is necessary to create employment opportunities for 3 people in shrimp aquaculture, while in Cambodia, Malaysia and Taiwan an investment of more than 10000 $ is necessary to create employment for one person.

Table 5.4: Employment creation through investment in shrimp aquaculture in different Asian countries

	(labourers/1000$)	(labourers/ha/1000$)	(days/ha/year/1000$)
Vietnam	1.43	0.81	315
India	0.63	0.45	130
Bangladesh	0.60	0.11	36
Philippines	0.55	0.07	17
Indonesia	0.43	0.21	57
Sri Lanka	0.34	0.59	184
Thailand	0.13	0.16	50
Cambodia	0.08	0.03	8
Malaysia	0.05	0.05	15
Taiwan Province of China	0.03	0.01	4

Source: Farm survey data analysed for social BMP study

The situation in Asia also seems to contrast with that in Latin America where shrimp farming is often dominated by larger farms and corporate businesses. Employment on shrimp farms in Ecuador is estimated at 1-0.25 persons per ha (Olsen and Coello, 1995), perhaps due to the low intensity of farming systems in this country and/or the greater proportion of large farms.

The employment generated in supply of inputs and in the processing and packing of shrimp after harvest is also significant. In Thailand, more than 150,000 people are directly employed in shrimp farming (Kongkeo, 1995 – update figures), with a large additional number also involved in input supplies, support services and handling and processing of shrimp products. In Ecuador, according to the **case study** figures, some 1,567 firms were involved in shrimp farming, processing and hatcheries, employing 195,000 people. There were in addition, 17,000 part-time people (larveros) engaged in catching wild post-larvae, earning as much in two or three days of moon tides as they can in one month as agricultural areas. The people involved in catching shrimp larvae were among the poorest of the coastal communities. The shrimp farm industry in Ecuador is reported as one of the countries largest employers, although as the discussion above illustrates this employment has been severely impacted by outbreaks of shrimp disease.

5.3.1.3 Conclusions

Shrimp farming can generate significant local employment in shrimp producing countries. The employment figures are favorable when compared to other forms of coastal activity.

There are also some general recommendations on these issues from WWF work – these will be included when results are available. BMPs will be included from the social/poverty thematic review when available.

5.3.2 Social impacts

5.3.2.1 Major issues

The employment generated through shrimp aquaculture can be significant to local and national economies. However, there are also negative social impacts reported. There are also opportunities to improve the social impact of farming, and reduce or eliminate negative social impacts. The cases in some countries provide a much needed better understanding of problems, social costs and benefits, conflict resolution and for the development of appropriate and workable solutions to identified problems.

5.3.2.2 Major findings and lesson's learned

In Asia, small-scale farmers make up major proportion of the shrimp farming population, although there is a considerable variation between countries. A 1996 survey of 400 intensive shrimp farmers in **Thailand**, showing the majority of shrimp farmers were 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.

By contrast, shrimp farming in Bangladesh has reported to have led to several cases of significant local conflict. The picture that emerges from the **social case study in Bangladesh** is that such problems can be almost, if not entirely, eliminated, by encouraging participation of local people in shrimp aquaculture. 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.

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.

In some countries, also, concern has been raised about the distribution of benefits from shrimp farming (Olsen and Coello, 1995) and social conflicts have also sometimes arisen with other coastal resource users and communities as a result of rapid expansion of ponds (Bailey,1988; Clay,1996).

The case studies also provide some examples that show the costs of conflict are significant (Jason to provide more elaboration).

There are growing experiences in resolving conflicts. In Bangladesh, for example, shrimp farming in 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. As mentioned above, there has also been 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 **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 a 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).

5.3.3 Poverty alleviation

5.3.3.1 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.

5.3.3.2 Major findings and lesson's learned

a) 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.

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. More examples may be provided from the ongoing social BMPs study

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.

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.

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

Unfortunately, much coastal aquaculture development has been resource driven – GIS planning based on resources (see also GESAMP 2000 report). 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.

b) 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 targeted credit schemes, 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.

Land use and tenure is very important issue. For example, the result of public land tenure in Indonesia is uncertainty of land tenure security that makes it difficult to obtain credit and reduces private incentives to maintain and care for the land. It also creates jurisdiction disputes between agencies and confusion and cynicism in the community with respect to public agencies. To address this issue,

Proyek Pesisir established a formal task force (see box) comprising government, university, NGO and private sector.

Kabupaten Task Force in Lampung Selatan Regency formed to address issues of coastal land use and land use planning:
Proyek Pesisir established a formal Kabupaten Task Force in Lampung Selatan Regency comprised of the government, university, NGO, and private sector. The Task Force is led by the government head of the Regency (Bupati of Lampung Selatan) and provides an institutional forum for coordination, strategic planning, policy strengthening, problem solving and decision making. Meetings are bi-monthly, or more frequently depending on the urgency of the problems to be addressed. The issues that the Task Force is currently addressing are coastal spatial planning and resource monitoring. The Task Force is empowered by letter of dercree from the office of the Lampung Selatan Regency. Groups represented in the Task Force as members and executive officers include: Regency Development Planning Board; Tourism Service; Public Works Service; Fishery Service; Agriculture Service; Villagers Development Office; Regency Law Division; Environmental Impact Assessment Division; Head of District; Regency Branch of Indonesian Fisherman Group; and, Heads of Villages.

5.4 Economics and cost of management and barriers to adoption of better practice

5.4.1.1 Major issues

The following are notes – this section will discuss the economics of better 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.

5.4.1.2 Major findings and lesson's learned

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.

5.4.1.3 Conclusions

The following summarizes the direction for better management strategies, and an estimated cost associated based on farmer consultations in Thailand. This section needs further work.

5.5 Institutional and policy issues

5.5.1 Experience with integrated coastal area management

5.5.1.1 Major issues

There is a need for effective planning of shrimp aquaculture development in coastal areas, that allows for balanced use of coastal resources and optimizes social and economic benefits. 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 represents 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.

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.

5.5.1.2 Major findings and lesson's learned

ICM 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 (for a critical review of experiences in ICM, see Sorensen, 1997).

An important principle of ICM 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 can not 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.

5.5.1.3 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.

5.5.2 Codes of Practice and industry progress

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 by industry and governments. Codes of conduct and other forms of guidance on management practice in shrimp farming fulfill 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 fulfill a useful function either as a support to legislative measures or to address matters, which 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 needed to support implementation.

Whilst Codes of Practice and Conduct are a welcome move forward, particularly when led and owned by 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 there 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.

5.5.3 Legislation and experience with existing regulations and procedures

5.5.3.1 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**.

This **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, which 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.

5.5.3.2 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 in adjacent box.

Regulatory control techniques presently applied to shrimp aquaculture:

- 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 authorisations;
- 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; and
- 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

- and 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. It is good to see that, in several jurisdictions, such as Thailand, work on legislation of this kind is in progress.

Progressively, 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. It is unfortunate, therefore, that sufficiently detailed information about implementation of legislation, and particularly enforcement activities, has not been provided in any response to the questionnaire. Although some responses did provide information about the formal allocation of duties for implementation and enforcement of legislation, these tended to overlap with previous discussion of the respective role of institutions with responsibility for aquaculture, rather than providing any further information about actual enforcement practice where unlawful activities are suspected or identified. Other responses noted that various criminal offences were provided for, and noted the existence of specified penalties for offences, alongside details of the formal procedures that must be followed. However, this information falls well short of an assessment of the actual impact of shrimp farming legislation in practice. Without a means of evaluating the impact of regulation upon shrimp farming practice, the profound difficulty remains that there is no way of assessing how effective legislation is in achieving its objectives.

Despite its importance, it must be recognized that information about enforcement practice and regulatory impact is remarkably difficult to obtain from questionnaire enquires of the type that were used in this survey. Meaningful comparisons and overall conclusions about the effectiveness of enforcement depend upon information about the staffing and resources of enforcement bodies and their capacity effectively to identify unlawful activities. Having identified an infringement of the law, the policy and practice of the enforcement body needs to be ascertained to establish the circumstances in which an infringement will give rise to legal proceedings and what consequences will follow from

these. Perhaps most revealing is information about the degree of compliance with legislation though, again, this is tremendously difficult to gather with any degree of objectivity. Although the questionnaire sought insights into these matters by enquiring about the legal consequences of various kinds of offences, which might arise in relation to shrimp farming, the responses that were provided have been insufficiently detailed to support any useful conclusions on the issue of enforcement.

5.5.4 Institutional responsibilities and capacity

5.5.4.1 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, with little attempt having been made to consolidate these under the jurisdiction of a single authority with overall responsibility for shrimp farming. 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.

5.5.4.2 Major findings and lesson's learned

a) 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 cases 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.

b) 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** case studies, 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.

c) 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 (Srivastava et al, 1999). 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, although they may suffer weaknesses from lack of technical expertise.

5.5.5 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.

Some activities of the Surat Thani (Thailand) shrimp farmers association in 1999 and 2000:

Shrimp production:

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

International trade:

- 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.

Environmental conservation:

- 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.

Given this range of potential benefits, it is regrettable that shrimp producers' associations are not thought to exist in many of the countries surveyed by the **legislation thematic review**. Where associations did exist, the information that was provided about their activities was rather thin. It was noted in some instances that organizations had an active role in matters such as research, ensuring product standards and improving farming and environmental performance. However, this was exceptional, since most countries were able to provide little or no information about the existence of associations or, if existent, what role they performed.

There are various ways in which governments may encourage, and provide incentives for,

shrimp farming associations, which 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 (**Thailand case study**) 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.

6 Toward better management practices in shrimp aquaculture

The case studies show a 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 (8th- 11th 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 2001, as information from other studies becomes available and comments on the findings and BMP list are received from different stakeholders.

6.1 Issues to be addressed

The issues to be addressed have been identified in the previous sections, and are summarized below. The information below also builds further on discussions during the FAO/Australia expert consultation.

- 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.
- Control 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?

These issues are addressed below.

6.2 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

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.

6.2.1.1 Shrimp farm siting

Worse practice	■ Shrimp farms siting that cause direct and indirect damage to mangroves and coastal ecosystems functioning, affect 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.
Better practice	■ Avoiding siting farms with significant technical, environmental and social problems are 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

6.2.2 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-sulphate 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 that 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	■ Smallholder 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

6.2.3 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 brackish water 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 ■

6.2.4 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

6.2.5 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 ■ Improved public image ■ 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.

6.2.6 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 fish meal 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 adapt 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.

6.2.7 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 wastes 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

6.2.8 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 programmed

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

6.2.9 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.

6.2.10 Shrimp culture as cornerstone for rural development and poverty alleviation

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

6.2.11 Better practice for integration of shrimp aquaculture into coastal area management.

Worse practice	■
Better practice	■ Still to be done ■ Local institutional and co-management arrangements that support poor people's participation.
Financial/production impacts	■
Environmental and social impacts	■
Key constraints	■
Public sector governance	■ Still to be done.
Private sector governance	■

6.3 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:

- the need for technical guidelines that support implementation of better practices, and particularly their implementation at local and national levels
- 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 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 adaptation to local levels also needs to be based on careful consideration of the local circumstances and fully involved 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 according to local conditions.

7 Impacts of the Consortium Program

There are indications already that the consortium approach and case study findings are having positive impacts. This section will be further expanded during 2001 as more details on how these impacts are manifesting themselves become available. 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 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 will be 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 focused aquaculture development.

Shrimp aquaculture in Bangladesh has been marked by significant local social conflict and confrontation between NGO's, 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.

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. While the consortium will explore the implications of such "screens" (e.g., simple vs. complex, etc.), it will not be involved in any way in establishing such screens or undertaking certification or screening activities.

The findings from some of the cases were also discussed at the recent FAO/Australia expert consultation on shrimp aquaculture management, held in Brisbane during December 2000. An agreement was reached on a set of broad guiding principles for sustainable shrimp aquaculture management, that will be put forward to obtain formal government consensus at an FAO Technical Consultation in 2002 and the first COFI (Committee on Fisheries) Sub Committee on Aquaculture (2002 in China). The consortium has agreed to prepare documentation and reports together for this possible intergovernmental meeting and will therefore potentially have significant impact at intergovernmental level for reaching broader consensus on guiding principles for future management of shrimp aquaculture.

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.

8 Follow up activities and recommendations

The consortium program has created a framework for review and evaluating successes and failures in sustainable shrimp aquaculture, which can inform policy debate on management strategies for sustainable shrimp aquaculture. It has also identified future development activities and assistance required for the implementation of better management strategies that would support the move towards a more sustainable shrimp culture industry. Some of these issues are discussed below.

8.1 Requirements for 2001

The consortium agreed that the cooperative approach provides an important platform for gaining understanding and sharing experiences globally on shrimp aquaculture management and should be continued. The main objectives for 2001 are to finalize reports and outstanding case studies being prepared under WWF, NACA or FAO funding and ensure the information collected and the lesson's learned are summarized and widely disseminated. The individual case study reports should continue to be reviewed, edited and published during 2001, and translated as appropriate.

A further stage of work is required to support implementation of better management practice findings. This reflects a key concern among all 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.

8.1.1 Completion of case study reports

There are a small number of (non-Bank funded) cases that are outstanding, some of which were identified during the Brisbane meeting. These include a case study on shrimp certification case (Australia, Colombia), and study of the costs and benefits of conflicts management, a study of shrimp farm estates (Aqua-star, Dipasena, that would become part of the social BMPs case) and legal reviews. The case study on Ecuador will also be completed in 2001 and a case study on feed and feed management is planned for completion in May 2001. (see **Annex A**). The completion of these cases is essential before the final synthesis document from the consortium program can be completed.

The estimated costs of the case studies are US$ 36,000 and will be supported through WWF, NACA and FAO funds.

8.1.2 Economic analysis of BMPs

The consortium research has identified a list of potential BMPs for shrimp aquaculture. There is a need for study on the cost and impacts of BMPs in selected countries. Honduras and Nicaragua (Latin America) and Thailand (Asia) have been identified for these studies and farmers associations have agreed to work together for these studies.

The estimated cost of the economic analysis and write up is about $16,000 (Latin America) and $10,000 (Asia). These funds will come from NACA and WWF and US$15,000 is requested from the Bank.

8.1.3 Finalisation of synthesis report and BMP document

The present document forms the basis of the final synthesis document, but will continue to be developed in 2001, to be published in late 2001 in time for circulation to the COFI sub-committee meeting in April 2002. A small meeting will be held (tentatively in June/July 2001) among key consortium partners to review this draft and prepare a final draft and BMP document. The draft will also be circulated more widely for comments and input from a wider range of stakeholders.

The Bank has requested an update for the Environmental Assessment Sourcebook on shrimp aquaculture. NACA will take the lead in initial drafting of the document, and pending funding availability, may organize a small expert group meeting during September/October 2001 to finalize the document.

The estimated costs for the final synthesis are mainly associated with editing and publication. The preparation will be covered under existing NACA, FAO and WWF funds. An estimated US$10,000 is required for editing, design and publication of the final synthesis document in good time for the COFI meeting.

$10,000 will be sought by NACA for travel/subsistence for four experts to attend an expert working group meeting in Bangkok during September 2001 to prepare environmental assessment sourcebook.

8.1.4 Publication

The individual case study reports will be finally reviewed (external and internal peer review) and prepared (final edit and design) for publishing. Selected documents will also be translated into major languages. Case study reports will be published in hard copy (estimated 200 copies per case study) but the internet will be the major medium for publishing and dissemination of case studies. The electronic versions of the cases will be made available on a new NACA web site (www.enaca.org), and World Bank and FAO web sites as appropriate. WWF is holding discussions with Island Press concerning the web publishing of the case studies under a special site on aquaculture.

There is a need for an estimated US$ 35,000 for editing, design and publication of final documents and for translation of key case studies into local languages. The costs will be partially met by WWF, NACA and FAO funds and an additional US$15,000 is requested from the Bank.

8.1.5 Dissemination of findings to stakeholders

The consortium members will continue to promote the consortium work, and particularly the findings, at meeting with various stakeholders. There are opportunities at the following meetings:

- Asia meeting of farmers associations, planned for later in 2001.
- ASEAN/SEAFDEC meeting in November 2001 (Bangkok)
- Honduras aquaculture meeting in 2001
- "Aquaculture, economy and environment" at the World Aquaculture Society meeting in Beijing on the 23rd-27th April 2002.

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. The Thai shrimp farmers association has agreed to co-host this meeting with NACA. The funding will come from NACA and private sector funding but US$15,000 is requested from the Bank to support publications and some travel of participants representing small-scale farmers and NGO groups.

There are also opportunities emerging in Asia to link the consortium BMP findings to a GEF being prepared by UNEP, and to disseminate the findings to various national level activities, including Bank funded projects in Bangladesh, Vietnam and elsewhere.

8.1.6 Funding

The Consortium partners have agreed to continue to seek funds to support cases. The following are the estimated funding requirements for 2001. During 2001, consortium partners will continue to discuss and seek to define and seek funding opportunities to support longer-term implementation.

Items and estimated costs	NACA	WWF	Bank	FAO	**Total**
Case studies[7]	$15,000	$21,000			$36,000
Economic analysis of BMPs	$5,000	$6,000	$15,000		$26,000
Editing, translation and printing	$5,000	$15,000	$15,000		$35,000
Synthesis document	$10,000		$10,000		$20,000
Dissemination of findings	$5,000	$5,000	$15,000		$25,000
Total	**$40,000**	**$47,000**	**$55,000**		**$142,000**

8.2 Beyond 2001

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 by farmers. Therefore, an organized programmed to encourage and assist adoption of BMPs at the farm level in as many shrimp farming nations as possible is required. The focus of the follow up work beyond 2001 should therefore be primarily towards ***implementation*** of better management practices, and support to farm level and community level actions.

To fill gaps of information, there may be a need for a small number of additional case studies identified as key issues during phase I of the research. Some of the issues might include biodiversity issues, more detailed study of the role and promotion of farmer organizations, and particularly small-farmer organizations in dissemination of information on shrimp aquaculture BMPs, management of shrimp farm cluster areas and monitoring strategies and possible new thematic reviews on relative water quality impacts (e.g. based on development of Australian work). Further recommended studies were also identified in Brisbane (see Annex C).

The BMP matrix may also be further developed to address all aspects of shrimp culture. One or more BMP technical guidelines or manuals with details on support to implementation will be essential and work is required to extend the BMP systems to farmers. In Asia, probably more with governmental agencies and in Latin America with shrimp producer associations. There is also a need to undertake surveys and consultations to determine the degree of adoption of BMPs by farmers, and seek other ways to understand and support farmers in implementation.

Governments ultimately will make regulations about shrimp farming, and BMPs could possibly be a major aspect of these regulations. Thus, continuing effort should be made to identify and support development of the legal and institutional requirements to support better practices.

The cases studies have also identified the various constraints to implementation of better management practices, including financial, capacity, training requirements, institutional and other technical aspects. The follow up could also provide assistance towards overcoming such constraints. This will require some attention to the following:

[7] $6,000 for Social BMPs study (WWF), $15,000 for Ecuador study (NACA), $15,000 for feeds case study (WWF)

1. In-country training/workshops related to the implementation of BMPs
2. Meetings/publications.
3. Support to training/extension – including some extension materials in local languages, perhaps some teaching materials *etc*.
4. Manuals, which could be developed through consultation, at national, or regional level.
5. Translation of background/summary materials into local languages.

The follow up might also seek to disseminate knowledge to countries or areas, which are just starting shrimp culture, and a priority should be given to Africa in this regard. There are certainly opportunities to coordinate with existing coastal zone management efforts in Tanzania and Kenya, and incipient ones in Mozambique. SEACAM could be a partner in proposed activities in the region.

During 2001, further consultations will be held with the view to prepare a comprehensive follow up activities, work for inclusion in the final synthesis document and possible discussion at the COFI aquaculture sub-committee meeting in April 2002.

Finally, the consortium meeting in December 2000 identified poverty and aquaculture as an area of particular interest where cooperation and exchange of experiences might be particularly valuable. The discussions were focused mainly on shrimp aquaculture, but the consortium approach may be more widely applicable to other areas of aquaculture.

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, such cooperation might be extended towards poverty alleviation, as there is clearly an urgent need to share learning experiences and support directed poverty alleviation efforts, in line with international poverty alleviation targets. 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 issues such as aquaculture and poverty alleviation.

9 Reference list

10 Annex A: List of shrimp aquaculture case studies

10.1 Summary table

	Country	Title of case study	Funding	Case Coordinator	Status
Africa and the Middle East Region					
1	Egypt	The Current State of Shrimp Culture Systems in Egypt Prepared by: *Rafael Rafael (SEACAM, Madagascar)*	WWF		1st & 2nd drafts
2	Iran	The Status of Shrimp Culture in I.R. Iran Prepared by: *Mehdi Shakouri*	WWF		1st & 2nd drafts
3	Madagascar	The Current State of Shrimp Culture Systems in Madagascar Prepared by: *Rafael Rafael (SEACAM, Madagascar)*	WWF		1st & 2nd drafts
4	Mozambique	The Current State of Shrimp Culture Systems in Mozambique Prepared by: *Rafael Rafael (SEACAM, Madagascar)*	WWF		1st & 2nd drafts
5	South Africa	The Current State of Shrimp Culture Systems in South Africa Prepared by: *Rafael Rafael (SEACAM, Madagascar)*	WWF		1st & 2nd drafts
6	Tanzania	The Current State of Shrimp Culture Systems in Tanzania Prepared by: *Rafael Rafael (SEACAM, Madagascar)*	WWF		1st & 2nd drafts
Asia-Pacific Region					
1	Australia	The Environmental Management of Shrimp Farming in Australia Prepared by: *Nigel Preston, Peter Rothlisberg, Michele Burford and Chris Jackson (CSIRO Marine Research)*	CSIRO/Australia	M. Phillips	1st draft
2	Bangladesh	Social Aspects of Shrimp Aquaculture in Bangladesh Prepared by: *Anwara Begum and S.M. Nazmul (CARITAS, Dhaka, Bangladesh)*	World Bank/NACA	M. Phillips	1st draft available – currently being edited
3	Bangladesh	Case Studies on Shrimp Aquaculture Management in Bangladesh Prepared by: *Rahman (DOF, Dhaka), M., P.P.G.S.N. Siriwardena (NARA), and Wajed Shah (ICLARM)*	World Bank	M. Phillips	2nd draft
4	China	Shrimp Culture Renovation in Rushan Country, Weihai, Shandong Province, China Prepared by: *Jie Huang (YSFRI, China) and Anantha Duriappah (IVM, the Netherlands)*	World Bank	M. Phillips	2nd draft
5	India	The Role of Small Farmer Groups and Associations in Sustainable Shrimp Aquaculture Management Prepared by: *Kutty, M.N., (Private consultant), P. Ravichandran, M. Krishnan and C.P. Balasubramanian (CIBA, Chennai, India)*	World Bank/NACA	M. Phillips	1st draft
6	Indonesia	Good Practices for Community-Based Planning and Management of Shrimp Farming in Sumatra, Indonesia Prepared by: *James Tobey (URI, USA), Hermawati Poespitasari (Proyek Pesisir, Indonesia), and Budy Wiryawan) Bogor University, Center of*	World Bank	M. Phillips	1st draft

		Coastal and Marine Resource Studies)			

7	Philippines	Mangrove Management and Aquaculture in the Philippines Prepared by: *Dioscoro M. Melana, E.E. Melana, C.E. Yao and Edgar L. Abuan*	World Bank/NACA	M. Phillips	1st draft available, undergoing revision, based on comments received
8	Sri Lanka	Report on a Code of Best Practices for Shrimp Aquaculture in Sri Lanka Prepared by: *Siriwardena, P.P.G.S.N. (National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka)*	FAO	Rolf Willmann	1st draft
9	Thailand	Case Study on Institutional Aspects of Shrimp Aquaculture in Thailand Prepared by: *Nissapa, Ayut and Somsak Boromthaanarat (CORIN, Hat Yai, Thailand)*	World Bank	M. Phillips	Final draft
10	Thailand	Assistance and Issues in the Implementation of the Code of Conduct for Shrimp Aquaculture Prepared by: *Siri Tookwinas (DOF, Thailand)*	World Bank/NACA	M. Phillips	Summary presented in Brisbane. Draft under preparation
11	Vietnam	Coastal Shrimp Aquaculture: Searching for Better Management Strategies – Case Studies From the North and North-Central Coastal Area of Vietnam. Prepared by: *Tran Van Nhuong (RIA-1, Hanoi), Raymon van Anrooy (FAO, Vietnam) and Michael John Phillips (NACA, Bangkok)*	World Bank	M. Phillips	Final draft
12	Vietnam	Silvofishery Farming Systems in Ca Mau Province, Vietnam Part a) background and technical recommendations Prepared by: *Barry Clough, Danielle Johnston, Tran Thanh Xuan, Michael Phillips* Part b) Socio-economic studies Prepared by: *Pednekar, Sunil S. (NACA, Bangkok), Nguyen Huu Thien, Pham Le Thong, Truong Hoang Dan (Can Tho University, Vietnam)*	World Bank/NACA	M. Phillips	Final draft
13	Vietnam	Studies on Mixed Rice-Shrimp Aquaculture Systems in the Mekong Delta Prepared by: *Nigel Preston (CSIRO, Australia)*	ACIAR	M. Phillips	Draft available 31st December
Latin America					
1	Belize	Evaluation of Belize Aquaculture, Ltd. - A Super-Intensive Shrimp Aquaculture System in Belize Prepared by: *Claude E. Boyd (University of Auburn, USA) and Jason Clay (WWF,US)*	WWF	J. Clay	Final draft
2	Brazil	Key Management Challenges for the Development and Growth of a Shrimp Farm in Northeast Brazil -- A Case Study of Camanor Produtos Marinhos Ltd. Prepared by: *Barbara Schwab, Michael Weber and Bernard Lehmann*	WWF	J. Clay	2nd draft
3	Brazil	Barriers to Investing in Shrimp Aquaculture – Lessons from Brazil Prepared by: *Patricia Moles, et al.*			

4	Colombia	The Integration of Mangrove and Shrimp Farming: A Case Study on the Caribbean Coast of Colombia Prepared by: *Dominique Gautier (University of Auburn, USA)*	WWF	J. Clay	Final draft

5	Colombia	The Adoption of Better Management Practices (BMPs) by the Shrimp Industry on the Caribbean Coast of Colombia Prepared by: *Dominique Gautier (University of Auburn, USA)*	WWF	J. Clay	2nd draft
6	Ecuador	Case studies on shrimp aquaculture management in Ecuador covering: (1) Shrimp production in mangrove areas; (2) Use of wild shrimp post-larvae; (3) Composition of shrimp pond soil in mangroves areas versus non mangrove areas; (4) Shrimp farm management and concentrations of potential pollutants in effluents; and (5) Water exchange practices. Prepared by: *Jorge Calderon, Stanislaus Sonnenholzner (CENAIM, Ecuador) and Claude E. Boyd (University of Auburn, USA)*	NACA	C.Boyd/ M.Phillips	NACA funded case due by end of Jan. 2001
7	Honduras	Science and Society in the Gulf of Fonseca: The Changing History of Mariculture in Honduras Prepared by: *Denise Stanley Carolina Alduvin and Amanda Cruz*	WWF	J.Clay	2nd draft
8	Honduras	Coastal Water Quality Monitoring in Shrimp Farming Areas with an Example from Honduras Prepared by: *Claude E. Boyd and Bart Green (University of Auburn, USA)*	World Bank	Claude Boyd	Final draft
9	Mexico	Shrimp Aquaculture, People and the Environment in Coastal Mexico Prepared by: *Billie R. De Walt (University of Pittsburgh), Lorena Noriega (Sonora), Jaime Renan Ramirez Zavala (Sinaloa) and Rosa Esthela Gonzalez (Nayarit)*	World Bank	J.Clay	Final draft
Thematic Reviews					
Mangroves					
1	Global	Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture Prepared by: *Donald J. Macintosh (Aarhus University, Denmark), Michael J. Phillips (NACA), Robin Lewis III (USA), and Barry Clough (AIMS, Australia)*	World Bank/WWF/ NACA	M.Phillips	1st draft
Codes of Practice					
2	Global	Codes of Practice for Marine Shrimp Farming Prepared by: *Claude Boyd (Auburn University, USA), John Hargreaves, and Jason Clay*	World Bank	J.Clay	Final draft
Shrimp Disease and Health Management					
3	Global	Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture Prepared by: *Rohana Subasinghe (FAO), Dan Fegan (BIOTEC, Thailand), Richard Arthur (Canada) and Melba Reantaso and Michael Phillips (NACA)*	World Bank/FAO/ NACA/WWF	R.Subasinghe	Final draft

Thematic Overview of Social Equity, Benefits and Poverty Alleviation BMPs of the Shrimp Aquaculture Industry					
4	Global	Improving the Social Impact of Shrimp Aquaculture in Asia: Best Management Practices to Improve Employment, Benefits and Equity within the Industry Prepared by: *Connor Bailey (University of Auburn, USA)*			
5	Global	Social Best Management Practices in Latin America Prepared by: *Billie R. De Walt (University of Pittsburgh)*	World Bank/WWF	J. Clay	1st draft
6	Global	Socio-Economic Analysis of Shrimp Aquaculture in Coastal Areas of Asia Prepared by: *Catherine Michielsens*			
7	Global	Synopsis of Results of Research on Southern Thai Shrimp Farming: Some Recommendations Prepared by: *Emanuel Mike Polioudakis*			
Legislation and Shrimp Aquaculture					
8	Global	An Analysis of Shrimp Aquaculture Legistration Prepared by: *Annick Van Houtte and William Howarth*			
9	Global	Confusion, Conflict, and Corruption: The On-Going Struggle to Achieve Effective Legal and Regulatory Systems in Responsible Shrimp Aquaculture Prepared by: *David Barnheizer, Esq.*			

10.2 Executive summaries of case studies

10.2.1 Africa and the Middle East region[8]

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, **The Current State of Shrimp Culture Systems in Madagascar**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in South Africa**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Tanzania**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Mozambique**. 2000.
Rafael Rafael, **The Current State of Shrimp Culture Systems in Egypt**. 2000.
Mehdi Shakouri, **The Status of Shrimp Culture in I. R. Iran**. 2000.

Need to split these into study by study summaries.

Summary: These case studies summarise existing experiences with shrimp aquaculture in Africa through consultation with people involved in shrimp aquaculture development in Africa (private and government) and analysis of major issues. The reports also provide lessons that Africa might learn from the management experiences documented in Asia and Latin America. Rafael Rafael (SEACAM) participated in the Aquaculture Millenium Conference and FAO/Australia expert consultation (see below) providing opportunities for exposure to shrimp farm development and management strategies worldwide. The study provides an opportunity for cooperation between Africa and Asia in sharing of management experiences in shrimp aquaculture.

10.2.2 Asia-Pacific region

10.2.2.1 Australia

The study in Australia was cordinated 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.** 2001

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, analysed effluent composition, determined the effects of different effluent treatment strategies and traced the fate of effluent in receiving waters. The results 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, there are ongoing public concerns 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. This process has already commenced with an initial focus on the Queensland shrimp farming industry. This study has identified that the environmental management of shrimp farms needs to be incorporated into environmental management of the water body and catchment adjacent to shrimp farms. By this means, aquaculture can be compared to other forms of

[8] In the final report, it is suggested to incorporate these case study executive summaries in the Annex.

agriculture, particularly in relation to permitted discharge loads. This concept is not unique to Queensland or Australia but has rarely been addressed. 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.

10.2.2.2 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**. 2000

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

Summary: 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 salinisation 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 – emphasising 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.

10.2.2.3 China

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

Jie Huang and Anantha Duriappah, **Shrimp Culture Renovation in Rushan County, Weihai, Shandong Province, China**. 2000. Available in Chinese and English.

Summary: 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.

10.2.2.4 India

The study in India was prepared by M. N. Kutty and assisted by a team from the Central Institute of Brackish water 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.

Summary: 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]**.**

10.2.2.5 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.** 2000.

Summary: This case study presents a pilot project in Indonesia that is working to promote environmentally responsible and sustainable shrimp aquaculture. The project is located in Pematang Pasir, a coastal village located in Lampung Province on the island of Sumatra, in Indonesia. Lampung province is the second largest shrimp-producing province in Indonesia. It has achieved this status over a very short period of time. Like so many other places around the world, the rate of growth has overwhelmed government capacity to plan and guide shrimp aquaculture growth in a responsible manner.

The pilot project in Pematang Pasir is part of the Indonesian Coastal Resources Management Project (Proyek Pesisir) whose overall objective is to decentralize and strengthen coastal resource planning and management. As a “pilot” project, it is intended to test and expand knowledge of effective methods and lessons learned that could be replicated on a wider scale.

The case describes what has been learned to date, and offers strategies, methods and tools of community-based coastal resource management that can be used worldwide in efforts directed at analyzing constraints to adoption of good practices for shrimp farming and how to overcome them.

10.2.2.6 The 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.** 2000.

The conversion of mangroves to brackish water 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.

10.2.2.7 Sri Lanka

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 Best Practices for Shrimp Aquaculture in Sri Lanka**. 2000.

Summary: 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 NGO's 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.

10.2.2.8 Thailand

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, **Case Study on Institutional Aspects of Shrimp Aquaculture in Thailand.** 2000.

Summary: 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.

Summary: 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.

10.2.2.9 Vietnam

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.** 2000.

Summary: 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 practises, 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 specialise 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 benefitted 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 commercialisation, 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 centres. 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 favour 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 uder 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 managment, 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. 2000

The case study is divided into two parts:
Part a) background and technical recommendations
Prepared by: *Barry Clough, Danielle Johnston, Tran Thanh Xuan, Michael Phillips*
Part b) Socio-economic studies
Prepared by: *Pednekar, Sunil S. (NACA, Bangkok), Nguyen Huu Thien, Pham Le Thong, Truong Hoang Dan (Can Tho University, Vietnam)*

Summary: 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 practising 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, inavailability 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 knowhow 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 knowhow, 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.** 2000.

Summary: 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.

10.2.3 Latin America

10.2.3.1 Belize

Claude Boyd and Jason Clay, **Evaluation of Belize Aquaculture, Ltd.—A Super-Intensive Shrimp Aquaculture System in Belize.** 2000.

Summary: Belize Aquaculture, Limited has developed a superintensive shrimp aquaculture system that is operated in lined ponds with heavy mechanical aeration and water recirculation. The pilot study of the operation has been in progress for two years and a number of 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 has 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 is as efficient 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 shrimp production 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: (a) describe the production system; (b) present a summary of its performance; (c) discuss the unique aspects of the system; (d) compare the system with conventional shrimp production systems; (e) identify potential areas of concern with the current Belize Aquaculture system; (f) discuss potential implications of expanding the current system in Belize; and (g) assess the socioeconomic aspects of shrimp culture by this method.

In conclusion, because the system is highly intensive and more "environmentally-friendly" than traditional aquaculture systems, the study authors are convinced that the Belize Aquaculture production system, or some modification of this system, will very likely be the shrimp aquaculture system of the future. However, there are two issues of concern that remain. First, all super intensive shrimp aquaculture production systems have failed in the past. It is important that this one be monitored carefully so that as much can be learned about it as possible. Second, as with any good idea someone will inevitably try to "improve" on it. It is important that the key elements of this program not be changed in "improved" models. The basic elements that appear to be crucial to the success to date of the Belize Aquaculture system include: small lined ponds, aeration, disease-resistant omnivorous shrimp species.

10.2.3.2 Brazil

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.** 2000.

Summary: This case study discusses the main lessons of management-practice on the shrimp farm "Camanor," Rio Grande do Norte (RN), Brazil. Since its foundation in 1982, data has been collected on the farm that provides insights into some key-points in the history of the company. The lessons learned from the past should be considered when addressing future development potentials and challenges of the shrimp aquaculture industry. This 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 is an attempt to document the most important lessons learned by Camanor during the past 18 years. The most important challenges before the shrimp aquaculture industry involve developing "better practices" and achieving industry-wide standards that are more sustainable.

Camanor, like other shrimp producers in Brazil, is increasing its production rapidly. Besides the current operation there are three more farms under construction. Some are beginning production. This expansion in production leads to new challenges in processing, administration and the whole management of the farm. The description and the analysis of the past development of Camanor in this case study give some ideas about the preconditions that had to be fulfilled to support the current expansion, and provide more general lesson's for the development of shrimp culture in Brazil.

The study provides good economic justification for adoption of "sustainable" management practices and provides the following ideas on how a shrimp farm could support a sustainable growth on local level. The study emphasizes that an operation can not work isolated from the local reality. Camanor is integrated into a local system and influenced by the national and international market and economic developments. At the local level, other shrimp farms have a strong impact on the environment and social circumstances of production. Effluents, water pollution, destruction of mangroves, exploitation of employees, are just a few points that could become issues at the local level. These circumstances have a strong impact on the image, on the expansion possibilities and on

the development of Camanor. The management of Camanor has to be concerned about these factors. The transfer of know-how, sharing of experience and giving technical assistance to other farmers are some of the ways Camanor intends to work at the local level to help other producers avoid making conditions difficult for everyone. This is both possible and financially attractive for two reasons. First, semi-intensive shrimp farming is strongly connected to the environment (e.g. pumping water, water exchange, introduction of species, etc.). Second, larger shrimp farms with a good infrastructure can guarantee the use of their capacity either for selling PL or processing the production of others as long as demand increases.

At the national level, a single farm does not have tremendous potential to affect the industry except to lead by example. A single farm is affected by the national policies, politics and market development. To improve a sustainable development of the national shrimp sector, it is very important to collaborate and to become committed to an industry-wide organization such as ABCC. The organization itself can generate considerable credibility by cooperating with other organization such as environmental and social NGOs and community organizations.

Patricia Moles, et al. **Barriers to Investing in Shrimp Aquaculture—Lessons from Brazil**. Terra Capital Fund, Banco Axial, Sao Paulo, Brazil. 2000.

Summary: The case study explores the barriers to investing in shrimp aquaculture in Brazil. It focuses on the history of the industry and the importance of monetary and trade policies on its development. When government policies keep local currencies artificailly high, it makes it very difficult for exporters to compete on global markets. This issue, and its flip side of having local currencies very weak, explain much of the expansion and contraction of the industry in different parts of the world.

10.2.3.3 Colombia

Dominique Gautier, **The Integration of Mangrove and Shrimp Farming: A Case Study on the Caribbean Coast of Colombia.** 1999.

Summary: Shrimp aquaculture has been accused of threatening mangrove forests worldwide. In response, one management action is to develop the concept of integrated mangrove-shrimp farm systems. Mangrove and shrimp ponds are known to have mutually supportive functions. Mangrove wetlands can be used to treat effluents from shrimp ponds to remove suspended solids and nutrients. As a result, shrimp culture can be expected an enhancement of mangrove productivity. This report describes an example of integrated mangrove wetland-shrimp farm functioning in Colombia since 1996. Shrimp farm effluent is recirculated through a 120-ha mangrove area. Suspended solids are considerably reduced in the effluent and nutrient concentrations in the adjacent lagoon have been decreased. Mangrove growth and regeneration in the biofilter are very high. Nevertheless, nutrient cycling in the biofilter is poorly understood. Moreover, long-term impact of effluents on mangrove ecosystem has to be assessed. This case is a positive example of responsible aquaculture development in coastal areas, but at the same time, it reveals the needs of 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.** 2000.

Summary: The case study surveys the better management practices currently adopted by shrimp farmers on the Caribbean coast of Colombia, and explores benefits and constraints from their adoption. The case uses a review of the Columbian industry in 1997 by MacAllister and Elliot as a baseline. That study, undertaken on behalf of the industry and paid for by the government, was

intended to flag the main impacts and suggest ways that they could be addressed. Our study (undertaken by Gautier who also worked on the 97 research) was designed to identify which of the impacts had been addressed, how, and why, as well as which had not yet been addressed and why. We did not do a lot of economic analysis but rather simply asked the producers. In many cases the expenses or trouble were seen as being too great for little payoff. Where the information and incentives were clear there seems to be adoption of BMPs. The case is useful for thinking about how to take work forward on better management practices forward towards implementation.

10.2.3.4 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).

Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Use of wild post larvae in past five years.**
Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd.**Composition of shrimp pond soils areas versus non- mangrove areas**
Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Farm management and concentration of potential pollutants in Ecuador**
Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Water exchange practices in past five years**
Jorge Calderon, Stanislaus Sonnenholzner and Claude E. Boyd. **Review of coastal wetland habitats and shrimp aquaculture.**

Summary: 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.

10.2.3.5 Honduras

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

Summary: 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.** 2000.

Summary: 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, Panamerican 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.

10.2.3.6 Mexico

Billie R. Dewalt, Lorena Noriega, Jaime Renan Ramirez Zavala, and Rosa Esthela Gonzalez, **Shrimp Aquaculture, People and the Environment in Coastal Mexico**. 2000.

Summary: 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.

10.2.4 Thematic Reviews

10.2.4.1 Mangroves

Donald J. Macintosh, Michael J. Phillips, Robin Lewis III and Barry Clough. **Thematic Review of Coastal Wetland Habitats and Shrimp Aquaculture.** 2000.

Summary: 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 NGO's, 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.

10.2.4.2

10.2.4.3 Codes of Practice

Claude Boyd, John Hargreaves and Jason Clay, **Codes of Practice for Marine Shrimp Farming.** 2000.

Summary: 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.

10.2.4.4 Shrimp diseases and health management

FAO, NACA, World Bank and WWF. **Thematic Review on Management Strategies for Major Diseases in Shrimp Aquaculture.** 2000.

Summary: The case study was prepared through an Expert Workshop on Management Strategies for Major Diseases in Shrimp Aquaculture, held in Cebu, Philippines from 28-30 November 1999.

The workshop included 15 country review papers (5 countries from the Latin American Region: Equador, 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) that provided the history and current national status of major shrimp diseases, including their socio-economic 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. The workshop also discussed and made recommendations on four major issues(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 programmes 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.

The four broad 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 case study is also complemented by a special analysis of management strategies for shrimp disease control in the small-scale sector, under a special project of ACIAR. The major recommendations arising from the Expert Workshop provided a 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.

10.2.4.5 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-2001. 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.** 2000.

Billie R. de Walt, **Social Best Management Practices in Latin America.** 2000.

Catherine Michielsens, **Socio-Economic Analysis of Shrimp Aquaculture in Coastal Areas of Asia.** 1999.

Emanuel Mike Polioudakis, **Synopsis of Results of Research on Southern Thai Shrimp Farming: Some Recommendations.** 2000.

Summary: 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.

10.2.4.6 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. **Comparative study on shrimp aquaculture legislation.** 2001

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, Phlippines, 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 Internationalisation of Standards
18. Guidance and Producers' Organizations
19. Enforcement
20. Other Issues

David Barnheizer, Esq. **Confusion, Conflict, and Corruption: The On-Going Struggle to Achieve Effective Legal and Regulatory Systems in Responsible Shrimp Aquaculture.** 2000.

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.

11 Annex B: List of meetings and stakeholder consultations

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ finders	Buyers	Certifiers	Trade association	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	3	3			3	3	3					
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	3	3			3	3	3					
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	3	3	3	3	3	3	3					3
Hanoi, Vietnam	Follow up workshop to approve a government policy document on "Sustainable Aquaculture for Poverty Alleviation" ("SAPA") (14th September 2000).	40	3	3	3	3	3	3	3					3
Polder-23, Khulna district, Bangladesh	Participatory Rural Appraisal (PRA) with shrimp fry collectors (landless, women) on social aspect of coastal shrimp aquaculture (10th February 2000)	31					3	3	3					3
Polder 23, Khulna district, Bangladesh	PRA with shrimp farmers on social aspects of coastal shrimp aquaculture (11th February 2000)	33	3				3	3	3		3			3
Polder 22, Khulna district, Bangladesh	PRA with shrimp farmers, agriculture farmers, businessmen on social aspect of coastal shrimp aquaculture (22nd February 2000)	53	3				3	3	3		3			3
Polder 33, Khulna district, Bangladesh	PRA with shrimp farmers on social aspect of coastal shrimp aquaculture (24th February 2000)	30	3				3	3	3		3			3
Polder 33, Khulna district, Bangladesh	PRA with shrimp fry collectors (landless, women) on social aspects of coastal shrimp aquaculture (25th February 2000)	35					3	3	3		3			3

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ finders	Buyers	Certifiers	Trade association	Consultants
Dacope (upazilla), Khulna district, Bangaldesh	Workshop on review of PRA findings with local officials (Upazilla) officials and NGOs in Dacope (27th March 2000) (Upazilla = local administrative unit)	23												
Paikegacha (upazilla), Khulna district, Bangaldesh	Workshop on review of PRA findings with local (Upazilla) officials in Paikegacha (29th March 2000)	20												
Khulna district, Bangladesh	Workshop on field findings of two upazilla with district/divisional officials (30th February 2000)	45												
Dhaka, Bangladesh	Workshop on shrimp aquaculture case studies in Bangladesh to present findings of case study to policy makers (3rd July 2000)	51	3	3	3	3	3	3						3
Nice, France	World Aquaculture Society meeting	2,500	3x	3x	3x	3x	3x	3x		3x	3x	3x	3x	3x
Thailand	Local workshops on the Thai Code of Conduct for Responsible Shrimp Aquaculture (Rayong and Hat Yai) (June/July 2000)	15	3	3			3							
Bangkok, Thailand	Workshop to prepare the thematic review on coastal wetland habitats and shrimp aquaculture (14th-16th February 2000)	25	3x	3x			3x	3x						3x
Bangkok, Thailand	NACA/FAO/Government of Thailand Conference on Aquaculture in the Third Millenium. (20th-25th February 2000)	550	3x	3x	3x	3x	3x	3x	3x	3x		3x	3x	3x
Thoduwawe, Welihena,, NW province, Sri Lanka	Small-scale farmer consultation – NARA (National Aquatic Resources Agency) researchers and farmers	225	3					3						
Pinkatiya, Mundal, NW Province, Sri Lanka	Consultation on shrimp farm management practices – farmers, NW Province provincial govt officials, central govt officers, and researchers	25	3	3				3						
Chilaw, NW Province, Sri Lanka	Consultation among Sri Lanka stakeholder on future development of shrimp aquaculture in Sri Lanka - NARA researchers, govt officials, feed suppliers, farmers and exporters	25	3	3				3		3	3		3	
Chilaw, NW Province, Sri Lanka	Consultation with shrimp hatchery operators on hatchery best practice NARA researchers, govt officials, consultants.	20	3	3						3			3	3
Cebu, Philippines	Interviews on Community-based project for Badian, Alegria, Cebu. (July 26-28, 2000)	10	3	3	3		3		3					
Mahanay Island, Bohol Philippines	General membership meeting of MAPCODA, a people's organization involved in coastal resource management at Mahanay Island, Bohol.	25	3	3	3		3		3					
Mahanay Island, Bohol Philippines	Interviews on Community-based project for Mahanay Island, Bohol (August 10-11, 2000	16	3	3	3		3		3					
??	China – more details awaited													

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ funders	Buyers	Certifiers	Trade association	Consultants
Cebu, Philippines	Management strategies for major diseases in shrimp aquaculture. (28th-30th November 1999)	40	3x	3x	x		3x	3x					3x	3x
Nellore/Muthukur, Kandaleru Creek, AP, India	Consultation meeting with District administrators, DoF and DoA officials & representatives of Nellore District Prawn Farmers' Welfare Association; Consultation meeting with ANGRAU Fisheries college Dean/aquaculture faculty & students, farmers at Muthukur; & Stake holders' participatory workshop (5-7 December 2000)	50	✓	✓			✓	✓	✓				✓	
Kolkota, Dhigirpar, 24 Parganas, W Bengal, India	Consultation meetings with DoF officials, Block and Panchayat/village level administrators and framers groups; and Stakeholders, participatory workshop (13-16 December 2000)	70	✓	✓			✓		✓				✓	
Puerto Vallarta, Mexico	Trans-boundary aquatic animal pathogen transfer and the development of harmonized standards on aquaculture health management (joint APEC/FAO/NACA consultation) (24th-28th July 2000)	49	3	3	3		3							3
Brisbane, Australia	FAO/Australia consultation on management practice and institutional and legal arrangements for shrimp aquaculture (4th-7th December 2000)	65	3x	3x	3x	3x	3x	3x				3x	3x	3x
Beijing, China	Final workshop on Asia Regional Health Management for the Responsible Transboundary movement of live aquatic animals (27th-30th June 2000)	45		3	3	3								
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	3	3	3	3	3	3						3
Hanoi, Vietnam	Meeting on a potential Code of Practice for shrimp aquaculture in Vietnam (December 2000)	17	3	3		3		3						3
Hanoi, Vietnam	Workshop for drafting of EIA guidelines for government on coastal aquaculture developments in Vietnam (13th December 2000)	10		3		3	3	3						3
Guayaquil, Ecuador	Annual meeting of ISANet. December 1998	30					x	x	x					x
Guayaquil, Ecuador	Meeting with the Ecuadorian Shrimp Industry. January 1999	20	x				x	x			x		x	x
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					x	x						
Washington, DC	Meeting on Economic Analysis of Shrimp BMPs	3					x	x						

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ funders	Buyers	Certifiers	Trade association	Consultants
Caracas, Venezuela	Meeting with WWF Latin American Marine Program staff to discuss shrimp aquaculture. May 1999	20					x							x
Auburn University, USA	Presentation to Auburn U. Aquaculture Staff. June 2, 1999.	26						x						x
Los Altos, CA, USA	Met with Packard Foundation to advise on the priorities for their expanded marine program	15						x		x				x
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	x	x			x	x	x		x		x	x
Washington, DC, USA	NOAA meeting to discuss implications of reaching goal of increasing aquaculture production 5-fold in 20 years. August 1999.	250	x	x			x	x	x				x	x
Salzburg, Austria	Salzburg Seminar on sustainable development in the humid tropics. Aquaculture featured. Clay gave keynote. August 1999.	90			x	x	x	x		x				x
Guayaquil, Ecuador	Bi-Annual Meeting of the National Shrimp Producers Association. October 26-31.	500	x	x			x	x			x	x	x	x
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					x	x			x			x
Belize	Met with Belize Aquaculture and other producers to tour operations and discuss BMPs for shrimp aquaculture. December 12-15, 1999.	12	x				x	x						x
Bangkok, Thailand	NACA/WWF/WB/FAO meeting to discuss BMP work and the role of the consortium. April 20-23, 1999.	40	x3	x3	x3		x3	x3	x3					x3
Sydney, Australia	World Aquaculture Society Meetings. Session on shrimp aquaculture and the environment. April 27-30, 1999.	150	X	x			x	x						x
Maputo, Mozambique	Meeting on Threats to the East African Marine Ecoregion. Discussion on shrimp aquaculture. January 14-21, 2000.	25			x		x	x	x					x
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	X	x			x	x	x					x
New Orleans, LA, USA	Aquaculture America 2000. Session on Environmentally Sound Aquaculture. February 3, 2000.	150	X	x			x	x						x
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					x	x		x		x		x

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ finders	Buyers	Certifiers	Trade association	Consultants
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					x	x		x		x		x
Bangkok, Thailand	ISANet Annual Meeting. February 19, 2000.	40					x	x	x	x				x
Bangkok, Thailand	Meeting with ISANet to discuss the work of the consortium. February 20, 2000.	12					x	x	x					x
Bangkok, Thailand	Meeting on Organic Shrimp Certification with Agro-Eco. February 24, 2000.	7	x	x			x	x				x		
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	x	x	x	x	x	x						x
Washington, DC, USA	Gulf of Mexico shrimp fishery modeling session. March 4-5, 2000.	20		x			x	x						x
London, UK	Chatham House session on Business and Biodiversity. Discussed BMPs and shrimp aquaculture. April 3, 2000.	140	x	x	x		x	x		x	x	x	x	x
Mohonk, NY, USA	Social Venture Network Meeting on sustainability. Discussed BMPs using shrimp aquaculture as an example. April 13-16, 2000.	350	x				x	x		x	x	x	x	x
Monterey, CA, USA	SeaWeb/Packard Foundation Seafood Consumer Initiative Workshop. April 26-27, 2000.	55					x	x			x	x	x	x
Recife, Brazil	Meeting at Instituto Josue de Castro on shrimp aquaculture. May 22, 2000.	60	x	x			x	x	x					x
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on the work of the consortium. May 23, 2000.	250	x	x			x	x	x					x
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on BMPs and shrimp aquaculture development in Brazil. May 24, 2000.	200	x	x			x	x	x					x
Recife, Brazil	Mangrove 2000 Conference. University of Pernambuco. Talk on the Mexican case study of the consortium. May 24, 2000.	150	x	x			x	x	x					x
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		x			x	x						x

Location	Meetings Held or Attended in 1999 and 2000 to further the Work of the Consortium. NACA (3) and WWF (x) responsibility.	Participants	Producers	Govt officials	Mult-lateral	Bi-lateral orgs	NGO's	Researchers/universities	Community groups	Investors/ finders	Buyers	Certifiers	Trade association	Consultants
Washington DC, USA	World Wildlife Fund staff meeting. Presented the work of the consortium. July 14, 2000.	75					x	x						x
Georgetown, Guyana	Addressed the President and Members of Parliament regarding natural resource management, BMPs and marketing. September 11, 2000.	150		x		x	x	x						x
Zurich, Switzerland	Addressed WWF-Switzerland Conference on the identification and use of BMPs. October 18-19, 2000.	80					x	x						x
Washington, DC, USA	Addressed ISANet Board on preliminary findings of the consortium's work. October 22-23, 2000.	12					x	x						x
Panama City, Panama	Fourth Latin American Aquaculture Congress and Exhibition. October 25-28, 2000.	300	x	x	x		x	x		x	x		x	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					x	x		x				x
Baja, Mexico	Pew Fellows' Fifth Anniversary Meeting of Marine Fellows. November 5, 2000.	75					x	x		x				x
Washington DC, USA	Met with Marine Aquarium Council to discuss differences between certifying aquaculture and wild caught products. November 20, 2000.	4					x							
Washington DC, USA	Addressed the IFC's agriculture and sustainability divisions on BMPs with reference to shrimp aquaculture and agriculture. November 21, 2000.	35			x		x							
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			x		x							

12 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.

12.1 Objectives and operating principles for shrimp sustainable shrimp aquaculture

1. 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.

2. 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)

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  - 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.
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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.

3. 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 salinisation during construction and operation.
- Employ techniques to minimize disturbance of acid-sulphate 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 sulphate soils (PASS) or acid sulphate 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.

4. Minimize impacts on local water resources

Operational principles for on-farm management:
- 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

Operational principles for sectoral management:
- 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.

5. Avoid release or escape of exotic species and transgenics into the environment

Operational principles for on-farm management:
- 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

Operational principles for sectoral management:
- 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.

6. 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.

7. 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.

8. Reduce dependence on wild stocks for farmed shrimp production

Operating principles for on-farm management:

- Preserve genetic diversity of natural stocks
- Use hatchery-reared post larvae and domestication to enhance culture performance and health

Operating principles for sectoral management:

- None provided

9. 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.

10. Optimize social and economic benefits to the wider community and country

Operating principles for on-farm management:

- 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

Operating principles for sectoral management:

- 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.

10a. Conduct shrimp farm operations to minimize impacts on surrounding resource users.

Operating principles for sectoral management:

- 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.

11. Ensure the health and safety, rights and welfare, of staff in farm operations

Operating principles for on-farm management:

- 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

Operating principles for sectoral management:

- 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.

12. 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.

12.2 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; and
- 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;

13 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.

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.