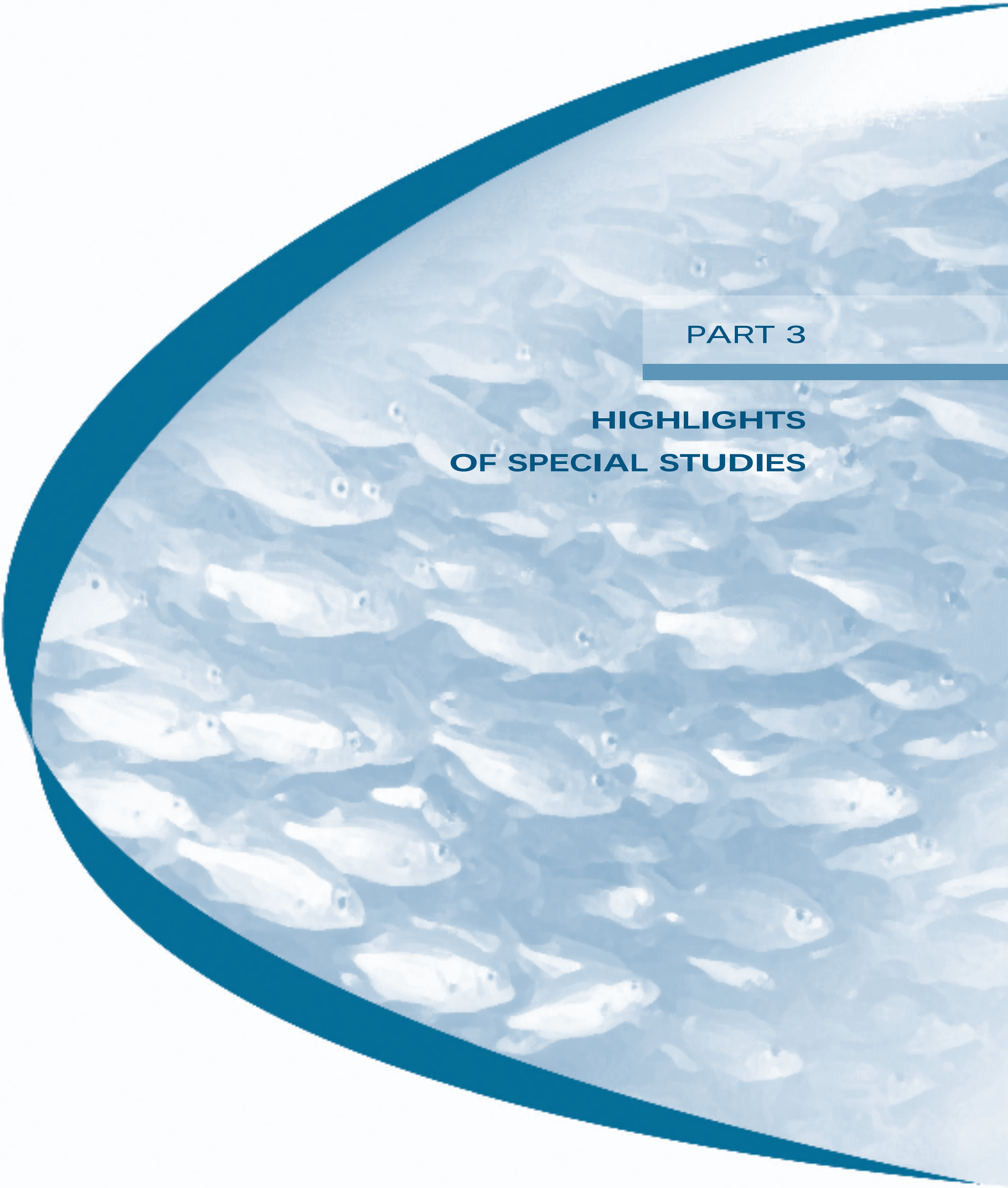
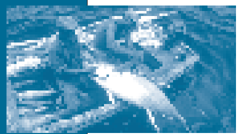


PART 3

HIGHLIGHTS OF SPECIAL STUDIES

HIGHLIGHTS OF SPECIAL STUDIES



Rehabilitation of riverine habitat for fisheries[1]

INTRODUCTION

Human activities have left their mark on streams and rivers for thousands of years. As a consequence of industrialization and human population growth, pressure on natural watercourses and their aquatic habitats has intensified through history and the degradation of aquatic habitats has accelerated – with negative consequences for aquatic species and therefore also for fisheries. Currently, nearly all watercourses in developed countries have been adversely affected by development to various degrees and inland water habitats in many developing countries are following the same route.

However, the situation is gradually changing and many developed countries are trying to reverse these longstanding negative impacts through rehabilitation of riverine habitats. The international community, including FAO, through the Code of Conduct for Responsible Fisheries,[2] has acknowledged the value of understanding ecosystem processes – the biological, physical and chemical qualities of aquatic habitats; habitat protection and rehabilitation; nutrient cycling; and the interactions of non-target species – in maintaining the productivity of fisheries. The Code thus recognizes the need to conserve and rehabilitate habitats cost-effectively through an ecosystem approach. According to the Code's technical guidelines for inland fisheries: "States should clearly formulate national plans for the use of water including allocation for fisheries and for the protection of the aquatic environment".[3]

Unfortunately, there have been only a limited number of good studies of habitat rehabilitation and monitoring on which to base advice, especially for developing countries. Although the studies reviewed provide technical information on rehabilitation projects from various parts of the world, most were undertaken in temperate countries, and modifications of the methods and strategies used there may be necessary before they can be adapted to other riverine habitats. Another concern is that many studies on the effectiveness of habitat rehabilitation have analysed the physical–chemical parameters of the water, i.e. the water quality, rather than the increase in fish production.

GENERAL PRINCIPLES

Restoration of riverine habitats to pristine conditions is generally not practical; it is usually only realistic to aim at rehabilitating key functions in the ecosystem through the rehabilitation or re-creation of functional habitats and the establishment of connectivity between them. Where habitats have been degraded and fish production has decreased as a result, rehabilitation efforts should be preceded by assessments of what has happened to the aquatic ecosystem, i.e. what functions have been lost or degraded. The goal of such assessments is both to identify the impacts on specific areas of the ecosystem or on key ecosystem processes that affect stream habitats, and to specify management actions required to restore or rehabilitate those processes that sustain aquatic habitats and support fish production (Table 13).

Restoring specific fish populations is subordinate to the goal of restoring the ecosystem that supports multiple species. As long as all rehabilitation actions are consistent with the overriding goal of restoring ecosystem processes and functions, habitats will be restored for multiple species.

Many conflicting uses, and thus social and economic interests, are at stake in inland waters. Indeed, the requirements for the maintenance of healthy stocks of fish and other living aquatic resources and the fisheries that depend on them are frequently of secondary importance to other considerations. Therefore, the costs and benefits of

Table 13
Specific conditions of aquatic habitats important for the rehabilitation of fisheries

General category	Examples
Water flow	Minimum acceptable flow Timing of flow Speed of change in discharge or water level
Habitat connectivity	Maintenance of access to critical habitats (longitudinal; lateral) Removal of obstructions to fish movement or mitigation (e.g. fish passage facilities) Maintenance of access to inflowing tributaries in lakes Connectivity to lateral marshes, floodplains, etc.
Habitat diversity	Maintenance of and access to critical habitats Provision for adequate diversity in main waterbody Maintenance of riparian vegetation structure
Water quality	Avoidance of chronic or acute, diffuse or point source pollution by toxic substances Regulation of nutrients with critical limits
Physical disturbance	Limitation of boat wash road and other development Limitation of forest and plant removal and on weed cutting Limitation of grazing or other disturbance
Basin characteristics	Land-use practice to avoid erosion and uncontrolled runoff Avoidance of inappropriate types of vegetation cover Connectivity buffer zones

Source: Adapted from R.L. Welcomme. 2001. *Inland fisheries: ecology and management.* Oxford, UK, Fishing News Books.

maintaining or restoring inland fisheries need to be balanced against the costs and benefits of other uses of the water. Moreover, it should be recognized that the costs of all alternative uses of inland waters comprise not only actual expenses incurred, but may also include losses of future opportunities. It should also be recognized, when estimating the costs of maintaining healthy fish stocks, that there are alternative approaches to protection, mitigation and rehabilitation.

Benefits from rehabilitation include not only the income that can be generated from fishing, but also ecosystem services such as nutrient cycling, sediment transport and carbon sequestering, as well as less tangible benefits such as those relating to the aesthetic and conservation aspects of an intact ecosystem. Because cost–benefit calculations may favour non-fisheries use in the short term, it is important to consider the time horizon taken into account in the analysis. The time horizon should be long enough to allow the short-term result to be balanced with the long-term interests and values inherent in the ecosystem. This applies not only to new projects for the use of freshwater but also to existing ones. Neglecting an already degraded environment will only delay – and possibly increase – the bill for rehabilitation.

A multidisciplinary basin-wide approach that includes land and water management is needed if rehabilitation is to be achieved sustainably. Fisheries managers, and those responsible for conserving the environment, must negotiate the best possible conditions for the maintenance of fish stocks and fisheries. However, the economic interests of other sectors, for example power generation, navigation, agriculture and industry, are difficult to counterbalance because it is not easy to provide well-documented and accurate figures that demonstrate the economic value of the intact aquatic habitat and its associated fish populations and biodiversity. In this process, it is the task of fisheries managers and those responsible for conserving the environment to negotiate the best possible conditions for maintaining the fish stocks and fisheries. Where politicians have defined an enabling framework, tensions among the various stakeholders can be reduced and larger benefits derived from the many goods and services the aquatic ecosystems supply, including products for human consumption.

Decision-makers may choose from management schemes ranging from “do nothing”, when the costs involved with rehabilitation are unacceptable, to “provide mitigation and rehabilitation", or to "provide total protection" with the establishment of sanctuaries in which no activities are allowed in the watershed.

METHODS FOR REHABILITATION

Rehabilitation of rivers should focus on creating structural diversity (depth, flow, substrate and riparian structures) and re-establishing longitudinal and lateral connectivity (Table 14). At the same time, it should aim to create conditions that favour communities of species. Many rehabilitation measures are currently guided by the principle of the "potentially natural species composition", where not only existing species are considered as targets of rehabilitation, but also species that had lived there in the past and might one day return/be brought back. The habitat characteristics requiring improvement must be identified accordingly, including all functional units used by fish and especially during sensitive stages of the fishes' lifecycles. However, the final rehabilitation strategy must be sufficiently flexible to allow new knowledge and tools to be incorporated.

The level of knowledge concerning species and ecosystems associated with inland waters is variable and patchy on a global scale. Relatively simple and species-poor systems, such as temperate salmonid streams, are relatively well understood, while the much more complex large tropical rivers are less well studied and only

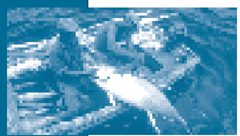


Table 14
Common categories of habitat rehabilitation and examples of common actions

General category	Examples	Typical goals
Road improvements	Removal or abandonment Resurfacing Stabilization Addition or removal of culverts	Reduce sediment supply Restore hydrology Improve water quality
Riparian restoration	Fencing to exclude livestock Removal of grazing Planting of trees and vegetation Thinning or removal of underbrush and bushes	Restore riparian vegetation and processes Provide shade and shelter Improve bank stability and instream conditions
Floodplain connectivity	Levee removal Reconnection of sloughs, lakes Excavation of new floodplain habitats	Reconnect lateral habitats Allow the river channel freedom to meander and shift its course
Dam removal and flow modification	Removal or breaching of dam Increase in instream flows Restoration of natural flood regime	Reconnect migration corridors Allow natural transport of sediment and nutrients
Instream structures	Placement of log or boulder structures Engineered log jams Placement of spawning gravel Placement of brush or other cover Re-meandering a straightened stream	Improve instream habitat conditions for fish
Nutrient enrichment	Addition of organic and inorganic nutrients	Boost productivity of system to improve biotic production Compensate for reduced nutrient levels from lack of anadromous fishes
Miscellaneous rehabilitation techniques	Reintroduction or removal of beavers Brush removal Bank protection Habitat protection through land acquisition, conservation, easements or legal protection (laws) Instream flows	Reduce or increase habitat complexity Prevent erosion or channel migration Protect habitat from further degradation Provide adequate flows for aquatic biota and habitat

poorly understood. It is therefore frequently necessary to work with models that require only limited knowledge of the biology of individual species, but focus more on the restoration of ecosystem functions and processes. Detailed planning for the conservation of specific species requires more complete knowledge of the biology and the behaviour of the species involved.

Structural diversity

Fish abundance may be increased locally in the short to medium term. It has been demonstrated that the improvement of habitats through enhancing structural diversity – by adding instream structures such as logs or boulders or by creating pools and riffles that serve to oxygenate the water, trap sediments and provide shelter – increases fish abundance locally in the short to medium term. However, because this often does not address the underlying causes of habitat degradation, a more permanent solution requires large changes that restore or mimic natural processes.

Many rivers and streams have been canalized, for navigation purposes or in order to carry away water more efficiently. In this situation habitat complexity may be increased through decanalization and by restoring meanders and reconstructing floodplain habitats. This will increase the length of the streams and lead to physical and biotic changes that will benefit fish and invertebrates. However, such large-scale projects are relatively recent and there has not yet been enough time to evaluate the results properly.

Restoration of processes

Important elements in restoring the ecosystem processes are the linkages between aquatic and terrestrial ecosystems. A few studies indicate that in areas with degraded riparian habitat where there is no tree cover on the banks, water temperatures, for example, tend to be higher and fish abundance lower than in areas where the vegetation is intact. Riparian vegetation is also important in providing shade, shelter, nutrients, woody debris and food for fishes. Replanting and protection to exclude cattle and other grazers of riparian vegetation have proved effective as a means for restoring fish populations in some areas.

Restoration of floods

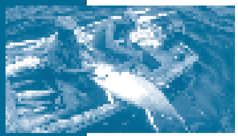
Floods are necessary for a variety of ecological processes and associated species of plants, trees, animals, fishes and birds. Where the natural flood pattern cannot be fully restored it may still be possible to restore partially key features of the flood cycle. Important elements in the flood cycle include timing, amplitude, duration, rapidity, smoothness and upstream drawdown level. Managers of dams and hydroelectric plants should be encouraged to time the release of their water in accordance with natural flood cycles to enable rehabilitation of fisheries that are dependent on floods.

Longitudinal connectivity

Rehabilitation of river fisheries depends on the longitudinal exchange of fish, nutrients, sediments, organic matter and water in sufficient quantity and quality. Rehabilitation strategies often include small-scale interventions that are easy to implement but may have limited long-term impact. For example, because of the decrease of anadromous fish species, some streams currently have only 6–7 percent of their historic nitrogen and phosphorus levels. In such situations, nutrient flows along the river have been augmented with salmon carcasses or inorganic nutrients, resulting in some increases in juvenile salmon and macro invertebrate abundance.

However, more serious rehabilitation projects should involve longer-term strategies that address fish movements, water flow, land-use planning and water-resource management for the entire catchment level or river basin.

Migratory fishes are often the most valuable commercially, but are among the first to disappear when water becomes polluted or when migration routes are interrupted by physical structures. Migratory species are therefore often used as indicators of



ecological health. However, it is not only the long-distance migratory species that suffer from habitat fragmentation but all species that during their lifecycle depend on longitudinal movements.

When improving migration conditions for fish, it is important to look at all life stages as their requirements might be quite different (e.g. upstream migration of small young eels; downstream migration of large adult eels). Passage mitigation structures should thus be designed according to the needs and abilities of the different species and the different life stages of those species. For example, the design of sluices that regulate the flow of water in and out of poldered areas will determine whether pelagic fish eggs, bottom-living juveniles or adult fishes are able to enter the area.

When migration routes have been blocked by dams, the best solution for fisheries is to remove the dam in order to ensure both upstream and downstream passage. Dams have a limited operating life (around 50 years) and are costly to maintain. In the United States of America, approximately 500, mostly small, dams have been removed during the past 20 years. Apart from allowing fish movement both upstream and downstream, removal is also highly effective at restoring processes that have been disrupted as a result of damming, such as nutrient cycling and transport of nutrients and sediments.

Fish passes, which facilitate the movement of fish past blocking structures, have commonly been used to restore fish migration. When fish passes are incorporated into the early design of a dam construction project, their costs are equivalent to only a small percentage of the total costs. But if fish passes have to be fitted retroactively, costs increase drastically. If dam construction cannot be avoided, it is thus the responsibility of fisheries managers at least to ensure that the appropriate types of fish passes are planned at the earliest stages of the project. It is also important to choose the fish pass design that matches most closely the behaviour and requirements of the species present (or likely to be present at a later stage). Fish passes designed for salmonids, for example, should not be used blindly if non-salmonid species are the target group, because these passes might be ineffective or less effective for species with swimming abilities different from those of salmon. If little is known about the requirements of the species present, the most versatile fish pass design should be chosen, which in many cases would be the vertical slot pass (Figure 37).

Figure 37

Vertical slot fish pass, Iffezheim, River Rhine, France/Germany

M. Larinier

Lateral connectivity

Lateral connectivity of habitats to the main river channel is also essential for many fisheries. Lowland rivers with floodplains are often contained by massive levee systems erected to protect cropland, settlements and other infrastructure against floods. The result of such development is that the floodplains become isolated from the rivers, and the seasonal dynamics of the system are eliminated, with negative consequences for the fisheries.

Heavy anthropogenic modifications (e.g. densely populated areas along rivers), and the resulting social and economic costs involved in removing levees, mean that this rehabilitation method is not always feasible. However, dikes can be set back to allow a partial flooding of the former floodplain. In certain areas the river may also be allowed to inundate the entire floodplain. By re-allowing the fish to enter flooded areas to spawn and feed, the large surplus production of juvenile fishes, which is characteristic of healthy floodplains, ensures adequate recruitment of fish to restore fish populations.

Isolated waterbodies such as side channels, oxbow lakes and floodplain pools may be linked through the installation or improvement of culverts or through the creation of natural channels. These are good options because they rely on already existing habitats that only need reconnection. When such natural habitats are absent they can be replaced by human-made waterbodies such as gravel extraction sites or borrow pits, which can be engineered to favour species diversity.

CONCLUSION

The studies reviewed in this section clearly indicate that riverine habitat rehabilitation should be based on an ecosystem approach in which key processes are re-established and maintained. In this way rehabilitation will benefit a number of aquatic species and therefore help improve inland fisheries. To ensure the maximum efficiency of remedial measures, the ecological requirements of all riverine species during all their life stages (particularly those of migrants) must be taken into consideration from the earliest planning stages. The watershed, or basin, provides a geographic setting: the entire basin should be considered, as no rehabilitation project can be considered in isolation from its basin and the people who live there. Activities upstream can counteract any effort made at the local level.

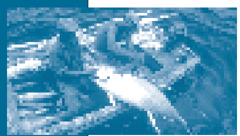
Inland fisheries are most seriously affected by factors external to the fishery sector. Social, economic and institutional issues, and competing uses of inland waters, often impede the application of technologies to rehabilitate rivers for fisheries. Major interventions (re-meandering, floodplain restoration or removal of dams) are costly and require the active cooperation of riparian landowners and other stakeholders, or the acquisition of the land by the state. Although the cost-effectiveness of rehabilitation projects has seldom been studied, it is clear that habitat protection is the most cost-effective means for maintaining riverine fisheries.

Knowledge of inland waters, including their aquatic biodiversity and fisheries, remains partial in many parts of the world and few habitat rehabilitation projects have been adequately evaluated. Although further research and information are clearly desirable, the rehabilitation methods reviewed above do show promise, and our existing knowledge of ecosystem functions, ecosystem processes and the requirements of aquatic species should allow us to act now to rehabilitate many important fisheries if the political will is strong enough.

Responsible fish trade and food security

BACKGROUND

Since ancient times, fish from the oceans and other aquatic bodies have been an important source of food. However, those who specialize in harvesting fish cannot consume all the fish caught. Even at low levels of productivity, there is a need to barter or exchange the surplus. Trading, even locally and domestically, is more innate to a fishery than it is to livestock or agriculture.



A major component of global trade has long been food products such as spices, grains, salt, fruits, sugar, meat and fish. The global food trade has bridged vast distances and cultures. Today, fish is being transported to the market from all over the world. The biggest fish market in the world, Tsukiji Fish Market in Tokyo, is a good example – fresh fish from all the world's oceans are on display there.

Trade in fish products connects producers with consumers and contributes to food security and higher living standards. For some time, observers of fish trade have been debating whether or not this is true for all those involved in and/or linked with trade in fish and fish products. In these debates, concerns relating to fish and food security have tended to focus directly on fish for consumption. Consequently, when fish exports have been examined, the focus has been primarily on how they reduce the availability of fish for domestic consumption; fish imports, on the other hand, have been seen mostly as a means of increasing local food-fish availability. In fact, the relationship between trade (exports and imports) and food security is more complex. Production for export can enhance the incomes of poor fishers substantially and thus raise their trade-based entitlements, enabling them to achieve greater food security.

In order to understand how, when and where trade in fishery products contributes to, and/or detracts from, food security, FAO and the Norwegian Agency for International Development (NORAD) commissioned a global study consisting of assessment studies in 11 countries: Brazil, Chile, Fiji, Ghana, Kenya, Namibia, Nicaragua, the Philippines, Senegal, Sri Lanka and Thailand.[4] The countries were selected as examples of countries actively involved in international fish trade and to ensure a wide geographical spread. Moreover, these countries have seen a rapid increase in their fish exports over the past 10 to 20 years.

The study addressed the trade issue from a broader perspective than has been the practice in much of the recent debate. It focused primarily on the direct and indirect influence of fish trade on food security and reviewed in detail the positive and negative impacts of international fish trade on food security in LIFDCs. Figure 38 illustrates schematically how the direct and indirect influences of fish trade were evaluated.

MAIN FINDINGS OF THE STUDY

The study's main conclusion was that international trade in fishery products has had a positive effect on food security in the developing countries participating in such trade.

International fish trade has increased dramatically over the past 20 years, from US$15.4 billion in 1980 to US$71.5 billion in 2004. Developing countries have particularly benefited from this increase, with their net receipts increasing from US$3.7 billion to US$20.4 billion over the same period. This was greater than their net exports of other food commodities such as coffee, bananas, rice and tea taken together.

There is, however, room for improvement. Trade statistics indicate no significant change in the composition of exports from developing countries over the past decades. Most exported fish products are frozen. While in some instances this is because of the nature of the product being exported, there is also some evidence that tariff escalation in developed countries has prevented the growth of an export trade in value-added fish products from developing countries.

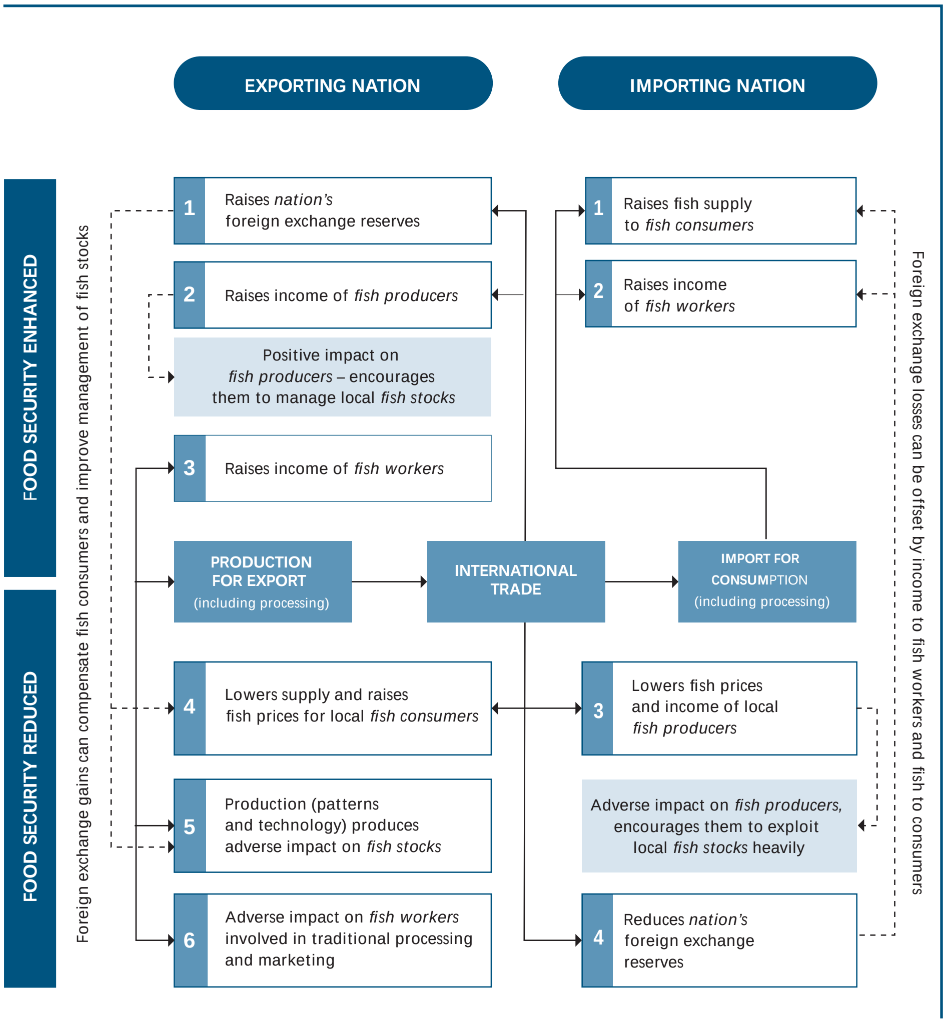
Production and trade statistics also indicate that international trade has not had a detrimental effect on the availability of fish as food. Increases in production, coupled with import and export of fishery products, have ensured continued availability of fish for the domestic markets in LIFDCs. Moreover, proceeds from fish exports are also used to import other foods, including fish products.

In all the countries studied, the number of people employed in export-oriented fisheries had increased over time. Significant new employment had been created in fish-processing activities as a result of international trade. At the time of the study, the total number of employees in fish-processing activities varied according to the size of the trade operations – from 900 in Kenya to 212 000 in Thailand.

In eight of the 11 countries studied, international trade had had a positive impact on food security.[5] This conclusion was based on outcomes related to the national economy and on impacts on fishers, fish workers and fish consumers.

Figure 38

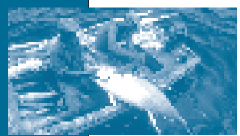
International trade in fishery products: impact on food security in low-income food-deficit countries



Additionally, fish exports were among the top ten foreign-exchange earners in eight of the countries – Chile, Fiji, Ghana, Kenya, Namibia, Nicaragua, Senegal and Thailand. Without doubt, in LIFDCs the earnings from international trade in fishery products contribute to ensuring food security at the aggregate level.

Thailand, one of the world's largest fish-exporting countries, has seen a considerable increase in rural incomes as a result of the overall export orientation of the economy. Fishers are likely to have benefited to the extent that their harvesting and production were linked to export-oriented species. Poverty levels in the rural areas have also dropped significantly.

Modern international trade also has consequences for the lives of the traditional fish processors, the vast majority of whom are women – generally middle-aged and with little education. Any change in the trade policy of a country has an impact on women fish workers. This has important bearings on the question of food security and poverty. On the one hand, as numerous studies have shown, an increase in the income of women, as opposed to men, has a greater positive impact on household food security. Expanding fish-processing activities in developing countries, including those generating additional value to fish destined for export markets, has created new jobs among women, mainly young women. On the other hand, increased exports of fishery products, particularly to developed countries, has led to a significant decline



in the quantity, and also an increase in the price, of fish available to women involved in traditional fish processing. This has resulted in some loss of employment, income or both.

The study found that international trade in food products generally has a negative impact on fish resources. Clearly, there is an urgent need for more effective and sustainable resource-management practices, without which there can be no sustainable international trade. Preserving the resource base and the integrity of the aquatic ecosystem is a *sine qua non* for food security – with or without international trade. The fundamental requirement is to sustain the growth of fish production and maintain a harmonious balance between the three realms – marine capture, inland capture and aquaculture – in accordance with the social and physical context. In aquaculture, achieving a new balance between intensive and extensive production techniques, including more efficient feed-conversion ratios and the search for non-animal protein feeds, should be a priority.

The study also highlights the need for free and transparent trade and market policies. These will help ensure that the benefits accruing from international fish trade are shared by all segments of society. In this respect, the study underscores the recommendation of FAO's Code of Conduct for Responsible Fisheries that states consult with all stakeholders, industry as well as consumer and environmental groups, in the development of laws and regulations related to trade in fish and fishery products.

Finally the study recommended the following targets for countries, particularly developing countries, aiming to increase food security through international fish trade:

1. better fishery resource management;
2. better information on the chain of custody and trade structure;
3. recognition of subsistence fishing as a major source of direct food security;
4. more social security for fish workers;
5. improved livelihood-related infrastructure, such as housing, sanitation and water supply;
6. better coordination in data and statistics collection;
7. assistance for developing countries in adapting to new market conditions;
8. better regional cooperation among developing countries;
9. more inclusive and responsible fish trade;
10. responsible fish consumption in developed countries.

Trash or treasure? Low-value/trash fish from marine fisheries in the Asia–Pacific region[6]

INTRODUCTION

Marine fishery products from both capture and culture continue to play a significant role in the food security, poverty alleviation and economies of many countries in the Asia–Pacific region. Over the past 20 years, major changes have occurred in these fisheries – overexploitation of marine coastal fishery resources has led to the encouragement of coastal aquaculture to meet the growing demand for seafood, income, employment and export earnings in many countries.

The shift to aquaculture to make up for reduced capture supply and quality may not have factored in the close link between capture fisheries and aquaculture. This is particularly the case where aquaculture depends on the capture fishery to provide its feed, either directly as fresh fish or through fishmeal and fish oil. Fishing and aquaculture have become locked into a loop (see Figure 39), where the demand for low-value/trash fish for fish and animal feeds supports increased fishing pressure on already degraded resources. This raises some important questions regarding the social, economic and ecological costs and benefits of this system, its sustainability and future trends.

Box 12

Low-value/trash fish: a definition

For the purpose of this article we define *low-value/trash fish* as: Fish that have a low commercial value by virtue of their low quality, small size or low consumer preference. They are either used for human consumption (often processed or preserved) or fed to livestock/fish, either directly, or through reduction to fishmeal/oil.

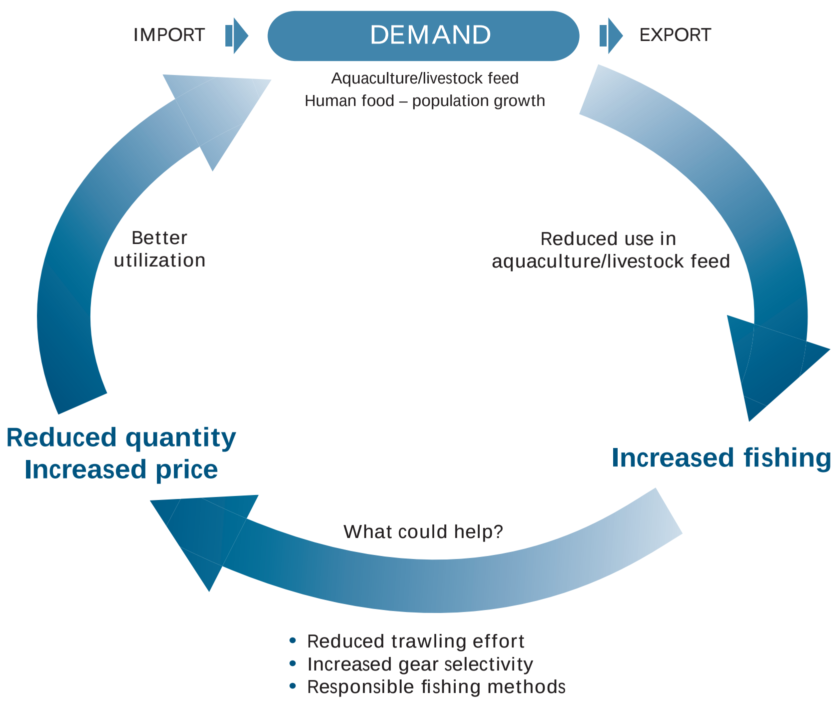
Note that in China and Thailand the term only applies to fish used as livestock/fish feed.

PRODUCTION OF LOW-VALUE/TRASH FISH

In many coastal demersal fisheries in Asia, "fishing down the food chain"[7] has resulted in an increase in the percentage of low-value/trash fish, especially in heavily fished areas in China, Thailand and Viet Nam. The Asia–Pacific Fishery Commission (APFIC) has provided initial estimates for six major fish-producing countries in the region (Table 15). A weighted average[8] of low-value/trash fish across the six countries amounts to 25 percent of the total marine catch, with estimates greater than 50 percent in specific fisheries.

Figure 39

The "low-value/trash-fish loop", where increasing demand sustained by increasing prices drives increased fishing and resource degradation



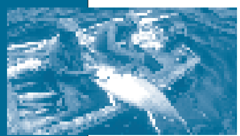


Table 15
Estimations of annual low-value/trash-fish production in the Asia–Pacific region

Country	Low-value/ trash fish (Tonnes)	Share of total catch (Percentage)	Dominant gear[1]	Year of estimation
Bangladesh	71 000	17	Gill nets (48) Non-mechanized set bags (42)	2001–02
China	5 316 000	38	Trawl	2001
India	271 000	10–20	Trawl	2003
Philippines	78 000	4	Trawl (41) Danish seine (22) Purse seine (12)	2003
Thailand	765 000	31	Trawl (95)	1999
Viet Nam	933 183	36	Trawl	2001

[1] Figures in parentheses are percentages.

Source: APFIC country studies cited in FAO. 2005. *Asian fisheries today: the production and use of low-value/trash fish from marine fisheries in the Asia–Pacific region*, by S. Funge-Smith, E. Lindebo and D. Staples. RAP Publication 2005/16. Bangkok.

USES OF LOW-VALUE/TRASH FISH

Low-value/trash fish (using the broader definition) are an important food source for poor people in many developing countries. Small-scale fishers generally keep low-value/ trash fish for home consumption, after selling other fish with higher market demand. Some of the low-value/trash fish are consumed fresh while some are preserved or processed (e.g. into fish sauce or pastes). The proportion of low-value/trash fish used for human consumption can be quite high; for example, in Bangladesh about 60 000 tonnes of the total 71 000 tonnes of low-value/trash fish landed are consumed either directly or in a dried form.

Varying amounts of the low-value/trash fish are used for livestock/fish feed in the different countries (100 percent in China and Thailand – by definition, and little in Bangladesh and India). A conservative estimate for the amount of fish used for livestock/fish food in Asia would be in the order of 25 percent of the capture fisheries production.

Box 13

Low-value/trash fish prices

At the local level, prices of low-value/trash fish vary according to the species, season and abundance of other fish and fishery products. At the low end, fresh low-value/trash fish have been known to fetch as little as US$0.04 per kg (e.g. in Thailand), while their price can be as high as US$1.50 per kg (e.g. in India). Fishmeal-producing industries in the Asia–Pacific region, however, buy low-value/trash fish at prices ranging from US$0.25 to US$0.35 per kg, depending on the protein concentrations of the fish.

There also has been considerable innovation and diversification into new fish products in recent years in an attempt to utilize previously unwanted bycatch, especially from shrimp and finfish trawlers.

Using FAO statistics for capture and aquaculture production in the region, a very approximate "back of the envelope" calculation can be developed to trace the flow of fish products through direct and indirect human use (Figure 40). For 2003, the recorded marine capture fishery landings in the Asia–Pacific region amounted to 39.3 million tonnes (for all carnivorous and omnivorous fish, excluding molluscs and seaweeds), with about 1.8 percent discarded,[9] giving a total capture figure of approximately 40.0 million tonnes. Of this, 29.5 million tonnes were used directly for human consumption and 9.8 million tonnes (25 percent) used for livestock/fish. The total aquaculture production in the region for all fish (again excluding molluscs and seaweeds) is estimated at 28.0 million tonnes. This indicates that approximately 50 percent of fish for human consumption produced in the Asia–Pacific region comes directly from capture fisheries, while 50 percent comes through an aquaculture pathway (this fish is consumed both within the region and exported).

ISSUES ASSOCIATED WITH LOW-VALUE/TRASH FISH

Several issues concerning low-value/trash fish need to be resolved in order to ensure that fisheries of the Asia–Pacific region contribute more to the region's sustainable development.

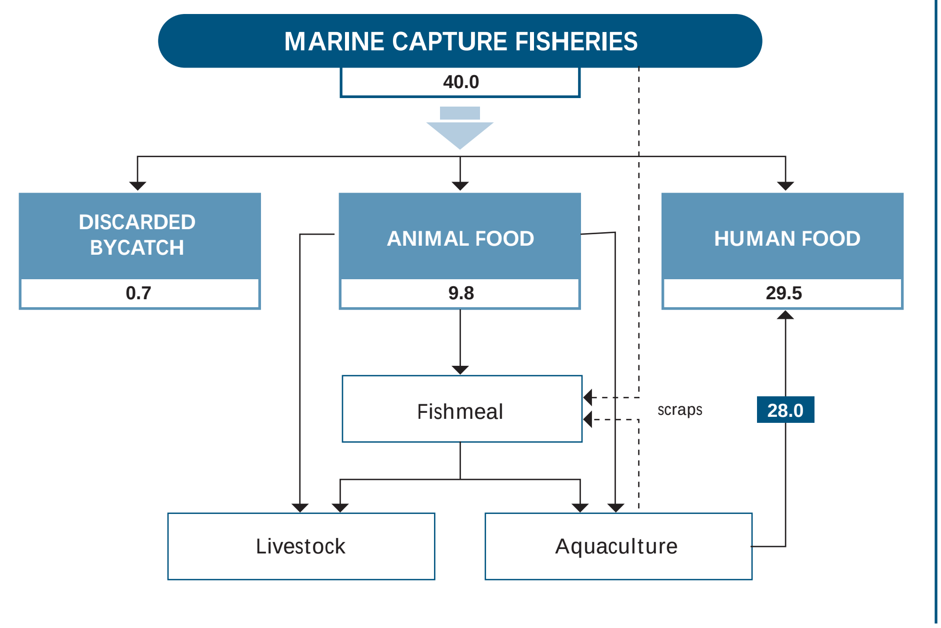
Increasing demand for low-value/trash fish for aquaculture and other animal feeds

FAO estimates that an annual global production increase of 3.3 percent until 2030 is feasible in the aquaculture sector.[10] The International Food Policy Research Institute (IFPRI) gives an estimate of some 2.8 percent until 2020.[11] The production of higher-value species will increase the most, given the rising demand for these fish products. The largest rise in production is expected to be in China.

In many areas, these culture practices have been transformed from extensive systems to semi-intensive and intensive culture systems, for which increasing amounts

Figure 40

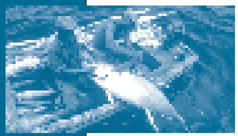
Production flows in the Asia–Pacific region, by major categories of fish
(million tonnes, live weight equivalent)



of feed are required. Fishmeal remains the preferred protein source for most aquaculture feeds. The fishmeal component of feeds can be replaced by vegetable protein (e.g. soya) or monocellular proteins, but the economics of this practice currently remain unattractive. It is worth noting that chicken, cattle and pigs do not naturally feed on fish and therefore the inclusion of fishmeal in feeds for these animals is a nutritional or economic convenience rather than an absolute necessity; the same cannot be said for carnivorous fish.

Competition between use for fishmeal versus use for human food

There is a growing conflict between those who favour using low-value/trash fish for animals and fish versus those who argue it should be used for human consumption. Some argue that it would be more efficient and ethical to divert more of the limited supply to human food (e.g. in the form of value-added products). However, without external interventions (such as incentives and subsidies), it will be the economics of the different uses of low-value/trash fish in different localities that will channel the fish one way or the other. For example, in Viet Nam, as the national demand for fish sauce is expected to double over the next ten years, the competition for mixed low-value/trash fish will increase between those who culture catfish (*Pangasius)* and those who use these fish as raw material for low-cost fish sauce. In contrast, culture operations for high-value marine finfish and lobsters can afford to pay more for anchovy than can fish sauce manufacturers in central Viet Nam. The purchasing power of those who culture higher-value species will tend to draw on lower-priced capture fishery resources. Where this happens, it is important to appreciate the employment and income generation afforded by high-value aquaculture and factor in the ability of those who are employed in this activity to purchase food, rather than produce it or catch it directly.



Sustainability of harvesting

Low-value/trash fish have ready local markets and can be sold easily in many landing sites, but may have relatively limited markets beyond these areas in view of their poor quality, appearance, size or bony nature. Hence, there seems to be little incentive to discourage the harvesting of low-value/trash fish given their important contribution to aquaculture, overall employment and consequent export earnings. Also, the low-value/trash fish catch is based on a large number of short-lived, highly productive species for which, apart from targeted low-value/trash fisheries in China, there is little evidence of current overexploitation leading to reduction in overall fish production.

The concern, for both capture fisheries and aquaculture, is that there is no way of knowing how sustainable this system might be. The WorldFish Center has analysed low-value/trash fish trends in several countries based on past scientific trawl surveys. The results show that many families of fish that include both low-value/trash fish species and commercial species have suffered severe declines in abundance, whereas families containing only low-value/trash fish species have been less affected.[12]

A further aspect of the sustainability issue is that the low value of these fish does not reflect their high ecological value. Removing large quantities of them from the environment creates a void in the food chain, which could also lead eventually to the reduction or loss of larger fish species. Moreover, fishing with demersal gears that destroy habitats adds to the overall ecological impact.

Growth overfishing – harvesting juveniles of commercial species

An issue related to that of low-value/trash fisheries is the capture of juvenile fish of important commercial species (so-called "growth overfishing"). Between 18 and 32 percent of low-value/trash fish in the Gulf of Thailand are juveniles of commercially important fish species. Given a chance to grow to a larger size, these high-value species could, when harvested, yield much more in terms of total quantity landed and, more importantly, in terms of value.

Juvenile/trash fish excluder devices have been tested in trawl nets in several Southeast Asian countries. However, given the many conflicting uses for low-value/trash fish, it is difficult to envisage a management system that optimizes the supply of these fish for both human and livestock/fish uses and at the same time excludes juvenile fish.

Lack of incentives for improved post-harvest

Because of the high demand for low-value/trash fish and the good economic gains they offer, many fishers have decided that careful handling and chilling are not essential. According to some reports in Viet Nam, 20–30 percent, or even 50–60 percent of high-value fish on some offshore trawlers, become low-value/trash fish as a result of poor storage.

Discarding of unwanted fish

Discarding practices are seen by many as a waste of fish and fish protein. For the Asia–Pacific region, discards in most fisheries in China and Southeast Asia are now considered to be negligible owing to the greater utilization of low-value/trash fish as food and feeds. There has also been a change in perception of what constitutes a target species. Given the expansion of markets for low-value fish, almost all catches can now be regarded as "targeted" (i.e. they produce neither bycatch nor discards). Exceptions will, of course, occur: for instance, in Brunei Darussalam, fishing for low-value/trash fish is not permitted (for aquaculture or local consumption), and hence a discard estimate of some 70 percent is still being quoted. Fisheries with high discard rates still exist; these include the Bangladesh industrial finfish and shrimp trawling fishery, which has an estimated discard rate of some 80 percent.

PRIORITY AREAS FOR FURTHER WORK

A draft action plan to address the above issues was developed during the APFIC Regional Workshop on Low Value and "Trash Fish" in the Asia–Pacific region.[13] This plan recommends the action outlined below.

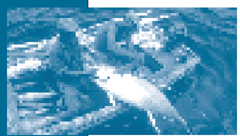
- **Fishery interventions**
  1. Reduce trawling and push net effort (and clearly monitor the effect of capacity reduction).
  2. Introduce improved selectivity of fishing gears/fishing practices.
  3. Facilitate a reduction in the "race for fish" through rights-based fisheries and co-management.
  4. Protect juvenile nursery areas (refugia/closed areas, seasonal closures).
  5. Provide alternative social support measures (including employment).
- **Improved utilization**
  6. Improve post-harvest fish handling.
  7. Develop new fish products through processing.
- **Improve feeds for aquaculture**
  8. Change from direct feeding to pellet feeding.
  9. Reduce fishmeal content by substitution of suitable ingredients in pellets.
  10. Invest in feed research for inland/marine species.
  11. Promote adoption of, and changeover to, pellet feeds.

The challenge is now on how to implement these actions. Several activities have been planned by the APFIC, including a Regional Consultative Forum Meeting and the development of recommendations through the Commission.

Conservation and management of shared fish stocks: legal and economic aspects

SOME KEY ISSUES

A shared fish stock is one that is harvested by two or more states (or entities). The stock may be shared by virtue of the fact that it crosses the boundary of a coastal state's EEZ into one or more neighbouring EEZs (transboundary stock),[14] or because it crosses the



EEZ boundary into the adjacent high seas, where it may be subject to exploitation by distant-water fishing states (highly migratory or straddling stock),[15] or finally because it is to be found exclusively in the high seas (discrete high seas stocks). FAO estimates that as much as one-third of global marine capture fishery harvests may be based on such shared stocks, and argues that the effective management of these stocks stands as one of the great challenges faced in achieving long-term sustainable fisheries.[16]

In response to this challenge, FAO, in cooperation with the Government of Norway, convened the Norway–FAO Expert Consultation on the Management of Shared Fish Stocks in October 2002.[17] FAO also provided technical support to the Sharing the Fish Conference 06, held in Australia,[18] one of the major themes of which was the management of (internationally) shared fish stocks.

Shared fish stocks are more difficult to manage than those confined to the waters of a single coastal state's EEZ because, with a few exceptions, a strategic interaction develops between and among the states sharing the resource or resources. If, for example, two coastal states are sharing a transboundary stock, the harvesting activities of the first state are bound to have an impact upon the harvesting opportunities of the second state and vice versa. Thus, a strategic interaction inevitably develops between the two coastal states, with each state attempting to predict and respond to the harvesting plans of the other.

TRANSBOUNDARY FISH STOCKS

At the close of the Third United Nations Conference on the Law of the Sea in 1982, transboundary stocks were seen as *the* shared fish stock management problem. It was believed that only a small percentage of world capture fishery harvests would come from fish stocks lying outside the emerging EEZs. Consequently, stocks crossing the EEZ into the adjacent high seas were seen as a minor resource-management problem.[19] No one questioned the importance of transboundary fish stocks, which were, and continue to be, ubiquitous. In a thorough study of such stocks, the number of transboundary stocks was estimated conservatively to be in the order of 1 000–1 500 worldwide.[20]

The legal framework for the management of these stocks is provided by the 1982 United Nations Convention on the Law of the Sea, Article 63(1). The article imposes an obligation upon coastal states sharing a transboundary stock, or stocks, to negotiate in good faith over arrangements for management of the stocks. What the article does not do, however, is to impose an obligation on the states to reach an agreement. If the states are unable to do so, then each state is to manage that segment of the stock within its EEZ, in accordance with its rights and obligations laid down by other parts of the 1982 Convention.[21] Thus, the Convention does allow for non-cooperative management of the resource or resources. This could be referred to as the default option.

In light of this default option, two questions must be addressed:

(a) What are the consequences, if any, of coastal states adopting the default option and not cooperating in the management of transboundary stocks, at least not beyond the exchange of scientific information? and

(b) What conditions must prevail if a fully fledged cooperative resource management arrangement between and among the coastal states is to be stable over the long run?

If the answer to question (a) is that the negative consequences of non-cooperative management are trifling, then question (b), of course, becomes irrelevant.

In addressing these questions, it should be recognized that the strategic interaction between and among coastal states sharing transboundary stocks referred to earlier plays a critical role in the resource management problem. Economists, in attempting to find answers to questions (a) and (b), find themselves compelled to do so through the lens of the theory of strategic interaction (or interactive decision theory) – popularly known as game theory. Once deemed to be an esoteric specialty, game theory is now so widely used in the field of economics that the Nobel Prize in Economic Sciences has been awarded twice to specialists in game theory, the latter time being in 2005.[22] The theory is, moreover, applied widely in other fields, such as international relations, legal studies, political science and evolutionary biology.

The theory of strategic interaction – game theory – is divided into two broad categories: the theory of non-cooperative games and the theory of cooperative games. The insights provided by the theory of non-cooperative games offer guidance in addressing question (a). What these insights warn is that one cannot safely assume that the "players" (coastal states) will find some way to manage their respective shares of the resource effectively. There is a serious risk that the players will be driven to adopt courses of action ("strategies") that each player knows will be harmful, if not destructive. This goes under the title of the "Prisoner's Dilemma", from a famous non-cooperative game designed to illustrate the point.[23] These predictions of non-cooperative game theory have been validated many times over in the real world of shared stock fisheries.[24] Explicit cooperation in transboundary fish stock management does, other than in exceptional cases, truly matter. Question (b) cannot be avoided.

In turning to the cooperative management of transboundary stocks, two preliminary questions must be dealt with. First, what is the desired level of cooperation? Over 25 years ago, John Gulland distinguished between two levels of cooperation: the primary and secondary levels.[25] The primary level of cooperation involves the exchange of scientific information and data alone; the secondary level involves cooperation in the "active management" of the resource(s), which in turn involves determining (i) the allocation of benefits from the fishery, (ii) the optimal resource-management programme through time, and (iii) effective implementation and enforcement. The Norway–FAO Expert Consultation concluded that, while the primary level is useful as a precursor, it is seldom adequate in, of and by itself. Coastal states must be prepared to cooperate in the "active management" of the resource(s).

The second question is: what in fact is to be allocated among the coastal states sharing the resource? Is it shares of the agreed-upon total allowable catch (TAC) between, or among, the coastal state fleets, or is it the net economic returns from the fishery over time? The two are not necessarily the same. Historically, one of the most effective fishery cooperative management regimes, both in terms of the profitability of the fishery and the conservation of the resource, was that focused on the fur seals of the North Pacific from 1911 to 1984. Four states were involved (Canada, Japan, Russia/Union of Soviet Socialist Republics and the United States of America). The fleets of two of the states received annual allocations of zero. Nonetheless, all four states benefited economically from the cooperative management of the resource.[26]

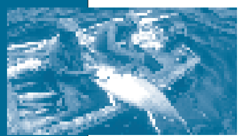
The theory of strategic interaction, in the form of the theory of cooperative games, highlights the conditions that must be met if the cooperative regime is to remain stable through time. Of course, the allocation of the economic benefits from the shared fishery must be seen to be fair. There is, however, a requirement, or rather a condition, that goes beyond this, which could be referred to as the bedrock condition. The condition is that each participant (coastal state) in a cooperative resource-management arrangement must at all times expect to receive long-term benefits from the cooperative arrangement that are at least equal to the long-term benefits it would receive if it refused to cooperate. In game theory parlance, this is referred to as the "individual rationality condition".

This bedrock condition, once stated, seems obvious. The report of the Norway–FAO Expert Consultation observes, however, that, although obvious, the condition is often ignored in practice.[27]

In the first instance, the condition requires that the implementation and enforcement provisions of the cooperative management arrangement be fully effective. If a participating coastal state believes that it has received a "fair" allocation, but also believes that enforcement provisions are so weak that cheating will be encouraged, the state may well calculate that its economic returns from cooperation will fall short of what it could expect to gain from non-cooperation, and will act accordingly.

In the second instance, the individual rationality condition requires that the scope for bargaining should be kept as broad as possible. If, for example, the cooperative resource-management arrangement is such that each coastal state's economic returns from the fishery are to be determined solely by the harvest of its fleet within its EEZ, the scope for bargaining may be too narrow to ensure a stable cooperative resource-management regime. The report of the Norway–FAO Expert Consultation, in addressing the issue, talks in terms of "negotiation facilitators" (also known as side payments). The report states that the "… development of cooperation can be facilitated by supplementing the allocation of TAC shares by such devices as access arrangements and quota trading (both trading in kind and cash)".[28] If, in fact, what is being shared among the participating states is the flow of net economic benefits from the fishery, then it makes no sense to restrict the allocation of these benefits to TAC shares among the coastal state fleets.

The second fundamental requirement, or condition, that must be met if the cooperative resource-management arrangement is to prove stable over time is that the arrangement be "resilient". Every cooperative arrangement can be expected to be subject to unpredictable shocks, arising from environmental, economic, political or other factors. If the arrangement lacks flexibility or resiliency, a hitherto stable cooperative arrangement can be easily thrown into disarray, such that the "individual rationality" condition for one or more participants is no longer satisfied.[29]



STRADDLING AND HIGHLY MIGRATORY FISH STOCKS

The comfortable belief, at the close of the Third United Nations Conference on the Law of the Sea in 1982, that fish stocks to be found both within the EEZ and in the adjacent high seas were of minor importance, proved, during the remainder of the 1980s and the early 1990s, to be quite simply wrong. Case after case of overexploitation of such stocks emerged, for example groundfish resources on the Grand Bank of Newfoundland, pollock resources in the Bering Sea "Doughnut Hole", jack mackerel resources off the coasts of Chile and Peru, orange roughy resources off the South Island of New Zealand and bluefin tuna in the Atlantic and Southern Oceans.[30] The problem became so serious that the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks was convened from 1993 to 1995 in order to address it. The Conference resulted in the 1995 UN Fish Stocks Agreement,[31] which was designed to buttress the 1982 Convention.

Straddling and highly migratory fish stocks are covered in the 1982 Convention, in Articles 63(2) and 64 of Part V on the EEZ and in Part VII on the high seas. The Convention, Part VII in particular, leaves somewhat uncertain the rights, duties and obligations of coastal states and distant-water fishing states (DWFSs) with regard to the high seas segments of straddling and highly migratory fish stocks. This lack of clarity, in turn, made it difficult to establish effective cooperative management arrangements for these stocks.[32] The 1995 UN Fish Stocks Agreement was meant to address this weakness.

Under the Agreement, straddling and highly migratory fish stocks are to be managed on a region-by-region basis through RFMOs,[33] which are to be open to states (including DWFSs) having a genuine interest in the resources. Only those states belonging to an RFMO, or agreeing to abide by the management and conservation measures established by the RFMO, are to have access to the fishery resources encompassed by the RFMO.[34] Each RFMO is, *inter alia*, called upon to ensure that the management measures for the high seas segments of the resources and those measures for the intra-EEZ segments of the resources are compatible with each other.

The two questions posed above with respect to transboundary stocks – (a) the consequences of attempts to establish cooperative management arrangements being unsuccessful and (b) the conditions that must be met if a cooperative management arrangement is to be stable through time – are equally relevant to the management of straddling and highly migratory stocks. Once again, economists, in attempting to answer these questions, find themselves compelled to do so through the lens of the theory of strategic interaction (game theory).

The answer to the first question is the same as the answer provided in the context of transboundary stocks: non-cooperative management carries with it the threat of a "Prisoner's Dilemma" type of outcome with overexploitation of the resources. Indeed, it was the manifest consequences of non-cooperative management of straddling and highly migratory stocks that provided the motivation and rationale for convening the UN Fish Stocks Conference.[35] Once again, cooperative management is of critical importance to the sustainability of these stocks.

Moving to the second question, the conditions that must be met to ensure the long-term stability of cooperative resource-management arrangements, discussed in the context of transboundary stocks, apply with equal force to RFMOs. The cooperative management of straddling and highly migratory stocks through RFMOs is, however, a much more demanding undertaking than the cooperative management of transboundary stocks. First, the number of participants in an RFMO is likely to be substantially greater than the typical transboundary stock cooperative management.[36] The larger the number of participants, the more difficult it is to achieve stability, if for no other reason than the fact that the enforcement problem becomes steadily greater as the number increases.[37]

Second, while the participants in a transboundary stock cooperative arrangement can generally be expected to be constant in number and nature over time, this is not the case with RFMOs. A typical RFMO will include DWFSs among its participants, whose fleets are nothing if not mobile. In particular, a DWFS that was not a founding member of the RFMO may request membership subsequently. The 1995 UN Fish Stocks Agreement explicitly calls upon RFMO founding members to accommodate prospective new members or entrants.[38] How prospective new members can be accommodated, and persuaded to be members of good standing within the RFMO, without undermining the willingness of founding members to cooperate, is an issue that has not yet been resolved.[39] This issue is closely linked to the most marked difference between transboundary stock cooperative arrangements and RFMOs – the threat of "free riding".

Free riding involves the enjoyment of the fruits of cooperation by non-participants in the cooperative arrangement. If free riding is extensive, participants in the arrangement may calculate that their benefits from cooperation will be less than what they would obtain through non-cooperation – the "individual rationality condition" once again. Free riding is conceivable in a transboundary stock cooperative management arrangement, but real-world cases are very difficult to find.[40] In contrast, free riding has been a chronic problem with regard to fishery resources in the high seas.

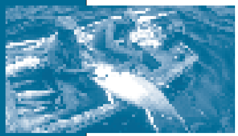
Fishing activities by non-RFMO participants in the high seas area governed by the RFMO, contrary to the management provisions of the RFMO, are deemed to constitute *unregulated* fishing, as opposed to illegal fishing. Uncontrolled and unregulated fishing provides strong encouragement for free riding, in spite of Article 8 of the 1995 UN Fish Stocks Agreement.

Free riders can, of course, be encouraged by RFMO members to change their ways and become new members of the RFMO. Is this really a viable solution, however? Recent "cutting edge" analysis by economists applying the theory of strategic interaction to straddling and highly migratory stock management suggests that, if unregulated fishing is not curbed, there will be cases in which the circle cannot be squared, in which it is not possible to satisfy all RFMO members, old and new. The attraction of free riding will be too strong. In such cases, the RFMO will prove to be inherently unstable.[41] The inevitable conclusion is that, in order for the emerging RFMO regime to prosper, it is of utmost importance that unregulated fishing be effectively curbed. In this context the importance of the IPOA-IUU and its effective implementation cannot be overstated.

DISCRETE HIGH SEAS STOCKS

Until recently, there was little that could be said about discrete high seas stocks, which had been described as the "orphans of the sea".[42] The legal framework for their conservation and management is provided by Part VII of the 1982 Convention, which obliges states to cooperate with each other, negotiate the adoption of measures and, as appropriate, establish subregional or regional organizations. The attention of the international community has focused increasingly on these stocks, particularly as a consequence of a growing concern regarding deep sea fisheries and species. The recent opening to signature of the South Indian Ocean Fisheries Agreement (SIOFA) and the ongoing negotiations towards the establishment of the South Pacific Regional Fisheries Management Organisation (SPRFMO) (see p. 56) are illustrative of that trend. An important step forward was also made when the UN Fish Stocks Agreement Review Conference addressed high seas discrete stocks within the ambit of the Agreement (see p. 55). Thus, the questions raised above also apply to the high seas "discrete" fish stocks.

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



INTRODUCTION

During the first half of the 1990s, in response to the increasing concern about many of the world's fisheries and following 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. The *State of World Marine Capture Fisheries Management Questionnaire* was developed by FAO in 2004 in response to this need. FAO used this questionnaire to carry out a study on the trends of marine capture fisheries management in 32 Indian Ocean countries.[43]

METHODOLOGY

Fisheries management experts were requested to complete the detailed questionnaire for 30 countries,[44] focusing on direct and indirect legislation affecting fisheries, costs and funding of fisheries management, stakeholder involvement in management, transparency and conflict management, and compliance and enforcement.

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

Within the countries surveyed, 55 large-scale, 61 small-scale and 18 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 data are to be used with caution.

On completion of the questionnaire, subregional reviews were drafted based on the individual country reviews. An analysis of the combined questionnaire responses provided a snapshot of fisheries management in the Indian Ocean during the 2003–05 period and partial results are provided below.

OCEAN-WIDE TRENDS

Political and legislative frameworks

All countries within the region had specific legislation for the management of marine capture fisheries and almost all such legislation provided a legal framework for fisheries management, with slightly less providing an administrative framework. However, the term "fisheries management" was defined in only one-quarter of those countries responding, and only 57 percent of the countries had laws and regulations designed to serve as a legal framework for fisheries management and fisheries management plans. In addition, in only a minority of cases did national legislation require that fisheries management decisions be based on at least one of the following analyses: biological analyses/stock assessments, social impact analyses, economic analyses, or monitoring and enforcement analyses. There was therefore relatively little legal guidance on the processes for taking management measures and, hence, fisheries managers often lacked the interdisciplinary information required to develop proper management measures.

The legislation in most countries identified a single agency or other authority[45] as being responsible for marine capture fisheries management at the national level; however, these agencies/authorities legally shared management responsibilities with other agencies and/or were further assisted by government or quasi-government agencies (which, in turn, were supported by universities) in their fisheries research. In many cases, 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.

The policy framework in place within the region was more often than not development-oriented, despite many fish stocks being considered at least fully exploited.[46] When specific fisheries management objectives were provided for in the legislation, the objectives tended to be split into either development-oriented or sustainability-oriented lines. Countries in the Red Sea and the Gulf Sea tended to have development-oriented objectives; those countries along the eastern rim of the Indian Ocean tended to specify sustainability criteria within the legislation; while those along the western rim tended not to have specific management objectives within their legislations (South Africa and Madagascar excluded). However, most countries' fisheries management was affected by at least one other national legislation based on sustainability concepts.

In only approximately half of the countries were a large majority of the marine capture fisheries considered as being "managed in some way"[47] and, of those fisheries considered managed, most lacked any formal documented management plans. Nevertheless, the perception within the countries is that the number of fisheries managed in some way has increased over the past ten years.

Status of the fisheries

When matched up with global comparisons of large-scale versus small-scale fisheries,[48] the relative sizes between these subsectors in the Indian Ocean remained consistent (Table 16). The small-scale fisheries involved over 2.5 times more participants (employed part-time or full-time, or as subsistence fishers) than the large-scale fisheries and total landings from the two subsectors were approximately equal in size.

The number of participants had increased over the previous ten-year period in most fisheries across the three subsectors, yet had decreased in some of the fisheries.

Directional changes over the previous five years in landings from large-scale fisheries varied across the countries: seven countries reported decreased trends in terms of quantity, while 11 countries reported decreased trends in terms of value. It is interesting to note that in some of these countries trends in quantities and values moved in opposite directions over the five-year period. Most countries reported positive trends in both landings quantities and values within the small-scale sector and, when quantities and values went in opposite directions, quantities decreased while values increased. Changes in quality or price variations may explain this phenomenon.

Concerning stock status, an FAO report published in 2005 signalled little room for further expansion in these fisheries,[49] in addition to the possibility that some, if not most, stocks might already be overexploited. It should also be noted that, within the subregional reviews included in the 2005 report,[50] the review authors had indicated more serious conditions for certain species than were portrayed at the larger statistical area used in the 2005 report. These views stress further the need for precaution within the Indian Ocean, especially when the effects of IUU fishing and discarded bycatch quantities on the stocks are difficult to ascertain and control.

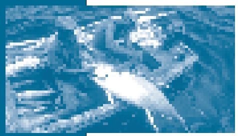


Table 16
Basic data on the largest Indian Ocean fisheries by subsector

	Fishery subsector		
	Large-scale	Small-scale	Recreational
Number of participants	1 600 000	4 300 000	90 000
Total landings *(tonnes)*	4 000 000	4 200 000	n.a.
Number of vessels	73 000	313 000	n.a.

Notes:
Data are for the top three (by quantity) fisheries for each subsector within 30 Indian Ocean countries.
Indonesia and Malaysia include data from both Pacific and Indian Ocean fisheries.
Data for recreational fisheries include only 11 out of 18 fisheries identified owing to lack of available information.
n.a. = not available.

Management tools in use within the largest fisheries

The toolkit of technical measures for fisheries management used in the region included spatial restrictions, temporal restrictions, catch and size restrictions, rights/incentive-adjusting restrictions and gear restrictions (Figure 41). The results of the questionnaire brought to light certain tendencies within the Indian Ocean countries.

- Countries preferred the use of spatial (especially marine protected areas and marine reserves) and gear (especially type and size) restrictions over other technical measures for managing marine capture fisheries.
- Other than the issuance of fishing licences, very few incentive-adjusting or rights-providing mechanisms were used.
- Tools currently in use within the small-scale sector had been, for the most part, established or increased within the last ten years, while those tools in use within the large-scale and recreational fisheries had not experienced many changes in use patterns, with the exception of increased use in spatial restrictions.
- Although recreational fisheries were active in at least ten countries in the region, few management measures were applied to these fisheries other than the establishment of marine protected areas and reserves and, less frequently, the granting of licences and the adoption of gear type restrictions.

Participatory mechanisms and conflict management within 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 had been identified in most fisheries across the three subsectors. In many 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 sentiments were less strong within the small-scale subsector.

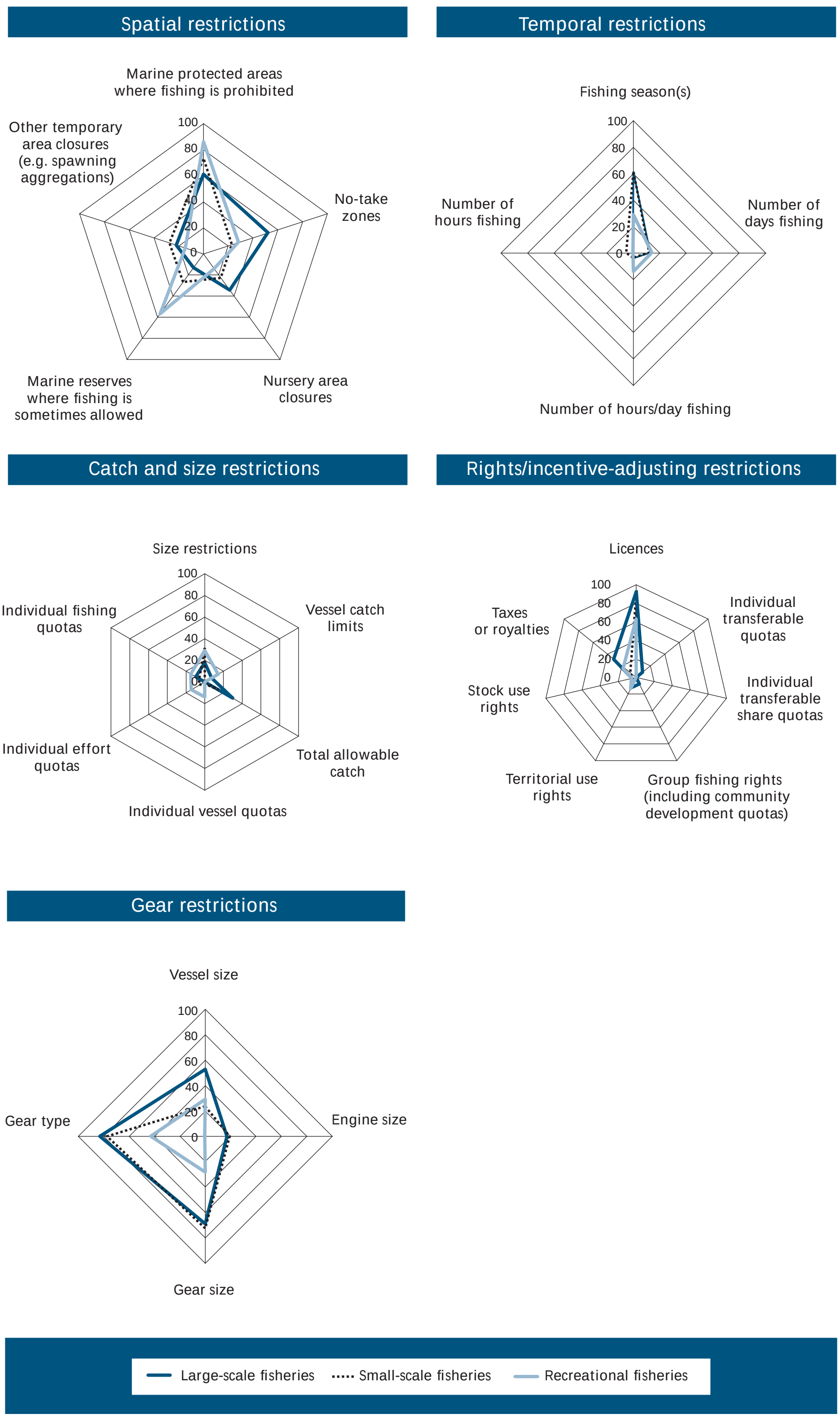
If stakeholders were part of the fisheries management decision-making process, the management process had often been accelerated within the large-scale subsector but not necessarily within the small-scale subsector and rarely within the recreational subsector. However, the participatory approach had led to a reduction in conflict within the fisheries and had created incentives and reasons for stakeholders to practise "responsible" fisheries stewardship voluntarily.

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

Conflict-resolution processes were used within about a third of the fisheries reviewed; such processes included zoning for specific users, stock enhancement, resource allocation between and among the fisheries, and educational methods to

Figure 41

Technical measures for fisheries management in use in the Indian 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.

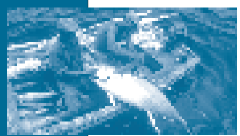
sensitize users regarding the multiple-use nature of certain resources. There was little variation among the subsectors except that sensitization methods were more common in the recreational subsector than elsewhere.

Fleet capacity management within the largest fisheries

Within the Indian Ocean, fleet capacity was measured in the majority of large-scale and recreational fisheries; however, capacity measurement within the small-scale subsector was rarely undertaken. In addition, although there was often a sense that overcapacity existed within almost half of the fisheries, very few capacity-reduction programmes were put into place to adjust for the levels of effort.

When measures were used, the preferred method for reducing capacity levels was the purchase of fishing licences from the fishery, followed by a less-used approach of buying-out fishing vessels licensed to operate in the fisheries. Licence removal was found to be an efficient means for immediately reducing any excess fishing capacity, while vessel buyouts were considered much less effective. In addition, these initial licence removals, when 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 funds, but several instances occurred in which programmes were paid for by participants within the fishery itself or, occasionally, by participants within other fisheries.



Costs and funding of fisheries management

Budget outlays for fisheries management included, *inter alia*, funding for research and development, monitoring and enforcement, and daily administrative management. Only in approximately 10 percent of the countries were these activities not covered in some way by national government funding. However, national funding sources tended to decrease as management moved towards regional and local levels – contrasting with the increased trends in management costs at these levels, owing in part to decentralization policies throughout the region.

Fisheries management cost-recovery mechanisms, other than licence fees, were uncommon within the large-scale and small-scale fisheries. In cases where revenues were collected from fisheries activities, more often than not these revenues went directly to the central government budget. Therefore, the link between benefits and costs of management services could not be made and fisheries authorities continued to base their management activities on governmental appropriations. Interestingly, the use of licence fees and other resource rent-recovery schemes were common within the small number of recreational fisheries, perhaps reflecting differing views as to whether access to a resource is assumed to be a right or a privilege.

Compliance and enforcement

In most cases, the above-mentioned increases in management costs were associated with increased monitoring and enforcement activities, but were also a result of increased conflict management and stakeholder consultations. Linked to increased monitoring and enforcement is the perception that, over the past ten years, the numbers of infractions had increased in many countries.

Compliance and enforcement tools within the region focused on inspections, whether on-land or at-sea. The use of additional tools, such as onboard observers or VMS, was less widespread within the region.

When faced with infractions, most countries relied on small fines or the revocation of fishing licences as deterrents; however, the perception within the vast majority of countries within the region was that the funding provided was not sufficient to enforce all fisheries regulations, the penalties for non-compliance were not severe or high enough to act as deterrents, and the risk of detection was too low to promote adherence to fisheries regulations.

SUMMARY AND CONCLUSIONS

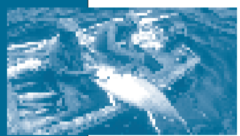
The challenges regarding fisheries exploitation and management in the Indian Ocean countries are not dissimilar to those in other regions.

- Legislative reforms had improved the regulatory framework but application of such reforms had remained limited and lack of effective MCS had undermined fisheries management.
- Fisheries policies often remained development-driven and without consideration of economic, social, biological and environmental sustainability criteria; however, examples of holistic management approaches existed within the region and experiences from these could prove useful for the region.
- Conflicts between and among fisheries remained pervasive.
- The high number of small-scale vessels and fishers, combined with the potential role of small-scale fisheries in poverty alleviation and prevention, remained a constraint to the development and implementation of management of these fisheries.
- Reliance on classical and costly stock assessment had limited the ability of countries to gather consistent stock data. Combined with the need for "hard" data, fisheries planning capacities were often stalled at the status quo even while the qualitative data suggested that many stocks were fully exploited or overexploited.
- Socio-economic data were collected infrequently or not at all; therefore, the contribution of small-scale fisheries to human well-being, food security, and poverty alleviation and prevention was poorly understood and the impacts of potential management measures were not being evaluated throughout the three subsectors.
- Information on shared and transboundary stocks was often missing or inadequate and relevant institutions' arrangements were often non-existent.
- Integration of stakeholders in the fisheries management process had increased but remained limited, leading to continued difficulties in managing fishing capacity within all subsectors, but specifically within the small-scale subsector.
- The multispecies nature of most fisheries had not been taken into consideration.
- Clearly defined priorities regarding the objectives for each fishery were lacking, leading to inappropriate planning and increased conflicts within and among the fisheries.

Actions to address these issues may include:

- the introduction of adaptive and cost-effective management strategies, based on strengthened management structures with well-defined, prioritized objectives;
- the strengthening of the ecosystem approach to fisheries management;
- the investigation of cost-effective data gathering methods for biological, economic, social and environmental aspects of fisheries;
- an effective enforcement of fishery laws and regulations;
- a better control over growth in fishing fleet capacity;
- a greater harmonization of the definition and application of laws and regulations, where appropriate;
- the development of fisheries management plans with relevant stakeholders;
- the development of national plans of action to address IUU and fishing capacity issues;
- an active participation in regional initiatives such as RFBs 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;
- greater involvement of stakeholders in management with consideration given to co-management schemes, especially at the local level, requiring the creation or strengthening of organizations to represent fishers and other interests.

The countries of the Indian Ocean will need to continue in their development of sustainable fisheries-management frameworks, addressing both international norms and agreements as well as adapting to each country's 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 as well as 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, if there is a lack of political will to implement the relevant laws, regulations and management measures, even perfectly designed frameworks will remain on the bookshelves.

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

Refuelling the fishing fleet

THE ISSUE

The price of diesel rose by 100 percent in the two-year period January 2004 to December 2005 (Figure 42). This severely affected the profitability of the catching sector of the fishing industry, mainly by cutting the profit margins of fishing vessels, and almost certainly resulted in many fishing vessels making a financial loss in 2005.

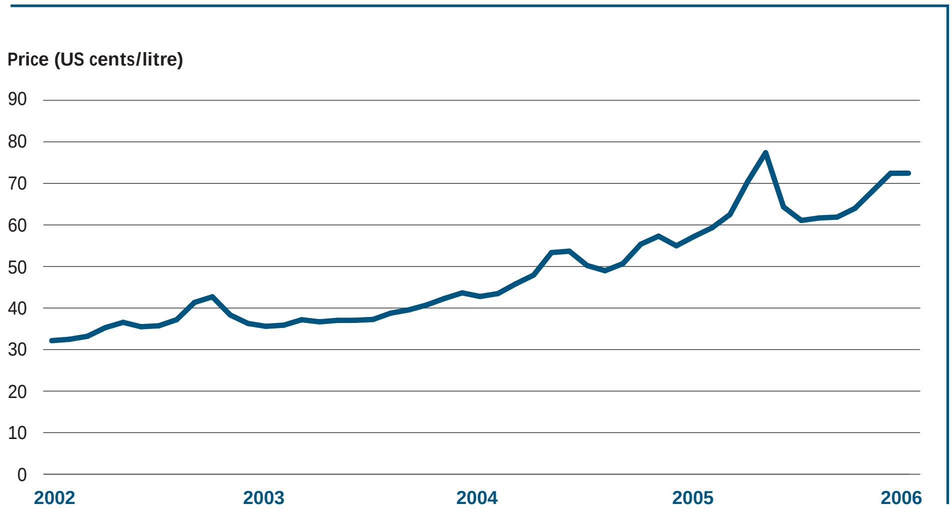
The fish-catching sector is entirely dependent on fossil fuel for its operations and currently has no alternative form of energy. Fishers and other entrepreneurs in the sector are locked into a situation in which they are the unfortunate victims of international circumstances. Although the present situation forces them to focus on the short-term problems, they must address those linked to the availability of petroleum in the medium-to-long term. As petroleum is a non-renewable resource, eventually supplies will decline and become more expensive in real terms. This sombre prospect is combined with a growing pressure to use less petroleum because of the greenhouse effect caused by carbon emissions from the use of fossil fuels. Thus, there is a pressing need to identify alternative sources of energy for the specific needs of the fishing industry.

It should be noted that fuel prices in the fishing industry worldwide are far more homogenous than for road transport because fuel for industrial use, including farming and fishing, is taxed at a lower rate. On the other hand, fuel for road transport varies widely in price because of the wide range of taxation rates levied. Some Southeast Asian countries have policies that subsidize fuel for fishing.

FAO estimates that in 2005 the fish-catching sector consumed 14 million tonnes of fuel at a cost equivalent to US$22 billion, or about 25 percent of the total revenue

Figure 42

Diesel prices, United States of America, 2002–06



Source: International Energy Agency.

of the sector projected to the equivalent of US$85 billion.[51] More efficiency is being sought within the fishing industry, *inter alia*, by using specialized fish transport and supply vessels, permitting fishing vessels to spend more time fishing and less time steaming to and from the fishing grounds. However, these and other operational fuel-mitigation measures taken by fishers (e.g. trawlers converted to pair trawling, which is a far more effective use of energy) are estimated to reduce consumption by no more than 20 percent and are unlikely to counteract the increase in fuel costs completely. Fish prices will probably take some time to adjust upwards, so, as long as the price of diesel fuel remains at 60 cents/litre, the sector will continue to experience financial difficulties.

Over the past decade, FAO has carried out a series of international studies of profitability in the fish-catching sector.[52] In all, 88 fisheries were sampled between 1995 and 1997, 108 fisheries in 1999–2000 and 75 fisheries in 2002–03. These studies revealed that vessels from developing countries were spending relatively far more on fuel than were vessels from developed countries. Fuel costs expressed as a percentage of the revenue from landed catch were almost twice as high in the former group of countries, as can be seen in Table 17. The table also shows a general rise during the period 1995–2003, from 14.85 percent to 18.53 percent, for the average cost of fuel worldwide measured as a share of revenue from fish landed. Estimated annual fuel costs at the 2005 average price level (all other costs and revenues assumed to remain unchanged) are also indicated.

The FAO studies also analysed the fuel consumption for different categories of fishing gear. The differences between active and passive fishing gears were not as pronounced as might have been expected (Table 18).

Several conclusions can be drawn from Table 18.

Table 17
Fuel costs as a percentage of the revenue from fish landed, developing and developed countries

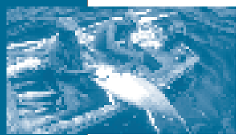
	Fuel costs as a percentage of revenue			
	1995–1997	1999–2000	2002–2003	2005[1]
Developing countries	18.52	20.65	21.63	43.26
Developed countries	11.08	9.78	10.20	20.40
Global average	14.85	16.70	18.53	37.06

[1] Estimated.

Table 18
Fuel costs as a percentage of the revenue landed by type of fishing gear, developing and developed countries

	Fuel costs as a percentage of revenue			
	1995–1997	1999–2000	2002–2003	2005[1]
Developing countries				
Active demersal	17.19	30.28	26.15	52.30
Active pelagic	17.33	17.60	16.99	33.98
Passive gear	18.78	17.06	19.33	38.66
Developed countries				
Active demersal	10.57	8.64	14.37	28.74
Active pelagic	n.a.	7.65	5.48	10.96
Passive gear	5.57	4.95	4.61	9.22

Note: n.a. = not available.
[1] Estimated.



- There are significant differences in the fuel costs between fishing fleets in developed and developing countries. Vessel owners in developing countries pay a far higher component of their revenues for fuel than do their counterparts in developed countries and the proportion has been rising. It is likely to have been almost twice as large in 2005 as in 2002–03. This difference does not only prevail in fisheries but throughout the industrial sector. Developed countries are far more energy-efficient than are developing countries.[53] It seems that fishers in developing countries are more susceptible to increased fuel prices than are their counterparts in developed countries.
- The difference in the relative importance of fuel costs is most discernable for passive gears. In all the three studies, developing country fishers using passive gears were found to spend, as a proportion of revenue, at least three times more than fishers using passive gears in developed countries.
- The average ratio of fuel cost to revenue rose from 14.85 percent to 18.53 percent between 1995 and 2002 – an increase of almost 25 percent.

SIMULATION OF ECONOMIC PERFORMANCE

As stated above, FAO has analysed the economic performance of fishing fleets worldwide. Of the 88 fisheries sampled in 1995–97, no fishery had a negative gross cash flow and only 15 had a negative net cash flow when depreciation and interest payments were taken into account.[54] The detailed data on expenditures and revenues available from the 1995–97 study can be used to simulate the effect of doubling the 1995–97 fuel prices. Such a simulation results in 55 fisheries suffering a negative net cash flow.

Given the large and rapid increases in the price of fuel and the potential for a fishing industry to collapse in the short term because of these changes, some governments might wish to protect the fishing industry from such violent changes. One possibility would be to adjust the price of fuel so that in any given year it would increase by no more than a specified percentage – say 10 percent above the consumer price index. This would allow the industry to adapt to the new circumstances and eventually readjust to the real price of fuel.

IMPACT ON THE PUBLIC SECTOR

Increases in fuel prices will affect fisheries not only through their impact on fishers and other entrepreneurs in the sector, but also through their impact on the public sector. As most of the public sector is allocated a set budget for running costs, higher fuel costs can result in reduced availability of fuel, *inter alia*, for patrol duties or for scientific research. More cost-effective methods will have to be sought for monitoring fishing fleets. VMS are likely to become more common and manned sea or air-borne patrols may be replaced by the use of unmanned aircraft.

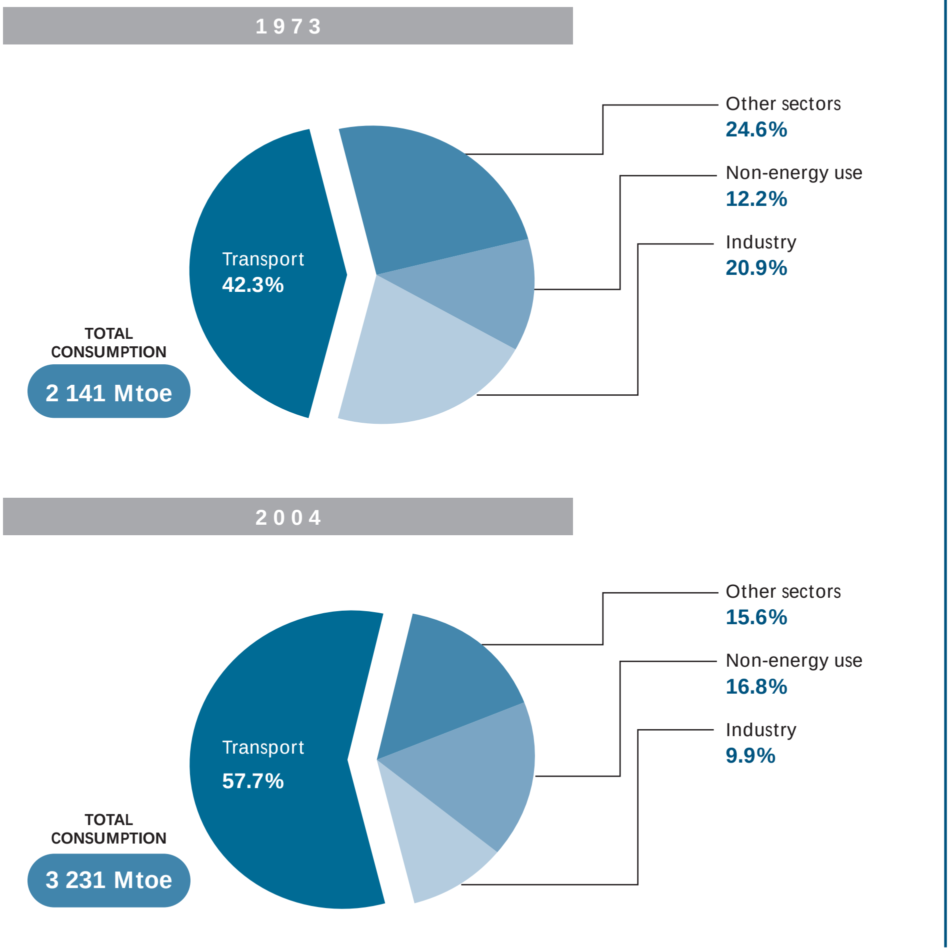
LONG-TERM FUEL PROSPECTS (BEYOND PETROLEUM)

The large increase in the price of fuel and doubts about future supplies require that these issues are taken into account in any discussion on fuel in the fishing industry. Figure 43 shows the increase in demand/supply of oil from 1973 to 2004 and the sectors to which the oil was supplied. It is clear that transport is the largest user of oil and that its share of the total oil supplied is increasing and is expected to increase further. On the other hand, the 14 million tonnes of fuel used by the global fishing industry accounts for less than 0.5 percent of global oil consumption. It follows that both the price and demand for oil are going to be determined by other consumers of oil, especially the transport sector.

The current fuel crisis is one of many that have occurred since that triggered by the Suez crisis in 1956. The main causes have not been the global lack of petroleum, but the uncertainty of the supply from the oil-producing countries to the oil-consuming countries. The hurricanes that affected the oil refineries in the Gulf of Mexico in 2005 are only one of the elements that have pushed the price of petroleum to the very high levels currently prevailing. For many, the reason that the current price levels are so high is that petroleum supply is so tightly bound to demand that any disruption causes a

Figure 43

Global consumption of oil by sector, 1973 and 2004



Notes: Other sectors comprise agriculture, commercial and public services, residential and non-specified.
Mtoe = million tonnes of oil equivalent.
Source: Key World Energy Statistics 2006 © OECD/IEA, 2006, p. 33.

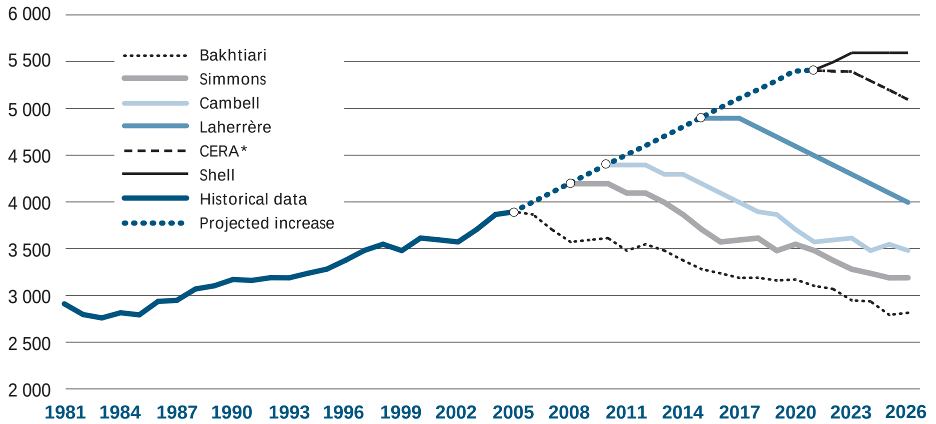
price hike. However, it is paradoxical that the entities that have been responsible for the supply of petroleum (i.e. the major oil companies and governments) are currently benefiting from the increased prices while the consumers, including fishers, have to pay a higher price for petrol and diesel. Petroleum has the most volatile price of all the commodities.

Another issue that might eventually have more serious implications for the fishing industry than the current price increases is the long-term sustainability of petroleum production. The issue is controversial and experts can be divided into the “petro-pessimists”, who predict the occurrence of oil “peaking” in the near future, and the “petro-optimists”, who maintain that this scenario is still some time in the future. But all are agreed that fossil fuels will be depleted by the end of the twenty-first century (see Figure 44).

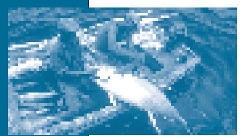
Some, perhaps the most enlightened, analysts point out that it is not the time at which oil peaks that is the important factor, but the actions that are taken by governments and energy companies prior to that event. It should be noted that many such actions are already being undertaken by governments and that alternative fuels are currently being sought for transport uses. These actions include the increased recovery of oil from existing wells, the conversion of gas and coal to liquid fuels

Figure 44

Simplified representation of some oil-peaking scenarios by a number of experts in 2006



Notes: Historical data series from BP. 2006. *Statistical Review of World Energy 2006,* workbook of historical data (see www.bp.com).
*CERA: Cambridge Energy Research Associates.



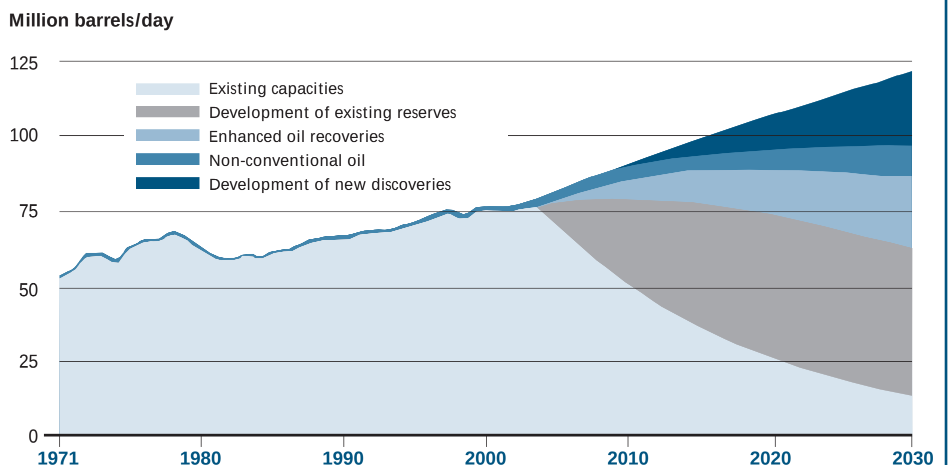
and the exploitation of heavy oils and tar sands. More efficient vehicles are being developed and ethanol is being produced as an alternative renewable fuel in agriculture (Figure 45). These developments are also being actively promoted in the interests of combating the effects of global warming. Already, motor vehicles are being powered by hydrogen in Iceland and California, the United States of America, and plans are in hand in Iceland to extend the use of this energy source to power fishing vessels. The disadvantage of this solution is that hydrogen, ethanol and methanol require far more storage space than the equivalent energy content of petroleum (i.e. energy density). However, extensive research is being carried out to develop more efficient hydrogen cells. The replacement of petroleum by such hydrogen cells will also depend on the relative costs of the two energy sources.

The solution for alternative energies for road transport might not necessarily be the most appropriate solution for the fishing industry. The International Maritime Organization (IMO) has regulations in force governing pollution caused by burning fossil fuels (International Convention for the Prevention of Pollution from Ships [MARPOL]) and safety (International Convention for the Safety of Life at Sea [SOLAS]) that relate to the flash point[55] of fuel on board ships. These safety requirements are repeated in the IMO Torremolinos Convention on Fishing Vessel Safety, which has not yet entered into force. Specifically, the use of fuel with a flash point below 60 ºC is prohibited. Although these regulations might not be strictly applied to fishing vessels it would be foolhardy not to take such considerations into account in an industry that has an extremely high fatality rate. This would mean that pure methanol or ethanol would not meet the requirements for fuel as they have flash point of 10 ºC and 12 ºC, respectively. However, this does not rule out the use of methanol and ethanol to form biodiesel.[56] This would also have the advantage that the energy density would be similar to that of conventional diesel, requiring little or no modification to the engines. Any substantial change in energy density would have a critical impact on fishing vessel design in a manner reminiscent of the change from steam power to internal combustion engines in the 1940s.

The rate at which alternative fuels are introduced will be totally dependent on the current and future price of petroleum. Sustained higher prices will accelerate the development of research on alternative fuels and their production. Increased

Figure 45

Past, current and projected world oil production, by source



Source: World Energy Outlook 2004 © OECD/IEA, 2004, p. 103.

uncertainty with regard to international politics or increased terrorism will increase the need for fuel security and will have a similar effect.

CONCLUSIONS

The predictions of Sheik Yamani, the ex-chairman of the Organization of the Petroleum Exporting Countries (OPEC), when he stated "The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil",[57] might well be true.

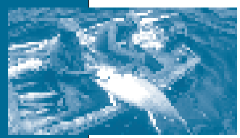
Causes of detentions and rejections in international fish trade[58]

INTRODUCTION

Fish and fishery products are one of the major traded food commodities and this trade is likely to increase in the future to meet the ever-increasing demand for fish and seafood. However, thousands of tonnes of imported fish and seafood products are detained, rejected or destroyed each year at the national borders of many importing regions in the world. This is a post-harvest loss that can be prevented, at least in part, providing more value for fishing efforts, making more fish and seafood available for human consumption and contributing to reduce pressure on fish stocks.

One of the most serious difficulties for exporters is that they face standards and regimes of safety and quality requirements that vary from one important target market to another. These differences concern regulations, standards and control procedures, including controls at the border where seafood products can be rejected, destroyed or put in detention awaiting permission to enter or destruction. In order to promote harmonization and equivalence among seafood-trading nations, these differences need to be reduced and ultimately removed and replaced by agreed international control systems and standards based on objective criteria and scientific techniques such as risk assessment.

It is important, however, to realize that, beyond sheer numbers, the type of border case (safety, quality or economic fraud) and its direct macro- and microeconomic impacts are different and this needs to be taken into account when comparing the different cases and strategies to reduce them.



RELATIVE FREQUENCY OF BORDER CASES BY IMPORTING REGION

The term “border case” is used to cover any situation where a fish product is detained, rejected, destroyed, returned to sender or otherwise removed, even if only temporarily, from the trade flow.

Figure 46 shows a quite dramatic difference in the absolute numbers of border cases in the various importing countries/regions when shown relative to import quantities.

At first glance, the United States of America has around ten times as many border cases per 100 000 tonnes as the EU or Japan, and three to four times as many as Canada. This should not be taken to indicate necessarily that the United States of America has a higher performance in border controls or that products exported to that country have more non-conformity problems. In fact, the data need to be adjusted and substantiated to enable comparisons of performance to be made among the regions studied. Three main reasons contribute to the number of border cases in the United States of America being overstated.

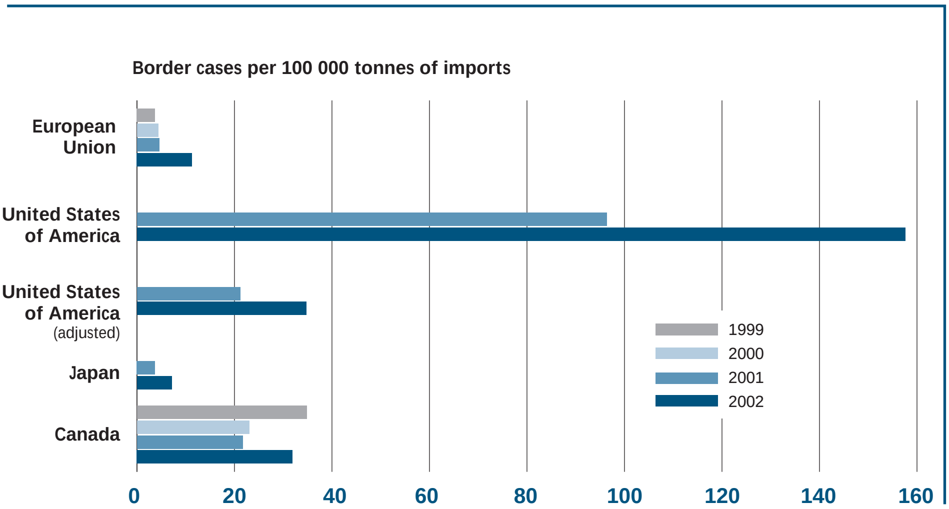
First, a high percentage of United States cases end up with the product actually entering the country after re-examination, sorting, re-packing, provision of new documentation and information or new labelling. During 1999–2001, 78 percent of detained shipments were eventually released for import into the United States of America.[59] Therefore, in this regional comparison only around 22 percent of the United States cases can be considered as “bona fide” border cases. Taking this into account, the United States of America had only around twice as many border cases than did the EU and Japan and only 60–80 percent of those reported by Canada (see Figure 46, United States adjusted data).

Second, the other countries/regions, especially the EU, use some sort of “prevention at source” approach. Indeed, the EU relies on national competent authorities in exporting countries to examine establishments and products to assess their conformity to EU requirements prior to shipment. By so doing, the authorities detect and stop several non-conformity cases in the exporting countries. This approach has proved to be more preventative and cost-effective than relying solely on controls at the border. However, it can also penalize well-managed seafood companies in countries that may not have the resources or the capacity to put together a competent authority that meets the EU requirements and cannot export to the EU as a result.

Canada, and to some extent Japan, have adopted a less formalized “prevention at source” approach but appear to be less active in promoting it than the EU. Canada has

Figure 46

Total border cases relative to import quantities for the European Union, the United States of America, Canada and Japan, 1992–2002



also concluded "Agreements" with a limited number of countries – Australia, Ecuador, Iceland, Indonesia, Japan, New Zealand, the Philippines and Thailand – whereas Japanese importing companies have a long tradition of fielding quality controllers to work at the exporting sites. In both cases, some non-conformity cases are eliminated before consignments are shipped.

In an increasing number of countries, including the United States of America,[60] experts advise administrations to adopt a "prevention at source" approach because of its higher performance and cost-effectiveness. This approach can only lead to a win–win situation for both the exporter and the importer: fewer safety and quality problems are experienced by the importer and the inherent costs and damages of border cases are reduced for the exporters. At the same time, administrations can make important savings as resources needed for control at borders are reduced significantly and can be used more effectively to target problem cases, increasing administrative efficiency. Moreover, a reduction in losses arising from rejections and detentions should eventually result in greater supply of safe fish and fewer illnesses attributable to unsafe foods. However, when introducing the "prevention at source" approach it is important to ensure that exporting developing countries are assisted in their efforts to build the national capacity needed to ensure safety and quality of exported fish products.

A third difference is the types and methods of control and standards applied at the border by the importer. In the importing countries studied, not only are border checks different, but the analytical techniques used, and the criteria or standards applied to judge conformity or non-conformity, vary from one country to another. Most importantly, these criteria and standards are not always based on fully fledged scientific risk assessments. This can not only create arbitrary barriers to trade, but it is also costly as it may cause safe products to be refused in some regions while unsafe products may be distributed in others. Consequently, there is a need to harmonize the procedures and the standards, at least as a first step, among these majors markets, using risk-assessment methodologies where applicable.

CATEGORIES OF BORDER CASES: PATTERNS AND TRENDS

The breakdown of border cases into three main categories – microbial, chemical and other causes – for the 43 countries and the EU/regions covered in this publication is summarized in Figure 47. The differences in the profile of each of these major importers are quite obvious, with both the EU and Japanese border cases being predominately microbial or chemical in origin, while these causes only account for a quarter to a third of border cases in the United States of America and Canada. Given the well publicized increase in 2001–02 of chemical (veterinary drug residues) contamination of fish products originating in Asia (especially for shrimps), it is interesting to note that this becomes evident in the EU data, where chemical contamination becomes a dominant category while, for other major importers, a similar trend is not noticeable. As these other regions also were importing large quantities of shrimp from Asia during this period, they were clearly handling the imported products differently, or recording the related data differently.

However, the obvious differences highlighted again point to the significant variations in approaches to controls at the borders of the countries being studied. For an exporter, it would be helpful if these procedures were harmonized, so that if they export a product, it should be treated the same way at the borders of all importing countries. The multitude of approaches to border control impose extra costs on traders. These differences in approach may be significant, but the economic effects are difficult to quantify owing to the lack of relevant data, most importantly about the quantities and value of rejected products and the costs of controls.

PERFORMANCE OF EXPORTERS, GROUPED BY CONTINENTS, IN MAJOR MARKETS

Again, the available data permit only a crude analysis here, but the results do provide a useful reference for discussion. The only two importing regions with full data over the

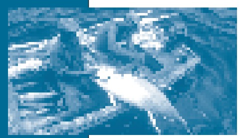


Figure 47

Relative frequency of causes of border cases for the European Union, the United States of America, Canada and Japan (percentage)

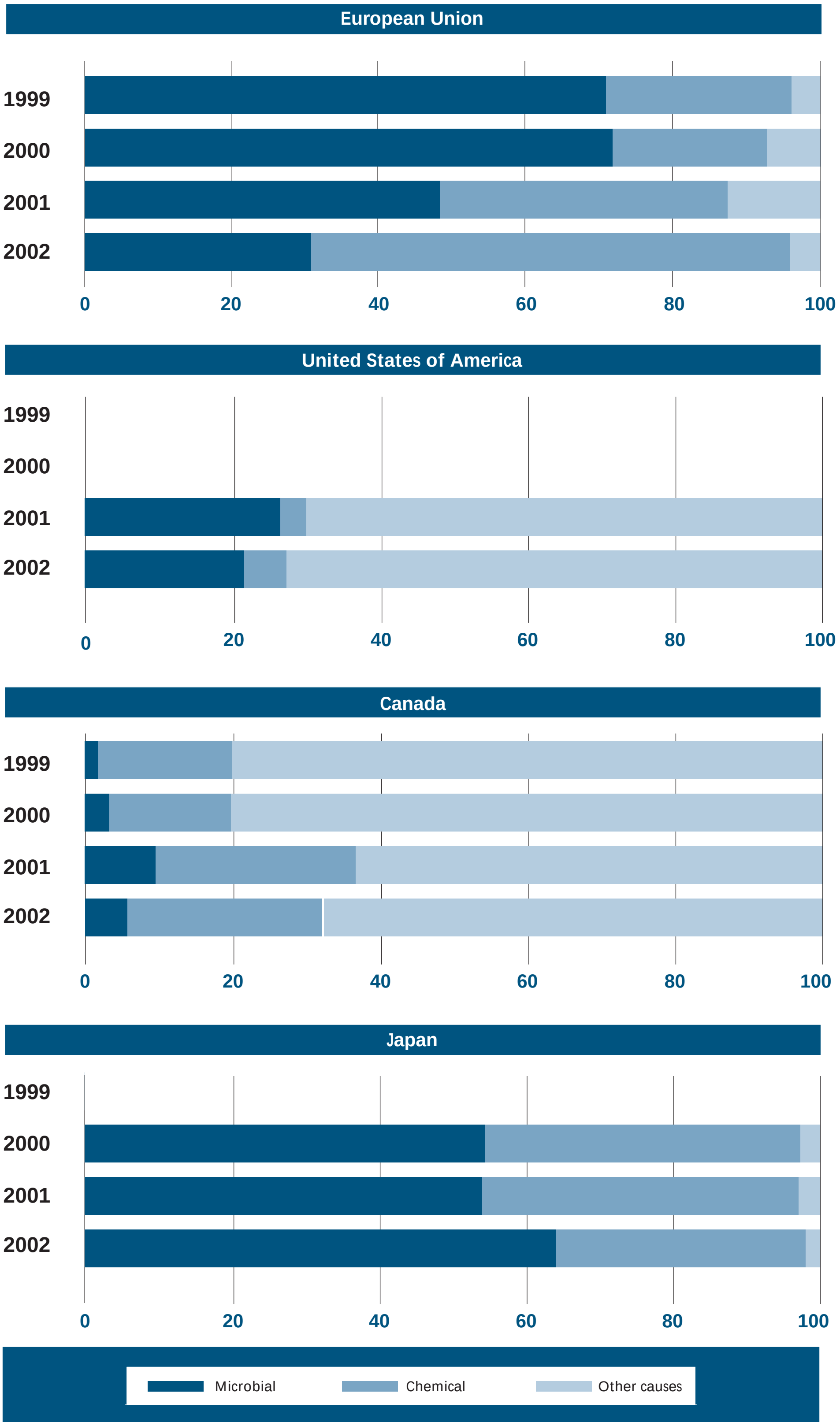


Table 19
Performance of continents in exporting to the European Union, Canada and Japan

	1999		2000		2001		2002	
	Border cases/ 100 000 tonnes	Rank	Border cases/ 100 000 tonnes	Rank	Border cases/ 100 000 tonnes	Rank	Border cases/ 100 000 tonnes	Rank
To EU								
Oceania	–	1	–	1	5.9	5	–	1
North America	–	1	1.0	3	1.1	2	0.7	2
Europe (not EU)	0.1	3	0.3	2	0.3	1	1.0	3
Central and South America	1.8	4	4.8	4	2.8	3	5.9	4
Africa	7.0	5	5.7	5	4.4	4	6.2	5
Asia	12.9	6	13.9	6	16.4	6	51.5	6
To Canada								
United States of America	1.0	1	0.5	1	2.6	1	1.3	1
Central and South America	31.6	2	19.1	3	25.6	3	25.2	2
Europe (not EU)	32.0	3	18.3	2	9.1	2	29.1	3
Asia	67.5	4	44.6	4	32.6	4	56.8	4
Oceania	113.8	5	177.7	5	136.0	5	144.2	5
EU	199.4	6	178.9	6	198.3	6	245.4	6
Africa	277.4	7	1 029.9	7	1 436.8	7	1 069.9	7
To Japan								
Europe					0.3	2	0.3	1
North America					0.5	3	0.5	2
Africa					0.0	1	1.1	3
Central and South America					0.8	4	1.5	4
Oceania					3.9	5	5.7	5
Asia[1]					6.6	6	12.5	6

[1] 2001 detention figures used are derived from an average 12-month period from April 2000 to October 2001; 2002 figures are from November 2001 to October 2002.

four-year period 1999–2002, allowing for comparison of the performance of exporting continents, are the EU and Canada. The Japanese data allow this comparison for the two periods 2000-01 and 2001-02 (Table 19).

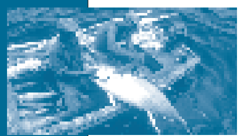
Looking at the data from the perspective of the importing market, significant variations can be seen in the relative performance of the exporters in the six continents, dependent on whether fish is being sent to the EU, Canada or Japan. This fact alone is worthy of comment. There are two main reasons why this might occur. First, the importing regions – the EU, Canada and Japan – apply different criteria for border actions (whether sampling frequencies, limits for contamination levels or other procedures); and, second, the six exporting continents send different volumes and products (either different risk categories or of varying quality) to the export markets.

If the latter is the case, and given that the products exported to the EU and Canada are fairly similar (frozen fish dominates, with significant numbers of crustacea, cephalopods, molluscs, etc.), it would seem that individual exporters recognize the differences and target their products to suit the market criteria. This certainly does happen, but it is probably more likely that importing regions treat the imports (as a whole) in different ways resulting in different border actions. In the case of the

Japanese market, the high number of border cases reported for products imported from Asia may reflect the fact that neighbouring countries also have access to high-risk products that are similar, if not identical, to those produced by Japanese fisheries. And it is these products that account for the high number of border cases. However, this is only conjecture given the nature of the data available.

A comparison of the incidence of border cases by each exporting continent is interesting. Specifically, Oceania ranks highest when exporting to the EU, but ranks very poorly when exporting to Canada and Japan. Africa is the poorest performer in terms of exports to Canada and second poorest in exports to the EU. However, the continent performs quite well in exports to Japan. The poorest performer by some margin in exporting to the EU is Asia; this performance level has been exacerbated in recent years by the veterinary drug residue issue mentioned above. Asia is also the poorest performer in terms of exports to Japan. However, it outperforms both Oceania and the EU in exporting to Canada, although it still performs only moderately. Central and South America performs very well in terms of exports to Canada but less well when exporting to the EU and Japan. North America is consistently a top-performing exporter.

It is not easy to determine the significance of this variation or what has caused it. It was noted above that there seemed to be a tendency for those exporting the smallest absolute quantities to have more border cases per unit volume – and this certainly applies in the case of exports to Canada. However, this does not apply to the EU, as Oceania is the smallest exporter but is one of the top performers with the lowest frequency of border cases. Neither does this pattern apply to Japan, as Asia is the largest exporter, but is a poor performer.



Additional research aiming to establish in more detail why these differences occur may give misleading results, mainly because of the overriding influence of two factors: the importing nations use different procedures (sampling plans, analytical techniques, type of defect) and/or the criteria regarding imports and the products exported differ among importing regions. Again, for the benefits of international trade, and ultimately the consumer, it is desirable that the importing rules are harmonized both in terms of the governing legislation and its implementation to enable proper evaluation of performance.

ECONOMIC IMPLICATIONS OF BORDER CASES

While international efforts are focusing on harmonization, several development agencies and donors have been exploring ways and means, both financial and technical, to assist developing exporting countries in building national and regional capacity to meet international safety and quality standards. Proper assessment of the extent of assistance needed is key in decision-making about such assistance. Therefore, costing the impact of substandard quality and safety products would be of interest not only to producers, processors, quality control authorities and consumers, but also to governments, donors, public health authorities and development agencies. In addition to the large economic losses incurred because of fish spoilage, product rejections, detention and recalls – and the resulting adverse publicity to an industry and even to a country – there are costs related to human health. Fish-borne illnesses cost billions of dollars in medical care and the loss of productivity of those infected causes large indirect costs to the community.

Furthermore, risk managers, who will be weighing different mitigation options, need economic data to assess the cost-effectiveness of the different options presented to them. Unfortunately, the detention/rejections data, as they are generally collected, cannot be exploited to assess the cost of border cases. It is important to have access to such information in future for the reasons mentioned above.

Table 20 represents an attempt to estimate the cost of border cases in Japan using data available from the Japanese Ministry of Health, Labour and Welfare (MHLW).[61] Unfortunately, similar data were not available for the other importing countries. The table estimates the total volume of Japan border cases at 255.2 tonnes and 490.6 tonnes, respectively, for 2001 and 2002. These represent a small fraction

Table 20
Estimated quantity and value of border cases for Japan

Product type	Import			Border cases		
	Quantity (Tonnes)	Value (US$ million)	Unit cost (US$/tonne)	Number	Quantity (Tonnes)	Value (US$)
2001						
Fresh fish	375 000	1 849	4 931	16	35.2	173 571
Frozen	2 344 000	8 647	3 689	84	184.8	681 727
Canned	281 000	1 786	6 356	4	8.8	55 933
Cured	34 000	320	9 412	11	24.2	227 770
Live	37 000	351	9 486	1	2.2	20 869
Total 2001	**3 071 000**	**12953**		**116**	**255.2**	**1 159 870**
2002						
Fresh fish	329 000	1 603	4 872	15	33	160 776
Frozen	2 362 000	8 730	3 696	174	382.8	1 414 829
Canned	353 000	2 033	5 759	4	8.8	50 679
Cured	36 000	329	9 139	28	61.6	562 962
Live	38 000	356	9 368	2	4.4	41 219
Total 2002	**3 118 000**	**13 051**		**223**	**490.6**	**2 230 465**

(0.0083 percent and 0.016 percent, respectively) of total imports to Japan in those years. They were valued at US$1 159 870 and US$2 230 465 (or 0.009 percent and 0.017 percent of total import values), respectively, for 2001 and 2002. For the period 2001–02, the average revenue lost was estimated at US$4 546 per tonne detained and US$10 000 per border case.

The revenues lost to exporting companies when consignments are rejected are, as a rule, much greater than the costs of prevention needed to enable the companies concerned to avoid these border cases. This affirmation has been confirmed by several studies, compiled and reported by FAO,[62] which estimated the costs of implementing good management practice and HACCP. In the United States of America, 1995 cost estimates for HACCP implementation for seafood-processing plants averaged US$23 000 in the first year and US$13 000 per year in subsequent years. In parallel, prices for seafood were also estimated to increase by less than 1 percent in the first year and less that 0.5 percent in subsequent years, with the larger cost increase expected to reduce consumption by less than 0.5 percent.

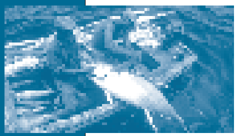
Other studies carried out in the United States of America estimated the costs of implementing the HACCP-based Model Seafood Surveillance Program (MSSP) in the United States crab industry at US$3 100 per plant or US$0.04 per kg, representing 0.33 percent of the processor price. Compliance costs were estimated at US$6 100 per plant. Investment costs averaged US$3 200 for large plants and US$1 700 for small plants. In all, the added cost per kg of product for compliance was US$0.02 for small plants and insignificant for large plants. For molluscan shellfish (oysters, mussels, clams), these costs were estimated at US$5 500 per plant. Annualized compliance costs per kg were estimated at US$0.11 for small plants and US$0.01 for larger plants.

In Bangladesh upgrading the plant and implementing HACCP for the shrimp industry were estimated to cost between US$0.26 and US$0.71 per kg and between US$0.03 and US$0.09 for the plant's maintenance. Those were higher than the corresponding estimates for the United States of America, mainly because the Bangladesh shrimp industry had to start from scratch and also had more small- and medium-sized enterprises. It is well established that in the fish-processing industry economy of scale lowers the costs of safety and quality systems in large enterprises. Nevertheless, even though these costs were high, they represent only 0.31 percent (implementation) and 0.85 percent (maintenance) of the 1997 prices.[63]

More importantly, the cost of installing and operating HACCP systems remains very low in comparison with the revenue lost by exporters in border cases, currently estimated to be US$4.55 per kg on average. Indeed, the per kg costs of implementing and maintaining HACCP or HACCP-based systems would represent between 1.46 percent and 3.4 percent (United States of America) or 6.45 percent to 17.6 percent (Bangladesh) of the revenue lost in border cases. Furthermore, these revenue losses should be considered only as the visible part of the iceberg. The cost of transportation, the resulting adverse publicity, the requirements for systematic physical checks of subsequent shipments, the loss of client confidence and ensuing market shares, market diversions, loss of momentum, decreased prices, reduced capacity owing to temporary or permanent closures, are certainly additional costs with far-reaching impacts, but unfortunately difficult to quantify.

CONCLUSIONS AND RECOMMENDATIONS

The study details the regulations governing imports into the EU, Canada, Japan and the United States of America and presents and discusses the data available about the border cases (detentions, rejections, re-exports, etc.) in the same countries/region.

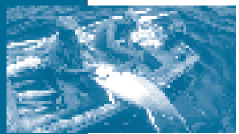


Key issues arising from the study include a need to harmonize the procedures and methods used to govern imports, to base the actions taken on risk assessment where consumer safety is in question and, importantly, to communicate the actions taken to all interested parties in a manner that is unambiguous, transparent and easily obtained and analysed. The study makes recommendations about the actions governments and industry can and should take to facilitate trade in fish and fish products by improving border control systems, border control data collection and dissemination, improving export performance and development assistance. It suggests further work that needs to be undertaken in this important, but little-studied, aspect of international trade.

NOTES

1. This section draws on the following sources: FAO. 2005. *Habitat rehabilitation for inland fisheries: global review of effectiveness and guidance for rehabilitation of freshwater ecosystems*, by P. Roni, K. Hanson, T. Beechie, G. Pess, M. Pollock and D.M. Bartley. FAO Fisheries Technical Paper. No. 484. Rome; I.G. Cowx and R.L. Welcomme. 1998. *Rehabilitation of rivers for fish.* Oxford, UK, Fishing News Books; FAO/Deutscher Verband für Wasserwirtschaft und Kulturbau. 2002. *Fish passes – design, dimensions and monitoring.* Rome, FAO; M. Larinier and G. Marmulla. 2004. Fish passes: Types, principles and geographical distribution – an overview. *In* R.L. Welcomme and T. Petr, eds, *Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume II*, RAP Publication 2004/17, pp. 183–205. Bangkok, FAO Regional Office for Asia and the Pacific; M. Larinier, F. Travade and J.P. Porcher. 2002. Fishways: biological basis, design criteria and monitoring. *Bull. Fr. Pêche Piscic.*, 364(Suppl.); FAO. 2001. *Dams, fish and fisheries. Opportunities, challenges and conflict resolution*, edited by G. Marmulla. FAO Fisheries Technical Paper No. 419. Rome; and G. Marmulla. 2003. Dams and fisheries. *In* FAO. 2003. *Review of the state of world fishery resources: inland fisheries.* FAO Fisheries Circular No. 942, Rev. 1, pp. 29–35. Rome.
2. FAO. 1995. *FAO Code of Conduct for Responsible Fisheries*. Rome.
3. FAO. 1997. *Inland fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 6. Rome.
4. The study report was published as FAO. 2005. *Responsible fish trade and food security*, by J. Kurien. FAO Fisheries Technical Paper No. 456. Rome.
5. Brazil, Chile, Fiji, Ghana, Namibia, Kenya, Nicaragua, the Philippines, Senegal, Sri Lanka and Thailand.
6. The article draws on a range of FAO documents and data sources to provide an insight into the current issues surrounding low-value/trash fish production in the region. These include: FAO. 2005. *Asian fisheries today: the production and use of low-value/trash fish from marine fisheries in the Asia-Pacific region*, by S. Funge-Smith, E. Lindebo and D. Staples. RAP Publication 2005/16. Bangkok; and FAO. 2005. *Discards in the world's marine fisheries: an update*, by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome.

   A number of comprehensive country studies were also initiated by the APFIC and have provided the basis for much of the information discussed. A recent review carried out under the auspices of the Australian Centre for International Agricultural Research (ACIAR) was also used: P. Edwards, L.A. Tuan and G.L. Allan. 2004. *A survey of marine low trash fish and fishmeal as aquaculture feed ingredients in Vietnam*. ACIAR Working Paper No. 57. Canberra.
7. "Fishing down the food chain" refers to the practice in some tropical demersal coastal fisheries whereby larger and more valuable fish species (often of a higher trophic level, e.g. carnivores such as bream, sharks and rays) become overfished, and fishing practices change to catching large quantities of mainly low-value species (often of a lower trophic level, e.g. squid and jellyfish).
8. An average weighted by the amount of low-value/trash fish caught in the different countries.
9. FAO. 2005. *Discards in the world's marine fisheries: an update*, by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome.
10. FAO. 2002. *The State of World Fisheries and Aquaculture 2002*. Rome.
11. IFPRI. 2003. *Fish to 2020 – supply and demand in changing global markets*. Washington, DC.
12. WorldFish Center. 2006 (forthcoming). *Regional synthesis on the analysis of "TrawlBase" data for low value/trash fish species and their utilization.* Penang, Malaysia.
13. FAO. 2005. *APFIC Regional Workshop on Low Value and "Trash Fish" in the Asia–Pacific Region*. Hanoi, Viet Nam, 7–9 June 2005. Asia–Pacific Fishery Commission (APFIC). RAP Publication 2005/21. Bangkok.



14. With regard to terminology, there is a second school of thought that uses the term "transboundary" as a generic one to denote all fish stocks exploited by two or more states (entities). This school of thought uses the term "shared" to denote stocks to be found within two or more neighbouring EEZs.
15. Highly migratory stocks are those set forth in Annex I of the 1982 Convention on the Law of the Sea, and consist primarily of the tuna species. Straddling stocks are all other stocks (excluding anadromous and catadromous stocks) to be found, both within the EEZ and the adjacent high seas. Transboundary stocks and highly migratory/straddling stocks are not mutually exclusive.
16. Shared fish stocks are also found in inland water bodies, including lakes and rivers, where they pose the same cooperative management challenges.
17. FAO. 2002. *Report of the Norway–FAO Expert Consultation on the Management of Shared Fish Stocks.* Bergen, Norway, 7–10 October 2002. FAO Fisheries Report No. 695. Rome; FAO. 2004. *The conservation and management of shared fish stocks: legal and economic aspects*, by G. Munro, A. Van Houtte and R. Willmann. FAO Fisheries Technical Paper No. 465. Rome.
18 Sharing the Fish Conference 06, Fremantle, Australia, 26 February–2 March 2006 (available at http://www.fishallocation.com).
19. FAO, 2004, op. cit., see note 17.
20. J.F. Caddy. 1997. Establishing a consultative mechanism or arrangement for managing shared stocks within the jurisdiction of contiguous states. *In* D. Hancock, ed. *Taking stock: defining and managing shared resources*, pp. 81–123. Australian Society for Fish Biology and Aquatic Resource Management Association of Australasia Joint Workshop Proceedings, Darwin, Northern Territory, 15–16 June 1997. Sydney, Australia, Australian Society for Fish Biology.
21. FAO, 2004, op. cit., see note 17.
22. The Nobel Prize in Economic Sciences in 2005 was awarded jointly to Thomas Schelling (United States of America) and Robert Aumann (Israel). The press release, announcing the award, read as follows: "Why do some groups of individuals, organizations and countries succeed in promoting cooperation while others suffer from conflict? The work of Robert Aumann and Thomas Schelling has established game theory – or interactive decision theory – as the dominant approach to this age-old question" (http://nobelprize.org/nobel_prizes/economics/laureates/2005/press.html). This is, of course, precisely the question that has to be confronted in the context of shared fish stocks.
23. The "Prisoner's Dilemma" and its relevance to the management of shared fish stocks is discussed in detail in FAO, 2004, op. cit., see note 17.
24. Ibid.
25. FAO. 1980. *Some problems in the management of shared stocks*, by J.A. Gulland. FAO Fisheries Technical Paper No. 206. Rome.
26. FAO. 1994. *Marine fisheries and the law of the sea: a decade of change*. FAO Fisheries Circular No. 853. Rome; S. Barrett. 2003. *Environment and statecraft: the strategy of environmental treaty-making*. Oxford, UK, Oxford University Press.
27. FAO, 2002, op. cit., see note 17.
28. Ibid., p. 8.
29. An example of a cooperative fisheries management arrangement being upset by an environmental shock is provided by the Canada–US Pacific Salmon Treaty. See: K.A. Miller. 2003. North American Pacific salmon: a case of fragile cooperation. In *Papers presented at the Norway–FAO Expert Consultation on the Management of Shared Fish Stocks.* Bergen, Norway, 7–10 October 2002, pp. 105–122. FAO Fisheries Report No. 695, Suppl. Rome.
30. United Nations. 1992. *The law of the sea: the regime for high seas fisheries: status and prospects.* New York, USA; FAO. 2006. *The state of the world's highly migratory, straddling and other high seas fish stocks, and associated species*. FAO Fisheries Technical Paper No. 495. Rome. Of the world tuna stocks for which the state of exploitation has been assessed, 29 percent are estimated to be depleted or overexploited. Bluefin tuna stocks figure prominently in this estimate (FAO, 2006, pp. 15–16).

31 The full title is Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

32. See G. Munro. 2000. The UN Fish Stocks Agreement of 1995: history and problems of implementation. *Marine Resource Economics,* 15: 265–280.

33. FAO, 2004, op. cit., see note 17.

34. Ibid.

35. Munro, Van Houtte and Willmann remark that "… the overexploitation of straddling/highly migratory fish stocks worldwide … bears powerful testimony to the predictive power of the economic analysis of the non-cooperative management of such resources". See FAO, 2004, op. cit., note 17, p. 45.

36. Transboundary stock cooperative arrangements with large numbers of participants do exist, but these are the exception, not the rule. In the case of RFMOs, large numbers of participants are the rule, not the exception.

37. With a large number of participants (players), it is standard in game theory analysis to talk of coalitions. All the players together constitute the "Grand Coalition". There can, in addition, be subcoalitions. In such a game, it is not sufficient to worry about individual players deciding they would be better off by not cooperating; stability of the Grand Coalition also requires that each subcoalition can expect to receive returns from cooperation that are at least as great as it would expect to obtain by going off and competing against the rest.

38. Articles 8, 10 and 11.

39. FAO, 2004, op. cit., see note 17.

40. Ibid.

41. M. Lindroos. 2002. *Coalitions in fisheries*. Helsinki School of Economics Working Paper W-321; P. Pintassilgo. 2003. A coalition approach to the management of high seas fisheries in the presence of externalities. *Natural Resource Modeling,* 16: 175–197.

42. FAO, 2004, op. cit., see note 17. The issue was also discussed in FAO. 2004. *The State of World Fisheries and Aquaculture 2004*. Rome, pp. 91–99.

43. This article is a summary of FAO. 2006. *Review of the state of world marine capture fisheries management: Indian Ocean*. FAO Fisheries Technical Paper No. 488. Rome. Similar reviews covering the Atlantic and Pacific Oceans are planned.

44. Questionnaires were received from Australia (west coast), Bahrain, Bangladesh, Comoros, Djibouti, Egypt (Red Sea coast), Eritrea, India (east coast), India (west coast), Indonesia (Pacific and Indian coasts), Islamic Republic of Iran, Iraq, Jordan, Kenya, Kuwait, Madagascar, Malaysia (Pacific and Indian coasts), Maldives, Mauritius, Mozambique, Myanmar, Oman, Pakistan, Qatar, Saudi Arabia, South Africa (east coast), Sri Lanka, the Sudan, Thailand (Indian Ocean coast), United Arab Emirates and Yemen. Questionnaires were not received for the Seychelles, Somalia and the United Republic of Tanzania.

45. Occasionally as a stand-alone authority or fisheries ministry but more often in the form of a fisheries department within an agriculture/livestock or environment ministry or a combined agriculture/fisheries ministry.

46. FAO. 2005. *Review of the state of world marine fishery resources*. FAO Fisheries Technical Paper No. 457. Rome.

47. Based on the questionnaire results, the concept of "managed" was mostly inferred to mean (i) published regulations or rules for specific fisheries: (ii) legislation concerning individual fisheries, and (iii) interventions/actions to support specific management objectives.

48. See, for example, D. Thompson. 1980. Conflict within the fishing industry. *ICLARM Newsletter*, 3(3): 3–4; 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.

49. FAO, 2005, op. cit., see note 46.
50. Subregional reviews covering the eastern, western and southwestern Indian Ocean. Australia was left as a stand-alone review.
51. FAO. 2007 (forthcoming). *A study into the effect of energy costs in fisheries*, by A. Smith. FAO Fisheries Circular No. 1022. Rome.
52. FAO. 1999. *Economic viability of marine fisheries. Findings of a global study and an interregional workshop*, by J.-M. Le Rey, J. Prado and U. Tietze. FAO Fisheries Technical Paper No. 377. Rome; FAO. 2001. *Techno-economic performance of marine capture fisheries*, edited by U. Tietze, J. Prado, J.-M. Le Rey and R. Lasch. FAO Fisheries Technical Paper No. 421. Rome; FAO. 2005. *Economic performance and fishing efficiency of marine capture fisheries*, by U. Tietze, W. Thiele, R. Lasch, B. Thomsen and D. Rihan. FAO Fisheries Technical Paper No. 482. Rome.
53. Energy intensity, measured in terms of the amount of energy required to produce a unit of GDP, increases during the first stage of industrialization in developing countries before decreasing as observed in maturing economies. OECD countries have a GDP of US$5 277 per tonne of oil equivalent (Toe), whereas non-OECD countries have an average of US$1 272 per Toe. Source: International Energy Agency Web site (http://www.iea.org/).
54. Op. cit., see note 51.
55. Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material.
56. The flash point of biodiesel is 150 ºC; however, it does become highly viscous and could freeze at low temperatures. This can be avoided by mixing biodiesel with conventional diesel.
57. Anon. 2003. The end of the oil age. *The Economist,* 23 October, p. 12.
58. This article summarizes FAO. 2005. *Causes of detentions and rejections in international fish trade*, by L. Ababouch, G. Gandini and J. Ryder. FAO Fisheries Technical Paper No. 473. Rome.
59. J. Allshouse, J.C. Buzby, D. Harvey and D. Zorn. 2003. International trade and seafood safety. *In* J.C. Buzby, ed. *International trade and food safety: economic theory and case studies*. Agricultural Economic Report No. 828, pp. 109–124 (available at http://www.ers.usda.gov/publications/aer828/aer828.pdf).
60. National Academy of Sciences. 2003. *Scientific criteria to ensure safe food*. Washington, DC, The National Academies Press (available at http:/www.nap.edn/openbook/030908928X/html./R3.html).
61. MHLW Web site (available at http://www.mhlw.go.jp/english).
62. FAO. 1998. *Seafood safety. Economics of Hazard Analysis and Critical Control Point (HACCP) programmes*, by J.C. Cato. FAO Fisheries Technical Paper No. 381. Rome.
63. J.C. Cato and C.A. Lima dos Santos. 1998. European Union 1997 seafood-safety ban: the economic impact on Bangladesh shrimp processing. *Marine Resource Economics*, 13(3): 215–227.