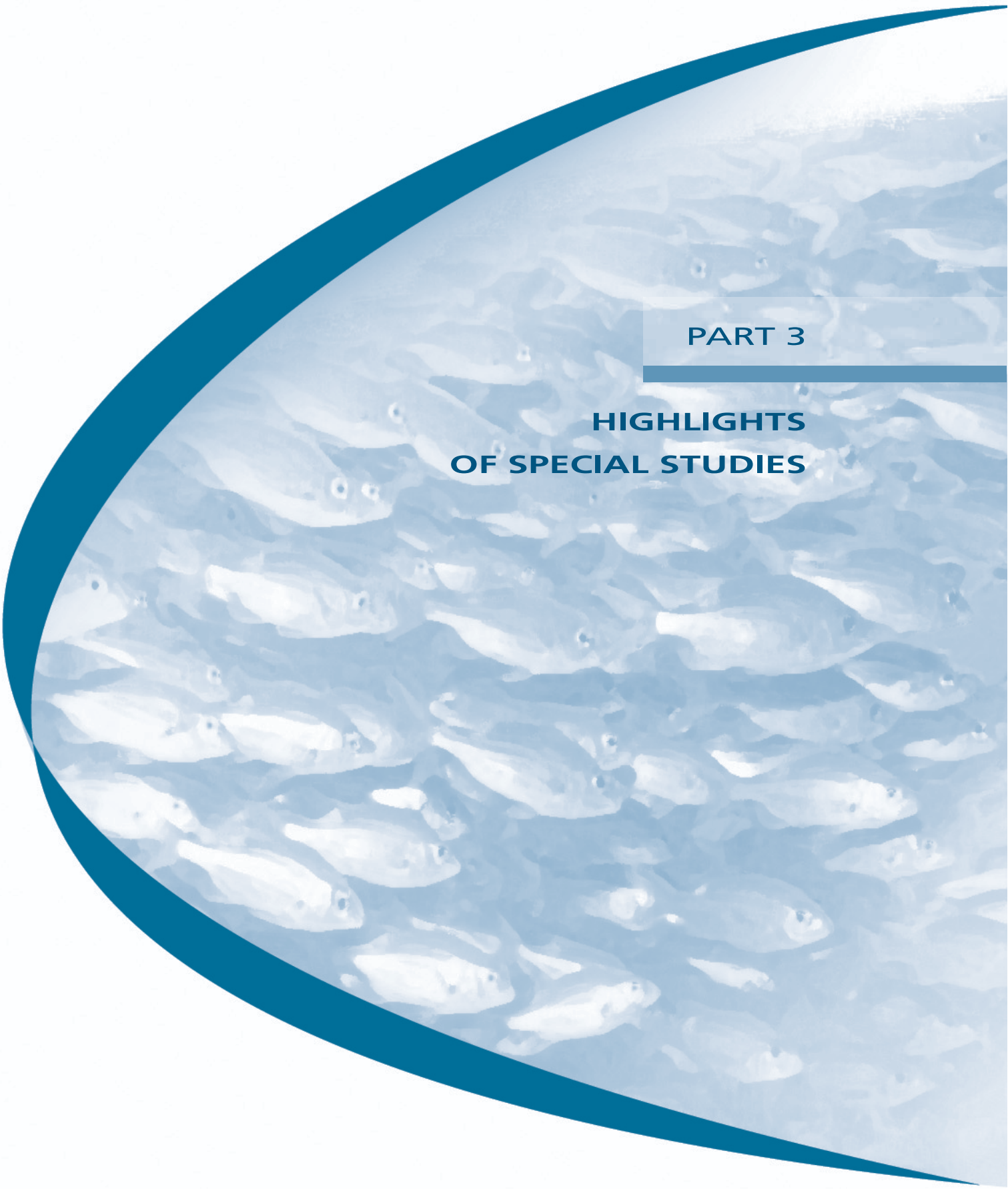


PART 3

HIGHLIGHTS OF SPECIAL STUDIES

HIGHLIGHTS OF SPECIAL STUDIES

Ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem

INTRODUCTION

The Benguela Current ecosystem occurs along the southwest Atlantic coast of Africa, extending from central Angola through Namibia to the south coast of South Africa (from about 14–17 °S to 36–37 °S). It is bounded by the Angola–Benguela Front in the north and the Agulhas Current in the south (Figure 45). The ecosystem is highly productive in terms of primary production and fisheries resources, with landings averaging about 1.5 million tonnes per year in the last decade. It is also the site of other important human activities such as mining, oil extraction and tourism. All these human enterprises provide important social and economic benefits for the three coastal states of the ecosystem but they also affect its biodiversity and health. Therefore, an integrated, ecosystem approach to managing all of these activities is essential. This need was recognized by the Steering Committee of the Benguela Current Large Marine Ecosystem (BCLME) Programme, one of the suite of large marine ecosystem programmes of the Global Environment Facility (GEF). The Steering Committee approached FAO for assistance in the implementation of an ecosystem approach to fisheries (EAF) in the region. This led to the development and implementation of a three-year project called "Ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem". The project was a cooperative effort by the BCLME Programme, the fisheries management agencies of Angola, Namibia and South Africa, and FAO. It started in January 2004 and was completed in December 2006.[1]

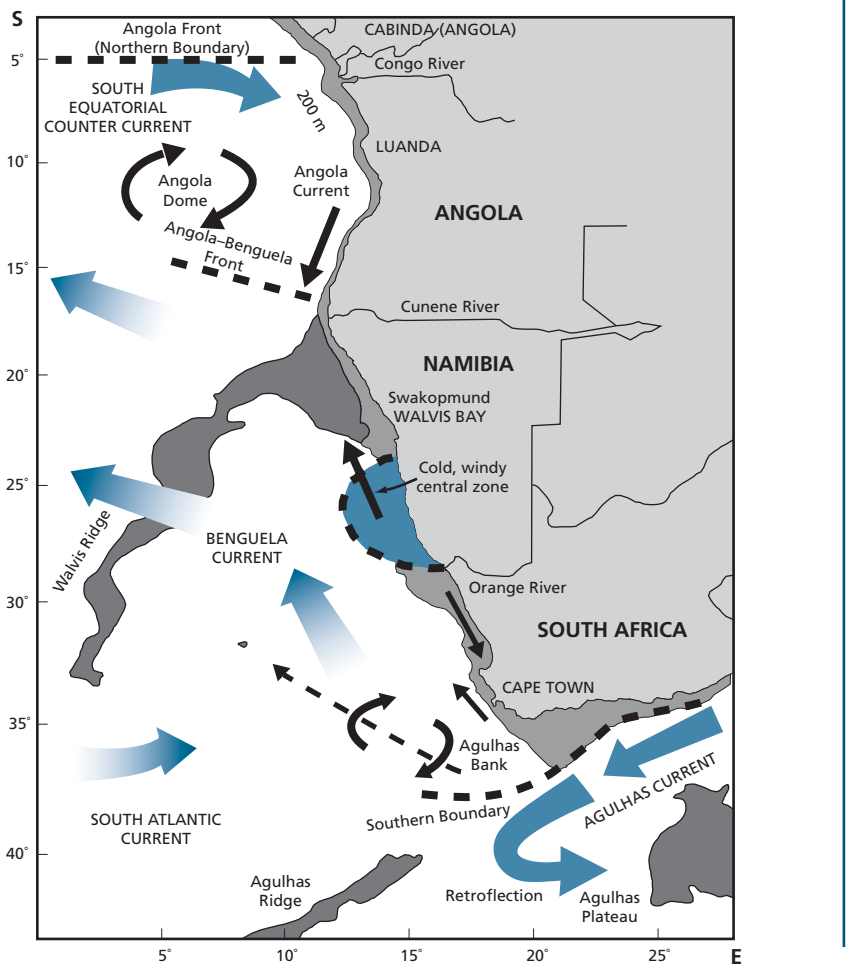
The region has a good history in ecosystem-based marine science, providing a strong knowledge-base for the development of an EAF. Fisheries management approaches and effectiveness vary across the three countries, but all three have reasonable management capacity and institutions. Therefore, the BCLME countries are in a strong position to move rapidly into proactive and comprehensive implementation of an EAF.

The primary objective of the cooperative project was to investigate the feasibility of implementing an EAF in the region. The approach followed was to examine the issues, problems and needs related to an EAF under the existing regional and national management regimes, and then to evaluate how these management systems needed to be strengthened, changed or supplemented in order to achieve sustainable utilization of the resources at an ecosystem level. In other words, an evolutionary approach was followed in order to build on the strengths of the existing management approaches and regimes, identifying needs and weaknesses, and considering how best to address them. It was considered that the most effective use of the financial and human resources available was to select some of the major fisheries as the starting point for the project, and to examine the feasibility of implementing an EAF for each of them, rather than attempting to study the whole fisheries sector simultaneously. The following ten fisheries were included in the study:

- Angola: demersal trawl (finfish); demersal trawl (deep-water shrimps); small pelagics; and artisanal fisheries.
- Namibia: hakes (trawl and longline); midwater trawl for horse mackerel; and purse seine fishery (sardine and juvenile horse mackerel).
- South Africa: hake (trawl and longline); small pelagics; and West Coast rock lobster.

Figure 45

The boundaries, major currents and physical features of the Benguela Current Large Marine Ecosystem



Source: FAO. 2007. *Results and conclusions of the project "Ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem"*, by K.L. Cochrane, C.J. Augustyn, G. Bianchi, P. de Barros, T. Fairweather, J. Iitembu, D. Japp, A. Kanandjembo, K. Kilongo, N. Moroff, D. Nel, J.-P. Roux, L.J. Shannon, B. van Zyl and F. Vaz Velho. FAO Fisheries Circular No. 1026. Rome.

INVESTIGATING THE FEASIBILITY OF AN EAF

An EAF has been accepted as the appropriate framework for marine capture fisheries, as reflected in, for example, the Reykjavik Declaration and the Plan of Implementation of the World Summit on Sustainable Development. At the Twenty-seventh Session of the Committee on Fisheries (COFI) in 2007, there was also broad agreement that an EAF was the appropriate and necessary framework for fisheries management. However, despite this high-level agreement, there remains considerable uncertainty at the operational level about the exact meaning of an EAF and what it entails. The approach used in this project, which draws heavily on the Australian model for implementation of ecologically sustainable development, has proved an effective means of helping decision-makers, managers and stakeholders to grasp why an EAF is necessary and what it means in practice.

The approach should include all stakeholder groups and be fully participatory. It starts by examining the strategies currently used for management in each fishery (it can equally be applied using, for example, a whole ecosystem or a fishing community as starting points). It identifies any problems or concerns related to the ecosystem as a whole that are not, in the view of any stakeholders, being satisfactorily

addressed. This exercise should consider ecosystem well-being, human well-being, and governance. It should also include any factors beyond the mandate or control of the fishery managers that are affecting the fishery. Once all the issues and concerns have been listed, they are prioritized. Next, potential management actions to resolve the problems are identified and described in performance or management reports. In this way, it is possible to identify where management systems may be failing to prevent or adequately control impacts that: (i) threaten the fishery itself; (ii) affect other stakeholders; or (iii) may threaten the long-term sustainability and productivity of the ecosystem and its resources.

The results from this process provide an assessment of the feasibility of implementing an EAF in the fisheries under consideration, and the implications (costs and benefits according to the different objectives for the fishery) of implementation.

THE ISSUES AND PRIORITIES FOR THE BENGUELA FISHERIES

In the course of the project, seven workshops on risk assessment for sustainable fisheries (RASF) were held. Their aim was to identify and prioritize the issues in the ten fisheries being considered in accordance with the approach described above. At the national level, the number of issues identified in each fishery ranged from 20 to 96, with a median number of about 70 issues per fishery. The percentage of issues considered high or extreme ranged from 23 percent in the South African small-pelagics fishery to 66 percent in the Angolan small-pelagics fishery. However, direct comparison across fisheries would be misleading because these percentages also reflect the different composition and perspectives among the groups of participants. Nevertheless, the number of issues with moderate, high and extreme risk values did indicate that the existing management approaches were failing to address some important needs in sustainable management, and that there was a need for the countries to make further progress in implementation of an EAF.

The types of issues identified also varied considerably from fishery to fishery, particularly in relation to ecosystem well-being. In all cases, many of the issues reflected problems in the existing single-species approaches to management, such as insufficient knowledge of abundance and life-history characteristics of targeted species, uncertainties about stock structure and distribution, and problems associated with high natural variability. On broader ecosystem issues that fall outside the conventional single-species approach, issues related to bycatch were prominent, including species of importance to other fisheries, species of conservation concern, and other species perhaps of less direct importance to humans but significant components of the ecosystem. Uncertainty and concerns about the impact of bottom-fishing gear on benthic habitat and about damage from other sources to other habitats important to species survival and ecosystem functioning were important themes across the three countries. Some of the highest-priority issues related to human well-being and governance, and these showed considerable similarity across all fisheries. They included the need to: (i) address the vulnerability of coastal communities arising from their high level of dependence on fishing and fish products; and (ii) improve governance, in particular through efforts to improve capacity for research and management and by improving consultation with stakeholders and implementation of co-management arrangements.

In addition to the national issues, the BCLME has several stocks and species that are shared between two or all three of the coastal states. These require coordinated and cooperative approaches in the management of activities affecting them. They include some species of commercial importance, e.g. hakes, sardines, horse mackerels and deep-sea crabs, as well as species of conservation concern (including some seabirds, turtles, deep-sea sharks and others). This led to a number of recommendations for strengthening regional cooperation, including the need for:

- Namibia and South Africa to cooperate in research and management of the deep-water Cape hake (*Merluccius paradoxus*);
- Angola and Namibia to cooperate in research and management of the shared sardine *Sardinops sagax* stock;

- the newly-formed Benguela Current Commission (BCC) to identify other priority species to be addressed at a regional level.

It was also noted that the BCC should consider some regional environmental issues, including: (i) monitoring and mitigating the impacts of red tides and of the regionally important low-oxygen events; and (ii) monitoring pollution from sources such as land-based activities, oil and gas exploration and extraction, and offshore mining. Their impacts on fisheries will need to be addressed.

OPTIONS FOR EAF MANAGEMENT ACTION

There may be a variety of management measures for addressing any group of issues. For example, if bycatch is creating a problem, potential solutions could include new gear regulations, closed seasons, closed areas (including marine protected areas [MPAs]), effort reduction in the fisheries taking bycatch, or some combination of these. Each option would have advantages and disadvantages for the different objectives being pursued in the fishery – which need to be considered in deciding on the best approach to use. This can be an intensive and demanding exercise, and it was not possible in the project to undertake such comparative evaluations for all the groups of issues in all the fisheries. Instead, a process for such evaluation was developed and tested. The process consisted of the following steps for each fishery:

- identifying the broad objectives for the fishery;
- identifying and aggregating the EAF issues into groups that could be addressed by the same management measures;
- identifying alternative and complementary measures to address each group of issues;
- assessing the costs and benefits (standardized measures of the advantages and disadvantages) across the set of broad objectives.

Within an EAF, identifying the broad objectives and their relative weightings for each fishery is an important step in its implementation. Indeed, this provided a useful starting point for the systematic implementation of the EAF, but the results will need to be reviewed and prioritized in consultation with the full set of stakeholders. Similarly, the exploratory identification of management solutions was a valuable exercise that demonstrated different solutions to many of the problems. This trial exercise also needs to be followed by careful planning, informed by the best available scientific and stakeholder knowledge, in order to identify management responses that would minimize the costs and maximize the benefits across all objectives for the higher-priority issues.

Working through the process described above, it was clear that significant steps had already been taken in most of the fisheries in the BCLME region to address some EAF objectives that fall outside the immediate objectives of a productive and sustainable target-species fishery. For example, in many of the fisheries, management measures are already in place to reduce bycatches of other commercial species and to reduce the impacts of fisheries on seabirds and seals. However, the current management measures and strategies have tended to be developed in disjointed and often reactive ways. As a result, the RASF workshops identified many gaps and conflicts between different objectives within the same fishery and between fisheries. Therefore, a fundamental recommendation that emerged from the project was for the national fisheries agencies and the BCC to adopt a coordinated and holistic approach in the development of management strategies that recognize and reconcile, as far as possible, the conflicting goals of all stakeholders, including both those within and those outside the fishery sector. A formal, transparent and participatory analysis of the costs and benefits of alternative measures, as demonstrated in the project, should underlie the choice of these strategies.

STRENGTHENING THE SCIENTIFIC BASIS OF MANAGEMENT

Implementation of an EAF should proceed on the basis of the best available information, and the project evaluated some aspects of scientific support for an effective EAF. These included the role of models, the use of indicators, and the implications of the high environmental variability that characterizes the Benguela upwelling system.

Models, be they conceptual, qualitative or quantitative, should represent the best understanding of the system, or subsystem, under consideration. They have a key role to play in fisheries management. Appropriate application of a precautionary approach is a prerequisite for responsible fisheries management, but rigorous and reliable information, commonly in the form of a model, can reduce the amount of precaution required in decision-making. This allows for more benefits to be obtained from a resource or ecosystem for a given level of risk than would be possible with less knowledge. In the case of an EAF, reliable ecosystem models can contribute important information to complement that from single-species stock assessment models in support of decision-making. As uncertainty tends to be compounded in ecosystem models, single-species models remain the foundation for tactical advice to fisheries. As a supplement to the single-species assessments and models, there is fair to very good competence in the development and use of ecosystem models in the BCLME region, and growing attention to their potential use for providing longer-term strategic advice.

The project also explored the role and nature of indicators for an EAF. It concluded that reliable and informative indicators are essential for management in order to track what is happening in the ecosystem and to enable management measures to be adjusted as necessary in order to achieve the desired objectives. The project did not attempt to recommend particular indicators for use in the fisheries. Instead, it recommended that a suite of indicators would be necessary to guide management and that it should cover:

- target species affected by the fishery;
- non-target and dependent species affected by the fishery (e.g. vulnerable species);
- effects on the ecosystem as a whole (e.g. diversity and trophic levels);
- environmental effects on fisheries.

Suitable indicators of social and economic status should also be an integral component of the suite. The Benguela ecosystem is characterized by high environmental variability. Its structure (e.g. the relative abundance and distribution of different species) and functioning are dynamic and can change substantially on different time scales. This has been particularly apparent in the northern Benguela ecosystem, where substantial changes have been experienced within approximately the last decade. Management and stakeholders need to be able to respond to such changes with a minimum of negative impacts on both human and ecosystem well-being. At present, it is almost impossible to predict such changes, and adaptive management is essential. The project also concluded that the governments of the BCLME countries should work with the fisheries sector to ensure that those dependent on fishing for their livelihoods are not highly vulnerable to such change. This should include ensuring that: (i) fishing capacity is commensurate with the long-term productivity of the resource; (ii) there is suitable diversification in livelihoods; and (iii) alternative livelihoods will be available for those who cannot be accommodated in a fishery when the "state" of the ecosystem changes. At the same time, attention should be given to developing improved forecasting capacity.

STRENGTHENING THE DECISION-MAKING PROCESS

Decision-making in fisheries management within an ecosystem approach has to address the widely divergent desires and needs of the different stakeholders and the conflicts that will inevitably occur among them. Effective decision-making is needed in order to identify and agree on solutions, usually in the form of management responses, that will satisfy the full range of stakeholders to the greatest extent possible. However, the project noted that, in common with fisheries throughout the world, management decisions in the fisheries in the BCLME were often made in a fragmented and unstructured way. Therefore, as a matter of urgency, it recommended that transparency, participatory management and decision-making be improved in the BCLME region. Failure to achieve this could lead to suboptimal decisions and widespread dissatisfaction among stakeholders, leading to conflict and lower compliance. Formal multicriteria techniques can contribute to effective decision-making.

INCENTIVES FOR FACILITATING AN EAF

Incentives can be thought of as any factor that affects individual choice of action. They can be either coercive or encouraging. For example, economic incentives can include fines for unacceptable practices, or rewards for adhering to rules (such as market accessibility through ecolabels). Incentives can be legal, institutional, economic or social. The project recognized that while incentives are being used in BCLME fisheries in order to encourage compliance and responsible fishing, the range of possible incentives and their potential application in the implementation of an EAF had not been formally evaluated. Some specific incentives to facilitate the implementation of an EAF in the region were identified. These included:

- improved communication among stakeholders, policy-makers and management;
- making scientific information available as a basis for negotiation with stakeholders;
- co-management;
- ecolabelling;
- allocation of long-term user rights, where not already in place;
- alternative livelihoods in cases where fishing capacity needs to be permanently reduced.

INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTATION OF AN EAF

Effective implementation of an EAF will frequently require some changes in the institutional structure of the designated management agency. In particular, institutions and processes will be required to integrate the different aspects of the EAF, including allowing for participation by the full range of stakeholders. However, in this case study, the overriding institutional problem for all three countries was considered to be the more general problem of insufficient capacity. This issue was affecting the ability of the fisheries management agencies to fulfil their responsibilities under a conventional target-species focused approach, and it would be even more of a problem in the implementation of an EAF. Strengthened capacity was particularly required in research and management, but the need also extended to other services, including policy, economics and social sciences.

The participants in the project also identified a number of other institutional priorities. These included the need to:

- develop resource management structures that involve the main stakeholders and that include co-management;
- improve communication with stakeholders outside the fishery sector but affecting fisheries (e.g. the oil and offshore mining industries) and with government departments responsible for those activities;
- increase the capacity to sustain long-term ecosystem monitoring, the deployment of scientific observers and improved data management.

Despite the problems being experienced with capacity issues, the project concluded that progress in implementation of an EAF could be made.

RESEARCH NEEDS

The project concluded that research capacity in the region was limited. This requires both medium- and long-term capacity building and, in the short-to-medium term, that the higher-priority research questions be identified and addressed. During the project, many research needs were identified. These should provide a useful starting point for countries and the BCC to review their research requirements and set the priorities for implementing an EAF. One important issue was the need to give serious attention to boosting capacity in social and economic research and in improving cooperation between natural scientists and the social and economic scientists active in fisheries. In addition, the individual countries and the BCC should ensure that long-term monitoring of indicator variables is taking place, this in order to provide effective feedback on key ecosystem states and functions. Linked to this point was a concern that the existing capacity for the quality control, storage and processing of data and information is inadequate and needs to be strengthened as a top priority.

CONCLUSIONS

The countries of the BCLME have made considerable progress in implementing an EAF, with differing degrees of progress in different fisheries. However, a primary finding of the project was that the implementation of the EAF had, in general, been done in a more or less ad hoc manner and that many gaps remained. The RASF workshops provided preliminary priorities and some tentative management solutions to fill in these gaps. In addition, some fundamental requirements and aids to improve implementation were identified. These covered indicators and reference points for the EAF, examination of means to improve decision-making, and the institutional needs for the EAF, as well as the potential contribution of incentives.

The problems and opportunities for EAF implementation that exist in the BCLME region will be unique in their detail. However, at a more general level, they are likely to be shared by many other countries, especially, but by no means exclusively, developing countries. Therefore, this case study may be of considerable interest and relevance to many other countries and regional fisheries management organizations in the global pursuit of effective ecosystem approaches to fisheries.

Increasing the contribution of small-scale fisheries to poverty alleviation and food security[2]

FAO Fisheries Technical Paper No. 481 (2007) suggests how inland and coastal small-scale fisheries could increase their contribution to poverty alleviation and food security in line with the commitment by the international community enshrined in the UN Millennium Development Goals (MDGs). A companion document to the Code of Conduct for Responsible Fisheries Technical Guidelines No. 10 on the same theme, it provides a rich body of practical examples and experiences from around the world.[3]

The paper consists of three main sections. After characterizing small-scale fisheries in the context of developing countries, the first section discusses the concepts of poverty, vulnerability and food security. It outlines how these concepts have evolved in recent years within the international community and, subsequently, in fisheries. Building on this conceptual framework, the second section considers the actual and potential contribution of small-scale fisheries to poverty alleviation and food security. The third section discusses ways of increasing the contribution of small-scale fisheries to poverty alleviation and food security through various entry points, including pro-poor policy, legislation and fisheries management instruments as well as through cross-sectoral policy approaches and making markets work better for the poor. The paper concludes with a discussion on the overarching need to develop better communication strategies. It recommends measures for bridging research, policy and action, including the establishment of fisheries fora, sensitization of governments and international development agencies, and advocacy to influence policy agendas.

CONCEPTS OF POVERTY, VULNERABILITY AND FOOD SECURITY

The OECD publication *The Development Action Committee Guidelines – Poverty Reduction* states: "The concept of poverty includes different dimensions of deprivation." (p. 37). These dimensions relate to human capabilities including consumption and food security, health, education, rights, voice, security, dignity and decent work.[4]

This new conceptualization of poverty results from a long evolution in the ways it has been perceived, understood and measured. In the 1960s, the concept of poverty was influenced by the income poverty approach then in widespread use. Thus, poverty was associated closely to low income or consumption. In the 1970s, the ILO and the United Nations Research Institute for Social Development pioneered the development of the basic-needs model. This model arose from the recognition that poverty is not simply the result of low income but also reflects a general deprivation of the

material requirements to meet minimally acceptable human needs, such as health and education, clean water and other services required to sustain livelihoods. This basic-needs model, premised on a multidimensional definition of poverty, later led to the formulation of the human development model by the United Nations Development Programme (UNDP).

The 1980s witnessed a further redefinition of the concept of poverty. An instrumental element in this new approach was the work of Sen and his concept of "food entitlement", i.e. the recognition that people's command over food does not depend simply on its production and availability in the market but is also governed by a range of social, economic, cultural and political factors.[5] Other influential concepts, such as the role of power, emerged in the same period, either in relation/reaction to Sen's entitlement concept, or independently. Powerlessness – or its counterpart, empowerment – refers to the means by which entitlements (access to resources) are maintained and defended. Chambers[6] and many others stressed that the poor usually suffer from a low level of sociopolitical organization and that their capacity to make their voice heard is consequently weak, resulting in exclusion from political and decision-making processes. Conjointly with the issue of power, or strongly related to it, the concept of participation then emerged in the literature. Underlying this participatory approach was the recognition that the involvement of various groups, and especially the poor, in the planning and decision-making processes was a necessary condition to ensuring their empowerment. The 1980s were also characterized by the wide recognition of the previously neglected issue of gender-related poverty.

The evolution and debate that have animated the international development community in the last 30 years have also been reflected more recently in the fisheries domain. In particular, the multidimensional nature of poverty in fishing communities is now widely acknowledged and accepted. Fishers generally live in remote and isolated communities, are poorly organized and politically voiceless, and often have a high exposure to accidents and natural disasters. The various related aspects of inadequate services, poor education, politically poorly-organized communities and vulnerability are some of the multiple dimensions of poverty that are now universally recognized. Therefore, poverty in fishery-dependent communities is not necessarily directly or only related to the resource or catch levels. For example, although resource overexploitation may be a major cause of impoverishment for fishing communities, extreme poverty can also be observed in remote fishing camps where fishers catch and trade reasonable volumes of fish but lack access to health and other public services and are politically unrepresented. This evolution in understanding has also been reflected in recent attempts to develop methods of assessing the different dimensions of poverty in fishing-dependent communities. Such methods combine measures of incomes, assets and the vulnerability context.

Several aspects of the multidimensional nature of poverty that affect the fishing community, both men and women, are induced, maintained or even increased by factors or socio-institutional mechanisms specific to fishing activities. For example, a certain degree of vulnerability is inherent to the activity of fishing communities. Another important specificity that may contribute to, or even increase, households' exposure to poverty is the fact that many of them are highly mobile. In Africa – and to a lesser extent in Asia – a significant number of fishing communities consist of groups of migratory individuals who live in temporary or semi-permanent fishing camps. Beyond the poverty aspects related to the frequent lack of infrastructure of these camps (access to water or sanitation and services such as schools and health centres), this status of "migrant" also generally augments the likelihood of political underrepresentation or social marginalization.

While efforts are ongoing to improve understanding of the nature and causes of poverty in fishing communities, a more recent focus includes a parallel effort to understand how small-scale fisheries can contribute to poverty alleviation. In this new focus, it is important to distinguish between poverty prevention and poverty reduction.

Failure to make this distinction may lead to unwanted outcomes and inappropriate policies.

Poverty reduction in fisheries communities describes a situation where people are becoming measurably better off over time owing to their involvement and/or investment in fisheries or fisheries-related activities. The three economic levels at which poverty reduction can occur – household and intrahousehold, local and national – depend on different mechanisms and, therefore, relate to and require different policies. Hence, in the paper, the overall contribution of small-scale fisheries to poverty reduction is grouped into three categories: (i) wealth generation at the household level and its distribution within households – to men, women and children; (ii) a rural development engine at community level; and (iii) economic growth at national level. The interdependence of these three levels is complex. A migrant fisherman may earn a significant cash income that is not remitted back to his household, leaving his wife and children in conditions of poverty. A few fishers may become very rich (wealth generation) without their community benefiting from their wealth. On the other hand, in several countries where artisanal fisheries contribute significantly to national economic growth (e.g. Ghana and Senegal), many fisheries communities (and, even more so, fishing households) in remote coastal areas still live at the margins of subsistence and dignity.

In contrast, *poverty prevention* refers to the role of fisheries activities in enabling people to maintain a minimum standard of living (even when it is below a given poverty line) that helps them to survive. Thus, poverty prevention refers to reducing risks and increasing safety net functions in a general context of vulnerability. Vulnerability can be conceptualized[7] as the combinatory result of:

- risk exposure (i.e. the nature and degree to which a household or community is exposed to a certain risk, for example, natural disaster, conflicts and macroeconomic changes);
- sensitivity to this risk – measured, for example, through the dependence of the household or community on the fishing activity for its food security or income generation;
- the adaptive capacity of the household or community to the risk considered (i.e. its ability or capacity to adapt in order to cope with changes).

Therefore, although the two concepts are intimately related, vulnerability is different from poverty. Vulnerability is a part of poverty in that poor people tend to be more vulnerable (higher risk exposure plus more sensitivity and lower adaptive capacity) than non-poor people. For example, they may not have access to insurance or good-quality services (e.g. health and education), or they may depend highly on the fisheries to ensure their food security. However, it is also true that, in a given environment, with the same level of income and similar access to public services, some people may be more vulnerable than others because of the very nature of the activity on which they depend. Experience shows that this is the case for many fishing households.

CONTRIBUTION, ROLE AND IMPORTANCE OF SMALL-SCALE FISHERIES

Building on the above conceptual framework, the second section of the technical paper considers the actual and potential contribution of small-scale fisheries to poverty alleviation and food security. Using concrete examples, it illustrates the role they can play in economic growth at national level and in poverty alleviation and rural development at local level through mechanisms such as income and employment multipliers, safety net mechanisms and coping strategies.

There is often little precise information on their real contribution to livelihoods and economies in developing countries, and many small-scale fishing communities are poor and vulnerable. However, it is now widely acknowledged that small-scale fisheries can generate significant profits, prove resilient to shocks and crises, and make meaningful contributions to poverty alleviation and food security, in particular for:

- those involved directly in fishing (fishers, and fishworkers in both pre-harvest and post-harvest activities);

- the dependants of those involved directly in fishing (fishing-related households and communities);
- those who buy fish for human consumption (consumers);
- those who benefit from related income and employment through multiplier effects;
- those who benefit indirectly as a result of national export revenues from fisheries, redistributive taxation and other macrolevel mechanisms.

In addition, while small-scale fisheries may overexploit stocks, harm the environment and generate only marginal profit levels, it is now recognized that they may have significant comparative advantages over industrial fisheries in many cases, such as:

- greater economic efficiency;
- fewer negative impacts on the environment;
- the ability to share economic and social benefits more widely by being decentralized and geographically spread out;
- their contribution to cultural heritage, including environmental knowledge.

ENHANCING THE ROLE OF SMALL-SCALE FISHERIES

The third and main section of the document discusses ways of increasing the contribution of small-scale fisheries to poverty alleviation and food security through various entry points. The first two entry points considered are policies and legislation. In these domains, the paper briefly revisits conventional fisheries policies and legislation, and discusses them in relation to poverty alleviation and food security. This part of the paper also highlights how non-sectoral regulations (e.g. legislation on migration or workers' rights) and non-sectoral policy frameworks (such as national poverty reduction strategy plans in each country) can have positive impacts, and how they can strengthen the contribution of small-scale fisheries to poverty alleviation and food security. Next, the paper considers two generic implementation issues – human capacity development and appropriate levels of funding to support the sector – which, without proper attention, are likely to prevent the successful implementation of the recommendations made throughout the paper. It then highlights the need for cross-sectoral interventions. It makes some recommendations on areas of required cross-sectoral integration and on how to facilitate such coordinated planning and implementation. Next, in a subsection on fisheries management, it proposes broad pro-poor or pro-small-scale fisheries principles. It then turns to a more detailed discussion on three of the main management instruments increasingly adopted in the world's fisheries: (i) property right approaches; (ii) co-management – as a governance reform; and (iii) protected areas – as a tool to control access. The broad principles on pro-poor fisheries management listed in the paper are presented below.

Preferential access for small-scale fishers. Where the resource is accessible to small-scale fishers (e.g. inshore zone), an important pro-small-scale and pro-poor component of management would be the exclusion of large-scale/industrial fleets (for example, through zoning). This would favour and protect access to the resource for the small-scale fishers, among whom the poorest are likely to be found. One of the first examples of this principle was the trawl ban imposed in Java and Sumatra by the Indonesian Government in 1980.[8] This decision has kept the Java Sea fisheries as the preserve of relatively small-scale fishers, thereby enhancing rural employment and wealth redistribution.

Decentralized management responsibilities. Where local capacities are present (e.g. through existing local professional organizations and committees supported by local government), devolution of management responsibilities to the local level (the principle of subsidiarity) can improve the representativeness and the accountability of the management system, thereby enhancing the chances of local poor fishers seeing their needs and priorities integrated into the decision-making process.

Improved post-harvest and local marketing capacities. An important part of pro-poor improvement in small-scale fisheries can be undertaken in the post-harvest sector

(i.e. processing and trading activities). In much of the developing world, the lack of adequate infrastructure (e.g. roads, landing-site facilities and cold-chain facilities) and the lack of access to credit reduce the market values of small-scale fish products dramatically. Local public and private investments are urgently needed in this domain to support small-scale marketing initiatives. Such initiatives could considerably improve both the economic situation of producers and the food and nutritional security of rural and urban consumers – through higher income for the former, and better quality and increased quantity for the latter. At the same time, they could contribute significantly to rural development and the economic empowerment of women.

Small-scale local processing and value-added products. Where infrastructure and labour are available, encouraging local (decentralized) small-scale, labour-intensive fish processing is a powerful way to increase the economic contribution of the small-scale fisheries sector to the local economy. Recent studies have revealed that the net additional income from fish sales, if retained in the local area, can exceed 100 percent. In other words, if fish can be produced and processed locally, the net income benefit to the area may be more than twice the value of the fish sales.[9] To be effective and have redistributional impacts, these employment and income multiplier effects need to be backed up by strong labour rights legislation and proactive policies (focusing on access to credit) that support local investment (as opposed to foreign investment) in processing and trading facilities.

Recognizing, granting and protecting land settlement and ownership rights. Many fisherfolk live in conditions of poverty because they do not have legally recognized tenure to the land on which they settle. With insecure tenure, fishing communities are often found in temporary housing because they have no incentive to invest in improving their housing conditions. Those living in these unofficial settlements also lack access to basic state-provided infrastructure, schools, health clinics, water drainage and sanitation, etc. Coastal and inland zone planning that legally designates zones for fishing households to settle and that protects traditional landing sites from alternative development will favour the marginalized and the poor, and improve living conditions in fishing settlements.

The paper devotes considerable attention to markets and making them work for the poor, and to the important issue of pro-poor financing systems (microcredit, subsidies, etc.). It highlights the complexity of the issues and reflects the current debate on the impact of markets and trade on poverty alleviation. It is recognized that both the domestic and the international fish trade generate "winners" and "losers". However, the poorest – who generally remain excluded from well-functioning market institutions – are likely to be among the losers. This debate reinforces the importance of microcredit schemes for the poor. It also raises the question of the conditions under which subsidies may or may not be used to support poverty alleviation programmes.

It is possible to improve the livelihoods of fisheries-dependent individuals, households and communities through initiatives that address issues completely outside the sector and the usual areas of intervention in fisheries development. A good example is the literacy programme initiated recently in the State of Mato Grosso in Brazil, where about 45 percent of professional fishers were illiterate.

Taking an even wider perspective, some integrated rural development initiatives seek to create or strengthen cross-linkages between *inter alia* literacy, housing, social security, health and infrastructure. Such initiatives can also have significant positive impacts on the livelihoods of small-scale fishers without necessarily addressing resource management issues directly. A good example of this type of approach is an FAO-funded project in Cox's Bazaar, Bangladesh. Here, the villages along the coast have been empowered to improve their well-being by first dealing with sanitation and health problems, then improving educational facilities and developing saving schemes and, as a last step, addressing fishery resource management and safety-at-sea issues. This type of holistic rural development approach helps to overcome the dilemma of how to conserve resources in the longer term when the immediate imperative is to alleviate poverty and reduce the vulnerability of fishworkers and their families.

Another important area of cross-sectoral initiatives is livelihood diversification through support for non-fishing activities as part of household and community livelihood strategies. In fact, the promotion of alternative livelihoods has recently become a common feature of fisheries programmes in tandem with other more conventional policy and management measures. Two main kinds of approaches can be distinguished: (i) those aimed at creating supplementary livelihoods, rather than alternative ones, to reduce dependence on fishing; and (ii) those aimed at encouraging people to withdraw from fishing activities. These approaches are not mutually exclusive. The former can be used as an initial step towards the creation and accumulation of sufficient capital and assets for a later definitive withdrawal from the sector.

Last, the paper examines the research agenda and associated information and communication strategies needed in order to increase the contribution of small-scale fisheries to poverty alleviation and food security. It proposes a re-orientation of monitoring and research programmes towards more participatory approaches, and enhanced integration of social science and indigenous knowledge systems. Research areas are identified around five major themes of importance to small-scale fisheries:

- Poverty and vulnerability, including: studies of income, expenditure and asset values; access to assets, property rights, and power relations; factors of vulnerability; and psychosocial impacts of poverty and marginalization.
- Demographic, economic, social and cultural issues among fisherfolk, including: gender, migration, and traditional knowledge and culture.
- The role and contribution of small-scale fisheries in rural and peri-urban economies in developing countries, e.g. value chain analysis, environmental evaluation, and fisheries policy analysis.
- Effectiveness of the changing fisheries governance regime, including: factors associated with successful comanagement; the role of local and central government; and the impact of regional and international agreements on poverty.
- Small-scale fisheries, resource and environmental conservation, including: small-scale fisheries as conservationists, and MPAs and their impacts on poverty.

A global study of shrimp fisheries

The world's production of shrimp, captured and farmed, is approximately 6 million tonnes, about 60 percent of which is traded internationally. Annual exports of shrimp are currently worth more than US$14 billion, or 16 percent of all fisheries exports. This makes it the most important internationally-traded fisheries commodity.

A recent FAO study has analysed the world's shrimp fishing industry, the issues that affect it, and how these are managed.[10] The study is global in scope and comprehensive in its portrayal and analysis of the industry. This text is not equally comprehensive. Following a summary of the current situation of the industry, it focuses on its management.

THE CURRENT SITUATION OF THE WORLD'S SHRIMP FISHING INDUSTRY

The world catch of shrimps is about 3.4 million tonnes per year (Table 11). Asia is the most important area for shrimp fishing. Together, China and four other Asian countries account for 55 percent of the total shrimp catch (Table 12).

Worldwide, slightly fewer than 300 species of shrimps are of economic interest. Of these, about 100 species account for the principal share of the catch. By weight, the most important single species in the world is the Akiami paste shrimp (*Acetes japonicus*).

Globally, little is known about the numbers of vessels and fishers involved in shrimp fisheries. However, production and trade statistics provide some knowledge of the overall importance of these fisheries. Table 13 presents indicators of the economic contribution of shrimp fisheries for selected countries.

Table 11
Catches of shrimps

FAO name	Scientific name	1965	1975	1985	1995	2005
				(tonnes)		
Natantian decapods NEI	Natantia	239 028	524 096	629 327	542 552	887 688
Akiami paste shrimp	*Acetes japonicus*	104 000	13 524	222 608	406 495	664 716
Southern rough shrimp	*Trachypenaeus curvirostris*		5 278	93 028	154 623	429 605
Northern prawn	*Pandalus borealis*	25 503	63 557	235 587	275 601	376 908
Penaeus shrimps NEI	*Penaeus* spp.	194 009	261 450	277 565	296 483	230 297
Giant tiger prawn	*Penaeus monodon*	9 981	12 940	12 195	207 097	218 027
Fleshy prawn	*Penaeus chinensis*		34 297	33 191	44 449	106 329
Banana prawn	*Penaeus merguiensis*	22 400	39 269	39 023	71 150	83 392
Metapenaeus shrimps NEI	*Metapenaeus* spp.	10 927	30 410	36 690	51 536	63 211
Atlantic seabob	*Xiphopenaeus kroyeri*	8 000	13 093	17 900	18 802	52 411
Northern white shrimp	*Penaeus setiferus*	32 141	26 802	44 573	39 959	50 253
Common shrimp	*Crangon crangon*	52 200	35 902	27 328	30 761	44 852
Northern brown shrimp	*Penaeus aztecus*	57 250	44 736	70 852	57 126	44 692
Sergestid shrimps NEI	*Sergestidae*		26 229	52 602	60 377	23 259
Deep-water rose shrimp	*Parapenaeus longirostris*	12 700	18 099	39 896	15 833	19 938
Southern pink shrimp	*Penaeus notialis*	1 900	6 744	6 896	21 484	14 648
Pacific shrimps NEI	*Xiphopenaeus, Trachypenaeus* spp.	9 113	63 564	15 222	15 130	12 125
West African estuarine prawn	*Nematopalaemon hastatus*					11 700
Parapenaeopsis shrimps NEI	*Pandalus* spp., *Pandalopsis* spp.	7 927	6 085	8 486	12 919	10 412
Redspotted shrimp	*Penaeus brasiliensis*	100	774	8 006	6 565	9 390
Northern pink shrimp	*Penaeus duorarum*	11 048	18 955	15 512	11 121	7 720
Argentine red shrimp	*Pleoticus muelleri*	300	190	9 835	6 705	7 510
Caramote prawn	*Penaeus kerathurus*	1 000	3 505	2 879	4 880	6 655
Chilean nylon shrimp	*Heterocarpus reedii*	5 900	7 934	2 949	10 620	3 880
Aristeid shrimps NEI	*Aristeidae*				2 551	3 174
All other species items		24 395	54 111	71 933	83 023	33 741
Total		829 822	1 311 544	1 974 083	2 447 842	3 416 533

Note: NEI = not elsewhere included.
Source: FAO. 2007. Capture production 1950–2005. FISHSTAT Plus – Universal software for fishery statistical time series (online or CD–ROM) (available at: http://www.fao.org/fishery/topic/16073).

As part of the study, the shrimp fisheries of ten countries (Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago, and the United States of America) were examined in detail. One of the main features to emerge is the current low profitability of many commercial shrimp fishing operations. The typical situation is one of rising costs (mainly fuel) and falling revenues (to a large degree owing to competition with farmed shrimp) in an environment where there is overcapacity in shrimp fishing fleets.

Table 12
Shrimp catches by country or territory, 2000–05

Country/ territory	2000	2001	2002	2003	2004	2005	Average 2000–05
				(tonnes)			
China	1 023 877	909 083	911 838	1 451 990	1 481 431	1 471 575	1 208 299
India	343 860	328 941	400 778	417 039	369 153	366 464	371 039
Indonesia	252 914	266 268	242 338	240 743	246 014	235 050	247 221
Canada	139 494	129 774	139 061	144 495	178 743	139 829	145 233
United States of America	150 812	147 133	143 694	142 261	139 830	118 446	140 363
Greenland	86 099	86 451	105 946	84 764	137 009	137 009	106 213
Viet Nam	96 700	94 282	94 977	102 839	107 069	107 900	100 628
Thailand	84 625	85 115	80 996	79 082	71 889	67 903	78 268
Malaysia	95 976	77 468	76 020	73 197	78 703	52 788	75 692
Mexico	61 597	57 509	54 633	78 048	62 976	66 968	63 622
Norway	66 501	65 225	69 148	65 564	58 960	48 310	62 285
Philippines	41 308	48 398	43 386	46 373	46 132	45 101	45 116
Argentina	37 188	79 126	51 708	53 310	27 293	7 654	42 713
Brazil	39 185	28 025	29 100	34 013	32 504	38 497	33 554
Republic of Korea	36 035	30 800	29 634	31 117	19 345	21 116	28 008
Iceland	33 539	30 790	36 157	28 787	20 048	8 659	26 330
Nigeria	20 446	19 714	30 489	28 205	22 915	28 549	25 053
Japan	27 345	25 682	25 751	24 265	23 069	22 981	24 849
Australia	23 773	27 329	25 670	23 090	23 745	20 336	23 991
Pakistan	25 130	24 936	22 532	24 411	24 774	18 923	23 451
Myanmar	23 000	22 500	22 000	21 500	21 000	20 404	21 734
Guyana	19 329	26 851	20 564	22 584	18 605	18 391	21 054
Germany	17 423	12 571	15 966	16 269	19 222	22 616	17 345
Russian Federation	36 926	20 921	13 299	11 544	11 646	9 144	17 247
Suriname	10 606	13 340	13 522	16 330	26 204	22 309	17 052
Spain	21 508	27 105	17 212	14 241	10 375	8 392	16 472
Taiwan Province of China	20 603	17 403	13 545	6 491	14 415	26 297	16 459
Netherlands	11 497	14 084	11 458	14 834	14 502	16 227	13 767
Estonia	12 819	11 241	14 240	12 966	13 586	12 381	12 872
Mozambique	11 195	11 139	10 913	14 964	13 395	14 779	12 731
Madagascar	12 127	11 776	13 223	13 314	11 315	10 900	12 109
Faeroe Islands	12 611	15 930	13 141	14 083	9 314	7 183	12 044
Venezuela (Bolivarian Republic of)	9 882	12 128	9 981	11 480	11 480	11 480	11 072
Italy	12 333	9 499	8 619	9 262	6 716	17 671	10 683
Cambodia	5 000	8 800	10 000	12 300	12 600	13 500	10 367

Source: FAO. 2007. Capture production 1950–2005. FISHSTAT Plus – Universal software for fishery statistical time series (online or CD–ROM) (available at: http://www.fao.org/fishery/topic/16073).

However, among shrimp fisheries, the greatest challenges occur in developing countries. These typically have the major problems of overcapacity, overexploitation, conflict with small-scale fishers and high discard rates for the industrial-scale trawl vessels. In addition, the countries in which these challenges occur characteristically have weak fisheries institutions and, thus, little ability to research and manage these difficulties. In short, there are many problems but few affordable solutions. Many of

Table 13
Some indicators of economic contributions of shrimp fisheries

Country	Contribution to GDP	Annual consumption *(kg/person)*	Employment	Annual catch value *(US$)*	Annual exports *(US$)*
Australia	NRA	2.2	1 040 people; about 5% of all fishing employment	240–292 million	128 million; net importer
Cambodia	NRA	NRA	No data available; crude estimate of 8 000 people involved in trawling	Official estimate not readily available; at US$2/kg, catch worth 7.4 million	1 578 tonnes (no official data on value); at US$4/kg, exports worth 6.3 million; most valuable fishery export
Indonesia	NRA	About 0.5	2 900 people on industrial trawlers; small-scale employment unknown but much larger	558 million	887 million; most valuable fishery export
Kuwait	About 0.01%	NRA	335 onboard; almost all expatriates	7 million	1 million; net importer
Madagascar	Industrial and artisanal sectors contributed 1%; traditional sector contribution not readily available	0.1 (crude estimate)	Industrial/artisanal shrimp fishing employs 3 970 people; traditional (part-time) varies between 8 000 and 10 000 people	70.2 million	68.2 million; most valuable fishery export
Mexico	NRA	0.66	One estimate indicates 190 884 fishers employed	300 million	346 million; most valuable fishery export
Nigeria	NRA	NRA	One estimate indicates 1.2 million people have formal or informal jobs associated with shrimp fishing and post-harvest	70 million from industrial vessels	49 million; most valuable fishery export
Norway	0.25%	1.7	998 people onboard	228 million	125 million; important export
Trinidad and Tobago	About 0.2%	NRA	324 fishers directly involved in shrimp trawling	2.72 million	800 000; most valuable fishery export
United States of America	NRA	1.9	NRA	425 million	15 000 tonnes; imports are 500 000 tonnes

Note: NRA = not readily available.

the countries in this category are highly dependent on the economic benefits of shrimp fishing.

For the past century, a major characteristic of most large-scale[11] and mechanized shrimp fishing has been the use of trawl gear. Despite considerable interest in developing an alternative to shrimp trawling, no substantial progress has been made. Therefore, in recent decades, most shrimp gear technology efforts have been channelled into improving trawl gear selectivity and trawling techniques, rather than developing new technology for industrial shrimp fishing.

There are several reasons for the interest in replacing the trawl. The most well-known is perhaps that of bycatch and discards. Other reasons are the negative consequences caused by the physical contact between the trawl and the sea-bottom, and the damage done to other fishing gear set on the same fishing grounds where trawling takes place.

Bycatch, particularly that which is discarded, is a serious concern because of various interconnected reasons that are not specific to shrimp fishing. First, the lack of identification of the animals killed and discarded (many of which are vulnerable or threatened emblematic species) impedes proper assessment of their state of exploitation and any direct management, thereby raising the risk of depletion or outright extinction. Second, the bycatch creates interactions with other fisheries targeting the same species, complicating assessment and management. Third, bycatch, like directed catch, affects the overall structure of trophic webs and living habitats. Finally, the discarding of killed animals raises the ethical issue of waste of natural resources.

A recent FAO study indicated that the shrimp trawl fisheries are the main source of discards, accounting for 27.3 percent (1.86 million tonnes) of the total estimated discards in world capture fisheries.[12] The aggregate, or weighted, discard rate[13] for all shrimp trawl fisheries is 62.3 percent, which is very high compared with other fisheries.

An important bycatch issue in both warm-water and cold-water shrimp trawl fisheries is the catch of juveniles of important commercial fish species. This is significant in several fisheries, including the bycatch of cod off Norway; rockfish off Oregon (the United States of America); red snapper and Atlantic croaker in the Gulf of Mexico; king mackerel, Spanish mackerel and weakfish off the southeast coast of the United States of America; and plaice, whiting, cod and sole in the southern North Sea.

The bycatch of sea turtles by warm-water shrimp trawling is a contentious topic. The subject has generated considerable publicity, and subsequent management action has had a major effect on most large shrimp fisheries in the tropics. The means to reduce turtle mortality by shrimp trawling are well known, but they come at a price.

There have been some significant reductions in the shrimp bycatch from large- and medium-scale shrimp fisheries. The situation appears manageable, and it is likely that further reductions in bycatch levels could be made, albeit with some sacrifices on the part of fishers. A major challenge at this point is to determine the acceptable levels of bycatch, considering the costs and benefits of reaching such levels.[14] The objective of reducing bycatch in many small-scale shrimp fisheries of developing countries is challenging and perhaps unattainable. The economic incentives in these fisheries do not favour bycatch reduction, and enforcement of any requirements for bycatch reduction can be extremely difficult.

Various measures have been used to reduce shrimp bycatch. They include: bans on trawling; bans on fishing in areas and/or periods when bycatch is known to be high; reducing the overall fishing effort; and, most commonly, modifications of the fishing gear – mainly through the use of bycatch reduction devices and other modifications to trawl nets. Other measures used to reduce bycatch are: catch quotas, discard bans, and limits in the shrimp-to-bycatch ratio.

The degree to which shrimp fishing, specifically trawling, alters the seabed and its associated effects on biodiversity have generated considerable discussion and

controversy, echoing and contributing to the more general and controversial debate on trawling. The factors complicating this debate include:

- the difficulty in clearly separating fishing impacts from environmental variability;
- the lack of information on the original state of some fishing grounds;
- a lack of agreement on the level and quality of the evidence of impacts;
- the doubts about the reversibility of these impacts;
- the objective difficulty in assessing the more insidious impact of the overall flattening of the ground and the less visible impacts on the benthic and microbial fauna;
- the relative importance attached to the ecological, social, economic and societal costs and benefits of fishing.

It is mostly in developing countries that large-scale shrimp fishing has several types of interactions with small-scale fisheries. These include: physical interactions, safety at sea, targeting the same resources, interaction through bycatch, habitat disturbance, and market interactions. To reduce the physical impacts of large-scale shrimp fishing on small-scale operations, the most common measure is to move the large boats offshore.

There is a general feeling among fisheries managers in several regions of the world that the various approaches for reducing negative interactions would be effective if enforced. However, in the developing countries where the conflicts generated by shrimp fishing are greatest, the required governance and enforcement are weakest. This is either because of a lack of capacity in monitoring, control and surveillance, or because the social costs of the measures, if enforced, are perceived as dangerously high.

MANAGEMENT OF SHRIMP FISHERIES

A fundamental problem of many of the world's shrimp fisheries is open access – the right of the public to participate in a fishery. In general, where there are no barriers to entry, fisheries typically produce at the point where total revenue equals total costs (or beyond, where subsidies are provided). The history of shrimp fishery management shows that management interventions that do not control access and/or removals (e.g. catch limits and closed seasons) are usually ineffective at preventing economic overfishing in the long term.

An additional problem is that management objectives are rarely prioritized and not always clearly stated. The long-term conservation of the resource is an important management objective in most shrimp fishery management schemes. Maximum economic yield is also an important objective in the management of many shrimp fisheries in developed countries. Maximum sustainable yield is also common, with Indonesia being an important example. Reducing bycatch/discards and physical impacts is becoming increasingly important, especially in developed countries. Conflict reduction plays an important role as a management objective in shrimp fisheries, especially in developing countries. Achieving an equitable allocation of shrimp resources among the various users is important in the penaeid fisheries owing to the movement of shrimp between shallow inshore areas and deep offshore areas. Maximizing employment is sometimes the de facto most important management objective in some poorer countries. Generation of government revenue through licence fees is often an unstated objective in the management of shrimp fisheries.

In this context, it should be noted that it is very difficult to prioritize the incongruous and conflicting objectives that are often set for shrimp fisheries. On the practical level, one situation is especially common – attempting to maximize economic yield in an open-access regime. Open-access shrimp fisheries, probably more common in the world than those with restricted access, often have maximizing employment as an important objective. However, this is incompatible with the economic efficiency needed to generate maximum economic yield.

In the process of managing shrimp fisheries, some form of balancing the benefits with the various costs is required. In view of the scarcity and limitations of the data on both shrimp fishing benefits and costs, there appears to be insufficient information on

the benefits in most countries to determine whether the costs incurred by management are justified. Although it is recognized that it is very difficult to compare benefits and costs for most shrimp fisheries, they are in effect being compared and trade-offs being made in the fisheries management process. The controversy that often results appears to stem, at least partially, from the lack of stakeholder consensus on the mechanisms for making the trade-offs and on the adequacy of the information used.

Various measures are available to the managers of shrimp fisheries. Some of the main management issues and associated management interventions are:

- *Economic overfishing* in shrimp fisheries has been addressed by catch limits, limiting/reducing participation, gear restrictions, stock enhancement, monetary measures and subsidies.
- *Growth overfishing* has been dealt with by closed seasons, closed areas, mesh sizes and minimum shrimp-landing sizes.
- *Discard/bycatch* has been addressed through bycatch reduction devices, turtle excluder devices, mesh sizes, other net modifications, gear restrictions, no-discard policies, closed areas, bycatch limits on particular species, unilateral trade measures and raising fishers' awareness.
- *Physical impacts and ecosystem damage* have been dealt with by gear restrictions, closed areas and fishing effort reductions. Total bans on trawling have been proposed.
- *Conflicts with small-scale fishers* have been addressed by zoning, bycatch reduction devices, reduction in large-scale fishing effort, time sharing of fishing grounds and total bans on trawling.
- *Resource allocation between groups of fishers* has been addressed through closed areas, closed seasons, gear restrictions and mesh sizes.
- *Inshore nursery-ground habitat degradation* has been addressed by controls on coastal-zone development and land reclamation, restricting pollution and watershed management.

In countries with effectively managed shrimp fisheries, legislation often requires or encourages certain positive features. These include:

- fisheries management plans;
- bycatch management plans;
- collaboration among the various stakeholders;
- provision for keeping management interventions at arm's length from the political process;
- ecosystem-based management;
- the flexibility to intervene quickly based on research findings or changing fishery conditions.

However, many of these features are important for fisheries management in general and not strictly specific to shrimp fishery management.

In general, the management of shrimp fisheries is associated with a more complex enforcement environment than most other fisheries (although there is a wide range of national conditions). The complicating factors for shrimp fisheries include: the use of many types of management measures (many of which require enforcement activities at sea); large incentives to circumvent restrictions on inshore trawling; the fact that many restrictions are counter to the short-term economic interests of fishers, some management measures infuriating fishers; and the huge problems of enforcing requirements in small-scale shrimp fisheries.

Some important enforcement issues emerged in the study:

- Poor enforcement appears to stem from: insufficient operational budgets, inadequate enforcement infrastructure, weak institutions, political considerations affecting enforcement priorities, and corruption.
- In many cases where there is efficient enforcement, the fishing industry itself has at least some enforcement responsibilities.
- If penalties for non-compliance are harsh enough, then the actual detection efforts do not need to be as great.

- A reasonable degree of compliance with some of the technical measures (e.g. mesh sizes, and bycatch reduction devices) requires at least some onboard observer coverage.
- Enforcement of regulations in small-scale shrimp fisheries is often considered too difficult and not attempted.

The foregoing has implications for improving the management of shrimp fisheries. It suggests that, in many countries, initiatives to enhance management should focus on institutional aspects. Formerly, in many countries, the agenda for improving the management of shrimp fisheries was oriented to biology and technology. In many cases, this was quite successful. At present, the major weaknesses – at least in many developing tropical countries where much of the difficulty occurs – relate to institutional problems and to understanding the need for and benefits of management intervention. This suggests that efforts to improve shrimp fishery management in these countries should include more attention on factors such as agency effectiveness, awareness generation, and the adequacy of legislation to support rights-based and dedicated-access systems. For developed countries, much of the challenge lies in improving economic conditions within shrimp fisheries in order to deal with rising fuel prices and competition from aquaculture.

The recent history of shrimp fishing, especially warm-water shrimp trawling, shows that much of the associated management activity is oriented to mitigating perceived problems. This typically involves: reducing negative interactions with small-scale fishers; alleviating overfishing of target and non-target species; decreasing bycatch and/or discards; and lessening impacts on the seabed and ecosystem.

Today, there is sufficient technology and management experience to mitigate these major problems. Substantial advances have been made in the understanding of the biology of the main shrimp species and their resilience to fishing pressure. Indeed, such work on shrimp has been commendable in showing the benefits of biological fisheries research in general. Spatial separation methods, enhanced by new technologies (e.g. vessel monitoring systems [VMSs]), can be used to reduce or eliminate industrial shrimp trawlers from interfering with inshore fishers. Much work has been done on bycatch reduction, and this has paved the way to successful interventions in terms of both gear modifications and fishing restrictions. Although the study of impacts on the seabed and wider ecosystem is challenging, the general understanding of these disturbances is increasing, and several effective mechanisms to reduce physical impacts have been developed.

Fisheries management institutions in some countries are able to alleviate many of the identified difficulties of shrimp fishing. Some of the best-managed fisheries in the world of any type are shrimp trawl fisheries. Australia's Northern Prawn Fishery and the Spencer Gulf Prawn Fishery are global models for many aspects of fisheries management, including stakeholder participation, flexibility/responsiveness of interventions, verifiable achievement of objectives, and the use of rights-based approaches. Some of the cold-water shrimp trawl fisheries are also exemplary for similar reasons.

Therefore, it is apparent that tools and models exist to enable effective mitigation of difficulties associated with shrimp fishing (Box 12). The inference is that shrimp fishing, including shrimp trawling, is certainly manageable. This is not to say there is an absence of problems with shrimp fishery management practices. In many countries, weak agencies dealing with fisheries, a lack of political will, and inadequate legal foundations cause failures in the management of shrimp fisheries. The point is that these types of factors are largely responsible for the lack of success, rather than there being any inherently unmanageable qualities of shrimp fishing gear or shrimp fishing practices.

For the large-scale and some small-scale shrimp fisheries, where open access exists, an overriding recommendation of this study is that serious consideration be given to introducing a regime to restrict access effectively and, subsequently, to providing secure tenure, either collectively or individually, to participating stakeholders.

Marine capture fisheries management in the Pacific Ocean: status and trends

INTRODUCTION

In the first half of the 1990s, in response to increasing concern about many of the world's fisheries, and following the United Nations Conference on Environment and Development (UNCED), a number of international fisheries instruments provided an impetus for countries to strengthen their fisheries management. A key step in supporting such efforts is the development of more-detailed, systematic and comparable information on fisheries management trends. In 2004, FAO developed the State of World Marine Capture Fisheries Management Questionnaire in response to this need. In 2007, FAO used this questionnaire to conduct a study of the trends in marine capture fisheries management in 29 Pacific Ocean countries.[15]

METHODOLOGY

In 29 countries, fisheries management experts were requested to complete the detailed questionnaire.[16] The focus was on:

Box 12

Tools for measuring compliance in national and local fisheries with the FAO Code of Conduct for Responsible Fisheries

Although the 1995 FAO Code of Conduct for Responsible Fisheries (the Code) is not a legally-binding instrument, it represents a consensus between countries as to the features that should characterize systems designed to ensure sustainable use of fishery resources. As the United Nations organization responsible for fisheries, FAO monitors implementation of international instruments developed in the course of its supporting role in fisheries management at the global level.

A report on progress towards implementation of the Code and related instruments – the four international plans of action (IPOA) and the Strategy for Improving Information on Status and Trends of Capture Fisheries – is submitted to the Committee on Fisheries every two years. A useful tool for the preparation of this report is the questionnaire sent to member countries biennially. The information provided on the status of national adherence to the Code constitutes valuable feedback to FAO for judging whether its objectives are being met, and it provides a metric to member countries in judging their general progress towards internationally-agreed initiatives. It also helps fisheries administrations to address specific gaps in national implementation.

In order to be effectively operationalized, the principles of the Code need to be applied within fisheries management arrangements and awareness at the levels of regional and local governments, communities, enterprises and fishers. However, specific provisions relevant at all these levels are rarely mentioned in the text of the Code. Work under the auspices of the FAO FishCode Programme seeks to encourage this process, and is the subject of a recent report.[1] It presents an approach based on the use of questionnaires adapted to evaluate compliance with the Code in national and local fisheries, and thus to indicate measures that might strengthen their management.

- direct and indirect legislation affecting fisheries;
- costs and funding of fisheries management;
- stakeholder involvement in management;
- transparency and conflict management;
- compliance and enforcement.

The information was organized into two major components: (i) national fisheries management in general; and (ii) the tools and trends in the top three fisheries (by quantity) in each of the three marine capture fishing sectors in the Pacific Ocean (large-scale/industrial, small-scale/artisanal/subsistence, and recreational). The fisheries analysed in the questionnaire were limited to national fisheries within continental and jurisdictional waters, excluding high seas fishing and foreign fishing in exclusive economic zones (EEZs) under access agreements.

In the countries surveyed, 81 large-scale, 70 small-scale and 45 recreational fisheries were identified as the top three largest fisheries by quantity in each subsector. As the definitions for each subsector (as well as whether a fishery was defined by gear or by species) were left open to allow for relative definitions within each country, the resulting pooled data had to be used with caution. An analysis of the combined questionnaire responses provided a snapshot of fisheries

The general questionnaire approach parallels the procedures used by the International Organization for Standardization (ISO). It offers a way of converting statements of principle in a global instrument into a semi-quantitative form that can be used more readily in a multidisciplinary fisheries evaluation of management performance. Emphasis is placed on displaying the results of questionnaires in a readily understandable form, and on how they may be incorporated into decision-making. The report presents a set of example questionnaires corresponding as closely as possible to clauses from Articles 7, 8, 9, 10, 11 and 12 of the Code.

The report discusses approaches that could be used in operationalizing the Code. It uses example cases where the Code has been applied in questionnaire form for evaluating fisheries objectives described by its different articles. Other assessment approaches used for related purposes are included for reference. For example, protocols are suggested for evaluating performance in relation to ecosystem management, fisheries co-management, and stock recovery strategies, based on the FAO Technical Guidelines for the Code, workshop experience and the fisheries literature.

The report provides different formats and procedures, and it describes some of the problems encountered. Using several practical applications, it discusses the use of questionnaires to promote adherence to the Code's provisions. The focus is mainly on applications of the Code at the grassroots level by local fisheries management authorities operating within national fisheries jurisdictions.

The report includes a CD–ROM containing excerpt questionnaires.

[1] FAO. 2007. *Using questionnaires based on the Code of Conduct for Responsible Fisheries as diagnostic tools in support of fisheries management*, edited by J.F. Caddy, J.E. Reynolds and G. Tegelskär Greig. FAO/FishCode Review No. 21. Rome.

management in the Pacific Ocean in the period 2003–06, and partial results are provided below.

OCEANWIDE TRENDS

Political and legislative frameworks

All countries in the region had specific national legislation for the management of marine capture fisheries, all of which provided a legal framework for fisheries management, and almost all of which provided an administrative framework for such management. In addition, 76 percent of the countries had laws and regulations designed to serve as a legal framework for fisheries management and management plans. Where extant, the legislation set up a series of steps or a process for developing, organizing and implementing fisheries management regulations (100 percent) and management plans (71 percent). However, the term "fisheries management" was defined in only one-third of those countries responding. The vast majority (86 percent) of national legislations required that fisheries management decisions be based on biological analyses/stock assessments, and slightly fewer (69 percent each) on the following analyses: social impacts analyses; economic analyses; or monitoring and enforcement analyses. Therefore, there was relatively strong legal guidance on the processes for taking management measures as well as on the interdisciplinary information required in order to develop proper management measures.

The legislation in most countries (93 percent) identified a single agency or other authority[17] with the responsibility for marine capture fisheries management at the national level. However, more than half of these agencies/authorities legally shared management responsibilities with other agencies and/or were further assisted by government or quasi-government agencies for their fisheries research (63 percent), to be further supported by universities. In many cases (67 percent), the fisheries agencies/authorities were also supported by at least one other agency (e.g. navy or coast guard) for the monitoring and control of fisheries laws.

In recent years, the policy frameworks in place in the region have moved towards sustainability (socio-economic and biological/ecosystem) objectives rather than being geared purely to production objectives. In part, this is because of the recognition of stock effects of historical overfishing and impacts on the fisheries ecosystems from within the fisheries sector as well as from other users of the aquatic environments. Where specific fisheries management objectives were provided for in legislation (76 percent), sustainability and optimal use of the resources were often listed as the principal objectives. In addition, in almost all countries, fisheries management was affected by at least one other piece of national legislation based on sustainability concepts. Moreover, the national fisheries legislation has given the fisheries management authorities the legal power to meet the priorities and obligations of international and regional agreements/conventions (86 percent).

In almost 70 percent of the countries, a large majority of the marine capture fisheries were considered "managed in some way".[18] However, for those fisheries considered managed, they were likely to be lacking any formal documented management plans (although often covered by published regulations or rules). However, the perception in the countries is that the number of fisheries managed in some way has increased in the past ten years.

State of the fisheries

When matched up with global comparisons of large-scale versus small-scale fisheries,[19] the relative sizes between the subsectors differed (Table 14). As was the case in the global estimates, the small-scale fisheries involved more than 2.5 times more participants (employed part-time or full-time or as subsistence) than did the large-scale fisheries. However, unlike the global comparison, total landings from the top fisheries in the large-scale subsector were 3.6 times higher than those in the small-scale fisheries.

Table 14
Basic data on the largest Pacific Ocean fisheries, by subsector

	Large-scale[1]	Small-scale[2]	Recreational
Number of participants	1.3 million	3.5 million	5.3 million[3]
Total landings (tonnes)	32 million	8.8 million	2.3 million[4]
Number of vessels	30 000	218 000	n.a.

Notes: n.a. = not available.
Data are for the top three (by quantity) fisheries for each subsector within 29 Pacific Ocean countries.
Guatemala, Indonesia, Malaysia and Panama include data from all bordering ocean/sea fisheries.
[1] Out of 81 fisheries, participants data missing for 33; landings data missing for 3; number of vessels data missing for 26.
[2] Out of 70 fisheries, participants data missing for 29; landings data missing for 18; number of vessels data missing for 25.
[3] Includes information for 9 out of 18 countries identified as having recreational fisheries.
[4] Includes information for 6 out of 18 countries identified as having recreational fisheries.

In addition, recent data collection efforts have shown that recreational fisheries involve potentially large numbers of fishers and landings, particularly in the developed countries in the region.

The number of participants had increased compared with the previous ten-year period in most small-scale and recreational fisheries (79 and 64 percent of the fisheries, respectively), and decreased in a small number of these fisheries (10 and 8 percent, respectively). The number of participants in large-scale fisheries had increased in almost half the countries (47 percent) and had decreased in a number of countries (37 percent).

Figure 46 shows five-year trends in landings values and quantities (based on data from the questionnaire). In the 48 large-scale fisheries of the 18 countries where comparative data were available, fewer than 40 percent of the fisheries values and quantities have decreased. In general, the trends in quantities and values have followed the same direction. However, values and quantities have followed different directions in four countries.

In the 28 small-scale fisheries of the 13 countries where data were available, 30 percent have decreased in value and 44 percent have decreased in quantity. In three countries, increased values have been experienced in the face of decreased quantities; in two countries, values have declined while quantities have risen.

The majority of large-scale fisheries presented were also considered to be top value fisheries in the countries. This was less the case in the small-scale fisheries, but still represented more than half of the fisheries investigated. Almost one-third of the recreational fisheries were considered top value fisheries.

Concerning stock status, an FAO report published in 2005 shows that, for the 181 stocks or species groups of the Pacific Ocean for which information was sufficient to evaluate the state of the resources, 77 percent were determined to fall within the range of moderately–fully exploited to overexploited/depleted.[20] These levels signal little room for further expansion, in addition to the possibility that some stocks might already be overexploited. It should be noted that there was still a large number of stocks for which it had not been possible to determine stock status.

Management tools in use in the largest fisheries

The toolkit of technical measures for fisheries management used in the region includes: spatial restrictions, temporal restrictions, catch and size restrictions, rights/incentive-adjusting restrictions, and gear restrictions (Figure 47). The results of the questionnaire brought to light certain tendencies within the Pacific Ocean countries:

- Countries have preferred the use of spatial (especially MPAs and temporary spatial closures) and gear restrictions (especially gear type and size) over other technical measures for managing marine capture fisheries.

Figure 46

Changes in the quantity and value of landings of the top fisheries

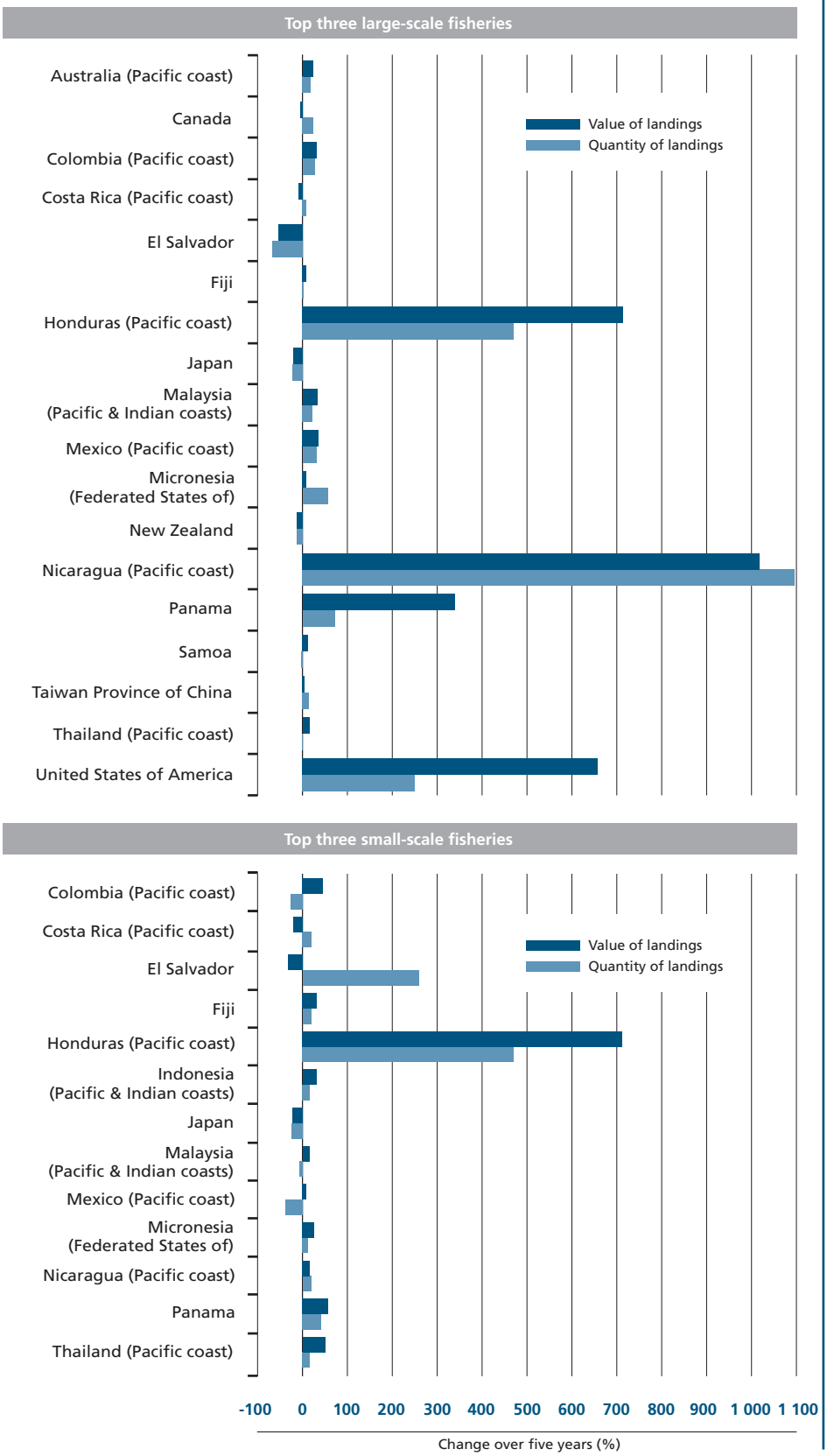
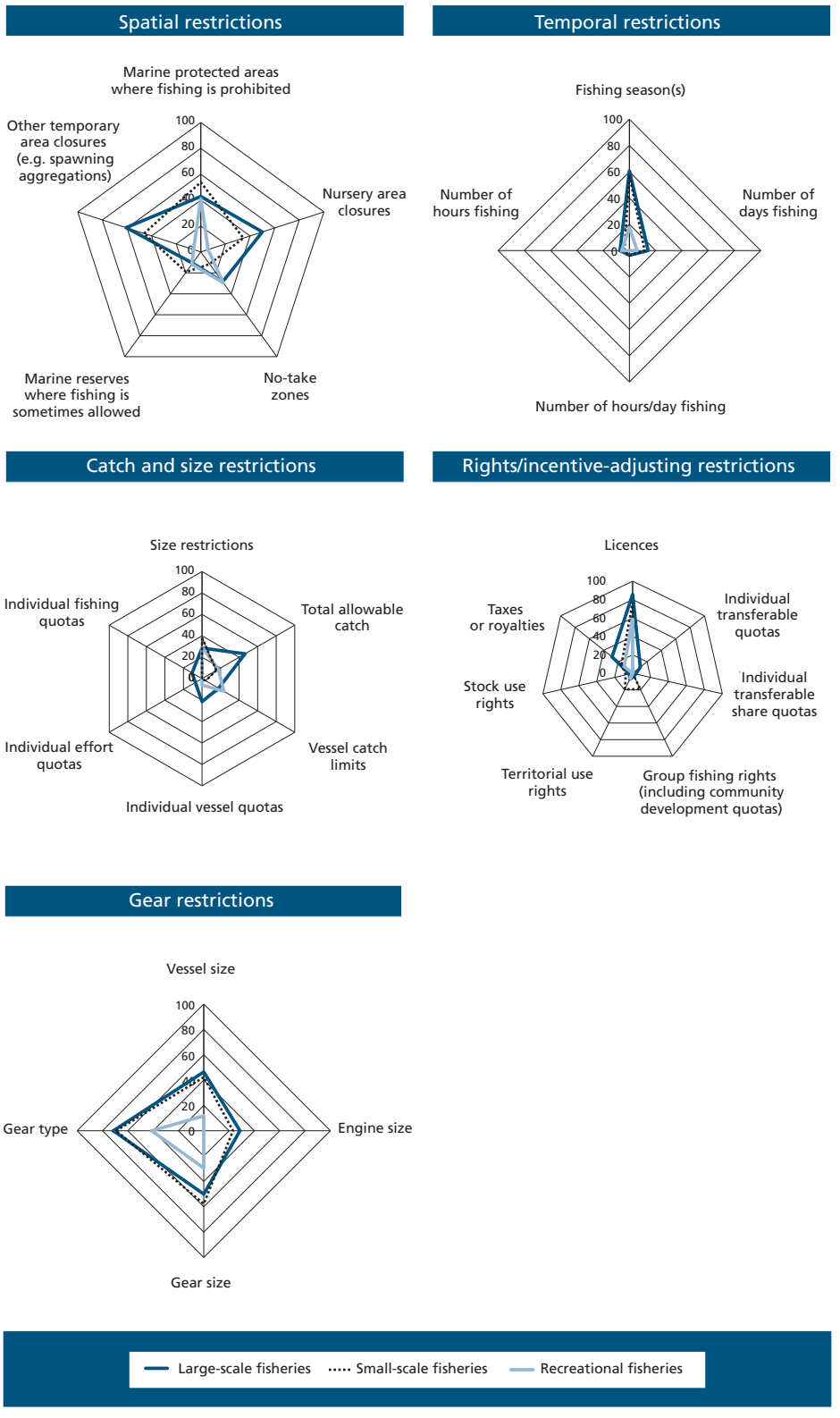


Figure 47

Technical measures for fisheries management in use in the Pacific Ocean countries (percentage of countries)



Note: Data refer to the percentage of countries in which the measure is used in at least one of the top three fisheries.

- Where used, temporal restrictions have focused on the definition of fishing seasons.
- Other than the issuing of fishing licences, very few incentive-adjusting or rights-providing mechanisms have been used.
- There has been a generalized increase in the use of management tools in the past ten years.
- Although recreational fisheries have been active in at least 18 countries in the region, few management measures have been applied to these fisheries other than the establishment of MPAs and reserves and, less frequently, the granting of licences and the adoption of gear-type restrictions.

Participatory mechanisms and conflict management in the largest fisheries

Although legal or formal definitions of those having an interest in the use and management of fisheries resources were not common in the region, stakeholders were identified in most fisheries across the three subsectors. In most cases, it was felt that arrangements had been made to consult these stakeholders and to work with them on the management of these fisheries. However, these views were less strong in the small-scale and recreational subsectors.

Where stakeholders were part of the fisheries management decision-making process, the participatory approach had led to a reduction in conflict within the fisheries. In at least half of the fisheries, it had created incentives and reasons for stakeholders to practice "responsible" fisheries stewardship voluntarily. The involvement of stakeholders tended to accelerate the management process in the large-scale subsector but not necessarily in the small-scale and recreational subsectors. Moreover, the attainment of stable stocks was not automatically associated with stakeholder involvement.

Although participatory approaches to management assisted in reducing conflict within and among the fisheries, conflict remained significant throughout the subsectors. Within the large- and small-scale subsectors, it was often caused by competition between different vessel categories or with other fisheries. In the recreational subsector, it tended to arise from competition with all other uses for the same area of water.

Conflict resolution processes were used on average in more than half of the large- and small-scale fisheries and in more than one-third of the recreational fisheries. These processes included: zoning for specific users, stock enhancement, resource allocation between and among the fisheries, and educational methods to sensitize users regarding the multiple-use nature of certain resources. There was little variation among the subsectors. However, sensitization methods were more common in the recreational subsector than elsewhere.

Fleet capacity management within the largest fisheries

Within the Pacific Ocean, fleet capacity was measured in at least half of the large-scale fisheries. However, capacity measurement in the small-scale and recreational subsectors was often not undertaken. In addition, although there was often a "sense" that overcapacity existed within at least half of the large- and small-scale fisheries, few capacity reduction programmes were put into place to adjust for the levels of capacity.

Where used, the method of preference for reducing capacity levels was the purchase of fishing licences from the fishery. This was followed by buying out fishing vessels licensed to operate in the fisheries. Licence removal was found to be an efficient means of immediately reducing any excess fishing capacity, while vessel buyouts were considered much less effective. In addition, these initial licence removals, where supported by ongoing licence purchases, were deemed effective for ensuring that any excess fishing capacity did not return.

Such capacity reduction programmes were generally supported through government funding. However, in a good number of cases, such programmes were paid for by participants in the fishery itself or, occasionally, by participants in other fisheries.

Costs and funding of fisheries management

Budget outlays for fisheries management included funding for research and development, monitoring and enforcement, and daily administrative management. In about 17 percent of the countries, these activities were not covered in some way by national government funding. National funding sources tended to decrease as management moved towards regional and local levels, contrasting the rising trends in management costs at these levels, in part a consequence of decentralization policies throughout the region. In practically all countries and at most management levels, management costs rose compared with the preceding ten-year period. On the other hand, budgets for fisheries management increased in fewer countries, and decreased in about one-third of them.

Fisheries management cost-recovery mechanisms, other than licence fees, were uncommon throughout the three subsectors. In cases where revenues were collected from fisheries activities, these revenues usually went directly to the central government budget. Therefore, no link between the benefits and costs of management services could be made, and fisheries authorities continued to base their management activities on governmental appropriations.

Compliance and enforcement

In most cases, the above-mentioned increases in management costs were associated with increased monitoring and enforcement activities, but they were also related to increased conflict management and stakeholder consultations. Compliance and enforcement tools in the region focused on inspections, whether on land or at sea. The use of additional tools, such as onboard observers or VMSs, was also widespread in the region.

When faced with infractions, most countries relied on fines or the revocation of fishing licences as deterrents. However, the perceptions in the vast majority of the countries in the region were that: (i) the funding provided was insufficient to enforce all fisheries regulations; (ii) the penalties for non-compliance were not severe or high enough to act as deterrents; and (iii) the risk of detection was too low to promote compliance with fisheries regulations.

SUMMARY AND CONCLUSIONS

Fisheries management within the Pacific Ocean varies from highly structured and centralized to devolved and community-based management systems, and from data-rich to data-poor systems. The countries also range from capital-intensive and developed economics to labour-intensive and least developed economies. Therefore, generalized comments can be easily countered by specifics. Nonetheless, several tendencies are shared across many of the Pacific Ocean fisheries.

In general, there has been a shift from development/production-oriented policies towards management and sustainability policies, and from ad hoc planning and decision-making to stated policy and management objectives supported by legal frameworks. The aim of these legal frameworks is to increased transparency in planning and decision-making by defining the roles and responsibilities of the various stakeholders, structuring the planning processes, increasing stakeholder consultations, devolving responsibility for developing and implementing management measures, and requiring more integrated information for decision-making. However, the ultimate decision-making has tended to remain at top levels without the assistance of transparent and well-defined decision-making rules and, hence, it has remained vulnerable to political and other pressures.

The funding of management comes primarily from state coffers although some countries have moved to at least partial recovery of management costs through the collection of licence fees throughout the fishing subsectors. Management costs have risen over the years as a consequence of increased monitoring and enforcement, modifying regulations and stakeholder consultations. However, the impression is that

there are insufficient funds to monitor and enforce fisheries legislation properly and that, combined with low penalties, the risks of being penalized are too low to act as deterrents – pointing to a weak point in management implementation throughout the Pacific Ocean countries.

Countries have started to expand their use of management tools, such as spatial and temporal restrictions. However, incentive-adjusting or rights-providing mechanisms have often been limited to the issuing of fishing licences. The use of varied management tools, as well as formal management plans, has been even more limited in the recreational fisheries subsector, although its importance (economic and biological) is acknowledged in a growing number of countries in the region.

Great efforts have been made to include stakeholders in the planning and management processes. This has helped to reduce conflict, increase voluntary stewardship of the resources and accelerate management processes. However, conflict has remained prevalent within and among the fisheries and among other users of the aquatic resources. To assist in minimizing these conflicts, conflict resolution methods have often been applied in the large- and small-scale fisheries, and included zoning, stock enhancement, resource allocations and sensitization methods.

Knowledge about fleet capacities and fishing efforts has increased, but only in certain areas. It is still sorely lacking in most small-scale and recreational fisheries. In addition, although knowledge about key target stocks has increased, many knowledge gaps remain, especially for the low-valued bycatch species. Contrary to a precautionary approach, and even where faced with overcapacity and overfishing, very few capacity reduction programmes have been used.

It appears that fisheries management has remained largely reactive – reacting to conflicts, stock/resource problems and international requirements – rather than providing a forward-looking framework for attaining sustainable use of aquatic resources. In addition, while legal and policy frameworks have been revisited and updated, their implementation, including their monitoring and enforcement, remains inadequate.

Actions to address these issues may include:

- the definition of pre-defined trigger and reference points for forcing management action, which would be guided by established decision-making rules and, thereby, help to increase decision-making transparency and reduce the susceptibility of decision-making to undue influences;
- the introduction of adaptive management strategies, based on strengthened institutional structures with well-defined, prioritized objectives;
- the strengthening of the application of the ecosystem and precautionary approaches to fisheries;
- the investigation of cost-effective data-gathering methods for biological, economic, social and environmental aspects of fisheries management;
- the investigation of creative and simple "win–win" techniques to minimize harmful impacts of fisheries;
- effective enforcement of fishery laws and regulations;
- improved control over growth in fishing fleet capacity;
- greater harmonization of the definition and application of laws and regulations among and within fisheries subsectors;
- the development and implementation of fisheries management plans with relevant stakeholders;
- the elimination of harmful subsidies;
- active participation in regional initiatives, such as regional fisheries bodies, to assist in the control of IUU fishing, the harmonization of fisheries laws and regulations, and the development of consistent management measures with respect to shared and transboundary stocks;
- continued involvement of stakeholders in management, with consideration given to co-management schemes requiring the creation or strengthening of organizations to represent fishers and other interests.

The countries of the Pacific Ocean need to continue in their development of sustainable fisheries management frameworks, addressing both international norms and agreements as well as adapting to their specific situation and needs. Although there is no panacea for managing all fisheries, countries could benefit from the experiences of other countries in the same region and elsewhere, and from existing literature, in the search for creative and cost-effective methods for managing fisheries.

In addition, regardless of the management framework chosen, where there is a lack of political will to implement the relevant laws, regulations and management measures, even perfectly designed frameworks will remain unenforced.

Finally, improved understanding of the effects of the management measures implemented in the fisheries (e.g. economic efficiency, social justice, and stock/ecosystem health) would greatly assist in the adaptive improvement of fisheries management.

Use of wild-fishery resources as seed and feed in aquaculture

INTRODUCTION

Since time immemorial, people have held fish captive and fattened them. Originally, the rich and powerful did this for fresh fish and, possibly, pleasure; the poor did so to save the bounty of one season for later use in periods of scarcity. Aquaculture was born when rural households recognized keeping fish as a valid component of their livelihood strategy. However, only last century, as people learned how to control the reproduction of some fish and shrimp species, did the practice develop, spread and become the focus of dedicated enterprises.

By the start of this century, aquaculture had grown much in sophistication and importance, but it had not yet – unlike the livestock industry – fully severed its dependence on wild animals. On the one hand, fish is used as feed for some cultured species; on the other, aquaculturists still depend on wild fish and crustaceans to obtain young specimens (seed) to culture. This dependence is both a strength and a weakness. It is a strength in that the industry usually has access to strong and healthy individuals. It is a weakness in that its reliance on wild stocks is, at times, detrimental to the health of these stocks[21] and, furthermore, it excludes the possibility of using selective breeding to enhance desirable commercial traits.

Recent FAO reports have shed some light on the extent and nature of aquaculture's dependence on wild-fishery resources.

WILD STOCKS AS A SOURCE OF SEED AND BROODSTOCK

Many cultured aquatic species can now be grown entirely in captivity because scientists have succeeded in closing their life cycle. However, this is not yet possible for some of the species now raised by aquaculturists, particularly for marine finfish. The aquaculturists depend on access to wild specimens either to obtain broodstock – animals that are later bred and spawned in captivity – or juveniles to raise in captivity. In fact, those species that can be reared through a closed farm cycle require the introduction of new broodstock from the wild from time to time in order to maintain the genetic strain and avoid inbreeding.

Thus, aquaculture practices may have an impact on wild stocks. While the capture of mature animals for captive reproduction is seen as having little long-term effect on the state of wild stocks, this is not the case for the capture of young animals.

A recent FAO study indicates that, before the 1960s and into the 1970s (when the quantities produced by hatcheries was difficult to predict and often fluctuated considerably), the use of wild seed for freshwater aquaculture was common *inter alia* in Bangladesh, India, Pakistan and Viet Nam.[22] However, in time, hatcheries in these countries met a large part of the seed needed by aquaculture and for capture-based fisheries. Today, aquaculturists in many countries depend partially or entirely

on hatchery-produced seed (e.g. in Brazil, Colombia, Cuba, Ecuador, Egypt, Indonesia, Nigeria, Sri Lanka, Thailand and Uganda). However, while some hatchery-produced fish are raised to maturity and become broodstock, the practice of obtaining broodstock from the wild is still common. In China, hatcheries rely on catching broodstock from natural waters for as much as 86 percent of the farmed freshwater fish species.[23]

An important concern in the freshwater aquaculture sector is genetic in nature. It is linked to the creation and use of composite populations. These consist of individuals created by mixing two species from the same family of fish. If returned to the wild, such individuals could reproduce with members of the parent populations and modify their genetic composition. An example of such a composite population is that of the genetically improved farmed tilapia, or GIFT tilapia, developed in the Philippines, from a wide genetic base of wild and farmed strains.

It appears inevitable that, either through deliberate stocking (e.g. culture-based fisheries) or through escapees, individuals from a composite population (which has been further modified through the domestication process) will eventually re-enter the natural environment inhabited by the parent stocks. Such introductions may result in the genetic breakdown of wild stocks and the loss of unique reservoirs of genetic diversity for the species. Therefore, it is necessary to conserve the genetic diversity of wild relatives of cultured species.[24]

In China, transfers and the movement of species from one river system to another have led to pathogen transfer and affected the genetic diversity of wild populations. These problems have been compounded by repeated introductions and escapees. This highlights the fact that the risks of moving species from one aquatic system to another should be analysed carefully.

However, hatcheries are not always competitive. For example, in Southeast Asia, hatcheries produce catfish fingerlings for sale, but farmers in some countries of the region still prefer wild-caught fingerlings. These are perceived to be of better quality, or are more easily available, as well as cheaper than those produced in hatcheries. In Japan, both private and state-operated hatcheries have successfully reproduced the Japanese yellowtail (*Seriola dummerili*), but farmers still prefer fingerlings from the wild.

In Asia, as in other parts of the world, some important mariculture industries (particularly those based on finfish) depend on stocks of cultured animals captured from the wild. These fisheries generally start as unregulated and attract little management attention. However, as the farming activity expands along with its economic importance, the impact of the "seed" fishery for large-scale aquaculture operations may have a considerable impact on wild stocks.

In Asia, the culture of species as diverse as the tropical spiny lobsters, the Japanese yellowtail and a variety of grouper species[25] have led to excessive fisheries of juveniles. Concerned authorities in Japan have introduced regulations to ensure the sustainability of the fisheries for juvenile yellowtail by limiting the number of fingerlings that can be captured on a seasonal basis and by regulating its international trade. For tropical spiny lobster, the relevant authorities in Viet Nam are considering the establishment of MPAs where this commercially important crustacean can safely reproduce.

These capture-based aquaculture practices also exist in Europe, and the European eel (*Anguilla anguilla*) is only one example. Early last century, young eel (known as glass eel) were so plentiful that they were used as chicken feed and raw material in glue manufacture. However, in the last three decades, the culture of eels based entirely on captured seed has become one of the most productive aquaculture industries (100 tonnes of produce per 1.5 person-years of labour). Today, the European eel is considered a threatened species, and the fishery for glass eels is strictly regulated in the EU.

Furthermore, as farming activities expand, the price of the seed material,[26] some of which is traded internationally, also increases. In Asia, shipping seed material between different countries is a common practice. For example, catfish seed cross borders in Southeast Asia, Japanese yellowtail fingerlings are sold from the Korean Peninsula

and mainland China to Japan, and snapper fingerlings from Taiwan Province of China to neighbouring countries. Such live exports also occur from one continent to another (e.g. European glass eel exported to China and Japan). Increasingly, this situation has led many countries experiencing national seed shortages to regulate or prohibit such exports.

However, as seed stock fisheries become fully exploited, the industry is increasingly recognizing the need to move away from capture-based to hatchery-based aquaculture. The same situation is true in the freshwater aquaculture sector, where a decrease in the availability of wild fish seed and broodstock has been evident.[27] A recent FAO study on the future of mariculture in the Asia–Pacific Region[28] reports that, although hatcheries in the region are working with greater numbers and a wider range of marine species, government officers responsible for the sector see hatchery developments as an immediate priority for regional collaboration.

Capture-based aquaculture does not always make use of the very young. In northern Europe, aquaculturists are experimenting with fattening wild-caught cod weighing 1–2 kilograms. This practice has not assumed proportions such that it can be considered a threat to the species (particularly as its fishery is highly regulated). The situation is somewhat different for the fattening of bluefin tuna species. Fattening of the Atlantic bluefin and southern bluefin tunas, *Thunnus thynnus* and *Thunnus maccoyii*, as practised in the Mediterranean Sea and off the southern coast of Australia, makes use of wild-caught specimens weighing 20–500 kilograms. As the fishery for bluefin tuna is regulated through internationally-agreed quotas, the capture of seed stock must be monitored and deducted carefully from allocated quotas. Efforts to close the life cycle of certain species of bluefin tuna have had mixed success.

WILD STOCKS AS A SOURCE OF FEED

Measured in volume terms, about half of global aquaculture production (including aquatic plants) does not rely on additional feed. Animals and plants raised in this manner make use of feed naturally found in the water. Foremost in this category are algae and molluscs[29]. Moreover, at times, some of the carps (e.g. silver carp and bighead carp) fall into this category, as do fish grown in rice fields.

In 2005, world aquaculture production (including aquatic plants) was estimated at 62.96 million tonnes,[30] of which about 28.2 million tonnes (44.8 percent) was dependent on the direct use of feed either as a single feed ingredient, farm-made aquafeed[31] or industrially-manufactured compound aquafeeds. Fish and other cultured aquatic animals (e.g. crabs and shrimps) dependent on feed include herbivorous and omnivorous fish (e.g. carps,[32] tilapia, catfishes and milkfish) as well as carnivorous fish and shrimps (e.g. marine finfish, salmonids, marine shrimps, and freshwater eels and prawns).

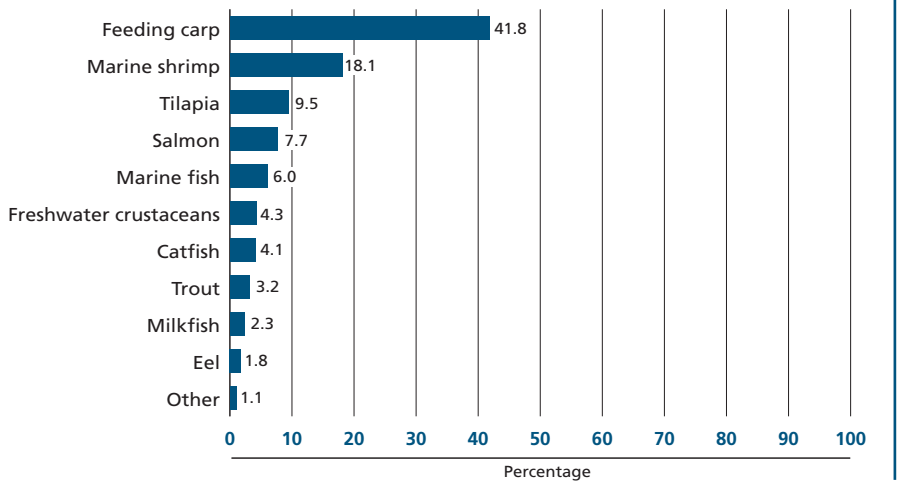
In terms of quantity of feed, the major consumers are herbivorous and omnivorous fish. An estimated 23.13 million tonnes of compound aquafeed[33] was produced in 2005, and about 42 percent of this was consumed by carps (Figure 48). In terms of absolute volume, carnivorous fish (e.g. marine finfish, salmonids and freshwater eels) and shrimps (marine and freshwater) consume less feed, but they cannot thrive without fish (or other marine proteins including shrimps, squid and krill) as a major component of their diet. Moreover, herbivorous and omnivorous fish are given fish in their feed, albeit in small proportions.

There are three basic methods for using fish (or other aquatic animals) as fish feed: in raw unprocessed form; mixed with agricultural products and by-products; and in the form of fishmeal and fish oil.

Providing fish, whole or in pieces, as the only feed may be feasible for a household raising fish mainly for own consumption. However, only in exceptional circumstances is it practical for an entrepreneur aiming to provide 10 or 100 tonnes of fish to the market, as it would be necessary to provide 8–15 kg of fish in order to be able to harvest 1 kg of marketable fish. Thus, most small farmers can only engage in this

Figure 48

Estimated global compound aquafeed production in 2005 for major farmed species (as percentage of total aquafeed production, dry as fed basis)



Source: Adapted from FAO. 2007. Global synthesis of feeds and nutrients for sustainable aquaculture development, by A.G.J. Tacon and M.R. Hasan. *In* M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon, eds. *Study and analysis of feeds and fertilizers for sustainable aquaculture development,* pp. 3–17. FAO Fisheries Technical Paper No. 497. Rome.

practice if they have access to large volumes of cheap fish for the full culture season. In Southeast Asia, some farmers still raise some freshwater fish (e.g. snakeheads and marble goby) and marine fish (e.g. grouper and Asian seabass) almost exclusively on raw fish.

Nevertheless, if the product raised is as valuable as bluefin tuna, then the entrepreneur can pay to bring feed fish from far away. Farmers who raised yellowtail in Japan initially had access to cheap trash fish. As the industry expanded, they started to feed sardines. Sardine catches reached about 4 million tonnes in the 1990s but later plummeted. At the time, many farmers ceased to raise yellowtail, while others (with the help of government-sponsored research) managed to introduce artificial feeds.

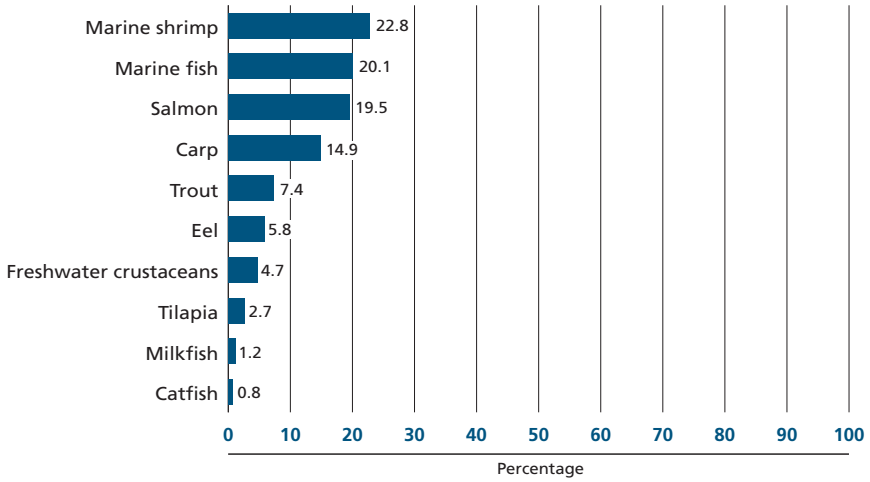
Globally, it seems clear that, in spite of the recently developed capture-based culture of yellowfin tuna (generally fed on small pelagics), the use of whole unprocessed fish as the only feed is declining. The practice is not a serious threat to wild fish stocks. However, in certain regions (e.g. the Mediterranean, Northwest Africa and some Asian countries), the purchase of fish for aquaculture feed can become a serious competitor in the market for small pelagics.

As artisanal fish farming becomes a market-oriented enterprise, farmers often find it in their interest to mix fish with agricultural products and produce farm-made fish feeds. Most small-scale Asian fish farmers use farm-made feeds. These feeds are manufactured when and where needed. Their content depends on the crop and livestock by-products available. Aquaculturists in Bangladesh, China, India, Indonesia, Philippines, Thailand and Viet Nam together used an estimated 19.33 million tonnes of farm-made feeds in the 2003–04 season. It is predicted that farm-made feed usage will increase in the next five years to 30.73 million tonnes, representing a growth of 60 percent from the levels of 2003–04.

About 5–6 million tonnes of low-value/trash fish are used as direct feed in aquaculture worldwide,[34] either provided without processing or as part of farm-made feeds. A recent estimate placed the Asian use of trash fish as fish feed at about 1.6–2.8 million tonnes per year. With the further expansion of mariculture activities in Asia, the use of low-value/trash fish may increase. The low and high predictions for

Figure 49

Estimated global use of fishmeal (percentage of dry as fed basis) within compound aquafeeds in 2003 by major cultivated aquatic animals



Source: Adapted from FAO. 2007. Global synthesis of feeds and nutrients for sustainable aquaculture development, by A.G.J. Tacon and M.R. Hasan. *In* M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon, eds. *Study and analysis of feeds and fertilizers for sustainable aquaculture development,* pp. 3–17. FAO Fisheries Technical Paper No. 497. Rome.

low-value/trash fish as direct feed inputs in Asia for 2010 are 2.2 and 3.9 million tonnes, respectively.[35]

However, as small-scale farmers expand and/or start to supply products to urban, and possibly external markets, they need to supply a quality product consistently. This can rarely be achieved with a feeding regime that fluctuates in both quantity and quality, which is often the case with farm-made feeds. In these situations, farmers have a need and a desire to substitute farm-made feeds with feeds manufactured in specialized animal feed factories.

Such feeds dominate in South America, where farm-made feeds are rare and the practice of providing whole fish as feed is almost unknown. This reflects the fact that, on the one hand, most South American aquaculture is export-oriented and, on the other, the continent regularly produces almost half of all the fishmeal produced in the world.

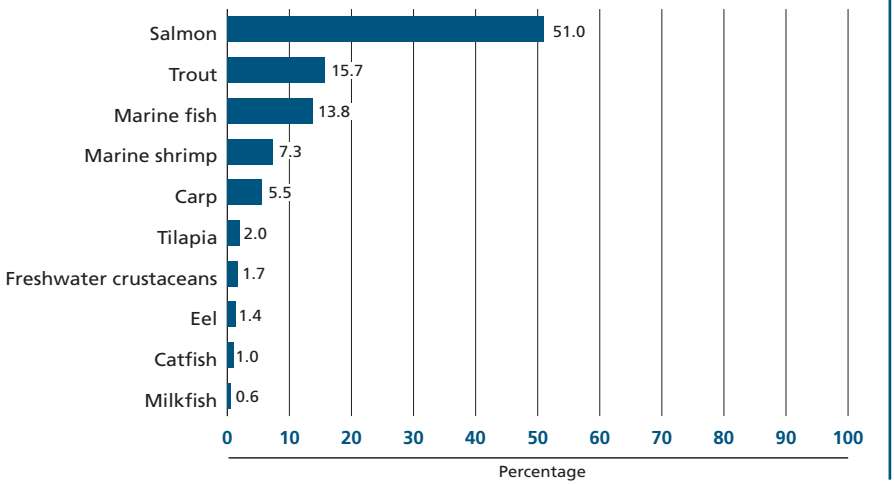
For decades, the need to provide fish as feed for other fish has been seen as an almost insurmountable obstacle given that the amount of fish that can be produced annually from the wild is finite. Thus, much research has focused on finding replacements for fishmeal and fish oil in fish feeds. Partial replacements have been achieved. However, no dramatic breakthroughs have been reported, and the share of fishmeal and fish oil used in aquaculture is increasing (recently at the expense of poultry).

The aquaculture sector consumed about 3.06 million tonnes (or 56.0 percent) of world fishmeal production and 0.78 million tonnes (or 87.0 percent) of total fish oil production in 2006.[36] Figure 49 details the major consumers of fishmeal, while Figure 50 presents the data on fish oil consumption, showing that more than 50 percent goes into salmonid diets. Other fishery products used in the production of aquafeeds are krill meal, squid meal, squid liver powder and squid oil, shrimp meal and crab meal. The market size for these products within aquafeeds is currently estimated to be about 0.29 million tonnes (range: 0.19–0.52 million tonnes).[37]

Thus, the total amount of fishmeal and fish oil used in aquafeeds is estimated to have grown more than threefold between 1992 and 2006, from 0.96 million tonnes to

Figure 50

Estimated global use of fish oil (percentage of dry as fed basis) within compound aquafeeds in 2003 by major cultivated aquatic animals



Source: Adapted from FAO. 2007. Global synthesis of feeds and nutrients for sustainable aquaculture development, by A.G.J. Tacon and M.R. Hasan. *In* M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon, eds. *Study and analysis of feeds and fertilizers for sustainable aquaculture development,* pp. 3–17. FAO Fisheries Technical Paper No. 497. Rome.

3.06 million tonnes and from 0.23 million tonnes to 0.78 million tonnes, respectively. Aquafeed manufacturers are increasing their use of fishmeal and fish oil at the expense of all other sectors (e.g. human consumption, industrial and pharmaceutical).

Globally, the demand for, and use of, fishmeal has increased rapidly, especially in some of the emerging aquaculture countries in Asia. China is the single largest user of fishmeal. In 2004, it used 1.6 million tonnes, with 1.2 million tonnes imported and the remainder coming from domestic production.[38] Of this total amount, about 75 percent was used for aquafeed production. The Asia–Pacific aquaculture sector uses about 2.4 million tonnes of fishmeal (equivalent to about 10.3 million tonnes of raw material) as a feed source.

NOTES

1. FAO. 2007. *Results and conclusions of the project "Ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem"*, by K.L. Cochrane, C.J. Augustyn, G. Bianchi, P. de Barros, T. Fairweather, J. Iitembu, D. Japp, A. Kanandjembo, K. Kilongo, N. Moroff, D. Nel, J.-P. Roux, L.J. Shannon, B. van Zyl and F. Vaz Velho. FAO Fisheries Circular No. 1026. Rome.
2. Based on FAO. 2007. *Increasing the contribution of small-scale fisheries to poverty alleviation and food security*, by C. Béné, G. Macfadyen and E.H. Allison. FAO Fisheries Technical Paper No. 481. Rome.
3. FAO. 2005. *Increasing the contribution of small-scale fisheries to poverty alleviation and food security*. FAO Technical Guidelines for Responsible Fisheries No. 10. Rome.
4. Organisation for Economic Co-operation and Development. 2001. *The DAC Guidelines – Poverty Reduction*. Paris (also available at www.oecd.org).
5. A. Sen. 1981. *Poverty and famines: an essay on entitlement and deprivation*. Oxford, UK, Clarendon Press.
6. R. Chambers. 1983. *Rural development: putting the last first*. London, Longman.
7. For an example on conceptualizing vulnerability, see W.N. Adger, N. Brooks, G. Bentham, M. Agnew and S. Eriksen. 2004. *New indicators of vulnerability and adaptive capacity*. Tyndall Centre for Climate Change Research. Technical Report 7 (available at http://www.tyndall.ac.uk/research/theme3/final_reports/it1_11.pdf)
8. C. Bailey. 1986. Government protection of traditional resource use rights: the case of Indonesian fisheries. *In* D.C. Korten, ed. *Community management: Asian experience and perspectives*, pp. 292–308. West Hartford, USA, Kumarian Press.
9. C.L. Delgado., N. Wada, M.W. Rosegrant, S. Meijer and A. Mahfuzuddin. 2003. *Outlook for fish to 2020: meeting global demand. A 2020 vision for food, agriculture, and the environment initiative*. Washington, DC, International Food Policy Research Institute, and Penang, Malaysia, WorldFish Center.
10. FAO. 2008. *Global study of shrimp fisheries*, by R. Gillett. Rome (in print as at April 2008). The study addresses the major issues in shrimp fisheries with a more detailed analysis of fisheries of ten countries representing the various geographic regions, as well as the variety of shrimp fishing conditions: large/small fisheries, tropical/temperate zones, developed/developing countries, and good/poor management. The ten countries selected were: Australia, Cambodia, Indonesia, Kuwait, Madagascar, Mexico, Nigeria, Norway, Trinidad and Tobago, and the United States of America.
11. In the study, "large-scale" shrimp fisheries are those that employ motorized vessels.
12. FAO. 2005. *Discards in the world's marine fisheries. An update*, by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome.
13. The discard rate is the proportion (as a percentage) of the catch (in weight) that is discarded.
14. Shrimp bycatch studies appear to be most advanced in Australia. Two Australian studies are especially relevant and provide an indication of what has been achieved in shrimp bycatch research:
    I. Poiner, J. Glaister, R. Pitcher, C. Burridge, T. Wassenberg, N. Gribble, B. Hill, S. Blaber, D. Milton, D. Brewer and N. Ellis. 1998. *Environmental effects of prawn trawling in the far northern section of the Great Barrier Reef 1991-1996*. Final Report to Great Barrier Reef Marine Park Authority and the Fisheries Research and Development Corporation (June 1998). Miscellaneous publication. Hobart, Australia, CSIRO Division of Marine Research.
    NORMAC. 2002. *Northern prawn fishery action plan 2002*. Australian Government, Australian Fisheries Management Authority. Northern Prawn Fishery Management Advisory Committee.
15. This article is a summary of FAO. 2007. *Review of the state of world marine capture fisheries management: Pacific Ocean*, edited by C. De Young. FAO Fisheries Technical Paper No. 488/1. Rome. This is a companion publication to FAO. 2006.

Review of the state of world marine capture fisheries management: Indian Ocean, edited by C. De Young. FAO Fisheries Technical Paper No. 488. Rome. It will be followed by similar reviews covering the Mediterranean/Black/Caspian Seas and the Atlantic Ocean.

16. Questionnaires were received for: Australia (Pacific coast), Cambodia, Canada, Chile, China, Colombia (Pacific coast), Costa Rica (Pacific coast), Ecuador, El Salvador, Guatemala (Pacific and Atlantic coasts), Honduras (Pacific coast), Indonesia (Pacific and Indian coasts), Japan, Malaysia (Pacific and Indian coasts), Mexico (Pacific coast), New Zealand, Nicaragua (Pacific coast), Panama, Peru, Philippines, Republic of Korea, Russian Federation, Taiwan Province of China, Thailand (Pacific coast), United States of America (Pacific coast) and Viet Nam. The Southwest Pacific Ocean Small Island Developing States were represented by reviews from Fiji, Micronesia (Federated States of) and Samoa. Questionnaires were not received for the Democratic People's Republic of Korea, and Singapore.
17. The authority responsible for marine capture fisheries management is occasionally a stand-alone authority or fisheries ministry but more often functions in the form of a fisheries department within an agriculture/livestock or environment ministry or a combined agriculture/fisheries ministry.
18. According to the questionnaire results, the concept of "managed" was mostly inferred to mean: (i) interventions/actions to support specific management objectives; (ii) published regulations or rules for specific fisheries; (iii) management plans for specific fisheries; and (iv) legislation about individual fisheries.
19. See, for example, D. Thompson. 1980. Conflict within the fishing industry. *ICLARM Newsletter*, 3(3); and F. Berkes, R. Mahon, P. McConney, R.C. Pollnac and R.S. Pomeroy. 2001. *Managing small-scale fisheries: alternative directions and methods*. Ottawa, International Development Research Centre.
20. FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome.
21. However, capture fisheries are also concerned with more indirect ways in which aquaculture can affect wild stocks through pollution of waters and release of captured animals. If the species are not already present in surrounding waters, aquaculture can have negative impacts on the established fish fauna. If they are, interbreeding may have a negative effect on the wild stocks. However, many of these impacts are independent of the industry's dependence on animals from the wild.
22. FAO. 2007. *Assessment of freshwater fish seed resources for sustainable aquaculture*, edited by M.G. Bondad-Reantaso. FAO Fisheries Technical Paper No. 501. Rome.
23. H. Honglang. 2007. Freshwater fish seed resources in China. *In* FAO. *Assessment of freshwater fish seed resources for sustainable aquaculture*, edited by M.G. Bondad-Reantaso. FAO Fisheries Technical Paper No. 501, pp. 185–199. Rome.
24. G.C. Mair. 2007. Genetics and breeding in seed supply for inland aquaculture. *In* FAO. *Assessment of freshwater fish seed resources for sustainable aquaculture*, edited by M.G. Bondad-Reantaso. FAO Fisheries Technical Paper No. 501, pp. 519–547. Rome.
25. FAO. 2008. *Capture-based aquaculture. Global overview*, edited by A. Lovatelli and P.F. Holthus. FAO Fisheries Technical Paper No. 508. Rome.
26. Glass eel cost about EUR40 per kilogram in about 1990. The price had increased to EUR300 per kilogram ten years later, see T. Nielsen and P. Prouzet. 2008. Capture-based aquaculture of the wild European eel (*Anguilla anguilla*). *In* FAO. *Capture-based aquaculture. Global overview,* edited by A. Lovatelli and P.F. Holthus. FAO Fisheries Technical Paper No. 508. Rome, FAO.
27. FAO. 2007. *Assessment of freshwater fish seed resources for sustainable aquaculture*, edited by M.G. Bondad-Reantaso. FAO Fisheries Technical Paper No. 501. Rome.

28. FAO. 2008. *The future of mariculture: a regional approach for responsible development in the Asia-Pacific region. FAO/NACA Regional Workshop, 7–11 March 2006, Guangzhou, China*, edited by A. Lovatelli, M.J. Phillips, J.R. Arthur and K. Yamamoto. FAO Fisheries Proceedings No. 11. Rome.
29. FAO. 2007. *Study and analysis of feeds and fertilizers for sustainable aquaculture development*, edited by M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon. FAO Fisheries Technical Paper No. 497. Rome.
30. FAO. 2007. FAO Fisheries and Aquaculture Department, Fishery Information, Data and Statistics Unit. FishStat Plus. Universal software for fishery statistical time series. Rome (available on CD-ROM and at www.fao.org/fi/statist/FISOFT/FISHPLUS.asp). Relevant datasets: aquaculture production (quantities 1950–2005; values 1984–2005); capture production (1950–2005); commodities production and trade (1950–2005); total production (1970–2005).
31. Farm-made feed usually refers to the feed produced by farmers using some form of processing, ranging from simple grinding and cooking to the production of moist dough or simple moist or dry pellets on-farm or by small-scale feed manufacturers according to farmers' specifications. Farm-made aquafeed is often used as a synonym for "home-made aquafeed".
32. Here, "carps" includes most of the non-filter feeding carps, such as common carp, crucian carp, Chinese carps (grass carp and black carp) and Indian major carps (rohu, catla and mrigal).
33. A compound aquafeed is a feed composed of several ingredients of vegetable or animal origin in their natural state, fresh or preserved, or products derived from the industrial processing thereof, or organic or inorganic substances, whether or not containing additives, for oral feeding in the form of a complete feed.
34. FAO. 2006. *Use of fishery resources as feed inputs for aquaculture development: trends and policy implications*, by A.G.J. Tacon, M.R. Hasan and R.P. Subasinghe. FAO Fisheries Circular No. 1018. Rome.
35. FAO. 2008. *Report of the FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and Its Implications to Food Security and Poverty Alleviation, Kochi, India, 16–18 November 2007*. FAO Fisheries Report No. 867. Rome.
36. A.G.J. Tacon. 2007. *Meeting the feed supply challenges*. Paper presented at the FAO Globefish Global Trade Conference on Aquaculture, Qingdao, China, 29–31 May 2007.
37. Op. cit., see note 34.
38. FAO. 2007. *Study and analysis of feeds and fertilizers for sustainable aquaculture development*, edited by M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon. FAO Fisheries Technical Paper No. 497. Rome.