guidelines for the
Environmental Assessment of Coastal Aquaculture Development

An Environmental Assessment (EA) manual to assist governmental agencies, Coastal Aquaculture developers non-governmental organisations (NGOs) and community organisations.

SEACAM
SECRETARIAT FOR EASTERN AFRICAN COASTAL AREA MANAGEMENT

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Document Guide

Purpose

The overall objective of these guidelines, and the associated training initiative, is to improve the environmental assessment capacity for coastal aquaculture developments in a variety of stakeholder groups in Eastern Africa. The guidelines and associated technical appendices provide detailed practical and technical information to reduce and mitigate the environmental and social impacts of coastal aquaculture developments along the Eastern African coast. The emphasis in the guidelines is on those forms of activity likely to pose the greatest threat.

The guidelines should serve as a "hands-on" technical manual that will assist, for example:

- government regulatory agencies to assess and recommend modifications to coastal aquaculture developments;
- policy makers and planners to improve the procedures for the environmental assessment and management of individual coastal aquaculture projects, and the coastal aquaculture sector as a whole;
- coastal aquaculture developers to recognize negative impacts from proposed developments and provide them with practical and cost effective measures to reduce the impacts; and
- NGOs and community organizations to better assess the social and environmental impacts of coastal aquaculture developments, and the efficacy of government EIA activity in this sector.

While the regional focus of this document is Eastern Africa, it draws heavily on experience from other parts of the world, and in particular SE Asia, where coastal aquaculture is far more developed, and where environmental issues related to aquaculture have already become significant. The document will therefore be relevant and useful to people from throughout the world with an interest in more sustainable coastal aquaculture development.

Scope

These guidelines go beyond previous environmental assessment (EA) compilations in one important respect. They strongly emphasize the need for sector EA (ideally as part of regional integrated EA) for aquaculture wherever it is likely to become a significant industry. This is necessary in order to address the problems associated with individually small scale but cumulative impacts, and the unacceptable costs of applying environmental assessment to large numbers of small aquaculture development proposals. These guidelines present specific and detailed advice on how to undertake these broader assessments.

Major sources

These composite guidelines draw on a wide range of existing resources. In particular, much of the more general structure and content is based on the UNEP EIA Training Resource Manual, (UNEP, 1996) and the accompanying book EIA: Issues, Trends and Practice (Bisset, 1996). These provide a thorough review of the "state of the EIA art", and represent broad international consensus on the nature of the EIA process, and best current and proposed future practice. This document in turn draws significantly on the findings of the International Study of the Effectiveness of Environmental Assessment (Sadler, 1996). Other key sources were the World Bank Environmental Assessment Source Book and OECD’s (1992) Good Practices for Environmental Impact Assessment of Development Projects. A wide range of other texts and guidelines were reviewed and contributed to the detail of these guidelines.

The literature on the application of EIA to aquaculture is more limited. The ADB (1987) Environmental Guidelines For Selected Agricultural and Natural Resources Development Projects, the UNEP (1990) Environmental Guidelines for Fish Farming, the NORAD (1992) Guidelines for initial environmental
assessment of aquaculture, and a more recent study by Vel (1996) on preparing an environmental impact assessment statement for aquaculture in India, served as useful starting points for adapting the more general EA guidelines to the specific needs of aquaculture.

The more detailed assessment and analytical tools related specifically to aquaculture are drawn from a wide range of literature on the resource characteristics of aquaculture and its interaction with the environment. Of particular relevance are Guidelines for the promotion of environmental management of coastal aquaculture development (Barg, 1992), and the various documents produced by GESAMP in recent years, including the current working papers and draft reports from GESAMP Working Group 31 on the Environmental Impacts of Aquaculture.

The document draws heavily on a range of guidelines and codes of practice for sustainable aquaculture which have been published in recent years, stimulated in part by the rapid development of shrimp farming. These include the FAO (1995) Code of Conduct for Responsible Fisheries, and the associated Technical Guidelines for responsible fisheries: aquaculture development (FAO, 1997); the draft World Bank report on Shrimp Farming and the Environment (Hempel and Winther, 1997); the FAO Technical Consultation on Policies for Sustainable Shrimp Culture (FAO, 1998); the Global Aquaculture Alliance Codes of Practice for Responsible Aquaculture; and Guidelines for the sustainable development of aquaculture in Belize (Huntington and Dixon, 1997).

Material relating specifically to Aquaculture in Eastern Africa is more limited. The Programme SEACAM de Formation en Evaluation Environnementale – Activite: Mariculture (Maharavo, 1999) is an important resource for the region, especially in relation to shrimp culture. Documents relating to the EIA for an environmentally responsible prawn farming project in the Rufiji Delta, Tanzania (Ndinbo et al., 1997), and those relating to an EIA of a shrimp farm near Bagamoyo (AIT, 1995) were important sources, as were recent documents from the Tanzania Coastal Management Partnership, especially the Mariculture Issues Profile (TCMP, 1998). A recent report on Estuarine Mariculture in South Africa produced for the South African Network for Coastal and Oceanic Research, and the Foundation for Research and Development (Cowley et al., 1998) provides important information on the context for coastal aquaculture development in South Africa.

**Terminology**

There is some variation in the literature in the use of terms. In particular some authors and organizations use the term environmental assessment (EA) while others use environmental impact assessment (EIA) for essentially similar activities. In this document we have used EA as a generic term for all forms of assessment. **EIA** is used specifically for project or farm level assessment. **Sector EA** is used to refer to environmental assessment of the effects of a particular sector (such as fisheries or aquaculture) or sector development plan, rather than to the effects of a specific project. **Integrated or regional EA** is the process of determining the regional cumulative environmental and socio-economic implications of multi-sectoral developments within a defined geographical area, over a defined period of time. **Strategic EA** is the process of identifying and addressing environmental consequences (and associated social and economic effects) of existing, new, or revised policies, plans and procedures. A full set of definitions and acronyms is presented in the Glossary.

**Document structure**

The structure of the guidelines (main document) is similar to that used by UNEP (1996) and many other standard guidelines on EA. Each section opens with a summary of content. Text boxes are used throughout the document to highlight specific lessons and experience, or to summarize key issues or techniques. References, plus a comprehensive bibliography, are annexed to the main document.
The Appendices contain several case studies; summaries of legal and institutional frameworks for aquaculture development in various countries; the bulk of technical material relating to the assessment and mitigation of the environmental effects of aquaculture; and the full text of the FAO Code of Conduct, and the Global Aquaculture Alliance Code of Practice.

Using these guidelines

Most policy makers or officials with some interest or responsibility relating to coastal development and environment will wish to use the overall summary (based on the individual section summaries) and refer to the main document only where necessary for clarification or further understanding. Those commissioning EA studies relating to aquaculture, or undertaking screening or initial environmental examinations, should read the bulk of the main guidelines. EA practitioners and technical specialists or academics are likely to make significant use of the technical material in the appendices.
Summary

Introduction and overview

1. Aquaculture is one of the most dynamic sectors in the world economy, with an annual growth rate exceeding 10%. Although growth has been slower and more erratic in Africa, there is great potential, and parts of the continent have a comparative advantage in terms of climate and resources. It is therefore probable that aquaculture, and especially coastal aquaculture, will grow significantly in future years.

2. Although aquaculture can compare well with many other development activities in terms of environmental impact, the over-rapid, unplanned, and unregulated development of the sector in some parts of the world (notably South and Southeast Asia and South America) has led to locally serious cumulative environmental impacts. Careful and strategic use of environmental assessment in its various forms should help prevent these problems occurring. Africa is fortunate in that it can draw on the experience and lessons from other parts of the world, where too often the benefits of coastal aquaculture development have been tainted by negative social and environmental impacts. It can also draw on the wealth of experience from around the world in the application of different environmental assessment methods and tools, and the use of a wide range of mitigation measures that can greatly reduce the potential environmental impacts of aquaculture.

3. Many African countries have already committed themselves in principle to the use of EA for development activities in the coastal zone. It is important that EA does not become a routine bureaucratic exercise, but rather is developed as a tool to facilitate and promote more sustainable aquaculture development. In order to minimize duplication and cost, and ensure consistency in assessment, sector level EA should be used to define the requirements and standards for farm or project level EIA, and as a means to address the cumulative problems associated with large numbers of small scale aquaculture developments.

Values and principles

4. In 1993 the Canadian Environmental Assessment Agency and the International Association of Impact Assessment launched an “International Study of the Effectiveness of Environmental Assessment” (ISEEA). It identified a series of core values, guiding principles, and operating principles. These are reproduced in full in section 2 of the guidelines.

5. EA can too easily become a cumbersome, routine, and ineffective set of bureaucratic procedures. It has often been lifted out of one context and applied inappropriately in another. By keeping these principles in mind, rather than focusing narrowly on specific procedures, the application of existing EA will be more flexible and cost-effective. These principles should also form a sound basis for the development of new or modified procedures applicable to particular sectors or development contexts.

Legal, policy and institutional context

6. EA cannot be effective as an isolated tool. If it is to be used to promote sustainable development and improve environmental management, and if the ISEEA principles are to be implemented, it must feed into a broader policy, planning, and regulatory framework. The lack of an adequate framework has been a significant constraint to the application of EA in many developing countries.
Developing and implementing environmental assessment systems

7. Section 4 of the guidelines discusses how environmental assessment systems and procedures can be initiated or improved in practice, specifically in relation to aquaculture. This will vary enormously from country to country, but some general principles and lessons learned from other countries are presented.

8. Particular emphasis is placed on the potential of (aquaculture) sector EA as an effective starting point for introducing or improving EA procedures, and ultimately as a building block for integrated coastal management.

9. The existence or setting of environmental quality standards is a precondition for effective EA, and an essential component of integrated coastal management. This can also serve as a practical starting point for improved procedures.

Overview of the environmental assessment process

10. Section 5 of the guidelines presents general guidance on the overall structure and process of EA, and the nature of the outputs, as it applies to aquaculture and other development types. It is strongly recommended that aquaculture sector EA be undertaken for the whole country, and preferably also in respect of important coastal systems. This should provide the basis for more efficient and effective project EIA if and when required. There is limited experience worldwide of sector EA to date.

11. The basic EIA process as applied to projects is now widely agreed. However, there are a variety of issues relating to best practice that are still the subject of intense debate. Although widely agreed as an essential part of the process, the scope and timing of public involvement is highly variable. The extent to which economic techniques can and should be used in EA also remains contentious.

Public involvement

12. It is widely accepted that EA should be open, transparent and democratic. Public involvement is seen as an essential component of EA by all major international organizations and development agencies.

13. The effective use of public involvement should shift the EA process from one of administration, regulation and document generation, to one which promotes more democratic decision making on issues affecting the quality of life, and which minimizes potential conflict, or resolves existing conflict.

14. Public involvement can be difficult, and requires great skill and sensitivity. Significant social conflict has been generated by coastal aquaculture development in Asian, and more recently African countries, and in some cases public involvement has actually increased conflict. Conflict is likely to be minimized if public involvement is an input to sector EA so that objectives, general principles and guidelines can be agreed without reference to specific and potentially contentious individual projects. Once these are in place, the ground rules are known, and the likelihood of conflict arising over individual projects is lessened.

15. If, nonetheless conflict arises, a variety of conflict resolution techniques may be used to minimize the damage and to move the EA process forward constructively.

Screening

16. Screening is the process used to decide whether or not a policy, plan, programme or project requires environmental assessment, and if so, at what level. Screening depends either on a subjective decision by an administrator, or (more usually) checking of a proposal against a set of standard criteria. These criteria may range from very general (such as “projects likely to cause potentially significant impacts”), to very specific (such as scale, location, type of activity, technology, relation to other resource users).
17. These criteria should be an output from sector environmental assessment. Where there is a strong environmental management framework, criteria can be made clearer and more explicit, and there will be less need for individual project EIA.

18. If there is uncertainty about a project in relation to the criteria, an initial environmental examination (IEE) or initial environmental assessment (IEA) may be required, and this may be subject to review by some form of advisory committee before decision is made about the need or otherwise for full EA.

19. Whatever criteria are used, it is important that they, and the screening procedures in general, should be widely known and understood, so that proponents can design to meet environmental standards, or locate in suitable areas, thereby minimizing costs to all parties, while maximizing environmental management benefits.

**Scoping**

20. Scoping is a process to identify and evaluate community and scientific concerns about a proposed policy, development plan, project or action, so that they can be addressed systematically in the EA. The output from scoping usually includes detailed terms of reference for further work.

21. Whereas in the past this was seen as a largely technical matter, it is increasingly seen as an important opportunity for public involvement in the decision making process. The use of improved techniques for the communication and exchange of information and opinion is therefore a vital part of scoping.

**Assessing**

22. Assessment is the core of EA, and involves identifying and defining more clearly the impacts that are to be investigated in detail, and analyzing these impacts in terms of their major characteristics and significance.

23. Assessing usually involves a range of techniques, from baseline data collection to modeling, and in some cases decision analysis.

24. Although many of the techniques are widely agreed, there is debate about the way in which different kinds of information (relating to social, environmental and economic impacts; or to impacts through time or space) can be presented or aggregated to provide an overall indication of impact significance or sustainability.

**Mitigation and impact management**

25. Since EA should be used more as a tool for improved environmental design and management, rather than as an administrative and regulatory procedure, the identification of mitigation measures becomes paramount. There is enormous scope for mitigating the environmental effects of coastal aquaculture. This can be done at several different levels through:

- improved planning and regulation;
- improved infrastructure;
- improved siting (closely related to planning and regulation);
- improved design;
- higher quality inputs;
- improved input and waste management; and
- improved husbandry and water quality management.

26. These measures can be encouraged or enforced through a suite of incentives, constraints and regulations, which are themselves a form of mitigation at sector level. The whole package, or parts of
it, may in turn be linked to quality or environmental management certification and/or product quality labeling initiatives.

27. Details of possible mitigation measures for coastal aquaculture can be found in the guidelines and appendices.

28. Public involvement and conflict resolution processes may contribute significantly to identifying and developing desirable or necessary mitigation measures.

**Reviewing and decision making**

29. Review of an EA report, and the process that generated it, is important to maintain standards and ensure neutrality, especially in respect of project EIA. It may also be used to provide a broader perspective on the issues raised, or a more specific perspective related to particular interest groups. In general terms it provides the additional information which decision makers may require in order to assess whether a proposal is acceptable (project EIA) or an environmental management plan for the sector desirable and feasible (sector EA).

30. The review process for project EIA should be clear and consistent, using standard criteria, for the sake of the proponent, the public, and the decision makers. This is likely to result in improved quality EAs.

31. Decision making will depend heavily on the report and the review process. It is essential therefore that both are clear and transparent. Decision making itself is not a single action, but a series of incremental actions, and the final outcome will depend heavily on many of the early decisions and choices. The nature of these early decisions must be clearly stated in the EA report.

**Monitoring**

32. Effective monitoring and follow up actions are essential if EA is to become an effective tool for environmental management and the promotion of sustainable development. Without follow up, EA becomes a costly and bureaucratic exercise with little long-term impact.

33. Monitoring is required not only to ensure than mitigation and environmental management plans are implemented, but also to see whether they work, and whether the analysis of impacts was accurate. As noted in the section on assessment, impact analysis is extremely difficult and is unlikely to be accurate in the first instance. Only through monitoring, adaptation and evolution will effective environmental management strategies be developed.
Chapter 1
Introduction and Overview

Summary

Aquaculture is one of the most dynamic sectors in the world economy, with an annual growth rate exceeding 10%. Although growth has been slower and more erratic in Africa, there is great potential, and parts of the continent have a comparative advantage in terms of climate and resources. It is therefore likely that aquaculture, and especially coastal aquaculture, will grow significantly in future years.

Although the environmental impacts from aquaculture can be relatively limited compared with many other development activities, the over-rapid, unplanned, and unregulated development of the sector in some parts of the world (notably S and SE Asia and S America) has led to locally serious cumulative environmental impacts. Careful and strategic use of environmental assessment in its various forms should help prevent these problems occurring in Africa. In this sense Africa is fortunate in that it can draw on the experience and lessons from other parts of the world, where too often the benefits of coastal aquaculture development have been tainted by negative social and environmental impacts. It can also draw on the wealth of experience from around the world in the application of different environmental assessment methods and tools.

Many African countries have already committed themselves in principle to the use of EA for development activities in the coastal zone. It is important that EA does not become a routine bureaucratic exercise, but rather is developed as a tool to facilitate and promote more sustainable aquaculture development. In order to minimize duplication and cost, and ensure consistency in assessment, sector level EA should be used to define the requirements and standards for farm or project level EIA, and as a means to address the cumulative problems associated with large numbers of small scale aquaculture developments.

Contents

- Global perspective on coastal aquaculture
- Coastal aquaculture in Eastern Africa
- What is EA?
- History and evolution of EA
- Relevance and importance for aquaculture development
- International commitments to EA
- Costs and benefits
- EA practice and experience in Eastern Africa
- International experience of the application of EA to aquaculture
1.1 Global perspective on coastal aquaculture

World Aquaculture production almost trebled in terms of production, and increased 3.5 fold in terms of value between 1984-1995. This corresponds to an average annual growth rate in production of 10% and in value of 12%, making aquaculture one of the most dynamic sectors in the world economy. There was significant expansion in all major categories.

**Figure 1.1. World Aquaculture Production Trends by Major Group (FAO).**

Although representing a relatively small part of total fisheries production, farmed crustacean production (mainly shrimp) has increased very rapidly, and now represents a significant proportion of total production, and a higher proportion of total value. A large part of this increase has come from marine shrimp production in Asia. Between 1983 and 1988 the average annual growth rate of marine shrimp farming in Asia was 41%, and by 1990 reached 5% of volume of cultured organisms (including fresh-water) in the region. The proportion in terms of value was very much higher. World production is now close to 700,000MT.

**Figure 1.2. Value of world aquaculture production.**
The success of shrimp farming is related mainly to:

- well established distribution and marketing systems in some countries (originally related to capture fisheries);
- high market value (US$5-10/kg farm gate price);
- short crop cycle (only 3-5 months for grow-out);
- the abundance of wild seed in some countries;
- the relative ease with which they can be spawned from wild broodstock;
- the ease of transportation of larvae;
- high tolerance of salinity variation and pond water quality during grow-out (especially Penaeus monodon); and
- adaptability to artificial diets.

Production of shrimp in Asia is now constrained by disease, shortage of wild broodstock, and in some cases the increasing scarcity of suitable sites. It is often associated with environmental degradation, and its impact on mangrove habitat has been of particular concern. While mangrove destruction and other environmental issues related to coastal aquaculture development is not yet a major concern in Africa, some problems have been identified in Cote d’Ivoire, the Gambia, Guinea Bissau, Madagascar, Mozambique and Senegal (King, 1993).

Despite the disease problems in many countries, well sited and managed shrimp culture remains extremely profitable, even on a small scale. Market demand (which is truly international) remains strong, providing a major incentive for entry of new countries/regions into marine shrimp production.

The culture of diadromous species (such as milkfish, salmon and seabass) has also increased very rapidly, and now amounts to more than 50% of production from capture fisheries. The culture of marine finfish on the other hand still contributes very little to total finfish production (capture and culture), although there is significant production of some high value species in Asian countries.

### 1.2 Coastal aquaculture in Eastern Africa

The growth of aquaculture production in Africa has been significantly less than in other parts of the world, and with some exceptions, production has been limited and erratic. Figure 1.3 provides an overview of trends in total aquaculture production in Eastern Africa, and figure 1.4 illustrates trends for some of the more significant coastal aquaculture activities in recent years. The most significant components at present are: giant tiger prawn (Penaeus monodon) production in Madagascar, seaweed (Eucheuma) culture in Tanzania, and mussel (Mytilus galloprovincialis) culture in South Africa.

Culture of the seaweed Eucheuma began in Tanzania in the '80s, stimulated by support from both government and private sector. However growth has slowed in recent years related in part to market constraints. The culture of the mussel (Mytilus galloprovincialis) in S. Africa began in the mid '80s, and has shown erratic growth since. The greatest contribution to the value of aquaculture production in the region is from tiger prawn (Penaeus monodon) production in Madagascar, where there has been significant investment in the planning and development of the industry in recent years. While the potential for shrimp culture has been recognized in several other countries, with significant proposals for shrimp farm development in Tanzania for example, development has been limited and erratic.
Figure 1.3. Aquaculture production in Eastern Africa countries.

Source: FAO

Figure 1.4. Significant mariculture activity in Eastern Africa countries.

Source: FAO

There has also been limited production of several other marine organisms including abalone, green turtle, Chelonia mydas, carpet shell (Tapes), and Mactra spp. Giant freshwater prawn (Macrobrachium rosenbergii), although not strictly a coastal species, is similar in many ways to brackish-water prawn culture, and is a significant industry in Mauritius and Reunion.

Pedini (1998) has summarized the reasons for the erratic and limited development of aquaculture in Africa:

- poor macro-environment for development;
- limited financial resources;
- differences in expectations between host countries and donor organizations;
• “project dependent” development;
• the novelty and low priority accorded to aquaculture;
• frequent drought and water shortage;
• lack of cohesive aquaculture development plans;
• inconsistency between aquaculture development strategies and local needs and circumstances; and
• excessively “top down” approaches to aquaculture development.

It is probable also that the lack of market and distribution infrastructure is a major factor.

Despite the recession in the world economy, demand for high quality seafood products is likely to remain high, and continuing rapid growth of aquaculture may be anticipated. Given the disease problems now endemic to coastal aquaculture industry in Asia, and the increasing scarcity of high quality sites in those countries, Africa offers significant potential for future expansion. Effective development policies must therefore be put in place if the mistakes made in aquaculture development in other countries are to be avoided.

1.3 What is environmental assessment (EA)?

Environmental (Impact) Assessment (EA or EIA) is:

The systematic, reproducible and interdisciplinary identification, prediction and evaluation, mitigation and management of impacts from a proposed development and its reasonable alternatives (UNEP, 1996)

The purpose of EA is to ensure that development proposals, activities, plans and programs are environmentally sound and sustainable. EA is a structured approach for obtaining and evaluating environmental information prior to its use in decision making in the development process. This information consists of predictions of how the environment is expected to change if certain alternative actions or policies are implemented, and advice on how best to manage environmental changes if one alternative is implemented. It may refer to individual physical actions, development projects, programmes, plans or policies. (modified from Bisset, 1996).

Increasingly, EA is considered as a management tool rather than as an administrative or regulatory process. In particular it may be used to:

• modify and improve the content or design of a policy, plan or proposal;
• ensure that resources are used efficiently;
• enhance the social aspects related to a proposal;
• identify measures for monitoring and managing impacts; and
• facilitate informed decision making, especially in relation to sustainability criteria.

1.4 History and evolution of EA

Environmental impact assessment procedures first evolved from the application of the US National Environmental Protection Act (NEPA) 1970. It spread rapidly to other countries in the late ’70s and early ’80s, and is now widely used and internationally recognized. There is a growing consensus on the main elements and procedures involved, but there remains considerable uncertainty about when and how it should be used.

In its original form the emphasis was on physical, chemical and ecological impacts of individual projects. In the late ’70s and early ’80s however, the scope expanded in many countries to include social and
health impacts, and more comprehensive analysis of risk. Public involvement in the process was also increasingly emphasized. In terms of outputs and reporting, emphasis was placed on impact management.

By the mid to late '80s the importance of addressing cumulative effects was recognized, and **Cumulative Environmental Assessment (CEA)** became an important component in effective project level EIA. This is of particular relevance to agriculture and aquaculture projects where the impacts of an individual farm may be insignificant, but those associated with many small developments may be highly significant. The need to integrate the EA process with policy, planning and regulatory frameworks also began to be recognized. Monitoring, audit and other follow up procedures – or impact management planning – also became important elements in best practice EIA.

Unfortunately, there has been a continuing – and in many countries increasing – trend of resource degradation and loss of biodiversity. Despite international commitments, many kinds of development having significant impacts on the environment have either not been subject to EA, or their impacts (especially those of an incremental or cumulative nature) have not been easy to mitigate through existing EIA procedures.

Awareness of this continuing loss, and the need to address environmental issues at a broader development planning and policy level was a major stimulus to the development of the idea of **sustainable development**, defined most succinctly in its original expression:

> Development that meets the needs of today's generation without compromising those of future generations (World Commission on Environment and Development, 1987).

Partly in response to this, a “second generation” of EA procedures has developed which may be used to promote sustainable development. They include **Integrated or Regional EA; Sector EA; Programmatic EA**; and **Strategic EA (SEA)** which refers to EA of higher level policies. Together with project EIA and Cumulative EA these represent a comprehensive package of tools that can be applied at all levels – and hopefully in a coordinated way – from international trade agreements down to individual projects.

The main principles relating to best practice application of all these approaches may be summarized as follows:

- fully integrate physical, social, economic and environmental analyses within the EA process;
- integrate EA into the development policy and planning process at all levels (project, program, plan, policy, budget/fiscal measures, structural adjustment measures, trade agreements) as a tool for decision making and the promotion of sustainable development;
- introduce EA at the earliest possible stage in policy, plan or project development, so that it can be used as a design tool rather than as a restriction;

**Box 1.1. The relevance of regional and sector EA to aquaculture**

Like agriculture, most individual aquaculture projects are relatively small scale and have little significant impact on the environment. A large number of such developments can however have significant effects.

Traditional “project” EIA is inadequate to address these “cumulative” or “incremental” issues. They can be addressed in part through the use of cumulative environmental assessment (CEA) as part of project EIA. However, a useful practical response in the case of an individual project assessment is unlikely: it is administratively and legally difficult to limit one development on the basis that there may be others.

Furthermore, high quality EIA applied individually to a large number of small aquaculture developments is likely to be unacceptably costly. Sector EA, or regional EA incorporating the aquaculture sector, should be undertaken to adequately address these issues, if possible within a broader framework of integrated coastal management (ICM), or national policy level Strategic EA.
• promote positive impacts as well as mitigate negative impacts;
• use EA as a framework for conflict resolution;
• encompass trans-boundary effects; and
• effectively link EA to monitoring and environmental management.

Goodland (1995) noted the new opportunities presented by EA when applied to sector studies and project appraisal. In the past the "least economic cost" criteria was commonly used to rank projects. If EA can be effectively integrated into such studies, projects may be ranked according to least economic, social, and environmental cost, providing a basis for the selection of the most sustainable development options.

To date the practical implementation of these more advanced approaches has been limited, especially in developing countries, but the concept is receiving widespread support from Governments, NGOs, Agencies and Development Banks.

1.5 Relevance and importance for aquaculture development

Aquaculture is one of the fastest growing sectors of the world economy. It is one of relatively few activities offering real hope of significant poverty alleviation or elimination in the coastal zone, where land-less people are commonly marginalized, and where land quality is often poor and unsuitable for agriculture. However, the success and potential of aquaculture has often been tarnished by social and environmental problems including:

• direct and indirect resource and biodiversity degradation;
• resource use conflict;
• social disruption, including increases in inequity;
• catastrophic or chronic disease problems; and
• direct and indirect health impacts, particularly in relation to indiscriminate use of chemicals and antibiotics.

Strategic and project level EA, undertaken as key components of more integrated approaches to development planning and project appraisal, provide a feasible and practical framework for addressing these issues, and promoting sustainable aquaculture. They may also serve as a keystone in the further development of integrated coastal management (ICM).

1.6 International commitments to EA

The role and importance of EA was formally recognized at the United Nations Conference on Environment and Development held in Rio in 1992. Rio Principle 17 states:

*Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.*

The commitment of African countries to this principle was reaffirmed in the communiqué issued by African Ministers and representatives at Durban, South Africa, June 24-25th 1995. They committed themselves to:

*Formalize the use of EA within a legislative framework for development planning and decision making at the project, programme and policy levels.*

The need to take account of environmental impact specifically in relation to aquaculture development is recognized in Article 6.19 of the FAO Code of Conduct for Responsible Fisheries:
States should consider aquaculture, including culture based fisheries, as a means to promote diversification of income and diet. In so doing, States should ensure that resources are used responsibly and adverse impacts on the environment, and on local communities are minimized.

and Article 9.1.5 states:

States should establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring with the aim of minimizing adverse ecological changes and related economic and social consequences resulting from water extraction, land use, discharge of effluents, use of drugs and chemicals, and other aquaculture activities.

Regarding shrimp aquaculture, at the FAO Bangkok Technical Consultation on Policies for Sustainable Shrimp Culture (FAO, 1998) Government representatives from major shrimp farming countries\(^1\) agreed that:

Achievement of sustainable shrimp culture is dependent on effective government policy and regulatory actions as well as the cooperation of industry in utilizing sound technology in its planning, development and operations.

Governments should have a legal framework which applies specifically to coastal aquaculture, including shrimp culture.

Considering the significance of appropriate national development planning for the sustainability of aquaculture, it was recommended that when States undertake strategic planning for national development, they should place aquaculture, including shrimp culture, within such plans.

The UN Convention on Climate Change and Biological Diversity (1992) places further obligations on member countries in respect of EIA.

The World Bank, Asian Development Bank and other international development aid agencies have all introduced and promoted EA as an important tool in development planning, feasibility studies, and project appraisal in recent years, and the World Bank in particular is promoting the more integrated and strategic approaches discussed above.

1.7 Costs and benefits

The costs and benefits of the application of EA to aquaculture have not been rigorously assessed, and evidence is limited, especially in Africa. However, the current problems associated with coastal aquaculture in developing countries which already implement some form of EA for aquaculture, suggest that it has not always been cost effective. The continuing emphasis on project level EIA, rather than sector or strategic EA, has almost certainly contributed to this failure.

1.7.1 Costs\(^2\)

The World Bank notes that the cost of preparing an EA rarely exceeds one per cent of the project costs and even this relatively low cost can be reduced further if local personnel are used to do most of the work. For instance, an investigation of water resource projects in Thailand found that the costs of EIAs there ranged from 0.01 per cent to 0.11 per cent of the total project costs.

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1  Bangladesh, China, Ecuador, India, Indonesia, Malaysia, Mexico, Philippines, Sri Lanka, Thailand, USA, Vietnam.
2  This section is summarized from the UNEP EA training resource manual, with some additions relating to the specific case of aquaculture.
The costs of EA, if applied to large numbers of individual fish farms, may however represent a significant cost to a small producer and to the sector as a whole. This is one reason why a size “threshold” is set for EIA requirements for aquaculture in some countries in Asia (e.g. Malaysia, Indonesia). Unfortunately this allows the majority of aquaculture development to “escape” the EA system, and has resulted in widespread uncontrolled development in some Asian and S American countries. The solution to this problem is not to reduce the size threshold, but rather to apply sector EA, which allows the cost to be spread over a large number of developments, while at the same time addressing the cumulative and incremental problems noted above.

Although proponents sometimes complain that EIA causes delays in projects, these are often caused by poor administration of the process rather than by the process itself. These occur when:

- the EIA is commenced too late in the project cycle;
- the terms of reference are poorly drafted;
- the EIA is not managed to a schedule;
- the EIA report is inadequate and needs to be upgraded; and
- there is a lack of technical data.

Adherence to the guidelines presented here should reduce the risks of these problems arising.

Furthermore, if there is a shift to sector EA, the need for individual project EIA should be reduced, since acceptable locations, type and scale of aquaculture activities would already have been defined.

There is no standard timeframe for the EA process. Most projects merely require screening and might take only an hour or two’s work. An initial environmental examination (IEE) might take a day or more. For a medium sized aquaculture project the whole EIA process may take a few weeks to a few months, whereas for a large farm or sector plan the EA process could take significantly longer. Regional or strategic EA may be on-going, routinely undertaken for example as part of regular (e.g. 5 year) planning.

The costs and time involved in EA decrease once experience is gained with the process and the availability of baseline data is increased.

1.7.2 Benefits

The potential benefits from EA increase when the process commences early in the policy development or project design process.

In general the benefits of EA include:

1. **Improved policies, programs, plans or regulations for promoting environmentally sustainable aquaculture.** These can be developed or adapted in the light of sector EA to optimize the location of aquaculture activities in terms of productivity, minimizing self pollution, minimizing conflict between farms or with other resource users, and minimizing resource and biodiversity degradation. They may promote restrained and sustainable aquaculture development, avoiding the social, economic and environmental disruptions caused by boom and crash production cycles at individual farm or sector level.

2. **More environmentally sustainable design or better siting of a farm or farms.** Carrying out an EA entails an analysis of possible alternatives in the design and siting of projects. This results in an overall improvement in the general state of the environment and location of projects or activities. A well designed project can also minimize the risk of project-induced disease and the associated costs of treatment or compensation.
3. **Savings in capital and operating cost.** Costs can escalate if environmental problems have not been considered at the beginning and require correction later. This may involve adopting expensive mitigation measures, or reducing the size or output of the project. The chances of expensive late changes can be minimized by carrying out EA at the earliest stages of the project cycle. The costs to the aquaculture industry of poor planning, siting, design and management (resulting in self pollution and disease) are well known, and amount to billions of dollars worldwide.

4. **Reduced time and costs of approvals of development applications.** If all environmental concerns have been taken into account before submission for project approval, then it is unlikely that delays will occur. Again, this particularly the case if sector EA has been undertaken.

5. **Increased project acceptance by the public.** This is achieved by public involvement throughout the process. Many of the social problems, which have arisen in relation to some of the larger shrimp farming projects in S and Central America and Asia, might have been avoided with adequate and carefully planned public involvement.

### 1.8 EA practice and experience in Eastern Africa

There are rather few objective studies of the application and value of EA procedures in Africa. An exception is the study by IIED (Mwalyoshi and Hughes, 1998) of the application of EA in Tanzania. This concludes that EA has had little impact on decision making in Tanzania. The following limitations were identified:

- usually started late in project development;
- under-resourced;
- limited stakeholder involvement;
- output, rather than process orientated;
- limited input to design or location issues;
- limited identification, costing and integration of environmental management into project design;
- poor definition of compliance responsibilities;
- EIA seen as an impediment to development; and
- limited monitoring or audit.

Although EA procedures are allowed for in the legislation of most African countries, experience of their application to aquaculture is limited. This reflects the generally undeveloped status of aquaculture, and the small scale of most individual developments. However EIA procedures have been applied to two shrimp farm projects in Tanzania in recent years. The first was an Initial EA, undertaken for a potential sponsor (NORAD) relating to a medium scale (160 ha) shrimp farm on the Ruvi river near Bagamoyo. The second related to a large shrimp farm in the Rufiji Delta, also in Tanzania. The latter was a comprehensive project EIA. It was specifically highlighted in the Mwalyoshi and Hughes study, as a case of an EIA that led to intense public debate – a clear example of “public involvement”.

These examples are instructive since the process and outcome were very different in the two cases. In the first case, funding had been sought from NORAD for a moderate scale shrimp farm development sited on the landward fringe of the mangrove of the Ruvi river estuary. NORAD required an initial EA using their own guidelines (NORAD, 1992), which was undertaken by foreign consultants (AIT, Thailand). Though few serious impacts were identified in relation to the project itself, the IEA report pointed out the dangers of associated cumulative development, and the lack of an appropriate coastal planning framework to address these issues. NORAD did not support the project, and it has not materialized. In the second case a much more comprehensive EIA was undertaken, including public meetings, which led to both local and international debate. These examples are used to illustrate particular aspects of aquaculture EA at various points in the guidelines, and form the basis for a more detailed case study (Appendix 1).
Madagascar is the only country in the SEACAM region which has undertaken a sector EA focussing in particular on shrimp culture, which has led to a set of clear guidelines and procedures for the assessment and development of the industry. The framework and approach used in Madagascar is presented and discussed in Appendix 2.

1.9 International experience of the application of EA to aquaculture

EA procedures relating to aquaculture are extremely varied throughout the world, and even vary significantly between states in federally organized countries. The main approaches may be summarized as follows:

- EIA not required for aquaculture projects (e.g. Thailand);
- full EIA not legally required, but specific forms of information and consultation required with environmental agencies or other interests prior to aquaculture development approval (marine cage culture in Scotland);
- aquaculture projects “screened” to determine need for EIA (e.g. Tanzania);
- initial environmental examination (IEE) required as input to screening (e.g. Sri Lanka, Indonesia, Philippines);
- EIA required for aquaculture above a certain scale (e.g. Malaysia 50 ha; India 40 ha);
- EIA required for aquaculture in “environmentally sensitive areas” (e.g. Indonesia, UK);
- EIA required for farms above a certain scale and located in environmentally sensitive areas (e.g. Sri Lanka, 5 ha; Malaysia, 50 ha (mangrove));
- EIA normally required for all coastal aquaculture (e.g. Australia; USA; many European countries); and
- EA undertaken for aquaculture sector leading to the establishment of a planning and regulatory framework for individual farms (e.g. Hong Kong, Tasmania, Norway).

In practice most countries operate a mix of these approaches. Some examples are provided in Appendix 2.

In developing countries, these different approaches have met with only limited success in terms of promoting sustainable aquaculture development. For example, both Sri Lanka and Indonesia, which have reasonably comprehensive sector specific legislation including well defined EIA procedures, have experienced serious local environmental degradation and industry crashes related to disease (see Case Study 2). Current procedures would appear to be inadequate to meet the challenge of the rapid and unplanned development of a highly profitable industry such as shrimp farming. The biggest problem probably relates to the nature of most aquaculture development. Fish farms are usually far too small to be subject to individual project environmental assessment. In the absence of broader sector EA, aquaculture development commonly escapes the “EIA net”. Furthermore, even when high quality EIA is undertaken for larger enterprises, follow through, in terms of environmental management, monitoring, and ensuring compliance is usually limited. Some developed countries operate comprehensive monitoring and follow up to ensure compliance, or in some cases to assess suitability and effectiveness of any discharge or management conditions set (e.g. Australia).

Overall, procedures appear to have worked rather better in developed countries, but this may be related to larger scale operations, and lower overall pressure for development.
Chapter 2
Values and Principles

Summary

In 1993 the Canadian Environmental Assessment Agency and the International Association of Impact Assessment launched an “International Study of the Effectiveness of Environmental Assessment” (Sadler, 1996). It identified a series of core values, guiding principles, and operating principles. These are reproduced in full in this section.

EA can too easily become a cumbersome, routine, and ineffective set of bureaucratic procedures. It has often been lifted out of one context and applied inappropriately in another. By keeping the following principles in mind, rather than focusing narrowly on specific procedures, the application of existing EA will be more flexible and cost-effective. These principles should also form a sound basis for the development of new or modified procedures applicable to particular sectors or development contexts.

At the end of this section some important general conditions and requirements for effective EA are summarized.

Contents

• Core values
• Guiding principles
• Operating principles
• Key requirements
• Comment

2.1 Core values

1. sustainability - the EIA process will result in environmental safeguards;
2. integrity - the EIA process will conform to agreed standards; and
3. utility - the EIA process will provide balanced, credible information for decision-making.

2.2 Guiding principles

1. participation - appropriate and timely access to the process for all interested parties;
2. transparency - all assessment decisions, and their basis, should be open and accessible;
3. certainty - the process and timing of assessment should be agreed in advance and followed by all participants;
4. accountability - decision makers are responsible to all parties for their actions and decisions under the assessment process;
5. credibility - assessments are undertaken with professionalism and objectivity;
6. cost-effectiveness - the assessment process and its outcomes will ensure environmental protection at the least cost to society;
7. flexibility - the assessment process should be able to adapt to deal efficiently and effectively with any proposal or decision making situation; and

8. practicality - the information and outputs provided by the assessment process are readily usable in decision making and planning.

2.3 Operating principles

EIA should be applied:

1. to all development project activities likely to cause potentially significant adverse impacts, or add to actual or potentially foreseeable cumulative effects;

2. as a primary instrument for environmental management to ensure that impacts of development are minimized, avoided or rehabilitated;

3. so that the scope of review is consistent with the nature of the project or activity and commensurate with the likely issues and impacts; and

4. on the basis of well-defined roles, rules and responsibilities for key actors.

EIA should be undertaken:

5. throughout the project cycle, beginning as early as possible in the concept design phase;

6. with clear reference to the requirements for project authorization and follow-up, including impact management;

7. consistent with the application of ‘best practicable’ science and mitigation technology;

8. in accordance with established procedures and project-specific terms of reference, including agreed timelines; and

9. to provide meaningful public consultation with communities, groups and parties directly affected by, or with an interest in, the project and/or its environmental impacts.

EIA should address, wherever necessary or appropriate:

10. all related and relevant factors, including social and health risks and impacts;

11. cumulative and long-term, large-scale effects;

12. design, locational and technological alternatives to the proposal being assessed; and

13. sustainability considerations including resource productivity, assimilative capacity and biological diversity.

EIA should result in:

14. accurate and appropriate information as to the nature, likely magnitude and significance of potential effects, risks and consequences of a proposed undertaking and alternatives to it;

15. the preparation of an impact statement or report that presents this information in a clear, understandable and relevant form for decision making, including reference to qualifications, confidence limits in the predictions made; and

16. ongoing problem solving and conflict resolution to the extent possible during the application of the process.
EIA should provide the basis for:

17. environmentally sound decision-making in which terms and conditions are clearly specified and enforced;
18. the design, planning and construction of acceptable development projects that meet environmental standards and resource management objectives; and
19. an appropriate follow-up process with requirements for monitoring, management, audit and evaluation that are based on the significance of potential effects, the uncertainty associated with prediction and mitigation, and the opportunity for making future improvements in project design or process application (Sadler, 1996).

2.4 Key requirements

Although the application of these values and principles should be flexible according to sector or local conditions, several key requirements have been identified for effective EA systems (Bisset, 1996):

- a legal base with accompanying regulations and guidelines;
- stakeholder involvement;
- high level political commitment;
- technical capacity;
- formal review of EA reports;
- mechanisms to encourage accountability of decision makers; and
- a clearly defined role for an environmental agency.

2.5 Comment

The values and principles set out above were discussed in detail at the training course held in Dar es Salaam in June 1999. The participants agreed with all the values and principles. However, it was felt that “neutrality” or “impartiality” should be included as a core value or guiding principle.

This has implications for the way in which EIA is commissioned. The cost of EIA is traditionally born by the developer, and it is therefore the developer who typically commissions the EIA. This may compromise the principle of neutrality. Countries should therefore examine ways in which EIA can be commissioned by an independent agency, while still ensuring that the full cost is born by the developer.

The participants also noted the difficulty of reconciling some of the principles. Participation, transparency, and credibility all cost a great deal of money, and may be difficult to reconcile with minimal or acceptable cost to society. Possible ways to get around these problems are discussed in the next two sections.
Chapter 3
Legal, Policy and Institutional Framework

Summary

EA cannot be effective as an isolated tool. If it is to be used to promote sustainable development and improve environmental management, and if the principles described in the previous section are to be implemented, it must feed into a broader policy, planning, and regulatory framework.

The lack of an adequate framework has been a significant constraint to the application of EA in many developing countries.

Contents

- The need for a framework
- International recognition of the need for a legal framework for EA of aquaculture
- Frameworks in practice
- Environmental agency

3.1 The need for a framework

Project or farm level EIA of aquaculture, in the absence of a broader legal, policy, planning or institutional framework, is unlikely to result in sustainability for the sector as a whole, nor will it address many of the principles listed in section 2. This has been a significant weakness in the application of EIA for aquaculture in many countries.

- A legal framework is required to allocate specific responsibility and accountability, as well as provide a broad policy framework for the development of more specific policies and plans relating to particular regions or sectors;
- A planning framework is required to take account of locational, cumulative, and strategic development issues; and to define development objectives, economic and environmental standards and targets, and decision criteria;
- A regulatory framework is required to prescribe and enforce specific operating or environmental standards;
- An institutional framework is required to develop policies and plans, to ensure compliance with regulations, and to monitor, review and adapt policies, plans and regulations in the light of experience.

Without such a context the findings of any EA will have little meaning, decision criteria will be inconsistent, and mechanisms for ensuring compliance with any recommendations will be lacking. In particular, there will be no mechanism for addressing cumulative and incremental environmental issues, which are a basic characteristic of agriculture and aquaculture developments.

For example, cumulative EA may be undertaken in respect of a particular project, and may identify impacts which are insignificant when considered in isolation, but which may cause problems when “added” to other existing or possible future developments in the area. However, since these are not directly
attributable to the development being considered, mitigation is hard to prescribe, and an appropriate regulatory response is unclear. It is hard to refuse authorization to a project on the basis that, if there were many more such projects, there could be environmental problems. If on the other hand, authorization is refused, this may limit development, rather than promote sustainable development. Box 3.1 provides a specific example of this dilemma, and the lack of a satisfactory solution in the absence of a broader planning or policy framework.

This problem should be solved in part through the application of Sector or Regional EA. The mitigation measures prescribed for the sector or region should encompass an adequate response to cumulative or incremental impacts. This might include zoning for different activities, and/or an overall ceiling on the number of developments, the total production from an area, or the total acceptable nutrient load. In all these cases some form of consistent overall framework is required.

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**Box 3.1. EIA of a shrimp farm in Tanzania**

*The importance of a broader environmental management framework for effective EA*

In 1994 a private company sought assistance from NORAD for the establishment of a shrimp farm on a 600 ha site on the south side of the Ruviu river, about 5 km from the sea, near Bagamoyo, Tanzania. Initially 160 ha of ponds were to be developed, with an estimated production of around 500 mt per year. The farm site was set adjacent to the mangroves of the Ruviu River, the largest single expanse of mangrove in the Bagamoyo District.

NORAD commissioned an initial EIA which was undertaken by AIT, Thailand (AIT, 1995), using the NORAD (1992) Guidelines. The EIA report discussed and summarized all the major impact issues, and proposed a comprehensive set of mitigation measures, covering design, technology and management. The overall tone of the assessment was positive, and the final paragraph of the executive summary stated:

> We believe that if such (mitigation) procedures are followed, the proposed project might become a model for the development of sustainable shrimp culture throughout the world, and in this sense offers a unique opportunity for realizing the undoubted and substantial potential benefits offered by well planned and managed farms.

However, it had already cautioned:

> If appropriately designed and managed, and if considered in isolation, this farm is unlikely to have a significant impact on the environment. However, in many other parts of the world successful farms have attracted uncontrolled smaller scale satellite developments which in places have had a serious cumulative impact on the environment and the sustainability of shrimp farming itself. It is essential that this and future developments take place within a planning and regulatory framework which will prevent uncontrolled development and ensure on-going responsible management practices. Without such a framework, this development may simply become a small part of a wider development problem.

It would appear that this caution, and the evident lack of any wider environmental management framework, was taken seriously, and funding for the project was rejected.

This example demonstrates that EIA in the absence of a broader environmental management framework cannot be used as a positive planning or management tool. It will either allow or restrict development, on a relatively ad hoc basis, dependent largely on the knowledge or bias of the EIA contractor and the decision maker. It will be based on no broadly accepted decision criteria. If mitigation measures are recommended, there will be little chance of them being implemented, especially if they are associated with additional costs.
3.2 International recognition of the need for a legal framework for EA of aquaculture

The importance of legal, procedural and planning frameworks designed to facilitate sustainable aquaculture development is emphasized in the FAO Code of Conduct for Responsible Fisheries:

9.1.1 States should establish, maintain and develop an appropriate legal and administrative framework, which facilitates the development of responsible aquaculture.

9.1.3 States should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities.

The need for a clear and comprehensive legal framework has been explicitly recognized by all those countries that have become significant producers of farmed shrimp. At the FAO Technical Consultation on Policies for Sustainable Shrimp Culture the following recommendation was made:

Governments should have a legal framework which applies specifically to coastal aquaculture, including shrimp culture.

and appropriate objectives for such a framework should be to:

• facilitate and promote the development of sustainable aquaculture practices;
• promote the protection of coastal resources; and
• promote the contribution of aquaculture to food security, national and international wise.

A variety of recommendations are presented in the FAO technical consultation report for the content of an appropriate legal framework, including provisions for EA, and a further technical consultation on the issue is planned.

3.3 Frameworks in practice

There will be a range of possible approaches depending on existing laws, traditions, and institutional structures. For example, the legal and institutional framework could be built up around:

• specific EA legislation;
• sector planning;
• regional or district planning; and
• watershed or coastal zone planning and management.

The key point is to develop or adapt a system that allows for the comprehensive application of the principles set out in section 2. It may also be worth introducing guidelines prior to specific legislation as a means of testing out different approaches.

3.3.1 Ideal frameworks

The ideal is perhaps a “tiered” system (sometimes known as a “planning cascade”) incorporating an appropriate form of EA at each level. An idealized framework applicable to aquaculture and other coastal activities is presented in Figure 3.1. Several “real world” examples are described in more detail in Appendix 2.
The framework presented in Figure 3.1 assumes a vertically and horizontally integrated planning and assessment framework. Broad national level policies define the scope, power, and responsibilities for lower level planning and assessment initiatives relating to aquaculture, coastal, or aquatic resources. These more local initiatives (perhaps at district, coastal bay, estuarine system or watershed levels) may in turn define or feed back into higher level policy. National and local level policy and planning should evolve steadily in parallel, and be progressively adapted and refined, with the overall objective of promoting or facilitating sustainable development, and/or constraining or preventing unsustainable development. Broad frameworks of this kind would go a long way toward meeting the principles presented in section 2.

### 3.3.2 Sector Environmental Assessment

In practice the level of vertical and horizontal integration required in these “ideal” systems may be difficult or impossible to achieve in many development contexts. Sector EA, associated with sector plans for a particular administrative unit (such as a district) or aquatic resource system (such as a bay or estuary), may be a more realistic objective, and more effective in the short term. This is of particular importance when addressing the sometimes rapid development of aquaculture. The process of sector or regional EA should define environmental standards, possible zones (suitable areas for aquaculture development), and criteria for the assessment of individual projects. A sector EA for the mariculture industry in Hong Kong provides an example of such an approach (Box 3.2). To a large degree such approaches should remove the necessity for project EIA on all but a few exceptional projects. Ideally sector EA would then “nest” within, and form the building blocks or stimulus for broader integrated coastal management initiatives.

Sector EA for aquaculture is probably essential if the values and principles presented in the previous section are to be applied in practice in a cost effective way.

### 3.4 Environmental agency

Several analysts suggest that the existence of an *environmental agency* may be an important component in any framework for the application of effective EA. The role of such an agency might include the following:

- approval of TOR;
- implementation of stakeholder involvement, including formal public hearings on draft/final EIA reports;
- review of EIA quality;
- making a recommendation, or issuing an environmental approval/decision document (though this perhaps role for another agency – e.g. local government);
- control over environmental management audit procedures; and
- development of standards and guidelines.

(modified after Bisset, 1996)

An environmental agency can play a key role in ensuring the neutrality and quality of any EA.
Figure 3.1. Model legal and institutional framework for effective EA of aquaculture.

National Umbrella Legislation (e.g. Coastal or Aquatic Resource Management):
- principles, values, definitions;
- provisions for access and title to coastal and aquatic resources;
- legal liabilities;
- fiscal incentives and disincentives (standard taxes, charges, subsidies);
- provisions and requirements for the design and application of more specific regulations;
- planning requirements/obligations at different administrative levels; and
- institutional responsibilities; enforcement responsibilities; accountability.

National Sector Legislation
- sector specific principles and objectives;
- identification of activities or practices requiring special attention or regulation;
- criteria for assessment, promotion or restriction of activities;
- broad codes of practice; and
- responsibility and accountability.

Regional Policy, Planning, and Regulation
- regional level policy statements based on regional resources;
- regional plans, including e.g. specific development and environmental quality standards/targets;
- location incentives or restrictions; specific regulations or guidelines;
- environmental monitoring and audit procedures; and
- procedures for project EIA.

District or Local Plan
- objectives and targets;
- voluntary agreements; local codes of practice; linked marketing initiatives;
- finance and investment initiatives;
- local incentives and constraints (consensus);
- training, awareness
- promotion; and
- conflict resolution.

Strategic/sector EA

Regional/sector EA

Project EA (on selected projects only)

Public involvement

- legal basis,
- stimulus; feedback; adaptation
- stimulus; information, review

National Environmental Agency (EA quality control)
Box 3.2. Sector EA of aquaculture: the case of Hong Kong

The rearing of high value marine finfish (grouper, seabream, etc.) in net cages was a growth industry in Hong Kong from 1970 to 1990. The government designated 28 mariculture zones under a Marine Fish Culture Ordinance in 1982, and in 1990 there were 1,770 licensed operators, and the industry supported directly and indirectly about 6,000 people. The production of fish in 1989 was 3,020 MT with sales of around US$ 24 m.

As marine cage farming developed in Hong Kong, impacts from people and animals residing on rafts, litter and debris affecting coastal areas, and the release of nutrients and organic matter from fish cages became of increasing concern. In response the Environment Protection Department of the Government of Hong Kong undertook a sector environmental assessment (EA) of the marine cage farming industry in 1990.

The EA quantified pollutant loads from the marine cages and made recommendations on the future environmental management of the industry. Particular attention was given to impacts of solid organic wastes on benthic communities, effects of release of soluble nitrogen on phytoplankton production, eutrophication and visual impacts. The study concluded that impacts of marine cage farming were fairly localized and that “there is a place for cage fish farming in the overall utilization of Hong Kong’s coastal waters”. It concluded that the concerns raised were mainly a result of:

(a) designation of some mariculture zones which were unsuitable because of their limited environmental capacity;

(b) lack of compliance by farmers with certain components of the Marine Fish Culture Ordinance (particularly those relating to visual impacts); and

(c) inefficient fish husbandry leading to pollution from feed wastage and dead fish.

The EA recommended further stepping up of enforcement of the Marine Fish Culture Ordinance to reduce visual impacts, and introduction of improved fish feed management practices to reduce wastage. It further suggested relocation of marine cage farmers from certain aquaculture zones (with limited environmental capacity) to more open water sites.

The Hong Kong government subsequently initiated a programme to replace the widely used minced ‘trash fish’, which has a high pollutant load, with a low polluting moist diet, which by 1997 was being used by an increasing number of farmers. There has also been experimental work on ‘offshore’ cages which can be located in more open waters with high environmental capacity.

However, implementation of the recommended management strategies were not successful in protecting the cage culture from the phytoplankton blooms which caused serious losses to the marine cage industry in early 1998. These blooms were probably caused by a wide range of factors (rather than aquaculture itself), and this highlights the need to incorporate the environmental management of aquaculture within broader coastal environmental management initiatives.
Chapter 4
Developing and Implementing Environmental Assessment Systems

Summary

This section discusses how environmental assessment systems and procedures can be initiated or improved, specifically in relation to aquaculture. This will vary enormously from country to country, but some general principles and lessons learned from other countries are presented.

Particular emphasis is placed on the potential of aquaculture sector EA as an effective starting point for introducing or improving EA procedures, and ultimately as a building block for integrated coastal management.

The existence or setting of environmental quality standards is a precondition for effective EA, and an essential component of integrated coastal management. This can also serve as a practical starting point for improved procedures.

Contents

- Building on existing procedures
- Minimizing bureaucracy, duplication and cost of EA
- Sector EA as a starting point
- The need for agreed environmental quality standards
- Learning from experience: monitoring and adaptation
- Overview of the relation between different environmental management initiatives
- Costs and financing

The introduction of efficient and effective environmental assessment for aquaculture will vary tremendously between countries depending on existing policies, laws, institutions, procedures, and attitudes to environmental issues. There is no simple formula. There are however some general principles that may be applied, useful approaches to developing procedures, and several examples to draw on.

Box 4.1. The statutory basis for EIA in South Africa

Marine Fisheries Policy:

- Development of mariculture operations will be encouraged within the limits of relevant appropriate environmental regulations;
- Mariculture research and the development of expertise will be a national effort, and will be promoted by the State as well as by the private sector;
- The introduction of foreign species will be controlled and care will be taken over possible environmental effects, particularly with respect to any resulting impacts on indigenous stocks;
- A full environmental, economic and social impact study will be carried out prior to the establishment of any commercial scale operations; and
- The problems of the effect of pollution, or from, mariculture will be addressed.

Marine Living Resources Bill

- No person shall engage in mariculture unless a right to engage in such activity has been granted to such person;
- An application to engage in mariculture shall be submitted to the Minister in the manner that the minister may determine;
- The minister may require an environmental impact assessment report to be submitted by the applicant; and
- The right to engage in mariculture may be granted for the period that the minister may determine

Source: Cowley et al., 1998
4.1 Building on existing procedures

The introduction of any new set of procedures is often disruptive, may involve extra work, may compromise existing power relations, and may be resisted by (or conversely taken over by) vested interests. While completely new institutions or responsibilities may be necessary in the long term, especially if integrated coastal management is the ultimate objective, it is usually wise to begin with what is available and possible within the existing order.

In most countries, some provision for environmental assessment of aquaculture already exists. In the case of South Africa (Box 4.1) national policy and legislation specifically provides for EIA for "commercial scale operations". However, this particular framework appears to allow for considerable flexibility of interpretation, as well as significant discretion on the part of "the minister". In this case, the various stakeholders should be able to influence the way these provisions are implemented to a significant degree.

The question is, should it be improved, and if so, how? Some suggestions as to how to improve existing systems are presented in the following sections.

4.2 Minimizing bureaucracy, duplication and cost of EA

If EIA is to be done thoroughly, and if the principles and values outlined in section 2 are to be applied, then EIA will be a long, complex, and difficult process. It must cover social as well as environmental issues; it should be integrated with engineering design, feasibility studies, and investment appraisal; it should involve extensive public consultation and participation; it will require monitoring and in some cases enforcement. In practice, if this is applied to individual initiatives or projects, it may cripple both the bureaucracy and the development process. It may lose credibility.

There are three possible solutions to this problem:

1. a scale criterion, so that only larger projects are subject to full EIA, or which provides for different levels of assessment according to scale or type (this is relatively common approach and is a simple form of screening, described in more detail in section 7);

2. more sophisticated screening processes, usually associated with location and operational guidelines, so that only those projects likely to have a significant impact are subject to full EIA (this process is also described in detail in section 7); and

3. an aquaculture sector plan, which defines clearly where coastal aquaculture development, of particular types is acceptable, at what scale or density, and under what conditions (including, in some cases, a requirement for full project EIA).

The first of these is a blunt instrument, which takes no account of the likely cumulative impacts of aquaculture development, including numerous small-scale developments, which have caused significant environmental damage in many parts of the world. Furthermore, it may lead to significant duplication of effort, since each new project which meets the scale criterion will require its own full scale independent EIA, and many of the issues addressed will be similar in each case. This approach is therefore likely to be costly, potentially contentious, and ineffective in the absence of a broader planning and management framework.

The second approach is likely to be inconsistent and ad hoc, unless based on clear guidelines or criteria. Defining such criteria implies some form of sector environmental assessment.

The third approach, if its objective were to promote sustainable aquaculture development, would require a sector environmental assessment as a key component in its development.

The second two approaches have many advantages including:
• minimal duplication of effort: the major issues which are likely to arise in relation to more specific projects are dealt with once (initially) and clear broadly agreed procedures for addressing these issues, coupled with necessary decision criteria are developed;
• public involvement and participation can be thorough, across a broad range of issues, and strategic approaches to development agreed;
• developers will have a much better idea of what is possible, and what decision criteria or conditions will be applied;
• sector EA would also identify institutional and regulatory needs for the environmental management of the industry as a whole; and
• the process of aquaculture sector EA, if undertaken properly, would in itself be a major step toward, and building block for, more comprehensive integrated coastal management.

It is instructive to consider the current situation in Tanzania in this regard (Box 4.2, Appendix 1 and Appendix 2). The Tanzania Coastal Management Partnership identified several shortcomings in the existing procedures for EIA. In particular, the document notes that:

Local communities play an important role in regulating mariculture development because site allocations should be decided at local level. In practice, most decisions on investment projects are made outside of the local community, which often leads to conflicts. On the other hand, consultation at the local level is time consuming, and approval by district and regional authorities can be frustrating due to contradictory and overlapping policies, regulations and legislation.

The document also points out the lack of transparency relating to land rights. In order to address many of these difficulties the Investment Promotion Centre is delegated responsibility for facilitating and coordinating decision-making – a “one stop shop”. Unfortunately, while such an approach should facilitate investment, it is unpredictable and ad hoc, lacks transparency, and does not meet the principle of local participation in decision making.

Thorough sector EA should help resolve these problems by reducing duplication of effort while at the same time promoting maximum public involvement.

4.3 Sector EA as a starting point

In many countries of Africa environmental procedures are either not in place or their application is unsatisfactory in one form or another. Change may be required in policy, legislation, institutions and procedures.

Aquaculture sector environmental assessment can be an important first step toward improving procedures. This can be undertaken by a project, by the sectoral agency (e.g. the Department of Fisheries) by a government agency or department responsible for environment, or by local government. Of these the least desirable is usually a project, since this is by definition short term, and likely to lie outside mainstream government procedures and activities. Some form of project may nonetheless support a government initiative (see financing below).

The sector EA should follow the basic procedures and structure set out in sections 5-12. The output of a sector EA would be a range of proposals for mitigating the potential environmental impacts of the sector, and might range from zoning proposals to regulations and financial incentives. It would also present proposals for approval procedures, including guidelines for screening and the application of project EIA. It could also serve as the basis for the development of an aquaculture development plan (see GESAMP, 1999), and would represent a major contribution to any integrated coastal management initiative. The process of assessing the impacts and defining the mitigation measures would inevitably require significant
liaison between different government and stakeholder interests and would serve to initiate a broader move toward more integrated management.

There are many advantages of using this approach as a starting point for regional environmental assessment and full blown integrated coastal management. It is:

- more modest and manageable in scope than regional EA or ICM;
- it has a clear sectoral focus and responsibility, while still promoting the ideal of integration;
- it should provide thorough technical and scientific foundation for improved policy and planning, while at the same time introducing the more participatory approaches required in dealing with social and environmental issues;
- it requires little immediate change (most sectoral agencies or local government will have a remit to undertake such studies), but the process is likely to lead to a demand for some change, and a wider recognition of the need for more integrated coastal management;
- the outputs are clear and practical.

Sector EA as a starting point for more integrated environmental management of coastal aquaculture has been used in Hong Kong (Box 4.2), Norway, and Tanzania (see Appendix 2). We are not aware of its application in any tropical developing countries other than Belize.

**Box 4.2. Sector EA as the starting point for policy development: the Case of Tanzania**

The following needs in terms of policy development were identified in the Tanzania Mariculture Issue Profile produced by the Tanzania Coastal Management Partnership (1998).

"The various sectoral policies relating to mariculture must be harmonized and integrated into a single statement. There are gaps in the various sectoral policies and regulations where concerns related to mariculture are not addressed. New policies and regulations are needed to cover these areas. Priority areas are:

- permitting procedures;
- procedures governing access to land and water tenure;
- water use regulations;
- water quality control and standards;
- monitoring guidelines and procedures;
- licenses addressing operational issues that affect environmental quality;
- strict enforcement of existing laws and regulations; and
- provision of oversight for the permitting process.

A thorough coastal aquaculture sector environmental assessment should provide much of the basic technical underpinning for the development of most of these policies and procedures, and if done well should start the process of public involvement and participation, and integration of government activity in the aquaculture sector. Ideally, these processes would continue, and the policies/regulations would be refined, through a broader process of integrated coastal management.

4.4 The need for agreed environmental quality standards

Agreed environmental quality standards are a precondition for effective environmental assessment and integrated coastal management. This is because the significance of any impact (a key issue addressed in EIA) cannot be assessed without some environmental standard to measure the impact against.

Ideally environmental quality standards should be developed and agreed prior to any form of EA or integrated coastal management. However, they are often lacking, or have been developed by environmental agencies or departments independently, or based on those from other countries. There is rarely any critical independent or public review of these standards. Since environmental quality is relatively subjective, and of great concern to the population at large, and since these standards are likely to vary according to local natural and social conditions, this technocratic approach is inappropriate. While science and scientists should play a major role in providing the technical information required, the setting of standards should be a far more accountable process, with more input from a broad range of institutions and the general public.
Any integrated coastal management or planning initiative should include the development of such standards as a key task early in the process. If ICM is not underway, or if existing environmental quality standards are lacking or inadequate, the issue must be raised at the outset of any EA process, and provisional standards, against which the assessment is made, stated clearly. This will require significant liaison between government departments or agencies, and ideally also significant public involvement. This may serve as a first step in consensus building, since the setting of such standards will be of interest to – and in the interests of - most institutions and stakeholders. Furthermore, agreeing on environmental quality standards and objectives at the outset is likely to reduce conflict at later stages, providing clear and agreed criteria for decision making.

4.5 Learning from experience: monitoring and adaptation

Environmental assessment is extremely complex, and new procedures are likely to be imperfect in many respects. Any change in policy and procedure should be carefully monitored and assessed. Whenever recommendations for change or adaptations are made, there should also be presented a mechanism for:

- monitoring their effects;
- assessing their success or otherwise (against defined objectives or standards); and
- adapting the policy or procedures in line with experience.

4.6 Overview of the relation between different environmental management initiatives

Figure 4.1 shows the dynamic relationships between the setting of standards, sector EA, project EIA, regional EA and integrated coastal management (ICM). These initiatives should all be seen as mutually reinforcing, and government should have a clear strategy for implementing and integrating them. While ICM (including the setting of environmental quality standards) should ideally be the overall integrating framework, sector EA or regional EA can serve as a more simple and practical starting point.

Figure 4.1. Relationships between different initiatives for environmental management of coastal aquaculture.
4.7 Costs and financing

Thorough environmental assessment (sector or project) is costly. The use of sector EA should reduce the need for project EIA and therefore reduce overall costs. However, the costs of project EIA have traditionally been borne by the developer, whereas government normally undertakes sector EA.

The marginal (additional) costs associated with sector EA will vary greatly according to existing institutional structures and capacity. It will also depend on the need or otherwise for technical research, modeling, GIS and so forth. In practice much can be done on the basis of existing information, and the main task will be improved liaison and coordination between government agencies and NGOs in order to assimilate this information. In the process additional information or research needs will be identified, and prioritized, and additional sources of finance may then be sought.

In any case, the process of sector EA should be seen as a major contribution to institutional capacity building, and should be a priority of any government committed to the principles of sustainable development.
Chapter 5
Overview of the Environmental Assessment Process

Summary

This section presents general guidance on the overall structure and process of EA, and the nature of the outputs, as it applies to aquaculture and other development types. Detailed guidance relating to each of the more complex and important stages is presented in sections 6-12. Specific examples of EA procedures and regulations as they are currently applied to aquaculture in various countries are presented in Appendix 2.

It is strongly recommended that aquaculture sector EA be undertaken for the whole country and preferably also in respect of important coastal systems. This should provide the basis for more efficient and effective project EIA if and when required. There is limited experience worldwide of sector EA to date.

The basic EIA process as applied to projects is now widely agreed. However, there are a variety of issues relating to best practice, which are still the subject of intense debate. Although widely agreed as an essential part of the process, the scope and timing of public involvement are highly variable. The extent to which economic techniques can and should be used in EA also remains contentious.

Contents

• Sector environmental assessment
• Project environmental assessment
• Integrating environmental assessment with economic appraisal and the investment project cycle
• Roles and responsibilities
• Terms of reference
• Timing

The following presents an overview of the main stages and overall process of EA. Details relating to the various components of environmental assessment, and supporting tools, are presented in sections 6-12.

The sector environmental assessment process is essentially similar to that for the better known project EIA, except that instead of being applied to a specific project, it is applied to the sector as a whole, within some defined area (such as an estuary, bay, lagoon system, or watershed system). It addresses similar issues using broadly similar tools. However there are significant differences of approach and emphasis in several components, and they are treated separately below.
5.1 Sector EA

5.1.1 Purpose

The purpose of (aquaculture) sector environmental assessment may be summarized as:

- to assist the sectoral agency responsible for aquaculture, and/or the environmental agency responsible for coastal environmental management to develop practical policy and strategy for the development and environmental management of coastal aquaculture development;
- to assist these agencies, and/or others concerned with environmental planning and management, to develop an environmental management plan for the sector;
- to provide the necessary technical information relating to the aquaculture sector as an input to broader integrated coastal management;
- to facilitate public understanding of the nature of coastal aquaculture development, the options available, and their technical, socio-economic and environmental characteristics and effects;
- to facilitate and promote informed public involvement in policy and planning related to the aquaculture sector; and
- to define procedures for screening for project EIA, and guidelines and standards for undertaking project EIA.

5.1.2 Process

The sector EA process will require a high level of integration and liaison between the responsible or initiating agency (usually the fisheries department or environmental agency), and other departments, agencies and stakeholders. It will probably be necessary to establish some form of joint committee or steering group (covering all relevant institutions and stakeholder representatives) to oversee the work and facilitate exchange of information, perspectives and ideas. The assessment may relate to the country as a whole, some administrative region or district, or some natural system such as an estuary, lagoon, delta or bay.

The process can be summarized as follows:

1. **Scoping**: the identification of key impacts from different forms of (actual or potential) coastal aquaculture development which require further investigation, and prepare the terms of reference for the study.
2. **Assessing:** the identification, analysis, and evaluation of the significance of impacts from different forms of coastal aquaculture development. This will require a broad and comprehensive understanding of the natural and human environment, and a thorough understanding of the technical characteristics of a range of coastal aquaculture development options, all of which will need to be assessed.

3. **Mitigation:** identifying and developing measures to prevent, reduce or compensate for impacts from the sector, and to make good environmental damage. Examples are given in Box 5.1.

4. **Reporting:** presenting the results of the impact assessment in a format useful for, and accessible to planners, decision makers and stakeholders.

5. **Reviewing:** Assessing the adequacy of the EA report, taking account of the views of all relevant government departments/agencies and stakeholders, and assessing the acceptability of the proposals in terms of existing plans, policies and standards. This process is likely to lead to debate over resource allocation issues, and may therefore be a significant stimulus to broader integrated coastal management initiatives.

6. **Decision making:** The objective of this component is to decide whether the proposed environmental management plan (suite of mitigation measures + proposals for implementation) for the sector is desirable and acceptable to all relevant stakeholders, and which parts can be implemented, when and by whom. The “decision maker” (which may be an individual, committee, hearing, local government assembly, etc.) will depend on local circumstances. The result of the decision making process may be a request to modify or improve the report and the environmental management plan. It may be that while there is agreement on the plan, there are major institutional or legislative constraints to its implementation, in which case the report may be used as a tool and rationale for institutional change.

7. **Monitoring and managing:** This involves implementing mitigation measures; monitoring the overall effects of the sector on the environment, and the efficacy of specific mitigation measures; and responding by adapting and improving the mitigation measures as appropriate.

8. **Public involvement:** The importance of public involvement in the EA process is now widely recognized. Sector EA provides an opportunity to involve the public in defining overall policy and strategy, and may pre-empt serious conflict related to individual aquaculture proposals. Public involvement ranges from relatively formal exchange of information and ideas about the effects of coastal aquaculture, to more participatory approaches to policy development and decision making. Public involvement will vary greatly in nature and scope according to local culture and tradition, but would typically encompass actual and potential stakeholders with an interest in all forms of actual and potential coastal aquaculture, from all parts of the region under study.

### 5.1.3 Outputs

The main tangible output from sector EA is a report. This must be accessible and comprehensible to all parties, and must clearly state the major issues, and options for the environmental management of the sector, in a non-technical way.

A **sector EA report** should include:

- an executive or non-technical summary (which may be used as a public involvement document);
- a rationale for the assessment (for example drawing on current problems or opportunities; the need for guidelines etc);
- description of the scope of the exercise. For example as a basis for improved regulation; for the development of guidelines or codes; as a basis for broader policy and plan development; as a basis for incorporating coastal aquaculture development into a broader integrated coastal management process;
- discussion of the environmental quality standards (either existing, or where these are lacking, proposed) against which the assessments of impact significance have been measured (under the sector EA) and should be measured (in project level EIA);
• description and comparative evaluation of coastal aquaculture systems, technology and management practices in the region, both actual and likely, in the short and medium term;
• discussion of the relationship between possible land/water use for coastal aquaculture and existing land/water-use policies;
• description of the conditions (biophysical, socio-economic etc) and locations in which coastal aquaculture development might take place;
• discussion of environmental capacity, in relation to environmental quality standards, for these locations;
• evaluation of the impacts of each kind of coastal aquaculture, with clear information on the criteria used to assign significance. Also, descriptions of the characteristics of each impact, the predictive methods and analytical techniques used, discussion of the uncertainties involved in interpreting the results, and descriptions of gaps in the baseline data or other data used in the EA work and included in the EA report;
• comparative evaluation of alternatives, covering significant adverse and beneficial impact, mitigation possibilities for different technical options (see for example Box 5.1) and monitoring;
• identification of environmentally preferred options, if possible using a set of sustainability criteria;
• an environmental management plan for the sector as a whole, based on identified mitigation (possibly including complete exclusion of some development options), including draft procedures for implementation and regulation;
• a monitoring plan and proposed training; and
• appendices: all technical information and description of approaches/methods used to provide conclusions in the EA report which are not suitable for the main text.

5.2 Project EIA

5.2.1 Purpose

The purpose of project EIA is to assist:

• the proponent to design and implement a proposal in a way that eliminates or minimizes the negative effect on the biophysical and socio-economic environments and maximizes the benefits to all parties in the most cost effective manner;
• the public to understand the proposal and its impacts on the community and environment, and to make an informed input into the decision making process; and
• the responsible authority to decide whether a proposal should be approved, and the terms and conditions that should be applied (adapted from UNEP, 1996).

5.2.2 Process

The process for undertaking EIA is presented in Figure. 5.1. This shows both the basic framework, which is widely applied and accepted and more recent additions or extensions to the basic methodology which are not applied universally, but which may be considered to represent best practice. The details and emphasis will also vary according to the particular requirements of a country, proponent, bank or donor. A summary comparison of the procedures recommended in different guidelines is presented in Appendix 3.

In practice it would be unreasonable and impractical to apply the more comprehensive “best practices” to individual small-scale aquaculture developments. This reinforces the need for sector EA, so that full project EIA is then only required for large scale or otherwise exceptional farms. “Best practice” options, such as integrating the environmental assessment with economic assessment; feasibility studies; economic
Figure 5.1. Summary of the EIA Process.

Initial environmental examination (IEE)

- No
- Yes

Screening of environmental effects: is EIA required?

- Yes
  - Scoping – identify key issues – draw up TOR

- No
  - Public involvement

Describe environment (base-line)

Preliminary assessment, or IEA

- Describe project

Assessment: identification of impacts; alternatives; prediction/analysis; significance of impacts

- Public involvement

Economic valuation of impacts

Selection of best option

- Integrate with project appraisal and feasibility e.g. CBA etc

- Monitoring requirements & audit arrangements

Decision support – e.g. ranking techniques

Identification of mitigation

- Monitoring

Impact management plan

Conclusions and recommendations reporting

- Panel or agency review

- Public involvement

Publication of account of decision

Decision-making: approval; conditional approval; rejection

- Impact management

Monitoring
valuation of impacts; and comprehensive public involvement are all much better done on a “once off” basis at sector level, except for very large individual projects.

The guidelines which follow are framed around the basic core components, which may be summarized (modified from UNEP, 1996) as:

1. **Screening**: An initial assessment to decide whether a project requires further investigation in an EIA. This may require a short report or submission in the form of an initial environmental examination (IEE).

2. **Scoping**: To identify the key impacts requiring further investigation, and prepare the terms of reference for the study. This is an important first opportunity for public involvement. In some cases this leads into an Initial Environmental Assessment (IEA) which is a limited form of assessment, sometimes used to determine the need or otherwise for a full EIA and the scope of the exercise.

3. **Assessing**: The identification, analysis, and evaluation of the significance of impacts. In some cases this stage may be extended to include economic valuation of impacts, and/or various ranking techniques with a view to providing information for selection of best options from an environmental perspective.

4. **Mitigation**: Identifying and developing measures to prevent, reduce or compensate for impacts, and to make good on environmental damage (examples in Box 5.2).

5. **Reporting**: Presenting the results of the impact assessment in a useful and accessible format.

6. **Reviewing**: Assessing the adequacy of the EIA report, taking account of the points of view of stakeholders, and assessing the acceptability of the proposal in terms of existing plans, policies and standards.

7. **Decision making**: To decide whether the proposal can proceed and under what conditions. The decision maker has the option to request that the project be redesigned (or aspects of the project redesigned) so that the environmental effects are minimized.

8. **Monitoring and managing**: This involves implementing mitigation measures, monitoring impacts for compliance, checking that they are as predicted, and where necessary taking action to ameliorate problems.

9. **Public involvement**: The importance of public involvement in the EA process is now widely recognized. In practice this involvement ranges from making information about a project, policy or plan more widely available through formal consultation, to more participatory approaches to project design and decision making. Public involvement will vary greatly in nature and scope according to local culture and tradition. The scope of the public involvement requirement will be much less if effective sector EA, with significant public involvement, has already been undertaken.

### Box 5.2. Types of mitigation for project EIA

- alternative location and siting;
- alternative/improved technology or design;
- limitations on scale or waste production/output;
- construction guidelines (e.g. guidelines for habitat restoration);
- guidelines for food or other input quality and quantity;
- guidelines for feed or other input use and management;
- guidelines/protocols for disease prevention and management;
- selection of suitable species and seed;
- management of influent and effluent water quality; and
- an overall “environmental management plan” for the project incorporating all proposed measures, including appropriate incentives and constraints, implementing and monitoring procedures.

### 5.2.3 Outputs

The main tangible output from the EIA process is the report. The quality of the report will reflect the quality of the process, and the process itself may bring benefits in terms of environmental awareness, capacity building, and liaison and integration between institutions and stakeholders.
In order to contribute effectively to the purpose of the assessment as stated above, EIA reports should:

- be proactive, aimed at assisting the proponent achieve good environmental design;
- be accessible and comprehensible to all parties; and
- state the issues clearly in a non-technical way.

The broad structure and content of an EIA report will usually be specified in the legislation or guidelines of the country or donor. These will usually be made more specific in accordance with the terms of reference established during the scoping process of the EA.

**A project EIA report** typically addresses the items listed below. It should include:

- an executive or non-technical summary (which may be used as a public involvement document);
- a description of the aims of the proposal;
- a description of the proposal and alternatives (in terms of siting; design; technology; management);
- discussion of the relationship between the proposal and current land/water-use or other relevant policies for the area likely to be affected;
- description of the expected conditions (biophysical, socio-economic etc) at the time of probable implementation, including potential impacts from other activities;
- discussion of the environmental capacity and environmental quality standards for the area likely to be affected;
- evaluation of the impacts of each alternative with clear information on the criteria used to assign significance. Also, descriptions of the characteristics of each impact, the predictive methods and analytical techniques used, discussion of the uncertainties involved in interpreting the results and descriptions of gaps in the baseline data or other data used in the EIA work and included in the EIA report;
- assessment of possible cumulative impacts associated with other developments (including aquaculture) likely to take place in the same area;
- comparative evaluation of alternatives covering significant adverse and beneficial impact, mitigation and monitoring;
- identification of the environmentally preferred option, if possible using a set of sustainability criteria;
- detailed proposals for mitigation;
- impact management plan, monitoring plan and proposed training; and
- Appendices: all technical information and description of approaches/methods used to provide conclusions in the EIA report which are not suitable for the main text.

### 5.3 Integrating EA with economic appraisal and the project cycle

Harou, Kjorven and Dixon (1995) have noted the need to integrate EA information into the economic appraisal of projects from the earliest stages through to project implementation and completion. It is particularly important that EIA begins during the project preparation and design phase, so that appropriate mitigation can be “built into” the project from the outset, thus improving the quality of mitigation, and reducing the chances of the project being rejected, and much investment lost. The integration of EIA into the project cycle is presented in Figure 5.2.

In practice this must be done with great care so as to avoid compromising the neutrality of the assessment. It is instructive to consider the case of the African Fishing Company in Tanzania in this regard (Box 6.5
and Appendix 1). Environmental considerations were built into the second phase of project design, to the extent that the proponent felt sufficiently confident to place the following sub-title on the EIA report: “an environmentally responsible prawn farming project in the Rufiji Delta, Tanzania”. Unfortunately this pre-judged the outcome of the assessment and any review, and undermined the neutrality and credibility of the EIA document as a whole.

The financial and economic appraisal of the project should also be extended where possible to take full account of environmental costs and benefits. This can be done formally – by extending the cost benefit analysis to include environmental impacts – or informally, by comparing economic cost benefit ratios with environmental impacts or benefits.

There is ongoing debate as to the desirability of converting environmental and social values into standard financial units and aggregating with economic values into a single index. The advantages are clear – decision making is easier, since it is based on a single index, and environmental concerns are automatically factored into the most common project decision making criterion. The disadvantages are that there are usually widely divergent views on the value or otherwise of environmental goods and services, and this divergence is not usually represented in the aggregate index. Although there are ways of dealing with this, they can be costly, complex and sometimes unreliable. Perhaps more seriously many of these approaches lack transparency – one of the fundamental principles of EA – since they are not accessible to non-specialists and the general public.

5.4 Roles and responsibilities

5.4.1 Sector EA

The sectoral agency responsible for the development and/or regulation of coastal aquaculture may be best placed to undertake or commission a sector EA, or at least contribute the bulk of the technical input. Alternatively the assessment could be carried out or commissioned by local government, or by an environmental agency, but with significant technical input from the sectoral agency and/or technical consultants.

Sector EA will require much liaison and exchange between different departments and agencies. This may be difficult in the absence of a clear policy direction or remit given by central government. In such circumstances, any agency or department wishing to undertake or commission sector EA should seek such a remit, or clear approval, from a higher level of government, along with a commitment to promote the exercise, and encourage liaison and free exchange of information and ideas between agencies and departments. It should also seek to establish a process by which the findings of the EA can be used in policy development and coastal environmental management.

A coordinating or steering committee with membership from a range of relevant interests will probably be desirable to oversee the process and ensure maximum cooperation and collaboration between different interests.

The sector EA itself should clearly identify roles and responsibilities for implementation of any proposals for mitigating the environmental impacts and promoting more sustainable coastal aquaculture development.

5.4.2 Project EIA

The proponent of the project should normally be responsible for the costs and effective implementation of the EA process. This would normally involve contracting independent consultants or government agencies to undertake parts of the work. In the case of project EIA some countries operate guidelines restricting the relationship between proponent and EA contractors.
An agency or government department will need to review the EA documents and process to ensure quality control and compliance with legislation and/or guidelines. They may seek technical assistance to do this.

A second government department or local government office would normally make the final decision.

5.4.3 The EA team
The assessment team should have clear roles and responsibilities but regular interaction. In the case of sector EA the team should work closely with economists and sociologists to consider a range of development strategies or plans, and mitigation options to maximize the benefits of the sector while minimizing environmental impacts. In an ideal project EIA the team (or individual) would work with the proponent, and the design and project appraisal teams, so that a variety of project options could be assessed in parallel on the basis of feasibility, cost, and environmental impact.

5.5 Terms of reference (TOR)
Whoever undertakes EA, be it related the sector or to an individual project, clear and agreed TOR will be required. Detailed TOR should be an output of the scoping exercise, and this is described in more detail in section 8.5.

In the case of sector EA, broad participation of all relevant agencies and stakeholders in the scoping process and development of TOR is particularly important. The TOR may provide for a sectoral agency to make assessments related to the activities and responsibilities of other departments or agencies, and this may be contentious. It is important to meet this challenge head-on, and to gain the broadest possible agreement on, and support for, the TOR and the whole process.

5.6 Timing
Strategic or sector EA should be undertaken before aquaculture development becomes significant. It is extremely difficult to change the rules for a sector mid way through a development boom, and it may already be too late to reverse environmental degradation except at great cost.

Environmental assessment of individual aquaculture projects should be initiated as early as possible in the planning or project cycle, so that it can be an effective management tool, influencing, for example, site selection and design to minimize impacts, and reduce the risks of conflict or abandonment at a later date.
Figure 5.2. Environmental assessment and the project cycle.

Source: after Harou et al., 1995
Chapter 6
Public Involvement

Summary

It is widely accepted that EA should be open, transparent and democratic (Bisset, 1996). Public involvement is seen as an essential component of EA by all major international organizations and development agencies.

The effective use of public involvement should shift the EA process from one of administration, regulation and document generation, to one which promotes more democratic decision making on issues affecting the quality of life, and which minimizes potential conflict, or resolves existing conflict.

Public involvement can be difficult, and requires great skill and sensitivity. There has been significant social conflict generated by coastal aquaculture development in Asian, and more recently African, countries, and in some cases public involvement has actually increased conflict. Conflict is likely to be minimized if public involvement is an input to sector EA so that objectives, general principles and guidelines can be agreed without reference to specific and potentially contentious individual projects. Once these are in place, the ground rules are known, and the likelihood of conflict arising over individual projects is lessened.

If, nonetheless conflict arises, a variety of conflict resolution techniques may be used to minimize the damage and to move the EA process forward constructively.

Contents

- The rationale for public involvement
- Public involvement in practice
- Constraints to public involvement
- Who are the stakeholders?
- Techniques for communicating and information exchange
- Conflict minimization and resolution
- Designing a public involvement programme

6.1 The rationale for public involvement

Public involvement is an essential tool in EA for the following reasons:

- environmental assessment makes judgements about the quality of life, the value of resources and development, and the trade-offs between them. Many of these assessments are subjective and can only be validated through the widest possible consultation;
- it can help evaluate the need for and define the scope of the assessment;
- it can provide essential information about local natural resources, their status, use and value (sometimes referred to as indigenous technical knowledge);
- it can help identify and assess benefits and impacts (especially secondary or higher order effects);
• it can generate new ideas for alternatives, siting, design, and mitigation;
• it may allow otherwise underrepresented groups access to the decision making process;
• it can reduce conflict through the early identification and resolution of contentious issues;
• It can provide valuable feedback on the report or hearings;
• local people and other stakeholders may serve an important role in quality control and monitoring of project implementation and impact;
• it creates a sense of accountability, ownership and responsibility;
• it increases confidence in the reviewers and decision makers; and
• it increases transparency and accountability in decision making.

Lack of consultation and public participation in the processes of shrimp farming in some countries (for example India, Indonesia, and some South American countries) has led to serious conflict and in some cases abandonment or prohibition of shrimp farming (Box 6.2). It is possible (though by no means certain) that this could have been avoided through greater public involvement in planning or project design, especially if this was of a participatory nature. Public involvement, though sometimes difficult, may reduce the likelihood of controversy at a later date.

Unfortunately, public involvement in the EA process is limited to the review stage in many countries. Public involvement should begin at the earliest possible stage if the potential benefits noted above are to be realized in full.

6.2 Public involvement in practice

Although public involvement is essential, it can also be difficult, expensive, and lead to conflict (see Boxes 6.2, 6.3, and 6.5). In some cases it has led to a “stalemate” situation of “development or no development” rather than contributed to more sustainable development. It is important to undertake it with great care, with adequate knowledge of local conditions, and at the right level.

Any new project is likely to upset some stakeholders, especially if there have been problems with similar developments elsewhere. Local meetings may inflame these feelings and lead to rapid polarization. Although conflict resolution techniques may reduce these problems, it is better to avoid such polarisation if possible.

Public involvement should be carried out at the sector level. It is important also at the project level for large-scale projects. There are several reasons for this:

• public involvement for a large number of small aquaculture projects would be impractical and costly;
• project EIA should be paid for by the proponent. It is naïve to expect a neutral appraisal, synthesis or interpretation of public opinion from the proponent;
• confidentiality may be important to the proponent in project EIA, constraining the scope or detail of public involvement;

Box 6.1. Objectives of public involvement

• exchange of information;
• identification of problems;
• generation of ideas;
• determination of values;
• evaluation of alternatives;
• feedback on decisions or analyses; and
• conflict avoidance, resolution and consensus building.
**Box 6.2. Social conflict and shrimp farm development: the case of India**

Shrimp farming in brackish-water ponds developed rapidly in India in the '80s, based mainly on improved extensive and semi-intensive techniques. It was very profitable. In the late '80s several large national and international corporations entered the sector with medium to large intensive operations. Access to fisheries was restricted in some areas, and there was local salination of ground and drinking water. There were also concerns about pollution.

Local fishermen began protests in Tamil Nadu, and near Lake Chilka in the early '90s. They and environmental activists took the issue to the High Court in Tamil Nadu, and restrictions were placed on brackish-water aquaculture. The conflict then spread to Orissa and Andhra Pradesh States, and culminated in a Public Interest Writ submitted to the Supreme Court of India in 1994. A final judgement was made in December 1996 based on existing coastal zone regulation which banned all non-traditional aquaculture within 500 m of the high water mark, or within 1,000 m of Lakes Chilka and Pulicat. Existing farms within these zones were to be demolished by March 31st 1997. An Authority was set up comprising environmental and aquaculture interests led by a judge to administer the ruling, and assess compensation for pollution impacts. Workers laid off from demolished farms were also to be paid compensation under existing labour laws.

In practice demolition has been limited, but the industry remains in a highly uncertain state. Much employment and income generation has been lost. "Traditional "aquaculture", which covers the largest areas, has not however been affected.

Although there is little doubt that there were problems with shrimp culture in some areas, the response has been extreme and unsatisfactory. While it has undoubtedly prevented some undesirable aquaculture development, it has not promoted sustainable development.

There are three lessons to be learned. Firstly, if environmental concerns had been taken into account more effectively in relation to the larger industrial developments, the conflicts may not have arisen. Secondly, conflict escalated rapidly, with an extreme polarization of positions. Effective use of conflict resolution techniques may have led to a more satisfactory overall solution. Thirdly, the extreme impact of the Supreme Court Ruling was based on existing coastal legislation which did not take full and proper account of the nature and role of aquaculture.

More effective public involvement, including where appropriate the use of conflict resolution techniques, would probably have resulted in a better planned, and more sustainable development of the shrimp farming industry in India. These approaches could have been applied within the framework of sector EA relating to the majority of semi-intensive developments in each State or District, and full EA for large intensive industrial operations.

- in the absence of any agreed overall strategy, public involvement in decision making related to individual small scale projects is likely to be ad hoc, inconsistent, and based on emotional rather than rational appraisal; and
- in the absence of agreed objectives and strategy, conflict is likely to be inflamed, and rational assessment will become more difficult.

If comprehensive public involvement takes place as part of a sector assessment exercise, then objectives, targets, general principles and guidelines can be agreed without reference to specific and potentially contentious individual projects. Once these are in place, the ground rules are known, and the likelihood of conflict arising over individual projects is lessened. This is a classic technique used in conflict resolution as described below in section 6.6.

Individual projects may also require public involvement. Criteria for such projects (e.g. scale, location) and procedures for the public involvement exercise should be an output of the sector EA process. These should set out clearly the ways in which the exercise will be undertaken, and how neutrality is to be ensured.

The difficulty of public involvement should not be under-estimated. However, these difficulties can be minimized through a more strategic approach, and where necessary the use of conflict resolution techniques. The risks of
avoiding public involvement and not facing up to possible problems as early as possible are high. Some of the large shrimp aquaculture operations, which were plundered by local people in Indonesia early 1998, probably regret they did not involve the public more fully during, project design and implementation.

6.3 Constraints to public involvement

Public involvement is likely to be more costly in rural areas and in developing countries. It will be more costly where communities are less well organized and represented where communications are poor, where language is diverse, and where levels of illiteracy are high. Behavioral norms and traditions in some countries may inhibit or preclude involvement of some potentially affected groups.

Many individual project proponents wish to minimize public involvement. They may consider it costly and time consuming. They may be reluctant to start it before the project is well defined. They may be concerned that it will be taken over by unrepresentative interest groups, or misrepresented in the media, and liable to increase, rather than decrease conflict. They may doubt the capacity of the public to fully understand the issues. All of these concerns should have been addressed to some extent if public involvement has already taken place at the sector level.

6.4 Who are the stakeholders?

The widest possible range of stakeholders should be consulted or actively involved. They might include:

- representatives of the aquaculture industry (sector EA);
- the proponent and other project beneficiaries (project EIA);
- the people, individuals or groups in the communities which may be affected;
- the administering agency;
- specialist government agencies;
- NGOs and technical specialists; and
- others, such as donors, the private sector, academics, etc.

It is sometimes very difficult to define exactly who is likely to be affected by a

**Box 6.3. Public involvement in mussel culture in Sweden**

When mussel farming first developed in Sweden, there was conflict between mussel farmers and local residents over the use of near shore areas. These areas were already heavily used for recreation, and there were fears related to physical disruption, aesthetic intrusion, and pollution.

The Environmental Protection Act of the time required that any new farm be discussed at public information meetings. These meetings "turned into regular catalysts of conflicts, and in some cases stirred emotions and stigmatized entrepreneurs to the extent that they had to abandon the project in spite of final approval by the authorities". Largely as a result, the legal requirement for such meetings was later dropped.

There is now renewed interest in mussel cultivation, and in order to avoid these problems in future "the political and social intentions of local communities and authorities need to be clearly formulated. This would pre-empt the disastrous social and personal effects" caused previously.

Source: Ellegard, 1999

**Box 6.4. Techniques for public involvement**

Note: many of the following are suitable for aquaculture sector EA, but only large individual aquaculture projects, and/or those sited in very sensitive areas would justify the more comprehensive and costly techniques.

- Media (television, radio, pamphlets, presentations, exhibitions);
- Open houses and field offices (manned information displays, access, opinion exchange);
- Participatory appraisal;
- Workshops;
- Public meetings; public hearings;
- Small representative or specialist meetings;
- Employment of community interest advocates;
- Individual interviews and two way consultations;
- Questionnaires;
- Advisory panels, working groups, task forces;
- Interim consultative reporting; and
- Demonstration projects.
development, especially with respect to indirect impacts, and consultation should therefore be as wide as possible in the early stages.

When direct local public participation is difficult, NGOs are sometimes used as "proxy" local representatives. Although this can be useful and efficient, it should be done with great care, as they may not always accurately reflect local opinion or knowledge.

### 6.5 Techniques for communicating and information exchange

Public involvement can be undertaken at different levels. **Informing** may involve a largely one way flow of information about a policy or project. **Consulting** involves a two-way interaction and exchange of information and opinion between the EIA team, or proponent and the public. **Participation** implies a greater role for the public in setting the agenda, analyzing information, and reaching decisions on the basis of consensus.

There is a range of specific techniques available which are more or less effective at these different levels (Box 6.4). These tools have particular strengths and weaknesses in terms of their contribution to the specific outputs or objectives of public involvement (summarized in Box 6.1).

An appropriate package will depend on the nature and scale of the project, and local social and cultural circumstances.

It should be remembered that many stakeholders with a significant interest in the outcome of a decision or development process might nonetheless have limited time for, interest in, access to, or aptitude for active participation. It is therefore important to raise general awareness of the process using rough and broader access techniques in the early stages (such as television, radio and papers), in order to identify important areas requiring the use of more specific and targeted techniques.

UNEP (1996) presents the following principles for making public involvement more effective:

- sufficient relevant information must be provided in a form that is easily understood by non-experts;
- sufficient time must be allowed for stakeholders to read, discuss and consider the information and its implications;
- sufficient time must be allowed to enable stakeholders to present their views;
- the selection of venues and the timing of events should encourage maximum attendance and a free exchange of views by all stakeholders (including those that may feel less confident about expressing their views); and
- responses should be provided to issues/problems raised or comments made by stakeholders. This enables confidence in the public involvement and EIA process to be maintained.

### 6.6 Conflict minimization and resolution

EA of aquaculture may be applied in a situation in which conflict already exists. This may have arisen in relation to previous aquaculture developments, or may be related to public perception of aquaculture as environmentally damaging. This is increasingly the case for shrimp farming.

On the other hand, comprehensive participation in an EA process may actually generate conflict by highlighting potential future problems or differences between the various stakeholders. This should not be used as an argument against public involvement, although (as noted previously) it does suggest that a
Box 6.5. Public involvement in aquaculture EA: the case of the African Fishing Company, Tanzania

Following a proposal in mid 1995 for a large prawn farming project to be sited in the Rufiji Delta, the District Commissioner requested that the proposer (African Fishing Company) collaborate with a consultant to write an initial environmental impact statement. The EIS was produced and submitted to relevant ministries for review in May 1996. Before an official answer was received the environmental community in Dar es Salaam requested the government to have a public debate on the proposal. AFC also increased the scope of their consultation to a range of government agencies, ministries and academic institutions. The National Environment Management Council then convened a forum of interested parties which was attended by more than 70 participants, mostly from government, regional authorities, aid assisted projects or programs, NGOs and journalists, embassies, and commercial companies. AFC and various technical experts described the project, and a range of academics made comments. The forum cleared up a good deal of misunderstanding about the project that had already grown up, and it was agreed that a comprehensive EIA was required. The forum offered some guidance on content. A large team was appointed, including aquaculture specialists, fisheries specialists, ecologists and sociologists.

The first contact with the villagers was by the fishery specialists. They observed that the villagers had many serious concerns, and some significant misconceptions as to the nature of the project. As a result they “advised that a high ranking governmental delegation be sent to the area to inform the people of the pro’s and cons of the project, and the benefits that such a project would bring to them”. The suggestion was immediately implemented. Other teams also visited the villages and found that the inhabitants did not have accurate facts. Subsequently, a critical report was produced by the sociologist reflecting the fears of the villagers. As a result a more technical team, including a fisheries specialist, a sociologist, and a representative of AFC, was sent to the villages to explain the nature of the project and the socio-economic benefits it would bring.

A final survey was then made by a new team in order to assess “whether or not the people are now aware of the project, and have accepted or rejected it, especially after the several visits to the area by senior government officials and experts”. The survey identified the nature of local economic activities, as well as a range of local concerns about health, education and transportation, and explored ways in which the project might contribute to their alleviation. They also reviewed both the positive and negative views of the project. Concerns included mangrove cutting, impacts on fisheries, impacts on local markets, pollution and chemicals, and fears that they would be prevented from fishing. A larger number of positive impacts were identified related to transportation, marketing and employment.

Subsequently, this project became the subject of “intense debate” over the appropriateness of a major aquaculture development proposal (Myatyosi and Hughes 1998). This debate became the subject of international comment on email discussion groups related to sustainable aquaculture and mangrove conservation. The EIA itself was criticised (Hughes, 1996) as being seriously biased.

There is little doubt that the EIA does not read as an impartial assessment. It is also clear from the notes above that the public involvement exercise was promotional in nature. This is unfortunate because in some ways the EA process was very good. The proposer appears to have set out to design an environmentally responsible farm using a respected consultant with international experience in mitigating the environmental impacts of shrimp farming. The analysis of impacts is generally thorough. But unfortunately, since the mitigation was “built in” to the project design, the proponent used the EA process as an opportunity to advocate, rather than impartially assess the project. However good the design, and however thorough the analysis, the EIA necessarily lost credibility. It should be added however, that this tendency to advocacy rather than assessment, was in part a reaction to the adversarial approach of environmental groups to any kind of shrimp farming.

The company itself, and the project designers, could have engaged the local people at an earlier stage to explain, discuss, and adapt project design, as well as take account of local concerns (information, consultation and participation). The EIA should then have been undertaken by a more independent team — although still working closely with the designer and proponent — to produce a more credible EA. Had conflict still arisen, some of the resolution techniques described below might have been used to gain a broader consensus.
more strategic approach is required. Either way, the sooner these issues are addressed and resolved the better. A good recent example of this was the EIA of a shrimp farm in Tanzania (Box 6.5) which led to a heated local and international debate. Clearly, if such conflicts arise, there should be efforts to resolve them, and this may be a significant role for the EA team.

The process needs to be culturally sensitive:

_The objective is to define traditional mechanisms for making agreements, for negotiations, and for managing conflict in affected communities. Understanding and working within cultural expectations and practices may enhance consultation and participation processes, especially in projects where there are multiple and competing stakeholders or where disputes or conflict are evident._ *(The World Bank, 1995).*

UNEP (1996) presents the following principles for minimizing conflict:

- involving all those likely to be affected, or have a stake in the matter;
- communicating the objectives of the proposal, and how it is planned to achieve them;
- actively listening to the concerns of affected people, and the interests which lie behind those concerns;
- treating people honestly and fairly, establishing trust through a consistency of behaviour;
- being empathetic, putting yourself in the shoes of the other party, and looking at the area of dispute from their perspective;
- being flexible in the way alternatives are considered, and amending the proposal wherever possible to better suit the interests of other parties;
- where others’ interests cannot be accommodated, mitigating impacts to the greatest extent possible, and looking for ways to compensate for detriment;
- establishing and maintaining open two-way channels of communication throughout the planning phase, and beyond into implementation; and
- acknowledging the concerns and suggestions of others, and providing feed-back on the way these matters have been followed up and evaluated.

Even allowing for the comprehensive application of these principles, conflict may arise. The coastal zone is notorious for ambiguities relating to resource access and control in most countries. Any new form of resource allocation, acquisition, appropriation, degradation, or control, is likely to result in conflict. Addressing some of the existing ambiguities related to resource use may also undermine existing power relations between different groups. A large aquaculture enterprise in Malaysia went through a long public consultation exercise, but was still plagued with conflict and disagreement, long after initial agreements were made (Al-Sahtout, 1997).

A summary of the different approaches to conflict resolution, and their advantages and disadvantages is presented in Table 6.1. They include litigation (court rulings) and a range of less formal techniques collectively referred to as “alternative dispute resolution” (ADR) techniques (Scialabba, 1998). These consist of direct negotiations between interest groups or their representatives, with or without some form of intermediary (conciliator, mediator or arbitrator), and usually based on agreed roles, ground rules, and objectives.

The table clearly presents the few advantages of litigation compared with the many advantages associated with ADR techniques. Litigation will in almost all cases result in one party “losing”; the root cause of the conflict may not be addressed; and the problem may not be solved in the long term. Examples of the use of litigation relating to aquaculture include the Supreme Court Judgement in India (Box 6.2) and the current ban on brackish-water aquaculture activities in some rice growing areas of Thailand. Both of
these have resulted in significant disruption of an established industry. Clearly litigation and arbitration should be used only as a last resort, and the need for their application should as far as possible be pre-empted by active promotion of ADR techniques. The EA process, at sector and individual project level, can and should effectively facilitate these processes.

Conflict resolution techniques usually involve one or more of the following:

- clear identification of interests;
- joint fact finding;
- informed dialogues;
- joint/creative problem solving and identification of alternatives;
- identifying opportunities for mutual gain; and
- clear identification of implementation procedures for agreed solutions.

There are four simple but essential pre-conditions for success (adapted from Bisset 1996):

- an impartial mediator (where one is used);
- equal status and access to information and support services;
- the option of withdrawal at any time; and
- no forced agreement.

There is no guarantee that consensus will be reached, and litigation may ultimately be required. However, the process can be especially effective when conflict is related to value differences (not moral right and wrong) and where problems are discrete and well defined. This is often the case in the coastal zone.

6.7 Designing a public involvement programme

The scope and cost of public involvement will need to be related to the complexity and uncertainty associated with the issues raised by the policy, plan or project.

TOR for the EA should include an outline for the public participation process, or a requirement that a public involvement programme be designed by those executing the EA as their first task. TOR may include a requirement for a sociologist with local knowledge to be a member of the EA team.

The public involvement programme should cover the scope, timing, techniques, and resources required. The programme should include at least the following:

- procedures for identifying stakeholders;
- procedures for informing the public about the objectives of the proposal and/or the EA at an early stage;
- provisions for updating the public and providing feedback on progress with the study;
- provisions for giving the public opportunities to share their knowledge, values and concerns; and
- methods of integrating with traditional decision making processes.

Ideally these provisions should provide for public involvement during all the major stages of the sector EA and project EIA process, including screening; scoping; assessment; mitigation; review; implementation and monitoring.
### Table 6.1. Comparative table of conflict resolution techniques.

<table>
<thead>
<tr>
<th></th>
<th>Litigation</th>
<th>Arbitration</th>
<th>Mediation</th>
<th>Negotiation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Result sought</strong></td>
<td>Court judgment</td>
<td>Arbitration award</td>
<td>Mutually acceptable agreement</td>
<td>Mutually acceptable agreement</td>
</tr>
<tr>
<td><strong>Voluntary/ involuntary</strong></td>
<td>Involuntary</td>
<td>Voluntary</td>
<td>Voluntary</td>
<td>Voluntary</td>
</tr>
<tr>
<td><strong>Binding/ non-binding</strong></td>
<td>Binding (Subject to appeal)</td>
<td>Binding (subject to review on limited grounds)</td>
<td>Agreement enforceable as contract</td>
<td>Agreement enforceable as contract</td>
</tr>
<tr>
<td><strong>Private/public</strong></td>
<td>Public</td>
<td>Private (unless judicial review sought)</td>
<td>Private</td>
<td>Private</td>
</tr>
<tr>
<td><strong>Participants</strong></td>
<td>Judge and parties</td>
<td>Arbitrator and parties</td>
<td>Mediator and parties</td>
<td>Parties only</td>
</tr>
<tr>
<td><strong>Third-party involvement</strong></td>
<td>Judge, not selected by parties and usually with no specialized subject expertise, makes decision based on law</td>
<td>Arbitrator, selected by parties and often with specialized subject expertise, makes decision</td>
<td>Mediator, selected by parties, facilitates negotiation process</td>
<td>Parties communicate directly</td>
</tr>
<tr>
<td><strong>First steps</strong></td>
<td>One party initiates court proceedings</td>
<td>Parties agree on arbitration and appoint arbitrator</td>
<td>Parties agree on mediation and appoint mediator</td>
<td>Parties agree to negotiate</td>
</tr>
<tr>
<td><strong>Approach/ methodology</strong></td>
<td>Formal</td>
<td>Less formal</td>
<td>Flexible</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td>Structured by predetermined rules</td>
<td>Procedural rules and substantive law may be set by parties</td>
<td>Usually informal and unstructured</td>
<td>Usually informal and unstructured</td>
</tr>
<tr>
<td></td>
<td>Adversarial</td>
<td>Less adversarial</td>
<td>Non-adversarial</td>
<td>Non-adversarial</td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
<td>Application of legal rules may help to address power imbalances</td>
<td>Quicker and cheaper than litigation</td>
<td>Parties can tailor procedure to suit their needs</td>
<td>Quicker and cheaper</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Parties can choose subject matter experts as arbitrators</td>
<td>Enables creative solutions to be found</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Can resolve conflicts over policy issues and/or where clear legal rights/obligations are lacking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Parties retain control over process and outcome</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Parties work together to find win-win solutions</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Substantive issues of importance to parties can be addressed</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Decisions can be tailored to needs of parties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Parties can directly contribute expert understanding and expertise</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Agreement more likely to be implemented and future problems solved in non-adversarial way</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mediation, in particular, can restore communication between alienated parties and break deadlock</td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
<td>Slow and expensive</td>
<td>Parties relinquish control over final decision</td>
<td>Success depends on competence of arbitrators</td>
<td>Power imbalances may be enhanced</td>
</tr>
<tr>
<td></td>
<td>Reinforces conflict between parties; may result in further litigation</td>
<td>Success depends on competence of arbitrators</td>
<td>No appeal against decision (usually)</td>
<td>Agreement may not be reached</td>
</tr>
<tr>
<td></td>
<td>Decision restricted within narrow legal parameters</td>
<td></td>
<td></td>
<td>Failure to implement agreement may necessitate enforcement through courts</td>
</tr>
<tr>
<td></td>
<td>Parties relinquish control over process and decision</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inappropriate for disputes involving wider policy issues</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: from Scialabba, 1998*
Chapter 7
Screening

Summary

Screening is the process used to decide whether or not a policy, plan, programme or project requires environmental assessment, and if so, at what level. Screening depends either on a subjective decision by an administrator, or (more usually) checking of a proposal against a set of standard criteria. These criteria may range from very general (such as “projects likely to cause potentially significant impacts”), to very specific (such as scale, location, type of activity, technology, relation to other resource users, etc.).

These criteria should be an output from sector environmental assessment. Where there is a strong environmental management framework, criteria can be made clearer and more explicit, and there will be less need for individual project EIA.

If there is uncertainty about a project in relation to the criteria, an initial environmental examination (IEE) or initial environmental assessment (IEA) may be required, and this may be subject to review by some form of advisory committee before decision is made about the need or otherwise for full EA.

Whatever criteria are used, it is important that they, and the screening procedures in general, should be widely known and understood, so that proponents can design to meet environmental standards, or locate in suitable areas, thereby minimizing costs to all parties while maximizing environmental management benefits.

Contents

- **Objective**
- **Criteria for the sector**
- **Criteria for assessing individual coastal aquaculture projects**
- **Screening procedures and methods**
- **Clarity of procedure**

7.1 Objective

To determine whether or not a policy, plan, programme or project requires full scale EA, and if not, at what level, if any, an assessment should be made.

7.2 Criteria for the sector

Operating principle No 1, as presented by the international study of the effectiveness of environmental assessment states that EA:

> Should be applied to all development project activities likely to cause potentially significant adverse impacts, or add to actual or potentially foreseeable cumulative effects. (Sadler, 1996).
According to this criterion, most intensive aquaculture, and extensive aquaculture developments that involve habitat conversion, however individually small, require some form of EA.

The Ramsar Convention on Wetlands of International Importance advocates EA for projects likely to negatively impact wetlands. Most coastal aquaculture currently takes place within salt marsh, mangrove, lagoon, and estuarine systems.

According to UNEP (1996) full scale EA is typically required for proposals which involve:

- exploitation of natural resources;
- infrastructure;
- industrial activities;
- extractive industries;
- waste management and disposal; and
- substantial changes in farming or fishing practices.

Most policy, planning or programme initiatives related to coastal aquaculture satisfy the first and last of these criteria, and there is a strong case for sector EA of such initiatives, preferably within a broader integrated coastal management initiative. This case is further strengthened since coastal aquaculture is typically developed in physically and ecologically valuable and sensitive areas including salt marsh, mangrove, lagoons, estuaries, and coral reefs. These are also areas where resource rights and ownership are often ambiguous, and where conflicts of interest between different resource users are common.

On the basis of these requirements and observations, clear and simple criteria for screening coastal aquaculture developments, and defining the level of EA, if any, which may be appropriate, are presented in Box 7.1.

In practice, most countries have not made significant use of sector EA for aquaculture, and therefore rely on screening procedures applied to most individual projects. These may classify aquaculture proposals into different groups requiring more or less rigorous EA. Figure 7.1 shows a simplified example from Belize (Huntington and Dixon, 1997).

### Box 7.1. When and how should EA be applied to coastal aquaculture?

All coastal aquaculture development should be subject to sector or regional EA, preferably as part of the development of an environmentally sustainable sector plan, or an integrated coastal management plan (ICM).

Sector EA should form the basis for developing screening criteria to determine which, if any, individual aquaculture projects should be subject to EIA, and the form that this assessment should take.

These criteria might, for example, relate to:

- location relative to sensitive natural habitat
- location relative to other resource users
- location relative to land/water use zones
- size
- design
- technology
- species
- management practices.

7.3 Criteria for assessing individual coastal aquaculture projects

If a sector or regional EA has been undertaken during the development of a sector plan, integrated coastal management plan, or district plan, then as part of the mitigation process, rational decision criteria for authorizing or restricting individual aquaculture development, or requiring IEE, or full EIA, should have been established. These criteria may be based on size; location; spatial relationship with other resources, farms or activities; technology; or management practices, and are likely to be closely related to the mitigation measures presented in section 10.

In the absence of strategic or sector EA, there is a strong argument for IEE of any aquaculture development that, through size or location, is likely to have a significant effect on any of the following:
• **natural habitat and biodiversity**: estuary, salt marsh, mangrove, lagoon and coral reef
• **other aquaculture operations**: in particular their water supply (in terms of pollution or disease); and
• **other resource users**: for example the quality and quantity of water available for agriculture or household use.

Note that in assessing significance, the cumulative effects of existing and likely future developments should be considered. On this basis, most coastal aquaculture operations, however small, would meet the criteria for IEE. This would represent a high cost and administrative burden, especially for developing countries, and further strengthens the argument for sector EA of coastal aquaculture. If done well, this broader assessment would remove the need for EIA of most aquaculture projects.

### 7.4 Screening procedures and methods

Screening procedures should be developed as an output of sector EA. Decision criteria should be made explicit in legislation, regulations or guidelines, and they should be sufficiently clear to ensure that different analysts will arrive at similar conclusions. The clear and consistent use of screening procedures is the first vital step in encouraging sustainable proposals, and reducing the cost of unnecessary EAs.

Screening may include either or both of the following:

• project lists with/without thresholds
• initial environmental examination.

#### 7.4.1 Project lists and standard criteria

Certain types of proposals, as listed in regulations or guidelines, will be either included (inclusion list) or excluded (exclusion list). Specific threshold values, technology, or location may characterize the types. For example the following may be subject to either IEE, IEA, or full EIA:

• farms located outside aquaculture development zones;
• brackish-water pond aquaculture projects of > X ha;
• cage farms with projected production > X mt;
• farms located in or within X m of sensitive natural habitat, such as mangrove or coral reef;
• farms located within X m of existing farms;
• brackish-water ponds located within < X m of agriculture or bore-holes for domestic water supply; and
• cages located in navigated waterways.

The actual threshold figures (represented above by X) should be based on local conditions, and developed as part of a sector or regional EA. Guidance on how to develop some of these figures is provided in sections 9 and 10. Criteria of this kind are simple, and once agreed (preferably drawing on significant public consultation), the process is virtually cost-free, the outcome is predictable, and both proponents and the general public can readily understand them. They may be used to define the need for EIA, or IEE, or the need to adhere to certain environmental management practices (as is done for example in Thailand). They can be adapted over time in the light of experience. In many ways they represent the best approach to screening aquaculture developments. However, they offer only limited response to the incremental and cumulative impacts commonly associated with aquaculture development, unless they are set within the context of a broader aquaculture or integrated coastal management plan.
For example, some countries have introduced standard size criteria for EA of aquaculture. In Sri Lanka for example, EA is required for aquaculture operations of more than 5 ha located in environmentally sensitive areas. However, farms close to this size usually do not (individually) have a significant impact, and are rarely turned down on the basis of an EA. Nor can compliance specified in any approval document be effectively monitored for a large number of individual farms. In Malaysia the size criterion is 40 ha, effectively excluding all small to medium scale aquaculture development. The value of the exercise is

**Figure 7.1. Proposed screening of aquaculture projects in Belize (simplified).**

- **Developer submits project proposal and environmental screening form (based on criteria below) to fisheries department**

- **Primary screening by fisheries department – using schedule criteria (see below)**

- **Schedule I**
  - EIA mandatory

- **Schedule II**
  - Referred to National Environmental Appraisal Committee (NEAC)

- **Schedule III**
  - EIA not required

  **NEAC decides on appropriate level, if any, of EIA**

**Criteria for schedule classification**

<table>
<thead>
<tr>
<th><strong>Schedule I (full EIA automatic)</strong></th>
<th><strong>Schedule II (secondary screening by NEAC)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• New mariculture ponds &gt; 40ha;</td>
<td>• New mariculture ponds &lt; 40.5 ha;</td>
</tr>
<tr>
<td>• New mariculture ponds abstracting &gt; 45,460 m$^3$ of seawater/day;</td>
<td>• New mariculture ponds abstracting &lt; 45,460 m$^3$ of seawater/day;</td>
</tr>
<tr>
<td>• Finfish production in the intertidal or sub-littoral zones;</td>
<td>• Any culture of seaweeds less than a total seabed area of 4 ha</td>
</tr>
<tr>
<td>• Any aquaculture project planning to use non-endemic species;</td>
<td></td>
</tr>
<tr>
<td>• Any culture of seaweeds exceeding a total seabed area of 4 ha</td>
<td></td>
</tr>
</tbody>
</table>

**Schedule III**

- Extensive (non nutritive input) culture of seaweeds or bivalves with an area not exceeding 2 ha;
- Aquaculture projects designed solely for subsistence use

*Adapted and simplified from Huntington and Dixon (1997)*
therefore questionable in both cases (see Case Study 2: EA of Aquaculture in Sri Lanka) since it cannot effectively address the cumulative problems of highly concentrated but small-scale aquaculture development.

**Location in relation to natural resources**

Coastal aquaculture developments are commonly located in, or close to, estuarine, salt flat, mangrove, lagoon, or coral reef resources. These are valuable natural resources providing a wide variety of physical and ecological functions and services. They are also vulnerable to physical conversion and pollution. Farms located in such areas, or in particular land-use categories of such areas, might be automatically included in such lists (as is the case for example in Indonesia), unless specifically allowed for within an integrated coastal management plan, sector plan or district plan which has been subject to thorough strategic EA.

**Location in relation to other aquaculture developments**

Coastal aquaculture is sometimes a victim of self (sector) pollution and spread of disease. It is arguable that any significant aquaculture development which is likely to share water supply or effluent channels with other farms should be subject to IEE, unless specifically allowed for within an integrated coastal management plan, sector plan or district plan which has been subject to thorough strategic EA.

**Location in relation to other resource users**

Brackish-water pond culture may affect the salinity of surface or ground-water, and may therefore affect drinking water supplies (as has happened for example in some parts of India) or agricultural activities (as has happened recently in Thailand). Any significant aquaculture development sited close to such uses should be subject to EA, unless specifically allowed for within an integrated coastal management plan, sector plan or district plan which has been subject to thorough strategic EA. Brackish-water pond culture may also restrict access and passage between villages and the coast, and may disrupt fishing activities. Again, if this is possible or likely, EA should be undertaken.

### 7.4.2 Initial Environmental Examination (Evaluation) (IEE)

Where there is uncertainty as to whether a full EA is required, an initial environmental examination can be undertaken. As noted above, this is probably the most appropriate response to any coastal aquaculture development project that is not specifically allowed for within a previously assessed ICM or sector planning framework. IEEs are normally based on existing or readily available information. Although similar in content and structure to full EAs, they address issues in much less detail, involve only limited quantification of impacts, and require less in the way of public involvement. As with full EIs, they may be used to improve design and

**Box 7.2. Typical procedure for an initial environmental examination (IEE)**

- describe the proposal and examine alternatives that might improve the environmental outcomes;
- describe the environment and its vulnerability to development impacts;
- identify and address the concerns of the local community;
- identify and assess the potential environmental effects;
- assess the degree of uncertainty associated with possible impacts;
- identify ways to mitigate adverse effects and enhance potential benefits;
- define appropriate environmental objectives for the programme or project; and
- contain environmental monitoring and management plans.
management of proposed projects, whether or not full EIA is recommended. They can be applied at policy, programme or project level. Summary content of an IEE is presented in Box 7.2.

Several aid agencies use a form of IEE in respect of development programmes. An example is the UNDP Environmental Overview (UNDP, 1992). Sri Lanka requires an IEE for all (official) aquaculture proposals (see case studies, Appendix 1).

7.4.3 Initial Environmental Assessment (IEA)

Some countries require an assessment for certain kinds of projects, which lies between an IEE and a full scale EA. This may be referred to as Initial Environmental Assessment (IEA). A detailed checklist for what should be addressed in an IEA specifically for aquaculture projects is presented in Appendix 4. It draws extensively on the NORAD (1992) guidelines for initial environmental assessment of aquaculture. Detailed discussion of most of the impacts or mitigation measures listed in the checklist is provided in Section 9 (assessment) and Section 10 (mitigation). For an IEE these issues should be addressed in less detail than for a full EA, based on review of existing documents, and direct consultation with the widest possible range of stakeholders including local communities.

7.5 Clarity of procedure

Procedures for screening should be spelt out clearly in regulations or guidelines, so that proponents are aware of their obligations, and therefore design more environmentally sound proposals.
Chapter 8
Scoping

Summary

Scoping is a process to identify and evaluate community and scientific concerns about a proposed policy, programme, project or action, so that they can be addressed systematically in the EA. The output from scoping usually includes detailed terms of reference for further work.

Whereas in the past this was seen as a largely technical matter, it is increasingly seen as a major opportunity for public involvement in the decision making process. Techniques for the communication and exchange of information and opinion (section 6) are therefore a vital part of scoping.

Contents
- Objectives
- Issues to be addressed
- Process
- Responsibility and administration
- Terms of reference and consultant brief

8.1 Objectives
The objectives of scoping are:

- to identify community and scientific concerns about a proposed policy, programme, project or action;
- to evaluate these concerns to determine the key issues for the purpose of the environmental assessment (and to eliminate those issues which are not significant); and
- to organize and communicate these to assist in the analysis of issues and the ultimate making of decisions.

Scoping can apply equally to project, sector, regional or strategic EA. However, one of the outputs of a comprehensive sector EA should be a definition of the scope appropriate to individual project EIAs (see section 5), which might vary according to the type and scale of aquaculture development in different locations. In this way sector EA can be used to make project EIA more efficient or effective, or remove the need for it altogether.

As with other stages in the EA process, scoping can contribute to heightened awareness of the issues, and lead to improved policy, better development programming, or improved siting and design with respect to specific project proposals.

8.2 Issues to be addressed
The scoping exercise seeks to define - and reach agreement among the major stakeholders and technical specialists on - the overall scope of the assessment, in terms of:
• the range of zoning, siting, and technical alternatives to be assessed (see Box 8.1);
• the possible impacts which should be addressed;
• the criteria or standards to be used for assessing significance;
• the methodologies to be used, including the mechanisms, extent and role of public involvement;
• the information available and required;
• the spatial boundaries of the study;
• the time period over which impacts should be considered (for example should it address issues related to abandonment or after use?); and
• the kinds of mitigation which should be explored.

By gaining consensus on the scope of the study, much irrelevant data collection and analysis can be avoided, and time and effort saved. It is also an opportunity to inform stakeholders about the policy, programme or project, the EA, and its objectives, and to obtain some preliminary knowledge of the local area, including in particular local concerns and values. It is clear (in retrospect) that one of the weaknesses of the Rufiji EIA (Box 6.5) was a late and rather limited public involvement in scoping.

TOR for the EA are normally the main output from the scoping exercise, supplemented in some cases with a more detailed consultant brief.

8.3 Process

Typical steps or stages in the scoping process are presented in Box 8.2. These should be considered as indicative only, and should be tailored to the type of EA, and local circumstances.

Scoping is a process of interaction between the interested public, government agencies, technical specialists and proponents.

Box 8.1. Alternatives to be explored during scoping

• location alternatives (e.g. the location and boundaries of an aquaculture development zone; the location of associated infrastructure or services such as canals, processing or feed mills (sector EA); the location of a particular farm (project EIA));
• activity alternatives (e.g. different aquaculture species or technologies);
• input alternatives (e.g. feed, fertilizer, chemicals);
• demand alternatives (e.g. using energy, food, or other resources more efficiently);
• process or management alternatives (e.g. water treatment or re-use; feed management; disease management); and
• scheduling alternatives (where a number of measures might play a part in an overall programme, but the order in which they are scheduled will contribute to the overall effectiveness of the end result).

Adapted from UNEP (1996)

Box 8.2. Typical steps in scoping

1. Prepare an outline of the scope, with headings such as:
   • objectives and description of the proposal;
   • the context and setting of the proposal;
   • constraints
   • alternatives
   • issues
   • public involvement (in scope); and
   • timetable.

2. Further develop the outline of the scope through discussion with the proponent, the EIA authority, and other key stakeholders and government agencies, assembling available information, and identifying information gaps.

3. Make the outline and supporting information available to those whose views are to be obtained.

4. Identify the issues of concern.

5. Evaluate the concerns from both a technical and subjective perspective, seeking to assign priority to the more important issues.

6. Amend the outline to incorporate the agreed suggestions.

7. Develop a strategy for addressing and resolving each key issue, including information requirements and terms of reference for further studies.

8. Provide feedback on the way comments have been incorporated.

Source: Ridgeway et al., 1996
Public and expert consultation and participation (see section 6), coupled with a preliminary analysis of existing documentation, are key tools for scoping.

Draft TOR may serve a useful function in the consultation process. The final TOR should be detailed, but flexible, to be adapted if required and agreed.

Scoping offers an important opportunity for an initial appraisal of alternatives in terms of zoning, siting, design and management, and appropriate modifications to the plan or proposal (Box 8.1).

Particular attention should be paid to secondary and higher order impacts, and the extent to which these should be covered in the assessment.

In addition to the specific scoping stage, scoping should be undertaken as an on-going part of all subsequent stages, so that the focus and boundaries of the effort can be defined and agreed.

8.4 Responsibility and administration

Depending upon the EA system, responsibility for scoping may lie with the proponent, or with the EA authority, or with an expert group set up for the purpose. Some authority will be designated with responsibility for ensuring that the completed EA meets the agreed scope or TOR.

8.5 Terms of reference (TOR) and consultant brief

The main output from scoping is normally, the TOR and in some cases a more detailed consultant brief presenting the findings, and defining the scope for the EA study.

In practice, the purpose of EA as presented in sections 5.1.1 (sector EA) or 5.2.1(project EIA) coupled with the outputs described in sections 5.1.3 and 5.2.3 respectively, should provide the broad basis or outline for the TOR. These should then be refined, and made more specific and relevant on the basis of the scoping exercise. Detail relating to specific methodologies or approaches, if required, may be based on an appraisal of relevant techniques described in sections 9 and 10. A broad outline for TOR for project EIA is presented in Box 8.3.

In some cases relatively detailed requirements in terms of public involvement may be laid down. The Terms of Reference can also contain various matters relating to project management, such as:

- the proposed study schedule;
- the budget allowed for the study;
- the expected outputs (interim and final reports, format of the environmental impact statement, number of copies); and
- the basis on which variations to the brief will be negotiated.
Chapter 9
Assessing

Summary

Assessment is the core of EA, and involves identifying and defining more clearly the impacts that are to be investigated in detail, and analyzing these impacts in terms of their major characteristics and significance.

Assessing usually involves a range of techniques from baseline data collection to modeling, and in some cases decision analysis.

Although many of the techniques are widely agreed, there is debate about the way in which different kinds of information (relating to social, environmental and economic impacts; or to impacts through time or space) can be presented or aggregated to provide an overall indication of impact significance or sustainability.

Contents

- Objectives
- Impact identification
- Impacts associated with coastal aquaculture
- Impact analysis
- Significance
- Summary and presentation
- Towards consistency in assessment

This is the core of EA and may require significant resources.

9.1 Objectives

- identifying and defining more specifically the impacts that are to be investigated in detail;
- analyzing impacts: the collection of baseline data; the important characteristics of impacts and the range of different analytical techniques; and
- determining impact significance or acceptability (UNEP, 1996).

9.2 Impact identification

This stage involves confirming the existence or relevance of impacts identified during the screening and scoping stages, and going beyond this to identify additional impacts which may be direct, indirect or cumulative. It involves gaining a better understanding of the nature of these impacts and their causes.

The range of impacts considered in EA has broadened substantially in recent years to include social, health, and economic and other issues. OECD/DAC (1994) defined environment for the purposes of EA to include:
• effects on human health, well-being, environmental media, ecosystems and agriculture;
• effects on climate and the atmosphere;
• use of natural resources (regenerative and mineral);
• utilization and disposal of residues and wastes; and
• resettlement, archaeological sites, landscape, monuments and social consequences as well as upstream, downstream and trans-boundary effects.

It is particularly important, and difficult (except with hindsight) to identify higher order impacts and confirm the links or relationships with particular activities (Box 9.1). There are often complex social-environment interactions and many ecological feedback loops. Possible links may be promoted and publicized by particular interest groups. It is essential that the EA team identifies all possible impacts of this kind objectively, and is not excessively influenced by particular groups or interests.

This implies the need for a structured and systematic approach to impact identification and improved understanding of their causes. These approaches also usually help in the presentation of information in the report. They are described in the following section.

9.2.1 Tools for impact identification

The most common methods or tools for impact identification are:
• professional and technical experience
• checklists
• matrices
• networks
• overlays and geographic information systems (GIS)
• expert systems (UNEP, 1996).

Table 9.1. Advantages and disadvantages of different impact identification methods.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>checklists</td>
<td>• simple</td>
<td>• do not distinguish direct and indirect impacts</td>
</tr>
<tr>
<td></td>
<td>• good for site selection and priority setting</td>
<td>• do not link action and impact</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• incorporation of values can be controversial</td>
</tr>
<tr>
<td>matrices</td>
<td>• link action to impact</td>
<td>• difficult to distinguish direct and indirect impacts</td>
</tr>
<tr>
<td></td>
<td>• good for displaying results</td>
<td>• may “double count” impacts</td>
</tr>
<tr>
<td>networks</td>
<td>• link action to impact;</td>
<td>• can become very complex</td>
</tr>
<tr>
<td></td>
<td>• checking for 2nd order impacts;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• handles direct and indirect impacts</td>
<td></td>
</tr>
<tr>
<td>overlays</td>
<td>• simple</td>
<td>• address only direct impacts</td>
</tr>
<tr>
<td></td>
<td>• good display</td>
<td>• do not address impact duration or probability</td>
</tr>
<tr>
<td></td>
<td>• good for siting issues</td>
<td></td>
</tr>
<tr>
<td>GIS</td>
<td>• good for impact identification and analysis;</td>
<td>• heavy reliance on knowledge and data;</td>
</tr>
<tr>
<td></td>
<td>• good for “what if”</td>
<td>• complex and expensive</td>
</tr>
</tbody>
</table>

(Source: UNEP, 1996)
These may be used together or alone. Most can also be used to help analyze and assign significance to different impacts. The particular mix will depend on local circumstances, resources, team experience, and the nature of public involvement. It may be useful to "pilot" a particular technique to see whether it is useful in meeting the objectives of the EA. The advantages and disadvantages of the different techniques are presented in Table 9.1

**Professional and technical experience**

Although impacts are likely to be different in different places, a great deal of international experience has now been built up on the social and environmental impacts of many different forms of aquaculture. This is summarized in Table 9.3 below, and in more detail in Appendix 5.

However, these cannot in any way substitute for the breadth of understanding, and ability to interpret and focus on key issues, which is the hallmark of a skilled and experienced professional with broad experience of the sector in a variety of natural environments and socio-economic contexts.

**Checklists**

Checklists are the basic tool for environmental assessment, and can be steadily developed and refined on the basis of both local and international experience. A checklist for IEA of aquaculture is provided in Appendix 4.

Checklists, however, have some limitations, and in particular, they are not effective for the identification of locally unique higher order impacts, or the relationships between impacts, or the relationships between impacts and project/plan activities.

**Matrices**

Matrices are used to identify the interaction between project activities and environmental features or characteristics. They are also of great value as a framework for discussions and exercises in workshops, and in presentations. Each cell can be used to describe the interaction in terms of its nature, severity, and significance. The cells may contain comments, or summaries presented in terms of numbers, symbols, shades or colours. Impacts may also be related to possible mitigation measures. A specific example of a simple matrix is presented in Table 9.2. This was designed to identify and explore a range of possible impacts within a systematic framework, and to serve as the basis for discussion and further research.

**Networks**

Networks are used to illustrate the complex links between aquaculture developments and environmental features or characteristics. They are particularly useful for identifying, presenting, and discussing higher order impacts and interactions.

A simple network illustrating some of the interactions between a hypothetical shrimp aquaculture development and the environment is presented in Figure 9.1. More detailed information based on local conditions should be presented in such networks, such as the probability of a link or impact, and the scale or quantification of the impact. Very detailed networks can be produced, but they are time consuming and can be difficult to interpret.

**Overlays and Geographic Information Systems (GIS)**

Overlay of different maps presenting different kinds of environmental data (e.g. land quality, land use, salinity regimes, population, existing activities, proposed activities etc) on a transparent background, is a simple and powerful tool for the analysis and presentation of data relating to environmental impacts and their interactions. It is suited to all kinds of assessment but especially to sector or regional EA.
Table 9.2: Example of matrix used as a summary of potential impacts of a proposed shrimp farm development in Tanzania

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Natural function and conservation value</th>
<th>Commercial function/uses</th>
<th>Possible physical impact from proposed farm</th>
<th>Possible biological impact</th>
<th>Possible economic impact</th>
<th>Affected groups or communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>mangrove</td>
<td>coastal protection, sediment trap, nursery</td>
<td>poles, fuel, charcoal, bait, manufactures; shellfish, fishery nursery,</td>
<td>locally increased water flow; increased salinity in dry season; increased nutrient; reduced oxygen; increased organic sediment; increased inorganic sediment (construction phase); pH change?</td>
<td>mangrove species change?; other species change? increased productivity; positive or negative effects on nursery areas?</td>
<td>increased commercial yield of mangrove products? Improved coastal protection?</td>
<td>artisanal fishermen; offshore shrimp fishermen; mangrove wood collectors (charcoal, poles, manufactures, firewood); villagers (subsistence products); charcoal manufacturers</td>
</tr>
<tr>
<td>river system</td>
<td>hippo, crocodile etc...</td>
<td>FW fishery</td>
<td>increased salinity in dry season; increased nutrient; increased organic sediment (if no settling); piscicides?</td>
<td>possible increased productivity; possible shift in species composition; accidental fish kills?</td>
<td>probably insignificant</td>
<td>probably insignificant</td>
</tr>
<tr>
<td>estuarine system</td>
<td>fisheries: milkfish; mud-crab; shellfish</td>
<td>little</td>
<td>little</td>
<td>probably insignificant</td>
<td>coastal fishermen</td>
<td></td>
</tr>
<tr>
<td>seagrass</td>
<td>nursery for coral reef and offshore species</td>
<td>possible slight impact of sediments in absence of settling</td>
<td>possible loss of fisheries</td>
<td>probably insignificant</td>
<td>coastal and offshore fishermen</td>
<td></td>
</tr>
<tr>
<td>coral reef (to the South of estuary)</td>
<td>tourism</td>
<td>more tourism</td>
<td>Possible suspended solids in absence of settling, but N flowing currents imply low risk</td>
<td>Fouling and loss of corals</td>
<td>probably insignificant</td>
<td>reef fishermen; tourist operators; collectors</td>
</tr>
<tr>
<td>floodplain grassland and scrub</td>
<td>rice salt</td>
<td>variety of arable arable etc</td>
<td>local loss (up to 160 ha)</td>
<td></td>
<td>probably insignificant</td>
<td></td>
</tr>
<tr>
<td>wider environment</td>
<td>antibiotics; nutrients</td>
<td>antibiotic resistance? red tides?</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from AIT 1995
Figure 9.1. Example of a network presentation of the environmental effects of aquaculture. Some possible interactions between shrimp farming and the environment.
The computerized version, known as GIS, is in essence a spatially referenced database, and adds flexibility of presentation, massive data storage capacity, and a range of analytical tools.

GIS is a powerful and increasingly accessible tool for environmental assessment and planning. It is particularly appropriate for sector or regional EA since spatial and locational considerations play a key part in these assessments. Furthermore, since they, and the planning processes with which they are associated, are regular exercises, the initial costs of setting up GIS (an in particular inputting data) can be spread over a range of planning and assessment exercises through time and space.

Some “warnings” are however appropriate. GIS and remote sensing are attractive and seductive technologies, and sometimes become a costly “end in themselves” rather than being developed, refined and focused for assessment and decision making purposes.

There are several examples of the application of GIS to regional or programme level planning for aquaculture development (see bibliography), and at least one related to environmental assessment of shrimp farming at the regional/sector level (McPadden, 1993 & Hambrey, 1993).

### 9.3 Impacts associated with coastal aquaculture

Clearly the actual impacts will vary according to location and development context, but a good deal of experience has now been built up relating to aquaculture impacts throughout the world, and these (both positive and negative) are summarized in Table 9.3. This information is presented in more detail in Appendix 5, where the following matrices can be found:

- matrix for impact identification and mitigation: hatchery;
- matrix for impact identification and mitigation: brackish-water pond aquaculture;
- matrix for impact identification and mitigation: coastal cage or pen culture; and
- matrix for impact identification and mitigation: seaweed and mollusc culture

This information is based on a wide range of publications and author experience relating to the environmental impacts on aquaculture, and represents accumulated experience over many years from many parts of the world.

#### 9.3.1 Impacts on biodiversity, ecosystem functioning and natural resources

**Figure 9.2: Black effluent Black effluent which is flushed into adjacent ecosystem when shrimp are harvested from the pond.**

These are generally easy to identify, but much more difficult to analyze (see below). Thus habitat loss or water quality change is easy to describe Figure 9.2, but very hard to analyze objectively in terms of impact on economic activity and/or long term significance. The matrix presented in Table 9.2 provides a graphic illustration of how difficult it is to translate physical effects into biological and ultimately economic impacts.

Although biodiversity may be quantified at various levels (for example in terms of number of
Table 9.3. Positive and negative impacts sometimes associated with coastal aquaculture

<table>
<thead>
<tr>
<th>Negative impact</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>on and off site damage to natural resources; associated social conflict</td>
<td>direct conversion of semi-natural habitat, or land used for other purposes; indirect impacts: organic or chemical pollution; introduction of salt water; over-exploitation of capture fishery resources for fish-meal or trash fish supply;</td>
</tr>
<tr>
<td>over exploitation of wild seed or broodstock</td>
<td>as above</td>
</tr>
<tr>
<td>over exploitation of wild seed or broodstock</td>
<td>poor fisheries management; lack of hatchery production</td>
</tr>
<tr>
<td>loss of biodiversity and wetland habitat</td>
<td>direct conversion; changes to hydrology; organic and chemical pollution; displacement of resource users, resulting in increased human pressure elsewhere</td>
</tr>
<tr>
<td>water pollution</td>
<td>poor nutrient ('food or fertilizer') conversion; poor water and sediment management</td>
</tr>
<tr>
<td>changes to hydrology or salinity</td>
<td>water extraction, use and management</td>
</tr>
<tr>
<td>solid waste production and disposal</td>
<td>poor food conversion; poor pond water management; poor pond sediment management; poor waste disposal</td>
</tr>
<tr>
<td>social inequity</td>
<td>land/resource appropriation for aquaculture development; rapid increase in income for successful farmers; increased cost of land or resources related to profitable aquaculture</td>
</tr>
<tr>
<td>demographic impacts</td>
<td>use of significant outside labour or technical expertise</td>
</tr>
<tr>
<td>aesthetic impacts</td>
<td>direct conversion; extraction activities; structures</td>
</tr>
<tr>
<td>impact on worker health</td>
<td>pesticides, disinfectants, antibiotics; water borne disease</td>
</tr>
<tr>
<td>disease spread</td>
<td>poor husbandry and stressed stock; mixed influent and effluent water; exchange of water between farms; diseased seed; diseased broodstock; stock movements</td>
</tr>
<tr>
<td>genetic pollution</td>
<td>introduction of new species; introduction of new races; introduction of associated organisms including disease</td>
</tr>
<tr>
<td>noise and disturbance during construction</td>
<td>pond, cage or building construction</td>
</tr>
<tr>
<td>secondary impacts at materials extraction sites</td>
<td>removal of (eg dyke) materials from borrow pits</td>
</tr>
<tr>
<td>secondary impacts on product quality</td>
<td>chemical and antibiotic residues in product</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>positive impact</th>
<th>cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>increased natural productivity in coastal waters and wetlands, including mangrove</td>
<td>nutrients and organic matter released at moderate concentrations to the coastal environment from semi-intensive and intensive shrimp and fin-fish culture</td>
</tr>
<tr>
<td>reduced plankton and nutrient loadings in coastal waters</td>
<td>filter feeding of farmed molluscs and planktivorous fish; nutrient uptake by seaweed culture</td>
</tr>
<tr>
<td>reduced extractive/exploitative pressure on semi-natural habitat</td>
<td>provision of alternative employment and income generation</td>
</tr>
<tr>
<td>increased individual and communal income</td>
<td>high profitability of some forms of aquaculture; increased spending in local economy</td>
</tr>
<tr>
<td>employment generation</td>
<td>aquaculture often supports a relatively high rate of employment per unit land</td>
</tr>
<tr>
<td>training and education</td>
<td>directly related to specific enterprises; secondary effect from increased income</td>
</tr>
<tr>
<td>stock enhancement</td>
<td>hatchery production of over-exploited or endangered species</td>
</tr>
<tr>
<td>increased bio-diversity</td>
<td>greater structural habitat diversity related to pond and canal construction</td>
</tr>
</tbody>
</table>
species in a particular area, or in terms of genetic diversity within species), it is hard or impossible to assess what the impact of local habitat conversion, or a slight change in water quality, will be on this quantity.

The main biodiversity and natural resource impacts associated with coastal aquaculture are summarized in Table 9.3.

9.3.2 Social impacts

Ultimately all environmental impacts are social in so far as they only have significance when set against cultural values and the quality of life. Some of those, which may be associated with aquaculture, are given in Table 9.3.

Social impacts or effects are “alterations in the way people live, work, play, relate to each other and organize to meet their needs, as well as changes in the values, beliefs and norms that characterize their ‘group’ and guide their individual and collective actions (UNEP, 1996).

Social impacts may be categorized as follows:

- demographic impacts such as changes in population numbers, population characteristics (such as sex ratio, age structure, in-and-out migration rates and resultant demand for social services, hospital beds, school places, housing etc);
- cultural resource impacts including changes in archaeological, historical and cultural artifacts and structures and environmental features with religious or ritual significance; and
- socio-cultural impacts including changes in social structures, social organizations, social relationships and accompanying cultural and value systems (language, dress, religious beliefs and rituals).

Information on most of these impacts is collected through the public involvement programme. It is recommended that social scientists, preferably with considerable local knowledge, lead any public involvement programme and analyse the information generated related to social impacts. However, they should work closely with biophysical scientists and economists working on the team.

9.3.3 Health impacts

Health impacts can be extremely disruptive and costly and should be assessed as early as possible in the EA exercise. There have been few health impacts formally reported for aquaculture, but some activities may be associated with health risks (Box 9.2), and should be explored in more detail. As for other kinds of impact, they may be direct or indirect. With respect to residual chemicals in aquaculture products, a recent paper by WHO (1998) concludes that overall the risks to food safety from disease treatment chemicals in aquaculture are negligible, provided good aquaculture management practices (such as withdrawal times, treatment using recommended doses, approved chemicals) are observed. A list of chemicals which are commonly used in intensive aquaculture, and their known effects and levels of risk, are presented in Appendix 9.
9.3.4 Economic and fiscal impacts

Any significant policy, programme or project is likely (indeed is intended) to affect employment, business activity, and levels of regional or individual income, and these may in turn cause social impacts (Box 9.3).

Fiscal impacts are the changes in costs and revenues of different government sectors resulting for example from demographic changes and associated changes in tax revenue and demand for infrastructure and services.

Some of these effects can be analyzed and predicted using standard economic techniques such as input-output models. Increasingly, as EA is integrated with sector analysis, policy development, integrated coastal management, local planning, and project appraisal, these economic analyses will be a normal part of the overall analysis.

Box 9.3. Factors affecting economic and fiscal impacts

Factors affecting economic impacts:
- duration of construction and operational periods;
- workforce requirements for each period and phase of construction including numbers to be employed during the peak phase for construction works;
- skill requirements (local availability);
- earning;
- raw material and other input purchases;
- capital investment;
- outputs; and
- the characteristics of the local economy.

Factors affecting fiscal impacts:
- size of investment and workforce requirements;
- capacity of existing service delivery and infrastructure systems;
- local/regional tax or other revenue raising processes; and
- likely demographic changes arising from project requirements (these need to be estimated during the assessment of social impacts).

Source: UNEP, 1996

9.4 Impact analysis

9.4.1 Overview

Impact analysis can become very complex and time consuming. It is therefore important that the methods used in impact analysis, and the detail of the analysis, should be in proportion to the scope of the assessment and the relative importance of the impact.

Assessments should be quantitative where possible. Simple description is the only realistic and "transparent" approach for some impacts, but these descriptions must be as focused and precise as possible.

In order to assess impacts there must be a baseline or standard to measure against. Describing baseline conditions can easily get out of hand. Baseline description should therefore always relate to significant impacts, and must be developed in parallel with impact analysis. It may be desirable to restrict the length of the baseline description. It may also be necessary to predict a "future (at time of implementation) baseline", taking into account trends, and other developments.

There are typically three closely related stages in impact analysis:

1. characterization;
2. quantification and prediction; and
3. assigning significance.
9.4.2 Impact characteristics

Impacts vary in (UNEP, 1996):

- nature (positive, negative, direct, indirect, cumulative, synergistic with others);
- magnitude;
- extent/location (area/volume covered, distribution);
- timing (during construction, operation, decommissioning, immediate, delayed, rate of change);
- duration (short term, long term, intermittent, continuous);
- reversibility/irreversibility;
- likelihood (risk, uncertainty or confidence in the prediction); and
- significance (local, regional, global).

They can be described or ranked in terms of these various attributes.

Nature

It is self-evident that impacts can be positive or negative, and both should be considered in an EA (examples are presented in Box 9.1).

Direct impacts are those that occur at the same time as some activity, for example habitat conversion, or increase in nutrients or organic matter in receiving water.

Indirect or higher order impacts are less obvious and may occur at a different time or place from the activity that causes them. An example is the positive or negative impacts of nutrient discharges on a fishery or shell-fishery.

Cumulative impacts are those that are insignificant when considered in isolation but which may accumulate through both time and space. For example, occasional use of antibiotics on one small fish farm may have negligible impact, but if done by a large number of small farms, or if done regularly over a long period of time, pathogen resistance may develop, and the overall impact may be serious. Many of the small impacts associated with coastal aquaculture are cumulative in nature.

Magnitude

The size of an impact is obviously important, and should be measured where possible. It is a relatively straightforward matter to calculate the magnitude of some of the causes of impacts from coastal aquaculture. It is more difficult to estimate the magnitude of any direct physical or ecological impacts, and it is usually very difficult to quantify indirect physical, ecological and social impacts. For example the nutrient (N, P, organic matter) loading from an intensive brackish-water pond can be calculated relatively simply (Box 9.4 and Appendix 6). The effects of this loading on nutrient levels in the soil or waterways is more difficult to assess in most “real world” situations (Appendix 7). And the impacts of these nutrients on ecology, fishery production, and the livelihoods of other resource users are usually extremely difficult to assess quantitatively or qualitatively.

In some cases, although it may be relatively straightforward to make detailed and accurate calculations on direct effects, the inability to translate these into impacts of relevance to the stakeholders, or to relate them in any way to the concepts of sustainability, may make such calculations largely worthless.

Extent and location

An indication of the location, distribution, and size of the areas to be affected should be given for each impact.
Assessing the extent of direct habitat conversion for aquaculture development appears at first sight to be a relatively straightforward matter. However, two important factors should be taken into account. Firstly, the effects are likely to be cumulative. If one farm is successful, others are likely to follow, and however small they may be the cumulative effect may be substantial.

Secondly, as with all impacts, it is necessary to compare the predicted impacts against a baseline, which may be moving. Figure 9.3 shows the loss of mangrove habitat in Thailand over a period of years when shrimp farming was developing rapidly. In practice shrimp farming was one of many activities leading to the destruction of mangrove (others were over-exploitation for charcoal and firewood, conversion for salt farming and agriculture, and rapid urban and industrial development. This has two important implications:

- correlation does not mean there is a causal link; and
- taken alone the impact of shrimp farming may have been acceptable, but together with other factors it was (in retrospect) unacceptable, and conversion for aquaculture is now illegal.

Figure 9.3. Mangrove destruction and shrimp farm development in Thailand.

Assessing the direct and indirect effects of nutrient loadings from intensive aquaculture has been referred to in the previous section, and methods for calculating the location and extent of the effects are also considered in Appendices 6-8. The importance of allowing for a probable upward baseline trend in nutrients in coastal waters should also be stressed.

Timing
Impacts will take place during site preparation, construction, operation, and in some cases post-operation. Furthermore, some of the effects will be immediate, while others will be delayed, in some cases for many years.

Duration
Impacts may be short term, long term, or intermittent. For example the immediate impacts of site preparation are likely to be short term, while the accumulation of organic matter in the immediate environment, or the release of antibiotics to the wider environment may have long term effects. Introduction of new species could have indefinite effects.
Reversibility

Some impacts may be relatively temporary, and the environment may revert to its previous state relatively easily and quickly. The release of phosphorus and nitrogen is likely to cause effects which are rapidly reversible. The build up of organic matter is also likely to be reversible, but over a longer period. The loss of mangrove or coral reef is also reversible, but it may be many years before the habitat regains its former biodiversity. Reversible impacts are generally amenable to restoration, in other words, specific actions may speed up the process or reversion (Figure 9.4).

Likelihood (risk) and uncertainty

It is important to distinguish between risk and uncertainty. If an impact may or may not happen there is a risk associated with it. If the probability of this impact is known, then the risk is quantifiable. If the probability of the impact is unknown, then we are dealing with uncertainty, which is far more difficult to quantify.

For example, the probability of achieving a particular food conversion rate on an intensive farm could be estimated from industry surveys, and the probability of associated nutrient loading then calculated. Disease, and the use of antibiotics are much less easy to predict, and is therefore associated with considerable uncertainty. The impacts associated with introducing new species or varieties of fish are likely to be extremely uncertain.

The level of uncertainty also tends to be much higher with secondary or higher order impacts.

Some effects are low risk but potentially high impact. Some species introductions may fall into this category.

Figure: 9.4. Abandoned shrimp ponds.
9.4.3 Quantification and prediction

The impacts can be predicted using a variety of methods including:

- professional judgement;
- quantitative mathematical models;
- experiments, physical models; and
- case studies.

It should be noted that quantification is often extremely difficult. For example, quantifying the impact on biodiversity can be almost impossible, except at the crudest level of habitat area.

**Professional judgement**

All forms of analysis involve some degree of professional judgement. However, this should be used as far as possible with systematic tools.

The role of professional judgement becomes more important with indirect and especially social effects. Professional judgement may have a significant effect on the outcome of the assessment.

Professional judgement should be restricted as far as possible to very experienced and respected practitioners with detailed knowledge of the issues, local conditions, and type of policy or project.

**Quantitative mathematical models**

Mathematical models can be readily developed to describe or simulate some aspect of reality. The calculation in Box 9.4 is an example of a very simple model for predicting the nutrient discharges from aquaculture. More complex hydrological models for predicting nutrient concentrations in receiving waters are presented in Appendix 7. Sophisticated computer based hydrological models are available commercially. Increasingly, these physical models can be linked to biological, economic and sometimes social models.

Whenever using mathematical models, of whatever complexity, the basic nature of the model must be clearly described, and all significant assumptions (especially those associated with a high degree of uncertainty) must be clearly stated.

Models have the enormous advantage that they can be used repeatedly to address “what if” type questions, based on varying parameters and input values. Furthermore, the analysis is by definition repeatable and comparable.

**Surveys of similar enterprises**

There have been many surveys of the environmental impacts of aquaculture in recent years. In particular a good deal of information has been collected on the release of nutrients to the environment from intensive coastal aquaculture. This work is summarized in Appendix 6, and may be used for rough assessments of nutrient loading. These figures, especially those related to nutrient concentrations, should be used with care. Actual loading will vary enormously according to feed quality, feed management, water and sediment management, and general husbandry practices, and should be modified according to the nature of the proposal. These variations form the basis of many of the mitigation measures presented in section 10.
Sensitivity analysis

Large changes in the magnitude of some impacts may result in relatively insignificant environmental changes, while small changes in others may result in major environmental effects. This can be analyzed or presented by comparing the percentage change in a direct impact (e.g. nutrient loading) with the likely percentage change in the environmental effect. An example of calculating the percentage change in concentration of a nutrient in a receiving water following a doubling of nutrient loading from a farm is given in Appendix 7.

Experiments and physical models

Experiments and physical models are rarely used to assess impacts related to aquaculture. However, there have, for example, been some experiments on the reversibility of mangrove destruction. Mangrove has been replanted in old shrimp ponds with considerable success (see section 10, mitigation). Physical models might also be used to model the impact of effluent from the whole aquaculture sector in a particular estuary or bay. Such procedures are well developed in relation to major industrial projects. However, physical modeling in relation to specific aquaculture developments is probably unnecessary and excessively costly.

Case studies

Case studies of policy or project impacts on the environment, or environmental assessments relating to similar policies or projects in similar environments elsewhere provide important clues as to the kinds of impacts which may be expected, and the ways in which they can be mitigated.

A set of case studies relating to coastal aquaculture developments in developing countries are presented in Appendix 1.

9.4.4 Significance

Once impacts have been identified and analyzed, their significance must be assessed. Significance only has real meaning if it can be agreed, and this implies a statement of values, which may be translated into specific criteria for use in decision making. An impact may be measured against some accepted standard or criteria (such as maximum nitrogen concentration in a waterway, or total allowable reduction in area of mangrove). It may also be measured against a more fundamental concept such as environmental capacity or sustainability.

The process

Significance assessment should be an iterative process (Figure 9.5). A preliminary assessment of significance is made at an early stage (screening and scoping) in order to define priorities for more detailed analysis; a preliminary analysis may then run counter to the original assessment of significance and further analysis may be downgraded or increased as appropriate. In this way the detail of the analysis should reflect the evolving assessment of significance.

![Figure 9.5. Assessment of significance - an iterative process.](image-url)
In order to assess significance, the characteristics – which will as far as possible have been quantified – are compared with, or multiplied by their value. In the most straightforward cases the value can be expressed in financial or economic terms and can be multiplied by the effect. For example an impact may result in a decrease or increase in fisheries yield, and the value of the fishery may be relatively easy to determine. Unfortunately the significance of most impacts is much more difficult to assess, since they are commonly difficult to quantify, and the valuation may be highly subjective, and vary between different stakeholders. This is why public involvement has an important role to play in the assignment of significance to different impacts.

**Standards**

One way round this problem of subjectivity is to compare impacts with existing or proposed “standards”, such as water quality standards (an example is presented in Box 9.5). Pre-defined environmental quality standards for a range of parameters in particular areas or zones would allow for the significance of impacts to be measured against standards. However this puts the problem one step back. Agreement on what such standards should be, and what they represent is commonly fraught with difficulty. Standards for water quality, either in the effluent itself, or in the receiving water (appropriately defined) are common, and can be simply applied, but they may bear little relation to environmental quality in terms of ecosystem diversity and function.

Another approach is to take the current ecological state, and its associated nutrient concentrations as the standard, but the zone in which such a standard is to be applied must also be defined. Either way, public involvement in defining standards, or in assessing significance on an ad hoc basis is essential, if there is to be any confidence in the EA. One solution to this problem is to use sector EA as the public forum and technical basis for setting such standards.

**Environmental capacity**

In order to fully understand how a direct impact (e.g. nutrient load) may relate to an environmental standard (e.g. a nutrient concentration in receiving waters) it is desirable to understand the assimilative capacity of the environment - for example, how rapidly the nutrients are diluted; how much is absorbed by sediments; how much is taken up by mangrove or plankton etc). This may ultimately be used to assess how much aquaculture can be supported by a particular system (e.g. a lagoon or estuary) before the
environmental standard is exceeded - i.e. to assess environmental capacity. Details of how this may be done for some of the impacts related to coastal aquaculture are presented in Appendix 8.

**Sustainable development criteria**

The concept of sustainable development is simple and important, but translating it into specific standards or criteria is difficult and often subjective. Although many specific sustainability criteria have been proposed (see Appendix 10) there is no single universally agreed set.

Some general criteria are presented in Box 9.6. It is probably more appropriate to develop detailed and locally appropriate criteria starting from these more general ones, than to use more detailed criteria promoted by specific interests. The most difficult, most political, and least widely agreed of these criteria, are those relating to social and equity issues.

An example of the assessment of intensive shrimp farming against these criteria is provided in Appendix 10. One particular aspect of this assessment is worth mentioning here as an example. Most intensive aquaculture of fin-fish or shrimp currently relies on trash fish or fish meal as a significant component of feed input. There are two sustainability issues associated with this. The sustainability of input supply is questionable given the poor state of the management of high seas fisheries. The efficiency of resource use is also questionable (conversion of fish to fish) although much depends on the measure of efficiency used. The ways in which these issues such as this can be addressed are dealt with in section 10 (mitigation).

**Significance and decision making**

Assessment of significance should not be confused with decision making. Significance information should be presented as clearly as possible so that decision makers can make an informed decision. It is not appropriate for the EA team to take on the role of decision making³.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Impact from shrimp farm</th>
<th>release of foreign genetic material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>Magnitude</td>
<td>increase by 0.1mg/l in wet season; 0.4mg/l in dry</td>
<td>Extraction of additional 50m3 of firewood</td>
</tr>
<tr>
<td>Extent/location</td>
<td>within 1 km of farm effluent</td>
<td>reserve mangrove forest</td>
</tr>
<tr>
<td>Timing</td>
<td>continuous during operation within six months of site preparation within 3 years of first operation</td>
<td>until alternative resources or employment found</td>
</tr>
<tr>
<td>Reversibility</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Probability</td>
<td>Certain</td>
<td>Medium</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Overall significance</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

³ Note that this is one of the arguments against economic valuation of "non-market” effects. In the extreme case the economist weights all values in order to reach an “optimal solution”. In effect the economist becomes decision maker.
9.5 Summary and presentation

In order to make the findings accessible to the general public and decision makers, a variety of presentations and summaries are possible.

Table 9.4 provides a summary of impacts and their characteristics, associated with semi-intensive or intensive brackish-water culture of shrimp.

9.6 Towards consistency in assessment

It should be clear from this section that the quantification and valuation of impacts - i.e. assessment of significance - is difficult, both technically and philosophically. As a result individual project EAs are likely to be inconsistent and difficult to interpret. In other words, they may provide a rather poor basis for decision making.

One way round this is to establish much clearer ground rules for individual project assessment. The wider application of regional or sector EA to assess impacts of different activities more generally, and to define appropriate environmental standards, possibly relating to different zones, should form the basis for this. An outline of the process is presented in Figure 9.6.

Figure 9.6. A hierarchical approach to developing assessment criteria

Regional Environmental Assessment:

Identify major environmental issues and sensitive/valuable ecosystems.
Define environmental standards relating to possible impacts in specific zones.
Define assimilative capacity relating to particular impacts in particular zones (e.g. N loading).

Sector (aquaculture) Environmental Assessment

- Assess environmental impacts of different forms of aquaculture against standards and zones;
- Define acceptable limits in terms of nutrient loadings, or other potentially adverse effects, taking account of other sectors;
- define possible restrictions on location;
- define rights, incentives, constraints, regulations; and
- define criteria for project EIA requirements

Project Environmental Assessment:

screening: assess need for project EA against standard regulations; and assess impact significance against defined environmental quality standards
Chapter 10
Mitigation and Impact Management

Summary

As EA is used more as a tool for improved environmental design and management, rather than as an administrative and regulatory procedure, the identification of mitigation measures becomes central to EA. There is enormous scope for mitigating the environmental effects of coastal aquaculture. This can be done at several different levels through:

- improved planning and regulation;
- improved infrastructure;
- improved siting (closely related to planning and regulation);
- improved design;
- higher quality inputs;
- improved input and waste management; and
- improved husbandry and water quality management.

These measures can be encouraged or enforced through a suite of incentives, constraints and regulations, which are themselves a form of mitigation at sector level. The whole package, or parts of it, may in turn be linked to quality or environmental management certification and/or quality labeling initiatives.

Public involvement and conflict resolution processes may contribute significantly to identifying and developing desirable or necessary mitigation measures.

Contents

- Overview of mitigation needs for coastal aquaculture
- Mitigation at the sector or strategic level
- Mitigation of the impact from individual farms

10.1 Overview of mitigation needs for coastal aquaculture

The mitigation measures that can used to address the impacts associated with specific coastal aquaculture activities are presented in the matrices in Appendix 5. The main categories of impacts and their corresponding mitigation measures are summarized in Table 10.1. This table may be further adapted and developed according to particular aquaculture systems and local circumstances. Public involvement and conflict resolution techniques have been discussed in detail in section 6. They may apply equally to regional, sector, or project EA. They are essential tools for the development of locally appropriate mitigation strategies and specific measures.

Below are presented the main ways in which mitigation can be effectively implemented.
Table 10.1. Summary of reported impacts of coastal aquaculture and corresponding mitigation.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Causes</th>
<th>Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>On and off site damage to resources and social conflict</td>
<td>Direct conversion; organic or chemical pollution; release of salt; introduction of salt water</td>
<td>siting, scale, conflict resolution</td>
</tr>
<tr>
<td>Social inequity</td>
<td>Land/resource appropriation for aquaculture development; rapid increase in income for successful farmers</td>
<td>taxes, regulations, controls, conflict resolution</td>
</tr>
<tr>
<td>Loss of biodiversity and wetland habitat</td>
<td>Direct conversion; changes to hydrology; organic and chemical pollution; displacement resulting in increased human pressure</td>
<td>siting, scale, management, compensation</td>
</tr>
<tr>
<td>Aesthetic impacts</td>
<td>Direct conversion; extraction activities; structures</td>
<td>siting, design, scale</td>
</tr>
<tr>
<td>Water pollution</td>
<td>Poor nutrient conversion; poor water and sediment management</td>
<td>siting, design, management, input quality and intensity</td>
</tr>
<tr>
<td>Changes to hydrology or salinity</td>
<td>Water extraction, use and management</td>
<td>siting, design, management</td>
</tr>
<tr>
<td>Solid waste</td>
<td>Poor food conversion; poor pond water management; poor pond sediment management; poor waste disposal</td>
<td>High quality feeds; good feed management; efficient species; better pond water management; better sediment management; better sediment treatment and/or disposal; better design</td>
</tr>
<tr>
<td>Disease spread</td>
<td>Poor husbandry and stressed stock; mixed influent and effluent water; exchange of water between farms; diseased seed; diseased broodstock; stock movements</td>
<td>Disease free stock; disease resistant stock; disease monitoring; control of stock movement; better husbandry; better disease treatment and management; high water quality supply; high quality effluent; disinfection procedures; separation of water supply (influent-effluent, and between farms); general siting, design, and management</td>
</tr>
<tr>
<td>Impact on worker health</td>
<td>Pesticides, disinfectants, antibiotics, water borne disease</td>
<td>Protocols for improved chemical use and management practices</td>
</tr>
<tr>
<td>Over exploitation of wild seed or broodstock</td>
<td>Lack of hatcheries; over-rapid development</td>
<td>Development of hatchery technology; restraint on development</td>
</tr>
<tr>
<td>Genetic pollution</td>
<td>Introduction of new species; introduction of new races; introduction of associated organisms including disease</td>
<td>Restriction on movement of exotic species</td>
</tr>
<tr>
<td>Noise and disturbance during construction</td>
<td>Pond, cage or building construction</td>
<td>Restrictions and guidelines</td>
</tr>
<tr>
<td>Secondary impacts at materials extraction sites</td>
<td>Removal of (eg dyke) materials from borrow pits</td>
<td>Restrictions and guidelines</td>
</tr>
<tr>
<td>Secondary impacts on product quality</td>
<td>Chemical and antibiotic residues in product</td>
<td>Restrictions on use of chemicals and antibiotics; testing procedures; quality standards and labeling;</td>
</tr>
</tbody>
</table>

10.2 Mitigation at the sector or strategic level

Table 10.1 suggests that most mitigation opportunities are either beyond the scope of an individual project to implement, or are related to management practices, so that monitoring, and some form of on-going incentive or regulation will be required if they are to be implemented. In other words, a broader planning and management framework is essential for the long-term sustainability of aquaculture development.

Siting in particular is difficult to change once an aquaculture development project is proposed, since it will be initiated largely on the basis of the availability of a site. Sector environmental assessment of aquaculture should identify opportunities for mitigation of the impacts of the aquaculture sector as a whole, within a particular area (for example a bay, estuary or watershed). These mitigation measures may be promoted through a wide range of instruments as described below. If possible, they should be brought together within the framework of an aquaculture development plan, ideally as part of an Integrated Coastal Management Plan.
10.2.1 Zoning

Zoning is one of the few available approaches for avoiding or pre-empting issues of resource use conflict. The alternative, where resource use conflict may be an issue, is conflict resolution, which has been dealt with in section 6. In practice the two are related, since zoning may be a solution or mitigation measure proposed through the conflict resolution process. Furthermore, public involvement should play a key role in the definition of zones, and agreeing the rules or procedures that should apply to such zones.

Zoning can be undertaken most effectively as part of a broader integrated coastal planning and management initiative, since rational allocation of land or water to specific activities requires a thorough assessment of the strengths and weaknesses of alternative uses. Zoning may be used to define exclusive zones for particular activities, priority zones, or mixed zones. The approach, if any, should depend on local circumstances.

If a zone is allocated to aquaculture and/or other activities, the issues of biodiversity conservation, pollution and water quality can be addressed systematically. Firstly, environmental quality standards for the zone should be set. An example of such standards relating to major coastal ecosystem types is presented in Box 10.1, (see also Boxes 10.2 and 10.3). This addresses one of the main problems discussed in section 9, the need for consistent criteria against which impacts can be judged.

10.2.2 Management of environmental capacity

Once a zone has been defined, it may be possible to assess the environmental capacity of the area, in terms of total nutrient loading (phosphorus, nitrogen, carbon, suspended solids) which can be assimilated or dispersed without exceeding environmental quality standards. Environmental capacity is likely to vary greatly according to local ecological and hydrological conditions. Methods for its estimation are presented in Appendix 8.

If environmental capacity can be estimated or approximated, three main approaches may be used to prevent it from being exceeded:

1. The ideal is to sell or allocate a portion of environmental capacity to individual enterprises (aquaculture and other resource users, including agriculture). This approach is being explored in New Zealand at the present time.

2. A variation on this approach, currently in use in Finland, is to define the total acceptable food input (which may be calculated on the basis of typical nutrient conversion on farms, coupled with estimates of environmental capacity for the nutrient), and then to allocate a portion of this to licensees.

3. A less desirable approach is to define total acceptable aquaculture production, on the basis of environmental capacity and the pollution rates from aquaculture (Appendix 6) and other activities,
and to halt the issue of permits once this production is reached.

The first approach should encourage improved environmentally friendly technology without specifically restricting production. The second encourages the use of higher quality feeds and improved feed management. The last offers no incentive for better management, and also restricts production.

In practice the accurate assessment of environmental capacity is difficult and expensive. An alternative approach is to use rough estimates initially, and then to monitor and adapt estimates in the light of experience. In line with the precautionary approach, these rough estimates should be conservative.

If environmental capacity cannot be estimated, then there are again two options:

1. environmental quality can be monitored against agreed standards, and restrictions or limits placed on development once they are reached; or
2. a flat rate tax for a zone may be applied to any pollution discharge – either measured, or estimated on the basis of the type of aquaculture, design and management.

There are several significant disadvantages with the first approach:

- aquaculture operations will anticipate restrictions on their activities at some uncertain time in the future. This may discourage desirable development;
- aquaculture operations will not be able to plan ahead in terms of production;
- by the time the restrictions are in place, the scale of activity may already be too high. It will be difficult to reduce the activity or output levels of existing farms; and
- the incentive for more environmentally friendly aquaculture technology is weak - the standards may be exceeded because of the activities of other farmer.

The second approach, while serving as a disincentive to pollution, will represent a significant financial burden to some operators.

Given these disadvantages, every effort should be made to estimate environmental capacity, even if only very roughly and provisionally, and use this as the basis for interventions. Monitoring should allow for the estimate to be steadily refined over time.
10.2.3 Codes of conduct and practice

Codes of practice amount to generalized and agreed forms of mitigation for the impacts of a sector, sub-sector, or individual farm. They may also serve as standards against which aquaculture siting, design or operation may be assessed.

There is increasing interest in codes of practice on the part of international organizations, governments, and the industry itself. Indeed, there is growing awareness that environmentally sensitive shrimp aquaculture may make good business sense. This is particularly so when considering the perceptions of some importing markets. This provides an incentive for both the shrimp industry (and supporting governments) to further promote adoption of environmentally and socially responsible farming practices through appropriate standards or codes of conduct. The benefits possible through the development and adoption of codes of practice in aquaculture are summarized in Box 10.4.

Examples range from general to specific and include the FAO Code of Conduct for Responsible Fisheries, and the associated Technical Guidelines which relate specifically to aquaculture; the Global Aquaculture Alliance (a newly formed international industry association) Codes of Practice; and a variety of more specific codes developed for particular countries, species or systems, such as the Code of Practice for Australian Prawn Farmers (Donovan, 1997), the guidelines produced in relation to coastal aquaculture in Belize (Huntingdon and Dixon, 1997) and recommended standards and practices for shrimp culture in Madagascar (Maharavo, 1999). The World Bank is also in the process of developing guidelines for planning shrimp farming, and recommended practices. FAO has facilitated agreement among many countries on a range of desirable policies for sustainable shrimp culture (FAO, 1998). A comprehensive synthesis of all these codes is presented in Appendix 11 along with a complete reproduction of the FAO Code of Conduct, and the GAA Codes of Practice. It is recommended that any new guidelines should be based on, or comply with, these widely agreed codes.

Box 10.3. Tasmania - an example of zoning and its relation to legal frameworks

The Marine Farming Planning Act was passed in 1995 and provides for the development of Marine Farming Development Plans. The Plans identify areas of water that may be suitable for marine farming (mainly cage culture of salmon, and oyster culture), while also considering the other users of the coastal zone. The plans consist of:

- a (sector) Environmental Impacts Statement;
- a Development Proposal, including maps of the area suitable/available for marine farming; and
- Management controls and operational constraints affecting activities within the zones, including provision for comprehensive environmental monitoring programme.

The plans are developed following a process of public consultation which takes account of:

- the physical suitability of the sites for aquaculture;
- the current legal situation; and
- the desire to minimize impacts on other users of the coastal zone.

General management controls for the Marine Farming Zones are as follows:

- Environmental controls relating to carrying capacity;
- Environmental controls relating to monitoring (water quality, benthos, shellfish growth);
- Chemicals (must comply with legal requirements);
- Disposal of waste;
- Disease controls;
- Visual controls to reduce visual impacts;
- Access controls; and
- Other controls, e.g., controls related to other legal requirements (such as predator control, other environmental management legislation).

Box 10.4. Benefits associated with the adoption of codes of practice

- enhanced public image and demonstrated industry responsibility;
- greater common understanding and agreement on measures required for sustainable aquaculture;
- clarification of roles and responsibilities;
- a framework and vehicle for awareness raising, information exchange, and training within and outside the sector;
- a framework for the development of market led incentives (such as labeling and product certification) for improved management and sustainability;
- a "pilot run" for more formal financial incentives or regulations;
- a building block in the development of integrated coastal management; and
- a strengthened and informed negotiating position for the sector.

Adapted and developed from Barg, 1996
There is much similarity and overlap between these and other codes and guidelines, although there are understandable differences in emphasis and detail relating to the interests of the organizations. All are designed to promote the development of sustainable aquaculture. Because of the importance of the shrimp farming sector, and the environmental issues which have been associated with its development, the GAA and Australian codes and guidelines, and the various World Bank initiatives are directed mainly at this sub-sector.

The practical application of different approaches to codes, guidelines, standards, etc, however, must be very carefully assessed. There may be some important lessons to be learnt from forestry for example, where after several years and much effort, there are still differing views on standards and certification programmes for ‘sustainable’ forestry. The development and implementation of appropriate standards and codes, therefore, will take time.

Particular attention should be given to the difficulty of implementing schemes where there are large numbers of small-scale farmers involved in shrimp farming, as is the case for many parts of Asia. Two approaches may serve to overcome this problem. One is to relate or link codes of practice to aquaculture zones as defined above. Operation in a zone might be conditional on adherence to certain codes of practice. The other is to promote farmer’s associations or similar groupings which can help develop, and agree to implement, area specific codes.

Without full farmer participation and willingness, compliance is likely to be a major problem, unless financial benefits (short, medium or long term) can be related to adoption of such codes. Links to marketing and environmental quality labeling schemes are one obvious way to make this link, but this can be difficult and costly in practice, especially for the smaller, less well organized, and more isolated farmers. Related to this, there is the need to ensure that the move towards adoption of codes (which may have a short term economic cost) does not adversely affect the poor small-scale farmers. Assistance from donors may be required to “kick start” this process, and this is also highlighted in the FAO Code of Conduct for responsible Fisheries.

Overall, codes of conduct have considerable potential, and may be promoted on a variety of fronts. Perhaps the most promising avenue is through linking them to other initiatives, such as coastal management plans, or conditions required for EA or license approval. Once again the requirement for a more comprehensive planning and administrative structure for aquaculture development is highlighted.
10.2.4 Disease exchange and stock movement protocols

Many social and economic benefits have accrued from the importation of aquatic animal species for aquaculture. However, requests for importation of fish, shrimp ad other species for an aquaculture project need to be given special attention in environmental assessments. The main concerns are introduction of diseases (which may impact aquaculture and wild fisheries) and impacts of introduced species on indigenous biodiversity resulting from escapes of aquaculture species (Figure 10.1).

There is very little information available on the status of aquatic animal diseases in Africa, but it has to be presumed that many of the serious diseases which have affected aquaculture elsewhere are not yet present. The risk of introducing new diseases can be minimized by following an appropriate quarantine strategy. Guidelines are being developed relating to these issues (FAO/NACA, 1998) and should be followed.

Figure 10.1. High concentration of hatcheries in an area which can lead to self pollution and spread of disease.

| Table 10.2. Semi-quantitative scoring system for assessment of quarantine stringency for imports of aquatic animals in pacific island nations. |
|---|---|---|
| **Age at transfer** | **Risk category** | **(Score)** |
| Egg Larvae or juveniles Adult | Lower | Higher |
| | + (1) | + (100) |
| **Source** | Farm or hatchery Wild caught | + (1) | + (100) |
| **Geographic origin** | Within natural range Outside natural range | + (1) | + (100) |
| **Country or regional disease status** | Free of specified diseases Status uncertain Specified diseases present | + (1) | + (100) + (100) |
| **Disease in candidate species** | Major disease not described Recognised host to major diseases | + (1) | + (100) |
| **Interpretation** | **Score** | **Quarantine strategy** |
| | <105 200-400 >400 | • Minimum quarantine; • Higher stringency; • Prolonged quarantine and testing of parent stock with transfer of progeny |

*Source: Humphries, 1995*
A semi-quantitative scoring system relating to some of these risks has been developed for the Pacific islands by Humphries (1995) and is given in Table 10.2.

Guidelines on procedures for assessing the risk of ecological impacts, including those on biodiversity, are given in the ICES/EIFAC Code of Practice on the Introduction and Transfer of Marine Organisms.

10.2.5 Regulation

Government regulations are often required for maintaining environmental quality, reducing negative environmental impacts, allocating natural resources between competing users and integration of aquaculture into coastal area management.

Mariculture is a relative newcomer among the many traditional uses of natural resources, and has commonly been regulated under an amalgam of fisheries, water resources, agricultural and industrial legislation. Land and water use in particular is commonly affected by a wide range of existing legislation that may not be appropriate for aquaculture. The need for a more rational legal and regulatory framework which takes specific account of aquaculture has already been discussed in section 3, and is now widely recognized and agreed (FAO, 1997, 1998). It is necessary not least to protect aquaculture development itself. Recent problems in India which have placed severe restrictions on coastal aquaculture within a certain distance of the coastline arose partly because the coastal zone regulation did not include specific mention of aquaculture (see Box 6.2).

Rubino and Wilson (1993) and Howarth (1995) define the key issues to be considered in aquaculture regulation as:

- land use (e.g. pond construction, impacts on wetlands);
- use of water column and bottom in coastal and offshore waters;
- water use and water discharge;
- protection of wild species;
- non-indigenous species;
- aquatic animal health; and
- use of drugs and chemicals.

Public health issues, quality control and trade laws may also be relevant.

Examples of regulations applicable to coastal aquaculture in Thailand are presented in Box 10.7. In practice an enormous range of regulations are possible, which might include for example:

- "no go" areas for aquaculture development;
- minimum distance between farms;
- requirement for water treatment such as settling;
- effluent water quality standards or discharge consents in terms of nitrogen, phosphorus, BOD, etc;
- regulations related to chemical use and disposal;

### Box 10.7. Regulations applied to intensive shrimp farming in Thailand

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

Note that 2, 3 and 4 are examples of best management practice (BMP).
• handling of diseased stock and notification of disease; and
• movement of stock; quarantine; disease certification.

**Box 10.8. Infrastructure as a tool for environmental mitigation**

**Seawater irrigation**

Many of the environmental and disease problems prevalent in brackish-water shrimp culture are related to poor water supply, mixing of influent and effluent, and exchange of water between adjacent farms. There are now several schemes in Thailand which involve the provision by government of well designed canal systems, including in some cases waste water treatment, to ensure that shrimp farmers receive high quality water, low in pathogens, and that influent and effluent streams for a whole group of small farmers are kept safely apart.

Shrimp farming is quite capable of generating sufficient profit to pay for such investments, so that the investment cost burden can be passed on to the farmers over a period of years.

**10.2.6 Economic and financial incentives**

Most business enterprises respond more rapidly and willingly to financial incentives rather than rules and regulations. In countries with a reasonably well-developed and regulated trading system, taxes and tax breaks can be applied with relative ease to encourage particular kinds of behaviour. These approaches were specifically allowed for under Principle 16 of the Rio (UNCED) Declaration, which requires that the costs of environmental damage be internalized, and that the polluter pays.

Financial incentives or restraints may include the following:

• Charges related to the issue of operating permits (user fees);
• Charges related to the rate of production;
• Charges related to the rate of pollution (pollution taxes);
• Tradable or non-tradable permits (e.g. a permit to discharge a certain amount of waste, or use a certain quantity of a resource, or to use a certain amount or proportion of environmental capacity);
• Deposit refund systems (a deposit or bond is deposited as a guarantee against environmental degradation, or to pay for restoration should this be required);
• Environmental trust funds (similar to deposit refund systems, but allowing for critical spills, accidents etc during normal operation);
• Subsidies for certain (environmentally friendly) technologies, or a tax or surcharge on less desirable technology; and
• Legal liability for certain kinds of environmental damage.

There are also more subtle ways of influencing the financial pressures operating on aquaculture operators. For example the provision of infrastructure (roads, canals, water treatment facilities, markets, processing facilities; laboratory/disease services; extension services; electricity supplies; etc.) may all make certain areas or zones more attractive to aquaculturists, while at the same time reducing environmental impact (Box 10.8). Such approaches may contribute significantly to the success of zoning systems described above.

**10.2.7 Market incentives**

European and American markets are increasingly demanding products which have been produced organically or in an environmentally sustainable way. This translates into a price premium for such goods. Finding ways
to certify or label products grown sustainably, market them at a premium, and ensure that some of the increased margin goes to the producer, represents a significant opportunity in terms of providing a financial incentive for particular forms of aquaculture. There is significant experience relating to such schemes for sustainable forestry, and more recently for sustainable fisheries, but these approaches are not easy to implement in developing countries, especially in more isolated regions or countries.

However, it may be possible to bring together the ideas of farmer associations, aquaculture zones, codes of practice, and infrastructure provision as mutually reinforcing elements in support of the development of product labeling and marketing schemes.

10.2.8 Institutional issues

Institutional capacity to support sustainability in aquaculture development is a critical consideration. Key issues include research, extension, monitoring and having sufficient trained and qualified people to implement supporting strategies. The importance of strengthening institutional capacity within developing countries to deal with the complex issues related to aquaculture development and integrated coastal resource management is now widely recognized.

Thus, application of any guidelines or codes designed to enhance sustainability in coastal aquaculture must also give consideration to ways to support human resource development within both government and non-government sectors to extend such guidelines to farmers. This may require increased education and training initiatives, communication and dissemination of appropriate information.

10.3 Mitigation of impacts from individual farms

Implementing relatively simple mitigating measures related to individual farm (or group of farms) siting, design, and management can lead to large decreases in nutrient loading on the environment, the use of chemicals, the incidence of disease, and the possibility of salination (Box 10.9).

10.3.1 Location and siting

Conversion or pollution of sensitive habitat, salination of agricultural lands, access problems, exchange of disease, and poor pond soil and water conditions, may all be avoided by careful site selection. Unfortunately, siting of farms is usually based on land availability rather than technical criteria. Mangrove land, for example, whilst widely recognized as a poor site for intensive shrimp pond development, was easily accessible for mariculture ponds because of lack of clear property rights, and further encouraged by government incentives which previously classified mangroves as ‘waste’ land. Government must now take a role in encouraging or facilitating aquaculture in areas best suited to the industry and least likely...
to compromise environmental or other resource user interests.

For sea-based farms, siting is also important to reduce impacts on coastal environmental integrity. Problems of overstocking of mollusc culture beds are recognized in the Republic of Korea where regulations have been developed to restrict the areas covered by mollusc culture. These measures (Table 10.3) are designed to reduce environmental impacts and contribute to the environmental sustainability of mollusc farming.

For marine cage culture, off-shore cages, and new technologies developed in European countries are attracting increasing interest in SE Asia. They may allow for siting well away from other interests, with minimal risk to water quality and sensitive habitat. Offshore cages, however, are large and expensive and, while appropriate for salmonids and yellowtail, are untested for tropical marine species, many of which are sold live and in relatively small numbers.

Rotation of culture sites can be used to reduce impacts of cages or rafts on the sediments. This must be considered carefully in terms of environmental objectives. In some cases a minor impact over a large area may be appropriate, while in others a more severe impact in a more restricted area may meet environmental objectives. This highlights the difficulty of prescribing specific mitigation measures in the absence of a broader environmental policy or plan including environmental quality standards or objectives, ideally for specific zones or locations.

10.3.2 Construction and design

Adoption of appropriate practices in the construction and design of farms can do much to mitigate environmental problems. Saltwater intrusion, for example, caused by seepage from ponds, can be controlled by careful compaction during dyke construction, and by siting farms on clay soils. The use of pond liners can also eliminate soil erosion, facilitate collection of waste materials, and may allow longer-term use of sub-optimal

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**Box 10.9. Examples of possible mitigation through siting**

**Ponds**
- Whenever possible, farms should be sited well away from each other to minimize the risk of disease spread;
- Where this is not possible water supply and disposal should be designed so as to minimize water exchange between different farms;
- Brackish and marine farms should not be sited in freshwater areas unless specific measures are taken to protect soils, groundwater and the interests of other resource users;
- Avoid permeable soils, or use liners;
- Farm location should not interfere with access; and
- Potential acid sulphate soils should be avoided.

**Cages and rafts**
- Farms should not disrupt access or navigation;
- Farms should be sited in areas where there is good water exchange;
- Rotation of culture sites, or siting in deeper water offshore may be used to reduce local impacts on sediments; and
- Environmentally sensitive habitat such as coral reef should be avoided.

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**Box 10.10. Examples of possible mitigation through design and construction**

**Ponds**
- Ensure dykes are well compacted;
- Allocate at least 25% of pond area for water and sediment treatment in the case of intensive production (10-15% for reservoir settling of routine discharge; 5-10% for settling effluent at pond drainage and harvest; 5% for drying/oxidation of pond sediments);
- Leave a buffer (i.e. unused semi-natural) zone around the farm. The width will depend on the nature and intensity of the farm, local soil and water conditions, and the nature and sensitivity of the surrounding environment;
- In mangrove areas a mangrove belt to seaward of the farm comprising at least 1ha of mangrove per tonne annual production of intensive farm may serve to assimilate most if not all nutrients released, as well as serve the function of a natural settling basin;
- Ensure supply canal is not contaminated significantly with effluents from other ponds or other activities; and
- Ensure discharge canal does not contaminate water supply to other farms or other resource users.

*Note. The above figures are for very rough guidance only. Engineering design should include comprehensive discussion and calculation related to these issues.*
Table 10.3. Methods for reducing environmental problems on oyster farms in the Republic of Korea.

<table>
<thead>
<tr>
<th>Management strategy</th>
<th>Potential benefit to environmental sustainability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dredge beds below and around oyster long-lines once every three years</td>
<td>Oxidation of sediments and maintenance of sediment quality. Ensures waste ‘emissions’ remain with assimilative capacity of seabed.</td>
</tr>
<tr>
<td>Distance of more than 100 m between sites</td>
<td>Adequate water circulation and to ensure supply of food to oysters.</td>
</tr>
<tr>
<td>Oyster beds (licensed area) must be within 1 ha – 20 ha in size</td>
<td>Ensures oyster beds to not interfere with other coastal resource users and that farms do not exceed local ‘carrying capacity’</td>
</tr>
<tr>
<td>Culture area must not exceed 3-10% of then total licensed area and no more than one 100 m long-line per 50 m²</td>
<td>Adequate food supply and ensures that farms do not exceed ‘carrying capacity’ of local environment.</td>
</tr>
</tbody>
</table>


soils with low agricultural value. However, water quality may be more difficult to manage in lined ponds. The incorporation of water treatment ponds (as in the case of Thailand, where larger farms are now required by law to incorporate a settlement pond in farm designs) can significantly reduce effluent load (Box 10.10). Buffer zones between farms and surrounding land can also be used to minimise impacts on surrounding ecosystems, protect nursery grounds for aquatic life, and protect traditional activities. Mangrove buffer zones provide protection from storms, maintain traditional fisheries and may even improve water quality (Figure 10.2).

10.3.3 Operation and management

Figure 10.1 shows the fate of nutrients in a coastal aquaculture pond, and the management interventions that can affect the total nutrient loading, or its partition between stock, water, sediment and effluent. Simple adjustments to management practice can significantly reduce effluent quantity and total nutrient loading.

Feed quality

Improved feed quality in semi-intensive and intensive pond and cage culture can have a significant impact on fish farm effluent quality, and may also reduce costs. For example reducing phosphorus content can be done relatively easily, and can be effectively regulated, as has been done in some European countries. Better formulated feeds will result in better food conversion and less waste. Both phosphorus and protein have been significantly reduced in salmonid diets without compromising growth, and this could probably be done for tropical marine fin-fish and shrimp, reducing nitrogen losses.

High handling and water stability (either whole rather than minced or chopped trash fish; or water stable pellets) will reduce pollution. Moist and chopped or minced fresh diets are more

Box 10.11. Examples of possible mitigation through operation and management at farm level

Feed and feeding
- Use low phosphorus diets;
- Use carefully formulated feeds which maximize nitrogen conversion efficiency and minimize protein requirement;
- Use water stable diets;
- If using trash fish use only that which is known to give efficient food conversion;
- Avoid chopping or mincing trash fish;
- Use feeding trays in ponds to gauge feeding activity and general health; and
- Feed according to the preferences of species in terms of quantity, quality, timing and frequency.

Disease and therapeutics
- Maintain high water quality at all times. Actual critical parameters are species dependent;
- Conduct regular health checks on stock;
- Do not discharge disease contaminated water to a shared or common canal;
- Break the production cycle periodically (fallow) to prevent pathogen build up;
- Use seed or broodstock which is health certified;
- Use antibiotics only for serious bacterial disease, and only when it is identified early enough to have a chance of success;
- Do not use antibiotics such as chloramphenicol which are important for disease treatment in humans;
- Do not use Azinphos (Gusathion) and organotin compounds; and
- Minimize use of organophosphates.
polluting and wasteful of resources, and may be associated with pathogens. Recent trends in intensive shrimp farms in Asia are towards reduced use of such diets.

**Feed management**

Simple improvements in feeding management in semi-intensive and intensive pond and cage systems can significantly reduce nutrient loading, improve water quality and reduce costs. Carefully controlled feeding and use of feeding trays can reduce feed losses and reduce pond environmental conditions in shrimp culture. Surveys have shown that Food Conversion Ratio is less on small family operated farms than on larger-scale shrimp farms.

**Disease prevention and management**

Disease prevention and management requires a suite of measures from national level to farm operation. The following might be important elements in such a strategy:

- effective procedures, protocols, and regulations relating to the movement of seed and broodstock;
- high technical capacity to check for disease;
- improved understanding of disease epidemiology;
- high quality, low pathogen water supply;
- high quality, low pathogen seed supply;
- high quality, pathogen free feed supply;
- more rapid diagnosis and treatment of disease;
- optimal grow-out conditions and quality husbandry to minimize stress;
- increased species and system diversity; and
- cautious intensification.

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**Box 10.12. Settling of organic wastes**

Settling is a simple and effective way of increasing the quality of effluents from coastal aquaculture ponds or tanks. The removal of suspended solids results in significant removal of organic matter (and associated BOD) as well as nitrogen and phosphorus.

The settling characteristics of aquaculture effluents are generally rather poor, being made up of finely divided and hydrated organic matter (food and fecal material). However there is considerable variation related to:

- the nature of aeration in the ponds or tanks;
- the hydrodynamics of the ponds or holding tanks;
- the feeding rate and type;
- salinity; and
- the age of the fish (which affects the size and quality of both feed and fecal wastes).

Settling requirements can be greatly reduced through well designed holding ponds/tanks and good feed management. In the case of pond culture, settling is most important and cost-effective with water discharged towards the end of a production cycle, or at the time of harvesting.

Settling is typically done in a simple pond, whose efficiency may be enhanced by using influent and effluent buffer zone to minimize turbulence and water velocity. It may be done in a large reservoir or lagoon, in which case biological degradation of sediment may also take place. In more intensive systems, tanks with tubes or plates to increase settling area may be used. These may be conical or wedge shaped to allow simple sludge removal.

For settling to take place, it can be shown mathematically that, irrespective of depth:

\[
\text{Area required} = \frac{\text{water flow}}{\text{settling velocity}}
\]

The water flow per unit area of settling pond is known as the *overflow rate* and is the critical design parameter for a settling pond. Settling velocity for particular effluents can be measured relatively easily in experimental water columns. For most pond aquaculture effluents, about 50% of the solids will settle in less than 1 hour in still water. The residual is usually made up mostly of plankton and is difficult to settle but has limited environmental impact.

*Overflow rates for settling tanks or ponds for aquaculture should be in the range of 10-30 lpm/m² or 15-45 m³/m²/day*

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The detailed implications of such a strategy will depend on species, aquaculture system and local conditions, but will require coordinated efforts at various decision making levels, and should be initiated before any disease problems arise. If such a strategy is successful it should greatly reduce the use of chemicals, and reduce negative feedback to and between farmers.

Attention to water supply and the possibility of introducing infrastructure (as described in Box 10.8) may be a significant part of such a strategy.
The development of captive broodstock for major farmed shrimp species followed by genetic improvements should result in farmers having better quality seed free of and/or resistant to specific pathogens. Pathogen free/low pathogen/high health seed production is also showing promise.

As a matter of policy the use of antibiotics of particular importance for human health should not be allowed.

**Selection of suitable species and seed**

Shrimp and marine fish culture in some countries rely heavily on collection of fry and juveniles from the wild, leading to concerns about social and environmental impacts of seed collection. The increasing trend towards use of hatchery reared shrimp provides a basis for reducing the reliance (and potential impact) on wild stock. Seed production is now also possible for a range of marine finfish species and governments should take all measures to encourage and facilitate the development of commercial hatcheries. The use of indigenous species would be preferable to introduced species, and genetic improvements may provide better stocks. Care needs to be taken not to impact wild stocks with such practices, but protocols now being developed may help in this regard (e.g. FAO, 1997).

**Effluent water management**

Environmental sustainability requires that the surrounding environment can assimilate wastes from aquaculture systems, and also supply nutrients and organic matter to extensive mariculture farms (Figure 10.3).

For sea-based aquaculture, where waste materials are discharged directly into the surrounding environment, appropriate siting and feed management as described above are the main forms of mitigation.
In land-based ponds (and tanks), there are various options for control of effluent discharge. Recent research has shown that reducing water exchange in intensive shrimp ponds can dramatically reduce effluent loads. Many shrimp ponds in Thailand now operate with zero water exchange for a significant proportion of the production cycle, and completely closed systems are possible and operating. Although this practice developed mainly to avoid the introduction of pathogens in the intake water, it has the effect of reducing the nutrient load on the external environment. In effect intensively aerated shrimp ponds operate in part as their own oxidation ponds, with significant in-pond waste removal. However there will be greater accumulation of organic wastes in the pond sediment of these near closed systems, and care must be taken to not to flush these into the environment in a concentrated slug at the time of, or shortly after harvest. These sediments may be left in situ, and oxidized through drying and in some cases tilling; physically removed, and spread elsewhere for oxidation, or used for alternative purposes such as soil conditioner; or flushed into settling ponds for subsequent removal.

Simple settling (Box 10.11) is effective in removing a significant proportion of the solids effluent from brackish-water ponds. Settlement ponds are increasingly being used to treat effluent from intensive shrimp ponds. In Thailand, large farms are required by legislation to allocated 10% of pond area to settlement ponds.
It should be emphasized that effluents from coastal aquaculture are normally of relatively high water quality, and commonly exceed the quality of secondary treated domestic and industrial wastes. It is only toward the end of the production cycle when stocking rates and feeding rates are at their highest, and particularly at the time of harvest when pond sludge may be re-suspended, that problems may occur. This means that rather little effort is required in practice to significantly reduce the overall loading on the environment. For example, settling may only be required in respect of water pumped from ponds at the end of the production cycle, so greatly reducing the area of settling ponds required.

If necessary, further reductions can be made using bio-filters, artificial or natural wetlands. Mangrove is effective at removing significant quantities of solids, nitrogen and phosphorus from aquaculture effluents (see Appendix 8). The use of intensive aquaculture effluent as a source of nutrients and organic material for extensive or semi-intensive aquaculture, including oysters and plankton feeding fish is a further option.

Management strategies for effluent should be carefully balanced against discharge targets. 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. For example, the use of suction pumps or high pressure hoses to clean pond bottoms, as practiced in Chantaburi province in Thailand and also reported for Taiwan, produces a very high pollutant load. The practice of allowing pond sediment to dry before removing the sediment by mechanical means, as is common in Southern Thailand, is more environmentally sound. The need to find environmentally sound ways to manage bottom sediments is most important in intensive systems with high stocking and feeding rates. Because of environmental concerns, some countries have already placed restrictions on indiscriminate discharge of shrimp farm sediments (FAO/NACA, 1995).
Chapter 11
Reviewing and Decision Making

Summary

Review of an EA report, and the process which generated it, is important to maintain standards and ensure neutrality, especially in respect of project EIA. It may also be used to provide a broader perspective on the issues raised, or a more specific perspective related to particular interest groups. In general terms it provides the additional information which decision makers may require in order to assess whether a proposal is acceptable (project EIA) or an environmental management plan for the sector desirable and feasible (sector EA).

The review process for project EIA should be clear and consistent, using standard criteria, for the sake of the proponent, the public, and the decision-makers. This is likely to result in improved quality EAs.

Decision making itself will depend heavily on the report and the review process. It is essential therefore that both are clear and transparent. Decision making itself is not a single action, but a series of incremental actions, and the final outcome will depend heavily on many of the early decisions and choices. The nature of these early decisions must be clearly stated in the report.

Contents

- Reviewing
- Decision making

11.1 Reviewing

The following is a brief outline of the review process for both sector and project EIA.

1.1.1 Objectives

The objectives of the review process are broadly similar for sector and project EA:

- to determine whether the information is correct, and scientifically and technically sound;
- to determine whether the information has been presented so that it can be understood by both the decision-makers and the public;
- to determine whether the EA report is an adequate assessment of environmental effects, and of sufficient relevance and quality for decision-making;
- to determine whether additional information or prescriptions are required;
- to collect and collate the range of stakeholder opinion about the acceptability of the proposal or proposals and the quality of the EA process;
- to ensure that the EIA report and process complies with the Terms of Reference;
- to determine whether the proposal complies with existing plans, policies, standards and codes of practice; and
• to ensure that the EA process was conducted appropriately, and the points of view of all parties involved have been taken into account.

### 11.1.2 Sector EA

The review process should allow for a broad and critical appraisal of the quality of the assessment, and the desirability and feasibility of the proposals for environmental management of the coastal aquaculture sector.

Where the EA has been undertaken or commissioned by a single organization, the review process should be coordinated by a different organization. This would normally be a non-sectoral department or agency, such as an environmental agency/department, a planning agency/department, or local government.

Where the process has been overseen by an inter-agency steering committee, this same committee may coordinate the review.

All relevant stakeholders (government and non-government) should be involved in this process. This reinforces the need for a clearly written and presented report. Public presentation of the report may be required, as may summary reports or resource materials related to specific issues. The techniques discussed in the section on public involvement (section 6) are again relevant here.

If the report is broadly supported, the review should serve as the starting point for a series of discussions or workshops on how to implement the proposals. If the report is not acceptable, it should serve to develop broadly agreed recommendations for improving the report or undertaking further work.

### 11.1.3 Project EIA

The review process for project EIA is a more formal and routine process. It should generate the additional information that decision-makers will require in order to decide whether the proposal and its effects are acceptable.

The EIA review process should be clear and consistent, using standard criteria, for the sake of the proponent, the public, and the decision-makers. This is likely to result in improved quality EAs. The application and utility of criteria should be reviewed so that they can be steadily improved.

It is recommended that a short review report is published, so that decision makers and the general public have a thorough understanding of the status of the EIA report and the nature of any further deliberations.

The steps recommended for best practice approach to reviewing an EA are presented in Box 11.1.

#### Who should review?

Review of project EIA reports may be undertaken by government, independent authorities, independent accredited experts, or review panels. Members of such review panels should not be stakeholders in the proposal. Review can also be carried out by proponents during the preparation of the report, as part of a quality assurance process. In this way proponents can ensure that their work is of an appropriate standard before it is subject to external review.

Review through stakeholder input can be undertaken using the draft EA report, or its summary, as a resource document at public meetings, briefings or as a basis for media reports. It is important that the
results are effectively recorded, collated and summarized for decision-makers. Examples of presentation techniques have been dealt with in section 9 (assessment). They include GIS, matrices, networks, ranked and sorted tables, graphs and transects, etc. (Box 11.2).

**Timing**

It is preferable for the review to be held before the final EA report is submitted to decision makers, so that it can be used as a monitoring and project management tool to ensure that progress is satisfactory, and that the terms of reference are being complied with. When there are issues requiring further research or where the report is inadequate, reviewing may be an iterative process, with the report being returned to the proponent for amendment to remedy inadequacies identified.

### 11.2 Decision-making

The purpose of EA is to provide information and analysis to decision-makers so that:

- full account is taken of environmental issues;
- environmentally damaging developments are prevented;
- developments which are allowed are well managed to minimize any possible negative impact and maximize benefits; and
- the sector as a whole develops in a sustainable manner.

In order to provide this information in a usable form, a range of subsidiary decisions are made by different individuals or groups during the EA process (Box 11.3). EA may be considered as a process of review, negotiation and incremental decision-making. Many of the decisions are value-laden, and constrained by expectations, political culture or existing higher-level policy decisions.

Many of the smaller decisions and choices made during the preparation of an EA report will affect the final outcome, and should be taken and recorded with great care.

#### 11.2.1 The decision makers

The people making decisions on a proposal subject to project EIA, or those capable of promoting or implementing the recommendations of a sector EA, will frequently be elected central, state or local government politicians. They are expected to use the information provided by EA, along with information obtained from other sources, to inform them of the environmental consequences of their decision-making. Apart from the summary, they will seldom have time to read
the EA report and other EA documentation. They will depend upon their officials and technical specialists for a summary evaluation of the earlier stages of the EA process, and the detailed technical content of the report.

11.2.2 The nature of decision making: trade-offs

The decision making process involves a large number of trade-offs (Box 11.4). In practice these trade-offs can be very complex. It is important that the EA report analyses and presents them as clearly and simply as possible. Furthermore, these trade-offs should be made explicit in the justification and reporting of any decisions related to the EA.

Making a trade-off between, for example, an economic benefit and an environmental loss implies assigning relative values or priorities (see Box 11.5). If these values and priorities are not made explicit, decision making is unlikely to be consistent. A variety of quantitative techniques have therefore been developed which allow the assessor to analyze or summarize the differences and trade-offs between options, with a view to facilitating more rational and consistent decision making. These techniques can provide simple summaries of complex information, and are therefore attractive to some decision-makers. Necessarily however, all these approaches require value judgements to be made, usually (though not always) by the assessor rather than the decision maker, in the form of weighting, ranking and aggregation of variables. If they are described and justified in detail, then the method is no longer an effective summary. If they are not, then the decision making process lacks transparency, and therefore fails to meet one of the guiding principles of EA.

There is increasing interest in techniques (e.g. multi-objective decision analysis) which clarify, rather than quantify and aggregate the trade-offs that need to be addressed.

11.2.3 The neutrality of EA

EA should have a significant impact on decision making, although it is rarely the sole basis. An important and controversial question is whether EIA should be neutral in its presentation of information and options, or whether it should promote or advocate environmentally optimal solutions. The predominant view is that EA should be a rational assessment, and a clear and accessible presentation, of different options and their environmental consequences. It should not specifically advocate environmental interests.

11.2.4 Outcomes

There can be a number of different outcomes from project level decision-making. These include:

- the proposal can be approved;
- the proposal can be approved with conditions;
- the proposal can be approved subject to ongoing investigations;
- further investigations of particular issues can be requested before the EA report is reconsidered;

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**Box 11.4. Trade-offs in EA decision making**

- between simplification and the complexity of reality;
- between the urgency of the decision and the need for further information;
- between facts and values;
- between forecasts and evaluation;
- between certainty and uncertainty; and
- between ecological, equity and economic considerations.

Adapted from Wood, 1995

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**Box 11.5. Trade-offs between different kinds of value in coastal aquaculture development**

Coastal aquaculture development (like most development) may bring significant short and medium term economic benefits, but also some loss of natural habitat.

More extensive production systems may involve the conversion of larger areas for the same net economic benefit, but may also be more accessible to poor local communities.

The information in the EA report must make the nature of these trade-offs clear, and where possible provide quantification (e.g. how much of one "value" is lost per unit gain of another).
• a supplementary document or new EA report can be requested if there are any significant problems with the original investigation or EA report; and
• the proposal, as formulated, may be rejected.

Decisions related to sector EA may result in a variety of individual or planned interventions.

11.2.5 Decision making in sector EA

A sector environmental assessment is not usually subject to any kind of "final" decision; rather it serves to inform a wide range of decisions, initiatives or interventions designed to mitigate the impacts of the sector. These may be specific technical or political decisions (such as setting discharge consents or banning aquaculture in certain areas), the promotion of guidelines or codes of practice, or broad frameworks for decision making, such as a local plans, sector plans or integrated coastal management plans.

As with project EA there will be substantial uncertainty associated with many of the assessments and predictions, and provision should be made to monitor and adapt or modify decisions in the light of experience.

11.2.6 Accountability and transparency in decision making

A number of checks and balances are built into EA processes that help ensure accountability and transparency.

In the case of project EA, approvals for the proposal are made by a body other than the proponent, and the reasons for the decision and any conditions attached to it are made public, in some cases in the form of an official decision report. In some jurisdictions this goes as far as including an explanation of how the EA report and review influenced the decision. There may also be provision for public right of appeal against any decision. This can increase public confidence in the process, although it may raise costs and add to delays.

Any plans developed on the basis of sector EA are normally subject to substantial peer review and public involvement.

11.2.7 Participation in decision making

As has been noted frequently in these guidelines, public participation in the EA process is of great importance. Although direct public involvement in detailed post-EA decision making is likely to be limited, effective input at the review stage should provide the basis for significant influence on the final outcomes.
Chapter 12
Monitoring

Summary

Effective monitoring and follow up actions are essential if EA is to become an effective tool for environmental management and the promotion of sustainable development. Without follow up, EA becomes a costly and bureaucratic exercise with little long-term impact.

Monitoring is required not only to ensure than mitigation and environmental management plans are implemented, but also to see whether they work, and whether the analysis of impacts was accurate. As noted in the section on assessment, impact analysis is extremely difficult and is unlikely to be accurate in the first instance. Only through monitoring, adaptation and evolution will effective environmental management strategies be developed.

The application of EA to aquaculture in developing or newly industrialized countries in Asia is an excellent example of this (see Appendix 1: Sri Lanka case study). However, without effective management and clear procedures for using information generated, monitoring itself may become a costly and pointless exercise.

Monitoring should not be undertaken in isolation from other activities. The way in which cost-effective monitoring is defined by, and in turn defines, other environmental management activities is presented in Box 12.1.

A detailed design for a monitoring programme should form a part of the EA report. Monitoring applies equally to sector and project level EA.

Contents

- Objectives of monitoring
- Legal and policy frameworks
- Scope
- Responsibilities and procedures
- Environmental monitoring activities
- Environmental effects monitoring
- Environmental audit
- Social and economic monitoring
- Feedback and adaptation
- Environmental performance assessment
12.1 Objectives of monitoring

Environmental assessment monitoring is the planned, systematic and repeated collection of environmental data to meet specific objectives and environmental needs.

The objectives of monitoring are broadly similar for project and sector EA:

- to document the baseline conditions at the start of the EA;
- to assess performance and ensure that conditions of approval are adhered to (project EA);
- to ensure that the anticipated impacts (from the project or sector) are maintained within the levels predicted;
- to ensure that mitigation measures are effectively applied;
- to verify the accuracy of past predictions of impacts and the effectiveness of mitigation measures, in order to transfer this experience to future activities of the same type;
- to identify trends in impacts;
- to identify, measure, and manage unanticipated impacts;
- to provide information for periodic review and alteration of environmental management plans, or sector plans;
- to optimize environmental protection through good practice at all stages of the project or planning process; and
- to provide feedback on how the EA process is working.

(Adapted from UNEP, 1996)

12.2 Legal and policy frameworks

The importance of a broader policy, institutional and legislative framework in which EA can be effectively undertaken has already been emphasized. This is particularly the case in respect of monitoring and follow up. Ideally sector EA should be used in the design of sector-specific planning and regulation. This should include provision for a suite of measures to encourage, facilitate, or require compliance with mitigation measures proposed for the sector as a whole, and compliance with specific project EA conditions. Monitoring is largely pointless if there is no way for the findings to be used for improved environmental management (Box 12.2).

12.3 Scope

Monitoring of the impact of coastal aquaculture can be done at different levels:

- individual farm;
- group of farms; and
- estuary, bay, lagoon, or wetland which may be affected by aquaculture activities.

In general the level of monitoring will be related to the level of EA: at the farm level for a project EA; and at the estuary, lagoon or bay level for sector EA. Groups of farms involved in quality management schemes may monitor at the farm group level.
Monitoring is costly, and the capacity to undertake it effectively may be limited. In poorer countries, priority should therefore be given to higher level (estuary, lagoon or bay) monitoring (with the cost spread over many activities). If quality standards are threatened, individual operations should then be investigated.

Monitoring should be focused on the impacts that are either significant, uncertain, or not well understood (requiring further analysis). The collection of information needs to be regularly reviewed to ensure that sufficient data is collected, while at the same time minimizing redundancy. In other words the information must be both necessary and sufficient for the task.

The information may relate to physical/chemical, biological/ecological, socio-economic and health impacts, according to the findings of the EA.

### 12.4 Responsibilities and procedures

Monitoring is easy to agree on, but rarely implemented well. Before any plan or project is approved, responsibilities need to be defined and allocated:

- who will do the monitoring;
- who will pay;
- how the information will be collected, stored, analyzed and communicated;
- how the results will be used; and
- how any required action will be implemented.

The main stages and procedures for developing and implementing an environmental monitoring programme are presented in Box 12.3.

### 12.5 Environmental monitoring activities

A number of different monitoring activities can be identified:

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**Box 12.2. Possible roles for stakeholders in monitoring.**

- responsible authorities make decisions on, and inspect or check implementation of, the terms of the conditions;
- proponents or their agents are responsible for implementing the projects by monitoring the actual effects, implementing remedial measures, and verifying the accuracy of predictions;
- environmental protection agencies as regulatory authorities check compliance with regulations, and verify the effectiveness of mitigation measures; and
- the public can be formally or informally involved in monitoring activities and may highlight inadequacies in monitoring programmes. They may also have practical suggestions to help solve problems as they arise.

*Source: UNEP, 1996*

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**Box 12.3. Main stages in the development of an environmental effects monitoring programme.**

- Determine environmental quality standards and associated indicators (strategic or sector EA, or other higher level environmental policy initiatives; public involvement);
- Identify those which may be affected, and in what ways, by the aquaculture sector or specific developments (impact prediction and analysis);
- Define an environmental management plan to mitigate these impacts;
- Define the objectives and scope of monitoring in relation to quality standards, and the objectives of the environmental management plan;
- Identify sites or critical habitats where standards are most likely to be breached, or which are most sensitive to changes in the defined indicators and parameters; define the boundaries and select maps and plans, and sites for observation, measurement and sampling;
- Design a program of repeated measurements over a specified period of time, taking into account seasonal variation, to monitor key indicators and parameters at these critical sites (see Box 12.4);
- make decisions on the level of accuracy required in the data;
- Ensure compatibility and minimal overlap with previous or existing data collection programmes;
- Agree on procedures and responsibilities for analysis, reporting, and mitigating action, including possible emergency responses, should standards be approached or breached;
- If feasible actions within existing regulatory and planning structures are likely to be ineffective, call for review of planning and regulatory framework;
- Implement monitoring program; and
- Review quality and value of information collected, and efficacy of follow up actions, on a regular basis.
• **Baseline monitoring** refers to the measurement of environmental parameters during a pre-project period for the purpose of determining the nature and ranges of natural variation and to establish, where appropriate, the nature of change;

• **Effects monitoring** involves the measurement of environmental parameters during sector development or project implementation so as to detect changes in these parameters which can be attributed to the sector or project;

• **Compliance monitoring** takes the form of periodic sampling and/or continuous measurement of environmental parameters, levels of waste discharge or process emissions to ensure that specific regulatory requirements are observed and standards met.

**Surveillance and inspection** may form a part of compliance monitoring but need not necessarily involve measurement of a repetitive activity.

Closely related to monitoring, though not based on repeated measurements, is **Environmental Audit**, which is a one-off or regular assessment of environmental performance of an enterprise, and compliance with codes, standards and regulations.

If any form of natural resource management plan, or integrated coastal management plan, is in place or under development, regular **State of the Environment Reporting** may be particularly suitable, since it will address all sectors, interactions between sectors, and incremental or cumulative change. It is particularly important as a follow up to sector EA, and any plans that may be developed on the basis of such assessments. The further development of State of the Environment Reporting should be a major priority, and is called for under Section 17.8 of Agenda 21 ("...it is necessary to …conduct regular environmental assessment of the state of the environment of coastal and marine areas").

Specific monitoring activities related to aquaculture and other sectors may form the basis for more accurate and comprehensive state of the environment reports.

In addition to these specific approaches to monitoring, it should be noted that many countries monitor water quality in rivers, estuaries and coastal waters on a routine basis. This may be further developed or adapted to meet the needs of sector EA and sector planning, or monitoring in the vicinity of major projects or aquaculture production areas. However this kind of monitoring must be clearly linked to any standards set as part of the EA process, and there must be clear procedures for action where standards are breached.

### 12.6 Environmental effects monitoring

This may range from simple observation of key parameters and reporting by locally affected people (which can very useful and cost effective) to comprehensive soil and water quality sampling programmes linked to higher level state of the environment reporting.

The main stages in developing an environmental effects monitoring programme for aquaculture are presented in Box 12.3. Specific advice relating to sampling and data collection is provided in Box 12.4.

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**Box 12.4. Effective data collection and management**

*Environmental monitoring programmes should have:*

- a realistic sampling programme (temporal and spatial)
- sampling methods relevant to source (point source, aerial, 3D)
- collection of quality data
- compatibility of new data with other relevant data
- cost-effective data collection
- quality control in measurement and analysis
- innovations (e.g. in tracing contaminants and automated stations)
- appropriate databases
- multi-disciplinary data interpretation to provide useful information
- reporting for internal management and external checks
- allowance for, and response to, input from third parties
- presentation in the public arena (external assessment)

*Source: UNEP, 1996*
Typical indicators of environmental quality associated with aquaculture include BOD, suspended solids, total nitrogen, total phosphorus, total organic carbon, and possibly antibiotic and other chemical residues (see Appendix 9 for a range of chemicals used in aquaculture, some of which might form a component of a monitoring programme). In some cases they may include secondary indicators or indicator organisms such as plankton abundance and type, benthos composition, and presence or absence of certain indicator organisms, such as benthic worms and fungi.

The monitoring programme should follow directly from the impact assessment and analysis. For example, current meters may have been used to assess the distribution and concentration of nutrients or chemicals released from marine cage culture (Appendices 7 and 8). The results of this assessment should form the basis for an appropriate monitoring sampling frame.

Of particular importance is the way in which monitoring data is managed, organized and presented. A variety of techniques can be used including maps, photographic records, databases, standard tabulations/reports and graphs. Maps of the scale 1:5000 are normally sufficient for data presentation and a scale of 1:10 000 is adequate for catchment maps and general site maps. If there is a higher level natural resource integrated coastal management plan, the incorporation of the data into a GIS database may be possible and desirable.

Monitoring programmes should provide time series data which can be analyzed from time series graphs. This can be done by:

- visual qualitative assessment of the graphs;
- testing statistical significance of variations;
- determining rates and directions of change; and
- noting the approach to, or exceeding of, critical levels (eg water quality guideline levels).

### 12.7 Environmental audit

Audit is a term taken from financial accounting which implies verification of practice and certification of data. In terms of environmental management, the objectives of audit include:

- the organization and interpretation of the environmental monitoring data to establish a record of change associated with the implementation of a project or the operation of an organization;
- the process of verification that all or selected parameters measured by an environmental monitoring programme are in compliance with regulatory requirements, internal policies and standards, and established environmental quality performance limits;
- the comparison of project impact predictions with actual impacts for the purpose of assessing the accuracy of predictions;
- the assessment of the effectiveness of the environmental management systems, practices and procedures; and the determination of the degree and scope of any necessary remedial or control measures in case of non-compliance or in the event that the organization’s environmental objectives are not achieved.

*An EIA audit* can provide an evaluation of compliance with the conditions of approval along with an assessment of the effectiveness of a particular EA at predicting impact type and characteristics. Feedback from this type of audit can be used to improve the effectiveness and efficiency of other EAs in the future.
Environmental impact assessment auditing is a management tool that:

- determines the actual impacts and outcomes of projects or decisions that have been subjected to an EIA;
- assesses whether the conditions established by statutory bodies for mitigating the environmental impacts of developments have been implemented and enforced, and whether they ensured that the environment was protected;
- identifies the nature and accuracy of impact predictions, and evaluates the role of impact prediction in the management of environmental impacts of developments;
- evaluates the effectiveness of the EIA process in order to identify areas that could usefully be revised or refocused; and
- examines the effectiveness of an individual EIA in an attempt to identify ways of improving the utility and efficiency of future assessments.

They can include the completion of checklists and questionnaires, as well as following written guidelines and using rating systems. The table of contents of an Impact Management Plan can be used as a checklist for an audit. An EIA audit can be difficult in the absence of an effective environmental monitoring programme.

**Auditing can also result in:**

- an improved image for the product as environmentally sound;
- reduction in public opposition to operations; and
- avoidance of penalties which could result from non-compliance with stricter environmental controls.

EA audits are not always straightforward. Quite often impact predictions have not been made in a form which can be audited, and the design of the project may have changed between the EA and implementation. Many of the impacts associated with coastal aquaculture are gradual and cumulative, and may be difficult to identify without many years data. Others are low risk, but long term and potentially serious, such as escapes and genetic pollution, which are not apparent until they are serious.

**12.8 Social and economic monitoring**

Social and economic monitoring in relation to a single project is unlikely to be cost effective unless the project is very large. This should be determined in the assessment. However, it will normally be a an important part of monitoring the implementation of any sector plan and appropriate indicators and a monitoring programme would normally be defined in sector EA. However, many socio-economic indicators are routinely collected by local and national government and may be simply adapted for monitoring purposes.

**12.9 Feedback and adaptation**

Environmental audit can be used to review and adapt/improve environmental monitoring, as can routine analysis of monitoring data. Public involvement and comment on predicted or new impacts can be used to adapt and refine both the monitoring programme and environmental management plan.
12.10 Environmental performance assessment

An impact management plan coupled with an appropriate monitoring programme, and possibly environmental audit, may form the basis for comprehensive environmental performance assessment, and possibly associated certification and/or product labeling. Although this may be an ambitious target for aquaculture enterprises in developing countries, some forms of coastal aquaculture (notably shrimp farming and marine fin-fish), are supported by high value international markets with significant quality and environmental awareness. An annual cycle of reporting and review is usually necessary to meet regulatory requirements or quality standards.

Examples of existing standards include environmental management systems ISO 14000 series and BS 7750, and quality assurance ISO 9000 series. These or other standards may be linked to labeling initiatives resulting in a price premium. If this premium can be passed down to the producer, there will be a strong incentive for compliance and willingness to accept inspections. This approach has the enormous advantage that the market may ultimately bear the bulk of the cost. As an example, there is now great interest in Thailand in developing such standards, and linking them to a variety of environmental management initiatives related to coastal aquaculture, including infrastructure (high quality water supply and waste water treatment) and codes of practice.
Bibliography

This bibliography is divided into two parts:

- a list of documents specifically referred to in the text of the guidelines.
- a comprehensive bibliography, broken down into major subject sections, intended as a resource for further reading and research.

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Mitigation and regulation of the environmental effects of coastal aquaculture


Economics and sustainability


Glossary

Assessing. Identifying and defining clearly environmental and social impacts, and analysing these impacts in terms of their major characteristics and significance.

Cumulative impact. An impact which may be small or insignificant in relation to an individual enterprise, but which, when added to impacts from other existing or future activities, may become significant.

Cumulative Effects Assessment (CEA) and Cumulative Impact Assessment (CIA). Refers to the assessment of the impacts on the environment which results from incremental impact of an action when added to other past, present or reasonably foreseeable actions regardless of what agency or person undertakes such actions. Cumulative impact can result from individually minor but collectively significant actions taking place over a period of time.

An Environmental Impact Statement (EIS) is an assessment of the changes in environmental resources or values resulting from a proposed project. It has been largely superceded by the term environmental assessment report, which implies, in addition to the above, a more comprehensive coverage of issues including mitigation, impact monitoring and management.

(Environmental) Health Impact Assessment ((E)HIA) is used to identify, predict and appraise those environmental factors which might affect human health. Factors can include geology, vegetation, demography, economics, pollutants as well as the availability of health services.

An Initial Environment Evaluation or Examination (IEE) is a report containing a brief, preliminary evaluation of the types of impacts that would result from an action. It is often the product of a screening process to assess whether or not proposals should undergo full scale EA.

Initial Environmental Assessment (IEA). This lies between an IEE and a full scale environmental assessment. It is usually a thorough report based on secondary sources and rapid appraisal of the main stakeholders/technical experts. It may take from a few days to several weeks.


Mitigation. Reducing the severity of environmental or social impacts through improved planning, infrastructure, regulation, design, technology, or management practices.

Significance. Assigning significance to an impact implies measurement against some standard, which may reflect values relating to environmental quality or socio-economic wellbeing.

Regional Environmental Assessment (REA) is the process of determining the regional cumulative environmental and social implications of multi-sectoral developments within a defined geographical area over a defined period. They are usually called for when a relatively pristine area is likely to be subjected to relatively intense development pressure for the first time. If part of a broader process including economic analysis this may be referred to as Integrated Environmental Impact Assessment (IEIA).

Social Impact Assessment is that component of EA concerned with changes in the structure and functioning of social orderings, such as changes in social relationships; community (population, structure, stability etc); people’s quality and way of life; language; ritual political/economic processes; attitudes/values. It may also include health impacts (UNEP, 1996).
Scoping. Scoping is a process to identify and evaluate community and scientific concerns about a proposed policy, programme, project or action, so that they can be addressed systematically in the EA. The output from scoping usually includes detailed terms of reference for further work.

Screening. A preliminary examination of a plan or project to determine whether more detailed environmental assessment is required.

Strategic Environmental Assessment (Strategic EA) is the process of identifying and addressing environmental consequences (and associated social and economic effects) of existing, new, or revised policies, plans and procedures. These may be at any level from international agreements to district level policy or plans.

Sector Environmental Assessment (Sector EA) refers to environmental assessment of the effects of a particular sector (such as fisheries or aquaculture) or sector development plan, rather than to the effects of a specific project. Like Strategic EA, Sector EA has the great advantage that it can address cumulative or incremental impacts which may be insignificant for an individual activity or operation, but which may be of great significance for the sector as a whole. It is particularly suited to agriculture and aquaculture developments, since individual farms tend to be small, while the impacts of the sector can be substantial.
Appendix I: Case Studies

- Environmental Assessment in Tanzania: its application to shrimp culture
- Effectiveness of Procedures for Environmental Assessment of Shrimp Culture in Sri Lanka
- Integrated coastal development: Kung Krabaen Bay Royal Development Study Center (KKBDRDSC) Project, Thailand

Case Study I

Environmental Assessment in Tanzania: its application to shrimp culture

This case study is based on several reports and other documents (listed at the end of the case study) as well as discussions held during the training course held in Dar es Salaam, June 1999.

Figure A1.1. Aquaculture production trends in Tanzania

![Aquaculture production trends in Tanzania](image)

Source: FAO

Status and potential of aquaculture in Tanzania

A few tonnes of Tilapia (*Oreochromis niloticus*) have been produced in Tanzania for many years, and reached more than 300 tonnes in 1989. Since then production has been low and erratic.

The farming of seaweed (*Eucheuma spp.*) began in the late '80s, stimulated by government promotion and the active involvement of international corporations in promoting small-scale production. The industry grew rapidly in the early '90s reaching 4,000 tonnes in 1995, but has since declined, related partly to marketing difficulties.
There has been significant interest in shrimp farming for several years. Tanzania has good international trade routes, suitable climate, and a long coastline well suited to brackish-water pond production. To date the main interest has been in medium to large-scale projects with significant foreign interests. Environmental assessments have been carried out in respect of at least two proposed shrimp farm developments. The procedures and outcomes have been unsatisfactory in several respects, and it is instructive to consider what has happened, what lessons can be learned, and how procedures might be improved.

Proposed legal and institutional framework

Government responsibility for aquaculture lies with the Ministry of Natural Resources and Tourism, Division of Fisheries (Fisheries Development and Resource Utilization). There are aquaculture advisory and extension services, but the main focus of activities is in freshwater aquaculture. There is limited activity with respect to coastal aquaculture, and there are no District staff, although District councils may have fishery officers under Technical Support and Extension services. The role and responsibilities of the Division of Fisheries is summarized in Box A1.1.

Proposed approval procedure for commercial mariculture

The proposed procedure for the approval of commercial mariculture projects is summarized in Figure A1.1. This is based on the National Environmental Management Council (NEMC) Environmental Assessment Guidelines, presentations at the Dar es Salaam Training Course, and TCMP (1998).

The acquisition of land is a key issue in this process. Usually the investor acquires land first. Community consultation is required in order to do this, and a lease may then be issued for industrial, agricultural or residential use, with few conditions. Once the land is obtained however, it may be leased to other users without further community consultation.

If land acquisition is the first stage in the process, a major principle of environmental assessment – the examination and comparison of alternative sites - is immediately undermined. Environmental assessment becomes more regulatory (yes or no to a development) rather than a planning tool (yes, but at site A rather than site B).

Under the proposed approval procedure proposal, using standard application forms, is submitted to the Ministry of Natural Resources and Tourism for technical feasibility appraisal, and to the National Environmental Management Council (NEMC) for environmental assessment screening (see Box A1.2). NEMC may require no EIA, a preliminary assessment, or a full EIA (while EIAs are often implemented in practice, EIA regulations are not yet required by law). In practice however, EIA is expected under the guidelines to be mandatory for
Figure A1.1. Proposed framework for environmental assessment and project approval in Tanzania.

Land acquisition?  
- (usually first)

Proposal (registration)

**Screening**  
(National Environmental Management Council (NEMC))

Scoping (NEMC/proponent)

Terms of Reference for EIA

EIA, EIA Report

Review

Approve (provisional environmental permit) or reject

Implement

Monitor and audit

Environmental permit (from NEMC within two years of implementation)

Source: NEMC
“artificial fisheries (aquaculture for fish, algae, crustaceans, shrimps, lobsters or crabs)” (NEMC). If the NEMC decides that EIA is required (as would be the case with aquaculture) then a public scoping exercise is undertaken by the proponent in consultation with NEMC, and draft TOR are developed. These must address any public concerns expressed during the scoping exercise. TOR are then reviewed and further developed by NEMC in consultation with a cross-sectoral Technical Review Committee (TRC) comprising a range of relevant government departments. This committee also reviews the EIA report. If there is strong public concern, and impacts are extensive and far reaching, NEMC organizes a public hearing as part of this review process. NEMC may then issue or refuse a provisional environmental permit, or require improvements to the EIA report. If a provisional permit is issued and the project goes ahead, monitoring is the responsibility of the proponent, but with auditing by NEMC. A full environmental permit is issued within two years subject to satisfactory performance, adequate reporting, and compliance with mitigation measures and permitting/approval conditions.

Throughout this process the Tanzania Investment Centre (TIC, previously the Investment Promotion Centre) plays a key role in coordinating and facilitating the approval process, serving as a “1 stop shop” to potential investors. However, TIC does not serve on the EIA Technical Review Committee.

**Examples of the application of EA procedures to aquaculture**

EA procedures have been applied to two shrimp farm projects in Tanzania in recent years. The first was an Initial EA, undertaken for a potential sponsor (NORAD) relating to a medium scale (160 ha) shrimp farm on the Ruvu river near Bagamoyo. The second related to a large (10 000 ha) shrimp farm in the Rufiji Delta.

**Initial environmental impact assessment (IEIA) of a shrimp farm near Bagamoyo**

In 1994 a private company sought assistance from NORAD (Norwegian Development Aid Agency) for the establishment of a shrimp farm on a 600 ha site on the south side of the Ruvu river, about 5km from the sea, near Bagamoyo. Initially 160 ha of ponds were to be developed, with an estimated production of around 500 mt per year. The farm site was set adjacent to the mangroves of the Ruvu River, the largest single expanse of mangrove in Bagamoyo District.

NORAD commissioned an initial EIA, which was undertaken over a period of 1 month (10 days in the field) by a small team of international consultants from Thailand (AIT, 1995) in collaboration with a local consultant, using the NORAD (1992) Guidelines.

Some difficulty was experienced in presenting and discussing the possible environmental impacts because of the limited baseline information, understanding of the physical and ecological systems, and lack of local environmental standards or development objectives. The “significance ratings” were therefore subjective and based on the experience of the (mainly foreign) consultants.

There was very little public involvement because of limited time, and the difficulty of operating outside official representative channels on a short visit. The consultants were unable to discuss alternative sites, since site selection had already taken place.
Despite these limitations, the consultants were able to identify and discuss the main impacts (summarized in Box A1.3), and present clear and simple recommendations for mitigation, in terms of both design and operation (summarized in Box A1.4).

The overall tone of the assessment was positive, and the final paragraph of the executive summary stated:

_We believe that if such (mitigation) procedures are followed, the proposed project might become a model for the development of sustainable shrimp culture throughout the world, and in this sense offers a unique opportunity for realizing the undoubted and substantial potential benefits offered by well planned and managed farms._

However, it had already cautioned:

_If appropriately designed and managed, and if considered in isolation, this farm is unlikely to have a significant impact on the environment. However, in many other parts of the world successful farms have attracted uncontrolled smaller scale satellite developments which in places have had a serious cumulative impact on the environment and the sustainability of shrimp farming itself. It is essential that this and future developments take place within a planning and regulatory framework which will prevent uncontrolled development and ensure on-going responsible management practices. Without such a framework, this development may simply become a small part of a wider development problem._

It would appear that this caution, and the evident lack of any wider environmental management framework, was taken seriously, and funding for the project was rejected.

**Lessons learned**

This example illustrates the difficulty of using EIA as a positive planning or management tool in the absence of a broader environmental management framework:

- it will either allow or restrict development, on a relatively ad hoc basis, dependent largely on the knowledge or bias of the EIA consultant and the decision maker;
- it will be based on no broadly accepted decision criteria;
- if mitigation measures are recommended, there will be little chance of them being implemented, especially if they are associated with additional costs; and
- although it can identify possible cumulative impacts from other large developments or smaller “satellite” developments, it is unlikely to be able to identify an appropriate mitigation strategy, since this requires action at the sector, rather than the farm level.
Large scale shrimp farm on the Rufiji Delta

Following a proposal in mid 1995 for a large shrimp farming project to be sited in the Rufiji Delta, the District Commissioner requested that the proposer (African Fishing Company) collaborate with a consultant to write an initial environmental impact statement (EIS). The EIS was produced and submitted to relevant ministries for review in May 1996. Before an official answer was received the environmental community in Dar es Salaam requested the government to have a public debate on the proposal. AFC also increased the scope of their consultation to a range of government agencies, ministries and academic institutions. The National Environment Management Council then convened a forum of interested parties at a large Hotel in Dar es Salaam, which was attended by more than 70 participants, mostly from government, regional authorities, aid assisted projects or programs, NGOs and journalists, embassies, and commercial companies. Some local people from the Rufiji Delta also attended. AFC and various technical experts described the project, and a range of academics made comments.

The forum cleared up a good deal of misunderstanding about the project which had already grown up, and it was agreed that a comprehensive EIA was required. The forum offered some guidance on content.

A large team of local and international consultants was appointed, including aquaculture specialists, fisheries specialists, ecologists and sociologists. This team sought not only to assess the project, but also to further develop and design the project to take account of environmental concerns – in other words to include mitigation measures in the design from the outset. A prominent international expert was appointed to the team to help ensure that this was done to the highest international standards.

The first contact with the villagers was by the fishery specialists. They observed that the villagers had many serious concerns, and some significant misconceptions as to the nature of the project. As a result they “advised that a high ranking governmental delegation be sent to the area to inform the people of the pro’s and cons of the project, and the benefits that such a project would bring to them”. The suggestion was immediately implemented. Other teams also visited the villages and found that the inhabitants did not have accurate facts. As a result a critical report was produced by the sociologist team reflecting the fears of the villagers. As a result a more technical team, a fisheries specialist, a sociologist, and a representative of AFC was sent to the villages to explain the nature of the project and the socio-economic benefits it would bring.

A final survey was then made by a new team in order to assess “whether or not the people are now aware of the project, and have accepted or rejected it, especially after the several visits to the area by senior government officials and experts”. The survey identified the nature of local economic activities, as well as a range of local concerns about health, education and transportation, and explored ways in which the project might contribute to their alleviation. They also reviewed both the positive and negative views of the project. Concerns included mangrove cutting, impacts on fisheries, impacts on local markets, pollution and chemicals, and fears that they would be prevented from fishing. A larger number of positive impacts were identified related to transportation, marketing, and employment. Overall the company organized survey found that about 82% of interviewees and members of focus groups accepted that the project would beneficial, while only 18% opposed it. A series of suggestions were also reported for more local participation in the development of the project.

Subsequently, this project became the subject of intense debate over the appropriateness of a major aquaculture development proposal in the Rufiji Delta. At the local level there was a polarization of opinion with fisheries specialists generally in favour, and forestry specialists and NGOs strongly opposed. The local media became heavily involved and generally negative. The local people were pulled in different directions according to their exposure to different specialist interests and the media. This debate became the subject of international comment on email discussion groups related to sustainable aquaculture and mangrove conservation with heavy involvement of international environmental NGOs. This debate was highly polarized (for or against) and generally rather poorly informed.
The output of the EIA process was two detailed volumes amounting to more than 450 pages entitled "Environmental Impact Assessment for an environmentally responsible prawn farming project in the Rufiji Delta, Tanzania". The assessment was technically thorough, analyzing in detail possible impacts on the physical and ecological system of the Rufiji Delta, as well as socio-economic impact. Some concerns were raised about inadequate information on discharge levels (water, effluents and sediments) and their potential impact on the Delta, as well as on the hatchery and processing plants. The overall tone was however positive, since it had already “designed in” a range of mitigation measures identified by the team.

After much further delay and debate, the project was approved by the government, amid much bitterness and controversy. However, the project has not been implemented to date, and as early 2000 was the subject of court case.

**Lessons learned**

The EIA has been strongly criticized by some (e.g. Hughes, 1996) as being seriously biased. There are several reasons for this. The first is obvious in the title of the EIA, which pre-judges the outcome of the assessment, and this language is repeated throughout the report. While understandable – since the proponent had sought expert advice and designed mitigation into the project – this undermined the neutrality and credibility of the whole document. This is particularly unfortunate, since integrating environmental assessment with project design is one example of best practice EIA.

The second was the nature of public consultation. This appeared to be based on the need to inform local people of the benefits of the project, rather than to provide them with an unbiased presentation of costs and benefits, solicit their views on the proposal, and tap their knowledge of local conditions and resources. The location of the public hearing – at an international hotel in Dar es Salaam – was also criticized by some as being inappropriate in both location and style for a project based in Rufiji.

The lack of agreement between different government interests (such as forestry and fisheries) probably also contributed to the polarization of the debate. Although a forestry management plan existed for the area, there was no cross sectoral agreement in the form of an integrated coastal management plan or strategy, and no obvious forum for the development of such a plan or strategy. This

**Box A1.5. Public involvement in Rufiji EIA**

**Weaknesses:**
- Did not involve local community from outset;
- Limited exchange of information relating to local resources, impacts and benefits;
- Limited feedback and response to local concerns;
- Inadequate attention to selection of representative groups for discussion/consultation; and
- Location of public meeting at Sheraton Hotel (better under a tree in Rufiji?).

**Alternative approaches:**
- Identify current land/water use activities;
- Gain understanding of land tenure system;
- Meet with village council to outline nature of project;
- Follow up meetings to address in more detail;
- Positive and negative impacts;
- Alternative activities;
- Selection of best options;
- Mitigation measures for best options;
- Reach consensus; and
- Monitoring and impact management.

**Problems**
- Who are the stakeholders, and how should their views be weighted?
- Pastoralists, agriculturalists, experts;
- Communications;
- Language (English at public meeting not accessible to all);
- Technical level and understanding;
- When should consultation take place? and
- Timing of community activities must be taken into account.

**Solutions/recommendations**
- Information about the project and associated positive and negative effects must be communicated at a range of levels from scientific and technical, to practical and local, using appropriate communication techniques, at the earliest opportunity; and
- There should be written backup of information presented at these different levels, whatever the medium of communication used on the ground.

**Source:** output of working group exercise, SEACAM mariculture EA training course, Dar es Salaam, June 1999.
meant that there were no clear or agreed criteria for reviewing the EIA and assessing the significance of impacts. Indeed, it is probable that the EIA, which highlighted many different practical resource use issues, added to latent inter-departmental conflict.

In retrospect, the company itself, and the project designers, could have engaged the local people at an earlier stage to explain, discuss, and adapt project design, as well as take account of local concerns. In other words the public consultation exercise could have been more participatory, rather than promotional.

The EIA should then have been undertaken by a more independent team – although still working closely with the designer and proponent - to produce a more credible EA. Had conflict still arisen, conflict resolution techniques might have been used to develop a broader consensus.

However, the difficulties of appropriate public consultation, which have been highlighted in the main report of these guidelines – should not be under-estimated, especially when powerful interest groups – business on the one hand, and environmental groups on the other – become involved.

**Strengths and weaknesses of Tanzania EIA procedures**

Mwalyosi and Hughes (1998) have reviewed the application of EA in Tanzania. They conclude that EA has had little impact on decision making. They summarize the weaknesses as follows:

- usually started late in project development;
- under-resourced;
- limited stakeholder involvement;
- output, rather than process orientated;
- limited input to design or location issues;
- limited identification, costing and integration of environmental management into project design;
- poor definition of compliance responsibilities;
- EIA seen as an impediment to development; and
- limited monitoring or audit.

The procedures were also reviewed at the SEACAM EA Training Course in Dar es Salaam in June 1999 specifically in relation to aquaculture. The following limitations and weaknesses were identified:

- the Tanzania Investment Centre are not on the Technical Review Committee (TRC);
- drafting of TOR tends to be sectoral (i.e. specific sectoral requirements from different TRC members);
- many sectors and interests are involved, leading to lengthy procedures and extended discussion of contradictory interests;
- the legal framework is weak; and
- enforcement, monitoring and auditing are ineffective.

The Tanzania Coastal Management Partnership (TCMP, 1998) identified several shortcomings in the existing procedures for EIA relating to mariculture. In particular, the document notes that:

> Local communities play an important role in regulating mariculture development because site allocations should be decided at local level. In practice, most decisions on investment projects are made outside of the local community, which often leads to conflicts. On the other hand, consultation at the local level is time consuming, and approval by district and regional authorities can be frustrating due to contradictory and overlapping policies, regulations and legislation.
The document also points out the lack of transparency relating to land rights. In order to address many of these difficulties the Tanzania Investment Centre is delegated responsibility for facilitating and coordinating decision-making — a “one stop shop”. Unfortunately, while such an approach should facilitate investment, it is unpredictable and ad hoc, lacks transparency, and does not meet the principle of local participation in decision making.

The following weaknesses were also identified:

- permitting procedures unclear to potential investors;
- land acquisition procedures not clear, especially to local poor people;
- many overlapping and contradictory policies regulations and legislation;
- local level approval either time consuming, lack local legitimacy or by-passed;
- TIC may facilitate more rapid approval (in accordance with the Investment Act) (good and bad);
- lack of communication and coordination between all stakeholders;
- lack of integration: lack of an inter-sectoral approach; sectoral fragmentation; lack of coordination and planning; territoriality in jurisdiction; no forum for expressing shared interests;
- lack of oversight and accountability; and
- no licensing for mariculture except for product export.

TCMP identified the following needs in terms of policy development:

“The various sectoral policies relating to mariculture must be harmonized and integrated into a single statement. There are gaps in the various sectoral policies and regulations where concerns related to mariculture are not addressed. New policies and regulations are needed to cover these areas. Priority areas are:

- permitting procedures;
- procedures governing access to land and water tenure;
- water use regulations;
- water quality control and standards;
- monitoring guidelines and procedures;
- licenses addressing operational issues that affect environmental quality;
- strict enforcement of existing laws and regulations; and
- provision of oversight for the permitting process

General conclusions

The existing policy framework for the EA of mariculture has many general limitations as discussed above. Some of these have been highlighted in the examples of EA as applied to shrimp farming. It is clear that a more strategic approach is required to the environmental assessment of aquaculture in Tanzania.

1. The various sectoral departments and agencies must develop a coherent and integrated policy relating to mariculture development, land acquisition and use, and coastal resource management in general. This implies at least a sector EA for aquaculture, and ideally a broader integrated coastal management initiative (this is currently beginning);
2. This broader process should involve extensive public consultation, and should generate clear guidelines for the project EIA process, including assessment and permitting criteria. This should reduce the time required to undertake individual assessments, reduce the likelihood of conflict in relation to specific
projects, and provide clear guidance to potential investors as to what is or is not acceptable;
3. This process must also generate a strategy to deal with the environmental impact of multiple small scale projects, which are likely to arise once commercial aquaculture has been demonstrated.

It is notable the Tanzania Coastal management Partnership, and in particular the mariculture working group, is already working in this direction.

References

Case Study 2

Environmental assessment of shrimp farming in Sri Lanka

The development of shrimp farming in Sri Lanka

The brackish water area in Sri Lanka is estimated to be 120,000 ha of which 80,000 ha are estuaries and large deep lagoons. The rest comprise shallow lagoons, tidal flats, and mangrove swamp.

Interest in shrimp farming developed in late 1970s with a small farm commencing operations in Batticaloa in 1977. Among the other influential factors, export demand and the export promotion policy of the government were major factors that led to the initiation of shrimp farming in Sri Lanka. The government has given various concessions and duty rebates to encourage the investors in this industry. Under the government investment promotion policy, a large area of suitable crown lands were rented to investors at a nominal rent. With these incentives, a large number of small scale entrepreneurs and a few large international companies have ventured into shrimp farming since 1982. They use local labor and in some cases expatriate technicians. Presently, the shrimp industry contributes over fifty percent of the total fisheries export sector with a total labor force exceeding 9,000 full time equivalent jobs.

More than 70% of shrimp farm developments are located in the coastal areas around Dutch Canal and Mundel Lagoon ecosystems between Negambo and Puttalam. The low population density in the NW, and easy availability of suitable land in these areas facilitates large scale operations. In the Western Province on the other hand relatively high population density prevents operation of large scale farms. The high returns from shrimp farming has led farmers to utilize all possible land, and due to the insufficiency of low salinity areas, high salinity areas are also used for farming, using ground water drawn through tube wells.

By 1994 there were 250 authorized farms covering an area of 1,400 ha. However, a survey undertaken by the Network of Aquaculture Centres in Asia (NACA) in 1994 estimated 740 intensive farms utilizing 1,875 ha and 80 extensive farms covering 400 ha. The actual number of shrimp farms is not known accurately due to the rapid development of unauthorized farms. Table A1.1 shows an estimate of the contribution of authorized and unauthorized farms developed on private and government lands.

Table A1.1. Distribution of farms on governmental and private land and its status.

<table>
<thead>
<tr>
<th>Category</th>
<th>Government lands</th>
<th>Private lands</th>
<th>Total lands</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Projects</td>
<td>Area (ha)</td>
<td>Projects</td>
</tr>
<tr>
<td>Approved</td>
<td>177</td>
<td>1407</td>
<td>63</td>
</tr>
<tr>
<td>Developed</td>
<td>172</td>
<td>1216</td>
<td>57</td>
</tr>
<tr>
<td>Unauthorized</td>
<td>243</td>
<td>187</td>
<td>216</td>
</tr>
<tr>
<td>Abandoned</td>
<td>8</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>


Unpublished data from the Provincial Land Commissioners Dept indicates the presence of 705 unauthorized farms covering an area of 788 ha.
Environmental Issues

Shrimp farm effluents contain significant nutrient and suspended solid loadings. This has resulted in increased turbidity and BOD in some receiving waters, and in some lagoons and estuaries a significant increase in nitrite, sulphide and ammonia concentrations. The depth of the main water source (the Dutch Canal) has been reduced due to increased siltation.

The land use pattern has changed with agricultural land converted to shrimp farms. Significant areas of mangroves and salt marshes have been converted. Due to limited access to brackish or fresh water in the shrimp farming area, farmers are restricted to taking their source water from the same canal that they discharge their pond effluent into. Further due to unplanned development, inlet and outlet canals of adjoining farms are closely located. The result is intake of discharged water with sub-optimal water quality from one farm into an adjoining farm. This situation contributed to a recent disease outbreak (1996/7) that resulted in closure of more that 50% of shrimp farms, and has become a chronic on-going problem.

Environmental assessment and management of shrimp culture

Legal framework

The regulation and management of coastal aquaculture in Sri Lanka is complex, and takes place within a broad national policy and legislative framework including provision for coastal zone management and coastal zone planning. The main legislation relevant to environmental management of aquaculture are presented in Table A1.2.

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisheries Ordinance</td>
<td>Introduction of new species</td>
</tr>
<tr>
<td>Draft Fisheries Act</td>
<td>Licensing of fish farms</td>
</tr>
<tr>
<td>Coast Conservation Act No. 57</td>
<td>Permit procedure for any development activity in coastal zone</td>
</tr>
<tr>
<td>Soil Conservation Act No. 25</td>
<td>Control of soil degradation</td>
</tr>
<tr>
<td>National Aquatic Resources</td>
<td>Prohibition of discharges and emission of effluent to environment</td>
</tr>
<tr>
<td>Research and Development Act-No. 54, 1981</td>
<td></td>
</tr>
<tr>
<td>Fauna and Flora Ordinance</td>
<td>Development, management and conservation of aquatic resources</td>
</tr>
<tr>
<td>National Wetland Heritage Bill</td>
<td></td>
</tr>
</tbody>
</table>

Institutions

A large number of agencies and institutions are required to coordinate and collaborate with regard to aquaculture and coastal management issues (Box A1.6).

Specific roles and responsibilities in relation to aquaculture are as follows:

- National Aquatic Resources Agency - operation, planning and management;
- Land Commissioner – planning;
• Department of Irrigation – planning;
• Central Environmental Authority - planning and monitoring;
• Coast Conservation department - planning and monitoring,
• Irrigation Department - planning; and
• Land Reclamation and Development Board - planning and operation.

Institutions with a role in environmental management include:

• Central Environmental Authority – management;
• Ministry of Fisheries and Aquatic Resources - management;
• Department of Coastal Conservation (management);
• National Aquatic Resources Agency - research and management; and
• Universities of Sri Lanka - research and education.

**Box A1.6. Institutions**

There are more than 20 institutions with an interest in the development of the shrimp industry in Sri Lanka.

**National Level Institutions**
1. Ministry of Fisheries and Aquatic Resources (MFAR).
2. National Aquatic Resources Agency (NARA).
3. Department of Coastal Conservation (CCD).
4. Central Environmental Authority (CEA).
5. Land Commissioner (LC).
6. Department of Irrigation (DI).
8. Department of Forest Conservation (FD).
10. Coconut Cultivation Board (CCB).

**Provincial Level Institutions**
15. Provincial Environmental Authority (PEA).
17. Wayamba Development Authority (WDA).
18. Industrial Services Bureau (ISB).

**International Agencies**
19. Agro-Enterprises Development Project (Ag-Ent).
20. United States-Asia Environmental Partnership (USAEP).

**Procedures for environmental assessment**

Sri Lanka has a well-developed system for environmental management of shrimp culture. In theory, this system should allow for the control of the density and location of shrimp farms in order to mitigate environmental impacts. The procedures are summarised in Figure A1.3.

All potential developers of aquaculture farms should forward an application with an initial environmental examination (IEE) to MFAR. MFAR will forward the application to its project approving agency called Inter-Ministerial Scoping Committee to examine the proposed project. The committee consists of MFAR, NARA, CEA, CCD, PMF and Department of Irrigation (see Box A1.6 for acronyms). In addition, representation from Coconut Development Authority and LRDB is invited whenever necessary. The committee can recommend the allocation of state land, and approval of the committee is important for obtaining financial assistance. Normally, Committee meetings are scheduled once a month.

The IEE provides details on the specific location, investment, soil quality, water quality, pond plans, water requirements, water discharge, basic sociological and environmental aspects. The IEE provides sufficient information to assess most of the small-scale projects in less environmentally sensitive areas. If the project is above 5 ha and appears to be located in an environmentally sensitive area, an EIA is required and official TOR are provided. Projects are usually approved with a set of general conditions and mitigation requirements (which includes requirements for effluent treatment), as well as conditions specific to the project. Once a development has been approved, an environmental protection licence is also required for the use of lakes, rivers, streams and coastal areas (including mangroves) for aquaculture. This licence has to be renewed annually.
Table A1.3. Tolerance limits for aquaculture wastewaters discharged into inland surface or marine coastal water in Sri Lanka.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inland Surface</th>
<th>Marine Coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD₅ (5 days at 20°C) mg/l</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>pH</td>
<td>6.0 - 8.5</td>
<td>6.0 - 8.5</td>
</tr>
<tr>
<td>Suspended solids (mg/l)</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>30</td>
<td>35 at point of discharge</td>
</tr>
<tr>
<td>Oil and grease (mg/l)</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total Nitrogen (mg/l)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Phosphate (mg/l)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Phenolic compounds (mg/l)</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Cyanides (mg/l)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Sulphides (mg/l)</td>
<td>2.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Fluorides (mg/l)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Total residual chlorine (mg/l)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Arsenic (mg/l)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Cadmium (mg/l)</td>
<td>0.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Chromium (mg/l)</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Copper (mg/l)</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Lead (mg/l)</td>
<td>0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Mercury (mg/l)</td>
<td>0.00005</td>
<td>0.01</td>
</tr>
<tr>
<td>Nickel (mg/l)</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Selenium (mg/l)</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Zinc (mg/l)</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Radioactive materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alpha emitters (μCi/ml)</td>
<td>10⁷</td>
<td>10⁴</td>
</tr>
<tr>
<td>Beta emitters (μCi/ml)</td>
<td>10⁴</td>
<td>10⁷</td>
</tr>
</tbody>
</table>

Effluent standards for brackish water aquaculture waste waters discharged into inland surface or marine coastal waters have been developed and agreed (Table A1.3). The standards are based on the assumption that the effluent flow will be diluted at least 8 times in the receiving water. Monitoring is carried out by the farmers themselves, as a report in effluent quality is required to renew the Environmental Protection Licence, although the Central Environmental Authority (CEA) intends to start its own monitoring in the future. If an aquaculture farm fails to comply with the terms of its permit, the CEA will apply for a Court Order to suspend the farm’s activities under Section 24 B (2) of the National Environmental Act. The activities of the developer will be suspended until he/she complies with the Directives of the CEA.

**Problems**

Despite a suitable legal framework and comprehensive environmental assessment procedures, there has been significant environmental degradation associated with shrimp culture, and water quality and disease problems have caused increasing problems for the industry itself. The cost of this failure is substantial: the shrimp farming industry is an important economic sub-sector of North Western Province as well as the economy of Sri Lanka.
The immediate reasons for these problems may be summarized as follows:

- Over-concentrated development (both official and unofficial) mainly along a single canal-lagoon system (the Dutch Canal) with inadequate infrastructure. This has resulted in poor water quality and facilitated the rapid exchange of disease organisms;
- Lack of any control over “unofficial” and small scale shrimp pond development. This has led to the incremental and cumulative destruction of lagoon and wetland habitat despite the relatively comprehensive provisions for environmental management;
- The plethora of institutions with diverse interests and overlapping responsibilities involved in environmental management. Local and national institutions in particular have different perspectives. This may have led to ad-hoc decision making based on negotiation and compromise rather than consistent and strategic decision making. Planning efforts and the application of policy has been fragmented and inconsistent;
- The “one-off” basis of decision making related to individual aquaculture development approval. Individual farms rarely have a significant impact in their own right, and can readily sign up to modest mitigation requirements. In practice the problem in the Dutch Canal has arisen because of the cumulative impact of the sector, rather than individual farms;
- A lack of post approval monitoring and management. This is mainly related to lack of manpower resources to both monitor and enforce; and
- Lack of extension and veterinary services and an overall disease prevention and management strategy. Farmers currently rely on private extension services, which poorer or small scale farmers cannot afford.

The development of unauthorized farms cannot be controlled due to insufficient manpower, and socio-economic problems such as poverty and the disparity of income distribution prevailing in the rural areas, and the pressure from the local politicians.
Lessons to be learned, and possible solutions

Ironically, what at first sight appears to be a comprehensive approach to the environmental management of coastal aquaculture turns out to be bureaucratic, time consuming, expensive, lacking in transparency, and ...ineffective.

The problems associated with rapid development in semi-closed estuarine and lagoon systems have been recognized for many years, and several scientists anticipated the disease problems in the Dutch Canal. Unfortunately the response has been bureaucratic rather than strategic, and ad-hoc rather than planned. It is exacerbated by the high profitability of shrimp farming creating enormous development pressures.

*The single most important lesson to be learned is that, however sophisticated the environmental management system of a country in terms of laws and institutions, it is almost impossible to control aquaculture development by assessing or regulating individual farms.* This is related both to the cumulative nature of impacts of aquaculture, and also to the political and economic pressures for approval in relation to specific projects.

*The second important lesson is that failure may be extremely costly, and is very difficult to correct.*

The Dutch Canal is a classic (semi-artificial) ecosystem requiring strategic natural resource planning. Sector, rather than project EA might have been undertaken, leading to an aquaculture development plan for the whole canal system. This may have involved gaining general agreement from all the stakeholders (farms and institutions) on an overall strategy in terms of location, density, intensity and scale of operations, designed to maximize the benefits to the economy while minimizing environmental impact. A suite of incentives and constraints might then have been developed – explicitly recognizing the real difficulties – to address development and environment issues as far as possible. These may have included necessary infrastructure and support services such as water supply and disposal; quality assurance of seed; extension and information services; credit; and a disease prevention and management strategy for the whole sector.

While it is understood that this is extremely difficult, it must nonetheless be attempted if the problems and opportunities of coastal aquaculture development are to be fully and sustainable realized. The investment is likely to be significant, but the potential returns from sustainable coastal aquaculture are very high.
Case Study 3

Kung Krabaen Bay Royal Development Study Center (KKBRDSC) Project, Thailand

Introduction

Kung Krabaen Bay (KKB) is an oval-shaped lagoon 4.6 km long and 2.6 km wide, with a single narrow water entrance of 656 meters. It is located in Chantaburi Province in E of Thailand on the Gulf coast. The bay, covering an area of about 640 ha, is an integral part of the KKB Royal Development Study Center (KKBRDSC) project, which was established to increase villagers’ income by application of integrated environmental management practices. The area is surrounded by a mangrove fringe, behind which numerous small-scale shrimp farms have been established. In the high land between the bay and hill, rice fields and fruit orchards form the major component of the agro-ecosystem. The upland area is still covered with mixed forest, orchards and rubber plantations.

KKBRDSC was founded on 30 December 1981 as a Royal Project in coordination of the Department of Fisheries (DOF). The main objective of KKBRDSC was to build the bay as an ideal demonstration project for sustainable management of coastal resources with an integrated management approach. The approach involves optimum use and conservation of the natural resource base of the area, maintenance of ecological balance, and local participation in the planning and management of various development initiatives.

A significant activity of the project was to provide local poor farmers with the land and extension support to develop shrimp farming. A 1.6 ha plot was granted to each of 100 farmer households, of which 0.96 ha was for three ponds (0.32 ha each), 0.16 ha for dikes and ditches and 0.48 ha on the seaward side for houses and mangrove plantation. Most of the farmers have been successful, with production rates generally in the range of 5-10MT/ha/yr, providing a very high net income relative to their previous agricultural activities. The incidence of disease has however increased in recent years, with lower average earnings and significantly increased risk.

Environment and development issues

The area has been subject to a variety of pressures on the natural environment closely related to development activities:

Seawater Intrusion: Seawater intrusion and consequently salination of agricultural soil is a major concern especially for the paddy fields. Since the expansion of shrimp culture on the late 80s some agricultural land has been abandoned.

Mangrove Area: In 1955 34% of the coastal land area of Chantaburi Province was dominated by mangrove. This declined rapidly in subsequent years due to a suite of development pressures, including charcoal production, collection for firewood, conversion to agriculture and salt farming, and most recently conversion to shrimp farming. In the project area approximately 166 ha of deteriorated mangrove was converted to shrimp farming, leaving a narrow belt of mangrove (14 percent) along the coast. There is now limited cooperation from the project farmers to conserve and restore the mangrove resource.

Waste Loading on the environment and “self-pollution”: A portion of shrimp farming wastes, either in suspended or soluble form, are discharged to the coastal environment causing a threat to the shrimp culture itself. Figure A1.5 describes the significant nitrogen (N), phosphorus (P) and sediment loading from the shrimp farms of KKB. Because the Bay is a semi-closed ecosystem with a single inlet-outlet,
Figure A1.4. Water supply for the KKB shrimp project.
(Diagram courtesy of Kung Krabaen Bay Royal Development Study Center)

1. Original Water System

2. New Water System (seawater irrigation)
there is limited dispersion of nutrients and sediment to the open sea. There is therefore a risk of serious impact on the lagoon ecosystem, which includes seagrass beds and nursery areas for shrimp and fin-fish. Furthermore, a significant proportion of waste materials discharged can re-enter the supply canals. The problem has been further exacerbated by the uncontrolled emergence of private farms adjacent to the project. Management of this loading to reduce impact on the bay, and on the shrimp farming itself, has become an important issue for the project management.

**Figure A1.5. Fate of wastes produced from the shrimp farm of the KKB (MT = metric tons).**

![Diagram showing waste production and discharge]

*Mangrove: shrimp pond area ratio:* If mangrove is to be effective as a buffer between shrimp ponds and the bay (sedimentation; nutrient absorption) a ratio of 1:5 is recommended. If sediments are exceptionally well managed, this ratio may be reduced to 1:1.6. The present ratio is 1:1.25.

**Institutional framework**

At least 19 governmental agencies are now cooperating with the center. These agencies are working together to promote and disseminate knowledge, skills and appropriate techniques on aquaculture, coastal environment protection and conservation, agriculture and animal husbandry through several “demonstration projects” and provision of training based on the study, research and experimentation work conducted by the center. Internal structure of the KKBIRDSC is presented in the Figure A1.6.

**Environmental management**

*Environmental assessment*

At the beginning of the KKBIRDSC, no comprehensive EA was undertaken. This was because initial scoping and preliminary assessment assumed that extensive aquaculture technology would be used, and that activities would be restricted to defined aquaculture zones. In practice the shrimp farmers intensified very rapidly as their skills developed, in order to maximize their returns. In addition, other “unofficial” farmers were attracted to the fringes of the project, and significant unplanned and unregulated development took place, which affected both land use (significant areas of paddy have been converted), and the main water supply system (pond effluent was discharged into project supply canals).

Several environmental assessment related activities were subsequently initiated in response to some of the disease and water quality problems which have become increasingly common in recent years. These
have included comprehensive monitoring of water quality in farm ponds and the bay, and a range of studies on environmental capacity of the lagoon, valuation of impacts, and impact management.

**Regulations**

Several policy and regulatory measures have been developed since the inception of the project to improve the environmental management of the shrimp farms and their surroundings:

- Mangrove land-use zoning policy;
- Rezoning of shrimp farming area;
- Preservation and reforestation of mangrove forest;
- Registration of shrimp farms;
- Requirement for settling pond construction by farmers; and
- Prohibition of sludge discharge to public waterways.
Extension and promotion

- Extension and promotion of improved pond management;
- Demonstration and promotion of waste handling practices and waste treatment systems, including the use of oysters as bio-filters, and pond sediments as soil conditioner;
- Demonstration and promotion of grouper and seabass culture by the project, and by some of the farmers, with a view to diversifying the cultured species for brackish water ponds, and thereby reducing the risk of disease;
- Use of the mangrove forest to treat wastes; and
- Environmental awareness raising among farmers.

Infrastructure

- Provision of pathology and veterinary service, including PCR testing of seed, disease identification, and advice on treatment.
- Development of a new sea water irrigation system.

Of these, the most ambitious is the sea-water irrigation system, which is nearing completion (1998). This comprises a major water intake on the open coast (outside the bay) and pumping facility to supply a network of supply canals (see Figure A1.4). It also includes provision for rationalizing effluent canals, and water treatment prior to discharge into the Bay. The objective is to provide high quality, low pathogen water to all farms within the project, thus maximizing shrimp health and minimizing disease. Water treatment, and an overall flushing of water, should also lead to improved water quality within the bay.

Socio-economic impact

A study was specifically commissioned by the funding Board to examine socio-economic consequences of the project, and especially the shrimp farming component. It concluded that the shrimp farming had made a significant contribution to increasing the income, education and standard of living of those closely associated with the project. Inequity between those with shrimp ponds and those without had increased.

Some lessons and conclusions

1. It is dangerous to assume that extensive aquaculture poses no threat to the environment and therefore requires no environmental assessment. There are three major reasons for this:

   - Extensive aquaculture itself requires habitat conversion in ecologically sensitive zones on a significant scale. If it is successful it will attract other farmers, and the impacts may become very extensive;
   - There are powerful financial incentives to intensify as farmer knowledge and skills increase. This is difficult to control, and in any case may be desirable from other development perspectives. It should therefore be planned for, rather than reacted to; and
   - Successful farms will attract other farmers, commonly resulting in unplanned and uncontrolled development, mixed influent and effluent within and between farms, and increased stress and disease in fish or shrimp ponds.

EA should therefore be applied to extensive as well as intensive aquaculture. Since it is unrealistic and probably pointless to undertake EA in respect of individual small or medium scale extensive operations, sector EA should be undertaken for specific systems. Kung Krabaen Bay and its surroundings is an ideal "ecological system" which could have formed the basis for such an assessment.
2. A strong permit or licensing system with effective implementation is essential if development is to be well organized and sustainable.

3. A variety of mitigation practices were adopted or tested with mixed success:
   - Simple settling is effective in significantly reducing nutrient and sediment loads especially if used at the time of harvest;
   - Many farmers have adopted semi-closed systems (greatly reduced water exchange, compensated by high levels of aeration) which they believe reduces the risk of disease, and incidentally reduces pollution loads (assuming pond sediments are effectively disposed of);
   - The conversion of pond sediments for use as a fertilizer or soil conditioner is possible, but salt removal is costly, and nutrient quality is not high; and
   - The use of oysters as biofilters in effluent channels has been only partially successful, and has not been enthusiastically embraced by farmers. The impact on effluent quality has been limited since effluent suitability for oyster growth is highly variable, and the relative value of the oysters is low.

4. Despite a project with a strong environmental theme and significant potential for environmental planning and management, shrimp farming intensified rapidly with inadequate infrastructure in terms of water supply and disposal. Although this is now being addressed, it is in reaction to significant disease and water quality problems, which have significantly reduced the success of the project in recent years. A more thorough and planned approach might have pre-empted these problems.

5. The institutional and organizational structure is extremely complex and costly. It is questionable whether this kind of approach, desirable as it is, could be repeated more widely. An approach which gives more responsibility to the farmers for environmental management might result in more responsible farmers.

6. Seawater irrigation systems may well enhance the sustainability of aquaculture, but they are expensive. The impact of the new system should be monitored to assess the cost effectiveness of such initiatives.
Appendix 2:

- Legal and Institutional Frameworks for the environmental assessment and management of aquaculture
- Details of Ministries and other agencies that co-ordinate and/or advise on Environmental Assessment

Legal and Institutional Frameworks in selected African countries

Madagascar

Shrimp culture has begun to “take off” in Madagascar over the last few years, following significant assessment and planning activity, including a sector EA relating to shrimp culture.

Figure A2.1. Framework for Technical and Environmental Evaluation of Investment projects in Madagascar.

1 Based on the output of a working group at the SEACAM Mariculture EA Training course, Dar es Salaam, June 1999
The basic approval structure for major projects is presented in Figure A2.1. The main control on development activity is the Technical Evaluation Committee which screens projects and reviews EIAs. A Code of Conduct for shrimp farming has been developed and is currently under review. A Code of conduct for seaweed culture is also in preparation.

**Strengths**
- The Technical Evaluation Committee represents a single integrated check on development proposals from social, economic and environmental perspectives;
- The Decree and associated ordinances have awakened environmental concerns in several Ministries;
- The concept of sustainable development is broadly accepted by investors and other stakeholders; and
- The Decree provides a legal framework for EIA, which in turn encourages the confidence of funding agencies

**Weaknesses**
- There is an insufficiency of tools for environmental assessment;
- The evaluation structure is relatively heavy, especially for smaller developments;
- There is limited awareness of the decree;
- Some investors are reluctant to undertake EIA because of the high fees; and
- The process does not apply well to small scale locally initiated aquaculture development.

**Opportunities**
- A management plan for sustainable development of shrimp culture; and
- Legislation to implement and strengthen the relevant codes of conduct.

**Mozambique**

The main institutions concerned with aquaculture and the coastal environment are presented in Figure A2.2.

**Relevant legislation and policy**
- Fisheries Act
- Fisheries Master Plan
- Environmental Law
- Water Act
- Land Act
- Health Act

**Strengths**
- Coastal Zone Management Unit plays an effective role in coordinating different sectoral interests.

**Weaknesses and constraints**
- Coastal zone management unit currently not involved in aquaculture; and
- Supporting legislation does not exist – no specific legislation in respect of aquaculture.

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2 Based on the output of a working group at the SEACAM Mariculture EA Training course, Dar es Salaam, June 1999
Figure A2.2. Institutional framework for aquaculture and environment in Mozambique.

Opportunities for clarification of responsibilities:
- Directorate for Livestock could serve as responsible authority for freshwater fish farming; and
- National Directorate for Fisheries could serve as responsible authority for coastal aquaculture
Opportunities for action:

- Ministry for Coordination of Environmental Affairs through master plan develop policies for the Coastal Zone Management Unit to coordinate sectoral interests;
- Research by Fisheries Research Institute; and
- Draft law on aquaculture in preparation by National Directorate for Fisheries with association with Fisheries Research Institute.

South Africa³

Responsible authority

Mariculture was originally the responsibility of the Fisheries Development Corporation (FDC), a statutory body charged to:

- develop the industry;
- train researchers;
- offer grants to universities and research institutions; and
- provide development finance.

This was phased out in the '80s. The Department of Agriculture is now the principal agency for aquaculture development (freshwater and marine). It convenes the Aquaculture Policy Committee which address national level issues. It also has organizational responsibility for freshwater aquaculture. However, the Department of Environmental Affairs and Tourism (DEAT), Directorate of Sea Fisheries (DSF) now controls and regulates coastal and estuarine mariculture.

DSF/DEAT functions:

- Permits;
- Research (mainly on environment issues so far);

Relevant legislation and policy

There is no national policy specifically for aquaculture, but the need is widely recognized and initiatives are afoot. However there is some provision for aquaculture within the Marine Fisheries Policy and the Marine Living Resources Bill.

Marine Fisheries Policy

- Development of mariculture operations will be encouraged within the limits of relevant appropriate environmental regulations;
- Mariculture research and the development of expertise will be a national effort, and will be promoted by the State as well as by the private sector;
- The introduction of foreign species will be controlled and care will be taken over possible environmental effects, particularly with respect to any resulting impacts on indigenous stocks;
- A full environmental, economic and social impact study will be carried out prior to the establishment of any commercial scale operations; and
- The problems of the effect of pollution, or from, mariculture will be addressed.

---

³ Based on Cowley et al., 1998. Estuarine Mariculture in SAfrica. South African Network for Coastal and Oceanic Research, and the Foundation for Research and Development
Marine Living Resources Bill:
- No person shall engage in mariculture unless a right to engage in such activity has been granted to such person;
- An application to engage in mariculture shall be submitted to the Minister in the manner that the minister may determine;
- The minister may require an environmental impact assessment report to be submitted by the applicant; and
- The right to engage in mariculture may be granted for the period that the minister may determine.

Opportunities for change
Hecht (cited by Cowley et al., 1998) recommends:
- Each province should have active development programmes (promotion, extension and regulation); and
- There should be a national policy statement – relating specifically to other policies and sectors.

Cowley et al., 1998 recommend:
- New policy relating to mariculture should be integrated in the CMPP of the DEAT;
- A framework of planning procedures and management guidelines should be developed – linked to extension, technical assistance, and monitoring. This system must be flexible and adaptive;
- EIA should be promoted and developed not as legal constraint, but as an all encompassing regulatory mechanism and management tool to provide improved planning and execution of new projects;
- An information access system should be developed; and
- A resource allocation strategy (essentially a zoning/aquaculture siting guidance system) should be developed from current research.

Legal and Institutional frameworks in selected Asian countries
The following information has been provided by the Network of Aquaculture Centers in Asia (NACA), Bangkok.

Table A2.1. Environmental management of coastal aquaculture in selected ASIAN countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Registration of farms</th>
<th>EIA</th>
<th>Specific aquaculture legislation</th>
<th>Effluent Standards</th>
<th>Licence abs/disc water</th>
<th>Monitoring</th>
<th>Effluent treatment requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Cambodia</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>China</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>India</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>India (Optional)</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Iran</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Indonesia</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Korea</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Malaysia</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Myanmar</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>Philippines</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Thailand</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Vietnam</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

= not available
Farm registration.
All of the countries (except for Bangladesh, Cambodia and Vietnam) reported a system of farm registration, which in most cases included restrictions or conditions under which the farm must operate. It is appropriate if farm registration requirements should be extended to cover all aquaculture farms, regardless of size.

Specific aquaculture legislation.
Only two of these countries returning had specific aquaculture legislation (Malaysia and Myanmar) although a further two had some specific legislation (India and Korea). In Thailand, coastal aquaculture is subject to a wide range of legislation that was originally formulated for other purposes, and it would be useful to have specific aquaculture legislation that identifies the parts of different existing statutes that are applicable to coastal aquaculture, and which provides additional legislation and regulations where there are gaps. Due to the length of time it takes to develop and promulgate legislation, it is recommended that Thailand begin the process of legislative development as soon as possible.

Environmental Impact Assessment.
Five countries in the region report a requirement for some form of environmental impact assessment, Hong Kong, India, Malaysia, the Philippines and Sri Lanka. In Hong Kong, instead of requiring EIA for individual developments the Government has carried out regional EIAs in some areas to assess the potential of the area for fin fish culture. This approach reduces the financial burden on individual farmers and allows coastal area assessment to be made taking into consideration other waste loadings and users. In India and Malaysia, farms exceeding 40 ha and 50 ha in size, respectively, are subject to EIA. In Sri Lanka (see below), all proposed farms are required to submit basic data on the site and size of the proposed development (an Initial Environmental Assessment) and farms over 5 ha which are located in an environmentally sensitive area require a full EIA. Similarly, the Philippines requires an Initial Environmental Assessment for all aquaculture related activated.

Effluent standards
A number of the countries in Asia reported having effluent standards for coastal aquaculture (Hong Kong, Indonesia, Korea, the Philippines and Sri Lanka) whilst others (India) reported that they are under development. The recommended effluent standards for coastal aquaculture in Thailand are discussed in Section 10. Only Indonesia and Sri Lanka have standards for shrimp farming. Effluent standard for coastal aquaculture are shown in Table A2.2.

Monitoring.
Only Korea, the Philippines and Sri Lanka carry out any monitoring of aquaculture effluents, and in the latter two countries the extent of this monitoring is very limited due to manpower and the logistical problems.

A brief summary of the procedures in countries which have developed environmental management practices for coastal aquaculture follows:

Sri Lanka - see Appendix 1

Indonesia
Indonesia uses the AMDAL process for assessing aquaculture development projects (ADB, 1992). Analysis Mengennai Dampak Lingkungan Method (AMDAL) is essentially an integrated review process designed to co-ordinate the planning and review of proposed development activities, particularly their ecological, socio-economic and cultural components as a complement to the technical and economic feasibility. Permits and licence conditions provide the means by which environmental mitigation and monitoring requirements developed in the AMDAL process can be made legally enforceable in the event of non-
compliance. There are four main types of permit: Investment Permits; Location Permit; Activity Permit; and Nuisance Permit. The use of water effluent and air emission standards is critical to the effectiveness of the AMDAL process.

The Ministry of Agriculture of Indonesia has prepared regulations applicable to the preparation of Environmental Monitoring Plans of aquaculture (Decree No 719/Kpts/RC 220/10/89). In most cases the monitoring will involve collecting data on the following parameters from effluent and affected receiving waters: pH; BOD₅; Total suspended solids; Nutrients (nitrogen total).

nitrogen, ammonia, nitrite and nitrate) and phosphorus (ortho-phosphate and total phosphorus) compounds; Temperature, dissolved oxygen, salinity/conductivity; and Chlorophyll a.

**Hong Kong**

Coastal aquaculture in Hong Kong is made up mainly of marine finfish cage culture and oyster culture and there is specific legislation covering both activities. The Marine Fish Culture Ordinance protects and controls marine fish culture and requires that all marine fish culture operations be conducted under licence within a designated fish culture zone. The licence specifies the size and location of fish rafts, the size and use of structures permitted on the raft and regulations on moorings and installation of lights, licence number plate and refuse containers. The release of pollutants is prohibited as is the unauthorised entrance of vessels into the fish culture zone. There are also restrictions on certain fish culture operations such as disposal of mortalities and other wastes. There are no specific effluent standards for marine fish cage culture, but there are effluent standards for other discharges into inland and coastal waters in Hong Kong.

**Republic of Korea**

In Korea there are codes of practice for the utilisation of lakes, rivers and coastal areas for aquaculture which cover specific criteria governing site selection procedures and stocking rates for finfish, mollusc and seaweed farms. All cage culture and aquaculture operations of more than 1,000 m² surface area should register with the Ministry of Environment under the Aquatic Environmental Protection Law. Major provisions aimed at mitigating the pollution loads from cage fish farms consist of the following:

- Supply drifting and low phosphorus feed only and the sinking rate should not exceed 10% in two hours;
- Feed fences 10 cm above the surface of the sea should be erected to control the dispersal of feed outside the cages;
- Dissolved oxygen levels should not be more than 20% less outside of the cage than inside;
- There should be facilities on the cages to retain human faecal materials;
- Regulation of the use of antibiotics and drugs for fish disease; and
- Immediate removal of dead fish.

There are no specific effluent standards for marine finfish culturists although under licensing and management regulations the following activities must be carried out:

- The seabed must be cleaned with dredges more than once every three years;
- A distance of more than 300 m must be kept between on licensed site and another;
- Licence areas are restricted to 0.5 to 10 ha for one finfish licence culture bed;
- Each cage should be 25 m²;
- Cage area will not exceed 5-20% of the total licensed area; and
- All finfish culture should have a licence from the municipal authorities.
Myanmar

Myanmar has recently adopted legislation to promote the development of aquaculture, including both coastal and inland aquaculture. However, this legislation does not cover the environmental management, EIA or effluent standards, although it does include registration and licensing for all aquaculture farms.

China

There are several environment protection laws in China which touch upon aquaculture, although these laws are not specifically drafted for aquaculture. The scope of the Fisheries Laws of the People’s Republic of China of 20/1/1984 includes protection of fisheries and aquaculture environments. In general in China, there is more concern about the protection of aquaculture and fisheries from industrial pollution and eutrophication, than with protection of the environment from aquaculture development. The Environment Division of the Bureau of Fisheries Management and Port Superintendence (Ministry of Agriculture) is planning to draw up further regulations on environmental protection for fisheries, including aquaculture, probably as a part of the existing environmental laws.

The Fisheries Law states that “the state shall encourage the best use of suitable water surfaces and tidal flats to develop aquaculture”. Aquaculture operations on state owned water surfaces and tidal flats that have been designated for aquaculture are required under this Fisheries Law to apply for an operating licence. Small-scale pond culture on private land does not require an operating licence. Licences are also required for using state and collectively owned land.

There are no set standards for effluent discharges from land-based aquaculture farms in China and no legal requirement for treatment of effluent from such farms. Under the Water Pollution Prevention and Control Law, it is prohibited:

(I) to deposit solid wastes and other pollutants on beaches and bank slopes below the highest water level of rivers, lakes, canals, channels and reservoirs; and

(II) to discharges pathogen-contaminates sewage unless it has been disinfected to meet the relevant national standards.

However, such regulations have not been applied to aquaculture.

The department of fisheries administration at various government levels are required under the Fisheries Law to monitor the pollution of fisheries waters. The monitoring network of fisheries environmental protection is incorporated into a national environment monitoring network. The monitoring of fisheries environment is co-ordinated at national level by the Bureau of Fisheries Management and Fishing Port Superintendence (of the Ministry of Agriculture), and undertaken at the national, provincial and local district or country level.

Environmental impact assessments (EIA) are not normally carried out prior to the development of an aquaculture farm although aquaculture projects supported by agencies such as the World Bank and Asian Development Bank incorporate an EIA. The Environmental Protection Agency, mandates EIA for mainly industrial, construction and large scale, non aquaculture development projects.

There are codes of practice for the use of some toxic substances, chemicals and pesticides in aquaculture.

The Water Pollution, Prevention and Control Law Decree No. 12 in China provides that competent central and local governments may define protected zones, and take measures to ensure that the water quality in those protected zones complies with the standards for their designated uses with regard to important fishery water bodies. “Fishery water bodies” are those parts of water bodies designated for the spawning, feeding, wintering, or migration passage of fish, or shrimp, and for breeding fish, shrimp, or
shellfish, or growing algae. The Regulations for implementation of the Fisheries Law also states that the natural spawning, breeding and feeding grounds of fish, shrimp, shellfish and algae as well as their major migration routes shall not be used as aquaculture grounds.

Malaysia

There are a number of laws and regulations in Malaysia that deal with aquaculture. The Fisheries Act in Malaysia provides for a license system for coastal aquaculture systems (but not for aquaculture in inland waters - this is the responsibility of the State Authority). Under this act, aquaculture is defined as the propagation of fish seed or the raising of fish through husbandry during the whole or part of its life cycle and “culture system” as any establishment, structure or facility employed in aquaculture and includes bottom culture, raceway culture, raft culture, rope culture and hatchery. The Director General of Fisheries (DGF) has the responsibility to grant coastal aquaculture licences.

Lately, the Department of Fisheries in Malaysia has started working on extending the licensing and permit regulations to encompass freshwater areas under the state’s jurisdiction and it also plans to introduce a “code of practice” for aquaculture activities covering detailed operational procedures for different culture systems. The environmental Quality Act in Malaysia constitutes a basic instrument providing for a common legal basis to co-ordinate all activities of environmental control including EIA. Under the Land Conservation Act, the competent authorities (“collector”) have certain duties with regard to the protection of land and water sources from soil erosion and siltation (physical pollution) from different activities, including coastal aquaculture. EIAs are only carried out in Malaysia for coastal aquaculture projects which cover an area of more than 50 ha (in mangrove areas). No effluent standards have been set for coastal aquaculture in Malaysia.

India

Under the Environment (Protection) Act, 1986, standards for effluent have been laid down, but these are not for aquaculture. Specific standards for aquaculture effluent are under development by state Pollution Control Boards. EIA in aquaculture was previously adopted for large donor supported projects, but now all large projects of coastal aquaculture (over 40 ha) are required under government guidelines to prepare an ‘environmental management plan’. No regulations to control the use of chemicals and drugs exist. Pollution control Board general regulations on effluent discharges include hazardous substances, but they are not specific to aquaculture.

Under the Notification of Union Ministry of Environment and Forests, each maritime state is expected to have its own coastal zone management plan, which includes zones for aquaculture. The zone up to 500 metres from the waterline along the sea is restricted against any construction activity, including aquaculture. In general, specific regulations for aquaculture are under development. Some states are considering enacting legislation for aquaculture development, as in the case of Tamil Nadu. The particularly relevant points of this Tamil Nadu legislation are as follows:

- establishment of an ‘ecorestoreation’ fund, which can be used for environmental improvements in aquaculture areas, particularly where farms have been ‘abandoned’;
- licensing of aquaculture development, and the identification of areas where aquaculture can be carried out (and restriction on development in conservation/protected areas);
- need for consent from the Tamil Nadu Pollution Control Board (PCB) before approval of an aquaculture licence; and
- general management provisions for reduction of impacts of aquaculture effluent, including the use of settlement ponds, if deemed necessary by the PCB.
Table A2.2. Effluent standards for coastal water in other Asia-Pacific countries.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hong Kong¹</th>
<th>India³</th>
<th>Indonesia</th>
<th>Korea³</th>
<th>Philippines⁴</th>
<th>Sri Lanka⁵</th>
<th>Australia⁶</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD (mg/l)</td>
<td>10-40</td>
<td>20-50</td>
<td>*</td>
<td>-</td>
<td>3</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>COD (mg/l)</td>
<td>50-85</td>
<td>75-100</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>250</td>
<td>-</td>
</tr>
<tr>
<td>PH</td>
<td>6.0-10.0</td>
<td>6.0-8.5</td>
<td>*</td>
<td>-</td>
<td>6.5-8.6</td>
<td>6.0-8.5</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Suspended solids (mg/l)</td>
<td>25-40</td>
<td>100</td>
<td>*</td>
<td>-</td>
<td>30% increase</td>
<td>100</td>
<td>90-200</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>40-45</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>30% increase</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>Total nitrogen (mg/l as N)</td>
<td>20-50</td>
<td>2.0</td>
<td>*</td>
<td>-</td>
<td>2.0</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Total phosphorus (mg/l as P)</td>
<td>5</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Phosphate (mg/l as P)</td>
<td>-</td>
<td>0.2-0.4</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total ammonia (mg/l as N)</td>
<td>-</td>
<td>0.5-1.0**</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nitrite (mg/l as N)</td>
<td>-</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nitrate (mg/l as N)</td>
<td>-</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Turbidity</td>
<td>-</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dissolved oxygen (mg/l)</td>
<td>-</td>
<td>&gt;3</td>
<td>*</td>
<td>-</td>
<td>5</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Coliform (MPN/100 ml)</td>
<td>1,000</td>
<td>-</td>
<td>&lt;70</td>
<td>70</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Sources:
1 = Environmental Protection Dept., Hong Kong, 1991
2 = Ministry of Agriculture, India, 1995
3 = Ministry of Agriculture, Forest and Fisheries, RO. Korea, Ordinance No. 699, for shellfish culture in sea
4 = DENR, Administrative Order No. 3, Philippines, 1990, for mollusc culture in sea
5 = FAO/NACA, 1995
6 = e-mail data from Dr. Paul Smith, ACIAR, Australia
* = not available
** = free ammonia (as NH₃-N)

Philippines

A series of laws have been enacted for the aquaculture and fisheries industry, which are related to conservation of resources and the environment. There are, however, numerous local regulations promulgated by some municipal governments which are also directed to utilisation of resources and the environment for aquaculture purposes. A new Fisheries Code is being prepared to encompass the main issues related to the environmental management of aquaculture in the Philippines.

There is limited provision for EIA for coastal aquaculture in existing regulations, but it is planned to include more comprehensive coverage under the new Fisheries Code. Water quality standards exist for mollusc culture areas, but no standards exist for shrimp farming effluent. Philippines law requires the registration of all coastal aquaculture farms, including shrimp, fish, seaweed and mollusc farms.
Indonesia

Table A2.6. Outline of environmental impact assessment procedures for shrimp aquaculture projects in Indonesia

<table>
<thead>
<tr>
<th>Steps</th>
<th>Actions</th>
<th>Outcome/result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project initiation</td>
<td>Investor/farmer to forward project plan to authorities</td>
<td>Advice given to investor/farmer on EIA procedures</td>
</tr>
<tr>
<td>2. Initial screening</td>
<td>Prepare preliminary environmental assessment covering: - project description - general environment at site - identification of major environmental concerns - follow up recommendations</td>
<td>Review indicates: project exempt or project unacceptable or EIA to be prepared under these circumstances: - introduction of new species - farm area &gt; 5 ha - farm within mangrove area - hatchery &gt; 40 million pcs/yr Following review of EIA by authorities, project: - rejected - modified - accepted.</td>
</tr>
<tr>
<td></td>
<td>Prepare environmental impact assessment covering: - environmental issues during construction, operations and abandonment - effects on environment - effects of environment on shrimp farm - identification of mitigative measures</td>
<td>Following acceptance, operational permit given defining mitigation and monitoring requirements developed in EIA procedure.</td>
</tr>
<tr>
<td>4. Farm start up and post permit monitoring</td>
<td>Environmental monitoring, particularly effluent quality: - pH, BOD and COD, solids, N and P, temp, chlorophyll. - other parameters as deemed necessary</td>
<td>Action can be taken if non-compliance</td>
</tr>
</tbody>
</table>

Adapted: Phillips, 1995

In other countries world-wide

In industrialised countries worldwide there are a variety of measures used to control the environmental impact of aquaculture. Some of the planning and regulatory options in use by other countries for the control or minimisation of environmental impact of aquaculture developments are shown in Table A2.3 (NCC, 1989).

Table A2.3. A summary of aquaculture control options used in various industrialised countries.

<table>
<thead>
<tr>
<th>Control Option</th>
<th>Can</th>
<th>Den</th>
<th>Fin</th>
<th>France</th>
<th>Japan</th>
<th>New Zealand</th>
<th>Norway</th>
<th>Sweden</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substantial Legislation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance Limits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>between sites from conservation areas</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limits on production per farm cage area or number by volume by stocking density</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Water Depth Regulations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted areas</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moratorium on new farms Regulations on Ownership EIS required</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water quality monitoring Management plan required</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulations vary with farm size</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: NCC, 1989
Some of the main points which emerged from this analysis were:

- In some countries (Denmark and Norway) the pace of development resulted in a temporary moratorium on new fish farm licences whilst environmental and other studies were undertaken;
- in some countries (Canada, Norway and France), regulations were made regarding the distance farms must be sited from conservation or other fishfarming sites;
- the size and scale of development is controlled in some way in most countries; and
- most countries have some form of consultation procedure with interested parties prior to the granting of a licence - this may depend on the scale of the development.

In 1992, a study was carried out to compare different approaches to effluent management in EC countries (Rosenthal and Hilge, 1993). The results are summarised in Tables A2.4 for freshwater aquaculture operations and Table A2.5 for marine cage farms. It should be borne in mind that these controls relate to intensive finfish culture in cages in the marine environment and land-based tank or pond farms in the freshwater environment. There is also freshwater cage culture of finfish in some countries.

In the freshwater environment, the most common ways of controlling effluent quality are to have a requirement for water treatment and restriction on water abstraction. These restrictions delimit the quality and quantity of effluent that may be discharged. Other commonly used controls were to place restrictions on the nutrient and organic load through effluent standards, taxing the volume and quality of effluent discharged or a requirement for EIA. Less commonly used were restrictions on production capacity and chemical monitoring requirements.

Table A2.4. Comparison of Controls Governing Freshwater Fish Farm Effluents in EC and other states.

<table>
<thead>
<tr>
<th>EC Countries</th>
<th>Prod. cap</th>
<th>Wat treat</th>
<th>Wate xtr.</th>
<th>N&amp;P load</th>
<th>Org load</th>
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<th>Feed Conv</th>
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Source: Rosenthal and Hilge, 1993

In the marine environment, restrictions are commonly placed on production capacity, nutrient and organic loads, feed composition and stocking density. There is also a requirement for EIA, water quality monitoring and separation distances in some countries.
Table A2.5. Comparison of controls governing marine fish farm effluent in some EC member states.

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<tr>
<th>Country</th>
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Source: Rosenthal and Hilge, 1993

Details of Ministries and other agencies that co-ordinat and/or advise on Environmental Assessment

COMOROS
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Ex-CEFADER
B. P. 860
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Fax: + 269 736849
E-mail: precncom@snpt.km

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National Environment Secretariat
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Nairobi
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Fax: +254 2 248851

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Ministere de l'Environnement
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Madagascar
Tel: + 261 202 240908
Fax: +261 202 241919
E-mail: minenv@dts.mg; one@dts.mg

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Mauritius
Tel:+230 212 4385, 2126975
Fax:+ 230 212 6671, 2100865
E-mail:denvmr@bow.intnet.mu
Internet website:www.ncbi.intnet.mau/environ.htm

MOZAMBIQUE
Ministry For Co-ordination of Environmental action (MICOA)
Av. Acordos de Lusaka
Maputo
Mozambique
Tel: +258 1 465843, 465851
Fax: + 258 1 465849
E-mail: micoa@ambinet.uem.mz

RÉUNION
Directres des Affaires Economiques
Hotel de la Region
Avenue Rene Cassin-Moufia
B.P.7190
97719 Sainte Clotilde
OTHER USEFUL CONTACTS

The World Bank
1818 H Street NW
Washington DC 20523
USA
Internet website: www.worldbank.org (Go to: “Operations and projects”, then “Environmental Assessment policy” under heading; “Operational policies”).

International Association for Impact Assessment (IAIA)
Internet website: www.ndsuest.nodak.edu/IAIA

Francophone Secretariat:
Secretariat francophone de l’Association (functions as an IAIA affiliate)
International pour l’évaluation d’impacts
380 St. Antoine Street West
Montreal, Quebec H2Y 3X7
Canada
Tel:+514 288 2663
Fax:+ 514 987 1567

References

## Outline of EIA Process according to selected guidelines

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<th>Preliminary Assessment</th>
<th>Detailed Assessment</th>
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<td>Screening a. Whether or not EIA is required b. Level of assessment needed</td>
<td>Preliminary Assessment a. Identify key impacts on the local environment b. Magnitude and significance of the impact c. Evaluate the importance of impacts for decision makers</td>
<td>Scoping a. Narrowing down of potential impacts b. What impacts will occur? c. Extent, Magnitude and duration d. Significance of impacts within local, national and international context e. Mitigate adverse impacts and optimize positive impacts f. Documentation</td>
<td>Review a. To address the adequacy of the assessment for decision making</td>
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<td>Monitoring a. Assess the effect of the project on the natural and cultural environment b. Collecting data</td>
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<td>Post project Auditing a. To learn from experience to refine project design and implementation</td>
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<td>Monitoring and Evaluation a. Ensure mitigation b. Identify additional mitigation c. Improve EIA procedures</td>
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Appendix 3
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Appendix 4:
Check-list for an initial environmental assessment (IEA) of an Aquaculture Project


1. Project Description
Rationale/Need for project
• beneficiaries
• related or downstream activities and multipliers; and
• resource use.

Alternatives
• technical
• location/siting
• resource/infrastructure differences for alternatives.

Technical description
• maps, areas used, areas affected, context;
• technical diagrams;
• intensity; inputs/outputs; production parameters;
• labour, skills - interactions with other projects; and
• establishment and operation

Implementation
• infrastructure
• markets
• credit
• institutions
• skills/environmental competence.

2. Description of the Environment – natural and man-made
Graphics, charts, etc. should be used where possible.
Sources of data should be presented, and reliability discussed.
• climate geology and soil conditions;
• hydrologic conditions (upstream and downstream);
• vulnerable or valuable species or ecosystems;
• unique natural or cultural areas;
• objects of
  - historic,
  - archaeological,
- cultural,
- aesthetic value,
- existing use of natural resources;
- demography/ethnography of user groups;
- settlement patterns; means of production; division of labour among affected groups;
- environment related illness; and
- existing or planned activities which might impact aquaculture.

3. Social impacts
The following should be addressed whether or not they are significant:
- Positive and negative effects on target group/beneficiaries;
- Effects on other groups; and
- Demographic change resulting from project.

4. Physical/environmental impacts
New species introductions (e.g. farmed animals; live feed; disease):
- impact on local species or ecosystems;
- impact on existing productivity;
- spread disease; and
- import control.

Reduced or changed biodiversity (commercially or aesthetically valued or vulnerable):
- impacts from site activity; and
- pollution.

Affect valued landscapes:
- visual impact affecting tourism and recreation; and
- visual or physical impact on locally valued sites.

Waste and pollution from activity, or associated downstream/upstream activities:
- organic matter;
- nutrients
- eutrophication, deoxygenation etc.;
- processing waste - smell; hygiene; eutrophication; and
- drugs, anti-foul, chemicals, disinfectants, pesticides.

Increase human disease:
- farm organisms as intermediate hosts;
- farm habitat as shelter for water borne vectors;
- inputs (e.g. sewage) - impacts on workers or consumers); and
- control of chemical use? quality control, residue checks?

Water and energy requirements:
- adequately assessed;
- competition with other users;
- level and salinity of water table;
- effect of evaporation on water quality;
- wood requirements for construction and eg smoking; and
- energy and fuel needs of activity, & associated transport and processing.

**Impact on local resource use:**
- a novel use of resources?
- level of intensity and suitability to local technical skills;
- economic and social change indirectly affecting utilization of natural resources;
- gender issues; and
- without project changes.

**5. Mitigation**

How can the likely impacts be reduced or *ameliorated*.

**Siting e.g.:**
- avoiding valuable habitat/resources;
- choosing locations with higher assimilative capacity;
- spreading or moving activities to reduce intensity of impacts; and
- location to maximize socio-economic benefits.

**Technology, e.g.:**
- waste/pollution reduction; and
- waste/pollution treatment or recycling.

**Management:**
- input selection and management (e.g. feed, chemicals);
- waste management; and
- Best Management Practice.

**Infrastructure:**
- canals
- water treatment; and
- waste handling and processing facilities.

**Legislation/fiscal:**
- effluent standards and control;
- licensing;
- taxation on pollution or inputs;
- Best Management Practice; and
- Price intervention on inputs or outputs.

**Market:**
- opportunities for environment related product labeling.
Appendix 5: Matrices of aquaculture activities, impacts and mitigation measures

- Brackish water and marine hatcheries
- Brackishwater pond culture
- Coastal cage or pen culture
- Coastal mollusc culture

Brackishwater and marine hatcheries

Checklist of environmental impacts and mitigation strategies for land-based marine hatchery/nursery (shrimp, fish) aquaculture projects

<table>
<thead>
<tr>
<th>Actions affecting environmental resources and values</th>
<th>Potential environmental impacts</th>
<th>Potential mitigation strategies for negative environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Site selection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Conflicts with other site users</td>
<td>On and off-site impacts resources and social conflicts</td>
<td>Appropriate regional land use planning Consultation process Participation of local people in aquaculture projects Resettlements/compensation agreements</td>
</tr>
<tr>
<td>2. Selection of ecologically sensitive site</td>
<td>Potential loss of biodiversity and wetland habitat</td>
<td>Careful site selection Management plan which identifies ecologically sensitive sites Habitat restoration, e.g. replanting of mangroves Maintain buffer areas around hatchery Prior assessments of impacts</td>
</tr>
<tr>
<td>3. Hazards to aquaculture from nearby pollution sources (e.g. agriculture, industry)</td>
<td>Water pollution from industry, agriculture affecting sustainability of aquaculture</td>
<td>Careful site selection Pre-treatment of water, selection of water sources Pressure from aquaculturists to reduce pollution from other sectors</td>
</tr>
<tr>
<td>4. Typhoons, flooding, hurricanes</td>
<td>Damage to physical facilities and loss of broodstock and pond discharge</td>
<td>Careful site selection. Hatchery design taking account of extreme climatic events. Buffer zones for wind breaks (e.g. mangroves)</td>
</tr>
<tr>
<td>5. Water quality</td>
<td>Water quality deterioration caused by self-pollution from hatchery effluent</td>
<td>Careful site selection in relation to other hatcheries. For large numbers of small-scale hatcheries, common effluent treatment systems Good hatchery management practices Design of inflow/effluent systems to control self-pollution. Treatment of effluent/effluent controls</td>
</tr>
<tr>
<td>6. Fish/shrimp broodstock availability</td>
<td>Potential impacts on biodiversity caused by over-harvesting of wild broodstock, Lack of sustainability of hatchery due to insufficient broodstock</td>
<td>Careful assessment of requirements Development of hatcheries Sourcing of wild broodstock.</td>
</tr>
<tr>
<td>7. Disease problems</td>
<td>Potential impacts caused by presence of serious pathogens/disease problems</td>
<td>Disease surveys of existing farms/broodstock sources to assess risk. Introduction of risk management strategies within hatcheries to reduce risk Careful disinfection/health management protocols for broodstock and seed. Health certification and quarantine protocols. Adoption of SPF (specific pathogen free) technologies.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>B. Hatchery design</strong></th>
<th><strong>B. Poor design can lead to environmental problems</strong></th>
<th><strong>B. Careful/appropriate design</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Attention to problems A (1) to A(7 ) above</td>
<td>As above.</td>
<td>As above.</td>
</tr>
</tbody>
</table>
2. Socio-economic impacts | Social inequities. | Participation of local people in aquaculture projects. *(note: small-scale hatcheries/nurseries projects offer good scope for involvement of local people).* Understand socio-economic conditions prior to project, and ensure developments do not negatively impact local people.

3. Impacts due to infrastructure | Local hydrological or salinity changes caused by poor design | Roads, canals and other infrastructure should not block tidal flow. Maintain buffer areas around hatchery.

4. Aesthetics | Aesthetic impacts | Development of green buffer zones. Avoid unsightly water supply/discharge canals, pipes. Locate away from tourist sites (e.g. high value beaches).

C. Hatchery construction | Poor construction practices can lead to various environmental problems | C.

1. Site clearance | Damage to terrestrial and wetland habitats and water quality problems during construction | Maintain buffer areas. Ensure site disturbance is limited to immediate construction area. Roads, canals etc should be constructed to minimise vegetation clearance. Sediments removed during construction should be disposed of in suitable locations. Excavation/disturbance of potential acid-sulphate soils should be minimised. Regulatory requirements should be followed during clearance and disposal of soils and vegetation.

2. Infrastructure development (access roads, canals) | As above | As above.

3. Obtaining filling materials | Removal of filling materials required for dykes, foundations, access roads may impact habitat, water quality | As above.

4. Labour, worker safety | Possible impacts on environment caused by labour force (e.g. noise, groundwater drawdown, sewage) | Provision of suitable infrastructure/facilities to support labour.

D. Hatchery operation and management

1. Solid waste disposal | Impacts on surrounding land-use/wetland habitats | Non-organic, solid waste materials should not be dumped into mangrove forests etc, but disposed of safely.

2. Waste water/effluent discharge | Impacts on local water quality and sediments | Use of settlement basins, borrow pits and other techniques to treat discharge water. Take particular care in treatment of water containing disease control/disinfectant chemicals. Water exchange minimised and water recycling when possible. Discharge of hatchery effluent into areas with adequate tidal flow. Avoid contamination of freshwater with saline effluent. Disposal of dead/diseased animals in sanitary manner. Minimise leaks from water pumps, generators etc.

4. Water intake and conveyance | Drawdown of groundwater supplies Water pollution problems impacting water quality | Water supplies from well-flushed supplies. Minimise use of groundwaters (although may be most suitable disease free water source).

5. Use of chemicals/water treatment | Potential impacts on workers health Water pollution Impacts on aquaculture product quality (e.g. chloramphenicol) | Use of approved chemicals according to standard practices. Reduce disease problems through preventative management, not chemicals. Education of workers in safe use/handling of chemicals.
| 9. Disease outbreaks and disposal of mortalities | Economic impacts on stock, product quality and native populations. | Implement preventative health management strategies (e.g. quarantine, isolation of infected tanks, maintain strict hygiene). Sanitary disposal of mortalities. |

**Brackishwater pond culture**

Checklist of environmental impacts and mitigation strategies for land-based brackishwater pond (shrimp, fish) aquaculture projects

<table>
<thead>
<tr>
<th>Actions affecting environmental resources and values</th>
<th>Potential environmental impacts</th>
<th>Potential mitigation strategies for negative environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Site selection</strong></td>
<td></td>
<td><strong>A. Appropriate site selection</strong></td>
</tr>
<tr>
<td>1. Conflicts with other site users and interference in livelihoods of local communities</td>
<td>On and off-site damage to resources and social conflicts</td>
<td>Appropriate regional land use planning Consultation process Participation of local people in aquaculture projects Resettlements/compensation agreements</td>
</tr>
<tr>
<td>2. Selection of ecologically sensitive site</td>
<td>Potential loss of biodiversity and wetland habitat</td>
<td>Careful site selection and integration of aquaculture into integrated coastal management Management plan which identifies ecologically sensitive sites Habitat restoration, e.g. replanting of mangroves Maintain buffer areas around farm Prior assessments of impacts</td>
</tr>
<tr>
<td>3. Hazards to aquaculture from nearby pollution sources (e.g. agriculture, industry)</td>
<td>Water pollution from industry, agriculture affecting sustainability of aquaculture</td>
<td>Careful site selection Pre-treatment of water Pressure from aquaculturists to reduce pollution from other sectors</td>
</tr>
<tr>
<td>4. Typhoons, flooding, hurricanes</td>
<td>Damage to physical facilities and loss of stock and pond discharge</td>
<td>Careful site selection. Pond design taking account of extreme climatic events (e.g. pond dyke height to prevent flooding). Buffer zones for wind breaks (e.g. mangroves)</td>
</tr>
<tr>
<td>5. Water quality</td>
<td>Water quality deterioration caused by self-pollution from aquaculture effluent</td>
<td>Careful site selection in relation to carrying capacity. Management practices and effluent controls Strategic planning to keep number of farms within carrying capacity.</td>
</tr>
<tr>
<td>6. Selection of site with poor soil quality</td>
<td>Soils inappropriate for aquaculture, e.g. acid-sulphate soils.</td>
<td>Soil surveys to identify problem soils (acid sulphate, peat). Construction and design to minimise disturbance of problem soils.</td>
</tr>
<tr>
<td>7. Fish/shrimp seed availability</td>
<td>Potential impacts on biodiversity caused by over-harvesting of wild stocks. Lack of sustainability of aquaculture due to insufficient seed supply.</td>
<td>Careful assessment of requirements Development of hatcheries Sourcing of wild broodstock.</td>
</tr>
<tr>
<td>8. Disease problems</td>
<td>Potential impacts caused by presence of serious pathogens/disease problems</td>
<td>Disease surveys of existing farms to assess risk. Introduction of risk management strategies to reduce risk.</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>B. Farm design</strong></td>
<td><strong>B. Poor design can lead to a variety of environmental problems</strong></td>
<td><strong>B. Careful/appropriate design</strong></td>
</tr>
<tr>
<td>1. Attention to problems A (1) to A(8) above</td>
<td>As above.</td>
<td>As above.</td>
</tr>
<tr>
<td>2. Socio-economic impacts</td>
<td>Social inequities leading to social unrest</td>
<td>Participation of local people in aquaculture projects. Understand socio-economic conditions prior to project, and ensure developments do not negatively impact local people.</td>
</tr>
<tr>
<td>3. Impacts due to infrastructure</td>
<td>Hydrological or salinity changes caused by poor design</td>
<td>Roads, canals and other infrastructure should not block tidal flow. Maintain buffer areas.</td>
</tr>
<tr>
<td>4. Aesthetics</td>
<td>Aesthetic impacts</td>
<td>Development of green buffer zones</td>
</tr>
<tr>
<td><strong>C. Farm construction</strong></td>
<td><strong>Poor construction practices can lead to various environmental problems</strong></td>
<td><strong>C.</strong></td>
</tr>
<tr>
<td>1. Site clearance</td>
<td>Damage to terrestrial and wetland habitats and water quality problems during construction</td>
<td>Maintain buffer areas. Ensure site disturbance is limited to immediate construction area. Roads, canals etc should be constructed to minimise vegetation clearance. Sediments removed during construction should be disposed of in suitable locations. Excavation/disturbance of potential acid-sulphate soils should be minimised. Regulatory requirements should be followed during clearance and disposal of soils and vegetation.</td>
</tr>
<tr>
<td>2. Infrastructure development (access roads, canals)</td>
<td>As above</td>
<td>As above.</td>
</tr>
<tr>
<td>3. Obtaining filling materials</td>
<td>Removal of filling materials required for dykes, foundations, access roads may impact habitat, water quality</td>
<td>As above</td>
</tr>
<tr>
<td>4. Dyke compaction</td>
<td>Poorly compacted dykes will lead to seepage problems.</td>
<td>Dyke compaction testing during construction.</td>
</tr>
<tr>
<td>5. Labour, worker safety</td>
<td>Possible impacts on environment caused by labour force (e.g. noise, groundwater drawdown, sewage)</td>
<td>Provision of suitable infrastructure to support labour.</td>
</tr>
<tr>
<td><strong>D. Farm operation and management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Solid waste disposal</td>
<td>Impacts on surrounding land-use/wetland habitats</td>
<td>Non-organic, solid waste materials should not be dumped into mangrove forests etc, but disposed of safely.</td>
</tr>
<tr>
<td>2. Waste water/effluent discharge</td>
<td>Impacts on local water quality and sediments</td>
<td>Use of settlement basins. Environmentally sound disposal of pond bottom sediments. Water exchange minimised and water recycling. Discharge of pond effluent into areas with adequate tidal flow. Disposal of dead/diseased animals in sanitary manner. Minimise leaks from water pumps, generators etc. Construction of artificial wetlands for effluent clean up. Secondary aquaculture, e.g. of filter feeding fish or molluscs. Salination avoided by buffer zones, pond liners, pond dyke compaction and site selection on low seepage soils. Sandy soils require special liners to eliminate seepage.</td>
</tr>
<tr>
<td>5. Harvesting and pond bottom management</td>
<td>Stirring up and discharge of pond bottom sediments leading to water pollution. Sedimentation caused by inappropriate disposal of pond sediment.</td>
<td>Harvesting techniques which do not stir up bottom sediments. Partial harvesting. Settlement pond to catch and trap pond sediment. Sediment management techniques which do not require sediment removal (e.g. ploughing, drying). Sediment disposal away from waterways. No flushing of pond sediments with water.</td>
</tr>
<tr>
<td>7. Seed collection/supply</td>
<td>Loss of biodiversity caused by harvesting of wild stocks.</td>
<td>Improved fishing techniques that reduce damage to non-target stocks. Development of hatcheries.</td>
</tr>
<tr>
<td>10. Operational failures</td>
<td>Sudden impacts caused by loss of stock and discharge of saline and nutrient rich pond water.</td>
<td>Accommodating operational failures in system design and management procedures. Routine dyke maintenance essential. Dykes should be designed to withstand flood events.</td>
</tr>
<tr>
<td>E. Critical environmental review criteria?</td>
<td>- how to assess/judge impact</td>
<td></td>
</tr>
</tbody>
</table>

Coastal cage or pen culture

Checklist of environmental impacts and mitigation strategies for sea-based intensive fish cage/pen aquaculture projects

<table>
<thead>
<tr>
<th>Actions affecting environmental resources and values</th>
<th>Potential environmental impacts</th>
<th>Potential mitigation strategies for negative environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Site selection</td>
<td>On and off-site damage to natural resources and social conflicts</td>
<td>Appropriate regional land use planning. Consultation process. Participation of local people in aquaculture projects. Resettlements/compensation agreements.</td>
</tr>
<tr>
<td>B. Appropriate site selection</td>
<td>Potential loss of biodiversity.</td>
<td>Careful site selection and integration of aquaculture into integrated coastal management plan which identifies ecologically sensitive sites. Maintain buffer areas around farm. Prior assessments of impacts.</td>
</tr>
<tr>
<td>3. Hazards to aquaculture from nearby pollution sources (e.g. agriculture, industry)</td>
<td>Water pollution from industry, agriculture affecting sustainability of aquaculture.</td>
<td>Careful site selection. Pre-treatment of water. Pressure from aquaculturists to reduce pollution from other sectors.</td>
</tr>
<tr>
<td>4. Typhoons, flooding, hurricanes</td>
<td>Damage to physical facilities and loss of fish stock.</td>
<td>Careful site selection. Pond design taking account of extreme climatic events (e.g. pond dyke height to prevent flooding). Buffer zones for wind breaks (e.g. mangroves).</td>
</tr>
<tr>
<td>5. Water quality</td>
<td>Water quality deterioration caused by self-pollution from aquaculture effluent</td>
<td>Careful site selection in relation to carrying capacity. Management practices and effluent controls. Strategic planning to keep number of farms within carrying capacity.</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7. Disease problems</td>
<td>Potential impacts caused by presence of serious pathogens/disease problems</td>
<td>Disease surveys of existing farms to assess risk. Introduction of risk management strategies to reduce risk.</td>
</tr>
<tr>
<td><strong>B. Farm design</strong></td>
<td><strong>B. Poor design can lead to a variety of environmental problems</strong></td>
<td><strong>B. Careful/appropriate design</strong></td>
</tr>
<tr>
<td>1. Attention to problems A (1) to A (7) above</td>
<td>As above.</td>
<td>As above.</td>
</tr>
<tr>
<td>2. Socio-economic impacts</td>
<td>Social inequities leading to social unrest</td>
<td>Participation of local people in aquaculture projects. Understand socio-economic conditions prior to project, and ensure developments do not negatively impact local people.</td>
</tr>
<tr>
<td>3. Interference with navigation, traditional users</td>
<td>Impacts on existing uses</td>
<td>Site farms in ways which do not impact traditional uses. On-shore infrastructure development in ways which roads, buildings do not cause environmental impact. Maintain buffer areas between farms and other uses.</td>
</tr>
<tr>
<td><strong>C. Farm construction</strong></td>
<td>Poor construction practices can lead to various environmental problems</td>
<td>C.</td>
</tr>
<tr>
<td>1. Siting</td>
<td>Impacts on benthos during construction and disturbance of wildlife</td>
<td>Maintain buffer areas. Ensure site disturbance is limited to immediate construction area.</td>
</tr>
<tr>
<td>2. Infrastructure development (access roads, boats)</td>
<td>As above</td>
<td>As above.</td>
</tr>
<tr>
<td>3. Labour, worker safety</td>
<td>Possible impacts on environment caused by labour force (e.g. noise, groundwater drawdown, sewage)</td>
<td>Provision of suitable infrastructure to support labour.</td>
</tr>
<tr>
<td><strong>D. Farm operation and management</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Solid waste disposal</td>
<td>Impacts on benthos, wildlife</td>
<td>Non-organic, solid waste materials should be disposed of safely. Culture site may be rotated to prevent extreme local impact, improve growing conditions, and allow for periodic recovery.</td>
</tr>
<tr>
<td>2. Waste water/effluent discharge</td>
<td>Impacts on local water quality and sediments</td>
<td>Efficient feeding practices (minimise use of trash fish). Site farms in areas with adequate tidal flow. Disposal of dead/diseased animals in sanitary manner on shore (e.g. bury in lime pits). Minimise leaks from water pumps, boat engines, generators etc Secondary aquaculture, e.g. of filter feeding molluscs, seaweeds in vicinity of cages.</td>
</tr>
<tr>
<td>4. Harvesting and post-harvest</td>
<td>Discharge of harvesting waste water causing water pollution</td>
<td>Harvesting techniques that capture wastes (blood, viscera etc).</td>
</tr>
</tbody>
</table>
Coastal mollusc culture

Check list of environmental impacts and mitigation strategies for sea-based extensive seaweed and mollusc aquaculture projects

<table>
<thead>
<tr>
<th>Actions affecting environmental resources and values</th>
<th>Potential environmental impacts</th>
<th>Potential mitigation strategies for negative environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Site selection</strong></td>
<td><strong>A. Appropriate site selection</strong></td>
<td></td>
</tr>
<tr>
<td>1. Conflicts with other site users and interference in livelihoods of local communities</td>
<td>Social conflicts</td>
<td>Appropriate regional water use planning Consultation process Participation of local people in aquaculture projects Resettlements/compensation agreements Involve local resource users in aquaculture</td>
</tr>
<tr>
<td>2. Selection of ecologically sensitive site</td>
<td>Potential impacts on biodiversity (e.g. corals or seaweed).</td>
<td>Careful site selection and integration of aquaculture into integrated coastal management Management plan which identifies ecologically sensitive sites Habitat restoration, e.g. seaweed culture suitable on degraded coral reef areas. Maintain buffer areas around farm Prior assessments of impacts</td>
</tr>
<tr>
<td>3. Hazards to aquaculture from nearby pollution sources (e.g. agriculture, industry)</td>
<td>Water pollution from industry, agriculture affecting sustainability of aquaculture.</td>
<td>Careful site selection. Pressure from aquaculturists to reduce pollution from other sectors.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4. Typhoons, hurricanes, storm damage</td>
<td>Damage to physical facilities and loss of stock (an important problem for sea-based aquaculture).</td>
<td>Careful site selection. Farm design, taking account of extreme climatic events.</td>
</tr>
<tr>
<td>5. Water quality</td>
<td>Water quality and benthic changes caused by aquaculture.</td>
<td>Careful site selection in relation to carrying capacity. Management practices: Strategic planning to keep number of farms within carrying capacity. Extensive seaweed and mollusc farms are net removers of nutrients from coastal systems and can contribute to water quality improvement.</td>
</tr>
</tbody>
</table>

**B. Farm design**  
**B. Poor design can lead to a variety of environmental problems**  
**B. Careful/appropriate design**

<table>
<thead>
<tr>
<th>1. Attention to problems A (1) to A(6) above</th>
<th>As above.</th>
<th>As above.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Socio-economic impacts</td>
<td>Social inequities leading to social unrest.</td>
<td>Participation of local people in aquaculture projects. Understand socio-economic conditions prior to project, and ensure developments do not negatively impact local people. Low cost, extensive aquaculture potentially appropriate for artisanal fishers.</td>
</tr>
<tr>
<td>3. Infrastructure development</td>
<td>Structures (e.g. guard house, worker accommodation) may lead to negative impacts on habitat.</td>
<td>Appropriate siting of structures.</td>
</tr>
</tbody>
</table>

**C. Farm construction**  
**Poor construction practices can lead to various environmental problems**  
**C.**

| 1. Site clearance | Damage to corals and existing habitat. Water quality problems during construction. | Ensure site disturbance is limited to immediate area. Do not site farms on high value corals. Regulatory requirements should be followed during clearance. |
| 2. Infrastructure development (guard houses, accommodation, processing areas) | As above. | As above. |
| 3. Labour, worker safety | Possible impacts on environment caused by labour force (e.g. noise, sewage, walking on reef flats). | Provision of suitable infrastructure to support labour. Limiting movements as far as possible to the construction site. |

**D. Farm operation and management**

<p>| 1. Solid waste disposal | Impacts on benthos and coral habitats. | Non-organic, solid waste materials should be disposed of safely on-shore. Careful disposal of fouling organisms from mollusca/farm structures. Rotation of farm locations to avoid accumulation in specific areas. |
| 2. Waste water/effluent discharge | No impacts from seaweed culture. Particulates may settle below mollusc farms. | Polyculture (mollusc, fish) can be promoted to improve productivity of water column. Site rotation. Keeping within carrying capacity. |
| 3. Harvesting | | |</p>
<table>
<thead>
<tr>
<th>4. Use of chemicals</th>
<th>Minimal use in seaweed culture and mollusc culture.</th>
<th>Use of approved chemicals according to standard practices (including antifouling agents on structures). Education of workers in safe use/handling of chemicals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Seed collection/supply</td>
<td>Introduction of exotic species can lead to negative impacts on biodiversity.</td>
<td></td>
</tr>
<tr>
<td>7. Operational failures</td>
<td>Sudden impacts caused by storm damage</td>
<td>Siting in areas not prone to storm damage.</td>
</tr>
<tr>
<td>8. Labour force</td>
<td>Impacts on water quality and habitats due to increased population.</td>
<td>Provision of sanitary conditions for workers. Environmental awareness training for workers</td>
</tr>
</tbody>
</table>
Appendix 6: Nutrient loads from aquaculture operations

Release of Nutrients from Aquaculture to Environment

If the nutrient composition of both feed and culture product is known, and food conversion is known or can be estimated, then the release of nutrients to the environment can be calculated quite simply (Box A6.1). Table A6.1 gives a range of figures calculated in this way for intensive shrimp farming in Thailand using a typical commercial pelleted feed.

It is also important to understand the fate of the nutrients released in both space and time. They may remain within the farm system, be deposited in sediments, or enter the wider environment in solution or as fine particles. The quantities may vary greatly over the production cycle, and this can be used to improve the effectiveness of environmental management measures. The following provides a brief overview of what is known about these issues.

Box A6.1. Example calculation of nutrient loading from intensive aquaculture

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P content of trash fish</td>
<td>0.5%</td>
</tr>
<tr>
<td>P content of fish produced</td>
<td>0.3%</td>
</tr>
<tr>
<td>N content of trash fish</td>
<td>1.0%</td>
</tr>
<tr>
<td>N content of fish produced</td>
<td>1.2%</td>
</tr>
<tr>
<td>(all wet weight)</td>
<td></td>
</tr>
<tr>
<td>food conversion ratio</td>
<td>6:1</td>
</tr>
</tbody>
</table>

then per tonne of fish produced:

P in fish produced = 0.003*1000 = 3kg
P in food given = 0.008*6*1000 = 30kg
P released to environment = 30-3 = 27kg

N in fish produced = 0.012*1000 = 12kg
N in food given = 0.01*6*1000 = 60kg
N released to environment = 60-12 = 48kg

Note that these figures should be adapted according to particular species, and food conversion.

Table A6.1 Nitrogen, phosphorus and organic solids (kg) produced per tonne of shrimp in intensive production systems.

<table>
<thead>
<tr>
<th>FCR</th>
<th>Organic matter</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>500</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>1.5</td>
<td>875</td>
<td>56</td>
<td>21</td>
</tr>
<tr>
<td>2.0</td>
<td>1250</td>
<td>87</td>
<td>28</td>
</tr>
<tr>
<td>2.5</td>
<td>1625</td>
<td>117</td>
<td>38</td>
</tr>
</tbody>
</table>

Pond Culture

Significant quantities of nutrients and chemicals are released to environment from pond aquaculture, though generally at relatively low concentrations. The quantity and quality of these releases are very variable between species and culture systems. Dissolved material from farm effluent enters the water column and may be widely distributed. Solid wastes on the other hand accumulate mainly in the pond bottom, or in the immediate vicinity of the farm. More nitrogen is released to the water column than phosphorus, most of which accumulated into the sediment. The typical fate of nutrients applied in an intensive shrimp pond is shown in the Figure A6.1. However, the application of different management practices will affect significantly the proportion of wastes which end up in sediments, water column and wider environment.
Aquaculture effluent may also carry bacteria or disease carrying microorganisms. These are rarely harmful to humans, though they may represent a threat to other farmers or wild fish.

Various studies have shown that the amount and concentration of effluent from aquaculture is far below that of many other domestic, agricultural and industrial sources. The quality of shrimp pond effluent is compared with domestic sewage in the Table A6.2. Standard domestic wastewater treatment is reasonably effective at removing solids and BOD but less efficient at removing N and P. Even after secondary treatment, domestic effluent is of significantly lower quality than that from intensive aquaculture except in respect of solids. (Beveridge et al., 1997).

**Figure A6.1. Fate of nutrients from 1 ha semi-intensive and intensive shrimp culture ponds.**

<table>
<thead>
<tr>
<th>Semi-intensive</th>
<th>Discharge</th>
<th>1.04</th>
<th>0.04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sediment</td>
<td>0.93</td>
<td>0.38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intensive</th>
<th>Discharge</th>
<th>25.28</th>
<th>5.48</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sediment</td>
<td>11.87</td>
<td>4.90</td>
</tr>
</tbody>
</table>

Keys: N- normal font; and P- italic. Open figures are in MT ha⁻¹ yr⁻¹. Figures in parenthesis and arrows indicate percentage.

**Source:** Briggs and Funge-Smith, 1994; Muthuwan, 1991; Satapornvit, 1993.

**Cage Culture**

While much information relating to nutrient release, distribution and assimilation is available for temperate fin-fish culture, that relating to tropical and sub-tropical environments is scarce. While the quantity of nutrients released, and their physical, chemical and biological characteristics are likely to be similar in these different zones, the nutrient assimilation capacity is much higher in tropics. Angel et al., (1995,1996) suggested that the capacity of sediments to absorb organic matter may be 3-4 times higher in warm than in temperate water.
Table A6.2. Characteristics of shrimp ponds effluent in comparison with domestic sewage (mg l⁻¹)

<table>
<thead>
<tr>
<th>Effluent characteristics (mg l⁻¹)</th>
<th>shrimp pond effluent</th>
<th>Domestic water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Untreated</td>
<td>Primary treatment</td>
</tr>
<tr>
<td>BOD₅</td>
<td>4.0-10.2</td>
<td>200</td>
</tr>
<tr>
<td>Total N</td>
<td>0.03-3.4</td>
<td>75</td>
</tr>
<tr>
<td>Total P</td>
<td>0.01-2.0</td>
<td>20</td>
</tr>
<tr>
<td>Solids</td>
<td>30-225</td>
<td>500</td>
</tr>
</tbody>
</table>

Adapted from Beveridge et al., 1997

A typical nutrient budget for finfish cage culture is presented in Figure A6.2. 80% of the food provided may be released to the environment in one form or another.

The effect of solids released from finfish cage culture includes a reduction in redox potential, increase in sedimentary C and N, and increase in H₂S, CH₄, and BOD₅ in the sediment. Major changes occur in the community structure of benthic fauna beneath the cages or rafts (Tsurumi, 1995). With the increase of pollutants, faunal dominance commonly changes from mollusks to polychaetes. Organic enrichment from marine cage-pan culture may contribute to the development of infectious disease, as deteriorated environment weakens the immune systems of the confined fish (Kusuda, 1990).

**Box A6.2. An example of carbon loading from tropical cage culture**

Estimated the flux of particulate matter released from fish cages:
- 4.5 g C m⁻² d⁻¹
- Area (approx.) 17000 m² under the fish farm.

*Source: Angel et al., 1996*

**Box A6.3. Organic matter loading from mussel and oyster culture**

- An individual mussel may produce 5.7 mg organic matter per day
- A typical oyster rack with 420,000 oysters can generate 16 t of faecal and pseudofaeces material during a nine month culture period

*Source: Dankers and Zuidema, 1995*

**Raft or Rack Culture of molluscs**

Additional food is not provided in mussel, scallop, or oyster culture, and since they feed on plankton and detritus, they operate as natural biofilters, resulting in a net overall reduction of nutrients in the water. However, if grown in dense culture, they concentrate nutrients through the production of faeces and pseudofaeces, and the release of ammonia and other dissolved metabolic products. This may cause local enrichment. Deposited organic matter from mollusc farms stimulates microbial activity, thus increasing BOD₅, sulfate reduction and denitrification (Nunes and Parsons, 1998). The release of ammonia may result in downstream plankton blooms. As with almost all forms of agriculture and aquaculture molluscs are 10-20% efficient at converting nutrients, implying 80-90% nutrient “regeneration”.

166
Figure A6.2 Estimated average flux of nutrients in a fish cage.

Source: Nunes and Parsons 1998

**Assimilation of Nutrients**

**Molluscs**

Culture of molluscs may help in removal of organic matter, while also serving as an important food source for a range of organisms, either directly, or indirectly by providing shelter and creating space for associated organisms. However, most of the organic matter filtered by mussels is deposited as pseudofaeces (see above). Figure A6.3 shows the mass balance of phytoplankton and detritus filter feeding by mollusks.

A problem with the high nutrient assimilation capacity of molluscs is the human health concern associated with accumulation of pathogens or toxic substances (Csavas, 1993).

**Seaweeds**

Seaweeds are net nutrient removers from aquatic ecosystems. Seaweed can also absorb nutrients that can not be absorbed by molluscs (Chandhrkrachang et al., 1991). The main problem associated with seaweed farming is the probability of heavy metal and industrial discharge accumulation (FAO/NACA, 1995).

Figure A6.3 Mass balance of phytoplankton and detritus filter feeding by mussel.

Source: Dankers and Zuidema, 1995
### Additional information

Table A6.3. Food, faecal and urinary wastes.

<table>
<thead>
<tr>
<th>Type</th>
<th>Feed</th>
<th>Faecal</th>
<th>Urinary</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmon cage farm</td>
<td>5-10%</td>
<td>230-400g/ kg food</td>
<td></td>
<td>Juell, 1991</td>
</tr>
<tr>
<td>Fish and crustaceans</td>
<td></td>
<td></td>
<td>60% of TKN to the environment</td>
<td>Beveridge et al., 1991</td>
</tr>
<tr>
<td>Do</td>
<td></td>
<td></td>
<td></td>
<td>Barg, 1992</td>
</tr>
</tbody>
</table>

Table A6.4. Nutrient budget in semi-intensive and intensive 1 ha shrimp ponds, Thailand.

<table>
<thead>
<tr>
<th></th>
<th>Semi-intensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production/ha/year (MT)</td>
<td>1.0</td>
<td>9.0</td>
</tr>
<tr>
<td>FCR</td>
<td>1.4:1</td>
<td>2:1</td>
</tr>
<tr>
<td>Nutrient input in production (t/yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2.98</td>
<td>38.3</td>
</tr>
<tr>
<td>P</td>
<td>0.45</td>
<td>5.83</td>
</tr>
<tr>
<td>Nutrient removal in harvest (t/yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2.66</td>
<td>23.99</td>
</tr>
<tr>
<td>P</td>
<td>0.18</td>
<td>1.59</td>
</tr>
<tr>
<td>Waste loading (kg/yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>29</td>
<td>1434</td>
</tr>
<tr>
<td>P</td>
<td>27</td>
<td>124</td>
</tr>
<tr>
<td>Waste loading (kg/t shrimp harvest/yr.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>9.7</td>
<td>53.1</td>
</tr>
<tr>
<td>P</td>
<td>9.0</td>
<td>15.7</td>
</tr>
<tr>
<td>Waste loading (kg/ha shrimp harvest/yr.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>275.5 (discharge)45%</td>
<td>275.5 (discharge)45%</td>
</tr>
<tr>
<td></td>
<td>161.3 (sediment)26%</td>
<td>161.3 (sediment)26%</td>
</tr>
<tr>
<td></td>
<td>66.4 (12%)</td>
<td>66.4 (12%)</td>
</tr>
<tr>
<td></td>
<td>237 (37%)</td>
<td>237 (37%)</td>
</tr>
<tr>
<td></td>
<td>285 (35%)</td>
<td>285 (35%)</td>
</tr>
<tr>
<td></td>
<td>245 (31%)</td>
<td>245 (31%)</td>
</tr>
<tr>
<td></td>
<td>Satapornvit, 1993</td>
<td>Satapornvit, 1993</td>
</tr>
<tr>
<td></td>
<td>Briggs and Fung-Smith, 1994</td>
<td>Briggs and Fung-Smith, 1994</td>
</tr>
<tr>
<td>P</td>
<td>50 (discharge)26%</td>
<td>50 (discharge)26%</td>
</tr>
<tr>
<td></td>
<td>45 (sediment)24%</td>
<td>45 (sediment)24%</td>
</tr>
<tr>
<td></td>
<td>13 (14%)</td>
<td>13 (14%)</td>
</tr>
<tr>
<td></td>
<td>38 (36%)</td>
<td>38 (36%)</td>
</tr>
<tr>
<td></td>
<td>29 (10%)</td>
<td>29 (10%)</td>
</tr>
<tr>
<td></td>
<td>243 (84%)</td>
<td>243 (84%)</td>
</tr>
<tr>
<td></td>
<td>Satapornvit, 1993</td>
<td>Satapornvit, 1993</td>
</tr>
<tr>
<td></td>
<td>Briggs and Fung-Smith, 1994</td>
<td>Briggs and Fung-Smith, 1994</td>
</tr>
</tbody>
</table>
References and further reading


Appendix 7:
Calculating nutrient concentrations in receiving waters

Case studies and worked examples
1. Assessment of impacts of nutrients from an intensive shrimp pond on water quality in a coastal lagoon.
2. Assessment of impacts of nutrients from an intensive shrimp farm on estuary water quality
3. Assessment of impacts of nutrients and suspended solids from tropical marine fin-fish cage culture

Assessment of impacts of nutrients from an intensive shrimp pond on water quality in a coastal lagoon.

An intensive shrimp (Penaeus monodon) farm using 16 ponds (2500 m² each) is proposed for construction in the supratidal area of a coastal region adjacent to a 150ha coastal lagoon. The total pond area will occupy about 4.5 ha with additional land use for infrastructure (approx. 15% of the pond area). The units are to be constructed above sea level and water supplied by pumping from a sea-water intake located 60 m offshore. Effluents are returned to the lagoon via run-off canals where they disperse along the shore. Daily water exchange is by partial draining and refilling with pumped sea-water at 5-10% of total volume early in the production cycle, increasing to between 25 and 30% by the end of the four month production period.

Nutrient loads.
Total planned shrimp production is approximately 40 t y⁻¹ derived from 2 production cycles per year with an average output of about 5 t ha⁻¹ cycle⁻¹. Feeds used amount to 10 t ha⁻¹ cycle⁻¹. Total nutrient loadings can be estimated from figures on shrimp production and feed input.

Shrimp feed is estimated as 76.0 g N/kg and 14.2 g P/kg
Harvested shrimp is estimated as 33.9 g N/kg and 4.0 g P/kg.

With a Food Conversion ration (FCR) of 2:1, these figures imply a total waste load of 118.1 kg N/tonne of shrimp production and 24.4 kg P/tonne of shrimp production.

Estimates of the fate of nitrogen and phosphorus in shrimp ponds suggest that around 85% of the phosphorus and around 50% of the nitrogen will be lost to the sediments (or lost from the ponds as nitrogen gas in the case of nitrogen). The remaining amount will be discharged from the ponds as effluent.

Based on these figures, the farm discharges around 2362 kg N (40*118.1*0.5) and 146.4 kg P (40*24.4*0.85) per year.
Note that the figures would be higher if the farm was to flush pond bottom sediment into the lagoon. However, the farm plans to dispose of dry pond bottom sediments away from waterways on nearby disused land thus reducing total nutrient and organic loads.

**Hydrology of the lagoon.**

The shrimp farm water supply and discharge point is a coastal lagoon. The lagoon covers a surface area of 150 ha and has a mean depth of 6 m at the high tide mark. There are two small freshwater streams that discharge small amounts of freshwater into the lagoon, but overall amounts are small. The tidal amplitude is 1.5 m with two exchanges of water per day. The lagoon water appears to be well mixed, and based on these figures the water exchange rate can be calculated as once per two days.

**Lagoon ecology**

The lagoon is an important fish nursery area with extensive seagrass beds. The water is clear and water quality surveys during the rainy and dry seasons have shown that nutrient levels are low. There are also extensive coral reef flats just outside of the lagoon, and the local environmental authority are concerned that the nutrients discharged from the shrimp farm should not negatively impact on water quality.

No environmental quality standards (EQS) have been set for the lagoon, but a literature review indicates tentative seagrass standards as follows:

(a) no increase in suspended solids;
(b) light levels should not normally fall below 10% of surface levels at 2 m; and
(c) mean total N not to exceed 500 ug/l.

Tentative EQS for coral reef habitats in other regions are that ambient nitrogen and phosphorus concentrations should not change by more than 5% of pre-development ambient concentrations.

Nutrient analyses carried out in four scoping surveys indicate mean nutrient levels of 25 ug/l total phosphorus and 150 ug/l total nitrogen in the lagoon water.

**Impacts on nitrogen and phosphorus levels in the lagoon.**

The assessment examines the effect of the farm on nitrogen and phosphorus levels in the lagoon using the following equation:

\[
\Delta P = \frac{P_d}{V \times T_w}
\]

Where:
- \( \Delta P \) = Predicted increase in nutrient concentration (mg/m³)
- \( P_d \) = Daily nutrient load from the shrimp farm (mg/day)
- \( T_w \) = Water exchange (times/day = reciprocal of flushing rate)
- \( V \) = Volume of lagoon at high tide (m³)

(i) Calculations estimating the increase in total nitrogen in the lagoon water are as follows:

- \( P_d \) = \( 2362 \times 10^4 \) mg N/ \( 365 \) = \( 6.47 \times 10^6 \) mg N/day
- \( T_w \) = 0.5
- \( V \) = \( 150 \times 10,000 \times 6 \) m³\(^2\) = \( 9 \times 10^6 \) m³

Therefore, \( \Delta P \) = 1.44 mg N/m³ (or 1.44 ug/l)
(ii) Calculations estimating the increase in total phosphorus in the lagoon water are as follows:

\[
\begin{align*}
P_b &= 146.4 \times 10^6 \text{ mg N/365} = 0.40 \times 10^6 \text{ mg N/day} \\
T_w &= 0.5 \\
V &= 150 \times 10,000 \times 6 \text{ m}^3 = 9 \times 10^6 \text{ m}^3 \\
\text{Therefore, } \Delta P &= 0.09 \text{ mg/m}^3 \text{ (or 0.09 mg/l)}
\end{align*}
\]

Compared to ambient levels, these calculations predict a change in mean nutrient levels of less than 0.5% in total phosphorus and 1.0% in total nitrogen. The calculations therefore suggest the proposed shrimp farm development will not cause significant impacts on nutrient concentrations within the lagoon, or adjacent coral habitats.

**Related issues**

Based on the tentative environmental quality standards (QS) for seagrass beds noted above, which raises concern over impacts of sedimentation on seagrass beds, the regulatory authority requests the shrimp farm to install a settlement pond to trap suspended solids during shrimp harvesting, and places a ban on flushing of pond sediments to the environment. Pond sediments are required to be removed from the pond after drying after harvest, and disposed of on dry land away from local waterways. The farm locates a suitable area of disused land for safe disposal of this pond sediment. It also introduces plastic liners on the pond walls to minimise erosion of earthen pond walls during shrimp grow-out operations.

**Recommended monitoring programme**

Based on the above, the regulatory authority requests the farm to undertake a water quality monitoring program in the lagoon. The water quality monitoring will include suspended solids, water turbidity and nutrient concentrations to be carried out initially four times per year.

Seagrass beds could be stratified into areas of high, medium and low probability of impact based on proximity to the discharge point. In annual sampling surveys, random sites should be selected within each stratum. Photographs of seagrass should be taken at the time of monitoring, and qualitative diver observations of site conditions and faunal abundance should be recorded.

Two years after the farm has reached maximum production, the scale of the monitoring programme should be assessed.

**Assessment of impacts of nutrients from an intensive shrimp farm on estuary water quality**


A medium scale shrimp farm, consisting of 40 ponds each of 4 hectares is planned to be built on the landward fringe of mangrove adjoining a medium sized river estuary. The estuary is important to local artisanal fishers, and is also a source of wild shrimp seed which will be used for the farm during the startup phase and before a proposed hatchery comes on line. The mangrove adjacent to the estuary is an important source of firewood, poles, and shellfish for poor local people.

**Water source and discharge**

A tidal creek, south of the main river outfall, will be the primary source of seawater. A canal of 2 to 2.5
km in length will be constructed from near the head of the creek to the seaward end of the farm site. The creek contains water of nearly full seawater concentration (approximately 35ppt). An inlet canal for river water, intended to dilute the seawater to optimal working salinity during the dry season, will be constructed by deepening the bed of an existing creek, which presently contributes to draining part of the farm area’s upper reaches into the river.

Pond effluent will be discharged to the river through a channel similar to the one made for intake of river water, except that the outfall channel will enter the river about 1 km downstream of the intake channel. The outfall is several km from the river mouth through several meandering loops. The river flow varies seasonally, with monthly means typically ranging from 3 - 41 cubic meters per second in the dry and wet seasons respectively.

The discharge plan remains to be finalized pending technical consultation to be engaged by the farm, and consideration of issues discussed below.

**Calculation of loadings, effluent concentrations and impact on river salinity**

The feasibility study and project description provided little information on pond water management (such as water exchange rate). This varies widely between different countries and indeed farms, and has a major effect on the nature and concentration of the effluents discharged. Reduced water exchange results in lower quantities of effluent carrying higher nutrient concentrations, and greater retention of nutrients in pond sediments. Intensive farms in Thailand have greatly reduced their water exchange rates in recent years.

A simple spreadsheet was created to make estimates of nutrient and salinity dilution in the receiving water based on a range of assumptions about water turnover rate and other parameters. In addition, the area of mangrove required to assimilate nutrients was calculated using the assimilation estimates presented in Appendix 6 and 8. It was assumed that mixing of the effluent with the river water was simple and complete – in other words no attempt was made to model the effluent plume and its dispersion in the river, since impacts were not expected to be severe. A summary of the spreadsheet assumptions, and sample output is presented below.

<table>
<thead>
<tr>
<th>1. Production parameters and other standard assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>area (ha)</td>
</tr>
<tr>
<td>Stocking rate Post-larvae (PL)/ha</td>
</tr>
<tr>
<td>survival %</td>
</tr>
<tr>
<td>harvest weight (g)</td>
</tr>
<tr>
<td>crops per year</td>
</tr>
<tr>
<td>Food conversion ratio</td>
</tr>
<tr>
<td>N content feed</td>
</tr>
<tr>
<td>N content shrimp</td>
</tr>
<tr>
<td>P content feed</td>
</tr>
<tr>
<td>P content shrimp</td>
</tr>
<tr>
<td>Dry season river flow (m³/sec)</td>
</tr>
<tr>
<td>Wet season river flow (m³/sec)</td>
</tr>
<tr>
<td>Pond effluent salinity</td>
</tr>
<tr>
<td>river salinity</td>
</tr>
<tr>
<td>Nitrogen assimilation capacity of mangrove (t/ha/yr)</td>
</tr>
<tr>
<td>Phosphorus assimilation capacity of mangrove (t/ha/yr)</td>
</tr>
</tbody>
</table>
2. Calculated nutrient production (see box A4.1 for sample calculation)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Typical</th>
<th>Semi-closed</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>annual production (t)</td>
<td>415</td>
<td></td>
<td></td>
</tr>
<tr>
<td>food requirement (t)</td>
<td>664</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total N waste (t)</td>
<td>34.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total P waste (t)</td>
<td>5.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Estimated effluent concentration of nitrogen and phosphorus under different water management regimes

(assumptions normal font, calculated values in italics)

<table>
<thead>
<tr>
<th>Management system</th>
<th>Typical</th>
<th>Semi-closed</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>proportion of N in effluent</td>
<td>23%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>proportion of P in effluent</td>
<td>65%</td>
<td>30%</td>
<td>10%</td>
</tr>
<tr>
<td>N released in effluent</td>
<td>7.82</td>
<td>5.10</td>
<td>3.40</td>
</tr>
<tr>
<td>P released in effluent</td>
<td>3.77</td>
<td>1.74</td>
<td>0.58</td>
</tr>
<tr>
<td>water depth (m)</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>water turnover rate per day</td>
<td>12%</td>
<td>6%</td>
<td>1%</td>
</tr>
<tr>
<td>pond utilization</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Total volume of effluent (m³)</td>
<td>62,791,680</td>
<td>31,395,840</td>
<td>5,232,640</td>
</tr>
<tr>
<td>N concentration (mg/l)</td>
<td>0.12</td>
<td>0.16</td>
<td>0.65</td>
</tr>
<tr>
<td>P concentration (mg/l)</td>
<td>0.06</td>
<td>0.06</td>
<td>0.11</td>
</tr>
</tbody>
</table>

4. Estimated area of mangrove required to assimilate nutrients

<table>
<thead>
<tr>
<th>Management system</th>
<th>Typical</th>
<th>Semi-closed</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>area of mangrove to assimilate N</td>
<td>35.72</td>
<td>23.29</td>
<td>15.53</td>
</tr>
<tr>
<td>area of mangrove to assimilate P</td>
<td>188.70</td>
<td>87.09</td>
<td>29.03</td>
</tr>
</tbody>
</table>

5. Estimated average nutrient concentration (mg/l) in river water

<table>
<thead>
<tr>
<th>Management system</th>
<th>Typical</th>
<th>Semi-closed</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>N dry season</td>
<td>0.083</td>
<td>0.054</td>
<td>0.036</td>
</tr>
<tr>
<td>P dry season</td>
<td>0.040</td>
<td>0.018</td>
<td>0.006</td>
</tr>
<tr>
<td>N wet season</td>
<td>0.006</td>
<td>0.004</td>
<td>0.003</td>
</tr>
<tr>
<td>P wet season</td>
<td>0.003</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>

6. Impact on river salinity (ppt)

<table>
<thead>
<tr>
<th>Management system</th>
<th>Typical</th>
<th>Semi-closed</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td>dry season</td>
<td>20</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>wet season</td>
<td>6</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

It was concluded that the most significant impact was the effect on salinity in the river in the dry season, and that this would warrant further investigation in terms of possible local ecological impacts. Use of closed or semi-closed system minimized this impact.
Note

*A typical or traditional water regime* involves relatively high rates of water exchange throughout the cycle to maintain optimal water quality.

*Semi closed systems* use significantly less water exchange – usually only as required, and mainly toward the end of the production cycle when larger quantities of food are being added, and the total stocking rate is high. The reduced water turnover is compensated using more intensive and carefully timed aeration.

*Closed systems* also use a reduced water turnover regime, but in addition, settle and sometimes treat (with for example chlorine) the effluent water before returning to a reservoir for re-use.
Appendix 8: Environmental capacity

Introduction

Conditions for achieving environmental sustainability include “holding waste emissions within the assimilative capacity of the environment without impairing it”. Environmental capacity models have been used to attempt to translate these concepts into practical siting and management guidelines for coastal aquaculture.

There are four components to environmental capacity relevant to aquaculture operations:

- the dispersal and dilution of nutrients in the receiving water;
- the assimilation of these nutrients in the water column or sediments;
- the effects that the absolute concentrations of nutrients, and their assimilation, have on resources or ecosystem integrity and functioning; and
- environmental quality standards – which may be based on nutrient concentrations themselves; or the wider physical and ecological impacts of these concentrations.

A practical definition of environmental capacity could therefore be:

*the total nutrient loading (or removal) which can be sustained in a particular defined area without leading to the breach of environmental quality standards.*

In practice this may refer to the rate at which nutrients are added without triggering eutrophication; the rate of organic flux to the benthos without major disruption to natural benthic processes; or the rate of dissolved oxygen depletion that can be accommodated without mortality of the indigenous biota” (GESAMP, 1996a). The use of environmental capacity and methods of application are discussed in detail by GESAMP, 1986 and by Barg, 1992.

It is important to distinguish this approach from those based on some assumed relationship between aquaculture production (measured for example in mt/yr for a particular area, or mt/yr/km of coast) and environmental quality. Beveridge, 1996 for example defined environmental capacity in relation to aquaculture as *aquaculture production that can be sustained by an environment within certain defined criteria.* These are more properly understood as “aquaculture carrying capacity” estimates, and imply a fixed relationship between nutrient production and aquaculture production rate. However, as shown in Appendix 6, relatively simple changes in management practice can dramatically change this relationship. It is therefore preferable to work with loadings (which can in any case be easily assessed) rather than production rate.

Factors likely to affect assimilative capacity

Some of the factors that might affect the assimilative capacity of coastal environments for shrimp culture, and which show the complexity of such analyses in multiple use coastal systems, are shown in Table A8.1.
Sector considerations

There is little point in examining environmental capacity in relation to aquaculture in isolation. Aquaculture is just one contributor (and in most cases a minor contributor) to nutrient and sediment loadings in estuaries, lagoons, and bays. Ideally environmental capacity estimates should be undertaken as part of a higher level integrated coastal or watershed management initiative, so that any incentives or controls can be applied to the sector(s) where they are likely to be most cost effective.

Such an approach is called for in so called Integrated Environmental Impact Assessments, which consider the absorption capacity of the whole coastal resource system, including all the various economic development activities. In the long term such approaches may be more cost-effective and more acceptable to all concerned.

Table A8.1. Some factors to be considered in determining the environmental capacity of coastal environments.

<table>
<thead>
<tr>
<th>Important Factors</th>
<th>Environmental Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>culture method/system</td>
<td>• management/system design influence amount of effluent reaching receiving water body;</td>
</tr>
<tr>
<td></td>
<td>• increased effluent load with intensification.</td>
</tr>
<tr>
<td>pond or cage area</td>
<td>• increased pond or cage area can lead to greater water use and increased effluent load;</td>
</tr>
<tr>
<td></td>
<td>• where ponds or cages cover a large area, then possible changes in local water quality, and absorptive capacity of local environment may occur.</td>
</tr>
<tr>
<td>water exchange in receiving waters</td>
<td>• increased water exchange leads to better flushing of pond effluent and increasing assimilative capacity.</td>
</tr>
<tr>
<td>Presence of conflicting water ‘users’</td>
<td>• pollution from industry, agriculture, domestic sources reduces assimilative capacity of water body, leaving lower capacity for aquaculture.</td>
</tr>
<tr>
<td>Sensitivity of water body to effluent input</td>
<td>• coastal water bodies differ in their sensitivity to environmental change (related to ecological conditions) ➤ <em>e.g.</em> areas with coral reef can be particularly sensitive to nutrient inputs, hence have lower assimilative capacity.</td>
</tr>
<tr>
<td>Environmental variability/interactions</td>
<td>• predictions of carrying capacity become more difficult in ‘open’ versus ‘closed’ environments.</td>
</tr>
<tr>
<td>Adjacent natural habitat type</td>
<td>• the prevailing habitat may affect the capacity of the environment to accept nutrients and organic material from ponds, ➤ <em>e.g.</em> mangroves have excellent nutrient and organic material trapping capability,</td>
</tr>
<tr>
<td></td>
<td>• changes in habitat type can change assimilative capacity.</td>
</tr>
</tbody>
</table>

(Adapted from Phillips, 1994)

However, the difficulty and complexity of these approaches, as indicated in Table A8.1, should not be underestimated, and considerable resources will be required to make realistic assessments.
Adaptation and management

In practice, even with the best science, the assessment of environmental capacity in coastal waters is extremely difficult. Preliminary working assessments should therefore be made, discharges, impacts and ecological conditions monitored, and assessments adapted and refined in the light of experience.

Estimation of carrying capacity

There are three main steps involved in the estimation of environmental capacity:

- Define environmental quality standards (EQS) - in terms of nutrient concentrations, physical or ecological state (environmental variables);
- Measure the current status of these variables; and
- Assess the total loading (or removal) required to change from the current state to the EQS.

The last of these requires an understanding of dilution/dispersion of nutrients from aquaculture, and also the assimilation of these nutrients in the sediments and the water column.

Dilution and Dispersion

Simple dilution in lagoons or rivers has already been dealt with in Appendix 5. More complex models of waste dispersion and dilution in the marine environment are widely used in relation to pollution from heavy industry, and have been applied to marine aquaculture in North America and Europe. They required detailed knowledge of water movement in terms of direction and velocity around the farm site. Coupled with knowledge of settling velocity and depth, the dispersion of solids and the dispersion and dilution of nutrients can be calculated. In practice this requires a large number of simple calculations and is normally done using computer software. These range from relatively simple packages (for example developed by Stirling Institute of Aquaculture) to highly sophisticated packages (for example those produced by the Danish Hydraulics Institute).

In practice the measuring of water movement can be very expensive, and rough estimates are usually more appropriate for assessing the impacts of aquaculture development. For example, it has been found that the bulk of fish farm sediments settle relatively close to the cages (within 50m even where currents are significant) while the rest is widely dispersed and has little direct impact. Soluble nutrient will be widely dispersed in most coastal environments, and rough estimates of overall dilution based on tidal exchange and overall water turnover should be adequate in most cases.

Assimilation by sediments

Measurements of organic matter decomposition in sediments under fish cages in the Gulf of Aqaba suggested that the capacity of sediments to absorb organic matter loadings may be 3-4 times greater in warm than in temperate waters (Angel et al., 1992). In practice acceptable loadings are likely to vary greatly according to local conditions and local water uses and environmental needs.

Assimilation in the water column and by other organisms

Mangroves

The buffering capacity of mangrove plays an important role in sustaining any coastal ecosystem. Robertson and Phillips, 1994 provided an estimate of the area of *Rhizophora* forest required per hectare of intensive or semi-intensive shrimp ponds to remove nitrogen and phosphorus from the pond effluent (Table 5). The requirement of mangrove area to remove phosphorus (21.7 ha) from the effluent of a 1 ha shrimp pond is
three times higher than that required to remove nitrogen (7.2 ha), which indicates low P assimilating capacity of Rhizophora mangrove forest.

**Box A8.1. Reported filtration rates and nutrient assimilation by molluscs**

- An individual mussel can filter between 2 and 5 litres of water per hour**
- A rope of mussels can filter more than 90,000 litres per day**
- Oyster may remove 94% of nitrogen and 48% of suspended solids**
- Green mussel can remove 68% of total nitrogen***
- Seaweed can remove 32% of N and 19% of P****

*Nunes and Parsons, 1996; **Ryther et al., 1995; ***Jones and Preston, 1996.

**Table A8.2. Estimates of Rhizophora mangrove forest area (ha) required to remove nitrogen and phosphorus loads produced during the operation of 1 ha of semi-intensive and intensive shrimp ponds.**

<table>
<thead>
<tr>
<th>Element from Effluent</th>
<th>Mangrove Forest Required (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Semi-intensive shrimp ponds</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>2.4</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>2.8</td>
</tr>
</tbody>
</table>

*Source: Robertson and Phillips, 1994*

**Plankton**

GESAMP, 1996 provides a hypothetical example of assessing the assimilation of nutrients by plankton in the water column. However, there are a range of difficulties with these estimates, and it is likely that rules of thumb (in terms of allowable increases in nutrient concentrations), adapted in the light of experience, will be more useful for the overall estimation of environmental capacity.

**General models**

General environmental capacity models combining several of the above elements have been developed, mainly in relation to temperate lakes or reservoirs (e.g. Beveridge, 1984). They have also been adapted for salmon culture. Though useful, they must be used with care and require further development.

**Sources and further reading**


Appendix 9: Characteristics of chemicals commonly used in coastal aquaculture

- Concerns over the use of chemicals
- Recommendations for governmental authorities
- Recommendations for the aquaculture industry
- Recommendations for the drug and chemical industry
- Recommendations for the scientific community

This Appendix is based on:


Concerns over the use of chemicals.
The primary environmental and human health issues associated with chemical use in coastal aquaculture are:

- Persistence in aquatic environments

Many aquaculture chemicals degrade rapidly in aquatic systems. For example, formalin, a widely used parasiticide and fungicide, has a half-life in water of 36 hours (Katz, 1989). Furazolidone, an antibacterial, has a half-life in sediments of less than one day (Samuelsen et al., 1991). The half-life of dichlorvos, a parasiticide, in seawater is in the range of 100-200 h, depending upon water pH (Samuelsen, 1987). Other chemicals may persist for many months, retaining their biocidal properties. Metal-based compounds, such as the organotin molluscicides and copper-based algacides are likely to be quite persistent in aquatic sediments, although precise data are lacking. Some antibacterials, notably oxytetracycline, oxolinic acid and flumequine, can be found in sediments at least 6 months following treatment (Weston, 1996). The persistence of chemical residues is highly dependent on the matrix and ambient environmental conditions. Very little is known about the environmental fate of many aquaculture drugs with available data being derived largely from temperate latitudes.

- Residues in non-cultured organisms

Use of pesticides, antibacterials and other therapeutants in coastal aquaculture has the potential to result in chemical residues appearing in wild fauna of the local environment. For example, uningested medicated feeds or faeces containing drug residues provide routes by which local fauna may ingest and incorporate medicants. Filter-feeding molluscs in down-current areas are particularly vulnerable to "secondary medication" from contaminated particulates. Such inadvertent chemical exposures and subsequent human consumption of aquacultural products theoretically can present hazards to human health although risks are probably extremely low in most coastal aquaculture situations.
• Toxicity to non-target species

Toxicological effects on non-target species may be associated with the use of chemical bath treatments, pesticides, disinfectants, or leaching of toxicants from antifouling chemicals employed in aquaculture. Among the pesticides that may have toxicological effects on the surrounding invertebrate fauna are the organophosphate ectoparasiticides, such as those employed in salmon culture. The use of carbaryl pesticides to eliminate burrowing shrimp from oyster beds in the north-western United States results in the unintended mortality of Dungeness crab, a commercially exploited species (WDF/WDOE, 1985).

• Stimulation of resistance

Since the first true antibacterial agents were introduced in the 1930s, users have been coping with the emergence of drug resistance among target organisms. As each new drug was developed, major successes in therapy were achieved but, within a few years, the first cases of drug resistant strains began to appear. In intensive aquaculture, antibacterial agents are used universally to treat bacterial disease and there is widespread prophylactic use. The most common routes of application are oral or by immersion. In both cases, significant quantities of antibacterial may reach the environment and lead to the selection of resistance. This has resulted in increased resistance both in obligate fish pathogens such as Aeromonas salmonicida and in the opportunistic pathogens such as Vibrio spp. and the motile aeromonads (Aoki et al., 1984; Zhao et al., 1992). It is theoretically possible for non-pathogenic bacteria in the marine environment to transfer resistance to human pathogens by plasmid transfer although it has been argued that such a scenario is unlikely (WHO, 1998).

• Effects on sediment biogeochemistry

The microbial communities of aquatic sediments degrade organic matter and recycle associated nutrients. Rates of oxygen consumption, ammonium and sulphide production in sediments are all highly dependent upon microbial activity. Accumulation of antibacterial residues in sediments has the potential to inhibit microbial activity and to reduce the rate of organic matter degradation. More studies are needed to assess such impacts.

• Nutrient enrichment

Fertilisers are often used in pond culture operations to increase primary productivity. If hypernutrified waters are discharged in the effluent, they could have similar effects in receiving waters, especially when the latter are nutrient limited. The nutrient input associated with the use of fertilisers could be additional to the contributions of feed in systems employing both feed and fertilisation. Whether these nutrient inputs are of significant ecological consequence depends on local conditions.

• Health of farm workers

There is potential for some chemical compounds used in coastal aquaculture to pose health risks to farm workers. Accordingly, proper training and the provision of adequate safety equipment is essential. Some chemicals, such as the organophosphates (dichlorvos and trichlorfon) and others that act as respiratory enzyme poisons (malachite green) must be handled with respect, especially in concentrated form. Rotenone in powder form is toxic by inhalation and may cause respiratory paralysis. If proper health and safety precautions for handling aquacultural compounds presenting significant health risk to humans are enforced, operator risk will be minimised.
• Residues in seafood

Perceptions regarding the hazards of chemical residues in aquacultural products are an increasing source of anxiety among consumers. Although most areas of aquaculture, particularly those which employ extensive production methods, use few or no chemicals that could give rise to persistent residues in the flesh of the products, these perceptions unfortunately affect the entire industry. Increasingly, developed countries are imposing restrictions on compounds used by their own fish farmers and introducing residue monitoring programmes for imports. Such monitoring programmes will also be required of producing countries who wish to continue exporting their aquaculture products into international markets. The protection of consumers against the risks of ingesting veterinary medicines is receiving much attention and although these risks may be difficult to quantify, it is essential that aquaculture products conform to standards no less protective than those already in place for many other areas of animal production (WHO, 1998).

These potential impacts can be mitigated by appropriate management practices and use of appropriate drugs and chemicals. The major chemicals used in coastal aquaculture are given in Table A9.1. Use of many of the chemicals classes mentioned in the table is common practice in animal husbandry (e.g., use of carotenoid feed additives in the poultry industry) and agriculture (e.g., lime). Because adoption of many of these chemicals by the aquaculture industry is a relatively new phenomenon and because of the release of residues to the aquatic environment, this practice has come under scrutiny. The following gives some recommendations from the GESAMP working group which can be considered in environmental impact assessments and the development of mitigation strategies.

Recommendations for governmental authorities

1. A system of registration for “approved” chemicals for use in aquaculture is essential in order to protect public health, the natural environment and the export economy.
2. On the basis of scientific data relevant to local environmental conditions and the species being cultured, governmental authorities should establish withdrawal periods (i.e. non-use prior to harvest and marketing) specific to each chemotherapeutic. Governments should enforce the use of such practices, in part by adoption of a residue testing programme, and solicit aquaculture industry collaboration to ensure their effective implementation.
3. Quantitative data on the usage of aquacultural chemicals, particularly those of greatest environmental and human health concern, should be gathered as a means to determine regulatory and research priorities.
4. Opportunities should be provided for training in the safe and effective use of chemicals in aquaculture for farm workers, other aquaculture support staff and chemical sales personnel. This training could be provided by government agencies, universities or trade associations. Drug and chemical companies should support such educational efforts.
5. There is a need for enhanced collaboration among manufacturers, suppliers and users of chemicals in aquaculture. Government authorities should encourage and facilitate such collaboration and provide expert advice, where required, to promote the safe and effective use of chemicals by aquaculturists. For these purposes, it will be useful to compile and disseminate contact details of manufacturers, importers and suppliers of chemicals as well as of hatchery and farm operators and any relevant trade associations.

Recommendations for the aquaculture industry
1. Chemotherapeutants should not be the first option when combating disease but used only as a last resort after environmental conditions, nutrition and hygiene have been optimised.
2. Prophylactic treatment should be avoided since the selective pressure for development of antibacterial resistance poses a threat to the long-term efficacy of a drug.
3. When multiple chemical alternatives are available, aquaculturists should select drugs not only on the basis of efficacy data but also on available information regarding environmental persistence, potential effects on non-target organisms, propensity to stimulate microbial resistance and rate of residue elimination.
4. Aquaculturists should utilise antibacterials having as narrow a spectrum of activity as possible but without loss of efficacy, so as to minimise selective pressure for resistance in other micro-organisms.
5. In order to document cost-effectiveness and guide future treatment, aquaculturists should maintain records of chemical use including agents used, amounts, reasons for use, methods of application, dates of use, amount/number and size of stock treated, success/failure of treatments and times of harvest of treated stock.
6. Aquaculturists should not discharge to natural water bodies any effluent containing chemical residues at concentrations likely to cause adverse biological effects and should first reduce concentrations, preferably by residue removal or increased residence time, and/or by dilution with other effluent waste streams within the farm.
7. Farms in close physical proximity should collaborate in minimising the risk of contaminating of their water supplies and those of neighbouring facilities with chemical residues and drug resistant bacteria.

**Recommendations for the drug and chemical industry**

1. Producers of chemicals used in aquaculture should support the development of efficacy, fate and environmental effects data specific to the species and the geographical region(s) of chemical use.
2. Aquaculture chemicals should be provided to the aquaculturist with labelling and/or data sheets in the principal local language(s). Information should be provided on active ingredients, intended use, route of treatment, environmental and health hazards, species and life stage to be treated, storage conditions, expiration dates and disposal requirements. Aquaculturists should be encouraged to purchase only chemicals with complete labeling and to follow all instructions regarding their use.

**Recommendations for the scientific community**

1. Scientists should continue to document and quantify the frequency, severity and spatial extent of environmental alterations related to chemical use in aquacultural activities. Such efforts have been very limited to date and quantitative assessments are urgently needed by regulators and the aquaculture industry.
2. Research is needed to develop safe alternatives to chloramphenicol, malachite green and organotin molluscicides.
3. Research and development of alternatives to chemotherapy are needed including development of probiotics, bioremediation, immunostimulants and vaccines.
### Table A.9.1. Main Characteristics of chemicals used in the aquaculture industry.

<table>
<thead>
<tr>
<th>Chemicals</th>
<th>Major use/purpose</th>
<th>Hazards and risks</th>
<th>Legal issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemicals associated with structural materials</strong></td>
<td>Structural materials, protective coatings and antifoulants</td>
<td>TBT residues highly toxic to humans and indigenous biota.</td>
<td>TBT banned for use in aquaculture in some countries</td>
</tr>
<tr>
<td><strong>Soil and water treatments</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Alum</td>
<td>Alum (potassium-aluminium sulphate) is widely used as a flocculant to reduce turbidity.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>* EDTA</td>
<td>Water treatment for removing heavy metals in shrimp hatcheries.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>* Gypsum</td>
<td>Widely used flocculant in ponds</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>* Lime</td>
<td>Commonly used to neutralise pH and sterilise pond bottoms</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>* Zeolites</td>
<td>Commonly used water treatment in ponds (of limited effectiveness)</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td><strong>Fertilisers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Organic manures</td>
<td>Chicken and other manures used in brackishwater shrimp, fish culture.</td>
<td>Low environmental risks from eutrophication/dissolved oxygen depletion if used excessively</td>
<td></td>
</tr>
<tr>
<td>* Inorganic fertilisers</td>
<td>Wide range of inorganic fertilisers used in brackishwater fish/shrimp culture</td>
<td>As organic manure</td>
<td></td>
</tr>
<tr>
<td><strong>Disinfectants</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Chloramine</td>
<td>Disinfection of tanks and equipment and treatment of bacterial/gill disease.</td>
<td>Active component is chlorine (available chlorine = 20%). See comments on chlorine below</td>
<td></td>
</tr>
<tr>
<td>* Formalin</td>
<td>General disinfectant for equipment.</td>
<td>See below</td>
<td></td>
</tr>
<tr>
<td>* Hypochlorite</td>
<td>Widely used disinfectant in hatcheries, some ponds for water treatment (particularly shrimp viral diseases)</td>
<td>Medium risk. Chlorine is highly toxic to aquatic life. Release of chlorinated water to the receiving water body without prior neutralisation with sodium thiosulfate could have localised biological effects.</td>
<td></td>
</tr>
<tr>
<td>* Iodophores</td>
<td>Used world-wide as disinfectants for aquaculture equipment and fish eggs.</td>
<td>Medium environmental risk is associated with disposal, which should be to the soil</td>
<td></td>
</tr>
<tr>
<td>* Ozonation</td>
<td>Occasional use by shrimp producers to disinfect hatchery water.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>* Quaternary ammonium compounds (e.g. benzalkonium chloride)</td>
<td>Used as &quot;topical disinfectants&quot; to remove ectoparasites from fish, as bactericides and fungicides in shrimp hatcheries. Widely used in shrimp ponds to control viral infections.</td>
<td>Medium environmental risk</td>
<td></td>
</tr>
<tr>
<td><strong>Antibacterial agents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* β-lactams,</td>
<td>Used occasionally in fish culture.</td>
<td>The β-lactams are important in human medicine.</td>
<td></td>
</tr>
<tr>
<td>* nitrofurans,</td>
<td>Have been used extensively in fish and shrimp farming. Use in the Europe and North America has declined as more active compounds.</td>
<td>Potentially carcinogenic.</td>
<td>Prohibited for use on food animals within the European Union.</td>
</tr>
<tr>
<td>Therapeutants other than antibacterials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>acriflavine</strong></td>
<td>Very occasional use as an antibacterial and external protozoan treatment for fish eggs and fry.</td>
<td>Potentially mutagenic.</td>
<td></td>
</tr>
<tr>
<td><strong>copper compounds</strong></td>
<td>Limited use. Effective against external protozoans and filamentous bacterial diseases in post-larval shrimp. It can be used to induce moulting in shrimp as a means of reducing cuticular fouling.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td><strong>dimetridazole / metronidazole,</strong></td>
<td>An antiprotozoal agent of very limited use in coastal aquaculture although favoured more strongly by the aquarium trade. Presented as a medicated feed.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td><strong>formalin</strong></td>
<td>Global use. Employed as an antifungal agent and in the control of ectoparasites, most often in hatchery systems.</td>
<td>Formalin is toxic to aquatic life at low concentrations. Dilution is necessary in order to ensure that therapeutic dosages may be safely discharged to receiving waters. Formalin is a potential carcinogen and should be handled very carefully to avoid skin contact, eye irritation and inhalation</td>
<td></td>
</tr>
<tr>
<td>Chemical/Method</td>
<td>Description</td>
<td>Risk</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>glutatione</td>
<td>Rare use in hatcheries/shrimp ponds</td>
<td>Potentially carcinogenic</td>
<td></td>
</tr>
<tr>
<td>malachite green</td>
<td>Use as an antifungal and antiprotozoal bath in the culture of shrimp and fish mainly in hatcheries</td>
<td>Human health concerns relate to its role as a respiratory enzyme poison. Lengthy withdrawal period essential following application because of persistent residues.</td>
<td>Its use is not permitted in the USA, the European Union and some Southeast Asian countries (e.g., Thailand)</td>
</tr>
<tr>
<td>methylene blue</td>
<td>Occasional use. Effective against fungal and protozoan infections in fish culture operations</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>niclosamide</td>
<td>Limited use. Applied as an anthelmintic in fish culture, including turbot</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>potassium permanganate</td>
<td>Occasional use as a bath treatment for fungal infections of milkfish and other cultured finfish.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>trifluralin (Treflan®)</td>
<td>Commonly used prophylactic fungicide; presented as a bath in shrimp hatcheries.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
</tbody>
</table>

**Pesticides**

<table>
<thead>
<tr>
<th>Chemical/Method</th>
<th>Description</th>
<th>Risk</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>Employed occasionally in shrimp culture as a piscicide prior to pond stocking</td>
<td>Low environmental risk</td>
<td></td>
</tr>
<tr>
<td>Azinphos ethyl (Gusathion®)</td>
<td>Has been used to remove molluscs from shrimp ponds in the Philippines</td>
<td>High environmental and health risks - toxic effects on aquatic life</td>
<td>Widely banned</td>
</tr>
<tr>
<td>Carbaryl (Sevin®)</td>
<td>Carbaryl pesticides are used to control burrowing shrimp in shrimp ponds of Central and South America and in on-bottom oyster culture in the north-western USA.</td>
<td>Medium environmental risk - Mortality to non-target species. Non-target crustaceans are likely to be at greatest risk</td>
<td></td>
</tr>
<tr>
<td>Organophosphates. Dichlorvos (Nuvar®, Aquaguard®, Diphos®, Dursban®, Demerin® and Malathion®)</td>
<td>Dichlorvos is a widely used organophosphate pesticide applied to control ectoparasitic crustacean infections in finfish culture. In addition to dichlorvos and trichlorfon, other organophosphates such as Diphos®, Dursban®, Demerin® and Malathion® are employed to control ectoparasitic crustaceans in freshwater fish and monogenetic trematode infections in shrimp hatcheries.</td>
<td>For all the organophosphates, effects on non-target aquatic organisms, particularly crustaceans is a major concern. Discharge of pond water containing residues or direct release of organophosphates to waterbodies may result in adverse effects on nearby organisms Due to the high neurotoxicity of organophosphates, potential effects on the health of fishfarm workers are also of concern.</td>
<td></td>
</tr>
<tr>
<td>Ivermectin (Ivomec®)</td>
<td>Limited use to control sea lice in salmon</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Nicotine (tobacco dust)</td>
<td>Occasional use to control fish predators and snails during preparation of fish and shrimp grow-out ponds.</td>
<td>Low environmental risk</td>
<td></td>
</tr>
</tbody>
</table>
| **Organotin compounds**  
Brestan®, Aquatin®, Thiodan® | Frequent use in the past in Southeast Asia for elimination of molluscs prior to stocking of shrimp ponds. | Organotin compounds are highly toxic, with acute toxicity to the most sensitive organisms occurring at concentrations in the nanogramme per litre range. | Severely restricted by Canada, France, Germany, Switzerland, United Kingdom, and the United States. Banned for aquaculture use in several SE Asian countries. |
| **Rotenone (derris root)** | A compound derived from derris root and used as a piscicide to remove nuisance fish from ponds prior to stocking of shrimp or fish. | Hazard to workers as inhalation may result in respiratory paralysis. | Use is strictly controlled by many countries. |
| **Saponin (tea seed meal)** | Widespread use in Southeast Asia. Employed during the preparatory phase in ponds as a piscicide prior to stocking of shrimps. Also used in the Philippines, Thailand and elsewhere to induce molting in shrimp. | Medium environmental risk | |
| **Trichlorfon**  
(Neguvon®, Dipterex®) | See entry under organophosphates | As organophosphates | |
| **Herbicides/algaecides** | Herbicides are widely used to control weed growth in freshwater aquaculture but have very limited applications in marine aquaculture. | Low environmental risk | |
| **Copper compounds**  
(Aquatrine®) | Limited use. Applied to shrimp ponds as a method of algae control | Low environmental risk | |
| **Feed additives** | There are no data on environmental or health effects specific to aquaculture, though many of these compounds are widely used as feed additives in terrestrial animal husbandry. | Low environmental risk | |
| **Anesthetics** | A number of anaesthetic agents have been used in aquaculture to assist immobilisation of brood animals during egg and milt stripping. Anaesthetics are also extensively used to sedate and calm animals during transportation. | Anaesthetics are fundamentally employed at very low doses, such that their limited use in coastal aquaculture presents no environmental risk although there may be hazards to users. | |
| **Hormones** | Maybe added to feed and used for breeding of fish. | Although the potential human health and environmental effects of endocrine disrupting chemicals is now a matter of considerable debate, the use of such chemicals in aquaculture is not currently a major concern. | |
Appendix 10: Assessing coastal aquaculture against sustainability criteria

- Broad sustainability criteria
- Practical indicators at local or enterprise level
- Quantitative indicators at enterprise level
- Sustainability analysis of intensive shrimp farming
- References

Broad sustainability criteria

For many years economists have referred to the "Hartwick Rule" (Hartwick, 1977) as criterion for sustainable development:

The capital stock (manufactured capital + natural capital) should not decrease over time.

Hanley et al., 1999 summarize and categorize the indicators of sustainability as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Group</th>
<th>Example/units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological/environmental</td>
<td>Air quality</td>
<td>NOx/Sox ppm</td>
</tr>
<tr>
<td>single</td>
<td>Water quality</td>
<td>DO mg/l</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Soil erosion</td>
<td>Tonnes/ha/yr</td>
</tr>
<tr>
<td>Aggregated</td>
<td>Net Primary Productivity</td>
<td>Energy/m² or tonnes/ha</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Environmental space</td>
<td>varied</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Ecological footprints</td>
<td>Ha/person</td>
</tr>
<tr>
<td>Economic</td>
<td>Consumption per capita</td>
<td>$/person</td>
</tr>
<tr>
<td>single</td>
<td>Real wages</td>
<td>$/person</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Unemployment</td>
<td>No. employed/region</td>
</tr>
<tr>
<td>Aggregate</td>
<td>Green net national product (NP-</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td>depreciation in natural capital – increased pollution stocks)</td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>Genuine savings (savings – depreciation in natural and man-made capital)</td>
<td>$</td>
</tr>
<tr>
<td>Socio-political</td>
<td>mortality</td>
<td>Deaths/1000</td>
</tr>
<tr>
<td>single</td>
<td>literacy</td>
<td>Literacy rate/1000</td>
</tr>
<tr>
<td>aggregate</td>
<td>Index of social and economic welfare</td>
<td>$ or $/person</td>
</tr>
<tr>
<td>aggregate</td>
<td>Genuine progress indicator</td>
<td>$ or $/person</td>
</tr>
<tr>
<td>aggregate</td>
<td>Human development index</td>
<td>Index</td>
</tr>
</tbody>
</table>

In practice it is difficult to translate most of these to practical criteria for the assessment of individual enterprises, although this is possible (for example) with the ecological footprint (e.g. what area of land or water is required to support a fish farm when land/water required to generate the inputs is taken into account?).
Practical indicators at local or enterprise level

The following practical sustainability indicators were proposed by Flemming and Daniel, 1995:

- Maintenance of habitat and ecosystems;
- Preservation of native plant and animal species;
- Preservation of areas of landscape and amenity value;
- Preservation of areas of cultural value;
- Reclamation and re-use of wastewater;
- Wastewater disposal within assimilative capacity;
- Groundwater extraction within sustainable yield;
- Improvement in surface water quality;
- Improvement in groundwater quality;
- Productive use of fertile soils;
- Prevention of erosion;
- Application of clean technology;
- Waste recycling or use;
- Material utilization allowing recycling or re-use;
- Increased use of metal substitutes

- Compatibility with existing operations or services;
- Local infrastructure compatibility;
- Minimization of greenhouse gas emissions;
- Airborne disposal within assimilative capacity;
- Use of renewable energy resources;
- Energy efficiency;
- Public acceptability;
- Involvement of the community;
- Improved recreational opportunities;
- Improved access to public open space;
- Full cost recovery for goods or services;
- Annual equivalent cost benefit ratio;
- Costs borne by consumers;
- Equitable cost-benefit distribution;
- Increased employment opportunities;
- Unit cost for good or service;
- Capital cost funding capability

Quantitative measures of sustainability at the enterprise level

Although useful, many of the measures noted above are not quantifiable or are difficult to quantify. Hambrey (1998) proposed the following quantifiable/measurable sustainability indicators relating to resource use on specific enterprises:

- the efficiency of conversion of nutrients and raw materials into usable product; or
- the quantity of raw materials or nutrients used per unit product, or per unit land.

Food conversion efficiency is a classic example of the latter. However, he suggested that these may be less appropriate in developing countries than indicators which compare resource use with income generated. For example:

- Resource use, or waste production, per unit economic or social benefit

Specific indicators of this kind include a wide range of simple ratios, which may include both environmental and social elements. For example:

- land/unit income;
- land/unit profit;
- land/\(\text{NPV}^1\);
- annual cost of raw materials/employment
- nutrient waste/unit income;
- nutrient waste/unit profit;
- land/employment;
- investment/employment
- nutrient use/employment; and
- nutrient waste/employment.

In the case of aquaculture and agriculture for example, it may be informative to calculate and compare income generated per kg of nitrogen consumed, per kg nitrogen discharged, or per kg protein consumed.

1 Net Present Value
The relative weights given to these various indicators will depend on local conditions in terms of nitrogen supply, nitrogen pollution, or protein shortage.

**Sustainability analysis: intensive shrimp farming**

The following provides a practical example of a broad qualitative analysis of the sustainability of shrimp farming (Hambrey, 1996).

<table>
<thead>
<tr>
<th><strong>Sustainability Criterion</strong></th>
<th><strong>Current Status of Shrimp Farming</strong></th>
<th><strong>Potential Improvement</strong></th>
</tr>
</thead>
</table>
| continuity of input supply   | • wild seed supply erratic and seasonal;  
|                             | • hatchery supply may be erratic and subject to availability of wild broodstock;  
|                             | • feed shortage or expense may arise related to variations in industrial fisheries supplying fish meal | • further develop hatchery seed supply;  
|                             |                                      | • improve hatchery skills; close the breeding cycle;  
|                             |                                      | • reduce fishmeal content of diet; increase contribution of natural feed |
| quality of inputs            | • seed from wild may carry disease;  
|                             | • hatchery seed may vary greatly in quality - multiple spawnings; poor feeding; excessive use of antibiotics;  
|                             | • feed formulation - quality may be compromised in favour of low cost;  
|                             | • feed quality may decline rapidly in tropical climate;  
|                             | • skills and training frequently inadequate;  
|                             | • quality and efficacy of many chemicals and other inputs questionable | • further develop hatchery production;  
|                             |                                      | • introduce seed quality certification;  
|                             |                                      | • introduce feed quality standards;  
|                             |                                      | • develop indigenous feedmill industry;  
|                             |                                      | • provide improved vocational training;  
|                             |                                      | • research efficacy of proprietary chemical products;  |
| social, economic and environmental costs of inputs | • feed highly dependent on fishmeal from industrial fisheries, some of which are poorly managed and may not be sustainable; and whose intensive exploitation may reduce availability of other higher value marine species which feed on them.  
|                             | • a wide variety of impacts may be related to the production of chemicals  
|                             | • use of wild seed may reduce recruitment to capture fisheries; affect other species dependent upon them; and result in significant by-catch of discarded juveniles of other species | • reduce fishmeal content of feed; develop alternative protein/amino acid sources;  
|                             |                                      | • reduce dependence on chemicals through disease prevention: better husbandry, feed quality, site and water quality, water management, water supply and discharge design and infrastructure  
|                             |                                      | • increase hatchery production of seed;  |
| continuity of output         | • disease is a major factor reducing the quantity and continuity of output;  
|                             | • declining pond soil and water quality may result in a steady decline in growth and output and increased susceptibility to disease | • emphasize disease prevention: better husbandry, feed quality, site and water quality, water management, water supply and discharge design and infrastructure  
|                             |                                      | • better pond soil and water management - training; water supply infrastructure |
### financial viability
- very high while production is maintained;
- often negative following poor management

### socio-economic impact
- return to labour, and employment potential/ha very high compared with agricultural alternatives in the coastal zone;
- investment/job high relative to more traditional agricultural and artisanal fishery activities;
- displacement as a result of increased land value; salinization; interference with navigation; destruction of habitat yielding subsistence products for local people

### environmental impact
- previously unused brackishwater environments (eg mangrove, estuarine flats, saltmarsh) may be converted, resulting in destruction of relatively natural habitats;
- significant quantities of nitrogen and phosphorus released to environment (water, pond soil, air);
- significant quantities of organic matter (resulting in BOD) released to the environment;
- a wide variety of chemicals released to the environment, including disinfectants, pesticides, and antibiotics, the latter having the potential to cause increased resistance in bacteria.

### input productivity/resource use efficiency
- poor conversion of protein (nitrogen) and phosphorus;
- moderate-high energy productivity;
- very high land and labour productivity;
- high capital productivity

### environmental impact
- identify high quality natural habitat and enforce protection;

### socio-economic impact
- develop lower cost technologies
- consult all stakeholders prior to allocating previously commonly held land;
- zone aquaculture and agriculture to minimize chances of salinization

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1 see earlier discussion for more detail on these sustainability criteria
References


Appendix II: Codes of Practice

- FAO Code of Conduct for Responsible Fisheries
- Global Aquaculture Alliance Code of Practice
- Synthesis of available codes of practice

FAO Code of Conduct for Responsible Fisheries

Section 9 - AQUACULTURE DEVELOPMENT

Article 9.1 Responsible development of aquaculture under national jurisdiction
Article 9.2 Responsible development within transboundary aquatic ecosystems
Article 9.3 Use of aquatic genetic resources
Article 9.4 Responsible aquaculture at the production level

9.1 Responsible development of aquaculture, including culture-based fisheries, in areas under national jurisdiction

9.1.1 States should establish, maintain and develop an appropriate legal and administrative framework which facilitates the development of responsible aquaculture.

9.1.2 States should promote responsible development and management of aquaculture, including an advance evaluation of the effects of aquaculture development on genetic diversity and ecosystem integrity, based on the best available scientific information.

9.1.3 States should produce and regularly update aquaculture development strategies and plans, as required, to ensure that aquaculture development is ecologically sustainable and to allow the rational use of resources shared by aquaculture and other activities.

9.1.4 States should ensure that the livelihoods of local communities, and their access to fishing grounds, are not negatively affected by aquaculture developments.

9.1.5 States should establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring with the aim of minimizing adverse ecological changes and related economic and social consequences resulting from water extraction, land use, discharge of effluents, use of drugs and chemicals, and other aquaculture activities.

9.2 Responsible development of aquaculture including culture-based fisheries within transboundary aquatic ecosystems

9.2.1 States should protect transboundary aquatic ecosystems by supporting responsible aquaculture practices within their national jurisdiction and by cooperation in the promotion of sustainable aquaculture practices.

9.2.2 States should, with due respect to their neighbouring States, and in accordance with international law, ensure responsible choice of species, siting and management of aquaculture activities which could affect transboundary aquatic ecosystems.
9.2.3 States should consult with their neighbouring States, as appropriate, before introducing non-indigenous species into transboundary aquatic ecosystems.

9.2.4 States should establish appropriate mechanisms, such as databases and information networks to collect, share and disseminate data related to their aquaculture activities to facilitate cooperation on planning for aquaculture development at the national, subregional, regional and global level.

9.2.5 States should cooperate in the development of appropriate mechanisms, when required, to monitor the impacts of inputs used in aquaculture.

9.3 Use of aquatic genetic resources for the purposes of aquaculture including culture-based fisheries.

9.3.1 States should conserve genetic diversity and maintain integrity of aquatic communities and ecosystems by appropriate management. In particular, efforts should be undertaken to minimize the harmful effects of introducing non-native species or genetically altered stocks used for aquaculture including culture-based fisheries into waters, especially where there is a significant potential for the spread of such non-native species or genetically altered stocks into waters under the jurisdiction of other States as well as waters under the jurisdiction of the State of origin. States should, whenever possible, promote steps to minimize adverse genetic, disease and other effects of escaped farmed fish on wild stocks.

9.3.2 States should cooperate in the elaboration, adoption and implementation of international codes of practice and procedures for introductions and transfers of aquatic organisms.

9.3.3 States should, in order to minimize risks of disease transfer and other adverse effects on wild and cultured stocks, encourage adoption of appropriate practices in the genetic improvement of broodstock, the introduction of non-native species, and in the production, sale and transport of eggs, larvae or fry, broodstock or other live materials. States should facilitate the preparation and implementation of appropriate national codes of practice and procedures to this effect.

9.3.4 States should promote the use of appropriate procedures for the selection of broodstock and the production of eggs, larvae and fry.

9.3.5 States should, where appropriate, promote research and, when feasible, the development of culture techniques for endangered species to protect, rehabilitate and enhance their stocks, taking into account the critical need to conserve genetic diversity of endangered species.

9.4 Responsible aquaculture at the production level

9.4.1 States should promote responsible aquaculture practices in support of rural communities, producer organizations and fish farmers.

9.4.2 States should promote active participation of fishfarmers and their communities in the development of responsible aquaculture management practices.

9.4.3 States should promote efforts, which improve selection and use of appropriate feeds, feed additives and fertilizers, including manures.

9.4.4 States should promote effective farm and fish health management practices favouring hygienic measures and vaccines. Safe, effective and minimal use of therapeutics, hormones and drugs, antibiotics and other disease control chemicals should be ensured.

9.4.5 States should regulate the use of chemical inputs in aquaculture which are hazardous to human health and the environment.
9.4.6 States should require that the disposal of wastes such as offal, sludge, dead or diseased fish, excess veterinary drugs and other hazardous chemical inputs does not constitute a hazard to human health and the environment.

9.4.7 States should ensure the food safety of aquaculture products and promote efforts which maintain product quality and improve their value through particular care before and during harvesting and on-site processing and in storage and transport of the products.
Preface

Codes of practices

The "Guiding Principles for Responsible Aquaculture" are broad statements that summarize primary environmental and social responsibilities of the aquaculture industry. Specific guidelines on how to conduct environmentally and socially responsible shrimp farming are provided as a series of Codes of Practice, each containing recommended management practices, for use by aquaculture associations, companies, and individuals. Codes address the following issues:

- Guiding Principles for Responsible Aquaculture
- Mangroves
- Site Evaluation
- Design and Construction
- Feeds and Feed Use
- Shrimp Health Management
- Therapeutic Agents and Other Chemicals
- General Pond Operations
- Effluents and Solid Wastes
- Community and Employee Relations

A background document, "Principles for Sustainable Shrimp Farming" provides the technical justification for individual codes.

Management practices in the individual Codes of Practice must be applied judiciously. Shrimp farms and their settings differ tremendously, and there will be few instances where all of the management practices will be necessary to afford environmental protection and community acceptance. Moreover, the specific methods for implementing a particular management practice will differ depending upon shrimp farm production methods and goals and local conditions. It also must be recognized that as technology advances, some of the management practices will require revision. Thus, the Codes of Practice are intended as flexible guidelines for use in formulating site-specific systems for responsible shrimp production, and their use should be guided by common sense. Nevertheless, adherents to the Codes are expected to comply with the management practices as appropriate for their situation and to strive for continuous improvement in environmental stewardship and community and employee well-being. There also are benefits to the shrimp producer who complies with these codes. Shrimp are sensitive to environmental conditions, and improvements in water quality and other environmental aspects, both on farms and within adjacent waters, will make conditions better for shrimp production.

In addition to encouraging the use of better management practices to reduce possible adverse environmental impacts, the producer should strive to use "environmentally-friendly" products and equipment.
Guiding Principles for Responsible Aquaculture

There is a great demand for shrimp in the world market, and to meet that need, shrimp farming has burgeoned. Like all human endeavors, shrimp farming can effect the environment and influence people’s lives. However, with proper planning and management, shrimp farming is environmentally-benign, socially beneficial, and economically rewarding at all levels. To aid in promoting environmentally and socially responsible shrimp farming, the Global Aquaculture Alliance has developed a series of management recommendations based on guidelines for responsible aquaculture presented by the Food and Agriculture Organization (FAO) of the United Nations in Article 9 - Aquaculture Development of the Code of Conduct for Responsible Fisheries. To comply with the Guiding Principles for Responsible Aquaculture, companies and individuals engaged in shrimp farming, singularly and collectively:

1. Shall coordinate and collaborate with national, regional, and local governments in the development and implementation of policies, regulations and procedures necessary and practicable to achieve environmental, economic, and social sustainability of aquaculture operations.

2. Shall utilize only those sites for aquaculture facilities whose characteristics are compatible with long term sustainable operation with acceptable ecological effects, particularly avoiding unnecessary destruction of mangroves and other environmentally significant flora and fauna.

3. Shall design and operate aquaculture facilities in a manner that conserves water resources, including underground sources of freshwater.

4. Shall design and operate aquaculture facilities in a manner that minimizes effects of effluent on surface and ground water quality and sustains ecological diversity.

5. Shall strive for continuing improvements in feed use and shall use therapeutant agents judiciously in accordance with appropriate regulations and only when needed based on common sense and best scientific judgement.

6. Shall take all reasonable measures necessary to avoid disease outbreak among culture species, between local farm sites, and across geographic areas.

7. Shall take all reasonable steps to ascertain that permissible introductions of exotic species are done in a responsible and acceptable manner and in accordance with appropriate regulations.

8. Shall cooperate with others in the industry in research and technological and educational activities intended to improve the environmental compatibility of aquaculture.

9. Shall strive to benefit local economies and community life through diversification of the local economy, promotion of employment, contributions to the tax base and infrastructure, and respect for artisanal fisheries, forestry and agriculture.
Mangroves Code of Practice

Purpose

The Code is designed to foster greater environmental awareness within the shrimp farming industry to assure continued protection of mangrove forests from potentially adverse impacts of coastal aquaculture. Recognizing the multitude of different conditions impacting mangroves in different countries and regional locations, this Code is to be interpreted as a flexible set of criteria to be used to assist any and all interested parties in formulating codes, regulations, and principles for protecting mangrove forests.

The Code helps to achieve several of the “Guiding Principles of Responsible Aquaculture” by encouraging the following:

- The shrimp aquaculture industry will promote responsible and sustainable development and management practices ensuring the preservation of mangroves and the sustainability of shrimp aquaculture.
- Shrimp aquaculture industries will promote alternative development programs aimed at protecting mangroves while benefitting local communities in mangrove areas.
- Producers shall adhere to national and local regulations applicable to mangroves and to shrimp farming.

Management Practices

It shall be the objective of all adherents to this Code to not harm mangrove ecosystems, and whenever possible, to preserve and even enhance the biodiversity of these ecosystems. The following practices will ensure the protection of mangrove ecosystems:

1. New shrimp farms should not be developed within mangrove ecosystems.
2. Realizing that some mangrove must be removed for canals when new shrimp farms are sited behind mangroves, a reforestation commitment of no net loss of mangroves shall be initiated.
3. Farms already in operation will continue ongoing environmental assessments to recognize and mitigate any possible negative impacts on mangrove ecosystems.
4. All non-organic and solid waste materials should be disposed of in an environmentally responsible manner, and waste water and sediments shall be discharged in manners not detrimental to mangroves.
5. The shrimp aquaculture industry pledges to work in concert with governments to develop sound regulations to enhance the conservation of mangroves including regulations regarding restoration of mangrove areas when old farms located in former mangroves are decommissioned.
6. The shrimp aquaculture industry will promote measures to ensure the continued livelihood of local communities that depend upon mangrove resources.
Site Evaluation Code of Practice

Purpose
The Code is designed to promote site evaluation as a means to ensure that new shrimp-farming projects are harmoniously integrated into local environmental and social settings. Site evaluation can identify limitations that influence the suitability of a site for farm construction and operation, reveal the possibilities of negative environmental and social impacts, and allow estimates of technical and financial requirements for mitigation of unfavorable conditions. Recognizing that enormous variation in environmental and social conditions exists from site to site, this Code presents adaptable guidelines to assist any and all parties interested in making site evaluations for shrimp farms.

The Code helps to achieve several of the “Guiding Principles of Responsible Aquaculture” and promotes the following:

- Use of site evaluation to avoid siting farms where significant technical, environmental, and social problems are likely.
- Prevention of significant negative environmental and social impacts through use of site evaluation findings in planning mitigation methods. A proper site evaluation will provide most of the information required to produce an environmental impact assessment (EIA).

Management Practices
All adherents to the Code shall thoroughly evaluate potential sites for shrimp farms to assure that local ecological and social conditions are protected and even enhanced. The following practices will ensure that appropriate sites are selected for shrimp farms:

1. Evaluate hydrologic features including tidal patterns, freshwater influences and flood levels, offshore currents, and existing water uses.
2. Determine water quality characteristics of coastal waters in the vicinity of the site.
3. Ascertain the suitability of topography, soil, and ecosystem for siting and construction of ponds.
4. Make sure that previous site use has not resulted in contamination of water or soils.
5. Acquire long-term climatological records to determine the likelihood of drastic events such as flood, droughts, or severe storms that could negatively impact the project.
6. Survey the existing flora and fauna with particular concern for effects of the project on ecologically sensitive areas such as migration routes and nesting grounds or protected areas such as parks and refuges.
7. Document regulatory requirements for the site, and consider alternatives for compliance with regulations.
8. Consider alternatives to mitigate potential negative environmental impacts and to alleviate conditions not conducive to shrimp farm construction and operations.
9. Survey local communities to determine demography, resource use patterns, availability of work force, and compatibility with project goals.
10. Consider alternatives to mitigate potential negative social impacts.
11. Determine if any areas within the site are of significant archaeological or historical importance and consider methods for their preservation.
Design and Construction Code of Practice

Purpose

The Code is intended to promote environmental protection through proper shrimp farm design and good construction methods. Good site selection and incorporation of mitigative features in the farm design are the best ways to avoid problems related to flood levels, storms, erosion, seepage, water intake and discharge points, and encroachment on mangroves and wetlands. Planning of clearing and earth moving activities can prevent or greatly limit ecological damage during farm construction. Recognizing that a site-specific approach to design and construction is necessary, the Code provides basic design and construction criteria for environmentally-responsible shrimp farms.

The Code helps to achieve several of the “Guiding Principles of Responsible Aquaculture” and it promotes:

- Use of design features and good construction methods to overcome site limitations and to prevent or mitigate potential negative environmental and social impacts.
- Adoption of successfully proven and accepted design and construction procedures.

Management Practices

Adherents to the Code shall strive to design and construct shrimp farms in a responsible manner to protect the environment and coastal communities. The following practices can afford this protection:

1. Farms should not be built on ecologically sensitive mangrove areas or other wetlands and in places where it is impractical to correct site-related problems such as highly-acidic, organic, or permeable soils.
2. Comply with all environmental impact assessment (EIA) procedures before initiating construction and abide by EIA restriction during construction.
3. Embankments should be designed to prevent erosion, and where practical, methods for reducing seepage through pond bottoms should be included.
4. Ponds should have separate intake and outlet structures to permit control of filling and draining.
5. Inlet and discharge canals should be separate so that water supply and effluent are not mixed.
6. Storms and flood levels should be considered in earthwork design.
7. Infrastructure and access roads should not necessarily alter natural water flows, cause salinization of adjacent land or water, or impound flood water.
8. Canals should be designed to prevent excessive water velocity and scouring.
9. Water intake point(s) should provide a sufficient volume of high quality water available.
10. Pump intakes should be screened, vegetative buffers provided around pump stations, and containment installed to prevent fuel spills.
11. Where possible, vegetative buffer zones, riparian vegetation, and habitat corridors should be maintained, and vegetative cover provided on exposed earthwork.
12. Sediment traps and basins should be incorporated in the design where suspended solid concentrations are expected to be high in effluents.
13. Outfalls should be designed to prevent erosion and avoid discharge of effluents into stagnant water.
14. Disturb as little area as possible during construction.
15. Erosion should be controlled during construction.
16. Cut and fill construction techniques are preferable, and earthwork should be compacted.
17. Degraded areas such as unused soil piles, barrow pits, and uncontrolled refuse dumps should not be created.
Feeds and Feed Use Code of Practice

Purpose

The Code is designed to improve the efficiency of supplemental feeds and feed management in shrimp farming and to minimize the waste load in ponds. Feeding is a standard practice in shrimp production, because it permits higher production than can be achieved from natural pond productivity. Recognizing that feed is expensive, it should be used wisely to reduce production costs. However, using good feeds and feeding practices also are important steps towards reducing waste loads in pond effluents. Guidelines presented in this Code can be used by feed manufacturers and shrimp producers to improve feeds and feeding practices.

The Code helps to achieve several of the “Guiding Principles for Responsible Aquaculture” and promotes awareness of two major issues:

- Shrimp feed should be made from high quality ingredients by good manufacturing techniques and stored properly.
- Feed should be used conservatively to ensure efficient conversion to shrimp flesh and minimize waste and expense.

Management Practices

Those supporting the Code shall strive to improve feed quality and feeding with the goal of optimizing the conversion of feed to shrimp and reducing the amount of waste entering ponds. This goal can be achieved through the following practices:

1. Feed ingredients should not contain excessive pesticides, chemical contaminants, microbial toxins, or other adulterating substances.
2. Pellet binders and suitable manufacturing techniques should be used to provide a water-stable pellet.
3. Manufacturing processes should provide adequate vitamin and nutrient concentrations in feed.
4. Feed should be purchased fresh and not stored for more than a few months.
5. Feed should be stored in cool, dry areas to prevent mold and other contamination. Do not use contaminated feed.
6. Feed management practices should be implemented to assure the shrimp consume the maximum amount of supplemental feed and not leave excess amounts decomposing in the pond attributing to poor water quality.
7. Feeding rates should be determined from standard feed curves and adjusted for shrimp biomass, appetite, and pond conditions. Feed trays can be used to monitor feeding and prevent under or overfeeding.
8. The most efficient supplemental feeding can be obtained by distributing the supplemental feed several times through the day and night. Supplemental feed should be widely distributed throughout the pond, either by manual or mechanical dispersement or use of feed trays.
9. Appropriate feed curves commensurate with shrimp biomass and appetite should be utilized on a site specific, species specific basis and with the recommendation of shrimp feed specialists.
10. Medicated feed should be used only if necessary for the control of a specific diagnosis of disease.
11. Cut fish should not be used as shrimp feed.
12. Research to reduce the level of fish and other marine meals in shrimp feed should be encouraged.
13. Pond managers should keep careful records of daily feed application rates so that feed conversion ratio (FCR) can be assessed. Reductions in FCR through careful feeding will improve production efficiency and reduce waste loads.
Shrimp Health Management Code of Practice

Purpose

The purpose of this Code is to promote shrimp health management as a holistic activity in which the focus is on disease prevention instead of disease treatment. Authorities on shrimp health management recognize that stress reduction through better handling, reasonable stocking densities, good nutrition, and optimal environmental conditions in ponds can prevent most infectious and non-infectious diseases. Treatment should be undertaken only when a specific disease has been diagnosed. Also, effective measures must be taken to minimize the spread of diseases between farm stocks and from farm stocks to natural stocks. This Code provides adaptable guidelines that should provide effective management of shrimp health.

The Code helps to achieve several of the “Guiding Principles for Responsible Aquaculture” and advances three basic premises as follows:

- Many disease problems can be prevented through stress management.
- Disease treatments should be made only after a clear diagnosis of the causative factors.
- Spread of disease should be minimized by reasonable regulation of importation of broodstock and larvae and by isolation and disinfection of affected ponds.

Management Practices

Adherents to the Code shall adopt the principles of good shrimp health management to reduce the incidence of diseases and to protect natural fisheries. The following practices should be used to achieve these goals:

1. Shrimp farming associations should work with governments to formulate and enforce regulations to include quarantine procedures for importation and exportations of broodstock, nauplii, and post-larvae.
2. Healthy post-larvae should be used for stocking ponds. Survival of post-larvae should then be optimized by preparing the pond to ensure adequate availability of natural food, by properly acclimating post-larvae before stocking, and by avoiding stress by using appropriate handling and transportation techniques.
3. Good water quality and bottom soil management should be used. Stocking rates should not be excessive and high quality feed and good feeding practices should be used.
4. Strong chemical treatments that can stress shrimp should not be employed.
5. Shrimp should be routinely monitored for disease, and a definite diagnosis obtained for any observed shrimp health problem.
6. For non-infectious diseases related to pond conditions, carry out the best option for disease treatment or for correcting pond conditions.
7. For mild infectious diseases with potential to spread within a farm, quarantine the pond and carry out the best option for disease treatment.
8. For serious infectious diseases that may spread widely, isolate the pond, net harvest remaining shrimp, and disinfect the pond without discharging any water.
9. Dispose of dead, diseased shrimp in a sanitary manner that will discourage the spread of disease.
10. When disease occurs in a pond, avoid transfer of shrimp, equipment, or water to other ponds.
11. Drug, antibiotic, and other chemical treatments should be done in accordance with recommended practices and comply with all national and international regulations.
12. The shrimp industry should work with governments to develop certification programs for disease diagnosis laboratories and pathologists.
13. Each country or geographical area should develop its own pond dry-out, farm situation, and biosecurity strategy.
Therapeutic Agents and Other Chemicals Code of Practice

Purpose
The Code is intended to foster greater awareness within the shrimp industry of the proper use of certain potentially toxic or bioaccumulative compounds in shrimp production. Careful control over the use of therapeutants and other chemicals in production will assure that farm-reared shrimp are less likely than wild-caught shrimp to contain residues of pollutants or contaminants. Environmental benefits also will accrue from responsible chemical use. This Code contains flexible criteria that will allow prudent use of certain drugs, antibiotics, and other chemicals in production without endangering food safety or threatening the environment.

The Code helps to achieve several of the “Guiding Principles for Responsible Aquaculture” and promotes three basic objectives:

- The shrimp farming industry in each nation should work with governmental and international agencies to develop lists of approved feed additives, pesticides, drugs, antibiotics, and other chemicals and to specify approved uses for each compound.
- Shrimp farmers who adhere to the Code will rely on good management to prevent water quality and disease problems and chemicals should be used only when necessary.
- Chemical use in ponds should only be done after an accurate diagnosis of the situation and treatments should conform to acceptable protocol.

Management Practices
Adherents to the Code should strive to produce a wholesome product for consumers through responsible use of drugs, antibiotics, and other chemicals. Use of the following practices will assure this goal:

1. 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.
2. 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.
3. 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.
4. 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.
5. When potentially toxic or bioaccumulative chemicals are used in hatcheries and ponds, waters should not be discharged until compounds have naturally decomposed to non-toxic form.
6. Careful records should be maintained regarding use of chemicals in ponds as suggested by the Hazard Analysis and Critical Control Point (HACCP) method.
7. 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.
8. The shrimp-farming industry should work with governments to develop regulations for labelling the content and percentage of active ingredients in all chemicals including liming materials and fertilizers.
General Pond Operations Code of Practice

Purpose
The purpose of the Code is to prevent eutrophication, salinization, reductions in biodiversity, and other environmental perturbations by using responsible pond management practices. Experience demonstrates that it is possible to optimize efficiency of shrimp production and be good stewards of the environment at the same time. This Code contains broad guidelines on pond management that can be used to standardize and improve operations for sustainable shrimp farming.

The Code helps to achieve several of the "Guiding Principles of Responsible Aquaculture" and asserts that:

• Responsible pond operations can protect or even improve environmental quality and enhance sustainability.
• Both profitability and environmental sustainability can be achieved at the same time.

Management Practices
It shall be the objective of adherents to the Code to use pond operation methods that are environmentally responsible while allowing profitable shrimp production. The following practices should be used to promote profitable, yet sustainable shrimp farming:

1. Farms should be encouraged to use hatchery larvae rather than wild-caught larvae.
2. Where wild caught postlarvae are used, a screening method should be used to separate by-catch and return it to the estuary.
3. Native species should be cultured whenever feasible; however, if non-native species are used, all applicable regulations should be obeyed regarding importation and inspection.
4. Only healthy postlarvae should be used.
5. Good water quality should be maintained by using stocking and feeding rates that do not exceed the assimilative capacity of the culture system and by using high quality feeds and good feeding practices.
6. Water exchange should be reduced as much as possible.
7. Fertilizers, liming materials, and all other chemicals should be used in a responsible manner and only as needed.
8. Good shrimp health management should be used.
9. Aerators should be positioned and operated to minimize erosion and creation of sediment mounds in pond bottoms.
10. Freshwater from wells should not be used in ponds to dilute salinity.
11. Effluents, sediment, and other wastes should be disposed responsibly.
12. Bottom soils should be evaluated periodically between crops and necessary treatments applied to remediate deterioration in soil conditions that occur during culture.
13. Water inlets and outlets to ponds should be screened to prevent entrance of competitors and release of culture species.
14. Predator control methods that do not require destruction of ecologically important species should be used.
Effluents and Solid Wastes Code of Practice

Purpose

The Code is designed to increase the awareness of proper waste management within the shrimp farming industry and enhance protection of coastal land and water resources. Recognizing that a number of production activities produce wastes, shrimp producers and processors should formulate systems of waste management for protecting lands and waters in the vicinity of their activities. This Code provides a set of guidelines that can form the framework for responsible waste management that will benefit all coastal resource users including shrimp farming.

The Code helps to achieve several of the “Guiding Principles of Responsible Aquaculture” and specifically recognizes that:

- The shrimp aquaculture industry should promote responsible methods of effluent and solid waste management to protect environment quality and public health.
- Effluent and solid waste management is a continuous activity, and each member farm should strive to improve waste management procedures and reduce amounts of waste released to the environment.
- In countries where quality and volumes of effluent are not regulated by permits from governmental agencies, adherence to the Code is an alternative way of protecting the environment.

Management Practices

Adherents to the Code should continuously strive to improve waste management. Particular attention should be given to the following practices:

1. Canals and embankments should be maintained to reduce erosion of above water portions.
2. Minimize water exchange to the extent feasible.
3. Use efficient fertilization and feeding practices to promote natural primary productivity while minimizing nutrient inputs.
4. Store and use fuels, feeds, and other products in a responsible manner to avoid accidental spills that could contaminate water. An emergency plan should be made for containing accidental spills.
5. Ponds should be drained in a manner to minimize resuspension of sediment and prevent excessive water velocities in canals and at effluent outfalls.
6. Where feasible, pond effluents should be discharged through a settling basin or mangrove forest.
7. Design outfalls so that no significant impact of effluents on natural waters occurs beyond the mixing zone.
8. Shrimp pond effluents should not be discharged into freshwater areas or onto agricultural land.
9. Sediment from ponds, canals, or settling basins should be put back into areas from which it was eroded, used as earthfill, or disposed in some other environmentally-responsible way.
10. Sanitary facilities for disposal of human wastes should be provided at hatcheries, farms, and processing plants.
11. Garbage and other farm wastes should be burned, put in a land fill, or disposed of by other acceptable methods.
12. Shrimp farms, hatcheries, and processing plants should comply with existing governmental regulations related to effluents and other wastes.
13. Processing plants, and where necessary, shrimp hatcheries should install effluent treatment systems of appropriate type and capacity.
14. Managers should routinely evaluate waste management procedures and continually attempt to improve them.
Community and Employee Relations Code of Practice

Purpose
The purpose of the Code is to foster good relationships among shrimp farm officials, workers, and local communities. Aquaculture can be a powerful stimulus to improving the standard of living in coastal communities by providing jobs and services, contributing to the tax base, improving the physical and social infrastructure, and creating a larger and more diverse and dynamic economy. Recognizing that public relations and employee welfare are complex issues, this Code is intended to provide some general guidelines for enhancing the prospects for harmonious interactions with workers and the local community. Conditions, expectations, and mores are highly variable from place to place, so considerable flexibility will be necessary in applying these guidelines.

The Code helps to achieve several of the “Guiding Principles for Responsible Aquaculture” and specifically promotes the following:

- Shrimp farms should employ local workers to the extent possible, provide good working conditions, and wages commensurate with local pay scales.
- Shrimp farms should abide by local laws and regulations regarding the rights of local people to use coastal resources.
- Shrimp farms should be supportive of local communities and engage in community activities.

Management Practices
Shrimp farms range in size from small, family operations to large corporate enterprises. Most of the guidelines given below apply primarily to large shrimp farms:

1. Shrimp farm owners should have clear title or right to their property or other current, legal land concession agreements.
2. Shrimp farm management should schedule meetings with local communities to exchange information. This is particularly important in the planning stages for new farms or expansions.
3. Shrimp farm management should attempt to accommodate traditional uses of coastal resources through a cooperative attitude towards established local interests and environmental stewardship.
4. Shrimp farm management should contribute to community efforts to improve local environmental conditions, public health and safety, and education.
5. Local workers should be employed to the extent possible, and all practical means made to prevent conflicts between local people and workers from outside.
6. Workers should be fairly compensated with respect to local wage scales.
7. Healthy and safe living and working conditions should be provided. Procedures should be established for dealing with illness and accidents, and employers must be responsible for making sure that workers are fully aware of these procedures.
8. Shrimp farm management should have clearly-defined and posted security policies.
9. Employees should have a clear understanding of their duties and of company expectations regarding their performance.
Synthesis of main guidelines and codes of conduct* for the promotion of sustainable aquaculture development

1. Policy level

Principles

- Conserve genetic diversity and ecosystem integrity;
- Conserve water and aquatic resources including underground water;
- Reduce impacts on sensitive habitat through the identification of alternative enterprise or livelihood;
- Minimize pollution of water resources;
- Minimize disease spread;
- Use native species wherever possible;
- Careful and responsible species introductions;
- Bring benefits to local and community life, and address social/poverty issues;
- Use participatory approaches to develop responsible aquaculture practices;
- Improve food safety and product quality;
- Coordination and collaboration between aquaculturists and government;
- Improve research, education and information exchange;
- Comply with all relevant existing regulations and protocols; and
- Continually evaluate and improve waste management procedures.

Policy, legal, regulatory and administrative frameworks

- Devise and introduce an appropriate national legal and administrative framework;
- Develop aquaculture development strategies and plans;
- Clarify title or right to resource use;
- Title or rights to resource use tied to siting, design and/or management practices;
- Legal bans or restrictions on the use or conversion of environmentally sensitive habitat;
- Develop pollution control standards;
- Introduce enforceable legislation and protocols relating to species introductions and transfers;
- Introduce procedures and protocols relating to genetic change of broodstock;
- Protect trans-boundary ecosystems;
- Introduce quarantine and disease prevention protocols;
- Develop disease certification programs;
- Develop feed quality certification/regulation schemes;
- Advance evaluation of genetic and ecological impacts;
- Use tax incentives (positive and negative) for sustainable aquaculture practices;
- Use conflict resolution;
- Provide/facilitate effective veterinary services;
- Research on impact of introductions;
- Improve education, training and extension;
- Effective information collection, exchange, storage, synthesis, and dissemination;
• Industry/government collaboration to develop lists of approved feed additives, pesticides, drugs, antibiotics, and other chemicals and to specify approved uses for each compound;
• Improved and accurate labeling of therapeutants and other chemicals used in aquaculture; and
• Develop alternatives to fish meal in aquaculture feeds.

Credit
• Provide appropriate credit availability, including cost recovery procedures; and
• Tie credit tied to siting, design and/or management practices.

Impact assessment and monitoring
• Assess possible effects of aquaculture development on biodiversity and ecological functions; identify and protect biodiversity;
• Advance evaluation of genetic and ecological impacts;
• EA to include social/poverty/livelihood/cultural assessment;
• Quality baseline data and effective monitoring;
• Integrate aquaculture with broader coastal management initiatives;
• Improve monitoring and reporting; and
• Promote government/NGO/business partnerships.
2. Farm level

Site selection
- Use of EIA and integrated coastal management to guide site selection;
- Thorough assessment of hydrology, existing water quality, and susceptibility to climatic disruption;
- Thorough assessment of soil (including possible previous contamination), topography and ecosystem;
- Responsible siting to avoid social, technical and environmental problems;
- Know and apply/comply with existing siting regulations;
- Avoidance of environmentally sensitive habitat;
- Specific principles or restrictions relating to mangrove use or conversion, including the principle of no net loss of mangrove;
- Scale of development within carrying capacity of environment;
- Performance requirements/standards relating to adjacent natural habitat; and
- Define mitigation opportunities.

Pond construction
- Buffer zones between farms and adjacent farms, water bodies, or conservation areas (e.g. distance limits);
  - Removal of solid wastes to non-wetland areas;
  - Sediment and waste water treatment;
  - Minimize erosion (in ponds and canals) and seepage;
  - Separate intake and outlet;
  - Separate inlet and discharge canals; and
  - Minimize off site damage related to borrow pits, etc.

Operation and Management (General)
- Responsible management;
- None destructive solutions to predation; and
- Safe storage of all materials and inputs.

Feed and fertilizer management
- Use fresh, high quality, water stable, well stored feed; and
- Maximize efficiency of utilization of, and minimize waste associated with feed, fertilizer and other inputs through improved management.

Health management
- Minimize stress and disease through good nutrition, and sound stock and pond management;
- Correct, safe (enclosed), effective, and minimal use of therapeutants, hormones, drugs, and chemicals - administered to the water or the feed;
- Safe storage of chemicals and drugs;
- Delay discharge of chemical contaminated water until natural degradation has taken place;
• Routine monitoring of stock for disease;
• Quality records and information relating to disease outbreaks and chemical use;
• Isolation and quarantine of diseased units or stock;
• Avoid discharge of infected water;
• Safe and effective waste (related to inputs or dead stock) disposal; and
• Balance stocking rate and productivity against disease risk.

Water and waste management
• Minimize water exchange and drainage;
• Minimize re-suspension of sediments at harvest;
• Discharge water to settling basin, or some buffer zone (e.g. mangrove) if possible;
• Design out-falls to minimize impact;
• Avoid discharge of saline effluents to agricultural lands or fresh-water environments;
• Dispose of solid wastes responsibly or to specially prepared sites;
• Use water recycling and waste treatment where possible;
• Investigate polyculture systems to reduce waste and increase resource use efficiency;
• Avoid use of fresh well water to reduce pond salinity;
• Screen intake and outlet;
• Maximize in pond waste treatment (eg through effective circulation and aeration);
• Develop/use environmentally friendly chemicals/water treatments;
• Maintain pond soil quality;
• Inter-crop pond treatment;
• On-going mitigation of external impacts on sensitive habitat; and
• Specific water quality standards for effluents.

Stock management
• Use healthy stock;
• High quality husbandry;
• Minimize escapes;
• Protocols for dealing with dead or diseased stock (e.g. dispose or burn in location isolated from farm; rapid and effective disinfection of ponds with chlorine); and
• Report diseases to responsible authority.

Seed and hatcheries
• Develop hatcheries;
• Use hatchery in preference to wild seed;
• Protect and rehabilitate by-catch of wild seed fishery; and
• Close the breeding cycle (ie use captive as opposed to wild reared broodstock).
Employment and community relations

- Clear resource rights or title;
- Public involvement in design and management;
- Minimal disruption of traditional resource use;
- Involvement in community development and environment initiatives;
- Maximum employment of locals;
- High standard of working conditions; and
- Clear statements of duties, roles and responsibilities.


References

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About SEACAM

In August 1997, the Secretariat for Eastern African Coastal Area Management (SEACAM) was launched in Maputo, Mozambique. The Reference Group of country representatives from the ten Eastern African countries officially opened the Secretariat in October 1997. The Secretariat springs from the desire of the Eastern African countries to accelerate implementation of integrated coastal zone management (ICZM) in the region as put forth in the Arusha Resolution (1993) and Seychelles Statement (1996) on ICZM.

The Secretariat is a truly regional organization, which works with ten countries: Comoros, Eritrea, Kenya, Madagascar, Mauritius, Mozambique, Réunion (Fr.), Seychelles, South Africa, and Tanzania. SEACAM is designed to assist the many different stakeholders in the region striving to improve the management of coastal resources, including: Governments, local and international NGOs, donors, academics, communities and the private sector.

The Secretariat is hosted by the Ministry for Coordination of Environmental Affairs of Mozambique (MICOA). The Swedish International Development Cooperation Agency (Sida/SAREC) is the major international supporter of SEACAM.
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