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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2008

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2008

FAO Fisheries and Aquaculture Department

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FOREWORD

A milestone may be near. After growing steadily, particularly in the last four decades, aquaculture is for the first time set to contribute half of the fish consumed by the human population worldwide. This reflects not only the vitality of the aquaculture sector but also global economic growth and continuing developments in fish processing and trade.

Until a year or so ago, the production trends in aquaculture and capture fisheries were continuing without any drastic modification to those already in place at the start of this decade. The capture fisheries sector was regularly producing between 90 and 95 million tonnes per year, and aquaculture production was growing rapidly, albeit at a gradually declining rate.

However, the substantial increases in energy and food prices, which started in 2007 and have continued into 2008, as well as the threat of climate change, mean that the conditions for capture fisheries and aquaculture are changing. That said, the combined effects of rising prices and climate change are complex, and they affect a very large number of fisheries and aquaculture operations in a mosaic of natural, social and economic contexts. Hence, it is too early to have a clear understanding of the cumulative impact worldwide on fisheries and aquaculture.

Nonetheless, it is clear that there will be both winners and losers among fishers, aquaculturists and those employed in ancillary industries. On the one hand, rising prices for staple foods will also cause an increase in the price of many fish and fish products, and this will stimulate all in the sector to produce more. However, those who capture or culture fish, or other aquatic animals, using energy-intensive forms of production may find recent cost increases prohibitive. They may well face difficulties in continuing in their occupation, at least in the immediate future. On the other hand, low-intensity aquaculture and most small-scale and artisanal fisheries will attempt to expand production. This will increase the importance of improved governance in both aquaculture and low-energy-consuming fisheries (some near-shore fisheries, passive fishing gear, etc.).

This issue of *The State of World Fisheries and Aquaculture* features some of the aspects of fisheries and aquaculture that may receive increasing attention. Among these aspects are climate change, the use of marine genetic resources in areas beyond national jurisdiction, and the proliferation of private standards and certification schemes in the international fish trade. This issue also highlights a few of FAO's special studies. These include the use of wild-fishery resources as seed and feed in aquaculture, and reviews of the world's shrimp fisheries and of the management of marine capture fisheries in the Pacific Ocean.

The format of *The State of World Fisheries and Aquaculture* remains unchanged. As with previous editions, this issue contains a CD–ROM with the *World Fisheries and Aquaculture Atlas.*

Ichiro Nomura
Assistant Director-General
FAO Fisheries and Aquaculture Department

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Notes: Unless otherwise stated, the source of data for the figures and tables is FAO. Data for China do not include Taiwan Province of China, Hong Kong Special Administrative Region and Macao Special Administrative Region.

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The preparation of Part 1, World review of fisheries and aquaculture, was the overall editorial responsibility of R. Grainger, who wrote the overview and coordinated the contributions made by L. Garibaldi (production, capture fisheries), S. Tsuji (aquaculture production and fishing fleets), M. Lamboeuf, J.-J. Maguire and J. Csirke (marine resources), J. Jorgensen, U. Barg and G. Marmulla (inland resources), S. Vannuccini (fishers, utilization, trade, consumption), G. Laurenti (consumption), H. Josupeit and A. Lem (trade), I. Karunasagar (utilization), D. Doulman (governance and policy, marine fisheries), N. Hishamunda and R. Subasinghe (governance and policy, aquaculture), W. Emerson (governance and policy, trade). S. Montanaro, S. Tsuji and S. Vannuccini prepared most of the figures and the tables.

Contributors to Part 2, Selected issues in fisheries and aquaculture, included C. de Young and K. Cochrane (climate change implications for fisheries and aquaculture), A. Gudmundsson and J. Turner (the safety of fishing vessels and fishers: an opportunity to address safety in a holistic fashion), L. Ababouch (private and public standards and certification schemes: synergy or competition?), and N. Ferri (consultant) and J.-F. Pulvenis (marine genetic resources in areas beyond national jurisdiction as related to marine biodiversity and the sustainable use of living marine resources).

Contributors to Part 3, Highlights of special studies, included K. Cochrane (ecosystem approaches for fisheries management in the Benguela Current Large Marine Ecosystem), R. Willmann (increasing the contribution of small-scale fisheries to poverty alleviation and food security), F. Chopin and U. Wijkström (a global study of shrimp fisheries), C. de Young (marine capture fisheries management in the Pacific Ocean: status and trends), and M. Reantaso, A. Lovatelli, M. Hasan and U. Wijkström (use of wild-fishery resources as seed and feed in aquaculture).

Part 4, Outlook, was written by U. Wijkström with contributions from A. Gumy, N. Hishamunda, G. Laurenti, A. Lem, D. Soto, R. Subasinghe and S. Vannuccini.

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ABBREVIATIONS AND ACRONYMS

ABNJ
area beyond national jurisdiction

ASEAN
Association of Southeast Asian Nations

BCC
Benguela Current Commission

BCLME
Benguela Current Large Marine Ecosystem

BMP
better management practice

CCAMLR
Commission for the Conservation of Antarctic Marine Living Resources

CCRF
Code of Conduct for Responsible Fisheries

CCSBT
Commission for the Conservation of Southern Bluefin Tuna

CGRFA
Commission on Genetic Resources for Food and Agriculture

CO_2
carbon dioxide

COFI
Committee on Fisheries

EAA
ecosystem approach to aquaculture

EAF
ecosystem approach to fisheries

EEA
European Economic Area

EEZ
exclusive economic zone

EPA
Economic Partnership Agreement

EU
European Union

FIRMS
Fisheries Resources Monitoring System

GAP
good agricultural practice

GDP
gross domestic product

GEF
Global Environment Facility

GHG
greenhouse gas

GMO
genetically modified organism

GT
gross tonnage

HACCP
Hazard Analysis and Critical Control Point (system)

IATTC
Inter-American Tropical Tuna Commission

ICCAT
International Commission for the Conservation of Atlantic Tunas

ILO
International Labour Organization

IMO
International Maritime Organization

IOTC
Indian Ocean Tuna Commission

IPOA
international plan of action

ISO
International Organization for Standardization

IUU
illegal, unreported and unregulated (fishing)

JWG
joint working group

LDC
least developed country

LIFDC
low-income food-deficit country

MCS
monitoring, control and surveillance

MDG
Millennium Development Goal

MGR
marine genetic resource

MPA
marine protected area

MSC
Marine Stewardship Council

NACA
Network of Aquaculture Centres in Asia–Pacific

NEAFC
North East Atlantic Fisheries Commission

NGO
non-governmental organization

OECD
Organisation for Economic Co-operation and Development

OIE
World Organisation for Animal Health

RASF
risk assessment for sustainable fisheries

RFB
regional fishery body

RFMO
regional fisheries management organization

S&DT
special and differential treatment

SADC
Southern African Development Community

SIOFA
South Indian Ocean Fisheries Agreement

SPRFMO
South Pacific Regional Fisheries Management Organization

SSA
sub-Saharan Africa

TAC
total allowable catch

TBT
technical barriers to trade

UNCED
United Nations Conference on Environment and Development

UNCTAD
United Nations Conference on Trade and Development

UNDP
United Nations Development Programme

VMS
vessel monitoring system

WCPFC
Western and Central Pacific Fisheries Commission

WTO
World Trade Organization

WWF
World Wide Fund for Nature

PART 1

WORLD REVIEW OF FISHERIES AND AQUACULTURE

WORLD REVIEW OF FISHERIES AND AQUACULTURE

Fisheries resources: trends in production, utilization and trade

OVERVIEW

Capture fisheries and aquaculture supplied the world with about 110 million tonnes of food fish in 2006 (all data presented are subject to rounding), providing an apparent per capita supply of 16.7 kg (live weight equivalent), which is among the highest on record (Table 1 and Figure 1). Of this total, aquaculture accounted for 47 percent. Outside China, per capita supply has shown a modest growth rate of about 0.5 percent per year since 1992 (following a decline from 1987), as growth in supply from aquaculture more than offset the effects of static capture fishery production and a rising population (Table 2 and Figure 2). In 2006, per capita food fish supply was estimated at 13.6 kg if data for China are excluded. Overall, fish provided more than 2.9 billion people with at least 15 percent of their average per capita animal protein intake. The share of fish proteins in total world animal protein supplies grew from 14.9 percent in 1992 to a peak of 16.0 percent in 1996, declining to about 15.3 percent in 2005. Notwithstanding the relatively low fish consumption by weight in low-income

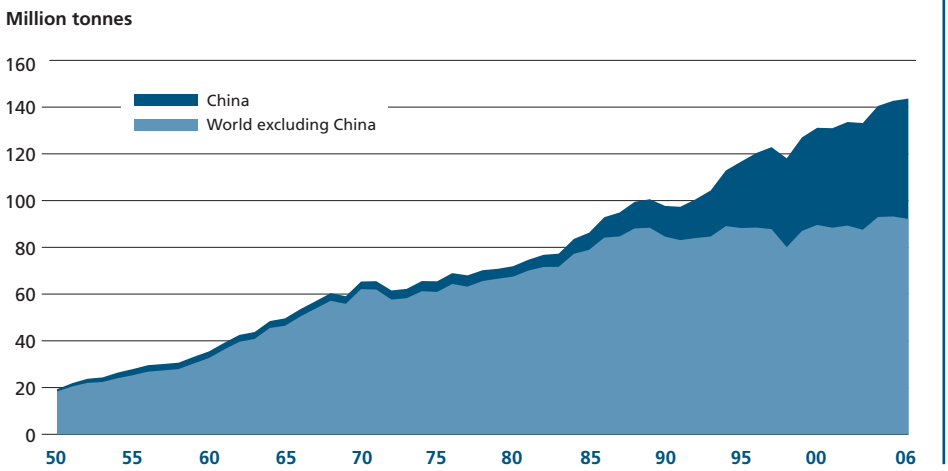
Table 1
World fisheries and aquaculture production and utilization

	2002	2003	2004	2005	2006
	(Million tonnes)				
PRODUCTION					
INLAND					
Capture	8.7	9.0	8.9	9.7	10.1
Aquaculture	24.0	25.5	27.8	29.6	31.6
Total inland	**32.7**	**34.4**	**36.7**	**39.3**	**41.7**
MARINE					
Capture	84.5	81.5	85.7	84.5	81.9
Aquaculture	16.4	17.2	18.1	18.9	20.1
Total marine	**100.9**	**98.7**	**103.8**	**103.4**	**102.0**
TOTAL CAPTURE	93.2	90.5	94.6	94.2	92.0
TOTAL AQUACULTURE	40.4	42.7	45.9	48.5	51.7
TOTAL WORLD FISHERIES	**133.6**	**133.2**	**140.5**	**142.7**	**143.6**
UTILIZATION					
Human consumption	100.7	103.4	104.5	107.1	110.4
Non-food uses	32.9	29.8	36.0	35.6	33.3
Population (*billions*)	6.3	6.4	6.4	6.5	6.6
Per capita food fish supply (*kg*)	16.0	16.3	16.2	16.4	16.7

Note: Excluding aquatic plants.

Figure 1

World capture and aquaculture production



food-deficit countries (LIFDCs) of 13.8 kg per capita in 2005, the contribution of fish to total animal protein intake was significant – at 18.5 percent – and is probably higher than indicated by official statistics in view of the under-recorded contribution of small-scale and subsistence fisheries.

Table 2

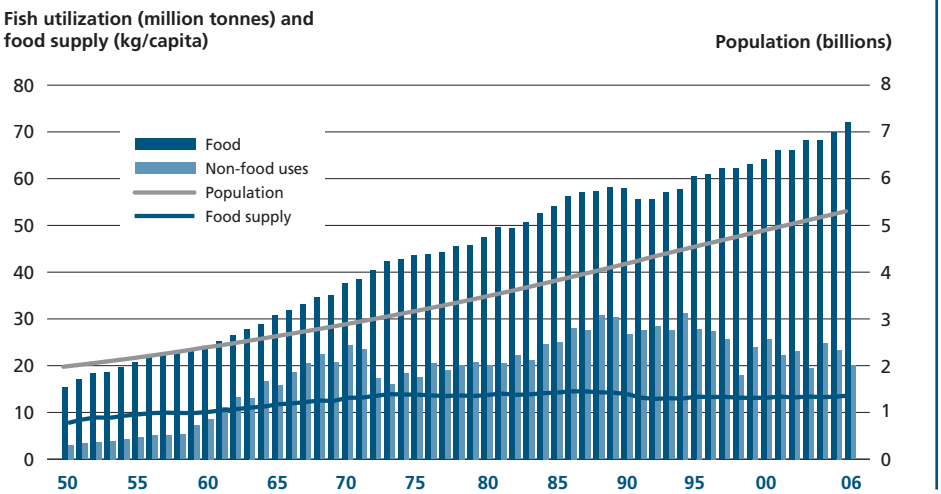
World fisheries and aquaculture production and utilization, excluding China

	2002	2003	2004	2005	2006
	(Million tonnes)				
PRODUCTION					
INLAND					
Capture	6.5	6.5	6.5	7.2	7.5
Aquaculture	7.1	7.8	8.9	9.5	10.1
Total inland	**13.5**	**14.2**	**15.4**	**16.7**	**17.6**
MARINE					
Capture	70.2	67.2	71.2	70.0	67.4
Aquaculture	5.5	6.0	6.4	6.6	7.1
Total marine	**75.8**	**73.3**	**77.6**	**76.6**	**74.5**
TOTAL CAPTURE	76.7	73.7	77.7	77.1	74.9
TOTAL AQUACULTURE	12.6	13.8	15.3	16.1	17.2
TOTAL FISHERIES	**89.3**	**87.5**	**93.0**	**93.2**	**92.1**
UTILIZATION					
Human consumption	66.2	68.1	68.3	69.9	72.1
Non-food uses	23.2	19.4	24.7	23.3	20.0
Population *(billions)*	5.0	5.1	5.2	5.2	5.3
Per capita food fish supply *(kg)*	13.2	13.4	13.2	13.4	13.6

Note: Excluding aquatic plants.

Figure 2

World fish utilization and supply, excluding China



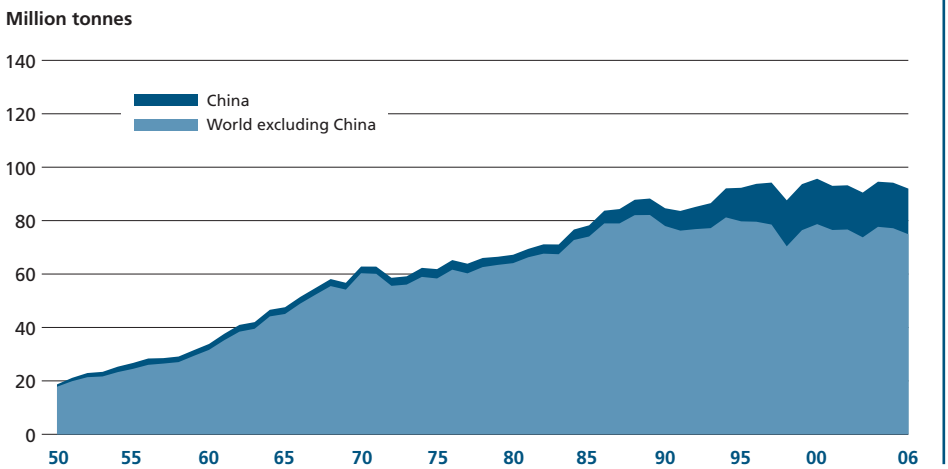
China remains by far the largest producer, with reported fisheries production of 51.5 million tonnes in 2006 (17.1 and 34.4 million tonnes from capture fisheries and aquaculture, respectively), providing an estimated domestic food supply of 29.4 kg per capita as well as production for export and non-food purposes. However, there are continued indications that capture fisheries and aquaculture production statistics for China may be too high, as noted in previous issues of *The State of World Fisheries and Aquaculture*,[1] and that this problem has existed since the early 1990s. Because of the importance of China and the uncertainty about its production statistics, as in previous issues of this report, China is generally discussed separately from the rest of the world. In 2008, China indicated that it was working to revise its fishery and aquaculture production statistics downwards based on the outcome of the National Agricultural Census of 2006, which included for the first time questions relating to fisheries and aquaculture, as well as fishery surveys. Revised statistics for a period of years are expected to be made available by 2009 and to be reflected subsequently in FAO statistics and in future issues of *The State of World Fisheries and Aquaculture*.

In 2008, China reported a downward revision of total fishery and aquaculture production for 2006 of more than 10 percent, corresponding to a reduction of more than 2 million tonnes in capture production and more than 3 million tonnes in aquaculture production. Preliminary estimates for 2007 based on reporting by some major fishing countries indicate that world fishery production excluding China is 96 million tonnes, representing approximately a 3 percent increase for capture production and a 7 percent increase for aquaculture production compared with 2006.

Global capture fisheries production in 2006 was about 92 million tonnes, with an estimated first-sale value of US$91.2 billion, comprising about 82 million tonnes from marine waters and a record 10 million tonnes from inland waters (Table 1 and Figure 3). China, Peru and the United States of America remained the top producing countries. World capture fisheries production has been relatively stable in the past decade with the exception of marked fluctuations driven by catches of anchoveta – a species extremely susceptible to oceanographic conditions determined by the El Niño Southern Oscillation – in the Southeast Pacific (Figure 3). Fluctuations in other species and regions tend to compensate for each other to a large extent. China remains by far the global leader with more than 17 million tonnes in 2006. Asian countries accounted for 52 percent of the global capture production. Overall catches in the Western Central

Figure 3

World capture fisheries production



Pacific and in the Western Indian Ocean continued to increase, whereas capture production decreased in both the Western and Eastern Central areas of the Atlantic Ocean. In the Eastern Indian Ocean, total catches in 2006 returned to growth after the decrease in 2005 caused by the destructive effects of the tsunami of December 2004. Catches from inland waters, almost two-thirds of which were taken in Asia in 2006, have shown a slowly but steadily increasing trend since 1950, owing in part to stock enhancement practices and possibly also to improved reporting.

Aquaculture continues to be the fastest growing animal food-producing sector and to outpace population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 6.9 percent. It is set to overtake capture fisheries as a source of food fish. From a production of less than 1 million tonnes per year in the early 1950s, production in 2006 was reported to be 51.7 million tonnes with a value of US$78.8 billion, representing an annual growth rate of nearly 7 percent. World aquaculture is heavily dominated by the Asia–Pacific region, which accounts for 89 percent of production in terms of quantity and 77 percent in terms of value. This dominance is mainly due to China's enormous production, which accounts for 67 percent of global production in terms of quantity and 49 percent of global value. China produces 77 percent of all carps (cyprinids) and 82 percent of the global supply of oysters (ostreids). The Asia–Pacific region accounts for 98 percent of carp, 95 percent of oyster production, and 88 percent of shrimps and prawns (penaeids). Norway and Chile are the world's two leading producers of cultured salmons (salmonids), accounting for 33 and 31 percent, respectively, of world production. Aquatic plant production by aquaculture in 2006 was 15.1 million tonnes. The culture of aquatic plants has increased consistently, with an average annual growth rate of 8 percent since 1970. In 2006, it contributed 93 percent of the world's total supply of aquatic plants, or 15.1 million tonnes (US$7.2 billion), some 72 percent of which was produced by China. However, growth rates for aquaculture production are slowing, partly owing to public concerns about aquaculture practices and fish quality. Genetically modified organisms (GMOs) remain a controversial issue. In response to these concerns, integrated multitrophic aquaculture (which promotes economic and environmental sustainability) and organic aquaculture are on the rise.

Fisheries and aquaculture, directly or indirectly, play an essential role in the livelihoods of millions of people around the world. In 2006, an estimated 43.5 million people were directly engaged, part time or full time, in primary production of fish either in capture from the wild or in aquaculture, and a further 4 million people were engaged on an occasional basis (2.5 million of these in India). In the last three

decades, employment in the primary fisheries and aquaculture sector has grown faster than the world's population and employment in traditional agriculture. Eighty-six percent of fishers and fish farmers worldwide live in Asia, with China having the greatest numbers (8.1 million fishers and 4.5 million fish farmers). In 2006, other countries with a significant number of fishers and fish farmers were India, Indonesia, the Philippines and Viet Nam. Most fishers and fish farmers are small-scale, artisanal fishers, operating on coastal and inland fishery resources. Currently, fleet-size reduction programmes in China and other countries, aimed at tackling overfishing, are reducing the number of full-time and part-time fishers. Globally, the number of people engaged in capture fisheries declined by 12 percent in the period 2001–06. On the other hand, in recent decades, major increases in the total number have come from the development of aquaculture activities. In 2006, the estimated number of fish farmers was nearly 9 million people, with 94 percent operating in Asia. For each person employed in the primary sector, it has been estimated that there could be four employed in the secondary sector (including fish processing, marketing and service industries), indicating employment of about 170 million in the whole industry. Taking account of dependants, about 520 million people could be dependent on the sector, or nearly 8 percent of the world population.

The number of fishing vessels powered by engines is estimated to have been about 2.1 million in 2006, of which almost 70 percent were concentrated in Asia. Of the remaining vessels, most were accounted for by Africa, followed by Europe, the Near East, Latin America and the Caribbean. As almost 90 percent of motorized fishing vessels in the world are less than 12 metres long, such vessels dominate everywhere, particularly in Africa, Asia and the Near East. The fishing fleets in the Pacific region, Oceania, Europe and North America tend to consist of vessels that, on average, are slightly larger. This characteristic is confirmed by the distribution of industrialized fleets (vessels of more than 100 gross tonnage [GT], roughly more than 24 m long, extracted from Lloyds Fairplay database), which shows them as rather evenly distributed among Asia, Europe, Latin America and the Caribbean, and North America. Correspondingly, there is a higher proportion of vessels of more than 100 GT in the Europe, North America and Latin America and Caribbean regions than in the Africa and Asia regions. Fleet reduction schemes have had mixed success. The numbers of both fishing vessels and fish carriers have stayed around the same level in the last ten years. While the size of the fishing fleet has declined slightly in terms of gross tonnage, the fleet of fish carriers in 2006 was less than half that of 1990, as recently built fish carriers have been much smaller than their predecessors. Moreover, scrapped vessels have on the whole been much larger than those built to replace them.

An overall review of the state of marine fishery resources confirms that the proportions of overexploited, depleted and recovering stocks have remained relatively stable in the last 10–15 years, after the noticeable increasing trends observed in the 1970s and 1980s with the expansion of fishing effort. In 2007, about 28 percent of stocks were either overexploited (19 percent), depleted (8 percent) or recovering from depletion (1 percent) and thus yielding less than their maximum potential owing to excess fishing pressure. A further 52 percent of stocks were fully exploited and, therefore, producing catches that were at or close to their maximum sustainable limits with no room for further expansion. Only about 20 percent of stocks were moderately exploited or underexploited with perhaps a possibility of producing more. Most of the stocks of the top ten species, which together account for about 30 percent of world marine capture fisheries production in terms of quantity, are fully exploited or overexploited. The areas showing the highest proportions of fully-exploited stocks are the Northeast Atlantic, the Western Indian Ocean and the Northwest Pacific. Overall, 80 percent of the world fish stocks for which assessment information is available are reported as fully exploited or overexploited and, thus, requiring effective and precautionary management. As stated before in *The State of World Fisheries and Aquaculture*, the maximum wild capture fisheries potential from the world's oceans has probably been reached, and a more closely controlled approach to fisheries

management is required, particularly for some highly migratory, straddling and other fishery resources that are exploited solely or partially in the high seas.

Accounting for more than 10 million tonnes in 2006, inland fisheries contributed 11 percent of global capture fisheries production, and landings from inland waters remain essential and irreplaceable elements in the diets of both rural and urban people in many parts of the world, especially in developing countries. Although global landings from inland fisheries have grown continuously, there are few examples of collapsing fisheries, and a number of fish stocks, especially in Latin America, remain lightly exploited. Thus, adopting a precautionary approach, the fisheries could be developed further.

Results from five case studies of river and lake fisheries show that inland fisheries are highly complex and that, where ecosystem processes remain largely undisturbed, stock dynamics are basically controlled by environmental processes and factors external to the fisheries, such as natural fluctuations in climate, flood patterns, and variations in nutrient inputs (whether natural or resulting from pollution). However, anthropogenic ecosystem impacts in the form of species introductions, pollution, habitat fragmentation and changes in the flood cycle can reduce the resilience of fish stocks to fishing pressure. Inland fisheries management requires an ecosystem approach, particularly in the catchment areas of large lake and river systems. The values and benefits of inland fisheries can be increased if such fisheries are protected through more effective governance and management.

In 2006, more than 110 million tonnes (77 percent) of world fish production was used for direct human consumption. Almost all of the remaining 33 million tonnes was destined for non-food products, in particular the manufacture of fishmeal and fish oil. In 2006, 48.5 percent of the fish destined for human consumption was in live and fresh form, which is often the most preferred and highly priced product form. Fifty-four percent (77 million tonnes) of the world's fish production underwent some form of processing. Seventy-four percent (57 million tonnes) of this processed fish was used for manufacturing products for direct human consumption in frozen, cured and prepared or preserved form, and the rest for non-food uses. Freezing is the main method of processing fish for food use, accounting for 50 percent of total processed fish for human consumption in 2006, followed by prepared and preserved (29 percent) and cured fish (21 percent). The utilization and processing of fish production have diversified significantly in the last two decades, particularly into high-value fresh and processed products, fuelled by changing consumer tastes and advances in technology, packaging, logistics and transport. The quantity of fish used as raw material for fishmeal in 2006 was about 20.2 million tonnes, representing a 14 percent decrease compared with 2005, and still well below the peak level of more than 30 million tonnes recorded in 1994. Another emerging application of fish, crustaceans and other marine organisms is as a source of bioactive molecules for the pharmaceutical industry.

Fish and fishery products are highly traded, with more than 37 percent (live weight equivalent) of total production entering international trade as various food and feed products. World exports of fish and fishery products reached US$85.9 billion in 2006. In real terms (adjusted for inflation), exports of fish and fishery products increased by 32.1 percent in the period 2000–06. Exports of fish for human consumption have increased by 57 percent since 1996. Available data for 2007 indicate further strong growth to reach about US$92 billion. Although some weakening in demand was registered in late 2007 and early 2008, as turmoil from the financial sector started to affect consumer confidence in major markets, the long-term trend for the trade in fish is positive, with a rising share of both developed and developing country production arriving in international markets. Prices of fishery products followed the general upward trend of all food prices in the course of 2007 and early 2008. This is the first time in decades that real prices of fish have increased. China further consolidated its position as the leading fish exporter with exports amounting to US$9.0 billion in 2006 and US$9.3 billion in 2007. China's fishery exports have increased remarkably since the early 1990s owing to its growing fishery production, as well as the expansion of its fish-processing industry. China has also experienced a significant increase in

its fishery imports in the past decade. In 2006, it was the sixth-largest importer with US$4.1 billion in fishery imports. In 2007, this figure rose to US$4.5 billion, partly owing to imports of raw material for processing and re-export. The fishery net exports of developing countries (i.e. the total value of their exports less the total value of their imports) continue to be of vital importance to the economies of many fish-exporting developing countries. They have increased significantly in recent decades, growing from US$1.8 billion in 1976 to US$24.6 billion in 2006. The contribution of farmed products to international trade has grown considerably, with export growth rates for species such as catfish and tilapia now exceeding 50 percent per year. These species are entering new markets where, only a few years ago, they were practically unknown. This highlights the potential for further growth in the production, trade and consumption of species and products that respond to the consumers' needs for moderately-priced white-meat fillets.

Preliminary estimates for 2006 indicate a slight increase of global per capita fish supply, to about 16.7 kg, after 16.4 kg in 2005. World apparent per capita fish consumption has been steadily increasing from an average of 9.9 kg in the 1960s, 11.5 kg in the 1970s, 12.5 kg in the 1980s, 14.4 kg in the 1990s, reaching 16.4 kg in 2005. However, this increase has not been evenly distributed across regions and it has mainly been due to increased apparent consumption in China, for which there is an impending revision of production statistics. In the last three decades, the per capita fish supply has remained almost static in sub-Saharan Africa (SSA) but has risen dramatically in China and in the Near East/North Africa region. It is estimated that fish provides at least 50 percent of total animal protein intake in some small island developing states, as well as in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone. The contribution of fish proteins to total world animal protein supplies rose from 13.7 percent in 1961 to a peak of 16.0 percent in 1996, before declining somewhat to 15.3 percent in 2005. Corresponding figures for the world, excluding China, show an increase from 12.9 percent in 1961 to 15.4 percent in 1989, slightly declining since then to 14.7 percent in 2005. Whereas fish provided about 7.6 percent of animal protein in North and Central America and more than 11 percent in Europe, in Africa it supplied around 19 percent, in Asia nearly 21 percent and in the LIFDCs including China about 19 percent.

Fisheries management poses challenges for all countries, especially those that are capacity poor. In some countries, improvements in resource management are proceeding hand-in-hand with public-sector reform and measures to promote better governance. These outcomes are increasingly being incentive-linked to the provision of development assistance. A key fisheries management issue is the lack of progress with the reduction of fishing capacity and related harmful subsidies. The 2007 session of the FAO Committee on Fisheries (COFI) referred to the lack of progress in this area and the need to match fishing capacity with sustainable harvesting levels. The United Nations General Assembly Resolution 62/177 in 2007 deplored the fact that fish stocks in many parts of the world are overfished or subject to sparsely regulated fishing effort. The relationship between excess capacity and illegal, unregulated and unreported (IUU) fishing was also highlighted in COFI, the United Nations General Assembly and regional fora. There was only limited progress in the implementation of measures *inter alia* to mainstream the precautionary and ecosystem approaches to fisheries, eliminate bycatch and discards, regulate bottom-trawl fisheries, manage shark fisheries, and deal with IUU fishing in a comprehensive manner. A sharp focus on capacity building for fisheries management is a priority both for developing and developed countries. A further and important reason to promote capacity building occurs where regional cooperation and collaboration underpin the implementation of agreements. Regional fisheries management organizations (RFMOs), the cornerstones of international fisheries governance, are struggling to fulfil their mandates despite concerted efforts to improve their performance. This situation results partly from the frameworks within which they operate and partly from an apparent lack of political will by members to implement decisions in a timely manner. In an effort to improve their effectiveness, many RFMOs are implementing performance reviews. Steps have been taken, or are being taken, to establish new RFMOs where none existed previously. Once these are

established, nearly all of the world's major fish stocks will be covered by RFMOs, the major exception being straddling stocks in the Southwest Atlantic Ocean. International cooperation is strengthened and many problems resolved through consultation and the timely exchange of information. For RFMOs, such exchanges are critical in dealing with common issues such as IUU fishing and the harmonization of data formats. FAO and non-FAO regional fishery bodies (RFBs) have met biennially since 1999 to consider matters of common concern and to learn how different bodies handle and resolve similar problems. These meetings marked a watershed in cooperation among RFBs. In 2007, the nature and scope of cooperation was taken a step further with the First Meeting of Regional Fishery Body Secretariats Network. The international dimension of aquaculture governance is gradually gaining ground.

There is an extensive array of international agreements, standards and procedures already in place for various aspects of aquaculture and its value chain elsewhere. Compliance with some of these agreements, standards and procedures is mandatory, and recognized competent authorities are empowered to verify compliance. New disciplines governing the use of subsidies in the fisheries sector are being negotiated in the World Trade Organization (WTO), and much progress has been achieved since the negotiations were launched.

CAPTURE FISHERIES PRODUCTION

Total capture fisheries production

According to the data compiled by FAO on the basis of reports from national authorities and other sources (e.g. regional fishery organizations), global capture production in 2006 was about 92 million tonnes. This represents a decrease of 2.2 million tonnes in comparison with 2005 (Table 1 and Figure 3). As in previous years, the change in total world capture production was mostly caused by environmentally-driven fluctuations in anchoveta catches. While total inland water catches increased significantly in 2005 and 2006, total global marine capture production (excluding anchoveta catches) has remained fairly stable since 2002 at between 74.3 and 75.3 million tonnes. However, important groups of species, countries and fishing areas do show different trends. These are discussed below in the section on marine capture production.

According to preliminary statistics by major fishing countries excluding China, total capture production in 2007 increased by about 3 percent in comparison with 2006. However, China's capture production decreased by more than 2 million tonnes following the adjustment to the national data collection system (as mentioned in the "Overview" section [above]).

The estimated first-hand value of global capture fisheries production amounted to US$91.2 billion, representing a 4.5-percent growth over the value recorded for 2005. Of this total, fish for reduction purposes had a first-hand value of US$3.4 billion.

China has remained by far the global leader with more than 17 million tonnes and a very stable capture production, as the variation from one year to the next in its reported total catches was less than 1 percent in the period 1986–2006. Compared with 2004, the ranking of the top ten producer countries (Figure 4) remained unchanged, with two exceptions. For 2006, Chile ranked two places lower as a consequence of the anchoveta catch decrease, and the Philippines replaced Norway in tenth position. In addition to the six Asian countries among the top ten producers, four other Asian countries (i.e. Myanmar, Viet Nam, the Republic of Korea and Bangladesh) occupied positions 12–15. This was reflected in Asia's share of total catches, which exceeded 52 percent of the global capture fisheries production in 2006, the largest share so far recorded.

World marine capture fisheries production

Global marine capture production was 81.9 million tonnes in 2006, the third lowest since 1994. Only in 1998 and 2003 was production lower, as also in those years anchoveta catches decreased considerably.

Although the ranking of the first eight principal marine fishing areas in 2006 (Figure 5) was still the same as in 2004, trends in the single regions diverged. Overall

Figure 4

Marine and inland capture fisheries: top ten producer countries in 2006

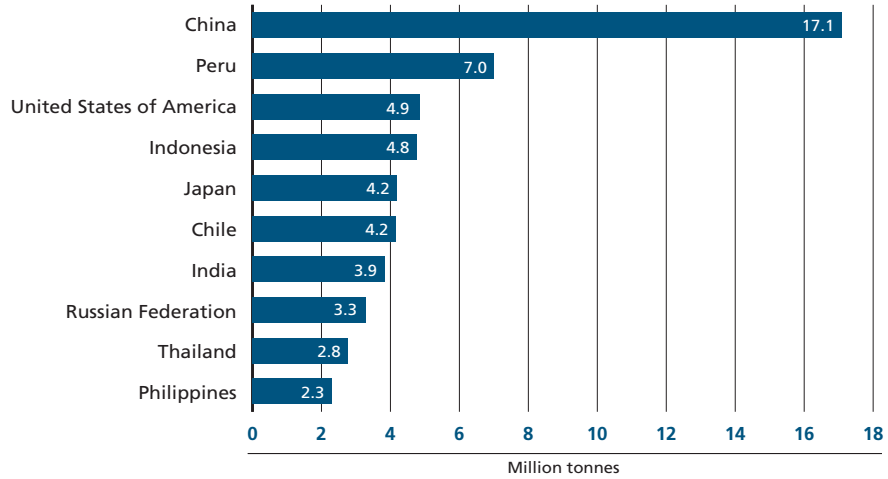
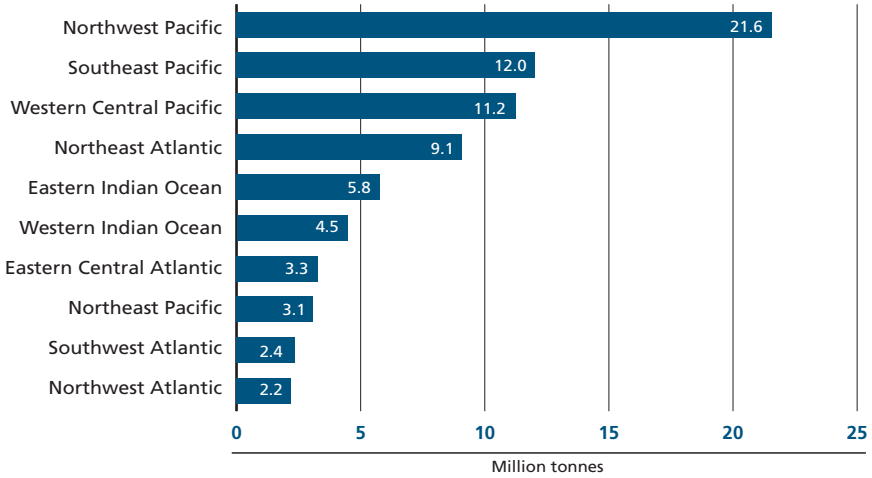


Figure 5

Capture fisheries production: principal marine fishing areas in 2006

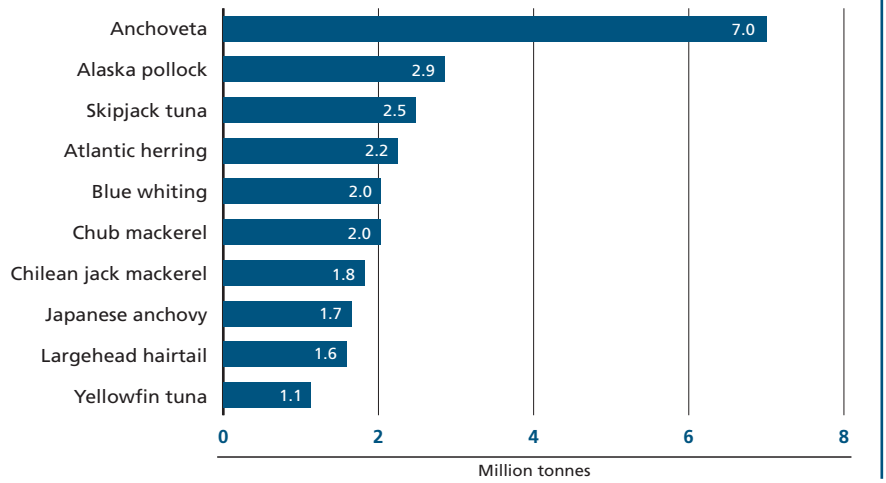


Note: Fishing areas listed are those with a production of at least 2 million tonnes.

catches in the Western Central Pacific and in the Western Indian Ocean continued to increase. In contrast, capture production decreased by more than 10 percent after 2000 in both the Western and Eastern Central areas of the Atlantic Ocean, although they are quite different in terms of the main fishery resources and type of fishing. In the Eastern Indian Ocean, total catches in 2006 rebounded after the decrease in 2005 caused by the destructive effects of the tsunami that affected parts of this region in December 2004. After submission to FAO of final catch statistics for 2005, it became clear that, among the Eastern Indian Ocean countries, those most affected by the tsunami in terms of reduced catches had been Sri Lanka (–51.1 percent), Malaysia (–12.1 percent) and India (–8.4 percent). However, in Indonesia, the 2004 total catch was maintained, as the tsunami impacts on fishing activities in the western part (Banda Aceh) of the country were offset by increased catches in other regions.

Figure 6

Marine capture fisheries production: top ten species in 2006



Among the temperate areas of both hemispheres, it is worth noting the considerable increase in 2006 catches of Argentine shortfin squid in the Southwest Atlantic, and of European anchovy in the Mediterranean and Black Seas. These increases contributed significantly to the overall 29 and 13 percent respective rise in total catches compared with the previous year. In contrast, in both the Southeast Atlantic and the Southwest Pacific, total catches fell by more than 10 percent in 2006. In the Southeast Pacific, the drop was even sharper. However, it affected fish for human consumption only marginally as it stemmed mostly from the decrease in anchoveta catches, the majority of which are processed into fishmeal and fish oil. In the Northeast Atlantic, catch decline has been progressive, with total catches falling by almost one-quarter in ten years.

In 2006, the ten species that contributed most to global catches (Figure 6) were the same as in 2004. There were only some minor changes in the ranking. This group of species, which represent more than 30 percent of the total global marine catch, consists of five small pelagic species (anchoveta, Atlantic herring, chub and Chilean jack mackerels, and Japanese anchovy), two tunas (skipjack and yellowfin), two low-value gadiformes (Alaska pollock and blue whiting) that are mostly marketed in processed forms, and the largehead hairtail, a bentho-pelagic species for which 90 percent of the catches are reported by China.

Total catches of some species groups continued to increase in 2006, setting new records. However, different trends can be noted within each group. The tunas reached a new maximum at more than 6.4 million tonnes, with skipjack catches higher than ever, whereas yellowfin catches were reported to have decreased by about 20 percent from the peak reached in 2003. Cephalopod catches also reached a new high in 2006 at 4.3 million tonnes. Within this group, recent catch trends for the three main species show very different patterns. Catches of jumbo flying squid in the Eastern Pacific continued to boom, growing almost fivefold since 2000. However, in the same period, catches of Japanese flying squid in the Northwest Pacific declined. In the Southwest Atlantic, catches of the Argentine shortfin squid recovered after a dramatic drop in 2004–05. Marine crustaceans as a whole totalled 5.7 million tonnes in 2006, with the crab and lobster groups at the highest level ever, and shrimps only slightly lower than the peak reached in 2004. Harvests of bivalves (scallops, clams, oysters and mussels) and gastropods decreased for most species groups in 2005, but they showed signs of recovery in 2006.

After reaching a high of about 0.9 million tonnes in 2003, catches of the "sharks, rays and chimaeras" group have declined. In 2006, they totalled 0.75 million tonnes, a

drop of 15 percent from the peak. When analysing the trend in shark catches in the last decade, it should be taken into account that this species group has been at the centre of the attention of international institutions (e.g. the FAO-promoted International Plan of Action for the Conservation and Management of Sharks, known as IPOA–Sharks), regional fishery organizations and the public. This raised awareness has helped to improve the reporting of catches for this group.[2] However, this improvement in reporting makes it difficult to identify the trends for actual exploitation. To obtain the best possible collation of available shark data, FAO also complements data reported by countries with those collected by the regional tuna bodies. However, collection and reporting of shark data still need to improve significantly as the formulation of appropriate management measures requires detailed information.

A significant number of tuna and shark species are classified as oceanic (epipelagic and deep-water). Box 1 analyses trends for such species in more detail.

World inland capture fisheries production

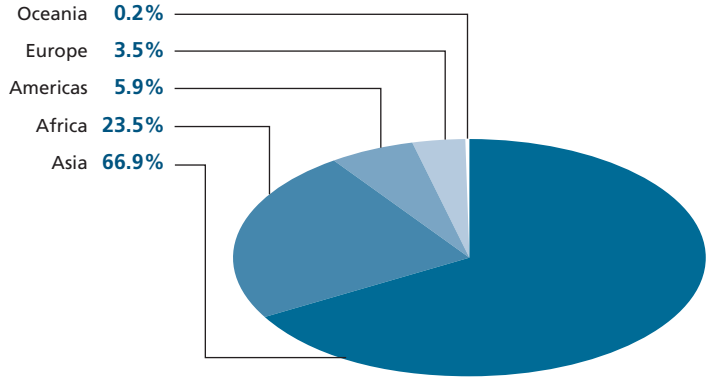
In 2006, reported global inland water catches exceeded 10 million tonnes for the first time. Compared with final 2004 data, this represented an increase of 12.8 percent. However, the reliability of inland water catch statistics reported by several countries remains questionable. It is also difficult to distinguish between real increases in catches and increased production reported as a consequence of an improved data collection system.

Almost all of the increase registered in the last two years for which data are available has come from Asia. This continent now accounts for two-thirds of total global inland capture production. With 2.4 million tonnes, Africa is a clear second in the ranking by continent (Figure 7) but its production decreased by 2.7 percent in 2006 after a decade-long rising trend. Total catches in the Americas were down slightly from the 2004 high, while the opposite occurred in Europe, with production recovering from the lowest total catch registered in 2004. However, figures for this continent are largely influenced by those of the Russian Federation, which accounts for about 60 percent of Europe's production.

China and other developing countries together now account for 95 percent of global inland capture production (Table 3). In several developing countries, inland fisheries constitute a primary source of animal proteins, and a significant addition to the main diet in many others. On the other hand, in most industrialized countries, the number of recreational fishers now greatly exceeds that of professional ones, as inland water harvests have been significantly reduced.

Figure 7

Inland capture fisheries by continent in 2006



Note: World inland capture fisheries production amounted to 10.1 million tonnes in 2006.

Table 3
Inland capture fishery production by economic class

	Production in 2006	
	(Million tonnes)	*(Percentage share of total)*
China	2.54	25.3
Other developing countries	7.01	69.7
Economies in transition	0.33	3.3
Industrial countries	0.18	1.8
Total	**10.06**	

The top ten producers have remained the same as in 2004 (Figure 8 on page 16). Bangladesh has replaced India in second spot, but it is still a long way behind China. Cambodia has gained four positions with an increase of 30 percent compared with 2005. This impressive performance probably in part reflects an extended coverage

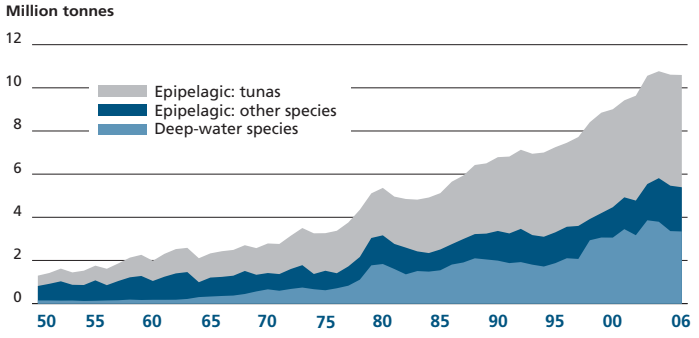
Box 1

Trends in high seas catches

Marine catches are reported by countries to FAO according to Fishing Areas set up in the 1950s, many years before the establishment of exclusive economic zones (EEZs). Because the boundaries of the FAO Fishing Areas and of the EEZs do not correspond, data on catches in the high seas (the ocean areas outside the national EEZs) cannot be obtained from the data submitted to FAO. In an attempt to obtain some information on high seas catches, oceanic species that occur in the FAO capture fisheries database (and are likely to be caught in the high seas) have been identified and classified into "epipelagic" and "deep-water" species according to their biological characteristics. The catch data for these two groups of species provide an indication of the trends in high seas catches.

The latest available release (2006 data) of the FAO capture database includes 133 species items classified as deep-water. This number has more than doubled since the first classification[1] based on 1999 data, although this also reflects greater global attention to deep-water fishing rather than only increased activities. In fact, the global catch of deep-water species had

World catches of oceanic species occurring principally in high seas areas



of the data collection system. In percentage terms, China still accounts for more than 25 percent of global production, and the share of the top ten producers as a group has grown as the total for inland catches by all the other countries has decreased to 31.6 percent.

Many countries do not report any species breakdown of their inland water catches but only a single amount for overall national production under the "freshwater fishes NEI (not elsewhere included)" species item. For 2006, more than 57 percent of the global inland water capture was registered under this category in the FAO database, an increased share as also most of the production gain in the last two years was reported as not identified by species or major group of species. The "miscellaneous freshwater fishes" (which includes the "freshwater fishes NEI" item but also another 65 species items) is by far the predominant group (Figure 9). The "carps, barbels and other cyprinids" group, which grew substantially in 2005 and maintained the same level in 2006, is now second, having overtaken the "tilapias and other cichlids" group. However, as most of the unidentified catches are reported by Asian countries such as Bangladesh, China and Myanmar, it is very probable that the great majority of this inland water production belongs to the cyprinid group, which is by far the most common in the continent.

grown to 3.9 million tonnes in 2003 (see accompanying figure) but it then decreased to 3.3 million tonnes in 2006. This reduction was mainly due to smaller catches of blue whiting, but also to measures taken by the regional fishery organizations (e.g. the North East Atlantic Fisheries Commission and the South East Atlantic Fisheries Organization) to manage fisheries in high seas areas. However, catches of valuable deep-water species, such as the orange roughy (which has an extended geographical distribution and is vulnerable as it grows very slowly and reaches sexual maturity late), have fallen to 20 000 tonnes, a decrease of 78 percent from the high reached in 1990, mostly as a consequence of overexploitation. On the other hand, overall catches of oceanic tunas (about 5.2 million tonnes in 2006) are still growing, and those of other epipelagic oceanic species were stable at about 2 million tonnes in 2004–06 as opposing trends in the main oceanic squid species have offset one another.

In an effort to move towards a better separation of catches taken inside and outside national EEZs, FAO is collaborating with regional fishery organizations on the modification of the statistical division boundaries. The first change was agreed with the South East Atlantic Fisheries Organization, whose Convention Area covers all waters in Fishing Area "47 – Southeast Atlantic" with the exclusion of the EEZs of the continental states. Starting with the 2007 inquiry, countries fishing in Area 47 are requested to return catch statistics according to revised statistical divisions that distinguish between catches taken within and outside the EEZs of the coastal states. This separation of catches will be helpful in evaluating the effects of the International Guidelines for the Management of Deep-sea Fisheries in the High Seas once they have been adopted.

[1] FAO. 2003. *Trends in oceanic captures and clustering of large marine ecosystems – two studies based on the FAO capture database*, by L. Garibaldi and L. Limongelli. FAO Fisheries Technical Paper No. 435. Rome.

Figure 8

Inland capture fisheries: top ten producer countries in 2006

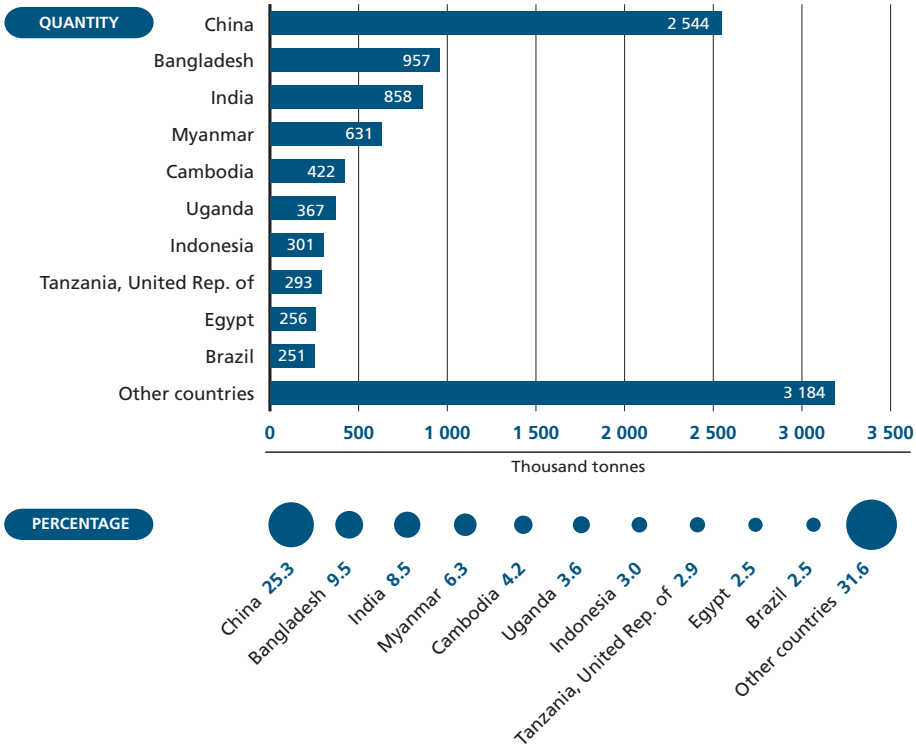
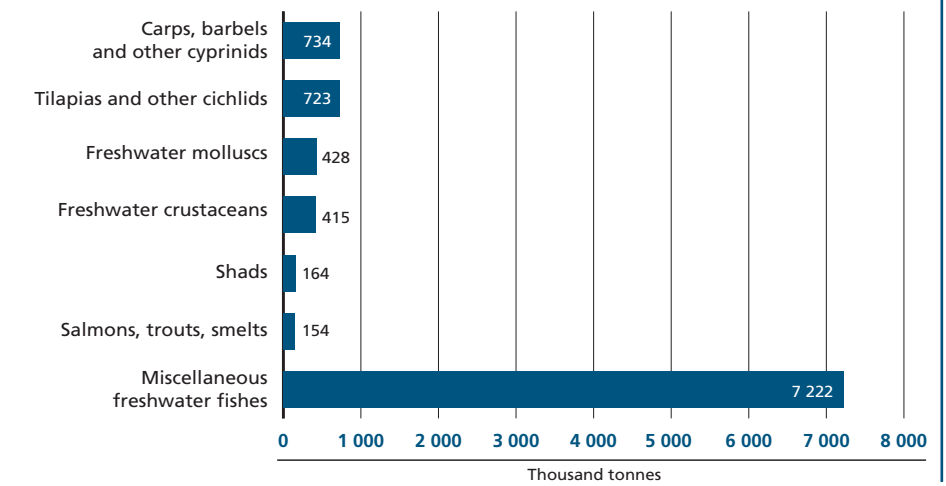


Figure 9

Inland capture fisheries: major species groups in 2006



AQUACULTURE

Aquaculture production

The contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals[3] has continued to grow, increasing from 3.9 percent of total production by weight in 1970 to 36.0 percent in 2006. In the same period, production from aquaculture easily outpaced population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth

rate of 7.0 percent. Aquaculture accounted for 47 percent of the world's fish food supply in 2006. In China, 90 percent of fish food production comes from aquaculture (2006). This indicates that aquaculture production in the rest of the world accounts for 24 percent of food fish supply.

In 2006, China contributed 67 percent of the world's supply of cultured aquatic animals and 72 percent of its supply of aquatic plants.

World aquaculture has grown dramatically in the last 50 years. From a production of less than 1 million tonnes in the early 1950s, production in 2006 was reported to have risen to 51.7 million tonnes, with a value of US$78.8 billion. This means that aquaculture continues to grow more rapidly than other animal food-producing sectors. While capture fisheries production stopped growing in around mid-1980, the aquaculture sector has maintained an average annual growth rate of 8.7 percent worldwide (excluding China, 6.5 percent) since 1970. Annual growth rates in world aquaculture production between 2004 and 2006 were 6.1 percent in volume terms and 11.0 percent in value terms.

If aquatic plants are included, world aquaculture production in 2006 was 66.7 million tonnes and worth US$85.9 billion.

In 2006, countries in the Asia and the Pacific regions accounted for 89 percent of production by quantity and 77 percent of value. Of the world total, China is reported to produce 67 percent of the total quantity and 49 percent of the total value of aquaculture production (Figure 10).[4]

An analysis of production by region for the period 1970–2006 shows that growth has not been uniform (Figure 11). The Latin America and the Caribbean region shows the highest average annual growth (22.0 percent), followed by the Near East region (20.0 percent) and the Africa region (12.7 percent). China's aquaculture production increased at an average annual rate of 11.2 percent in the same period. However, recently, China's growth rate has declined to 5.8 percent from 17.3 percent in the 1980s and 14.3 percent in the 1990s. Similarly, production growth in Europe and North America has slowed substantially to about 1 percent per year since 2000. In France and Japan, countries that used to lead aquaculture development, production has fallen in the last decade. It is apparent that, while aquaculture output will continue to grow, the rate of increase may be moderate in the near future.

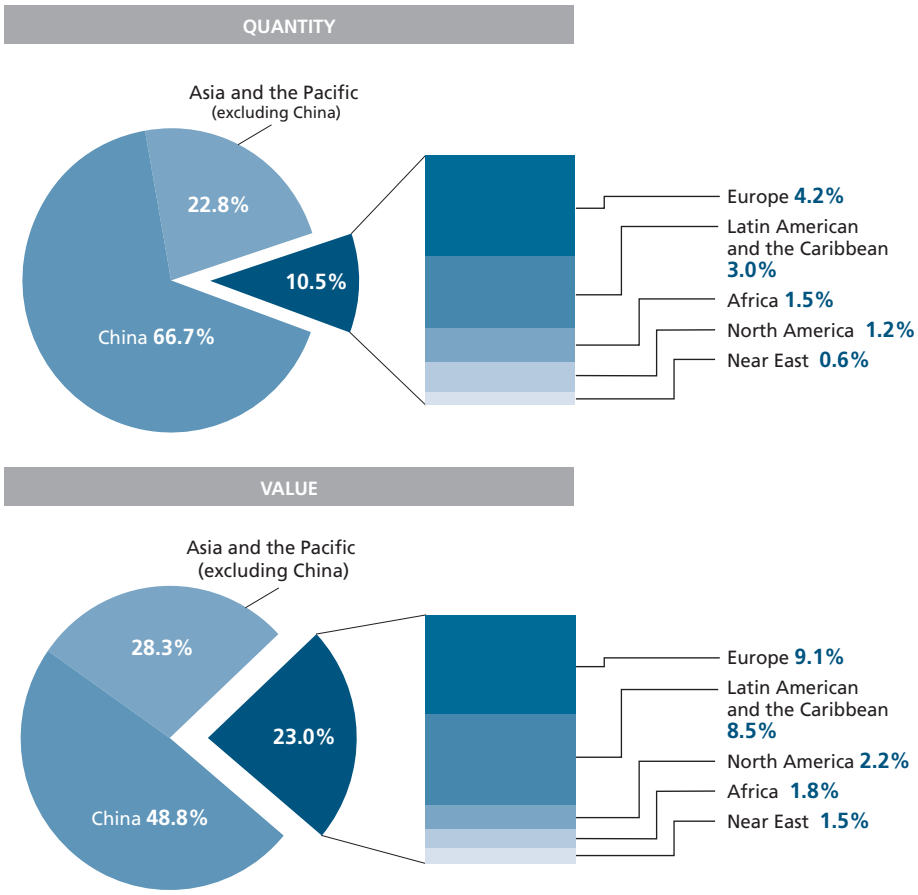
Table 4 lists the top ten producing countries for cultured aquatic animals in 2006, as well as the top ten countries in terms of annual growth in aquaculture production for the two-year period 2004–06 (but including only those countries that reported production of more than 1 000 tonnes in 2006). Chile and the Philippines have improved their position in the 2006 ranking – compared with that of two years earlier – while Japan and the United States of America have slipped down the list.

Most aquaculture production of fish, crustaceans and molluscs continues to come from inland waters (61 percent by quantity and 53 percent by value). An allocation of aquaculture production by aquatic environments shows that the freshwater environment contributes 58 percent by quantity and 48 percent by value. Aquaculture in the marine environment contributes 34 percent of production and 36 percent of total value. While much marine production is high-value finfish, production in this environment also consists of a large amount of relatively low-priced mussels and oysters.[5] Although brackish-water production represented only 8 percent of production in 2006, it contributed 16 percent of the total value, reflecting the prominence of high-value crustaceans and finfish. While production from brackish waters shows the highest growth in terms of quantity since 2000 (11.6 percent per year), the increase in value has stagnated at 5.9 percent. In the same period, the average annual increases in aquatic products from the freshwater and marine water environments have been 6.5 and 5.4 percent in terms of quantity and 7.8 and 8.3 percent in value terms, respectively.

In 2006, more than half of global aquaculture production was freshwater finfish. Output amounted to 27.8 million tonnes, worth US$29.5 billion. In the same year, molluscs accounted for the second-largest share, 14.1 million tonnes (27 percent of total production), worth US$11.9 billion. The much smaller amounts of crustaceans – 4.5 million tonnes – were worth significantly more: US$17.95 billion (Figure 12).

Figure 10

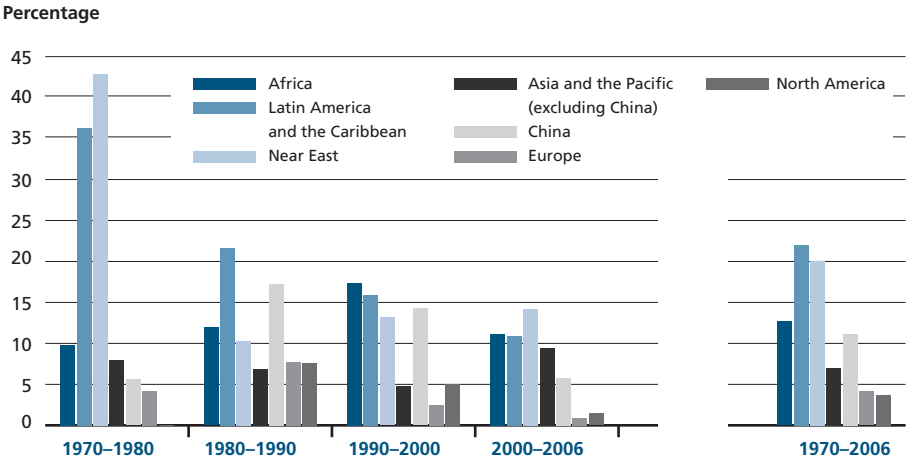
Aquaculture production by region in 2006



Note: Data exclude aquatic plants.

Figure 11

World aquaculture production: change in growth by region since 1970



Note: Data exclude aquatic plants.

Table 4
Top ten aquaculture producers of food fish supply: quantity and growth

	Top ten producers in terms of quantity, 2006				Top ten producers in terms of growth, 2004–06[1]		
	2004	2006	APR		2004	2006	APR
	(Tonnes)		(Percentage)		(Tonnes)		(Percentage)
China	30 614 968	34 429 122	6.05	Uganda	5 539	32 392	141.83
India	2 794 636	3 123 135	5.71	Guatemala	4 908	16 293	82.20
Viet Nam	1 198 617	1 657 727	17.60	Mozambique	446	1 174	62.24
Thailand	1 259 983	1 385 801	4.87	Malawi	733	1 500	43.05
Indonesia	1 045 051	1 292 899	11.23	Togo	1 525	3 020	40.72
Bangladesh	914 752	892 049	–1.25	Nigeria	43 950	84 578	38.72
Chile	665 421	802 410	9.81	Cambodia	20 675	34 200	28.61
Japan	776 421	733 891	–2.78	Pakistan	76 653	121 825	26.07
Norway	636 802	708 780	5.50	Singapore	5 406	8 573	25.93
Philippines	512 220	623 369	10.32	Mexico	104 354	158 642	23.30

Notes: Data exclude aquatic plants. APR refers to the average annual percentage growth rate for 2004–2006.
[1] For top countries in terms of growth, only countries with more than 1 000 tonnes production in 2006 were taken into account.

The growth in production of the major species groups continues, although the increases seen in the past decade have been smaller than those of the 1980s and 1990s (Figure 13). The period 2000–06 witnessed strong growth in the production of crustaceans in particular, and in marine fish. Production growth for other species groups has begun to slow, and the overall rate of growth, while still substantial, is not of the order seen in the previous two decades. Figure 14 presents aquaculture production by major species group.

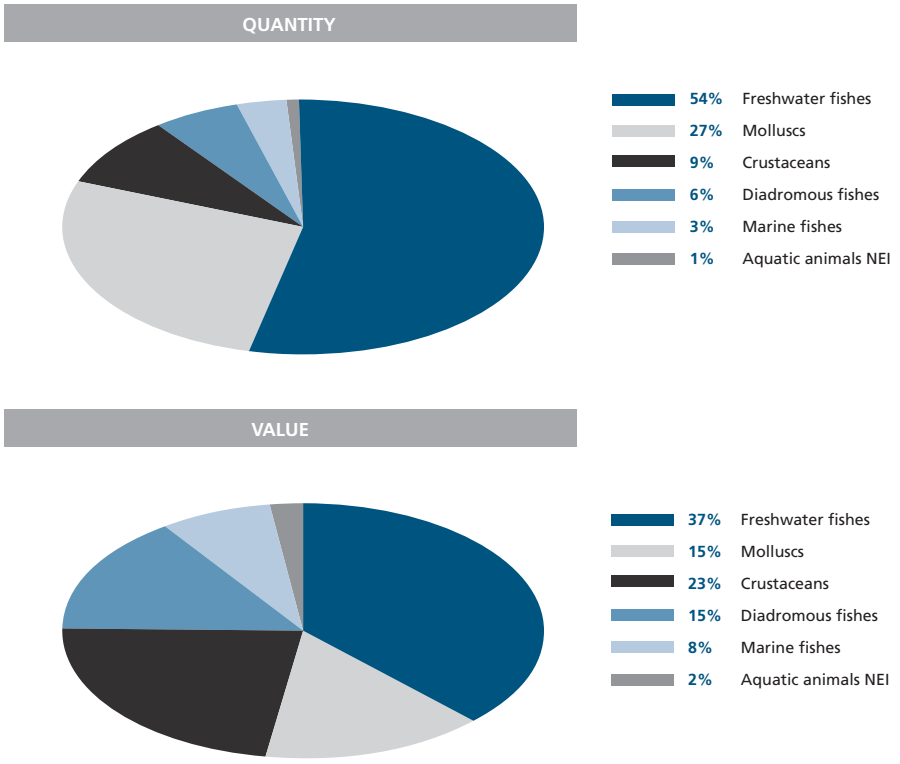
Aquaculture now accounts for 76 percent of global freshwater finfish production and 65 percent of mollusc and diadromous fish production (Figure 15). Its contribution to world supplies of crustaceans has grown rapidly in the last decade, reaching 42 percent of world production in 2006 and, in the same year, it accounted for as much as 70 percent of shrimps and prawns (penaeids) produced worldwide. Most cultured marine species are of relatively high commercial value, sometimes because wild stocks are small or declining. While the overall share of farmed fish in marine finfish production has stayed quite low, for the species that are farmed, aquaculture frequently dominates the market. This is the case for species such as the Japanese seabass, gilthead seabream, red drum and bastard halibut. In fact, for species such as these, the amounts now produced by aquaculture are often substantially higher than the past highest catch recorded by capture fisheries.

Production continues to differ much from region to region. In the Asia and the Pacific region, aquaculture production from China, South Asia and most of Southeast Asia consists primarily of cyprinids, while production from the rest of East Asia consists of high-value marine fish. In Latin America and the Caribbean, in the last decade, salmonids have overtaken shrimp as the top aquaculture species group as a result of outbreaks of disease in major shrimp-producing areas and the rapid growth in salmon production in Chile. In North America, channel catfish is the top aquaculture species in the United States of America, while Atlantic and Pacific salmon dominate in Canada.

Relative to other regions, SSA continues to produce little despite its natural potential. Nigeria leads in the region, with reported production of 85 000 tonnes of catfish, tilapia and other freshwater fishes. There are some encouraging signs in the continent. Black tiger shrimp (*Penaeus monodon*) in Madagascar and *Eucheuma* seaweed in the United Republic of Tanzania are thriving, and production of niche species such as abalone (*Haliotis* spp.) in South Africa is increasing. In North Africa, Egypt is by far the dominant country in terms of production (99 percent of the regional

Figure 12

World acquaculture production: major species groups in 2006



Note: NEI = not elsewhere included.

Figure 13

Trends in world aquaculture production:
average annual growth rate for major species groups 1970–2006

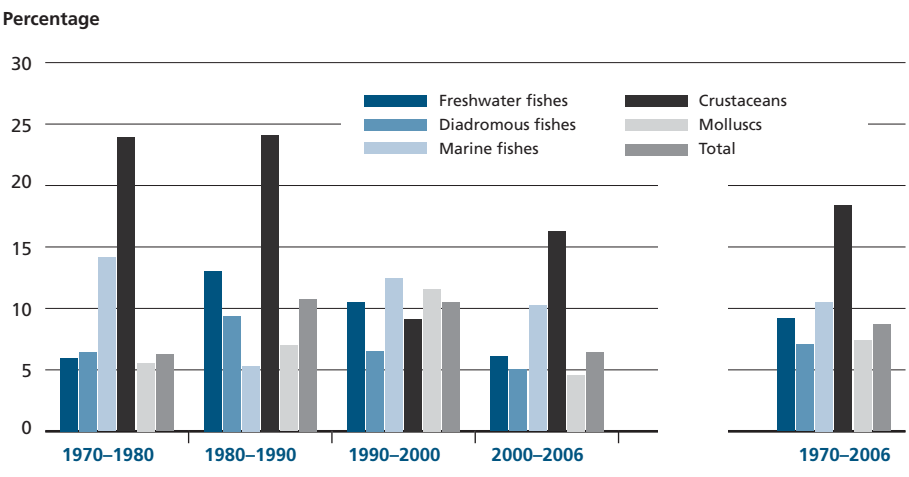
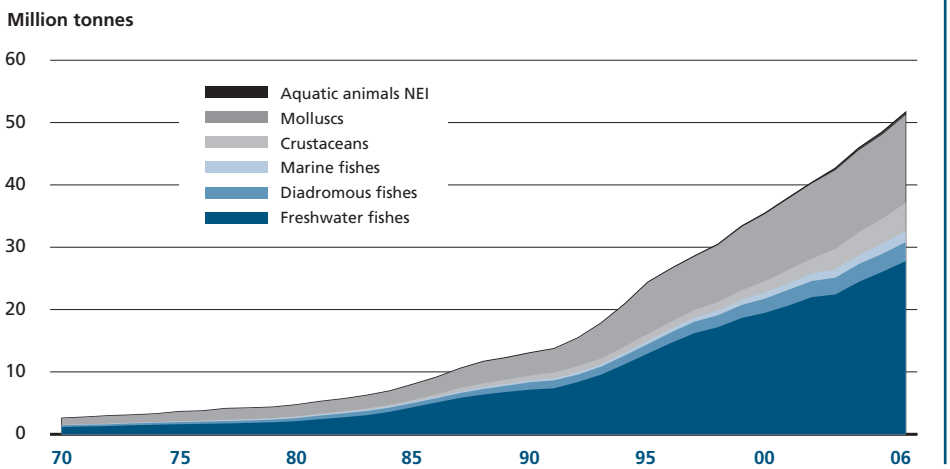


Figure 14

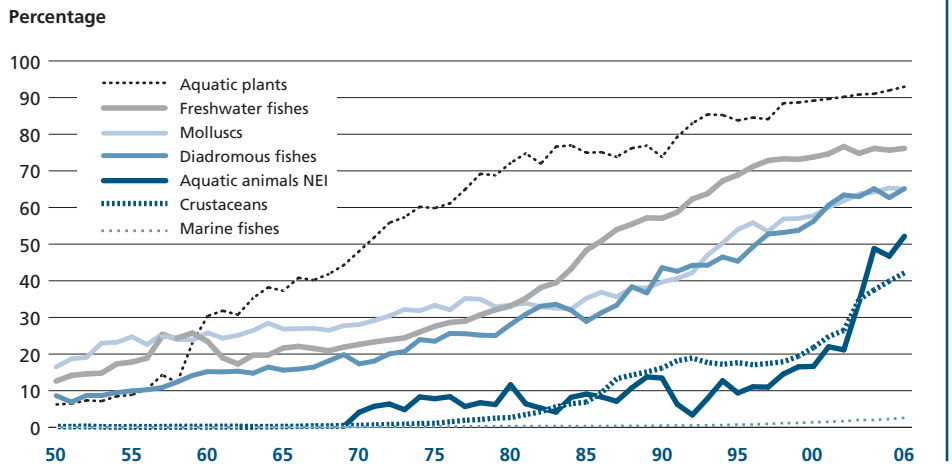
Trends in world aquaculture production: major species groups



Note: NEI = not elsewhere included.

Figure 15

Contribution of aquaculture to global production: major species groups



Note: NEI = not elsewhere included.

total) and, in fact, is now the second largest producer of tilapia after China and the world's top producer of mullets. In the Near East, Iran (Islamic Republic of) and Turkey are two leading countries in the region, each producing about 130 000 tonnes of trouts, carps and Indian white prawn.

However, in global terms, a few countries still dominate production of major species groups. China produces 77 percent of all carp (cyprinids) and 82 percent of the global supply of oysters (ostreids). The Asia and Pacific region accounts for 98 percent of carp and 95 percent of oyster production. Eighty-eight percent of shrimps and prawns (penaeids) also come from this region, with the top five producers (China, Thailand, Viet Nam, Indonesia and India) accounting for 81 percent. Meanwhile Norway and Chile are the world's leading producers of cultured salmons (salmonids), accounting for 33 and 31 percent of world production, respectively. Other European producers supply another 19 percent.

World aquatic plant production[6] by aquaculture was 15.1 million tonnes (US$7.2 billion) in 2006. The culture of aquatic plants has increased consistently, with an average annual growth rate of 8.0 percent since 1970. In 2006, it contributed 93 percent of the world's total supply of aquatic plants. Some 72 percent originated in China, with 10.9 million tonnes (US$5.2 billion). Virtually all of the remaining production also came from Asia: the Philippines (1.5 million tonnes), Indonesia (0.91 million tonnes), the Republic of Korea (0.77 million tonnes) and Japan (0.49 million tonnes). Japan is the second-most important aquatic-plant-producing country in terms of value (US$1.1 billion), owing to its high-priced Nori production. Japanese kelp (*Laminaria japonica* – 4.9 million tonnes) showed the highest production, followed by Wakame (*Undaria pinnatifida* – 2.4 million tonnes) and Nori (*Porphya tenera* – 1.5 million tonnes).

Integrated multitrophic aquaculture (incorporation of species from different trophic/nutritional levels in the same system) is on the rise. By converting solid and soluble nutrients from fed organisms and their feed into harvestable crops and/or extractive organisms (thereby reducing the potential for eutrophication) and by increasing economic diversification, integrated multitrophic aquaculture promotes economic and environmental sustainability. As the waste of one species becomes the nutritional input to another, the potential for contamination is a food safety and quality concern. However, as the practice is new, research is needed in this area to ensure that fish so produced do not present a danger to consumers.

Organic aquaculture has also attracted the attention of consumers, environmental advocates and entrepreneurial innovators. Some argue that it reduces overall exposure to toxic chemicals from pesticides that can accumulate in the ground, air, water and food supply, thereby lessening health risks for consumers. Some of its other merits include curbing topsoil erosion, improving soil fertility, protecting groundwater and saving energy. Moreover, organic standards prohibit the use of genetic engineering in production, which again reassures consumers. The growing interest in organic aquaculture has prompted governments to regulate the sector. Standards and certification procedures are being developed and tested – they are necessary tools to promote investment. In the absence of international standards, interested parties are developing their own specific organic aquaculture standards and accreditation bodies. These standards often vary significantly from place to place, certifier to certifier, and species to species.

GMOs continue to be a controversial issue also in aquaculture. Supporters claim that GMOs enhance the performance and profitability of farmed aquatic resources and, hence, improve food security. Opponents argue that they pose significant risks to the environment and, possibly, to human health. While there is universal consensus that GMOs should be regulated, there are disagreements as to what the regulations should contain. Some groups advocate a complete ban on GMOs, others call for mandatory labelling of genetically modified food and other products in order to alert consumers to potential health effects. However, GMO products from aquaculture have not yet appeared on the market.

Linked to, but distinct from, consumers' demand for fish quality standards is the public perception that aquaculture harms the environment. This public mistrust of aquaculture has occurred in some places leading to legal challenges, pressure on moratoria, and even vandalism. In some instances, attitudes towards aquaculture have influenced decision-makers, pressuring them to regulate and often to halt the expansion of aquaculture. A recent global FAO study on constraints facing aquaculture found that respondents in all regions except Africa and Eastern Europe expect such opposition to be a threat to its future development.[7] In some regions, the cause of the opposition is considered to be misinformation; in others, it is particular attributes of aquaculture. Aware of the need to address these issues, FAO and its partners have drafted guidelines for aquaculture certification (see page 103). These guidelines cover animal health and welfare, food safety and quality, environmental integrity and social responsibility associated with aquaculture. They provide guidance

on the development, organization and implementation of credible aquaculture certification schemes. The aims are: (i) to reassure producers, buyers, consumers and civil society regarding the quality and safety of aquaculture products; and (ii) to provide a further tool to support responsible and sustainable aquaculture.

FISHERS AND FISH FARMERS

Fisheries and aquaculture play, either directly or indirectly, an essential role in the livelihoods of millions of people around the world. In 2006, 43.5 million people were directly engaged, part time or full time, in primary production of fish, either by fishing or in aquaculture (Table 5). They accounted for 3.2 percent of the 1.37 billion people economically active in agriculture worldwide. In the last three decades, employment in the primary fisheries sector has grown faster than the world's population and employment in traditional agriculture. Eighty-six percent of the fishers and fish farmers worldwide are located in Asia, with China having the most (8.1 million fishers and 4.5 million fish farmers, see Table 6). Fishery employment in China experienced strong increases in the 1980s and 1990s to peak at 13.7 million people in 2001. The number of fishers and fish farmers then declined by 8 percent in the period 2001–06, mainly in the number of people engaged in capture fisheries. In 2006, other countries with a significant number of fishers and fish farmers were India, Indonesia, the Philippines and Viet Nam. Most fishers are small-scale, artisanal fishers, operating on coastal and inland fishery resources.

In recent decades, major increases in the total number of people engaged in fisheries and aquaculture have come from the development of aquaculture activities. Aquaculture can provide an important source of livelihood for the rural poor, generating income through direct sales of aquatic products, in processing and by providing ancillary services. In 2006, the estimated number of fish farmers was nearly 9 million people, with 94 percent operating in Asia. This figure is indicative only, as

Table 5
World fishers and fish farmers by continent

	1990	1995	2000	2005	2006
			(Thousands)		
Africa	1 773	1 896	3 631	3 589	3 637
North and Central America	760	777	891	1 034	1 038
South America	730	704	706	702	708
Asia	23 766	28 118	34 781	36 650	37 338
Europe	654	498	812	734	725
Oceania	55	52	49	54	55
World	**27 737**	**32 045**	**40 871**	**42 763**	**43 502**
Of which fish farmers[1]					
Africa	3	13	107	111	108
North and Central America	3	6	75	300	301
South America	66	93	71	69	69
Asia	3 738	5 986	7 369	8 078	8 107
Europe	20	26	44	71	73
Oceania	1	1	5	4	4
World	**3 832**	**6 124**	**7 672**	**8 632**	**8 663**

[1] Data for 1990 and 1995 were reported by only a limited number of countries and, therefore, are not comparable with those for later years.

Table 6
Number of fishers and fish farmers in selected countries

Country	Fishery		1990	1995	2000	2005	2006
WORLD	FI + AQ	(number)	**27 737 435**	**32 045 098**	**40 870 574**	**42 763 421**	**43 501 700**
		(index)	***68***	***78***	***100***	***105***	***106***
	FI	(number)	23 905 853	25 921 448	33 199 024	34 131 239	34 839 084
		(index)	*72*	*78*	*100*	*103*	*105*
	AQ	(number)	3 831 582	6 123 650	7 671 550	8 632 182	8 662 616
		(index)	*50*	*80*	*100*	*113*	*113*
China	FI + AQ	(number)	11 173 463	11 428 655	12 935 689	12 902 777	12 594 654
		(index)	*86*	*88*	*100*	*100*	*97*
	FI	(number)	9 432 464	8 759 162	9 213 340	8 389 161	8 091 864
		(index)	*102*	*95*	*100*	*91*	*88*
	AQ	(number)	1 740 999	2 669 493	3 722 349	4 513 616	4 502 790
		(index)	*47*	*72*	*100*	*121*	*121*
Indonesia	FI + AQ	(number)	3 323 135	4 177 286	4 776 713	4 486 776	4 496 680
		(index)	*70*	*87*	*100*	*94*	*94*
	FI	(number)	1 700 839	2 072 464	2 633 954	2 212 776	2 221 680
		(index)	*65*	*79*	*100*	*84*	*84*
	AQ[1]	(number)	1 622 296	2 104 822	2 142 759	2 274 000	2 275 000
		(index)	*76*	*98*	*100*	*106*	*106*
Iceland	FI + AQ	(number)	6 951	7 165	6 265	5 165	4 465
		(index)	*111*	*114*	*100*	*82*	*71*
Japan	FI + AQ	(number)	393 600	324 440	304 686	262 196	212 470
		(index)	*129*	*106*	*100*	*86*	*70*
Norway	FI + AQ	(number)	24 979	21 776	18 589	18 848	18 336
		(index)	*134*	*117*	*100*	*101*	*99*
	FI	(number)	20 475	17 160	14 262	14 626	13 932
		(index)	*144*	*120*	*100*	*103*	*98*
	AQ	(number)	4 504	4 616	4 327	4 222	4 404
		(index)	*104*	*107*	*100*	*98*	*102*
Peru	FI + AQ	(number)	56 550	62 930	66 361	70 036	72 260
		(index)	*85*	*95*	*100*	*106*	*109*
	FI	(number)	...	60 030	63 798	66 395	68 555
		(index)	...	*94*	*100*	*104*	*107*
	AQ	(number)	...	2 900	2 563	3 641	3 705
		(index)	...	*113*	*100*	*142*	*145*

Note: FI = fishing, AQ = aquaculture; index: 2000 = 100; ... = data not available.
[1] Data for 2005 and 2006 are FAO estimates.

some countries do not collect employment data separately for the two sectors, and some other countries' national systems do not yet account for fish farming.

Table 7 compares fish production by continent with the number of people employed in the primary sector. It illustrates the numbers of people involved and the different scales of operations. The highest concentration of people employed is in

Table 7
Fishery production per fisher and per fish farmer in 2006

	Production (capture + aquaculture)[1]	Percentage of production	Number of fishers and fish farmers	Percentage of persons	Production per person
	(Tonnes)	*(%)*	*(No.)*	*(%)*	*(Tonnes/year)*
Africa	7 684 068	5.3	3 637 316	8.4	2.1
Asia	94 300 307	65.6	37 337 594	85.8	2.5
Europe	15 552 606	10.8	725 498	1.7	21.4
North America	6 778 441	4.7	344 071	0.8	19.7
Latin America	17 832 018	12.4	1 401 764	3.2	12.7
Oceania	1 393 129	1.0	55 457	0.1	25.1
Total	**143 647 650**	**100.0**	**43 501 700**	**100.0**	**3.3**

[1] Production excludes aquatic plants. Data for total production also include 107 081 tonnes of "others not elsewhere specified".

Asia, but average production per person there is only 2.5 tonnes per year, whereas it is more than 21 tonnes in Europe and nearly 20 tonnes in North America. The high figure for Oceania in part reflects the incomplete reporting by many countries of this continent. The figures on production per person indicate the degree of industrialization of fishing activities, and also the key role played by small-scale fisheries in Africa and Asia.

While the number of people employed in fisheries and aquaculture has been growing steadily in most low-income and middle-income countries, employment in the sector has fallen or remained stationary in most industrialized economies. In Japan and Norway, the numbers of fishers have more than halved since 1970, down 61 and 42 percent, respectively. In many industrialized countries, the decline has occurred mainly in capture fisheries, while the number of fish farmers has increased. In 2006, the estimated number of fishers in industrialized countries was about 860 000, representing a decline of 24 percent compared with 1990. In recent decades, growing investment in onboard equipment, resulting in higher operational efficiencies and less need for seagoing personnel, has led to a significant decline in the number of people employed at sea. This has led to a rapid decline in recruitment in capture fisheries.

In industrialized countries, younger workers seem reluctant to go to sea on fishing vessels. For many young people, neither the salaries nor the quality of life aboard fishing vessels compares favourably with those of land-based industries. Moreover, widespread concerns about the status of stocks may contribute to the view that capture fisheries have an uncertain future. As a result, fishing firms in industrialized countries have begun to look elsewhere when recruiting personnel. In Europe, fishers from the economies in transition or from developing countries are starting to replace local fishers. In Japan, foreign workers have been allowed to work on Japanese distant-water fishing vessels under the "maru-ship system".[8]

A characteristic feature of employment in the fishing industry is the prevalence of occasional or part-time employment, peaking in the months of the year when riverine, coastal and offshore resources are more abundant or available, but leaving time in seasonal lows for other occupations. This is especially true in fisheries for migratory species and those subject to seasonal weather variations. In fact, in the past three decades, the number of full-time fishers has declined while the number of part-time fishers has grown quite rapidly. This trend has been particularly marked in Asia.

In 2006, in addition to the estimated 43.5 million part-time and full-time fishers, about 4 million occasional fishers and fish farmers were reported to FAO (2.5 million from India).

The fisheries sector, including aquaculture, is an important source of employment and income. However, employment in fishing and fish farming cannot be taken as the only indication of the importance of fisheries to a national economy. In addition to fishers and fish farmers involved in direct primary production of fish, there are people involved in other ancillary activities, such as processing, net and gear making, ice production and supply, boat construction and maintenance, manufacturing of fish-processing equipment, packaging, marketing and distribution. Others are involved in research, development and administration connected with the fishery sector. No official data exist on the estimated numbers of people involved in these other activities. Some estimations indicate that, for each person employed in capture fisheries and aquaculture production, there are about four jobs produced in the secondary activities, including post-harvest, for a total of more than 170 million jobs in the whole fishery industry. However, each jobholder on average provides for three dependants or family members. Thus, fishers, aquaculturists and those supplying services and goods to them assure the livelihoods of a total of about 520 million people, 7.9 percent of the world population.

Women play an important role both as workers in the fisheries sector and in ensuring household food security. Generally, they possess an in-depth understanding and knowledge of the natural environment and its resources. Millions of women around the world, especially in developing countries, work in the fisheries sector. Women participate as entrepreneurs and by providing labour before, during and after the catch in both artisanal and commercial fisheries. Their labour often consists of making and mending nets, baskets and pots, and baiting hooks. In fishing, women are rarely engaged in commercial offshore and deep-sea waters, but more commonly involved in fishing from small boats and canoes in coastal or inland waters – harvesting bivalves, molluscs and pearls, collecting seaweed and setting nets or traps. Women also play an important role in aquaculture, where they attend to fish ponds, feed and harvest fish, and collect prawn larvae and fish fingerlings. However, their most important role in both artisanal and industrial fisheries is at the processing and marketing stages. In some countries, women have become important entrepreneurs in fish processing; in fact, most fish processing is performed by women, either in their own cottage-level industries or as wage labourers in the large-scale processing industry. However, as much of this work remains invisible in available statistics, it goes unrecognized, and it is not possible to obtain a comprehensive picture of the role of women in the fisheries sector. This prevents them from obtaining due recognition in public efforts to develop the sector.

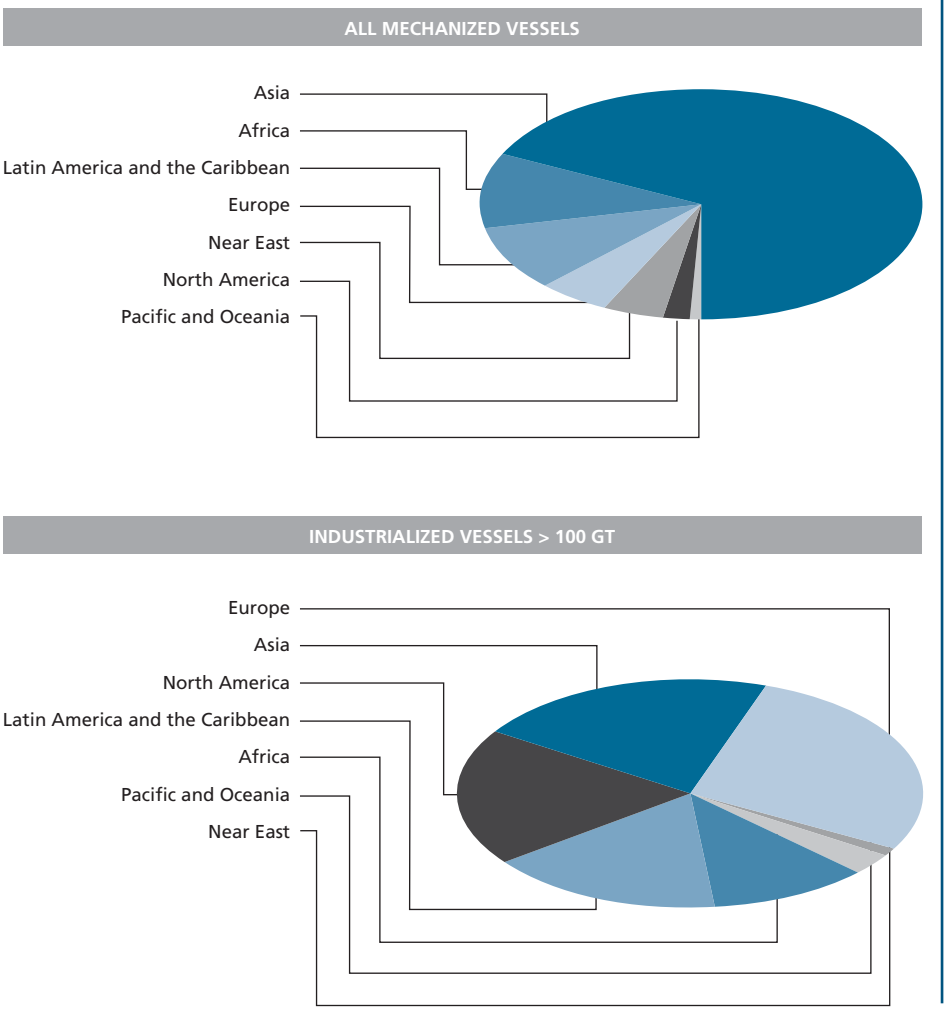
THE STATUS OF THE FISHING FLEET

In 2007, FAO obtained data on national fishing fleets from 97 countries (slightly fewer than half of those catching fish) either through direct reporting or through disseminated statistics. The quality of the data varies widely from quite fragmented records to consistent and continuous statistics over several years. Some data reported to FAO are based on national registers and/or other administrative records. However, these registers often do not cover small boats, especially those used in inland waters. Such craft are often not subject to compulsory registration. Even if they are, where the registers concerned are managed by provincial or municipal authorities, they are easily overlooked in reporting at the national level. In addition, registers and administrative records often include non-operational units. Taking these factors into consideration, the currently available information has only limited value for monitoring and detecting global trends in fishing capacity, and the figures reported in this section should only be considered indicative where they represent global trends.

Quite a large number of non-motorized boats are engaged in fishing operations, usually inshore or on inland waters. For the reasons already described, information about this category of vessel is generally lacking. In the past two years, very little information has been received about the non-motorized fleets. Therefore, there has

Figure 16

Distribution of fishing vessels by region in 2006

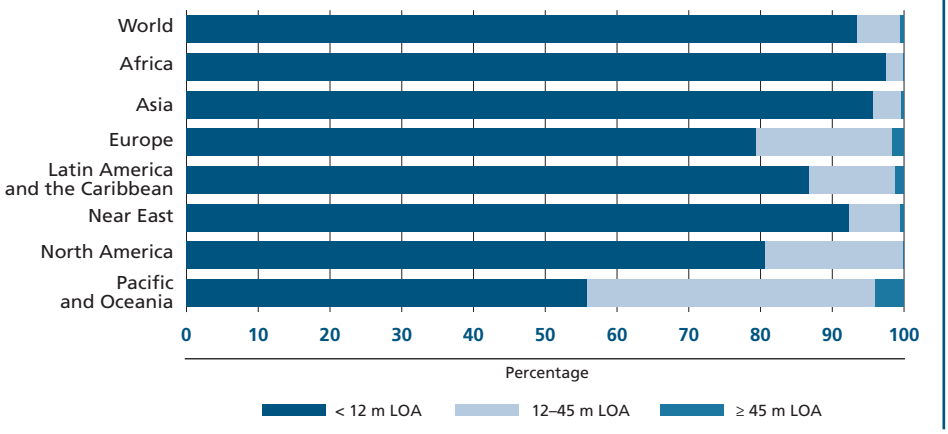


been no attempt to update the estimate made when preparing *The State of World Fisheries and Aquaculture 2006*.

The number of engine-powered fishing vessels is estimated to have been about 2.1 million in 2006, with almost 70 percent of them in Asia (Figure 16). Of the remaining vessels, most were reported to be fishing in Africa, followed by Europe, the Near East, and Latin America and the Caribbean. As almost 90 percent of the motorized fishing vessels in the world are less than 12 m in length, such vessels dominate everywhere, particularly in Africa, Asia and the Near East. The fishing fleets in the Pacific region and in Oceania, Europe and North America tend to consist of vessels that are, on average, slightly larger. This characteristic is confirmed by the distribution of industrialized fleets (vessels of more than 100 GT, roughly more than 24 m in length, extracted from the Lloyd's Fairplay database), which shows them as being rather evenly distributed among Asia, Europe, Latin America and the Caribbean, and North America (Figure 17). Correspondingly, there is a higher proportion of vessels of more than 100 GT in the Europe, Latin America and the Caribbean, and North America regions than in the Africa and Asia regions. This situation is reflected in the estimated average annual catches per vessel, which are lower in the Asia and Africa regions than elsewhere.

Figure 17

Size distribution of mechanized fishing vessels



Note: LOA = length overall.

Lloyd's database indicated that about 23 000 industrialized fishing vessels (for a total of 9.9 million GT) and 740 fish carriers (for a total of slightly less than 1.0 million GT) were operational at the end of 2007. The number of industrialized fishing vessels under the flag of the United States of America, about 3 300, was larger than that reported by any other nation. However, vessels under the flag of the Russian Federation accounted for the largest fleet in terms of gross tonnage, at 1.5 million tonnes (16 percent of the world total). The differences between these two fleets probably reflect the historical development of fishing capacity in the two countries. In the 1980s, the Soviet Union, of which the Russian Federation was then a part, had a centrally planned economy. On a production line basis, it built a fleet of large fishing vessels and fishery support vessels with the ability to operate in distant waters. The United States of America developed a fleet owned and built by individual entrepreneurs to their own specifications with an emphasis on the capacity to harvest local coastal stocks. Despite the changes brought about by the United Nations Convention on the Law of the Sea with regard to fisheries jurisdictions in the early 1980s, a similar pattern of vessel construction continued for a decade into the early 1990s. Some East European countries, e.g. Romania and Ukraine, also employ large vessels. The largest average size – 2 400 GT – was reported for the Belize-flagged fleet. Up to 8.5 percent of the vessels (8.9 percent in terms of total gross tonnage) in the database were recorded as having an "unknown" flag. This is a fleet larger than all national fleets with the exception of that of the United States of America. This "unknown" category has expanded quickly in recent years in spite of global efforts to eliminate IUU fishing activities. The database shows what a vessel's flag was before it became "unknown". In order of frequency, flags included in this category are those of Belize, the Russian Federation, Japan, Panama and Honduras. Correspondingly, Belize, the Russian Federation and Japan have reported a substantial reduction in their industrial fishing fleets since 2001. The vessels in the "unknown" category show a relatively high average age (31.4 years), so some of those vessels that have left the national registers – and are now classified as of "unknown" flag – might no longer be in operational condition.

The Russian Federation and China account for the largest share (35 percent) of fish carriers with 140 and 120 vessels, respectively. However, in tonnage terms, Panama, the Russian Federation and Belize dominate. Vessels flying one of these three flags account for more than 60 percent of the world's gross tonnage of fish carriers. Carriers under the flags of Belize, Cyprus or Panama are large; the average fish carrier in these fleets is 7 000–11 000 GT.

Figure 18

Relative changes in numbers and GT of industrialized fishing vessels and fish carriers > 100 GT

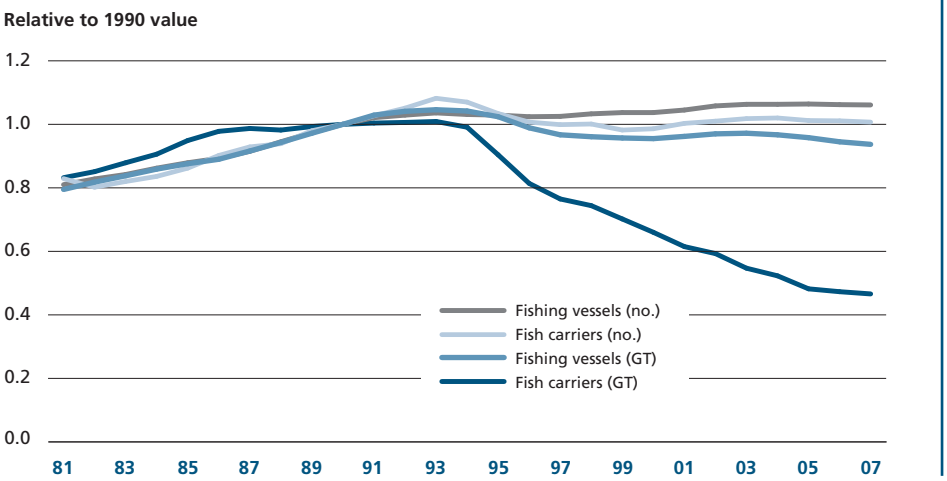


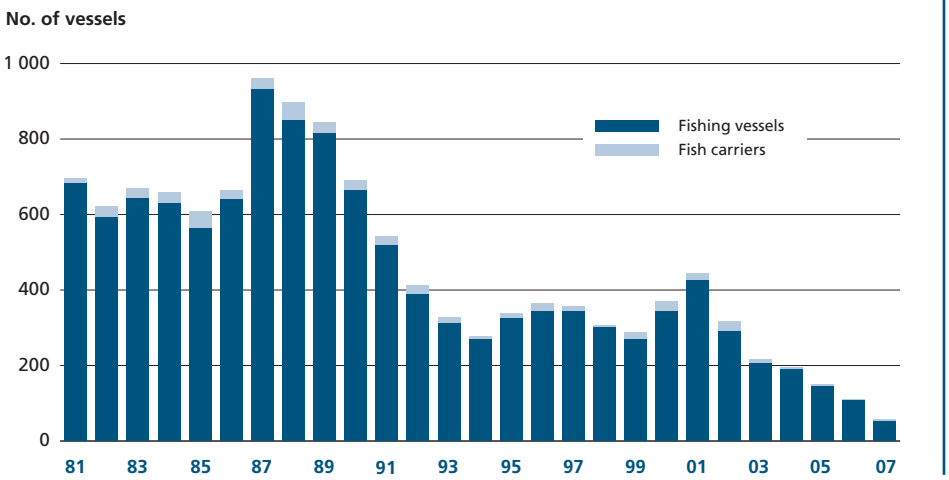
Figure 18 shows changes in the numbers and GT of industrialized fishing vessels and fish carriers of more than 100 GT relative to the 1990 levels extracted from the Lloyd's database. The numbers of both fishing vessels and fish carriers have stayed around the same level in the last ten years. While the size of the fishing fleet has declined slightly in terms of GT, the fleet of fish carriers in 2006 had fallen to less than half that of 1990. This implies that recently built fish carriers have been much smaller than their predecessors. In addition, scrapped vessels have on the whole been much larger (fishing vessels at 1 100 GT and fish carriers at 5 000 GT) than those built to replace them. These new vessels have averaged about 540 GT for fishing vessels and 590 GT for fish carriers. The average size of newly built vessels has remained relatively stable with some fluctuations in the last ten years. There have been suggestions that the recent rapid rise in fuel prices will increase the use of fish carriers in an attempt to cut overall fuel costs by reducing the time fishing vessels spend travelling to and from the fishing grounds. However, the recent change in the fleet size of fish carriers does not seem to support this view. The number of new fishing vessels being built declined substantially in the late 1980s, when it fell to about half of the previous level. It stayed at about this level until 2001 but has since declined substantially (Figure 19). Currently, the average age of operational fishing vessels is 27.4 years, and that for fish carriers is 22.9 years.

The issues of overcapacity in fishing fleets and their reduction to the levels that should be in balance with long-term sustainable exploitation of resources have received global attention in the past two decades. Many countries have adopted policies to limit the growth of national fishing capacity in order to protect aquatic resources and make fishing economically viable for the harvesting enterprises.

The State of World Fisheries and Aquaculture 2006 reported on attempts by China and the European Union (EU) to limit and control the capacity of their fishing fleets. The "Entry-Exit" scheme, briefly described in that edition, remains in force for EU members. The European Economic Area (EEA) reported declining fleets for EU members in the three years following its introduction in 2003. However, for EEA 18,[9] the rates of decline in number of vessels – about 3.2 percent annually – seem unaffected by the "Entry-Exit" scheme. However, a decline in GT terms has occurred. The annual rate of decline increased from 0.8 percent in the period 1998–2003 to about 2.1 percent thereafter. The enlargement of the EU by ten countries[10] in 2004 made a larger number of fishing vessels subject to the "Entry-Exit" scheme. The fishing fleets of these new members have shown a faster fall in fishing capacity than those of the original

Figure 19

Changes in number of newly built vessels



15 members.[11] The combined fleet shrank by 3.1 percent annually in terms of numbers of vessels and by 3.5 percent annually in GT terms in the period 2004–06.

China's five-year programme to de-license and scrap 30 000 fishing vessels ended at the beginning of 2008. It is unclear how many vessels were scrapped under the programme. Whatever its achievements, it appears that the fleet of commercial vessels in China continues to expand. Official data record an annual increase in vessel numbers of about 3.5 percent for the period 2002–06.

THE STATUS OF FISHERY RESOURCES

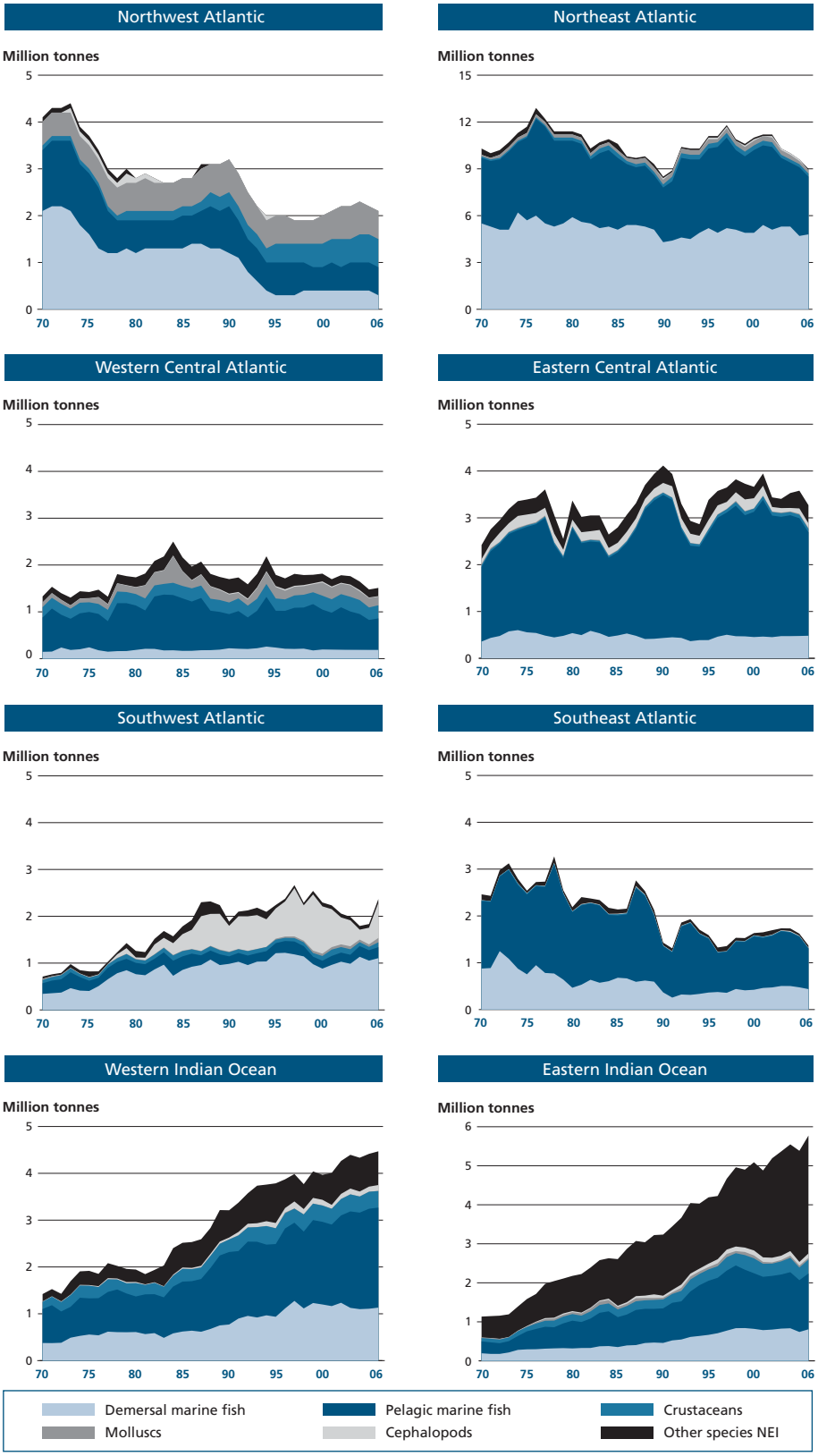
Marine fisheries

The global state of exploitation of the world marine fishery resources has tended to vary, with some trends in the observed exploitation categories (Figure 20). While the proportion of underexploited or moderately exploited stocks declined linearly from 40 percent in the mid-1970s to 20 percent in 2007, the proportion of fully exploited stocks remained steady at about 50 percent. The proportion of overexploited, depleted or recovering stocks appears to have stabilized at between 25 and 30 percent since the mid-1990s (Figure 21). The overall examination of the state of stocks and groups of stocks for which information is available confirms that the proportions of overexploited, depleted and recovering stocks have remained relatively stable in the last 10–15 years, after the noticeable increasing trends observed in the 1970s and 1980s. It is estimated that, in 2007, about one-fifth of the stock groups monitored by FAO were underexploited (2 percent) or moderately exploited (18 percent) and could perhaps produce more. Slightly more than half of the stocks (52 percent) were fully exploited and, therefore, producing catches at or close to their maximum sustainable limits, with no room for further expansion. The other 28 percent were either overexploited (19 percent), depleted (8 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum potential owing to excess fishing pressure in the past, with no possibilities in the short or medium term of further expansion and with an increased risk of further declines and a need for rebuilding.

Most of the stocks of the top ten species, which account in total for about 30 percent of the world marine capture fisheries production in terms of quantity (Figure 6 on page 12), are fully exploited or overexploited and, therefore, cannot be expected to produce major increases in catches. This is the case for: anchoveta (*Engraulis ringens*), with two main stocks in the Southeast Pacific that are fully exploited and overexploited; Alaska pollock (*Theragra chalcogramma*), which is fully exploited in the North Pacific; blue whiting (*Micromesistius poutassou*), which is fully exploited in the Northeast

Figure 20

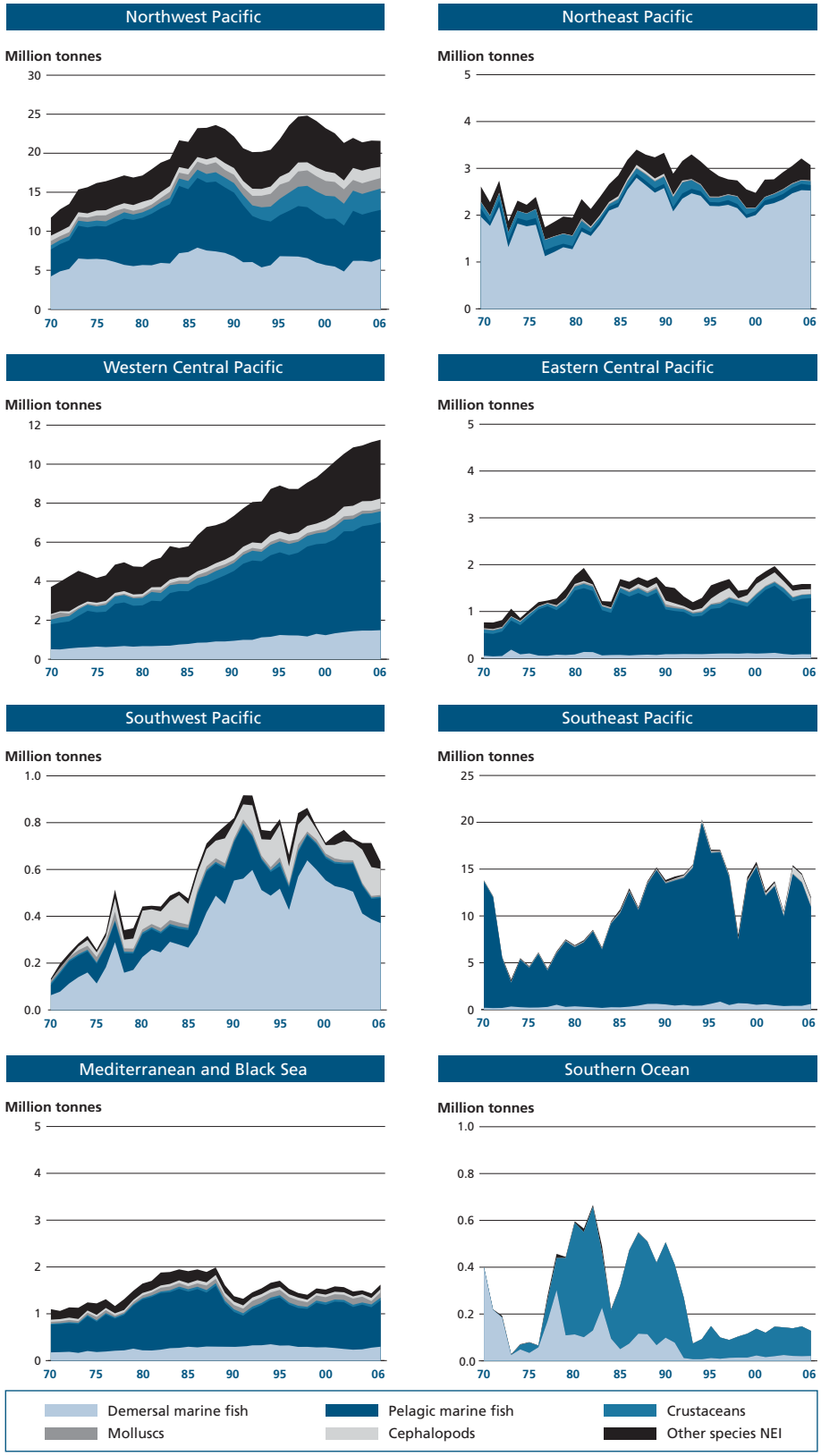
Capture fisheries production in marine areas



(Continued)

Figure 20 *(cont.)*

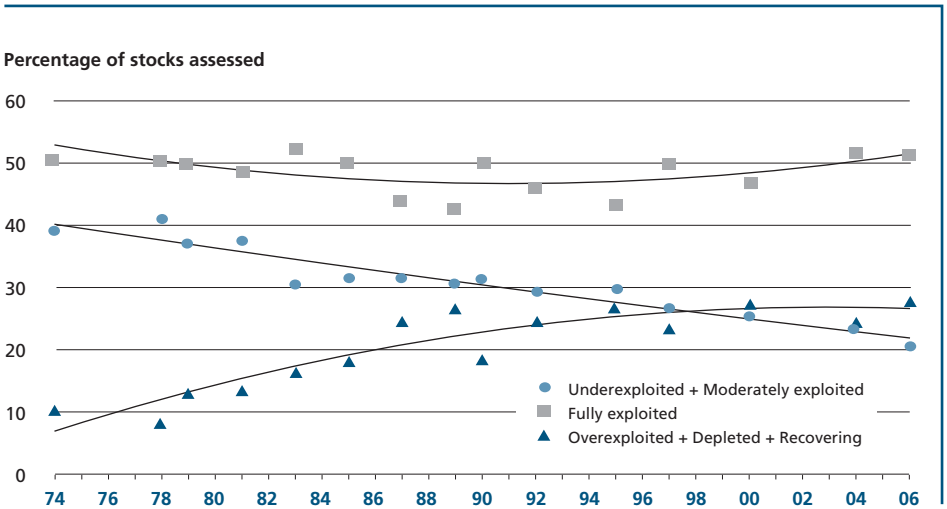
Capture fisheries production in marine areas



Note: NEI = not elsewhere included.

Figure 21

Global trends in the state of world marine stocks since 1974



Atlantic; Atlantic herring (*Clupea harengus*), with several stocks that are fully exploited, some that are depleted and some that are underexploited because of market conditions; Japanese anchovy (*Engraulis japonicus*), which is fully exploited in the Northeast Pacific; Chilean jack mackerel (*Trachurus murphyi*), which is fully exploited and overexploited in the Southeast Pacific; and yellowfin tuna (*Thunnus albacares*), which is fully exploited in the Atlantic and Pacific Oceans and probably moderately to fully exploited in the Indian Ocean. Some stocks of skipjack tuna (*Katsuwonus pelamis*) are fully exploited while some are still reported as moderately exploited, particularly in the Pacific and Indian Oceans, where they could offer some limited possibilities for further expansion of fisheries production. However, this may not be desirable as it is nearly impossible to increase skipjack catches without negatively affecting bigeye and yellowfin tunas. Some limited possibilities for expansion are also offered by a few stocks of chub mackerel (*Scomber japonicus*), which are moderately exploited in the Eastern Pacific, while other stocks are already fully exploited. The largehead hairtail (*Trichiurus lepturus*) is considered overexploited in the main fishing area in the Northwest Pacific, but its state of exploitation is unknown elsewhere.

The percentage of stocks fully exploited, overexploited or depleted varies greatly by area. The major fishing areas with the highest proportions (71–80 percent) of fully exploited stocks are the Northeast Atlantic, Western Indian Ocean and Northwest Pacific. The proportion of overexploited, depleted and recovering stocks varies between 20 and 52 percent in all areas except in the Northwest Pacific, Western Central Pacific and Eastern Central Pacific, where it is 10 percent or less. Relatively high proportions (20 percent or more) of underexploited or moderately exploited stocks can be found in the Eastern Indian Ocean, Western Central Pacific, Eastern Central Pacific, Southwest Pacific and Southern Ocean, and for some species of tunas.

Four FAO major fishing areas account for more than 10 percent each and collectively produced about 66 percent of the world marine catches in 2006. The Northwest Pacific is the most productive, with a total catch of 21.6 million tonnes (26 percent of total marine catches), followed by the Southeast Pacific, with a total catch of 12.0 million tonnes (15 percent), the Western Central Pacific with 11.2 million tonnes (14 percent) and the Northeast Atlantic, with 9.1 million tonnes (11 percent).

In the Northwest Pacific, small pelagics are the most abundant category, with the Japanese anchovy providing large catches, although there were signs of decline in 2005 and 2006 as compared with catches of more than 2 million tonnes in 2003. Other important contributors to the total catch are the largehead hairtail, considered overexploited, and the Alaska pollock and chub mackerel, both considered

fully exploited. Squids, cuttlefish and octopuses are important species yielding 1.4 million tonnes.

In the Southeast Pacific, total catches have oscillated around 12 million tonnes in the last five years. There has been no major change in the status of stocks since 2004. The stock of anchoveta has recovered from the severe El Niño event of 1997–98 and is considered fully exploited in most of the area. Two other important pelagic stocks, the Chilean jack mackerel and in particular the South American pilchard, remain in a decadal cycle of natural low abundance, producing a fraction of the record catches observed between the mid-1980s and mid-1990s. The stocks of South Pacific hake remain under heavy fishing pressure with no sign of recovery.

The Western Central Pacific is the most productive fishing area of the tropical regions, with total catches up about 3 percent on 2004. Tunas and tuna-like species make up about 24 percent of the total for this fishing area, with most species assessed as either fully exploited or moderately to fully exploited. The status of other species groups is highly uncertain. This region is highly diverse, its fisheries are mostly multispecies, and detailed data for reliable assessments are usually not available for most stocks. Analysis of survey information for some countries in the region (Malaysia, the Philippines, Thailand and Viet Nam) have shown considerable degradation and overfishing of coastal stocks, most dramatically in the Gulf of Thailand and along the east coast of Malaysia.

In the Northeast Atlantic, catches of blue whiting have stabilized at about 2 million tonnes per year since 2003, and the stock is considered fully exploited. Fishing mortality has been reduced in cod, sole and plaice. Cod remains depleted in the North Sea and in the Faeroes, but other stocks are healthier and considered fully exploited. Several stocks of haddock have shown spectacular increases in biomass since 2000, fisheries have grown and most stocks are now considered fully exploited. Saithe stocks have also increased since 2000. Some sand eel and capelin stocks have become depleted, while fishing for shrimp seems to have ceased in some areas.

A record high has been reached in total landings in the Eastern Indian Ocean, with a total of 5.8 million tonnes, a 5-percent increase compared with 2004. The category "marine fishes non-identified", representing 50 percent of the total catches in the area, accounts for most of this increase. "Miscellaneous pelagic fishes" (including Indian mackerels and various carangids) made up 11 percent of the catches and "miscellaneous coastal fishes" (croakers, ponyfishes, sea catfishes, etc.) 10 percent. Tuna catches in 2006 were slightly below the six-year (2000–05) average of 450 000 tonnes. While catches of most groups show either a rising trend or are fluctuating slightly with no clear trend, there are indications that parts of this fishing area could be overfished, with the situation being aggravated by increasing stress from pollution, sedimentation, modified river runoffs and intensive coastal aquaculture.

There have been several changes in the status of the stocks in the Southeast Atlantic since the last full assessment made in 2004. The important hake resources remain fully exploited to overexploited although there are signs of some recovery in the deepwater hake stock (*Merluccius paradoxus*) off South Africa. The status of the coastal fishes remains fully exploited or depleted. A significant change concerns the Southern African pilchard, which was at a very high biomass and estimated to be fully exploited in 2004, but which now, under unfavourable environmental conditions, has declined considerably in abundance and is overexploited throughout the region. In contrast, the status of Southern African anchovy has improved from fully exploited to fully to moderately exploited, and Whitehead's round herring is underexploited to moderately exploited. The condition of Cape horse mackerel has deteriorated, particularly off Namibia, where it is currently overexploited. The condition of the Perlemoen abalone stock has deteriorated, driven heavily by illegal fishing, and it is currently overfished and probably depleted.

Overall, 80 percent of the 523 selected world fish stocks for which assessment information is available are reported as fully exploited or overexploited (or depleted and recovering from depletion). It should be noted that the status of fully exploited is

not undesirable provided it is the result of an effective and precautionary management approach. Nevertheless, the combined percentage reinforces earlier observations that the maximum wild capture fisheries potential from the world's oceans has probably been reached. Therefore, a more cautious and closely controlled approach to development and management of world fisheries is still required (Box 2). As reported in *The State of World Fisheries and Aquaculture 2006*, the situation seems more critical for some highly migratory, straddling and other fishery resources that are exploited solely or partially in the high seas. An example highlighted in that earlier edition included the state of highly migratory oceanic sharks, with more than half of the stocks for which information is available being listed as overexploited or depleted. In the case of straddling stocks and of other high seas fishery resources, nearly two-thirds of the stocks for which the state of exploitation can be determined were classified as overexploited or depleted. These high seas fishery resources constitute only a small fraction of the world fishery resources, but they can be considered key indicators of the state of a major part of the ocean ecosystem. The United Nations Fish Stocks Agreement entered into force in 2001. It is providing a legal basis for management measures that are now being introduced and that are expected to benefit species fished on the high seas in the medium to long term. However, further rapid progress in implementation is necessary if the ocean ecosystem is to be safeguarded.

Inland fisheries

By landing more than 10 million tonnes in 2006, inland fisheries contributed 11 percent of global capture fisheries production. Although the amount may be small in comparison with marine fisheries, fish and other aquatic animals from inland waters remain essential and irreplaceable elements in the diets of both rural and urban people in much of the world, especially in developing countries. However, for demographic and cultural reasons, there are significant differences in the level of exploitation among the major geographical regions. Although global landings from inland fisheries have grown continuously, there are few examples of collapsing fisheries and a number of fish stocks, especially in Latin America, remain lightly exploited. Therefore, adopting a precautionary approach, the fisheries could be developed further.

Although statistics are improving in some countries, collecting accurate information on inland fisheries can be extremely costly. Moreover, many public administrations still do not collect such information or make assessments of the status of inland fishery resources. The very nature of inland fisheries makes assessment of their status extremely difficult. In addition, inland fisheries practised for sustenance or gain often take place in remote areas and are carried out by the poorer sectors of society. Catches are frequently not recorded by species or not recorded at all. Catch statistics are generally inadequate for use as a measure of stock status. Therefore, providing accurate statements on the status of inland fishery resources on a global or even regional level remains a challenge. Noting this and in order to enhance knowledge and awareness of the sector, FAO invited case studies of a number of inland fisheries in various parts of the world.[12] These studies were also meant to highlight some of the most crucial issues in ensuring the sustainability of such fisheries.

The five case studies presented below all confirm that inland fisheries are highly complex, and that, where ecosystem processes remain largely undisturbed, stock dynamics are basically controlled by environmental processes and factors external to the fisheries, such as natural fluctuations in climate or flood patterns. Often, the yields track intra-annual and interannual variations in nutrient inputs (whether natural or resulting from pollution), although response times depend on the life cycle of the fish. Therefore, the perception that fishing pressure is the only or main driver is mistaken; and fish stock assessments based on steady-state assumptions can be highly misleading, both in the interpretation of trends and in the use of fishery assessment models.

However, anthropogenic ecosystem impacts in the form of species introductions, pollution, habitat fragmentation and changes in the flood cycle reduce the resilience of fish stocks to fishing pressure, and the fisheries should be managed with this in mind.

Box 2

Reconciling conservation with fisheries

Is there a future for capture fisheries if we are to conserve aquatic ecosystems? Conversely, is there a future for capture fisheries if we do *not* conserve ecosystems? Can the social and economic goals of fishing be reconciled with the goal of conserving aquatic ecosystems? While in some arenas, fisheries and conservation may be seen as incompatible activities, it is widely recognized that both are fundamental elements of sustainable development. Capture fisheries are responsible for a significant share of the food supply for human consumption. They provide jobs and income for millions of people worldwide and have an important role in the economies of many countries (see Part 1 of this publication). Ensuring that the species and ecosystems that support these fisheries are maintained in healthy and productive states – in other words, that they are conserved – is essential if such benefits are to be sustained into the future.

Despite its social and economic importance, attempts to manage fisheries sustainably have been unsuccessful in many parts of the world due to several factors.[1] These management failures have given rise to widespread concerns, often accompanied by high-profile media reports, about the negative impacts of fisheries on marine ecosystems. In the eyes of many environmentalists and of public opinion in general, the overfishing of stocks, habitat modification resulting from destructive fishing practices, the incidental capture of endangered species and other impacts have made fisheries a primary culprit in an ecological crisis of global dimensions. While some of the claims have been exaggerated and some misleading, the underlying crisis is real and an urgent response is required at global level. However, in responding, there is a danger that the pendulum will swing too far in the opposite direction and, from an overemphasis on short-term social and economic goals, the long-term goals of conservation will become the only driving forces in the management of human impacts on aquatic ecosystems.

Many solutions to the ecological crisis have been proposed, including among them the banning of certain fishing practices, control of access to fisheries by global implementation of systems of access rights, greater use of positive incentives, regulation of trade in endangered species (e.g. through the Convention on International Trade in Endangered Species of Wild Fauna

That said, there are considerable opportunities to safeguard and enhance existing inland fisheries that provide food security for millions of people and to realize the potential for developing underexploited stocks. It is crucial that inland fisheries be integrated in natural resources management plans that cover all stakeholders who affect the quality or quantity of the water resources throughout the catchment basin concerned. Inland fisheries management needs an ecosystem approach, and this is particularly important in large catchment areas for large lakes and river systems. The values and benefits of inland fisheries would be increased and strengthened if these fisheries were recognized and protected through better governance and political will.

Africa – Lake Victoria

Lake Victoria, shared between Kenya, Uganda and the United Republic of Tanzania, is the second-largest lake in the world, covering an area of 68 000 km^2. In the mid-1980s, the lake's fish community and fishery changed drastically from being dominated by more than 200 endemic haplochromine species to a catch of basically three species:

and Flora, known as CITES) and the establishment of marine protected areas. All of these have roles to play in reconciling fisheries and conservation, but none of them would provide *the* solution if used in isolation. There is now broad agreement at the international policy level that the ecosystem approach to fisheries (EAF) is the appropriate and necessary framework for fisheries management. The EAF, which flows from and is consistent with the FAO Code of Conduct for Responsible Fisheries, is defined as an approach that "strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries". It addresses both human and ecological well-being and merges two paradigms – that of protecting and conserving ecosystems and that of fisheries management, which focuses on providing food, income and livelihoods in a sustainable manner.

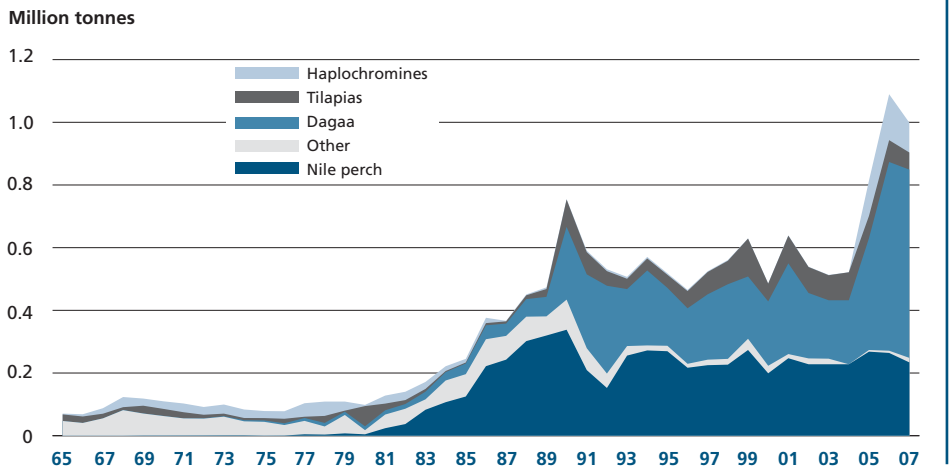
If, as is now widely recognized, the unsustainable use of aquatic ecosystems has its roots in ill-functioning institutions and communities, it is only to be expected that any solution to conservation will have to be: (i) socially acceptable and just; (ii) effective from both biodiversity and livelihood perspectives; and (iii) based on strengthened institutions at local and international levels. Therefore, the expanded objectives of the EAF will almost invariably require a diverse and comprehensive set of management tools in order to achieve the reconciled set of often conflicting goals. A common understanding of the concept is developing, and good progress has been made in incorporating the principles of EAF in policies at international and national levels. However, there is still much to do to make these principles operational in the practical management of fisheries.

[1] FAO. 2002. *Report and documentation of the international workshop on factors contributing to unsustainability and overexploitation in fisheries. Bangkok, Thailand, 4–8 February 2002*, edited by D. Greboval. FAO Fisheries Report No. 672. Rome.

the introduced Nile perch (*Lates niloticus*) and dagaa/omena (*Rastrineobola argentea*) in the open waters; and the introduced Nile tilapia (*Oreochromis niloticus*) along the shores (Figure 22). The endemic cichlids (haplochromines), that vanished almost completely as the fish community changed, have been reappearing in catches since 2000 and are probably recovering slowly. The inshore demersal species, originally mainly endemic tilapias (*Oreochromis esculentus, O. leucosticus* and *O. variabilis*), Nile catfish (*Bagrus docmac*), lungfish (*Protopterus aethiopicus*), the elephant-snout fish (*Mormyrus kanume*), and the ningu (*Labeo victorianus*), are all depleted, except the lungfish. Today, the Nile tilapia dominates, its abundance is increasing in surveys and it is considered moderately exploited. Dagaa stocks and catches have been increasing steadily. Since 2005, it has been the most important fishery in the lake by weight, but there are no signs of overexploitation. The economically most important Nile perch fishery supports an export industry worth some US$250 million per year. The status of this stock is controversial, but while many believe it is overfished, there are no objective data to support this claim.

Figure 22

Total annual catches in Lake Victoria 1965–2007 grouped into five main groups



Sources: J. Kolding, P. van Zwieten, O. Mkumbo, G. Silsbe and R. Hecky. 2008. Are the Lake Victoria fisheries threatened by exploitation or eutrophication? Towards an ecosystem based approach to management. *In* G. Bianchi and H.R. Skjoldal, eds. *The ecosystem approach to fisheries.* (in press). CABI Publishing; and Lake Victoria Fisheries Organization (unpublished data).

A recent analysis[13] has shown that the dynamics of fish production in Lake Victoria are, to a large extent, environmentally driven. Changes in land-use practices have led to an increased input of nutrients, resulting in a doubling in primary production since 1969, and providing the basis for the observed increase in fish production. However, eutrophication has also led to increases in fish kills and loss of habitat owing to deoxygenation. This poses a serious threat to the entire ecosystem.

Central Asia – Kyrgyzstan

The disintegration of the Soviet Union had a profound impact on the fisheries sector throughout Central Asia. Kyrgyzstan was one of the countries most severely affected. In 2004–06, its capture fisheries yield had dropped to only 3 percent of the level recorded in the early 1990s (Figure 23). All exploited fish stocks are in serious decline. In 2005, the naked osman (*Gymnodiptychus dybowskii*) and Issyk Kul marinka (*Schizothorax pseudoaksaiensis issykkuli*), two species that constituted an important part of the catch in the past, were recommended for inclusion in the Red Book of Kyrgyzstan.

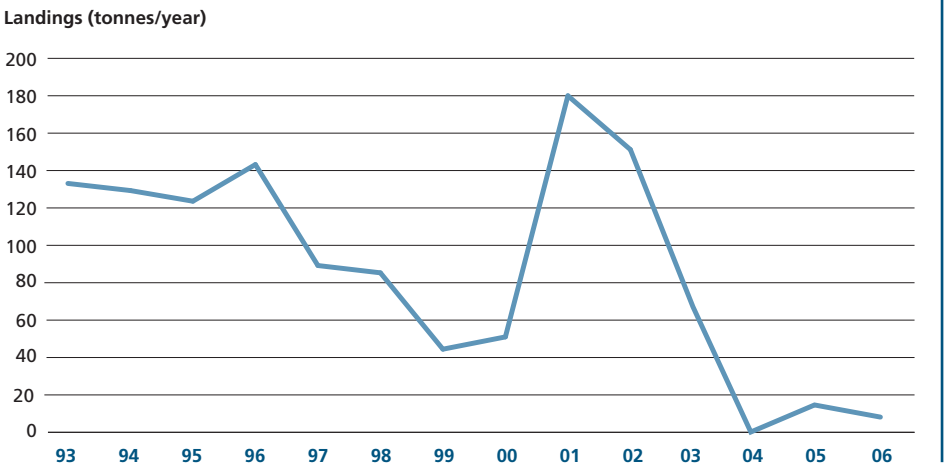
Most lakes in the country are oligotrophic with low fisheries yields. Therefore, since the 1930s, in an attempt to boost productivity, most lakes in the country have been intensively stocked with mainly exotic species, including also several predators. This has placed indigenous species under stress. In addition, illegal fishing is a serious problem – illegal catches are estimated to be several times higher than official catches. Fishing concessions have now been leased out to private entities, but short-term lease contracts have discouraged sustainable management of the resources. The authorities are addressing the issue, and the collapse of the fishery has led to a moratorium on fishing in the country's two largest lakes. However, recovery in the fish stocks is a long-term process and will depend on the implementation of new management measures.

Europe – Lake Constance

Lake Constance, shared by Austria, Germany and Switzerland, serves as a reservoir of potable water for more than 4 million people but also has an active fishery. Catch statistics have been collected on commercial fisheries since 1910, and yield statistics on angling since 1996. In 2006, about 140 commercial fishers caught 617 tonnes, of which

Figure 23

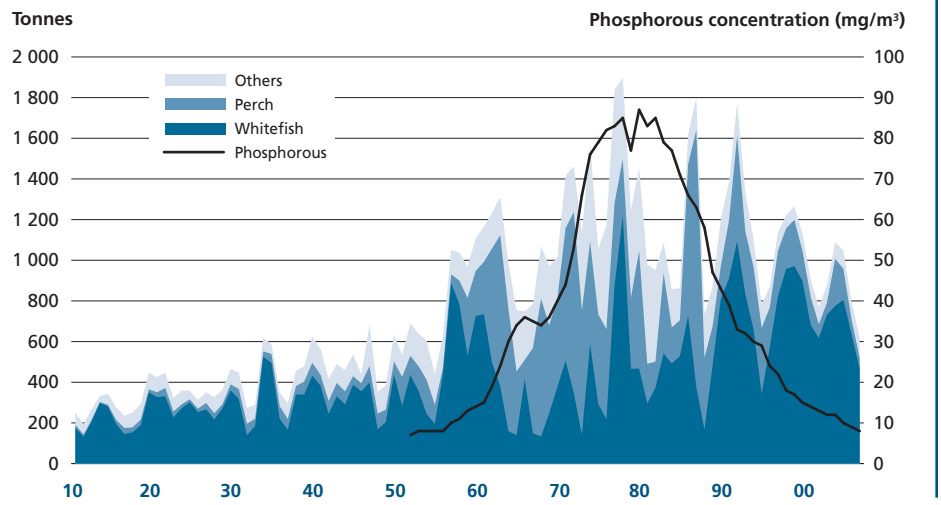
Landings from lakes in Kyrgyzstan 1993–2006



Source: FAO. 2008. *Capture fisheries and aquaculture in the Kyrgyz Republic: current status and planning,* by M. Sarieva, M. Alpiev, R. Van Anrooy, J. Jørgensen, A. Thorpe and A. Mena Millar. FAO Fisheries Circular No. 1030. Rome.

Figure 24

Landings from Lake Constance 1910–2006



Note: The line refers to phosphorous concentration in the water column.

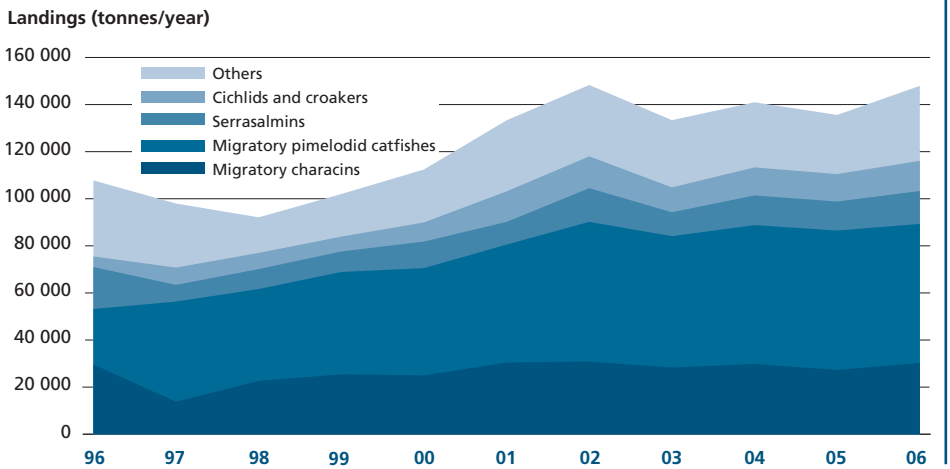
about 80 percent was whitefish (*Coregonus lavaretus*). Some 5 000 anglers caught 68 tonnes, mainly perch (*Perca fluviatilis*).

Until the 1960s, the oligotrophic lake supported a whitefish-dominated fishery. However, increasing eutrophication led to higher fish production but also changed catch composition. There was a drastic decline in whitefish yields, down to 20–30 percent of the total catch, while perch yields increased to about 50 percent at the time when the lake was most eutrophied (Figure 24).

In the last 30 years, intensive measures to reduce eutrophication have re-instated the lake's former oligotrophic state, reducing the total catch to the level before eutrophication while restoring the whitefish fishery, which again contributes about 80 percent of the annual yield.

Figure 25

Landings from commercial fisheries in the Brazilian Amazon 1996–2006



At present, whitefish and perch populations are fully exploited. Nearly all the individuals that can be caught by the gillnets allowed are taken. All other target species are only moderately exploited. Fishery management will need to adjust to lower yields, and the number of professional fishers may have to decrease further to ensure catches that will provide fishers with sufficient income.

Latin America – Amazon

The Amazon Basin covers 6.8 million km^2 and is shared by Bolivia, Brazil, Colombia Ecuador, Guyana, Peru and Venezuela (Bolivarian Republic of). The commercial capture fisheries in the Brazilian part of the basin are the most significant, contributing up to 17 percent[14] of total annual aquatic animal production in Brazil between 1996 and 2006. In that decade, the yield from these fisheries increased by 37 percent (Figure 25).

Most fish stocks (60 percent) are considered to be underexploited, while 30 percent are overexploited or recovering, including several large, slow-growing species such as tambaqui (*Colossoma macropomum*) and surubim (*Pseudoplatystoma* spp.) (Figure 26). Several medium-sized species including jaraqui (*Semaprochilodus* spp.) and curimatã (*Prochilodus nigricans*) are also showing signs of overfishing. The data on exploitation levels need to be interpreted with caution because environmental factors such as flood intensity overshadow the impact of the fishery, particularly for species with opportunistic life strategies and short life spans. High fishing pressure in combination with weak recruitment caused by unfavourable environmental conditions may lead to collapse. On the positive side, stocks of pirarucu (*Arapaima gigas*) and the large migratory catfish piramutaba (*Brachyplatystoma vailantii*) are now recovering. In the case of pirarucu, which became commercially extinct in the 1970s and completely disappeared in some areas, recovery can be related to the introduction of new community-based management practices.

Southeast Asia – Tonle Sap

The Mekong River Basin, shared by Cambodia, China, the Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam, sustains the largest inland fisheries in the world, with an estimated annual catch of 2.6 million tonnes.[15] Contrary to popular belief, available data indicate that catches in the basin are larger than ever before. However, as the number of fishers is growing faster than the yield, the catch per fisher is declining.

The dai[16] fishery in the Tonle Sap River (a Cambodian tributary of the Mekong River) has been monitored since 1995. More than 200 species are known from the river, but this fishery is dominated by a small number of opportunistic cyprinids maturing at a small

Figure 26

Exploitation level of species in the commercial fisheries in the Brazilian Amazon, based on landing data 1996–2006

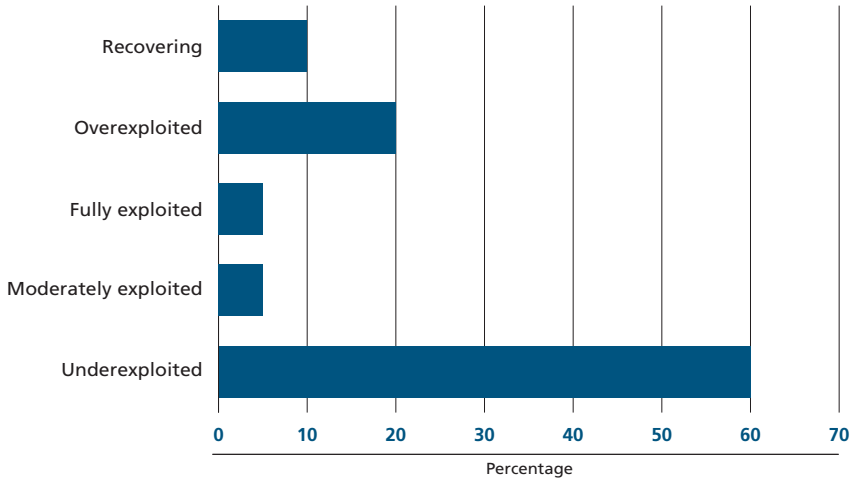
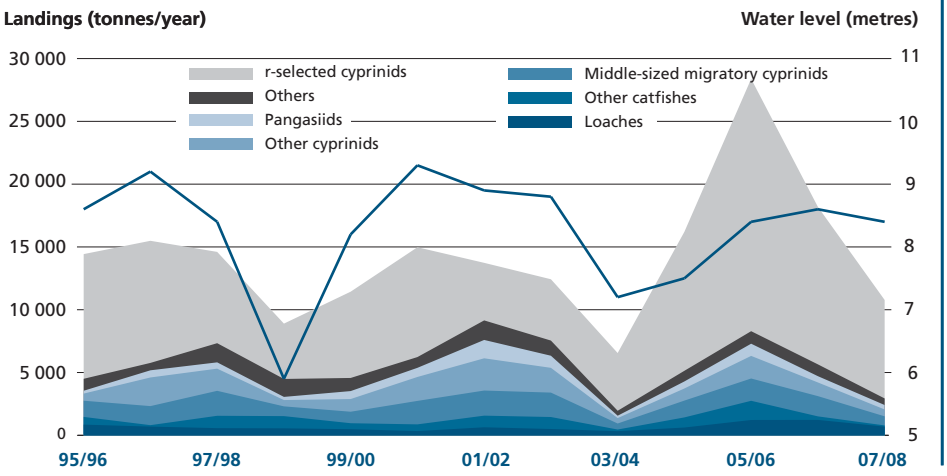


Figure 27

Landings from the dai fisheries of Tonle Sap by species groups 1995/96–2007/08



Note: The line refers to an index of the water level during peak flood.
Source: Data provided by Lieng Sopha and A. Halls, personal communication, 2008.

size (r-selected species), which in most years account for more than half of the catch (Figure 27). As these species are short-lived, they are recruited to the fisheries the year they hatch or the following year. When favourable conditions occur, which in general terms means a larger flood,[17] yield increases immediately. While the response time is longer for longer-living species, the same pattern can be seen for these, although they are also affected by other factors (including fishing mortality). While historical catch data indicate that larger and slower-growing species are less abundant than in the past, nothing in the available dataset points to any species being overexploited. Whether any population decline can be attributed to increased fishing pressure or a deteriorating environment (pollution, water abstraction, dam construction and flood protection) is debatable. However, habitat destruction and fragmentation as a consequence of dam construction are currently larger threats than fishing pressure to fish stocks.

Box 3

Fish utilization

An important feature of the fish-processing industry is that, while the operations are mostly small to medium scale, there is enormous diversity in the species of fish handled. For each type of processing, the fish can be prepared in several ways, from manual methods to fully automated operations, and then packaged in a wide variety of ways depending on the location and market demand. The various levels of progress and scales of operation available in the world increase the differences between species. What may be appropriate in an industrialized fishery is often not suitable for a small-scale artisanal fishery in a developing country. Furthermore, fish preservation and processing may vary according to species. Each of the many thousands of fish species has its own characteristic composition, size, shape and intrinsic chemistry. Fish is very perishable and several chemical and biological changes take place immediately after capture. Fish requires careful handling and preservation, special facilities such as cold storage and refrigerated transport, and rapid delivery to consumers. Therefore, the research and development of post-harvest systems for handling raw material are important to developing appropriate measures to: (i) increase its shelf-life; (ii) reduce physical, organoleptic (sensory) and nutritional losses; and (iii) preserve the quality and safety of the finished products. This is important for ecological, social and economic reasons – to safeguard consumer health and food security and to ensure the sustainability of the industry.

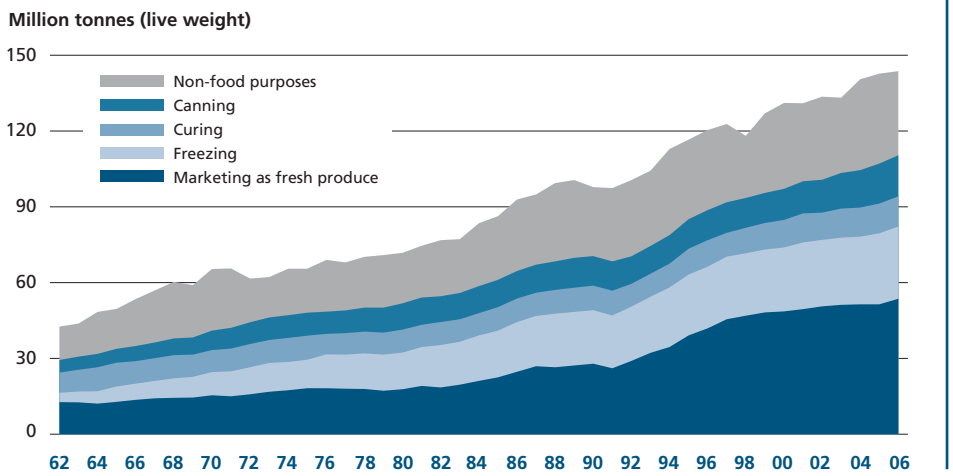
FISH UTILIZATION

In 2006, more than 110 million tonnes (77 percent) of world fish production was used for direct human consumption. Almost all of the remaining 33 million tonnes was destined for non-food products, in particular the manufacture of fishmeal and fish oil (see Table 1 on page 3). If China is excluded, the quantities were 72 million tonnes and 20 million tonnes, respectively (see Table 2 on page 4 and Figure 2 on page 5). In 2006, more than three-quarters of China's reported fish production was destined for human consumption, with the remaining amount (an estimated 13 million tonnes) reduced to fishmeal and allocated to other non-food uses, including direct feed for aquaculture. In China, aquatic products are traditionally most commonly distributed to the domestic market in live and fresh form. However, in recent years, processing has seen significant growth. For example, in 1996, total processed aquatic products for human consumption accounted for 20 percent of total domestic aquatic production, while in 2006 this share reached 33 percent. In the last few years, more value-added products have been made in China, including retail packs. China processes not only domestic production but also imported fish into an array of fish products, including salted, dried, smoked and various preserved fish products for both domestic and export markets. The Chinese reprocessing industry is labour-intensive and traditionally works on low margins, which have recently tended to narrow further with escalating costs for raw materials.

In 2006, 48.5 percent of the fish destined for human consumption was in live and fresh form, which is often the most preferred and highly priced product form. Fifty-four percent (77 million tonnes) of the world's fish production underwent some form of processing. Seventy-four percent (57 million tonnes) of this processed fish was used for manufacturing products for direct human consumption in frozen, cured and prepared or preserved form, and the rest for non-food uses (Box 3). Freezing is the main method

Figure 28

Utilization of world fisheries production (breakdown by quantity), 1962–2006



of processing fish for food use, accounting for 50 percent of total processed fish for human consumption in 2006, followed by prepared and preserved (29 percent) and cured fish (21 percent) (Figure 28).

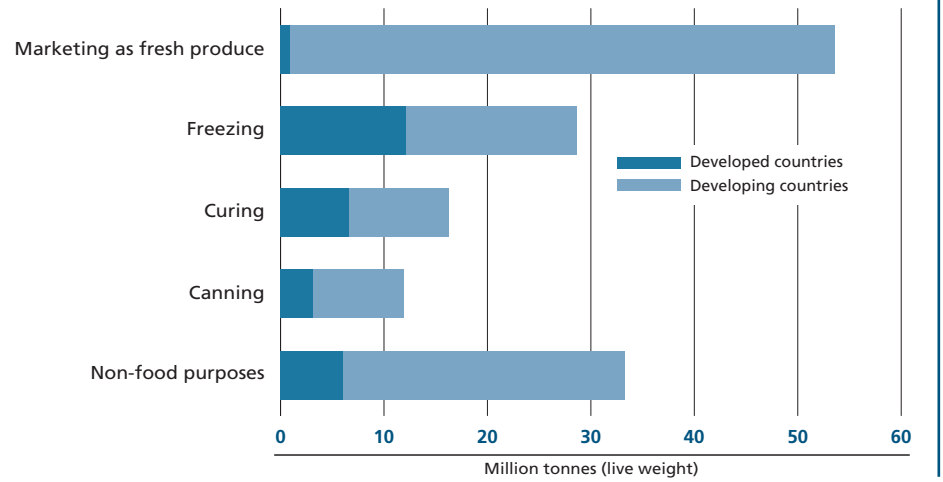
Fish is one of the most versatile food commodities and can be utilized in a great variety of ways and product forms. It is generally distributed as either live, fresh, chilled, frozen, heat-treated, fermented, dried, smoked, salted, pickled, boiled, fried, freeze-dried, minced, powdered or canned, or as a combination of two or more of these forms. However, fish can also be preserved by many other methods. The trade in live fish is special. In some parts of Southeast Asia, and particularly in China, the trade is not formally regulated but based on tradition. However, in markets such as the EU, the trade in live fish has to comply with requirements *inter alia* concerning animal welfare during transportation.

In many developing countries with tropical ambient temperatures, quality deterioration and significant post-harvest losses occur because of inadequate use of ice, long supply chains, poor access to roads and electricity, and inadequate infrastructure and services in physical markets. Market infrastructure and facilities are often limited and congested, increasing the difficulty of marketing perishable goods. Owing to these deficiencies, together with well-established consumer habits, fish production is utilized in such countries mainly in live/fresh form (representing 60.1 percent of fish destined for human consumption in 2006) or processed by smoking or fermentation (10.0 percent in 2006). However, in the last few years, there has been a slight increase in the share of frozen products in developing countries (19 percent in 2006, up 7.3 percent since 1996), with a more significant rise in prepared or preserved forms (11.1 percent in 2006, up 41 percent since 1996). In developed countries, the bulk of fish used for human consumption is in frozen and prepared or preserved forms. Freezing is still prominent as the primary form of production, with a proportion that has been constantly increasing, and it accounted for 42 percent of total production in 2006 (Figure 29). Processors of traditional products, in particular of canned products, have been losing market shares to suppliers of fresh and frozen products as a result of long-term shifts in consumer preferences.

The utilization and processing of fish production have diversified significantly in the last two decades, particularly into high-value fresh and processed products, fuelled by changing consumer tastes and advances in technology, packaging, logistics and transport. These changes include improvements in storage and processing capacity, together with major innovations in refrigeration, ice-making, and food-packaging and fish-processing equipment. Vessels incorporating these improved facilities and able to

Figure 29

Utilization of world fisheries production (breakdown by quantity), 2006



stay at sea for extended periods have been built. This has permitted the distribution of more fish in live or fresh form. Moreover, improved processing technology enables higher yields and results in a more lucrative product from the available raw material.

In developed countries, value-added innovation is mainly focused on increased convenience foods and a wider variety of high value-added products, mainly in fresh, frozen, breaded, smoked or canned form. These necessitate sophisticated production equipment and methods and, hence, access to capital. The resulting fish products are commercialized as ready and/or portion-controlled, uniform-quality meals.

In developing countries, and supported by a pool of cheaper labour, processing is still focused on less sophisticated methods of transformation, such as filleting, salting, canning, drying and fermentation. These traditional, labour-intensive fish-processing methods are a means for providing livelihood support for large numbers of people in coastal areas in many developing countries. For this reason, they are likely to continue to be important components in rural economies structured to promote rural development and poverty alleviation.

However, in many developing countries, fish processing is evolving. There is a trend towards increased processing. This may range from simple gutting, heading or slicing to more advanced value-addition, such as breading, cooking and individual quick-freezing, depending on the commodity and market value. Some of these developments are driven by demand in the domestic retail industry or by a shift in cultured species, for example, the introduction of *Penaeus vannamei* in Asia. These changes reflect the increasing globalization of the fisheries value chain, with the growth of international distribution channels controlled by large retailers. More and more producers in developing countries are being linked with, and coordinated by, firms located abroad. The increasing practice of outsourcing processing at regional and world levels is very significant, its extent depending on the species, product form, and cost of labour and transportation. For example, whole fish from European and North American markets are sent to Asia (China in particular, but also India and Viet Nam) for filleting and packaging, and then re-imported. In Europe, smoked and marinated products are being processed in Central and Eastern Europe, in particular in Poland and in the Baltic countries. The further outsourcing of production to developing countries is restricted specifically by sanitary and hygiene requirements that can be difficult to meet. At the same time, processors are frequently becoming more integrated with producers, especially for groundfish where large processors in Asia, in part, rely on their own fleet of fishing vessels. In aquaculture, large producers of farmed salmon, catfish and shrimp have established

advanced centralized processing plants to improve the product mix, obtain better yields and respond to evolving quality and safety requirements in importing countries. In many developed countries, processors are often facing reduced margins owing to increased competition from low-cost processors in developing countries. They are also experiencing increasing problems linked to the scarcity of domestic raw material because of declining stocks and the need to import fish for their business.

Fish plays an important role not only in terms of its use for direct human consumption but also in the production of animal feeds, particularly fishmeal. About one-quarter of world fish production is destined for non-food products, with the bulk being converted into fishmeal and fish oil. The remainder, mainly consisting of low-value fish, is largely utilized as direct feed in aquaculture and livestock. In 2006, the quantity of fish used as raw material for fishmeal was about 20.2 million tonnes, down 14 percent on 2005 and still well below the peak levels of more than 30 million tonnes recorded in 1994. The decrease in fishmeal production in the past decade has been irregular, its considerable fluctuations mainly reflecting annual variations in catches of small pelagics, especially anchoveta.

Another emerging application of fish, crustaceans and other marine organisms is as a source of bioactive molecules for the pharmaceutical industry. Chitin from shrimp and crab shells is already being used in the pharmaceutical industry. Chitin and chitosan have wide-ranging applications in many areas such as water treatment, cosmetics and toiletries, food and beverages, agrochemicals and pharmaceuticals. Japan is the largest market (20 000 tonnes) for chitin-derived products. Biomedical products from wastes derived from the fish-processing industry (e.g. skin, bones and fins) are attracting considerable attention from industry. Fish skin as a source of gelatine has attracted interest after bovine spongiform encephalopathy (BSE) and some religious requirements prompted a search for alternatives to mammalian sources of gelatine. It is estimated that about 2 500 tonnes of fish gelatine was produced in 2006. Similarly, fish collagen has advantages over bovine collagen in the pharmaceutical industry. Carotenoids and astaxanthins are pigments that can be extracted from crustacean wastes, and the pharmaceutical industry is now showing interest in seafood processing waste as a source of these important molecules. Fish silage and fish protein hydrolysates obtained from fish viscera are finding applications in the pet feed and the fish feed industries. A number of anticancer molecules have been discovered following research on marine sponges, bryozoans and cnidarians. However, following their discovery, for reasons of sustainability, these molecules are not extracted from marine organisms directly, but are chemically synthesized. Another approach being researched is aquaculture of some sponge species.

FISH TRADE AND COMMODITIES

In addition to its contribution to economic activity, employment and in generating foreign exchange, trade in fish and fishery products plays an important role in improving food security and contributes to fish products meeting nutritional needs. Fish and fishery products are highly traded with more than 37 percent (live weight equivalent) of total production entering international trade as various food and feed products (Figure 30). A specific feature of the trade in fish is the wide range of product types and participants. In 2006, 194 countries reported exports of fish and fishery products. World exports of fish and fishery products reached US$85.9 billion in 2006. This represented an increase of 9.6 percent on 2005 and of 62.7 percent on 1996 (Figure 31). Export value expanded at an average annual rate of 5 percent in the period 1996–2006. In real terms (adjusted for inflation), exports of fish and fishery products increased by 32.1 percent in the period 2000–06, by 26.6 percent in 1996–2006 and by 103.9 percent between 1986 and 2006. In terms of quantity (live weight equivalent), exports peaked at 56 million tonnes in 2005, with a growth of 28 percent since 1995 and of 104 percent since 1985. In 2006, exports decreased by 4 percent to 54 million tonnes. However, this decrease was due to reduced production and trade in fishmeal. In fact, exports of fish for human consumption rose a further

Figure 30

World fisheries production and quantities destined for export

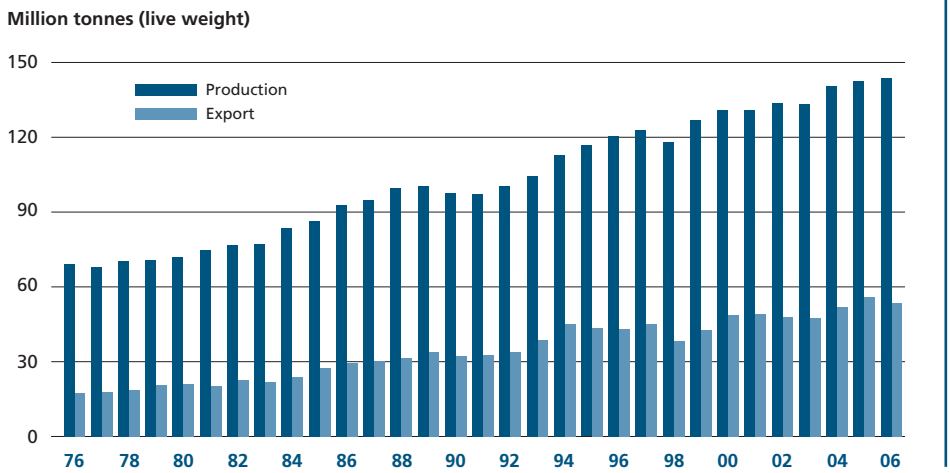
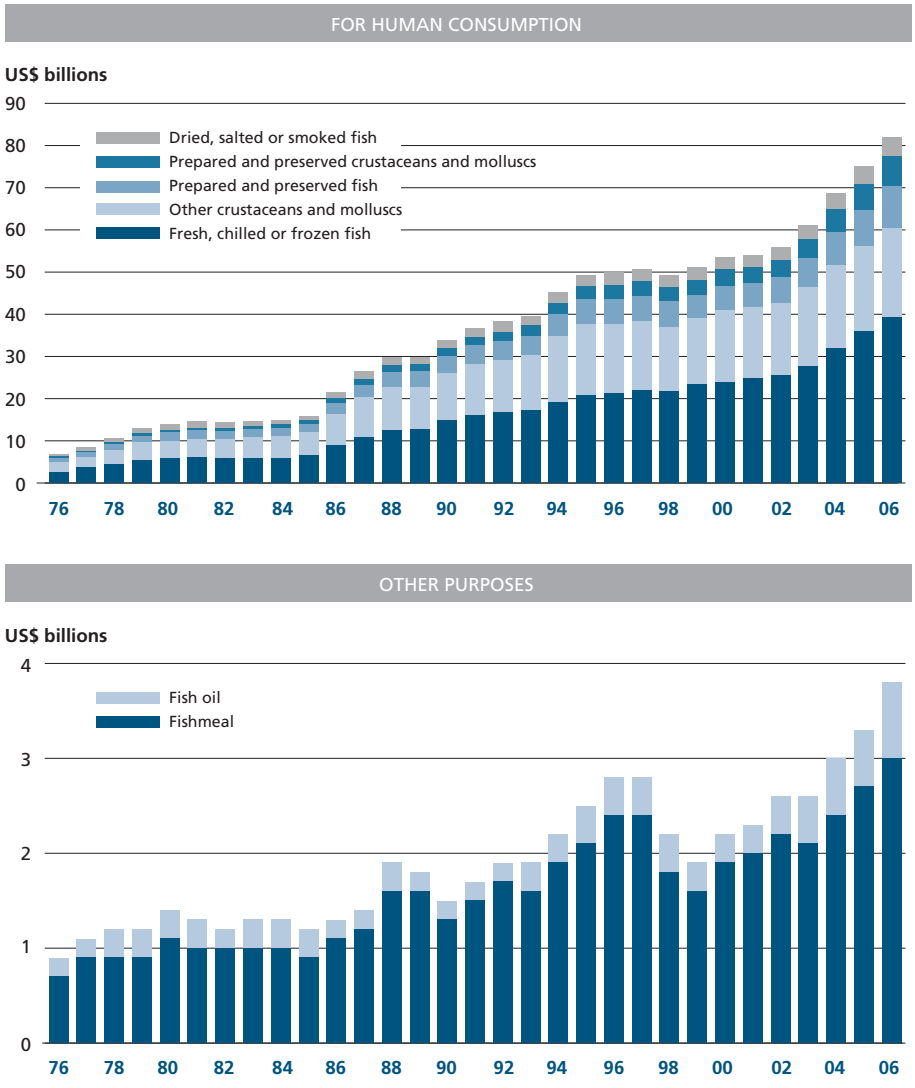


Figure 31

World fishery exports by major commodity groups



5 percent compared with the previous year and have increased by 57 percent since 1996. Available data for 2007 indicate further strong growth to about US$92 billion. However, some weakening in demand was registered in late 2007 and early 2008 as turmoil in the financial sector started to affect consumer confidence in major markets. This is expected to influence discretionary spending and sales of higher-value items in the short term. However, the long-term trend for trade in fish is positive, with a rising share of production from both developed and developing countries reaching international markets.

The growing exports of the last few years reflect the increase in consumption of fish and fishery products not only in the EU and the United States of America but in many other regions of the world, including Asia (with the notable exception of Japan). Furthermore, progress in processing, packaging, handling and transportation has enabled more rapid and efficient trade. Rising trade quantities (except for fishmeal) and values reflect the increasing globalization of the fisheries value chain, with the outsourcing of processing to other countries. At the same time, the growth of international and global distribution channels through large retailers has furthered this development.

In 2006, increased fishery exports coincided with an impressive global trade expansion, caused mainly by the increase in global economic activity. In its *World Trade Report 2007*, WTO indicated that all major regions recorded gross domestic product (GDP) growth outpacing population growth and that global GDP growth had accelerated to 3.7 percent, the second-best performance since 2000.[18] According to the UN Comtrade database, real merchandise export growth grew by 13.4 percent in 2006 compared with 2005, and well above the average annual rate of 8.7 percent in 1996–2006. An important factor was also the influence exerted by price movements and exchange rates on trade flows, in particular as a consequence of the weaker US dollar (which is used to denominate many commodity prices) and the marked appreciation of several currencies (especially European ones) against it. Since 2004, prices of various agricultural commodities (particularly of basic foods) have rebounded after a prolonged period of decline. They rose sharply in 2006, and some have been rising at an even faster pace since then. High feed prices have also raised costs for animal production and resulted in an increase in livestock prices. A series of long- and short-term factors have contributed to this growth. They include the tightening in own supplies, the intertwining of global markets, exchange rates, rising crude oil prices and freight rates. Prices of fishery products followed the general upward trend of all food prices in the course of 2007 and early 2008. This is the first time in decades that real prices of fish have been rising. Prices for species from capture fisheries are increasing more than those of farmed species because of the larger impact from higher energy prices on fishing vessel operations than on farmed species. However, aquaculture is also experiencing higher costs, in particular for feed. For more information on this issue, see Box 14 (page 160).

Table 8 shows the top ten exporters and importers of fish and fishery products in 1996 and 2006. Since 2002, China has been the world's largest exporter of fish and fishery products. In the last few years, it has further consolidated its leading position. In 2006, its exports reached US$9.0 billion, and they grew further to US$9.3 billion in 2007. Despite this, fishery exports represented only 1 percent of its total merchandise exports in 2006 and 2007. China's fishery exports have increased remarkably since the early 1990s. This increase is linked to its growing fishery production, as well as the expansion of its fish-processing industry, reflecting competitive labour and production costs. In addition to exports from domestic fisheries production, China also exports reprocessed imported raw material, adding considerable value in the process. China has experienced a significant increase in its fishery imports in the past decade. In 2006, it was the sixth-largest importer with US$4.1 billion, and imports reached US$4.5 billion in 2007. This growth has been particularly noticeable since the country's accession to the WTO in late 2001, as a consequence of which it lowered import duties, including those on fish and fishery products. The growth in imports is partly a result of the above-mentioned imports by China's processors of raw material for reprocessing and export. However, it also reflects China's growing domestic consumption of species, mainly of high value, that are not available from local sources.

Table 8
Top ten exporters and importers of fish and fishery products

	1996	2006	APR
	(US$ millions)		(Percentage)
EXPORTERS			
China	2 857	8 968	12.1
Norway	3 416	5 503	4.9
Thailand	4 118	5 236	2.4
United States of America	3 148	4 143	2.8
Denmark	2 699	3 987	4.0
Canada	2 291	3 660	4.8
Chile	1 698	3 557	7.7
Viet Nam	504	3 358	20.9
Spain	1 447	2 849	7.0
Netherlands	1 470	2 812	6.7
TOP TEN SUBTOTAL	23 648	44 072	6.4
REST OF WORLD TOTAL	29 139	41 818	3.7
WORLD TOTAL	**52 787**	**85 891**	**5.0**
IMPORTERS			
Japan	17 024	13 971	–2.0
United States of America	7 080	13 271	6.5
Spain	3 135	6 359	7.3
France	3 194	5 069	4.7
Italy	2 591	4 717	6.2
China	1 184	4 126	13.3
Germany	2 543	3 739	3.9
United Kingdom	2 065	3 714	6.0
Denmark	1 619	2 838	5.8
Republic of Korea	1 054	2 729	10.0
TOP TEN SUBTOTAL	41 489	60 534	3.8
REST OF WORLD TOTAL	11 297	25 357	8.4
WORLD TOTAL	**52 787**	**85 891**	**5.0**

Note: APR refers to the average annual percentage growth rate for 1996–2006.

In addition to China, other developing countries play a major role in the fishery industry. In 2006, 79 percent of world fishery production took place in developing countries. Their exports represented 49 percent (US$42.5 billion) of world exports of fish and fishery products in value terms and 59 percent (31.6 million tonnes in live weight equivalent) in terms of quantity. An important share of their exports consisted of fishmeal (35 percent by quantity, but only 5 percent by value). In 2006, in terms of quantity, developing countries contributed 70 percent of world non-food fishery exports. Developing countries have also significantly increased their share of the quantity of fish exports destined for human consumption, from 43 percent in 1996 to 53 percent in 2006. The fishery industries of developing countries rely heavily on the markets of developed countries, not only as outlets for their exports, but also as suppliers of their imports for local consumption (mainly low-priced, small pelagics as well as high-value fishery species for emerging economies) or for their processing industries. In 2006, in value terms, 40 percent of the imports of fish and fishery products by developing countries originated from developed countries. In fact, owing to the above-mentioned phenomenon of outsourcing, several developing countries are

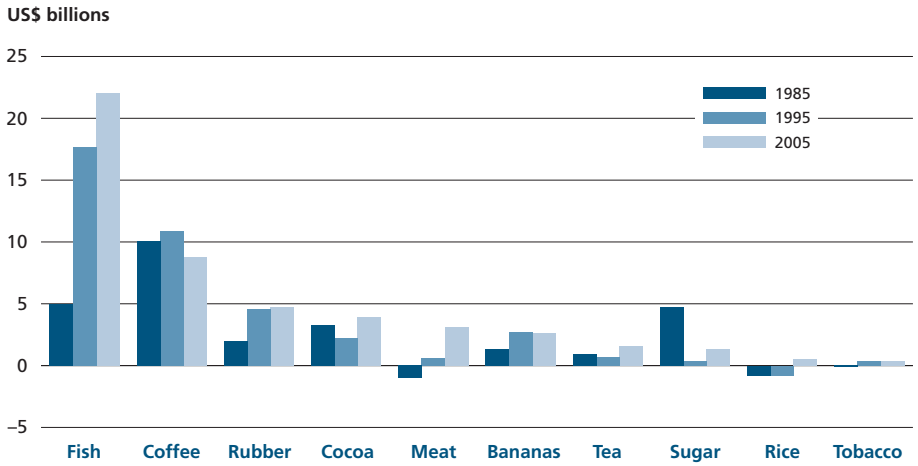
importing an increasing quantity of raw material for further processing and re-export to developed countries. Fishery exports of developing countries are gradually evolving from raw material for the processing industry in developed countries to value-added products and also high-value live fish. In 2006, in value terms, 75 percent of the fishery exports of developing countries were destined for developed countries. A share of these exports consisted of processed fishery products prepared using imported fish. Fishmeal was the only product for which exports from developing countries to other developing countries (58 percent of the total) were more important than exports to developed countries. This is mainly due to the significant aquaculture production in many developing countries and the resulting need for feed.

Fishery net exports (i.e. the total value of their exports less the total value of their imports) continue to be of vital importance to the economies of many developing countries (Figure 32). They have increased significantly in recent decades, growing from US$1.8 billion in 1976 to US$7.2 billion in 1984, to US$16.7 billion in 1996 and reaching US$24.6 billion in 2006. The low-income food-deficit countries (LIFDCs) play an active and growing role in the trade in fish and fishery products. In 1976, their exports accounted for 10 percent of the total value of fishery exports. This share expanded to 12 percent in 1986, 17 percent in 1996 and 20 percent in 2006, when their fishery exports were US$17.2billion and their fishery net export revenues were an estimated US$10.7 billion.

In 2006, world fish imports[19] reached a new record high of US$89.6 billion, an increase of 10 percent on the previous year, and of 57 percent since 1996. Preliminary data suggest that world imports of fish and fishery products totalled about US$96 billion in 2007. All major importing markets, except Japan, further increased the value of their imports of fish and fishery products, with the EU experiencing a significant 12-percent rise. Japan, the United States of America and the EU are the major markets, with a total share of 72 percent of the total import value in 2006. In total, developed countries accounted for 80 percent of imports in terms of value but only 62 percent in terms of quantity (live weight equivalent), indicating the higher unit value of products imported by developed countries. With stagnant domestic fishery production and growing demand, developed markets have to rely on imports and/or on aquaculture to cover a growing share of internal consumption. This is also the main reason why import tariffs in developed countries are so low and, albeit with a few exceptions (such as for some value-added products), do not represent any significant barrier to increased trade. As a result, in recent decades, fishery products from

Figure 32

Net exports of selected agricultural commodities by developing countries



developing countries have been able to gain increased access to developed-country markets without facing prohibitive custom duties. In 2006, about 50 percent of the import value of developed countries originated from developing countries. At present, rather than import tariffs, the principal barrier to increased exports from developing countries (beyond the physical availability of product) is the lack of ability to adhere to quality- and safety-related import requirements. Furthermore, they are also hindered by importing countries' increasing requirements that production processes respect animal health, environmental standards and social concerns. Not only is the emerging dominance of large retail and restaurant chains in seafood distribution and sales shifting negotiating power towards the final stages in the value chain, retailers are also increasingly imposing private- or market-based standards and labels on developing-country exports. This is making it more difficult for small-scale fish producers to enter international markets and distribution channels.

The maps in Figure 33 indicate trade flows of fish and fishery products by continent for the period 2004–06. However, the overall picture presented by these maps is not complete as information is not available for all countries. For example, about one-third of African countries did not report their trade in fishery products by country of origin or destination. However, the quantity of data available is sufficient to establish general trends. The Latin America and the Caribbean region holds a strong positive net fishery exporter position, as do the Oceania regions and the developing countries of Asia. Africa has been a net exporter since 1985, when the factory ships of the Soviet Union and Eastern Europe either stopped fishing or ceased landing massive quantities of inexpensive frozen pelagic fish in West Africa. Europe, Japan and North America are characterized by a fishery trade deficit (Figure 34).

In 2006, 97 countries were net exporters of fish and fishery products. In recent decades, there has been a tendency towards increased intensity of fishery trade within regions. Most developed countries trade more with other developed countries than with developing countries despite a growing share of fish consumption being covered by imports from developing countries. In 2006, some 85 percent (in value terms) of fishery exports from developed countries were destined to other developed countries, and about 50 percent of developed-country fishery imports originated in other developed countries. Intra-EU trade is particularly significant, with more than 84 percent of EU exports going to, and about 45 percent of imports coming from, other EU countries in 2006 and 2007. Trade in fish and fishery products among the more developed economies consists mainly of demersal species, herring, mackerel and salmon but also bivalves. In general, a significant share of trade among developed countries is of farmed origin.

The trade in fish between developing countries represents only 25 percent of the value of their fishery exports. This trade should increase in the future, partly as a result of the emergence of more liberal and effectively implemented regional trade agreements, and partly driven by the demographic, social and economic trends that are transforming food markets in developing countries. However, such trade is hampered by the fact that the majority of developing countries apply, in general terms, much higher import tariffs for all imported products than do developed countries. This is mostly to generate much-needed government revenue. Over time, the trade in fish and fish products between developing countries is likely to improve subsequent to a gradual trade liberalization and a reduction in import tariffs following the expanding membership of the WTO and the entry into force of a number of bilateral trade agreements with strong relevance to the trade in fish. With the accession of China and Viet Nam to the WTO (in 2001 and 2007, respectively), all the major fish producing, importing and exporting countries are now members of the organization, with the exception of the Russian Federation. The latter is a WTO observer and is involved in access negotiations, with the aim of becoming a full member within this decade. In addition to the member countries' individual commitments on import tariffs, the most important elements of the WTO agreements for trade in fish are those concerning subsidies, antidumping, technical barriers to trade (TBT), sanitary and phytosanitary standards, and dispute resolution.

Figure 33

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2004–06)

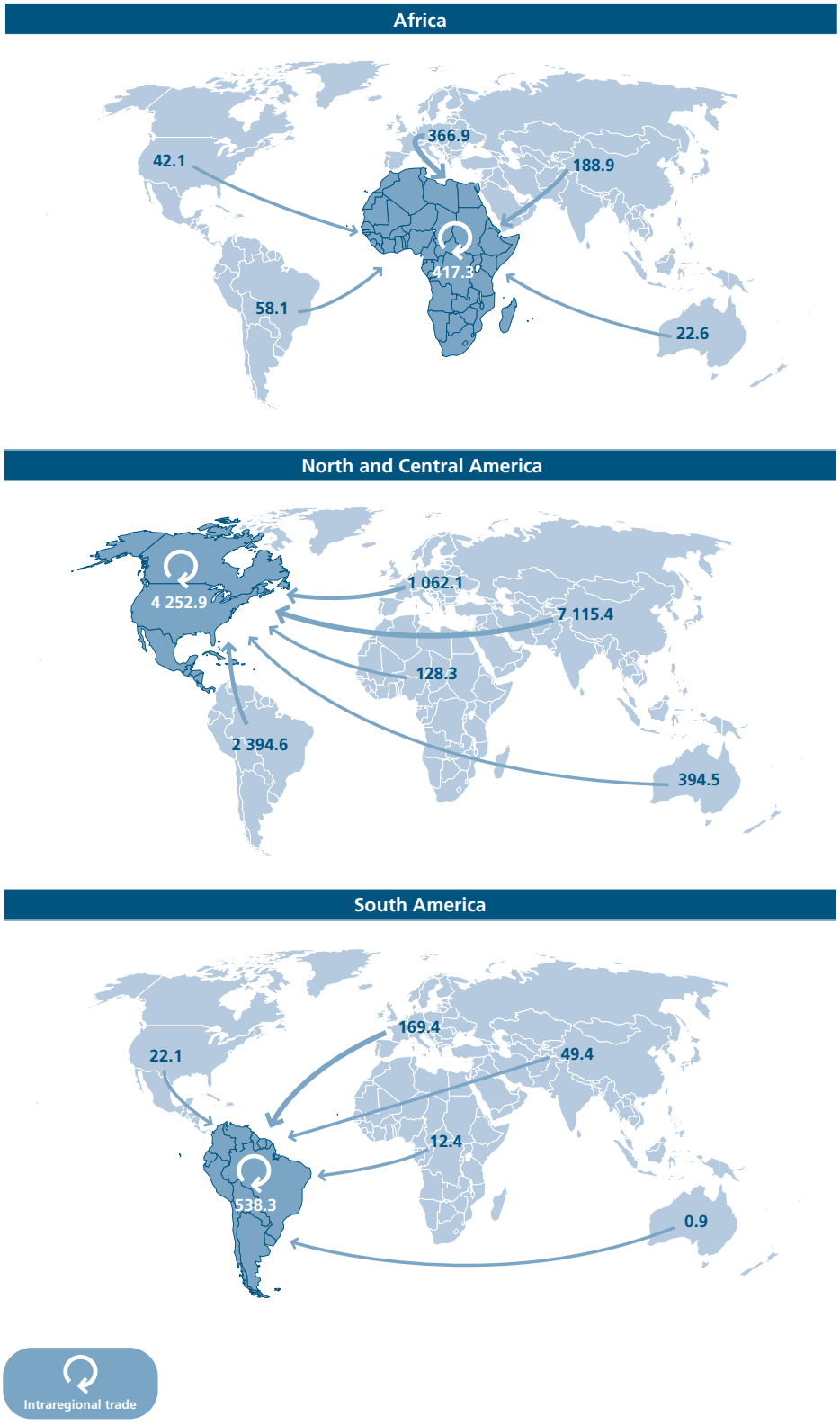


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Figure 33 *(cont.)*

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2004–06)

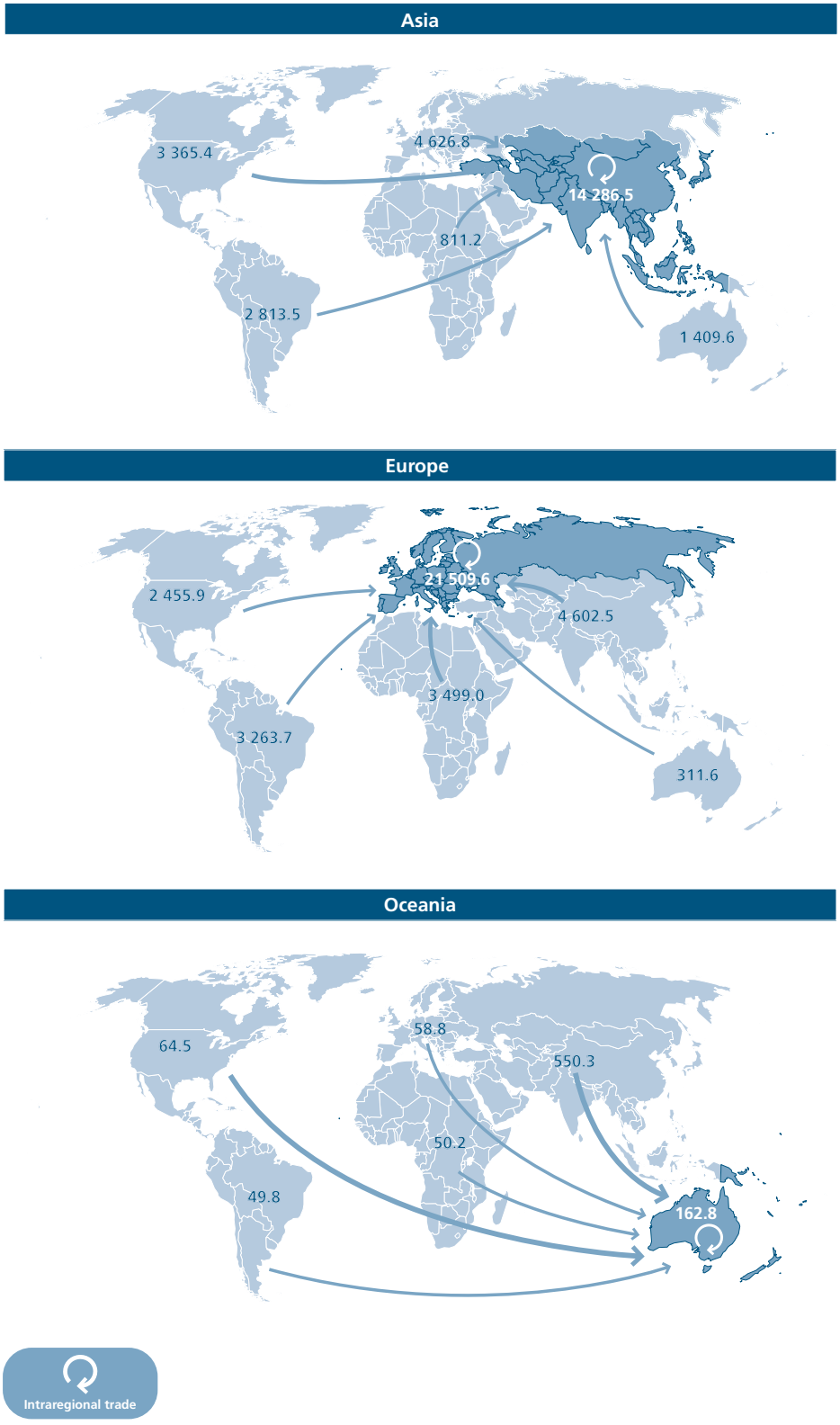
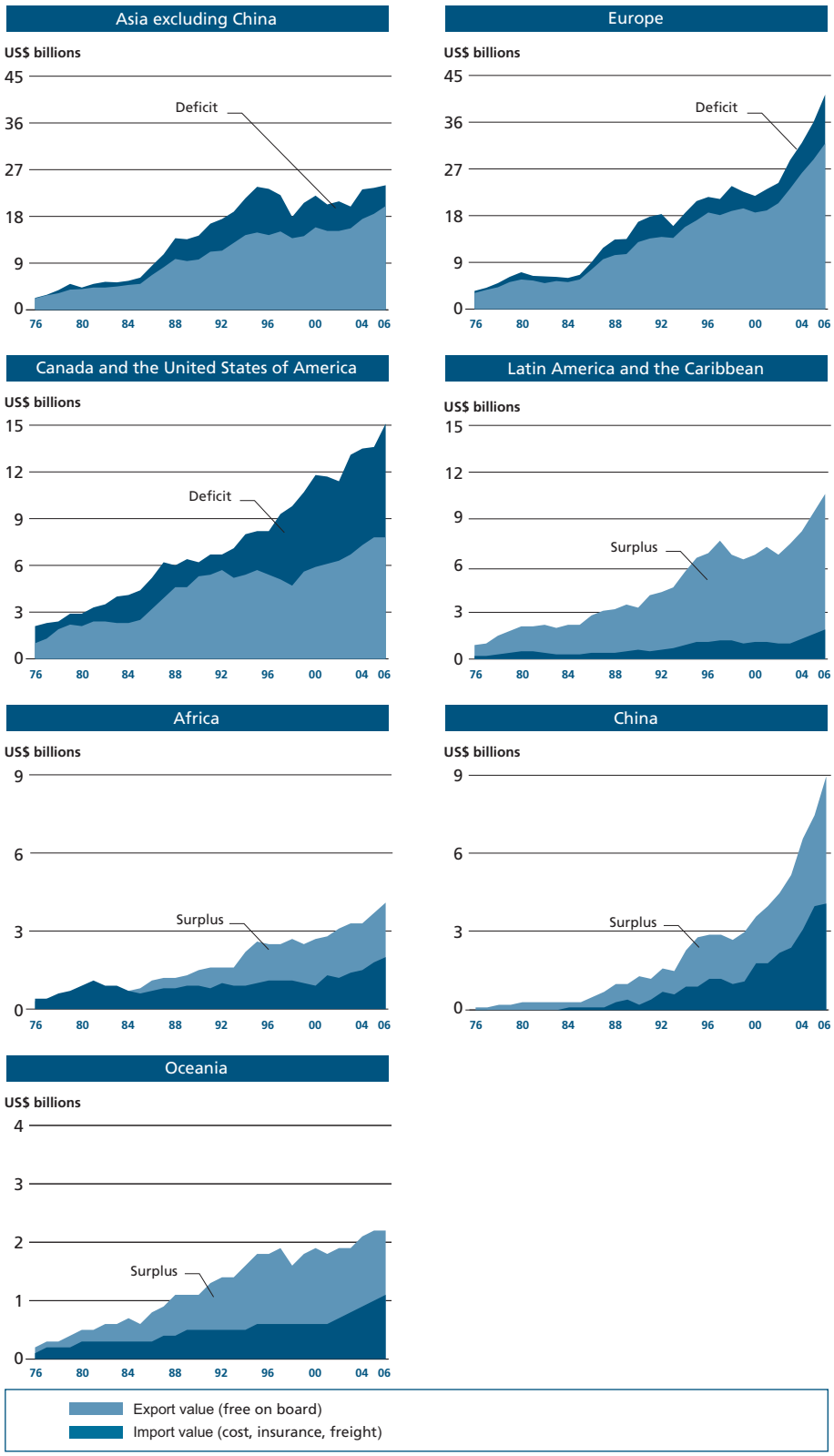


Figure 34

Imports and exports of fish and fishery products for different regions, indicating net deficit or surplus



Some of the major recent issues concerning international trade in fishery products have been:

- introduction by buyers and international retailers of private standards for food safety and quality, animal health, environmental sustainability and social purposes;
- continuation of trade disputes related to shrimp and salmon exports;
- the growing concern of the general public and the retail sector about overexploitation of certain fish stocks;
- the uptake of ecolabels by major retailers;
- certification of aquaculture in general and of shrimp in particular;
- the multilateral trade negotiations in the WTO;
- expansion of regional trade areas, and regional and bilateral trade agreements;
- the negotiations on economic partnership agreements between the African, Caribbean and Pacific Group of States and the EU;
- global warming and its impact on the fisheries sector;
- rising energy prices and their impact on fisheries;
- rising commodity prices in general and their impact on producers as well as consumers.

Commodities

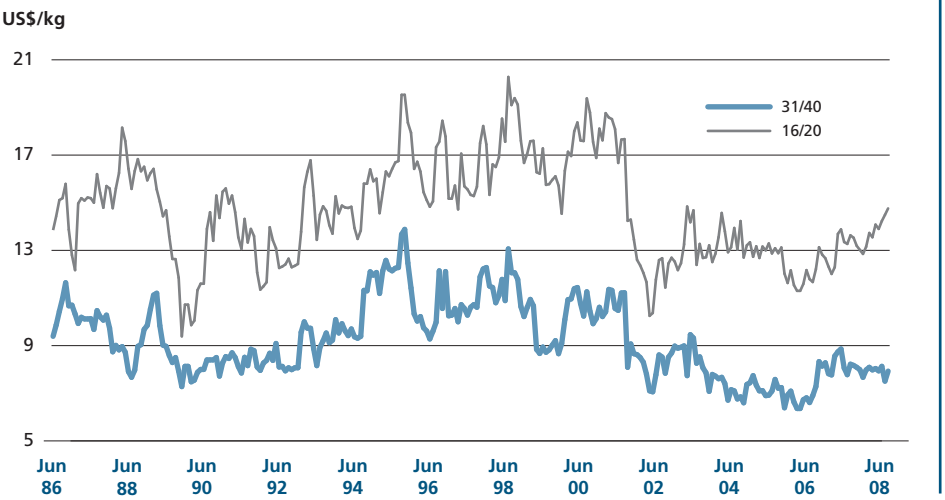
In world markets, the trade focus is mainly on high-value species, such as shrimp, salmon, tuna, gadiformes,[20] bass and bream. However, a number of high-volume but relatively low-value species are also traded in large quantities not only nationally and within major producing areas (such as Asia and South America) but also at the international level. Many of these species are farmed. With the tremendous growth in aquaculture production of the last few decades, the absolute and relative contribution of farmed products to international trade has also grown considerably. Many of the species that have registered the highest growth rates in the last few years are mostly destined for export. Export growth rates for species such as catfish and tilapia currently exceed 50 percent per year. These species are entering new markets where, only a few years ago, they were practically unknown. This highlights the potential for further growth in the production, trade and consumption of species and products that respond to consumers' needs for moderately-priced white-meat fillets and that, for the most part, are sold through the supermarket or food service channels. Many species, such as salmon, tuna and tilapia, trade increasingly in processed form (fillets or loins). However, trade in many aquaculture products is not yet well documented as the classification used internationally to record trade statistics for fish does not distinguish species between wild and those of farmed origin.

Owing to the high perishability of fish and fishery products, more than 90 percent of the quantity of international trade of fish and fishery products is conducted in processed form, albeit to varying degrees. In 2006, the share of live, fresh or chilled fish was 10 percent by quantity, but more than 18 percent by value. Live and fresh fish are valuable but difficult to trade and transport, and they are often subject to stringent health regulations and quality standards. Nonetheless, trade in live fish has increased in recent years as a result of technological developments, improved logistics and increased demand. International statistics on trade in live fish also include trade in ornamental fish, which is high in value terms but almost negligible in terms of quantity traded.

Exports of frozen fish have increased in the past decade, from 31 percent of the total quantity of fish exports in 1996 to 39 percent in 2006. Exports of prepared and preserved fish totalled 9.3 million tonnes (live weight equivalent) in 2006, representing 17 percent of total exports (10 percent in 1996). Exports of cured fish accounted for 5 percent of total exports in 2006, remaining rather stable in the last decade. In 2006, exports of non-food fishery products represented 29 percent of total fish exports in terms of quantity, a large proportion of which originated from South American countries.

Figure 35

Shrimp prices in Japan



Note: 16/20 = 16–20 pieces per pound; 31/40 = 31–40 pieces per pound.
Data refer to wholesale prices for black tiger, headless, shell-on shrimps. Origin: Indonesia.

Shrimp

Shrimp continues to be the largest single commodity in value terms, accounting for 17 percent of the total value of internationally-traded fishery products (2006). Despite growing export volumes, its share has been declining, with average prices showing a downward trend. In value terms, the major exporting countries are Thailand, China and Viet Nam. In 2007, shrimp imports were weaker in both the United States of America (the main shrimp importer) and Japan, whereas the EU consolidated its position as the leading shrimp market in the world. Apart from the United Kingdom, all major European countries experienced a stable or increasing trend for shrimp imports. Prices for cultured shrimp fell owing to softer demand, while prices for wild shrimp rose in early 2008 (Figure 35). With prices and margins under pressure, many producers of farmed shrimp are now looking into diversification and value-addition strategies in order to counter the price weakness, including cut-backs in output in order to stabilize prices.

Salmon

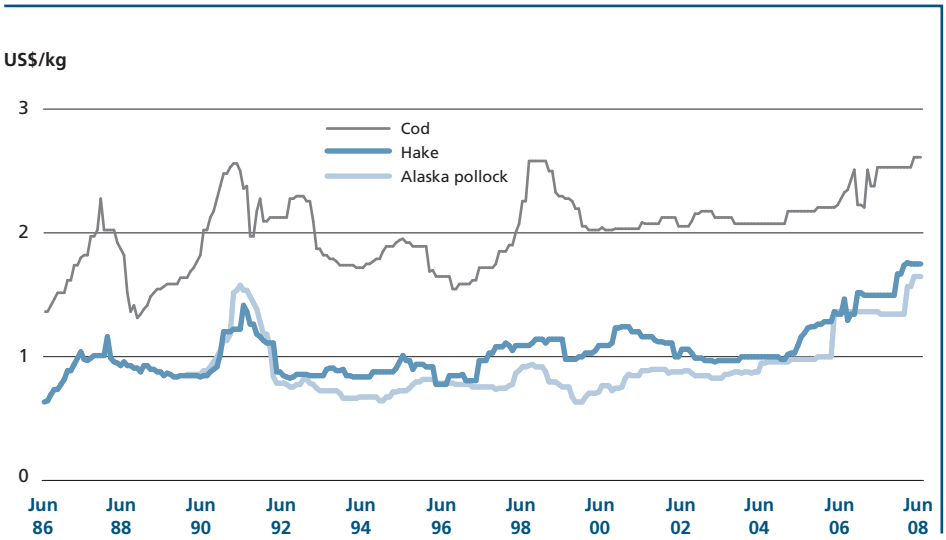
The share of salmon (including trout) in world trade has increased strongly in recent decades and now stands at 11 percent. This has been driven mainly by the strong growth in salmon and trout aquaculture in Northern Europe and in North and South America. Prices have oscillated in line with sudden shifts in supply, reaching record levels in 2006 but returning to more normal levels in 2007 and 2008. Industry concentration is enabling producers to benefit from economies of scale, in particular in the use of feed, but also in the handling of disease, a problem that has affected some of the larger companies. Demand for farmed salmon is firm, increasing steadily year by year, with new markets opening up in both developed, transition and developing countries. The increase in demand for farmed salmon is facilitated by the expansion of modern retail channels and the steady availability of product throughout the year.

Groundfish

Groundfish represented 10 percent of total fish exports (by value) in 2006. Globalization in the groundfish sector is evident with products processed in China and Viet Nam continuing to supply world markets. China consolidated its position in the cod and pollock fillet markets. In the United States of America, groundfish imports fell

Figure 36

Groundfish prices in the United States of America



Note: Data refer to c&f (cost and freight) prices for fillets.

as exporters preferred the "Euro area" (given the weak US dollar). Dollar weakness contributed to stable prices in local currency terms in key European frozen-fillet markets in 2007 (Figure 36). The relatively stable price situation was also helped by steady Alaska pollock supplies. Hake provisions from some origins (notably Argentina) were weaker than in 2006, influenced by buoyant regional demand in South America itself. The groundfish market is characterized by a high degree of substitution among the different groundfish species as well as with other species. Increasingly, the market for fillets is being supplied by freshwater species, such as tilapia, catfish and Nile perch. Annual farmed production of the first two species exceeds 2 million and 1 million tonnes, respectively. Tilapia has found a ready market in the United States of America, whereas catfish imports are growing rapidly in the EU, the Russian Federation, and the United States of America. Despite smaller quotas for a number of wild traditional groundfish species, the ample supply of ready substitutes from farmed sources has prevented prices from rising beyond certain levels.

Tuna

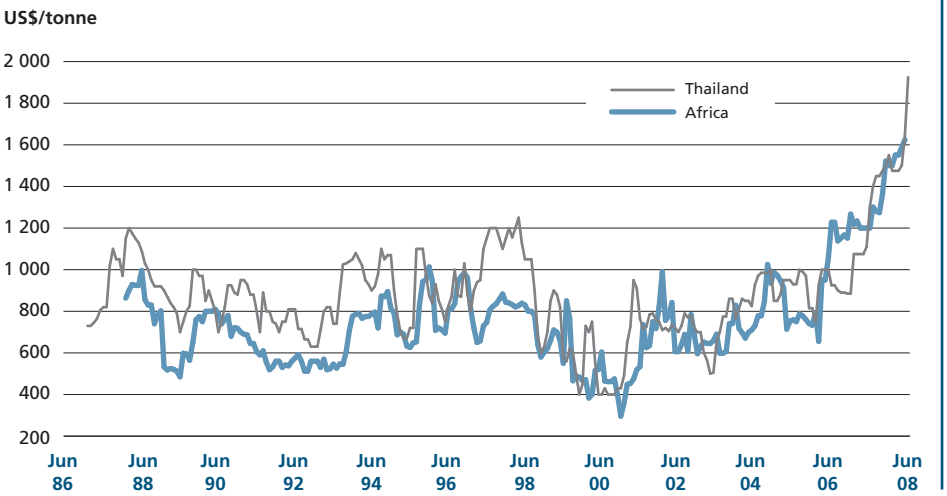
The share of tuna in total fish exports in 2006 was 8 percent. Tuna markets were rather unstable owing to large fluctuations in catch levels, and they declined in 2007. The main reason for this decline was the increased fuel price, which made long fishing trips uneconomical for the world tuna fleet. Prices increased in all main markets (Figure 37), and canned tuna prices soared for the first time in 20 years. Japan, the largest market for imported tuna, saw falling quantities in all categories. Import tariffs on tuna remain an important issue for both importers and exporters, as does the impact of preferential access for products from specific countries.

Cephalopods

The share of cephalopods in world trade in fish was 4.2 percent in 2006. Thailand is the largest exporter of squid and cuttlefish, followed by Spain, China and Argentina. Morocco is the principal octopus exporter. Spain, Italy and Japan are the largest importers of this species. Total annual catches of cephalopods are fairly stable at about 3.6–3.8 million tonnes. Squid prices plummeted in 2007 as traders in Argentina sold at prices much below those of the previous season. On the other hand, octopus production and trade declined in 2007 as a result of limited catches by the Mauritanian

Figure 37

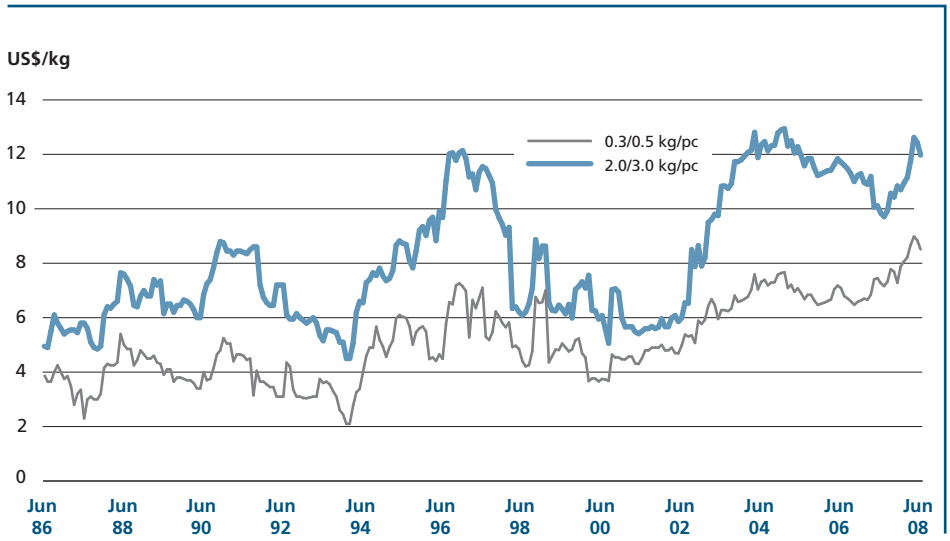
Skipjack tuna prices in Africa and Thailand



Note: Data refer to c&f (cost and freight) prices for 4.5–7.0 pounds of fish.
For Africa: ex-vessel Abidjan, Côte d'Ivoire.

Figure 38

Octopus prices in Japan



Note: kg/pc = kilograms per piece. Data refer to wholesale prices. Whole, 8 kg/block.

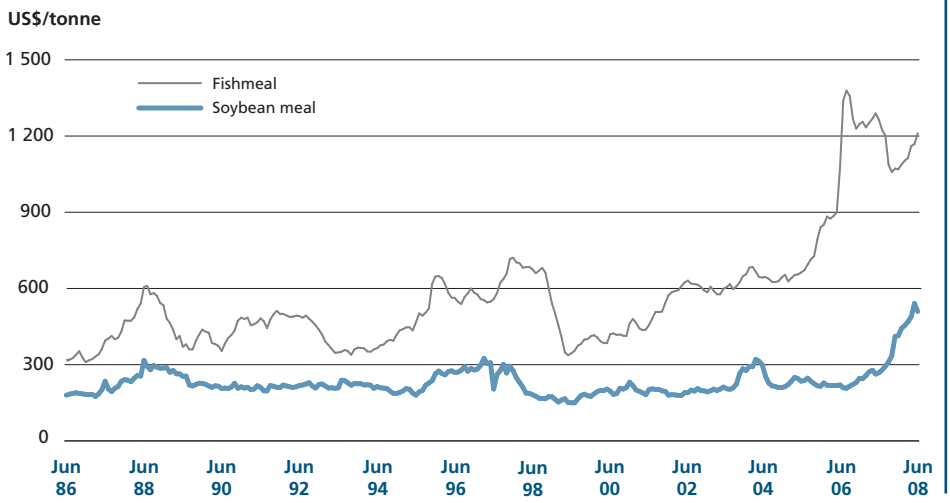
fleet. Demand for octopus in Japan improved, and lower imports resulted in an important price hike of US$2.00 per kilogram in the course of 2007 (Figure 38).

Fishmeal

In recent decades, fishmeal production has been remarkably stable at about 6 million tonnes (product weight), fluctuating between 5 million and 7 million tonnes depending on catch levels of anchovy off South America. Total fishmeal production of the main fishmeal exporters for 2007 reached 2.7 million tonnes, slightly below that of 2006. A significant reduction in anchovy catches off Peru in 2006 led to sharply higher

Figure 39

Fishmeal and soybean meal prices in Germany and the Netherlands



Note: Data refer to c.i.f. prices.
Fishmeal: all origins, 64–65 percent, Hamburg, Germany.
Soybean meal: 44 percent, Rotterdam, Netherlands.

Source: Oil World; FAO GLOBEFISH.

fishmeal prices in that year, but prices were rather stable in the course of 2007. In early 2008, fishmeal prices moved upwards again, and are likely to remain high, also in view of high vegetable meal prices (Figure 39). Of note is the large share of fishmeal now consumed by the aquaculture industry, estimated at 60 percent, with strong demand particularly in China. At the same time, the poultry industry has drastically reduced its fishmeal use.

Fish oil

Production of fish oil was relatively high in 2007. This resulted from the high fat content of the fish processed. In early 2008, fish-oil prices soared to an all-time record of US$1 700/tonne, compared with US$915/tonne one year earlier. Demand for fish oil for direct human use is boosting prices (Figure 40). For fish oil, the role of aquaculture is even greater than for fishmeal, with close to 85 percent of production consumed by the sector, and with salmonids responsible for more than 55 percent of the sector's share.

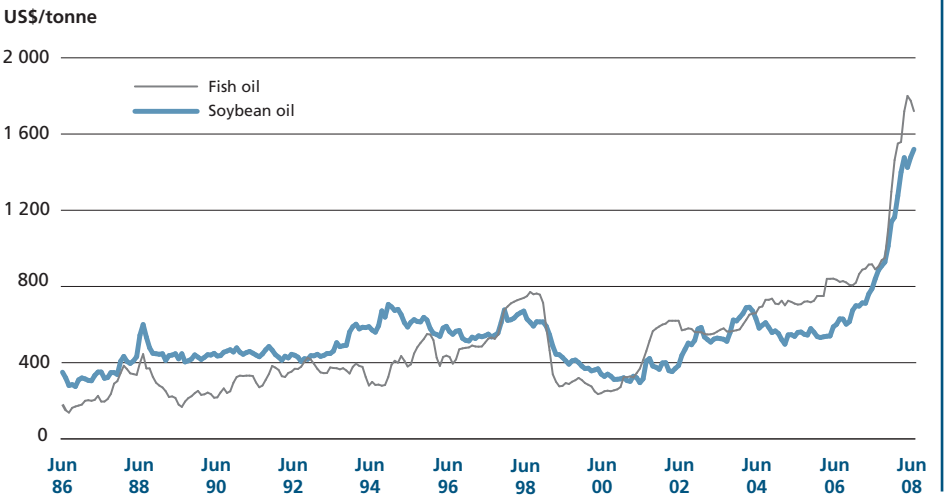
FISH CONSUMPTION[21]

Fish[22] consumption has undergone major changes in the past four decades. World apparent per capita fish consumption has been increasing steadily, from an average of 9.9 kg in the 1960s to 11.5 kg in the 1970s, 12.5 kg in the 1980s, 14.4 kg in the 1990s and reaching 16.4 kg in 2005. However, this increase has not been uniform across regions. In the last three decades, per capita fish supply has remained almost static in SSA. In contrast, it has risen dramatically in East Asia (mainly in China) and in the Near East/North Africa region. China has accounted for most of the world growth; its estimated share of world fish production increased from 21 percent in 1994 to 35 percent in 2005, when Chinese per capita fish supply was about 26.1 kg. If China is excluded, per capita fish supply is about 14.0 kg, slightly higher than the average values of the mid-1990s, and lower than the maximum levels registered in the 1980s (14.6 kg). Preliminary estimates for 2006 indicate a slight increase in global per capita fish supply to about 16.7 kg.

The global increase in fish consumption tallies with trends in food consumption in general. Per capita food consumption has been rising in the last few decades. Nutritional standards have shown positive long-term trends, with worldwide increases

Figure 40

Fish oil and soybean oil prices in the Netherlands



Note: Data refer to c.i.f. prices.
Origin: South America; Rotterdam, Netherlands.

Source: Oil World; FAO GLOBEFISH.

in the average global calorie supply per person and in the quantity of proteins per person. However, many countries continue to face food shortages and nutrient inadequacies, and major inequalities exist in access to food, mainly owing to very weak economic growth and rapid population expansion (Box 4). The majority of undernourished people in the world live in Asia and the Pacific, with the highest prevalence of undernourishment found in SSA.

There are large variations across countries and regions of the world in the amount of total fish supply for human consumption, reflecting different eating habits and traditions, availability of fish and other foods, prices, socio-economic levels, and seasons (Figure 41). Per capita apparent fish consumption can vary from less than 1 kg per capita in one country to more than 100 kg in another. Differences are also evident within countries, with consumption usually higher in coastal areas.

Of the 107 million tonnes available for human consumption in 2005 (Table 9), consumption was lowest in Africa (7.6 million tonnes, with 8.3 kg per capita), while Asia accounted for two-thirds of total consumption, of which 36.9 million tonnes were consumed outside China (13.9 kg per capita), with 33.6 million tonnes in China alone (26.1 kg per capita). The corresponding per capita consumption figures for Oceania, North America, Europe, Central America and the Caribbean, and South America were 24.5, 24.1, 20.8, 9.5 and 8.4 kg, respectively.

There are significant differences in fish consumption between the industrialized and the less-developed countries. In 2005, apparent fish consumption in industrialized countries reached 27.5 million tonnes (live weight equivalent), 14.2 million tonnes more than in 1961, for a growth in annual per capita consumption from 20.0 to 29.3 kg in the same period. The share of fish in total protein intake was 7.9 percent in 2005, back at the levels prevailing in the mid-1980s. The contribution of fish to total protein intake grew significantly in the period 1961–89 (between 6.5 and 8.6 percent), before gradually decreasing following the growth in consumption of other animal proteins. Since the early 1990s, the consumption of fish protein has remained relatively stable at about 8.2–8.6 g per capita per day, while the intake of other animal proteins has continued to grow.

In 2005, the average per capita apparent fish supply in developing countries was 14.5 kg, and 13.8 kg in LIFDCs. If China is excluded, these data become 10.6 and 8.3 kg,

Box 4

Fish and nutrition

Fish contributes to food security in many regions of the world, providing a valuable supplement for diversified and nutritious diets. Fish is highly nutritious. It provides not only high-value protein, but also represents an important source of a wide range of essential micronutrients, minerals and fatty acids. On average, fish provides about 20–30 kilocalories per person per day. It provides higher levels, up to 180 kilocalories per person per day, only in a few countries where there is a lack of alternative foods, and where a preference for fish has been developed and maintained (for example in Iceland, Japan and some small island developing states). The dietary contribution of fish is more significant in terms of animal proteins, which are a crucial component in some densely populated countries where total protein intake levels may be low. In fact, many populations, those in developing countries more than those in developed ones, depend on fish as part of their daily diets. For them, fish and fishery products often represent an affordable source of animal protein that may not only be cheaper than other animal protein sources, but preferred and part of local and traditional recipes. While the average per capita fish consumption may be low, even in small quantities fish can have a significant positive nutritional impact by providing essential amino acids that are often present only in low quantities in vegetable-based diets.

Table 9

Total and per capita food fish supply by continent and economic grouping in 2005

	Total food supply *(Million tonnes live weight equivalent)*	Per capita food supply *(kg/year)*
World	**107.0**	**16.4**
World excluding China	**73.4**	**14.0**
Africa	7.6	8.3
North and Central America	9.8	18.9
South America	3.1	8.4
China	33.6	26.1
Asia	70.5	17.9
Asia (excluding China)	36.9	13.9
Europe	15.2	20.8
Oceania	0.8	24.5
Industrialized countries	27.5	29.3
Economies in transition	4.1	12.3
LIFDCs (excluding China)	23.8	8.3
Developing countries excluding LIFDCs	17.6	16.2

respectively. Although consumption in LIFDCs excluding China has increased in the last four decades, and especially since the mid-1990s (+1.5 percent per year since 1995), the per capita fish intake is only half that of industrialized countries. Despite this relatively low level of fish consumption, the contribution of fish to total animal protein intake in 2005 was significant at about 20 percent. It may be higher than indicated by official statistics in view of the unrecorded contribution of subsistence fisheries. However, since 1975, when it peaked at 23.4 percent, this share has declined slightly notwithstanding the continued growth in fish protein consumption (from 2.0 to 2.5 g per capita per day in the period 1975–2005); this decline in relative share reflects the increased consumption of other animal proteins.

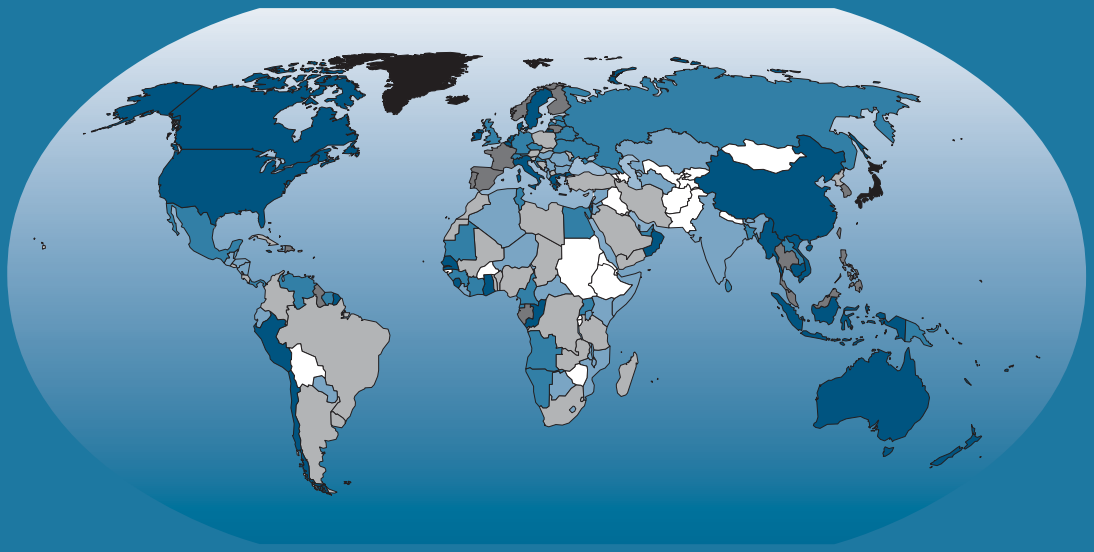
It is estimated that fish contributes to at least 50 percent of total animal protein intake in some small island developing states, as well as in Bangladesh, Cambodia, Equatorial Guinea, French Guiana, the Gambia, Ghana, Indonesia and Sierra Leone (Figure 42). The contribution of fish proteins to total world animal protein supplies rose from 13.7 percent in 1961 to a peak of 16.0 percent in 1996, before declining to 15.3 percent in 2005. Corresponding figures for the world, excluding China, show an increase from 12.9 percent in 1961 to 15.4 percent in 1989, then declining slightly to 14.7 percent in 2005. Figures for 2005 indicate that fish provided about 7.6 percent of animal protein in North and Central America and more than 11 percent in Europe. In Africa, it supplied about 19 percent, in Asia nearly 21 percent, in the LIFDCs including China about 19 percent and in the LIFDCs excluding China 20 percent. Globally, fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and nearly 3.0 billion people with 15 percent of such protein. Figure 43 presents the contributions of major food groups to total protein supplies.

Aquaculture production is playing an increasing role in satisfying demand for human consumption of fish and fishery products. In the past few years, major increases in the quantity of fish consumed have originated from aquaculture. The average contribution of aquaculture to per capita fish available for human consumption rose from 14 percent in 1986, to 30 percent in 1996 and to 47 percent in 2006, and it can be expected to reach 50 percent in the next few years. China is mainly responsible for this increase. In 2006, overall per capita fish supply from aquaculture was estimated at 7.8 kg, but it was 26.5 kg in China and only 3.3 kg for the world excluding China (Figure 44). However, the share of fish from aquaculture has increased steadily in the world excluding China, rising from 9 percent in 1986, to 15 percent in 1996 and 24 percent in 2006. Further growth in the availability of fish for human consumption is expected to come mainly from aquaculture. Aquaculture production has pushed the demand for and consumption of several freshwater species, such as tilapia and catfish (including *Pangasius* species) as well as for high-value species, such as shrimps, salmon and bivalves. Since the mid-1980s, these species have shifted from being primarily wild-caught to being primarily aquaculture-produced, with a decrease in their prices and a strong increase in their commercialization. Aquaculture has also had a major role in terms of food security in several developing countries, particularly in Asia, with significant production of some low-value freshwater species, which are mainly destined for domestic consumption.

Fish consumption differs among countries, and within countries it differs among segments of society. These differences reflect *inter alia* consumer preferences, availability, product developments, prices and levels of disposable income. Demersal fish are among the main species preferred by consumers in Northern Europe and in North America, whereas cephalopods are mainly consumed in Mediterranean and Asian countries. The consumption of crustaceans, being high-priced commodities, is concentrated mainly in affluent economies. However, as a result of the increased production of shrimps and prawns from aquaculture and the consistent decrease in their price, per capita availability of crustaceans increased more than threefold, from 0.4 to 1.6 kg between 1961 and 2005. The same reasons hold for molluscs (excluding cephalopods), whose availability increased from 0.6 to 2.0 kg per capita. The other

Figure 41

Fish as food: per capita supply (average 2003–2005)

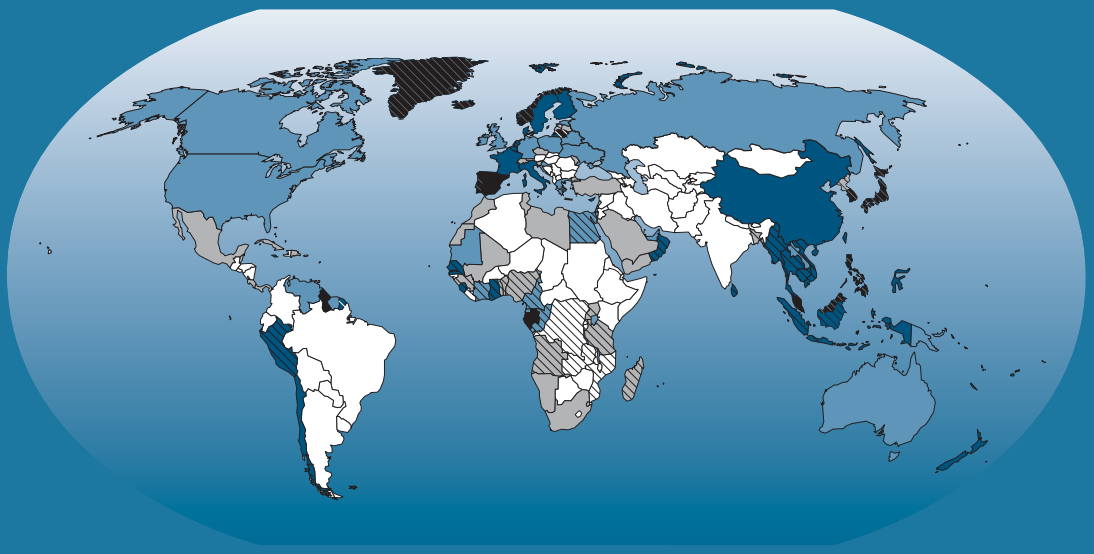


Average per capita fish supply (in live weight equivalent)

0–2 kg/year
2–5 kg/year
5–10 kg/year
10–20 kg/year
20–30 kg/year
30–60 kg/year
> 60 kg/year

Figure 42

Contribution of fish to animal protein supply (average 2003–2005)



Fish proteins (per capita per day)

< 2 g
2–4 g
4–6 g
6–10 g
> 10 g

Contribution of fish to animal protein supply

> 20%

Figure 43

Total protein supply by continent and major food group (2003–05 average)

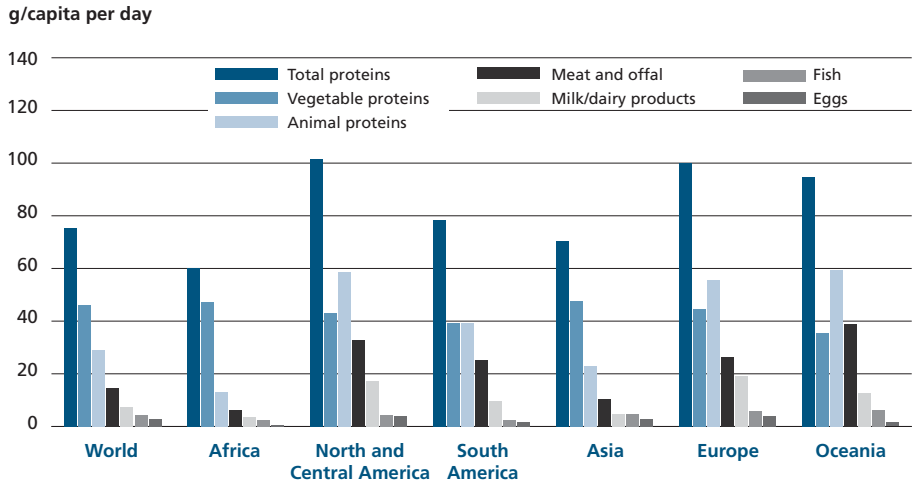
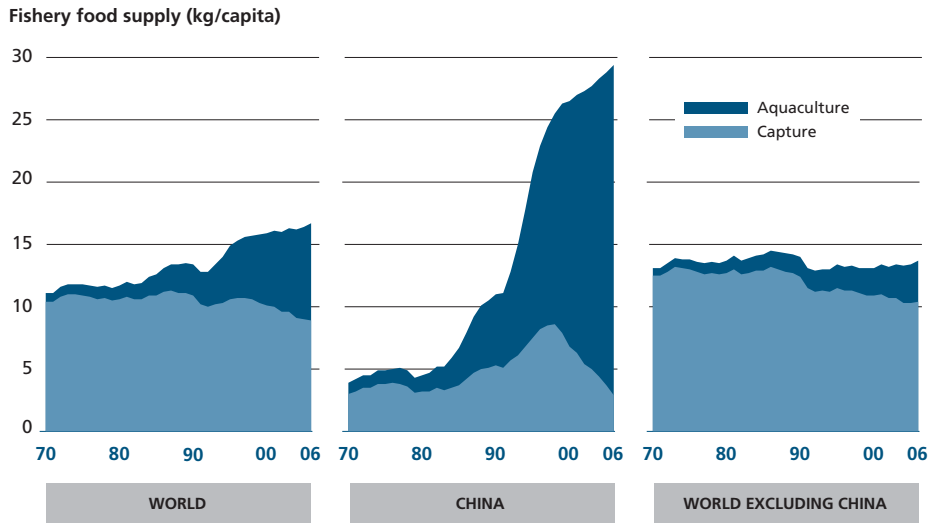


Figure 44

Relative contribution of aquaculture and capture fisheries to food fish consumption



broader groups did not show dramatic changes in their share in average world consumption, with demersal and pelagic fish species stable at about 3.0 kg per capita. Of the 16.4 kg of fish per capita available for consumption in 2005, about 74 percent came from finfish. Shellfish supplied 26 percent (or about 4.1 kg per capita), subdivided into 1.6 kg of crustaceans, 0.5 kg of cephalopods and 2.0 kg of other molluscs. Freshwater and diadromous species accounted for about 32 million tonnes of the total supply (about 4.9 kg per capita). Marine finfish species provided more than 47 million tonnes, of which 20.0 million tonnes were demersal fish, 19.9 million tonnes were pelagic species and 7.6 million tonnes were unidentified marine fish. The remaining share of the total food supply consisted of shellfish, of which 10.5 million tonnes were crustaceans, 3.5 million tonnes cephalopods and 12.9 million tonnes other molluscs.

Significant changes in fish and overall food consumption have taken place in both developed and developing countries. In developed countries, where incomes are generally high and basic dietary needs have long been more than satisfied, leading consumers often look for more variety in their diets. At the same time, the average consumer, particularly in European countries, Japan and the United States of America, is increasingly requiring high standards on different fronts, such as food safety, freshness, diversity and convenience. Furthermore, consumption in these countries will be increasingly determined by quality assurances, such as traceability, packing requirements and processing controls, that reinforce an underlying preference for premium-quality fish. Among other factors that are increasingly influencing consumption decisions are health and well-being. The populations of many industrialized countries are becoming older, richer, more educated and more health conscious. The demand for food that promotes health and well-being has increased in recent years. Fish has a particular prominence in this respect, following mounting evidence confirming the health benefits of eating fish. More stringent demands for assurance concerning safety is another high-profile issue that has emerged in recent years. It is considered very important to earn and maintain consumer confidence in the safety of fish. Consumers are increasingly requesting product attributes that depend on the production process. They now demand guarantees that their food has been produced, handled and commercialized in a way that is not dangerous to their health, respects the environment and addresses various other ethical and social concerns. Customers as well as major distributors are increasingly concerned about the sustainability and risk of depletion of marine stocks.

There are increasing calls for transparency in traceability systems – in order to trace the source, the quality, and the environmental and social impacts of food production and distribution. At the same time, consumers also want convenience and palatability. The response of the food industry has been to produce appealing and healthy fish products. Furthermore, societal changes, such as rising incomes, urbanization and greater female participation in the workforce, and media pressure are driving the demand for product diversification, higher-value products, semi-processed and processed products, and products that are ready to eat or require little preparation before serving. Markets have become more flexible, and new products and species have found market niches. Another trend is the increasing importance of fresh fish. Unlike many other food products, fish is still more favourably received on the market when it is fresh rather than processed. However, historically, fresh fish has been of little importance in international trade owing to its perishable nature and limited shelf-life. Improvements in packaging, reduced air-freight prices, and more efficient and reliable transport have created additional sales outlets for fresh fish. Food chains and department stores are also taking an increasing share of the fresh seafood sector. Many of them now provide fresh seafood counters with an extensive variety of fish and freshly prepared fish dishes or salads next to their frozen-food counters. Demand for products that cater to specific consumer tastes puts pressure on the whole value chain, especially on processors as well as on producers who need to provide what processors and consumers require. These developments involve fish originating from both capture fisheries and aquaculture. Aquaculture may have a potential advantage in providing raw material for higher-value processed products.

Per capita fish consumption in higher-income countries is expected to continue growing, but at a slower pace than in recent decades. New markets are emerging worldwide. Rising incomes and the ensuing diversification of diets are leading to a shift towards significantly higher fish consumption in developing countries. In emerging countries, especially in East and Southeast Asia, an expanding middle class is leading to increased fish consumption, in particular of high-quality and high-value products as purchasing power rises. In the last few decades, the increase in food consumption has been caused by growing consumption of red meat, fish, milk and eggs, at the expense of basic cereals. Protein availability has grown in both the developed and developing world, but the increase has not been equally distributed.

There has been a remarkable increase in the consumption of animal products in countries such as Brazil and China and in other less developed countries. However, the supply of animal protein remains significantly higher in industrialized countries than in developing countries.

The driving force behind the enormous surge in the consumption of animal products is a combination of population growth, rising incomes and increasing urbanization. Economic development and rising incomes usually lead to advances in the availability and quality of food, better overall nutritional status and the elimination of food shortages. This is normally accompanied by improvements in the supply chain of food, that is, in production, processing and marketing. Food distribution has undergone dramatic changes. Several developing countries, especially in Asia and Latin America, have experienced a rapid expansion in the number of supermarkets, which are not only targeting higher-income consumers but also lower- and middle-income consumers. Thus, they are emerging as a major force in developing countries, offering consumers a wider choice, reduced seasonality and lower prices for food products – and often safer food. Urbanization is a major force in global food demand. Growing urbanization usually modifies dietary patterns, both quantitatively and qualitatively, and changes the lifestyles of individuals. There is an increasing trend towards a global uniformity of urban consumer behaviour. Compared with the less-diversified diets of rural communities, city dwellers tend to have a more varied diet, richer in higher-energy foods, with more proteins from meat, poultry, fish and milk and fewer carbohydrates and fibres. Furthermore, urbanization stimulates development in infrastructure, including cold chains (which enable trade in perishable goods). In its 2007 Revision of World Urbanization Prospects, the United Nations Population Division indicated that the world population would reach a landmark in 2008.[23] For the first time in history, the urban population would equal the rural population of the world and, from then on, the majority of the world population would be urban. Nevertheless, major parts of the world remain largely rural. In Africa and Asia, six out of ten people still live in rural areas. The world's urban population is expected to nearly double by 2050, increasing from 3.3 billion in 2007 to 6.4 billion in 2050, with virtually all of the growth being absorbed by the urban areas of the less-developed regions.

The above-mentioned trends in fish consumption are expected to continue for the foreseeable future. Population and income growth, together with urbanization and dietary diversification, are expected to create additional demand and to continue to shift the composition of food consumption towards a growing share of animal products in developing countries. In industrialized countries, food demand is expected to grow only moderately and, in determining demand for food products, issues such as safety, quality, environmental concerns and animal welfare will probably be more important than price and income changes.

GOVERNANCE AND POLICY

Marine fisheries: industrial

The world's oceans support economic activities on a vast scale, and the need to rehabilitate and protect their common wealth and productivity has led the international community to focus intensely on how oceans are used and governed. A critical component of that equation is sound fisheries governance, especially in terms of achieving long-term sustainable management of living marine resources, a precondition for maintaining their social and economic value (Box 5). Intrinsically linked to this goal is the need to ensure greater responsibility and accountability by all individuals and private companies involved in the harvesting, processing and marketing of fish. More broadly, and also taking account of the potential for endemic corruption in resource-based industries,[24] sustainable management outcomes (including poverty reduction and alleviation, improved food security, stronger economic development and growth, and greater access to public services) depend to a large extent on concurrent improvements in public governance.

Box 5

The potential economic benefits from effective management of global marine fisheries

The "Rent Drain" study, a joint project of the World Bank PROFISH Global Program on Fisheries and FAO, describes the economic status of the global marine fisheries. The study shows that the difference between the potential and actual net economic benefits from marine fisheries is in the order of US$50 billion per year. The cumulative economic loss to the global economy over the last three decades is estimated to be in the order of US$2 trillion. In many countries, the catching operations are buoyed up by subsidies, so that the global fishery economy to the point of landing (the harvest subsector) was in deficit in the study's base year (2004). Improved governance of marine fisheries could capture a substantial part of this US$50 billion annual economic loss.

The study argues that the focus on the declining biological health of the world's fisheries has tended to obscure the even more critical economic health of the fisheries. Economically, healthy fisheries are fundamental to achieving not only the restoration of fish stocks but other accepted objectives for the fisheries sector, such as improved livelihoods, exports, fish food security and economic growth.

The "Rent Drain" study, builds on previous estimates of the global rents loss, in particular studies by FAO[1] and by Garcia and Newton.[2] Many of the problems characterized in the Garcia and Newton study still remain prevalent in global fisheries a decade later. More fish stocks are overexploited, overcapacity in fishing fleets remains problematic, income levels of fishers remain depressed and fish prices have stabilized or even fallen while the costs of harvesting fish have increased. Labour and fleet productivity has declined even as fishing technology has advanced.

Global marine capture fisheries production is relatively stagnant, producing 85 million tonnes in 2004, about the same quantity as in 1992. Analysis of trends in the value and costs of production show that marine capture fisheries are loss-making at the global level. For example, available global data suggest stable or even declining real per unit export values since the mid-1990s. Increased fuel costs, growing numbers of vessels and declining catch rates have reduced the economic efficiency of global marine capture fisheries. Subsidies for fuel and investment in fishing capacity have contributed even further to the decline in catch-per-fisher and catch-per-vessel ratios.

The study considered the global marine fishery as a single bioeconomic unit. Available global datasets were used to generate parameters for the

Fisheries management poses challenges for all countries, especially those that are capacity poor. In some countries, improvements in resource management are proceeding hand-in-hand with public sector reform and measures to promote better governance. These outcomes are increasingly being incentive-linked to the provision of development assistance. However, despite positive developments, there has been only limited progress in the implementation of management measures in most of the world.

In this respect, a key fisheries management issue is the lack of progress in reducing fishing capacity[25] and related harmful subsidies, a fundamental consideration if the state of world fisheries is to be improved. The 2007 session of the FAO Committee on Fisheries (the Committee) referred to the lack of progress in this area, and to the need

classical Schaefer and Fox biological models and to make estimates of the difference between the current (2004) and potential economic rent in the global fishery using each model. The estimate of US$50 billion is a mean from the two models. The estimate has a 95-percent confidence interval of between US$26 billion and US$72 billion. The rent loss estimate may increase by US$10–20 billion per year if discards are assumed to have an economic value and if allowance is made for the recent increases in fuel and food prices. A series of developing country case studies also lend weight to the rent loss estimates.

The estimate refers only to the harvest sector, that is, the global fisheries economy to the point of landing. However, a more economically efficient harvest sector can generate substantial additional downstream benefits. The estimate also excludes consideration of the value of biodiversity losses and losses by recreational fisheries and marine tourism.

The real cumulative global resource rent loss from inefficient marine capture fisheries in the period from 1974 to 2007 was estimated at US$2.2 trillion. The rent loss of US$50 billion in 2004 was used as a base value to construct a time series of losses. The 1974–2007 period was used because FAO produced its first "state of the marine fisheries" report in 1974, the first of a series of 14 such reports. The changing proportion of global fish stocks reported as fully exploited or overexploited in this series was used to build the annual loss estimates.

Capturing resource rent could generate economic growth both in the marine economy and other sectors, finance fisheries management systems, and help ensure an economically efficient and socially and environmentally sustainable use of the resources.

[1] FAO. 1993. *Marine fisheries and the law of the sea: a decade of change. Special chapter (revised) of The State of Food and Agriculture 1992*. Rome.
[2] S.M. Garcia and C. Newton. 1997. Current situation, trends and prospects in world capture fisheries. *In* E.L. Pickitch, D.D. Huppert and M.P. Sissenwine, eds. *Global trends: fisheries management*, pp. 3–27. American Fisheries Society Symposium 20. Bethesda, United States of America.
Source: World Bank. 2008. *The sunken billions. The economic justification for fisheries reform*. Washington, DC.

to match fishing capacity with sustainable harvesting levels. In a similar vein, in 2007, United Nations General Assembly Resolution 62/177 deplored the fact that fish stocks in many parts of the world are overfished or subject to sparsely regulated and heavy fishing efforts. The relationship between excess capacity and IUU fishing was also highlighted by both the Committee and the UN General Assembly. These issues and the nexus between them need to be addressed in tandem. They are also being deliberated on in other regional and global fora.[26]

There has been only limited progress in the implementation of measures *inter alia* to mainstream precautionary and ecosystem approaches to fisheries, eliminate bycatches and discards, regulate bottom-trawl fisheries (Box 6), manage shark fisheries and deal with IUU fishing in a comprehensive manner. Each of these issues has social,

Box 6

The need for additional indicators of fishing capacity

There is growing concern over the impacts that fishing gear may have on environments including: (i) the amount of fuel/energy consumed to capture the target species; (ii) the physical damage to the marine environment; (iii) the capacity of lost or abandoned fishing gear to "ghost fish"; (iv) the quantity and number of bycatch species; and (v) the quantity of fish and other animals discarded when using a particular fishing gear. These concerns have been raised in relation to commercial fishing gear including purse seines, bottom trawls, dredges, pots, hooks and lines, lift nets, gillnets and entangling nets.

While size and power of the fishing fleet may be useful indicators of trends in fishing capacity, vessel indices are unable to provide measures of the social, economic or environmental impacts attributed to a particular fishing method. First, the majority of small fishing vessels (which constitute 90 percent of global vessels by number) are multipurpose and use different types of gear depending on time, season and opportunity. Second, although some fleet data by vessel type are linked with fishing gear, the existing vessel statistics and information do not necessarily reflect the operational activities of the vessels. Third, the measurements used for vessel size and power often have no direct linear relationship with the impacts of fishing gear. This indicates the need to establish effective effort indices for fishing gear (for example, the days, number and types of gear used) in order to quantify the impacts of fishing gear on fisheries and monitor their trends.

This type of indicator will be useful in quantifying the impacts associated with each type of fishing gear type, and in identifying problems that need to be mitigated or resolved. For example, it has been claimed that bottom trawling is associated with high fuel consumption, physical damage to marine habitat, and high bycatch and discards. At the same time, a crude estimate indicates that 23 percent of global capture production, about 20 million tonnes, is obtained from bottom trawling. When considering a shift from bottom trawling to an alternative capture method, a fishing-gear/effort indicator, if analysed together with capture production data and socio-economic data (such as fuel consumption by vessel type and employment), would enable: (i) evaluation of the social, economic and environmental consequences of such a change; (ii) quantification of the extent to which environmental-impact-mitigation objectives can be or have been met; and (iii) monitoring of progress after the implementation of the new policy. Decisions on which types of fishing gear to promote or restrict should be based on a clear understanding of their relative benefits and disadvantages as well as the impacts and consequences of the measures.

economic and political dimensions, and the implementation of measures to tackle them effectively requires adequately trained human resources, well-structured and resilient institutions, and financial support.

A sharp focus on capacity building for fisheries management is a priority for both developing and developed countries. In a globalizing fisheries world, there is increasing interdependence between developing and developed states.[27] With respect to the implementation of international fisheries instruments (e.g. the 1995 United Nations Fish Stocks Agreement), it is recognized that there is an element of self-interest in the

provision of development assistance. This is because the instruments face a reasonable probability of floundering if they are not embraced widely by countries and if there is not a degree of implementation equivalency among parties to agreements. Principally for these reasons, most of the instruments concluded since the 1992 United Nations Conference on Environment and Development contain capacity-building provisions.[28]

A further and important reason to promote capacity building exists where regional cooperation and collaboration underpin the implementation of agreements. In these cases, capacity-poor countries become the weak links in the implementation process. For example, the adoption of harmonized and minimum standards for monitoring, control and surveillance (MCS) and regional port state measures envisages that they be implemented by countries in unison and with a similar degree of vigour. A failure to achieve coordinated implementation creates implementation loopholes, thereby undermining regional cooperation and outcomes.

Regional fisheries management organizations

Regional fisheries management organizations (RFMOs), the cornerstones of international fisheries governance, are struggling to fulfil their mandates despite concerted efforts to improve their performance. This situation results partly from the frameworks within which they operate and from an apparent lack of political will by members to implement decisions in a timely manner. Moreover, the effectiveness of RFMOs is impaired by: the use of consensus decision-making; placing national interests ahead of good fisheries governance; an unwillingness of members to fund research in support of management; time-lagged implementation of management decisions; a focus on crisis management rather than everyday fisheries management; and the lack of a real connection between day-to-day fisheries management requirements and an annual meeting based on diplomatic practice. However, there is a growing consensus that these fundamental issues require resolution if RFMOs are to be reinvigorated and become truly effective vehicles for sustainable fisheries management.

In an effort to improve their effectiveness, many RFMOs are implementing performance reviews. Most have opted for a mixed-panel approach, where there is a combination of internal and external professionals. Such an approach has many advantages, combining an intimate knowledge of the organization's operations and challenges with independent expert knowledge and input. A highly successful review, undertaken in collaboration with FAO, of the North East Atlantic Fisheries Commission (NEAFC) was concluded in 2006. This initial review paved the way for reviews of other RFMOs. Nonetheless, the international community recognizes that there are many differences among RFMOs, and it is essential that a flexible approach be adopted so that differences can be accommodated fully.

The RFMOs slated for performance reviews in 2008 include the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR).[29] The review of RFMOs responsible for the management of straddling fish stocks and highly migratory fish stocks established before the conclusion of the 1995 United Nations Fish Stocks Agreement (the Agreement) is especially important. This is to ensure that the Agreement's thrust and intent can be reflected in the revised mandates of these organizations. In 2007, the Northwest Atlantic Fisheries Organization completed an extensive review and amendment process in order to update its convention to bring it into line with the Agreement.

Despite pessimism in the international community about the lack of effectiveness of RFMOs and their inability or reluctance to take practical management decisions, steps have been taken, or are being taken, to establish new RFMOs where none existed previously. Once these have been established, nearly all of the world's major fish stocks will be covered by RFMOs, the major exception being straddling stocks in the Southwest Atlantic Ocean.

In 2006, following an initiative of the Ministerial Conference on Fisheries Cooperation among African States bordering the Atlantic Ocean,[30] FAO cooperated to establish the Fishery Committee for the West Central Gulf of Guinea. This organization complements two existing subregional organizations in adjacent areas (the Subregional Fisheries Commission and the Regional Fisheries Committee for the Gulf of Guinea). Each organization has fisheries management functions. Their goals are to support member countries in gathering information and developing plans as a means of contributing to improved fisheries management in West Africa.

Further initiatives to enhance fisheries governance are the negotiations in the Pacific Ocean to establish the South Pacific Regional Fisheries Management Organization (SPRFMO) and the Inter-governmental Meeting on Management of High Seas Bottom Fisheries in the North Western Pacific Ocean. Negotiations for both initiatives are based on principles of international law, the 1982 United Nations Convention on the Law of the Sea, and the 1995 United Nations Fish Stocks Agreement. The SPRFMO involves a large number of countries. Its goal is to establish an organization in which the precautionary and ecosystem approaches to fisheries management are applied in order to ensure the long-term conservation and sustainable use of fishery resources. The management focus is on non-tuna species, including discrete high seas stocks. The negotiations have been in train since 2006 and are expected to conclude in 2009. Consultations to establish the mechanism for the North Western Pacific Ocean commenced in 2006. The process involves four countries.[31] The nature and scope of the agreement for the proposed mechanism and the implementation of interim measures are under active discussion.

A major challenge for the international community is to bring agreements into force once negotiations have been concluded. In July 2006, the multilateral agreement to establish the South Indian Ocean Fisheries Agreement (SIOFA) was signed by six countries (Comoros, France, Kenya, Mozambique, New Zealand and Seychelles) and the European Community. Its purpose is to manage high seas fishing in the South Indian Ocean in order to ensure the long-term conservation and sustainable use of non-tuna resources. However, the SIOFA has not yet entered into force and it may not do so in the near future – there have been no ratifications, and no interim management measures for the target stocks have been agreed.

International cooperation is strengthened and many problems resolved through consultation and the timely exchange of information. For RFMOs, such exchanges are crucial in dealing with common issues such as IUU fishing and the harmonization of data formats. FAO and non-FAO RFBs have met biennially since 1999 to consider matters of common concern and to learn how different bodies handle and resolve similar problems. These meetings marked a watershed in cooperation among RFBs. In 2007, the nature and scope of cooperation was taken a step further with the First Meeting of Regional Fishery Body Secretariats Network. This meeting *inter alia* reviewed: decisions by the Committee on Fisheries (COFI) of relevance to RFBs (including their role); external factors affecting fisheries management; approaches to incorporate ecosystem considerations into RFB fisheries management programmes; the status of the Fisheries Resources Monitoring System (FIRMS);[32] and other relevant matters.

Independently of this FAO-led process for RFBs, the world's five tuna RFMOs have commenced an annual consultative process. They held their first meeting in Japan (Kobe, 26 January 2007) and their second meeting in the United States of America (San Francisco, 5–6 February 2008). Unlike the RFB grouping, all the tuna organizations have management functions, comparable management goals and similar challenges. In addition, most of the organizations have members in common, and often shared fleets. In at least one case, two RFMOs have overlapping mandates. Therefore, it is appropriate that they collaborate and seek to promote interregional harmonization on common issues including harmonized stock assessment, MCS, vessels monitoring systems (VMSs), vessel lists, trade and catch tracking systems, and transhipment controls. At the 2008 meeting, it was noted that all tuna organizations had taken

action to improve data sharing and strengthen MCS measures, primarily to deter IUU fishing.

At recent international fora, concern has been expressed that some RFMOs are failing to adopt management measures even where these are based on the best scientific advice available.[33] This failure is bringing the role and work of RFMOs into disrepute and jeopardizing their credibility. The 2008 report of the tuna RFMO meeting also referred to this issue. It noted that significant concern was shared among the RFMOs on the slow progress by some organizations in addressing matters such as the establishment of equitable and transparent allocation procedures, capacity control and management based on scientific advice. In fact, substantial concern was voiced regarding the consequences of RFMOs not adopting management measures consistent with the best available scientific advice. On this matter, there was criticism by Pacific Island parties and civil society in December 2007 concerning the failure of the Western and Central Pacific Fisheries Commission (WCPFC) to reach management decisions on bigeye and yellowfin stocks.[34] This situation has led to a souring of relations between Pacific Island countries and the distant-water fishing nations that are members of the WCPFC.

While RFMOs are the primary vehicles for promoting international cooperation for fisheries management, other organizations and mechanisms are also focusing increasingly on issues relating to fisheries and their long-term sustainability, the ecosystem, the environment and climate change, often in an integrated manner. The international community is encouraging broadening cooperation with these organizations and mechanisms, which include the White Water to Blue Water Partnership Initiative, the Association of Southeast Asian Nations (ASEAN), the Southern African Development Community (SADC), the MERCOSUR and the Regional Ministerial Meeting on Promoting Responsible Fishing Practices, including Combating Illegal, Unreported and Unregulated Fishing in the Region (Bali, Indonesia, 2007).[35]

Dealing with IUU fishing

The need to combat IUU fishing and related activities, now generally considered an environmental crime involving theft of resources,[36] is high on the international fisheries agenda. This is because IUU fishing constitutes a serious threat to: (i) fisheries, especially those of high-value that are already overfished (e.g. cod, tuna, redfish and swordfish); (ii) marine habitats, including vulnerable marine ecosystems; and (iii) food security and the economies of developing countries. The incidence of IUU fishing is also increasing in many areas,[37] undermining national and regional efforts to manage fisheries sustainably. There is international consensus that efforts to combat IUU fishing should focus on blocking fish from entering international trade, thereby depriving IUU fishers of financial reward. Hence, an increased burden is falling on the shoulders of port and market states, including both developed and developing states, to prevent the movement and laundering of IUU-caught fish through their ports and into their markets.

Countries acting as flag or port of non-compliance encourage IUU fishing, as they provide the flags for vessels to operate with few or no restrictions and the havens in which to base operations and to handle catches. A major initiative under way relates to the negotiation of a binding international instrument on port state measures (Box 7). It is being complemented by an innovative approach to flag state responsibility as the international community moves to develop criteria to assess flag state performance and to consider possible action against vessels flying the flags of states that fail to meet these criteria.[38] This approach changes the emphasis somewhat. While fishing vessels continue to be targeted, flag states will now be confronted directly, instead of indirectly as was generally past practice. This development should enable the international community to take more concrete action against irresponsible flag states.

The 2001 FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing calls on market states to implement

Box 7

Towards a legally binding agreement/instrument on port state measures

Illegal, unreported and unregulated (IUU) fishing undermines national and regional efforts to manage fisheries sustainably and inhibits progress towards improving ocean governance. The international community recognizes that it must be addressed in a comprehensive and multipronged manner, as evidenced by the approach taken to develop the 2001 FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU).

While not losing sight of the importance of the IPOA-IUU "toolbox" as a whole, international attention is focusing more intensely on the role of the port state in preventing IUU-caught fish entering international trade. If IUU fishers are unable to tranship or land IUU-caught product, or if the transaction costs associated with trying to launder it for sale through legitimate market channels are sufficiently high, the financial incentive to engage in IUU fishing will decline. This situation should, in turn, have a positive impact on the state of resources that have been targeted by IUU fishers.

The FAO Committee on Fisheries (the Committee) addressed the use of port state measures specifically to combat IUU fishing in 2005 and 2007. Initially, the Committee agreed that a lack of binding port state measures provided a loophole for IUU fishers. It endorsed the 2005 FAO Model Scheme on Port State Measures to Combat Illegal, Unreported and Unregulated Fishing (the Model Scheme) and encouraged countries to implement it. In 2007, the Committee further agreed that there was an urgent need to develop a new legally-binding instrument based on the IPOA-IUU and the Model Scheme.

Working to a tight timetable, in September 2007, FAO convened an Expert Consultation to Draft a Legally-binding Instrument on Port State Measures in Washington, DC, to elaborate an initial draft text for a legally-binding instrument. This meeting was followed in June 2008 by a technical consultation to negotiate a text for a binding international instrument. It will be forwarded to the Committee on Fisheries (COFI) in 2009 for review and consideration.

It is now clear that IUU fishing is fuelled and supported by IUU fishers transhipping, landing and laundering their illicit catches. By all accounts, IUU fishing continues to be a profitable activity. Profitability will not diminish until it becomes more difficult for IUU fishers to sell their catches.

Central to reducing the profitability of IUU fishing is the need to make the movement of IUU-caught product from the vessel to shore and on to the consumer's plate more onerous. Port states have a front-line role in ensuring that only legally harvested fish is landed and that opportunities and loopholes for laundering illegal catch are closed. States must ensure that effective port state controls are exercised, and that they do not permit IUU fishing vessels to use their ports for any purpose or for IUU-caught fish to be transhipped or landed. This situation could have an adverse impact on trade volumes in the short to medium terms. However, if unsustainable IUU fishing practices on stocks are not eradicated, fish supply levels may well decrease, leading to a decline in fish available for national consumption and international trade.

internationally-agreed market measures, consistent with WTO rules, to prevent the trade in IUU-caught fish.[39] Furthermore, several RFMOs have adopted catch and trade traceability schemes to ensure that only documented and legally-harvested product is offered for sale in member countries. The CCAMLR, CCSBT and Inter-American Tropical Tuna Commission (IATTC), for example, operate such schemes. The combination of national measures to block the importation of IUU-caught fish, RFMO traceability schemes, the implementation of flag state certification of catch schemes (e.g. such as those being implemented by the NEAFC and, shortly, by the EU) and enhanced port state measures should reinforce one another and reduce the opportunities for IUU products to enter international trade.

Underpinning efforts to address flag and vessel issues is FAO's work to consider the development of a comprehensive global record for fishing vessels, refrigerated transport vessels and supply vessels. It is seeking to develop a harmonized global list of fishing vessels, incorporating information from RFMO lists, national vessel registers and other sources that contain information on authorized vessels. An Expert Consultation on the Development of a Comprehensive Global Record of Fishing Vessels (FAO headquarters, Rome, 25–28 February 2008) addressed general concepts and policy considerations. It expressed the view that the global record would be an essential tool to ensure the effectiveness of port state measures. The Consultation also proposed a schedule of follow-up activities to be undertaken before COFI in 2009, where the matter will be considered further.

IUU fishing has severe impacts on developing countries. They are affected by IUU fishing, and often rampant IUU fishing (e.g. in West Africa), in their EEZs. In turn, because of a lack of capacity, they are handicapped in dealing with it. Furthermore, with the rise of catch and trade traceability schemes, many developing countries, at least initially, are likely to face the loss of market opportunities because of their inability to handle the technicalities associated with such schemes. This is a major concern for the international community and seen as an important reason for ensuring that capacity building to combat IUU fishing receives high priority in developing countries.

Given the serious harm caused by IUU fishing and the need to find more effective means of preventing the practice as soon as possible, a number of new ideas are being considered. An emerging proposal is whether RFMOs, in keeping with the philosophy of using financial incentives to influence IUU fishing, should levy charges on states issuing flags of non-compliance and whose vessels fish in a RFMO area.[40] The proponents of this approach argue that this compensation would be justified on the grounds that the members of these organizations incur higher participation fees because of IUU fishing (e.g. higher MCS costs that are paid for from members' contributions). In addition, as a result of IUU fishing, members are likely to have reduced fishing opportunities, with lower catches translating into lower incomes and profits.

In October 2007, the EU unveiled a new and forward-looking policy and legal framework on IUU fishing. It was introduced because the current EU framework could not guarantee that fisheries products imported from non-EU countries had been caught legally. The new framework hinges on reducing profit for IUU fishers and their collaborators. Two of its central tenets are to: (i) require flag states to certify that all imported fish has been harvested in a legal manner;[41] and (ii) impose sanctions on flag states that do not meet their international obligations. In addition, strict sanctions against EU nationals who engage in IUU fishing will be imposed, irrespective of whether they operate in the EU or abroad.

High seas fisheries

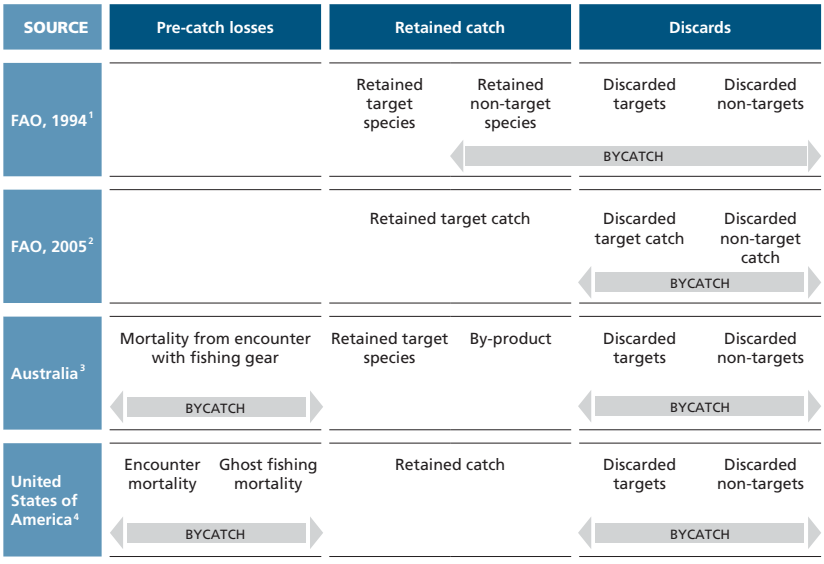
In line with international calls to address high seas fisheries governance and take account of the outcome of Deep Sea 2003 (an international conference on deep-sea fisheries held in Wellington, 27–29 November 2003), FAO embarked on work in 2006 to consider options for the management of deep-sea fisheries in the high seas. An initial

expert consultation (Bangkok, 21–23 November 2006) addressed key issues about these fisheries and proposed steps to: (i) enhance information exchange[42] in order to increase knowledge about these fisheries; and (ii) convene an FAO technical consultation to consider their management and to prepare guidelines and/or a code of conduct for management of these fisheries. In 2007, COFI considered the need for follow-up work and agreed that FAO should proceed with the elaboration of international guidelines (before 31 December 2008). A second expert consultation in 2007 (Bangkok, 11–14 September 2007) drafted guidelines that then formed the basis of negotiations at an FAO technical consultation (FAO headquarters, Rome, 4–8 February 2008). It was not possible to complete the work at that meeting, and the consultation was reconvened at FAO headquarters in August 2008. It is anticipated that international guidelines

Box 8

Replacing the bycatch concept in fisheries management?

In the last four decades, concern has been expressed by fishery managers and conservation/environmental groups that bycatch and discards may be contributing to biological overfishing and to altering the structure of marine ecosystems. In the last two decades, the search for solutions to the bycatch and discard problems has intensified, and bycatch has been reduced in several fisheries. However, in this period, the concept of what the term "bycatch" means to those both within and outside the fisheries sector has changed, and at this time there is no commonly accepted definition of the term.



[1] FAO. 1994. *A global assessment of fisheries bycatch and discards,* by D.L. Alverson, M.H. Freeberg, J.G. Pope and S.A. Murawski. FAO Fisheries Technical Paper No. 339. Rome.
[2] FAO. 2005. *Discards in the world's marine fisheries. An update,* by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome.
[3] Ministerial Council on Forestry, Fisheries and Aquaculture. 1999. *National Policy on Fisheries Bycatch.* Canberra, Department of Agriculture, Fisheries and Forestry.
[4] National Marine Fisheries Service. 2003. *Evaluating bycatch: a national approach to standardized bycatch monitoring programs.* Silver Spring, United States of America, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

endorsed by the consultation will be submitted to COFI in 2009 for consideration and approval.

Highly migratory species and straddling stocks

To promote participation in, and the implementation of, the 1995 United Nations Fish Stocks Agreement (the Agreement), and as a means of strengthening its position in customary international law, it is anticipated that the sixty-third session of the United Nations General Assembly in 2008 will agree to resume the Review Conference that was suspended in 2006. With a growing number of parties to the Agreement (68 parties in total as at March 2008), there is a consensus by both parties and non-parties that more intense dialogue is required to eliminate obstacles that are currently preventing non-

Already, in 1992, Murawski noted: "the use of the term bycatch adds considerable confusion to a topic that is already complex to both scientists and managers."[1] The term is relatively imprecise in that it constitutes a value judgment and may be inaccurate when used over any extended time to describe an element within a multi-species catch. In essence, "yesterday's bycatch may be today's target species."

The various components of recent key bycatch definitions are shown in the accompanying table. The definition used by FAO (2005) is the narrowest, and will lead to a lower estimate of bycatch than the other three, as it includes neither "retained non-target species" (referred to as incidental catch in FAO (1994) nor "unobserved mortalities". Therefore, in order to be useful for decision-makers and in public debates, any estimate of bycatch should be accompanied by a statement of which definition of bycatch has been used.

However, apart from being imprecise, the concept of bycatch has another weakness. It is not quite adequate for the modern fisheries manager. Given the present trend to move from single species to multispecies management and application of the ecosystem approach to fisheries, managers must manage more than catch and bycatch. They are expected to manage fisheries so that landings are sustainable, discarded catch minimized and pre-catch losses (unobserved mortality) reduced.

Fishers will probably always think in terms of catch and bycatch, but for scientists and managers these concepts are now too crude. Fishing is probably easer to manage if thought of in terms of pre-catch losses, landings and discarded catch. The term "catches", when used, then consists of landings and discarded catch.

[1] S.A. Murawski. 1992. The challenges of finding solutions in multispecies fisheries. *In* R.W. Schoning, R.W. Jacobson, D.L. Alverson, T.G. Gentle and J. Auyong, eds. *Proceedings of the National Industry Bycatch Workshop, February 4–6, 1992, Newport, Oregon*, pp. 35–45. Seattle, United States of America, Natural Resources Consultants, Inc.

parties from ratifying the Agreement. This development, which surfaced strongly at the seventh round of Informal Consultations of the States Parties to the Agreement (New York, United States of America, 11–12 March 2008), is seen as a highly positive one, reflecting good will by all participants to deepen implementation through increasing participation. A highly encouraging parallel development is the extent to which some non-parties are also taking steps to implement key aspects of the Agreement. Significantly, the 2008 seventh round of Informal Consultations of the States Parties to the Agreement identified a lack of capacity in developing countries as a barrier to its wider acceptance and implementation.

Bycatch and discards

In their various forms, bycatches can have significant consequences for populations, food webs and ecosystems. In recent decades, a broad-based public consensus has developed around the view that bycatch should be minimized to levels approaching insignificance (Box 8). This view, as reflected in worldwide legislation and agreements, demonstrates the widely-held belief that discarded portions of fishery catches represent an unacceptable waste of natural resources. Although no detailed estimate of bycatch is available, a crude estimate suggests that it could be more than 20 million tonnes globally (equivalent to 23 percent of marine landings) and growing. Decreases in abundance of traditional species, falling catch revenues, new markets for non-traditional species, increased demand for raw material for animal feeds and changes in regulations to prohibit discarding are all factors that may contribute to increased landings of non-target species.

However, global awareness of the bycatch problem has produced results. Turtle mortalities have been reduced through: (i) wider use of turtle excluder devices in shrimp trawl fisheries (these devices are a prerequisite for shrimp exports to the United States of America; and (ii) the promotion and use of circle hooks in pelagic longline fisheries. Although economically and ecologically important, less-charismatic bycatch species (including juveniles) have yet to be treated with the same intensity. In many fisheries, they remain a source of unregulated and unreported fishing mortality.

Global awareness on bycatch has also benefited seabirds. The IPOA and NPOA for seabirds (IPOA/NPOA-S) have stimulated improvements in seabird-avoidance techniques in commercial longline fisheries. However, while unreported and unobserved bycatch is a component of IUU fishing, the IPOA on IUU has tended to focus on illegal fishing. It may be that progress in managing bycatch species and reducing discards would be best served through a separate and focused international initiative.

As globally there are few management regimes that regulate and report on retained or discarded bycatch species, there is no way of knowing the true magnitude of the problem. Making all retained species a component of specific fisheries management arrangements remains a priority for those pursuing an ecosystem approach to fisheries. The lack of comprehensive monitoring programmes to assess bycatches and integrate them into population and multispecies models seriously impedes a full understanding of bycatch consequences and the efficacy of measures for their amelioration.

Aquaculture

Until about two decades ago, apart from very few subsistence operations, aquaculture production was largely market-driven. More recently, many governments around the world have been playing a more proactive role in aquaculture development. This role has been changing gradually and varying in nature depending on the importance or potential of aquaculture in the socio-economic life of the various countries.

Even where aquaculture has been designated among the strategic sectors and industries, and endorsed by policy-makers as a source of livelihood and a contributor to economic growth, poverty reduction or balance of payments, its most recent expansion has still been driven by the profit incentive. However, this time, it has been

accompanied by government involvement. In some cases, governments have intervened deliberately to provide fiscal and other incentives to entrepreneurs. Some countries in Africa are in the process of drafting aquaculture fiscal codes. Others have maintained an enabling economic environment in which entrepreneurs can compete but, having learned from earlier mistakes, they use good-governance tools to limit *laissez faire* excesses.

For entrepreneurs, good governance means providing law and order. In practice, it may mean: drafting a legislative framework; ensuring property rights; administering aquaculture regulations transparently; processing aquaculture licences rapidly and equitably; encouraging self-regulation through voluntary codes of practice; and promoting innovative, less-polluting production technologies. Many countries, both developed and developing, have enacted (or are in the process of drafting) national aquaculture legislations and regulations that govern the licensing, monitoring and control of aquaculture. These legal instruments ensure that any development of the industry is founded on sustainable ventures, is appropriately located, and is carried on in accordance with high standards of environmental and ecological protection. Most laws and regulations cover several aspects of the supply side of aquaculture, including planning and access, water and wastewater, seed, feed, aquaculture investment, and fish movement and disease control.

In terms of planning and access to productive resources, some countries have regulations regarding aquaculture zones. Under these regimes, aquaculture can only take place in designated zones, and any person wishing to engage in aquaculture must first apply for and obtain an aquaculture licence. In many instances, unlicensed operations can entail a fine, imprisonment or the destruction of the operation – or any combination of the three penalties. In some countries, there are also species-specific zones; only in particular zones can certain species be farmed. The challenge for many governments would be to license or register existing farms, in particular large numbers of small operations, which may not even qualify as an aquaculture operation. Although small in size, collectively they account for large areas of land that could continue to affect sustainability.

There are also laws and regulations on water access and use, and wastes. In most countries, the right to put up any structure in open water areas, such as fish traps and fish cages, or to dam flowing water for exclusive private use, requires a permit from the designated authority. However, such laws are often difficult to enforce because it is not always possible to monitor these activities. In many instances, local communities and/or farmers' associations manage water resources and resolve conflicts. Multiple uses of water, such as integrated fish–rice farming, have also been encouraged as an efficient way of using scarce water and a means of minimizing conflicts. In developed countries and in many developing countries where aquaculture is important, the governing authority generally defines effluent guidelines or standards for aquaculture wastewater discharges. In most cases, these are based not on risks or impacts upon receiving waters but on the performance of the technologies used for the treatment and control of the wastes. In many cases, the standards have been adopted from other countries. Aquaculture operations that intend to discharge wastewater must obtain a permit before initiating a discharge. The permit specifies the conditions and effluent limitations under which the operation may make a discharge, and it establishes pollutant monitoring and reporting requirements.

Seed production and seed quality are gradually becoming a focus for policies and regulations. In order to increase seed supply, some governments provide incentives to farmers in the form of soft loans or tax exemptions in lieu of subsidized seed produced from government hatcheries (government hatcheries are progressively being phased out). These incentives can be oriented to particular species that are deemed to have potential commercial value. In order to improve seed quality from the private sector, in many places, seed producers must be certified, and seed quality standards, which are often species-specific, are formulated and published. National and local seed inspection and certification committees ensure that these standards are adhered to by

certified producers. Moreover, many countries have legal provisions on the movement of fish (including broodstock and seed). In such countries, any introduction or import of eggs, fry, fingerlings or broodstock must be subjected to quarantine for evaluation and decision. There are also export regulations. The aim is to protect and maintain aquatic biosecurity and, in particular, to limit the spread of diseases within and beyond national boundaries. Some countries have established domestication and broodstock development and management programmes for some commercial species. This trend is continuing with significant success. However, because of the high costs of monitoring and enforcing the law, there are still many places in developing countries where aquatic animals move freely, without any inspection or certification.

Where aquaculture is developed, governments have generally focused on the quality of feed used, and set and controlled feed standards by regulation. Licences must be obtained for feed, additives and/or premixes produced domestically or imported. However, as with seed quality, monitoring can be constrained by a lack of financial resources or skilled personnel. In addition, the majority of fish feed in developing countries is still supplied by small, artisanal fish-feed units that usually do not adhere to any quality standards.

A further governance tool used by governments is that of promoting and supporting investments by small-scale farmers through economic incentives (including subsidized credit and collateral-free loans). A number of countries offer fiscal incentives, such as exemptions on, or reductions in, income tax, land taxes, sales taxes and import duties, to domestic and foreign investors. Some governments have also encouraged foreign investment but with limits on the extent of foreign participation. For the policy to be successful, they guarantee capital and profit repatriation. Where this has been applied, foreign participation has increased rapidly, especially in marine and brackish-water aquaculture.

Self-policing is becoming increasingly common. Farmers, particularly those with long-time horizons, are increasingly building on the FAO Code of Conduct for Responsible Fisheries (CCRF) to elaborate, support and enforce self-regulating management codes. Most have realized that it is in their best interests to minimize pollution because the latter directly affects their operations. However, there are arguments that self-regulation and environmental safeguards through voluntary codes of practice are ineffective forms of governance in the absence of binding legal obligations to enforce rules. Nevertheless, there are success stories on efficient self-regulation through cluster management. There is also evidence that, by empowering small-scale farmers, compliance with voluntary codes has improved the environmental sustainability of their operations, so enabling them to gain better access to international markets and to improve their competitiveness.

Having learned from past mistakes, many countries, early movers as well as newcomers in aquaculture, now emphasize environmental sustainability and social responsibility. In addition to laws and regulations, and voluntary codes of practice that aim to ensure environmental integrity, some of the means of achieving this goal include innovative, less-polluting production techniques, such as those based on the ecosystem approach to aquaculture (which emphasizes management for sustainability). In this regard, tools and indicators have been developed for the purpose of assessing and monitoring not only the impacts of aquaculture on the environment, but also the impacts of the environment on aquaculture and site selection.

In terms of improving social responsibility, governments are defining minimum wages, improved labour conditions, worker welfare systems, etc. – which are being embraced by many lobbyists. Certification systems for aquaculture practices and products are beginning to include standards for monitoring social responsibility and equity.

The international dimension of aquaculture governance is gradually gaining ground. For example, the EU has legislation on aquaculture and its value chain. It includes regulations on food additives, animal diseases, environment, labelling and packaging, marketing, research, sanitary and hygiene measures, structures and third

countries. These regulations are directly applicable and binding in all EU Member States without the need for any national parallel legislation. There is also an extensive array of international agreements, standards and procedures already in place for various aspects of aquaculture and its value chain elsewhere. Compliance with some of these agreements, standards and procedures is mandatory, and recognized competent authorities are empowered to verify compliance with these requirements.

The lack of financial and skilled human capacity to establish, monitor and enforce regulations in developing countries could particularly threaten efforts to govern aquaculture properly, thereby limiting its development in many countries. Most countries also have limited financial resources with which to monitor and enforce regulations. There is no indication that this situation will improve soon, particularly in countries with large numbers of small-scale farmers. There are still opportunities for self-governance, by empowering small-farmers through clustering, but significant effort will be required to realize their full potential. Policies and regulations may be enacted but, unless there are sufficient government personnel with adequate skills and financial resources to monitor and enforce them, they will remain ineffective. The lack of resources for monitoring and enforcement may be as critical as the absence of legislation or regulations.

There are many instances where regulations are overly cumbersome. Overregulation stifles entrepreneurial initiative and motivation – the very ingredients necessary for successful aquaculture. To avoid overregulation, policy-makers use a number of options, including consultation with farmers and other stakeholders, and they conduct a mandatory review of the costs and benefits of regulations prior to enactment.

Not only can the number of regulations hinder aquaculture development, the time to process regulations can have a similar effect. An example is the obligation to acquire permits or licences, which is now common in developed and developing countries. Depending on the country, it can take from three months to several years to obtain new licences to farm. To expedite the response to licence requests, some countries impose time constraints on the processing of the applications. In such countries, a decision has to be given within the established time limit; otherwise, the applicant has de facto a permit.

Trade and fisheries subsidies

New disciplines governing the use of subsidies in the fisheries sector are being negotiated in the WTO. This follows the WTO Ministerial Declaration mandating participants "to clarify and improve WTO disciplines on fisheries subsidies, taking into account the importance of this sector to developing countries" (paragraph 28, 20 November 2001). Much progress has been achieved since the negotiations were launched. In November 2007, the Chair of the group negotiating fisheries subsidies tabled a Chair's draft text. The Chair's draft proposes a broad ban on subsidies that contribute to overfishing and overcapacity. It also proposes general exceptions to the prohibitions for all WTO members and special and differential treatment (S&DT) for developing countries. However, the general exceptions and S&DTs are conditional on WTO members having in place a fishery management system designed to prevent overfishing. The Chair's text proposes that WTO members who wish to grant a subsidy that would fall under the general exception or S&DT provisions must notify FAO of their management system. It is proposed that FAO then undertake a peer review of the management system prior to the granting of the subsidy. However, at this stage, it should be noted that the negotiations in the WTO are still under way. When the fisheries subsidies negotiations have been concluded, the agreed text will clarify FAO's intended role and the nature of the peer review.

Following the accession of China and Viet Nam to the WTO in 2001 and 2007, respectively, all major fish producing, importing and exporting countries are members of the organization, with the exception of the Russian Federation. Countries whose accession is expected to be ratified in 2008 are Cape Verde and Ukraine. Parallel to the increase in WTO membership, a number of bilateral trade agreements with

strong relevance to fish trade have entered into force. The full impact of such bilateral agreements and regional trade agreements, in addition to (or in substitution of) broader multilateral agreements, remains to be seen. One trade agreement of significant relevance for trade in fish and fishery products is being negotiated at the regional level between six African, Caribbean and Pacific regions and the EU. The intention was to arrive at regional Economic Partnership Agreements (EPAs) and make them operational from January 2008. The deadline was important, as the waiver granted by the WTO to the preferences in the Cotonou Agreement expired at the end of 2007. However, by the deadline, only one region, the Caribbean, had concluded a full EPA with the EU.

Whereas the least developed countries (LDCs) from all regions continue to benefit from free market-access preferences to the EU market under the Everything But Arms initiative, this is not the case for non-LDCs. Therefore, many of these have entered into interim agreements with the EU. In total, 35 African, Caribbean and Pacific countries had entered into full or interim agreements by the end of 2007. Some of these agreements also include chapters on fisheries development and cooperation. Countries that are neither LDCs nor signatories to interim or full agreements can continue to export to the EU market under the EU's Generalised System of Preferences. However, this will lead to higher import duties for their products from 2008 onwards.

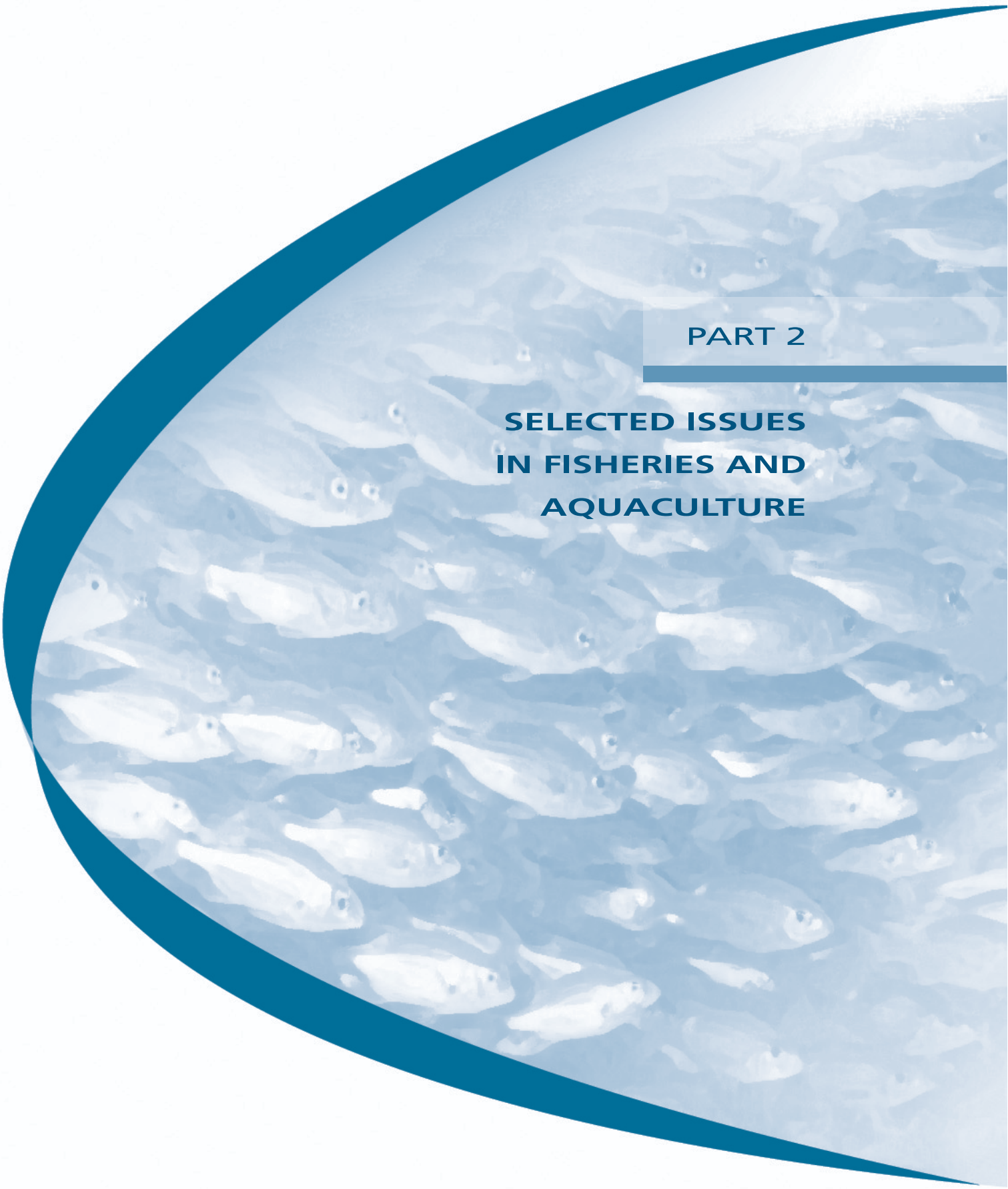
NOTES

1. See, in particular, FAO. 2002. *The State of World Fisheries and Aquaculture 2002*, Box 2, p. 9. Rome.
2. Comparing 1996 and 2006 data, the number of species items in the FAO database rose from 68 to 120, and unidentified catches reported above the family level fell from 68.3 to 57.1 percent.
3. The term "other aquatic animals" also includes amphibians (frogs) and reptiles (turtles). For brevity, referred to hereafter as "fish, crustaceans and molluscs" or "food fish supply" or "aquatic animals".
4. The regions match those presented in the "Outlook" section of this document.
5. While mussels and oysters are high-priced per kilogram of meat, they are relatively low-valued in terms of value per kilogram of whole animals, as shell weight can account for a large percentage of the total (live) weight. Statistics on aquaculture production are reported as live weight.
6. The production of aquatic plants is not considered in the figures in the remainder of this section.
7. FAO. (forthcoming). *Prospective analysis of aquaculture development: the Delphi method*. Fisheries Technical Paper No. 521. Rome.
8. A "maru-ship" is a Japanese ship operated partially by a non-Japanese crew.
9. EEA 18 consists of EU 15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom) plus Iceland, Liechtenstein and Norway.
10. The ten new EU members: Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. No fleet data available for the land-locked countries (Czech Republic, Hungary and Slovakia).
11. For the EEA 18 members, no fleet report is available for the land-locked countries (Austria, Liechtenstein and Luxembourg.
12. The five case studies were: Status and trends of the fishery resources of Lake Constance (by R. Rösch); Status and trends of the Lake Victoria fisheries (by J. Kolding and O. Mkumbo); Status and trends of the fishery resources of the Amazon Basin in Brazil (by M.L. Ruffino); the Tonle Sap fishery (based on data provided by the Inland Fisheries Research and Development Institute (Cambodia) and the Mekong River Commission; and Review of the fisheries of Kyrgyzstan (produced under project GCP/GLO/162/EC). FAO intends to publish the five case studies in full.
13. J. Kolding, P. van Zwieten, O. Mkumbo, G. Silsbe and R. Hecky. 2008. Are the Lake Victoria fisheries threatened by exploitation or eutrophication? Towards an ecosystem based approach to management. *In* G. Bianchi and H.R. Skjoldal, eds. *The ecosystem approach to fisheries*. (in press). CABI Publishing.
14. If the estuarine fisheries are included, Amazon landings in the last decade averaged 23 percent.
15. Estimate based on consumption surveys (K.G. Hortle. 2007. *Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin*. MRC Technical Paper No. 16. Vientiane, Mekong River Commission). Most fish is caught by subsistence fisheries, but large commercial fisheries also take place, particularly in Cambodia and Viet Nam.
16. A dai is a bagnet or a stationary trawl.
17. A larger inundated area increases both fish habitat and availability of food.
18. World Trade Organization. 2007. *World Trade Report 2007*. Geneva.
19. Fish import figures differ from export figures because the former are usually reported in c.i.f. (cost, insurance and freight), whereas exports are reported at f.o.b. (free on board) values.
20. Cod and related species.

21. Statistics reported in this section are based on data published in FAO. (forthcoming). *Fish and fishery products. World apparent consumption statistics based on food balance sheets. Revision 9: 1961–2005*. FAO Fisheries Circular No. 821. Rome. Some discrepancies may occur with other sections that quote data made available to FAO more recently. Food Balance Sheet (FBS) data calculated by FAO refer to "average food available for consumption", which, for a number of reasons (for example, waste at the household level), is not equal to average food intake or average food consumption. It should be noted that the production of subsistence fisheries as well as border trade between some developing countries could be incorrectly recorded and might therefore lead to an underestimation of consumption.
22. The term "fish" indicates fish, crustaceans and molluscs, including frogs and turtles, excluding crocodiles, alligators, aquatic mammals and aquatic plants.
23. The database of the United Nations Population Division can be accessed at http://esa.un.org/unup/
24. In January 2008, the World Bank and the World Conservation Union (IUCN) convened the first global workshop on corruption in fisheries (Fisheries and Corruption – from bad to worse, Washington, DC, 30–31 January 2008). It addressed wide-ranging issues including: types of corruption in fisheries; corruption and allocation of resources; corruption along the value chain; transboundary corruption and collusion; and the limits of responsible fish politics. The meeting also considered governance and anti-corruption strategies and how to clean up corrupt practices. In comparison, governance and corruption issues in the timber sector are fairly well studied and documented.
25. Very few countries have developed national plans of action (NPOAs) to manage fishing capacity, as called for in the 1999 FAO International Plan of Action for the Management of Fishing Capacity. Largely reflecting the political consequences of fleet reduction programmes, it is probably the least implemented of the four international plans of action. Information available to FAO indicates that about ten NPOAs–Capacity have been elaborated. There is little information on the extent to which these NPOAs are being implemented.
26. The 2007 Regional Consultative Workshop on Managing Fishing Capacity and IUU Fishing in the Asian Region adopted a call to action in which it was agreed that fleet overcapacity and IUU fishing threaten economic development and food security, and that the proactive tackling of capacity and IUU fishing delivers concrete benefits throughout the fisheries sector and economy generally. See FAO. 2007. *Managing fishing capacity and IUU fishing in the Asian region*. AFPIC Regional Consultative Workshop. RAP publication 2007/18. Bangkok.
27. The European Union (EU) recognizes this situation in its new policy and legal framework to combat IUU fishing. In a press release on 17 October 2007, the EU pointed out that "cooperation with our partners remains vital in any attempt to defeat international crime. For that reason, in addition to the new measures we are putting in place within the EU, intensified cooperation with our international partners will be key to our success, as will support to developing countries to protect their own resources against yet further plunder". The press release went on to say that "fighting illegal fishing effectively can have a tremendously positive effect for many developing countries, their economies and their natural resources. Under both its Common Fisheries Policy and its development cooperation, the EU will therefore prepare a series of accompanying measures in the coming two years to help developing countries to fight IUU operations more effectively".
28. Capacity building should be an ongoing activity because of the continual loss of trained human resources. In some countries, including small island developing states, the "brain drain" from the public sector to the private sector and abroad is often acute, necessitating that capacity building be continued almost on a regular basis.

29. The purpose of the performance reviews is to identify the strengths, weaknesses and performance gaps. Their recommendations provide guidance *inter alia* on remedial measures to enhance RFMO performance. Actions to implement the recommendations, which depend on the will and agreement of members, have the potential to be controversial and difficult.
30. The Ministerial Conference on Fisheries Cooperation among African States bordering the Atlantic Ocean was created under the 1991 Dakar Convention to promote cooperation concerning fisheries management and development in West Africa. It has played an important role in several regional meetings concerning different fisheries issues including regional monitoring, control and surveillance cooperation. The jurisdiction of the Conference extends from Morocco to Namibia, and as such is the only organization covering the whole West Africa region, although it is only open to coastal states.
31. The four countries involved are Japan, the Republic of Korea, the Russian Federation and the United States of America.
32. The Fisheries Resources Monitoring System (FIRMS) aims to assemble systematically comprehensive and reliable information on fisheries and fishery resources at the national, regional and global levels. An FAO initiative, FIRMS operates in partnership with RFBs.
33. These international fora have included the seventh round of Informal Consultations of the States Parties to the 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 (UN Headquarters, New York, United States of America, 11–12 March 2008).
34. The Western and Central Pacific Fisheries Commission (WCPFC) area accounts for more than 50 percent of world tuna catches. The management measures that were rejected sought to reduce: (i) the impact of purse seining on juvenile bigeye and yellowfin; and (ii) longline catches of adult bigeye.
35. The initiative relating to the Regional Ministerial Meeting on Promoting Responsible Fishing Practices, including Combating Illegal, Unreported and Unregulated Fishing in the Region involves Southeast Asian countries as well as Australia, Papua New Guinea and Timor-Leste. It is an interesting type of cooperation in that the initiative spans Asia and the Pacific regions.
36. See for example note 26. See also the UK Royal Institute of International Affairs (Chatham House). 2008. *The growth and control of international environmental crime – summary report*. London.
37. For example, in the Pacific Islands, IUU fishing is increasing as tuna stocks in other parts of the world decline. This fishing is undertaken by vessels of both members and non-members of the WCPFC. It is estimated that IUU catches in the WCPFC area could be as high as 10 percent of reported catches, or 200 000 tonnes in total. (Information summarized from an interview with the Executive Director, WCPFC, in *Islands Business*, December 2007).
38. The outcome of an initial March 2008 consultation on flag state responsibility led by the Governments of Canada and Iceland is expected to provide input for an FAO expert consultation prior to COFI in 2009.
39. There is a high degree of international acceptance that countries are at liberty to restrict or ban the import of IUU-caught fish because it is seen as equivalent to a stolen product. Restricting imports of such fish is not an impediment to international trade, and such action would be deemed consistent with WTO rules.
40. M. Gianni. 2004. IUU fishing and the cost to flag of convenience countries. Paper presented at *Workshop on Illegal, Unreported and Unregulated Fishing Activities*, 19–20 April 2004. Paris, OECD.

41. The requirement for flag states to certify that all imported fish has been harvested in a legal manner took effect on 1 May 2007. It is now being imposed by all NEAFC members for frozen fish imports.
42. With respect to the promotion of information and knowledge, the expert consultation recommended that FAO, in collaboration with RFMOs and other relevant mechanisms, should: undertake a global review of high seas deep-sea fisheries; review legal issues pertaining to the management of these fisheries; conduct research aimed at the reconstitution and analysis of historical high seas deep-sea fisheries data; identify and promote cost-effective ways for research on fisheries and habitats; and address the issue of defining destructive fishing in the deep sea and provide further guidance on reducing such practices.



PART 2

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

Climate change implications for fisheries and aquaculture

THE ISSUE

Climate change is a compounding threat to the sustainability of capture fisheries and aquaculture development. Impacts occur as a result of gradual warming at the global scale and associated physical changes, as well as consequences of the increased frequency of extreme weather events. These take place in the context of other global social and economic pressures on natural resources and ecosystems. In addition to action to mitigate the factors driving climate change, urgent adaptation measures are required in response to opportunities for and threats to food and livelihood provision arising from climate variations.

Physical and biological impacts

In terms of physical and biological impacts, climate change is modifying the distribution of marine and freshwater species. In general, warmer-water species are being displaced towards the poles and experiencing changes in habitat size and productivity. In a warmed world, ecosystem productivity is likely to decline in lower latitudes (i.e. most tropical and subtropical oceans, seas and lakes) and increase in high latitudes. Increased temperatures will also affect fish physiological processes, resulting in both positive and negative effects on fisheries and aquaculture systems.

Climate change is already affecting the seasonality of particular biological processes, altering marine and freshwater food webs, with unpredictable consequences for fish production. Increased risks of species invasions and the spread of vector-borne diseases raise additional concerns.

Differential warming between land and oceans and between polar and tropical regions will affect the intensity, frequency and seasonality of climate patterns (e.g. El Niño) and extreme weather events (e.g. floods, droughts and storms) and, hence, the stability of marine and freshwater resources adapted to or affected by them (Box 9).

Sea-level rise, glacier melting, ocean acidification and changes in precipitation, groundwater and river flows will affect coral reefs, wetlands, rivers, lakes and estuaries significantly. Such changes will require adaptive measures in order to exploit opportunities and to minimize negative impacts on fisheries and aquaculture systems.

Impacts on fisheries and aquaculture

The impacts of the above-mentioned changes on fisheries-dependent and aquaculture-dependent communities will be as varied as the changes themselves. In general, the strength of these impacts will depend on the vulnerability of each community. Community vulnerability depends on the sensitivity of the community and its exposure to the impacts, as well as its adaptive capacity (Box 10).

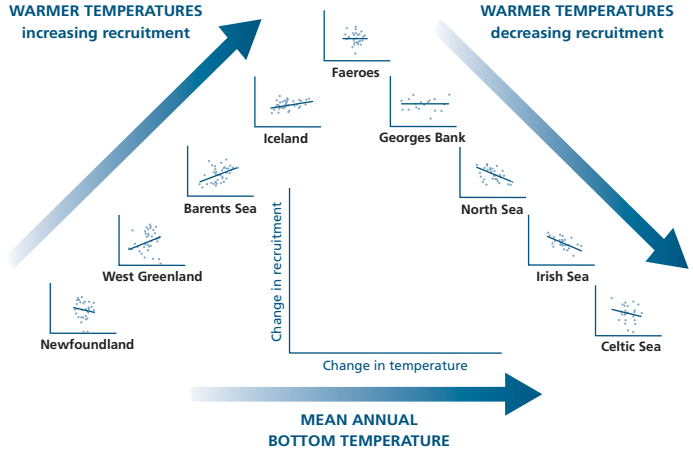
Aquatic-resource-dependent communities may face increased vulnerability in terms of less stable livelihoods, decreases in the availability and/or quality of fish for food, and risks to their own health if, for example, fishing under harsh weather conditions or farther from their home base. Overall, the impacts will result in changes, both positive and negative, in production and marketing costs, changes in the prices for fishery and aquaculture products, and increased risks of damage to or loss of infrastructure, tools and housing.

Fisheries located in the high latitudes and those reliant on systems particularly susceptible to climate change, such as upwelling and coral reef systems, appear to have

Box 9

Varying impacts of warming waters

Owing to the bell-shaped relationship between changes in stock recruitment and bottom temperatures (SST) for various cod stocks in the North Atlantic, populations at the poleward extents of their ranges tend to increase in abundance with warmer temperatures, whereas those in equatorial parts of their range tend to decline as temperatures warm.



Note: North Sea cod stock populations at the northern extents of their range tend to increase in abundance with warmer temperatures, whereas those more towards the southern parts of their range tend to decline in abundance as temperatures warm.

Source: Modified from B. Planque and T. Frédou. 1999. Temperature and the recruitment of Atlantic cod *(Gadus morhua). Canadian Journal of Fisheries and Aquatic Sciences,* 56(11): 2069–2077.

the highest potential exposure to impacts. In addition, fisheries communities located in delta or on coral atolls and ice-dominated coasts will be particularly vulnerable to sea-level rise and the associated risks of flooding, saline intrusion and coastal erosion. Of particular concern will be those regions with low adaptive capacity to change, such as the countries of sub-Saharan Africa (SSA). Coastal communities and small island states without proper extreme-weather adaptation programmes, in terms of infrastructure design, early warning systems and knowledge of appropriate behaviour, will also be at high risk.

In relation to aquaculture and in terms of its production, Asia is the core and possibly the most sensitive continent for the time being. However, recognizing the high growth potential for aquaculture in Africa and Latin America, as well as in other regions, there is the need to address climate change implications in these continents, more specifically in relation to future aquaculture developments.

New opportunities and positive impacts (e.g. from changes in species and new markets) will also be part of future changes. At the moment, these opportunities are not well understood, but they will depend on adaptive capacity.

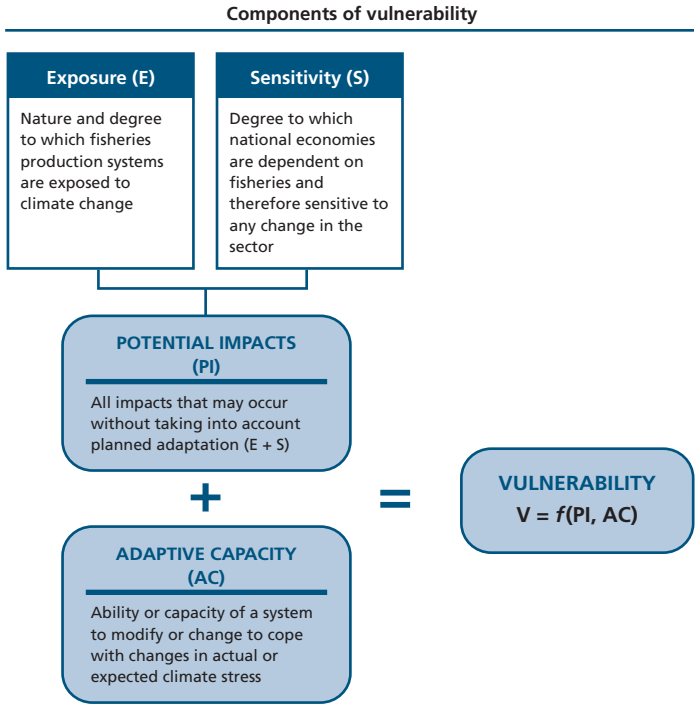
Carbon footprint of the fisheries and aquaculture sector

Fisheries and aquaculture activities make a minor but significant contribution to greenhouse gas (GHG) emissions during production operations and the transport, processing and storage of fish. There are significant differences in the emissions associated with the subsectors and with the species targeted or cultured.

Box 10

Components of vulnerability

The factors that determine the vulnerability of fisheries-dependent and aquaculture-dependent communities can be summarized thus:



Source: FAO. 2007. *Building adaptive capacity to climate change. Policies to sustain livelihoods and fisheries.* New Directions in Fisheries. A Series of Policy Briefs on Development Issues. No. 08. Rome.

The average ratio of fuel to carbon dioxide (CO_2) emissions for capture fisheries has been estimated at about 3 teragrams of CO_2 per million tonnes of fuel used. Good fisheries management can substantially improve fuel efficiency for the sector as a whole. Overcapacity and excess effort lead to lower catches per unit of effort and, therefore, lower fuel efficiency, while competition for limited resources can create incentives to increase engine power.

Energy consumption in aquaculture, which includes that consumed in producing fish food, tends to be higher in shrimp and carnivorous finfish farms and lower in omnivorous finfish, mollusc, bivalve and algae farms. Estimates of the ratio of edible protein energy output to industrial energy inputs for these species range from 1.4 to more than 100 percent, respectively.

As in all food production sectors, post-harvest activities entail stocking, packaging, transport and post-consumption waste – all linked with CO_2 emissions. Of special note in the post-harvest/trade operations are the particularly high emissions per kilogram of aquatic products that are transported by air. Intercontinental airfreight may emit 8.5 kg of CO_2 per kilogram of fish transported. This is about 3.5 times that for sea freight and more than 90 times that from local transportation of fish where it is consumed within 400 kilometres of catch. The continuing internationalization of the fish trade, upon which many developing nations depend for valuable export earnings, will increase fisheries' contributions to CO_2 emissions. Therefore, there are potential

trade-offs to consider between developing-country export benefits and air transport mitigation efforts. However, these aspects need to be considered in relation to the relatively minor contribution of the fisheries and aquaculture sector to GHG emissions as a whole.

POSSIBLE SOLUTIONS

The future impacts of climate change on fisheries and aquaculture are still poorly understood. The key to minimizing negative impacts and maximizing opportunities will be understanding and promoting the wide range of creative adaptive strategies – implemented by public institutions or the private sector – and their interactions with existing policy, legal and management frameworks.

Addressing the potential complexities of climate change interactions and their possible scales of impact requires the mainstreaming of cross-sectoral responses into governance frameworks. Responses are likely to be more timely, relevant and effective where they are brought into the normal processes of development and engage people and agencies at all levels. This requires not only the recognition of climate-related vectors and processes, and their interaction with others, but also the availability of sufficient information for effective decision-making and approaches that engage the public and private sectors.

The potential for the spatial displacement of aquatic resources and people as a result of climate change impacts and the impacts on transboundary resources requires

Box 11

Capacity building for climate change planning

Policy-making and action planning in response to climate change will require cooperation and coordination across a range of government line agencies and departments as well as community or political representatives at subnational and national levels. It will also be necessary to build and strengthen partnerships among public, private, civil society and non-governmental sectors. In addition:

- Nationally, information gaps and capacity-building requirements need to be identified and addressed through networks of research, training and academic agencies.
- Internationally, networks should be created or developed that encourage and enable regional or global exchanges of information and experiences, linking fisheries issues with those of other sectors such as water management, community development, trade and food security.
- Existing management plans for the fisheries and aquaculture sector, coastal zones and watersheds need to be reviewed and, where appropriate, further developed to ensure they cover potential climate change impacts, mitigations and adaptation responses. Connections to wider planning and strategic processes also need to be identified and adjusted.
- Communication and information processes that reach all stakeholders will be essential elements in sectoral responses. This will require focused application by communication specialists to ensure that the information is accessible and usable, presenting diverse and complex issues in a form that is targeted and understandable for each audience.

that existing regional structures and processes be strengthened or given more specific focus. Policy and legal mechanisms that address these issues will need to be developed or enhanced. Regional market and trading mechanisms are also likely to be more important in linking and buffering supply variability and maintaining sectoral value and investment.

Although generally perceived as having only negative impacts, climate change may provide the sector with an additional positive impetus to move towards sustainability. For example, the resilience and adaptive capacities of aquatic-resource ecosystems, fisheries and aquaculture production systems, and of aquatic-resource-dependent communities should be increased by applying existing good governance and management principles and approaches. Such approaches include the ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) – which include practices of adaptive and precautionary management based on appropriate social, economic, political and institutional incentives (Box 11). Similarly, improving the sector's fuel, energy and post-harvest efficiency would reduce its carbon footprint while bringing it closer to its sustainable development objectives.

RECENT ACTIONS

International activity related to climate change is intense. However, most of it refers to research and international agreements. Research focuses on: tracking indicators of change; studying cause–effect relationships; and the modelling, assessing and forecasting of primarily land-based impacts. International agreements, such as the UN Framework Convention on Climate Change and related instruments, aim at mobilizing attention and commitments of governments to reduce GHGs.

In fisheries, while climate change is increasingly being addressed in the scientific literature, the subject is only beginning to be formally addressed by some industry or fishery management administrations. However, the fisheries and aquaculture sector, including its research establishments, is not unfamiliar with the issue of climate variability, and it is experienced in dealing with variability on a range of time scales, such as El Niño events, decadal changes in ocean environments and longer-term regime shifts. As a result, the observation programmes, scientific analyses, computer models, and the experience gained and strategies developed by fishers, processors, fish farmers and management authorities, are extremely useful in dealing with climate change. Many of the principles and strategies developed to deal with "unstable" stocks will be of use in addressing climate change. The challenges are: (i) to adapt these approaches to the wider, longer-lasting and more pronounced variability expected under climate change; and (ii) to build the capacity to implement these approaches in regions and fisheries with limited management capacity and high vulnerability.

FUTURE PERSPECTIVE

The continued provision of food and livelihood security from fisheries and aquaculture systems will require additional multiscale understanding of the impacts of climate change and of the interacting contributions of fisheries and aquaculture to food and livelihood security. Significant knowledge gaps exist in relation to the responses and adaptations of marine and freshwater resources and ecosystems to climate change, including critical thresholds and points of no return. There is also considerable uncertainty over the synergistic interactions between climate change and other stressors (e.g. water use, eutrophication, fishing, agriculture and the use of alternative energy). This means that planning for uncertainty will need to consider the increased possibility of unforeseen events. Nevertheless, examples of past management practices in response to climate variability and extreme events can provide useful lessons for the future, even though they will have to be placed in context of greater uncertainty.

Better knowledge will be required about who is or will be vulnerable with respect to climate change, and food and livelihood security impacts, and about how this vulnerability arises and can be addressed. Better communication and application of what is known will be essential in knowledge building.

Innovative approaches will be needed in order to target financial instruments and create effective incentives to promote adaptation and mitigation efforts. At national and international levels, the public sector will have an important role in leveraging and integrating public-sector and private-sector investment, interacting through market mechanisms to meet sectoral aims for climate change responses and food and livelihood security. Many of these approaches are new and will need to be tested in the sector.

At national level, climate change action plans are likely to build on the FAO Code of Conduct for Responsible Fisheries (CCRF) and related international plans of action (IPOAs), guidelines and other instruments, incorporated into appropriately linked policy and legal frameworks and management plans. Responses will need to employ integrated ecosystem-based approaches for the sector throughout the entire resource-extraction, processing, supply and value chain. The future implications of climate change will intensify the justification for finding policy consensus to reform capture fisheries while respecting national-sector characteristics.

In addition, sectoral trade and competition issues linked with climate change mitigation and adaptation activities are likely to become more important at the global level. Therefore, fisheries sector representation in the pertinent policy and legal development processes is imperative.

The safety of fishing vessels and fishers: an opportunity to address safety in a holistic fashion

THE ISSUE

In recent years, little progress has been made in improving the safety of fishers despite attempts by FAO and others to raise awareness of the severity of the problem. Fishing at sea is probably the most dangerous occupation in the world. The International Labour Organization (ILO) estimates that 24 000 fatalities occur worldwide per year in capture fisheries.[1] The consequences of loss of life fall heavily on the dependants. In many developing countries, these consequences can be devastating. Widows often have a low social standing, and where there is no welfare state to support families and no alternative source of income, widows and their children may face destitution.

The safety of fishing vessels and fishers involves several interrelated components, such as the design, construction and equipment of vessels. However, social and economic pressures as well as overcapacity and overfishing of coastal resources are probably the major factors that have negated efforts to improve safety at sea. Furthermore, safety issues on fishing vessels are of a different nature from those on merchant vessels. On the latter, the majority of hazardous operations are carried out in the safety of the port. On the former (particularly small fishing vessels), crews have to work at sea, on deck in all weathers, frequently with hatches open, in order to locate, gather and process their catch.

Working conditions and efficiency have improved in many ways with increased mechanization. However, new dangers have arisen and the strain on the crew remains considerable, not least because of reductions in crew size to cut costs. Safety regulations accepted by the merchant fleet have encountered resistance in the fisheries sector, where crews resent any restrictions that might affect their income.

A major concern is the persistent view that fishing vessels can only be made safer through: (i) regulations that affect their design, construction and equipment; and (ii) the training and certification of crews. While such interventions may yield effective results, data suggest that this is only sometimes the case. Human behaviour or error is estimated to be responsible for 80 percent of accidents in the fishing industry.[2] Most accidents occur as a result of poor judgement exercised during fishing operations, brought about by the pressure to increase profits (or simply to remain financially viable). In a situation of overcapacity and overfishing, the competition to catch limited resources is intense. The need for economic survival leads to risk-taking and insufficient crew size.

The resulting fatigue among those working at sea contributes to the poor safety record. The context in which judgement is affected is one where crews are competing within a time limit, or are striving to maximize their share of the total allowable catch (TAC) or to maximize their catches during a limited days-at-sea fishery. In some cases, remaining financially viable means cutting costs, with direct impacts on vessel maintenance, the provision of safety equipment, and crew size.

Fisheries management regimes affect safety. Therefore, improved safety should become an explicit objective of fisheries management, which must ensure that the fishing effort is commensurate with the state of fishery resources.

The main lesson learned from FAO's experiences in implementing safety activities is that recommendations, no matter how sound, do not form an adequate basis for administrations to act or for industry to respond. Despite the development of instruments and guidelines related to the design, construction and equipment of fishing vessels (with more stringent regulations at national level), the accident rate in the fishing industry remains unacceptably high.

The main cause of accidents and loss of life in the fishing industry is not only poorly designed, constructed or equipped vessels, but inappropriate human behaviour, sometimes compounded by error, negligence or ignorance. In some cases, there is a simple lack of awareness of safety issues, and fishing practices and seamanship may be poor. These behavioural traits, practices and malpractices are sometimes regarded as facets of the fishers' culture: "…. a high risk of loss of life or injury has been accepted as a part of the 'fishing-culture'. A fisherman's life should and had to be dangerous. This attitude has perhaps been one of the major underestimated obstacles to improved safety and work environment in fishing."[3]

The safety of fishers at sea is as much a social issue as a technical one. Safety issues are multisectoral, and they have often been addressed on an ad hoc or piecemeal basis. The mandate for addressing safety for small-scale fishing is often unclear. Maritime administrations typically deal with the larger vessels, and fisheries administrations with fisheries management. There is a tendency for neither to address the safety of small fishing vessels adequately. Generally, administrations are vocal in their support, but specific actions are lacking. There is a need for an international organization such as FAO to lead the process of helping member countries in introducing and implementing appropriate measures. Safety at sea is a serious problem in both developing and developed countries. Effective solutions lie in the problem being tackled in a holistic fashion, while taking into account the nature and history of the fishing profession and the unique set of circumstances in which it is exercised.

POSSIBLE SOLUTIONS

Safety in the fishing industry cannot be divorced from fisheries management, and this is recognized in the provisions of the FAO Code of Conduct for Responsible Fisheries (the Code). The Code, which was unanimously adopted on 31 October 1995 by the FAO's governing Conference, provides a necessary framework for national and international efforts to ensure sustainable exploitation of aquatic living resources in harmony with the environment. The Code, which is voluntary, also addresses safety and health in the fishing sector.[4]

Long-standing cooperation between FAO and the ILO and the International Maritime Organization (IMO) has led to the development of guidelines and standards on the safety of fishing vessels and fishers: the FAO/ILO/IMO Code of Safety of Fishermen and Fishing Vessels, Parts A and B; the FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels; and the FAO/ILO/IMO Document for Guidance on Training and Certification of Fishing Vessel Personnel.

At the Twenty-seventh Session of the Committee on Fisheries (the Committee), a large number of Members expressed concern about safety at sea for fishing vessels, especially small-scale fishing vessels. FAO was urged to continue collaboration with the IMO, and it was suggested that FAO should develop guidelines on best practices for safety at sea. It was also suggested that the Committee should consider developing an IPOA on the subject.[5]

An IPOA on safety at sea, which would incorporate guidelines on best practices, could become another milestone on the path to improved safety, providing an opportunity to address safety in a holistic fashion.

An IPOA would have many advantages. Being a voluntary instrument, it would probably be easier to develop than a new binding international instrument. Foreseeably, it would apply to all sizes of vessel. It would have greater authority than guidelines. Following its adoption, such an IPOA would, in effect, require states to carry out a national audit of the problem and its underlying causes and to prescribe a broad range of actions to improve safety. It would also require states to report every two years to the Committee on actions undertaken and, thus, permit a sharing of experiences and lessons learned. The guidelines on best practices for safety at sea as referred to by the Committee would provide much of the substance supporting national plans of action.

RECENT ACTIONS

FAO has carried out several regional projects on the safety of fishing vessels and fishers. It has also participated in international and regional conferences and workshops on the subject. The most recent initiatives have been: a regional workshop on small-scale fisheries in the Southwest Indian Ocean (organized in Moroni, Comoros, in December 2006 in collaboration with the National Directorate for Marine Resources in Comoros); and a regional workshop for the Latin American and Caribbean region (held in collaboration with the Latin American Organization for Fisheries Development in Paita, Peru, in July 2007). The workshops raised awareness of the extent of the problem among policy-makers and administrations of the regions. They also adopted recommendations addressing the need for:

- political will;
- a national lead agency;
- appropriate legislation;
- a database on accidents;
- the need to include safety for fishers in fisheries management.

The main features of FAO projects are: (i) reliance on the involvement of all concerned stakeholders through a process of active consultation and participation; and (ii) identification of the main problems and underlying causes of accidents, supported by data where available. Awareness raising of the severity of the problem at policy level is an essential component of these activities, as is the message that the safety problem is not insurmountable.

An important aspect of FAO's work concerning the safety of fishing vessels and fishers is the publication of fisheries technical papers, circulars and other documents on the subject. In addition to its extensive and broad range of publications addressing the design, construction and equipment of fishing vessels, all of which directly link to safety, FAO has also published a number of reports devoted to improving safety at sea.[6] Recently, FAO has carried out an extensive study on the impacts of fisheries management on fishers' safety.

Recently, the FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels (Parts A and B) and the FAO/ILO/IMO Voluntary Guidelines have been revised. Currently, FAO is working with the ILO and IMO to develop new safety standards for small fishing vessels not covered by the revised code and guidelines. The provisional title of these new standards is Safety recommendations for decked fishing vessels of less than 12 metres in length and undecked fishing vessels. The target completion date for this work, which also includes the development of guidelines for the implementation of Part B of the Code of Safety for Fishermen and Fishing Vessels, the Voluntary Guidelines and the Safety Recommendations, is 2010.

FAO has participated in the development of various instruments dealing with the safety of fishers and fishing vessels as well as the working and living conditions on board such vessels under the auspices of the IMO and ILO. These include: the Torremolinos International Convention for the Safety of Fishing Vessels, 1977;

the Torremolinos Protocol of 1993 relating to the Torremolinos Convention; the International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (STCW-F), 1995; and the ILO Work in Fishing Convention, 2007 (No. 188). Despite all the work done in this regard, the effect of voluntary documents is often limited (unless they are continuously promoted), and mandatory instruments have little effect unless enforced.

The second meeting of the Joint IMO/FAO Ad Hoc Working Group on IUU Fishing and Related Matters was held on 16–18 July 2007 at FAO headquarters in Rome. The safety of fishing vessels and fishers was among the issues discussed. The joint working group (JWG) recommended that IMO, with the collaboration of FAO, should explore options relating to the implementation of the Torremolinos Protocol with a view to its early entry into force.

FUTURE PERSPECTIVE

FAO will continue its collaboration with ILO and IMO on the issue of safety of fishing vessels and fishers. Apart from the ongoing work, FAO will assist ILO and IMO in bringing the existing binding instruments into force.[7]

Governments, in particular those from developing countries, will seek assistance from FAO and others in implementing the FAO/ILO/IMO Code of Safety for Fishermen and Fishing Vessels (Parts A and B) and the FAO/ILO/IMO Voluntary Guidelines. The need for awareness raising among governments, fishing-vessel owners, fishers, boatbuilders and other stakeholders of the safety issue will grow.

It is not unlikely that consumers will put pressure on the fishing industry and on governments to improve health and safety conditions on board fishing vessels. This is related to their concerns on overfished stocks, the safety and quality of fish products, environmental protection, and illegal, unreported and unregulated (IUU) fishing.

Private and public standards and certification schemes: synergy or competition?

THE ISSUE

The context

Fish and fishery products are the most internationally traded food commodity. In recent decades, more than one-third of total annual production (live weight equivalent) has entered international trade. About half of this trade (as measured in value) originates in developing countries, whereas more than 72 percent is destined for three main markets: the European Union (EU), Japan and the United States of America. These three markets dominate fish trade in terms of both prices and market access requirements.

While fish supply from wild capture fisheries has stagnated, the demand for fish and fishery products has continued to rise. Consumption has more than doubled since 1973. This increased demand has been met by a robust increase in aquaculture production (with volume growth estimated at an average of 9 percent per year in the period 1990–2006). Similarly, the contribution of aquaculture to fish food supply has increased significantly, reaching a high record of 47 percent in 2006 (compared with a mere 6 percent in 1970). This trend is projected to continue, reaching 60 percent by 2020.

In 2006, FAO reported on the impact of market-based standards and labels on the international fish trade.[8] The reasons for them, and their potential implications for fisheries and aquaculture, were analysed, with the emphasis on small-scale fisheries and exporting developing countries.

Since then, the power of retailers and supermarket chains has grown, as have the influence and concerns of civil society and consumer advocacy groups. Their concerns about human health and the social and environmental impacts of fisheries and aquaculture show no sign of abating. Non-governmental organizations (NGOs)

have tapped into or driven these concerns and developed strategies to influence both consumers' purchasing decisions and the procurement policies of large buyers and retailers. In turn, buyers and retailers have responded by imposing private standards and certification back through the supply chain, especially on producers and processors. These developments have led to a proliferation of certification bodies and schemes designed to trace the origin of food products, their quality and their safety. These schemes are also beginning to address the environmental and/or social conditions prevailing in fishing, aquaculture production, and the processing and distribution of capture fisheries and aquaculture produce and feed. The United Nations Conference on Trade and Development (UNCTAD) estimates the number of schemes at 400 and rising. Table 10 presents the main standards and certification schemes in use in fisheries and aquaculture.

Implications

As standards, certification schemes and claims proliferate, producers and consumers are questioning their value. Producers and producing countries in particular question whether private standards and certification schemes duplicate or complement government work. In addition, consumers ask whether private schemes really provide better protection for them and the environment and/or contribute to social equity.

In areas such as food safety, animal health and environmental sustainability, government authorities have enacted laws and regulations, and they have developed inspection and certification programmes to enforce their application. Therefore, it is legitimate to question whether the work of private certification bodies is complementing or adding value to the work of governments or simply adding another level of compliance costs. These costs appear to fall disproportionately on producers. Concerns related to the costs and benefits for small-scale fisheries and aquaculture producers in developing countries have also been raised.

Many national sanitary regulations, standards and certification programmes are based on the work of the FAO/WHO Codex Alimentarius Commission, and of the World Organisation for Animal Health (OIE). Both are international organizations recognized by the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) as competent bodies for setting international trade standards for food safety and animal health, respectively.[9] Both organizations, as stipulated in the SPS Agreement, use scientific risk assessment to develop standards and a transparent, consultative process among their respective members to adopt them. Private standards developed to meet the needs of commercial parties (especially retailers and supermarkets) have not been tested for compliance with the disciplines of the SPS Agreement. Indeed, there is reason to believe that many private standards are not consistent with the obligations set in the SPS Agreement.[10] Growth in the implementation of private standards could ultimately undermine the hard-won improvements in international market access arrangements that have followed the establishment of the SPS Agreement in 1994.[11]

Consequently, many producers and exporting countries hold the view that private standards in the sanitary field represent unjustified restrictions to trade, especially where they introduce sanitary measures that duplicate those applied by the competent authority of the exporting country, which are based on the recommendations of relevant international standard-setting bodies (OIE and Codex Alimentarius Commission) or of the competent authority of the importing party (e.g. the EU Veterinary Commission).

Private standards are not always applied in a consistent manner to domestic and imported goods, or to all exporters, potentially leading to discriminatory treatment of certain products or countries. Indeed, some retailers currently impose a third-party certification in aquaculture because they claim that government certification processes are insufficient or of doubtful integrity. However, current practices do not support this claim. For example, many exporting countries have competent authorities accredited by the EU Veterinary Commission, which means they are capable of ensuring that

Table 10
Standards and certification schemes used in fisheries and aquaculture

	Scheme type[1]	Main market orientation	Market access issues addressed				
			Food safety	Animal health	Environment	Social/ethical	Food quality
Codex Alimentarius	S, C, G	Global	√	–	–	?	√
World Organisation for Animal Health (OIE)	S, C, G	Global	√	√	–	?	–
GLOBALGAP	S, CS	Europe	√	√	√	–	?
Global Aquaculture Alliance and Aquaculture Certification Council	CS, L	United States of America	√	–	√	√	–
Naturland	CS, L	Europe	√	–	√	√	?
Soil Association	C, G	Global	√	√	√	√	√
Friend of the Sea	C?	United States of America	–	–	√	–	–
International Organization for Standardization ISO 234	C, S?	Japan	?	?	?	?	?
Seafood Watch	C, L	United States of America	–	–	√	–	–
Alter Trade Japan	C, L	Japan	?	?	√	√	?
Federation of European Aquaculture Producers Code of Conduct	?	Europe	√	√	√	√	√
Bio Suisse	C, L	Global	√	√	√	–	–
Safe Quality Food	S, L	Global	√	?	?	?	√
British Retail Consortium, International Food Standard, European Food Safety Inspection Service	S, L	Global	√	?	?	?	√
Quality Certification Services	CS, L	Global	√	?	?	?	√
Fairtrade	?	Europe	–	–	?	√	–
International Organization for Standardization ISO 22000	?	–	√	?	√	?	√
International Organization for Standardization ISO 9001/14001	S	Global	–	–	√	?	√
Marine Stewardship Council	C, S	United Kingdom, Europe	–	–	√	–	–

	Scheme type[1]	Main market orientation	Market access issues addressed				
			Food safety	Animal health	Environment	Social/ethical	Food quality
Fair-Fish	S, L	France, Europe	–	√	√	√	–
International Federation of Organic Agriculture	S, L	United Kingdom, Europe	√	√	√	√	√
International Social and Environmental Accreditation and Labelling Alliance	S, C, L	Global	–	–	√	√	–
Scottish Salmon Producers' Organisation Code of Good Practice	C, L	Global	√	√	√	–	√
Pêche responsable Carrefour, France	C, L	Global	–	–	√ Sustainability	–	–
Tartan Quality Mark	C, L	Global	√	√	√	–	√
SIGES Salmon Chile	CS, L	Europe	√	√	√	–	√
Shrimp quality guarantee Brazilian Shrimp Farmers Association, Brazil	CS, C, L	United Kingdom, Europe	√	√	√	√	√
Thai quality shrimp, GAP, Thailand	S, L	Europe	√	–	–	–	√
Code of Conduct certified Thai shrimp, Thailand	S, L	Europe	√	√	√	√	–
Naturland	S, L	New Zealand	√	–	√	√	?
Soil Association	S, L	Europe	√	√	√	√	√
Agriculture Biologique	S, L	Europe	√	√	√ Organic	–	–
Bioland, Germany	CS, L	Europe	√	√	√ Organic	–	–
BioGro, New Zealand	S, L	Global	√	√	√ Organic	–	–
Debio, Norway	CS, L	United Kingdom, Europe	√	√	√ Organic	–	–
KRAV, Sweden	C, L	Europe	√	√	√ Organic	–	–
Bio Suisse	C, L	France	√	√	√ Organic	–	–
National Association for Sustainable Agriculture Australia, Australia	C, L	Europe	√	√	√ Organic	–	–
Irish Quality Salmon and Trout	C, L	Europe	√	√	√ Organic	–	√
Label Rouge, France	C, L	Global	√	–	√	–	√
La Truite, Charte Qualité	C, L	France, Europe	√	–	–	–	√
Norway Royal Salmon	S, L	China	√	√	–	–	√

	Scheme type[1]	Main market orientation	Market access issues addressed				
			Food safety	Animal health	Environment	Social/ethical	Food quality
Norge Seafood, Norway	S, L	China	–	–	√	–	–
Qualité-Aquaculture de France	S, L	China	–	–	√	–	√
Shrimp Seal of Quality, Bangladesh	S, L	Global	√	–	√	√	√
China Organic Food	S, L	China	√	√	√ Organic	–	–
China Green Food	S, L	China	√	√	√	–	–
China Safe Agri Foods	C, L	China	√	–	–	–	√
ChinaGAP	C, CS	Global	√	√	–	–	√
Fishmeal and fish oil Code of Responsible Practice	C, CS	Global	√	–	√ Sustainability	–	√
The Responsible Fishing Scheme	C, CS	United Kingdom	–	–	√ Responsible fishing	√ Safety of fishers	–

[1] S = standard; C = code; G = guidelines; L = label; CS = certification scheme.

Sources:
World Wide Fund for Nature. 2007. *Benchmarking study. Certification programmes for aquaculture. Environmental impacts, social issues and animal welfare*. Zurich, Switzerland, and Oslo, Norway.
FAO. 2008. *Ecolabels and marine capture fisheries: current practice and emerging issues*. Globefish Research Programme. Volume 91. Rome.
World Trade Organization. 1994. *Agreement on technical barriers to trade*. Geneva.

fish exports meet all the sanitary, production and processing requirements of the EU. Therefore, fish producers and exporters in these countries consider it unfair for any buyer or retailer in the importing country to impose third-party certification of sanitary issues. In addition, the costs of this certification, often high, are usually borne solely by the producers. Furthermore, there is no evidence that, in terms of consumer protection, private certification requirements add value to the current government and border inspection system. Moreover, as private standards are essentially private requirements imposed on suppliers by retailers, they may not be implemented or managed in a transparent manner.

This raises the issues of how to define boundaries between public regulations and private market standards, and of who is responsible for what and accountable to whom. While governments that are seen to use standards as trade barriers can be challenged through the rules of the WTO, what international mechanism or agreement should be invoked to challenge private companies whose standards are judged to create technical barriers to trade (TBT) between countries? Several countries and industry associations have raised serious concerns about the potential for private standards to limit or distort trade.

Proponents of private standards and certification schemes claim that they encourage suppliers to force the use of responsible practices in fisheries and aquaculture. Opponents see them as a private-sector attempt to replace/duplicate governmental policy in fisheries and aquaculture. The key issue is how private standards and certification schemes, if needed, can be reconciled with the public sector's responsibility to regulate the use of responsible practices in fisheries and aquaculture throughout the food chain.

A recent study by the World Wide Fund for Nature (WWF)[12] on standards and certification schemes used in aquaculture concludes that most of those analysed have significant shortcomings and lack an effective and credible regulatory framework. The shortcomings relevant to this context include:

- limited openness in governance of standards and insufficient multistakeholder participation in their development;
- few meaningful, measurable and verifiable criteria addressing the key areas of concern;
- insufficient independence in the operations of the bodies responsible for creating, holding, inspecting and certifying standards;
- frequent absence of effective mechanisms for applying corrective measures and sanction procedures as well as a deficient certification of the chain of custody.

POSSIBLE SOLUTIONS

The above issues are unlikely to be resolved without a concerted international effort. The growing influence of retailers and supermarket chains over the fish and seafood trade indicates a trend towards the increasing use of standards and certification schemes in fisheries and aquaculture. While the extent of private standards and certification schemes is not fully known, it is clear that effects differ from region to region. A precondition for an international understanding and an approach to dealing with this issue is better knowledge. More must be known about the effects of private standards and certification schemes. Such knowledge may enable solutions that will ensure the coherence of private standards with WTO trade rules.

It is also necessary to analyse whether and how private standards are duplicating or complementing the work of government authorities in order to guard against them undermining the operation of the SPS Agreement. Such an analysis should focus on the effects of private standards and certification schemes on the capacity of developing countries to access markets.

In order to reach an international solution to these issues, private standards and certification schemes must be transparent and harmonized with those of international standard-setting organizations such as the FAO/WHO Codex Alimentarius Commission (safety and quality, and import and export certification), the OIE (animal health and

welfare), FAO (ecolabelling, aquaculture and organic farming) and the International Organization for Standardization (ISO) (certification and accreditation). This will provide opportunities for mutual recognition of standards, and simplification of compliance procedures. In turn, this is likely to reduce costs, especially for developing countries and small enterprises where the burden is greatest.

Any solution will probably involve technical assistance and phase-in periods for small-scale producers and developing countries. International efforts to manage the negative impacts of standards will be more effective if they are coupled with similar efforts in regional and bilateral economic arrangements. In developing countries, external funds will be needed in order to support implementation and compliance. Industry standards would gain acceptance more readily if they were accompanied by realistic phase-in periods.

In aquaculture, many small-scale farmers face important technical, financial, knowledge and institutional constraints on their ability to adhere to certification schemes. It is estimated that more than 80 percent of the 12 million aquaculture farmers in Asia operate small-scale farms, from which a significant proportion of the production enters international markets. Their ability to comply with such schemes would increase if they were helped to develop farmers' associations, clusters or self-help groups. They could then respond collectively and be better placed to absorb institutional services and technical assistance. Such an approach has been successful in countries such as China, India, Thailand and Viet Nam. These experiences could be documented, and the lessons learned shared with fish farmers in other countries.[13]

RECENT ACTIONS

Since the early 1990s, the WWF has spearheaded the creation of standards for agriculture, forestry, fisheries and, more recently, aquaculture. In fisheries, the WWF, along with Unilever PLC, created the Marine Stewardship Council (MSC), which developed an ecolabelling scheme aimed at sustainability in the capture fisheries sector.[14] Since 1999, the MSC has operated independently. It is the largest and most international of all ecolabelling schemes targeting sustainability in capture fisheries. It claims to cover 7 percent of global edible wild capture fisheries.[15]

Since 1999, the WWF has organized several round tables, referred to as "dialogues" or "aquadialogues", involving aquaculture producers, buyers, NGOs and other stakeholders. These round tables have been working to develop standards for aquaculture certification in order to minimize or eliminate negative environmental and social impacts of aquaculture. These standards aim to:

- build consensus about the key impacts;
- identify and support adoption or adaptation of better management practices that significantly reduce or eliminate such impacts;
- determine globally acceptable performance levels;
- contribute to global shifts in performance within the aquaculture industry.

The dialogue groups have identified 12 species for review based on their degree of impact on the environment and society, their market value, and the extent to which they are traded internationally. Discussions have focused on tilapia, salmon, molluscs, shrimp, *Pangasius* and catfish. It is hoped that, once finalized, these standards will serve as the basis for an aquaculture ecolabel and be entrusted to an existing or new certification entity to manage.[16]

At the WTO, the development of private-market standards and labels and their potential impact on international trade have been the subject of recent debates at several sessions of the Committee on Sanitary and Phytosanitary Measures (the SPS Committee).[17]

The issue of private standards was first raised officially in the WTO at a meeting of the SPS Committee in June 2005.[18] The debate gained further importance after the SPS Committee decided to make it a separate agenda item (it had previously been one among many "specific trade concerns"). In the course of 2006 and 2007, papers were circulated by the SPS Committee secretariat to governments, observers and

organizations. Meetings were held to discuss how standards could affect the trading opportunities of food exporters, particularly in developing countries. In June 2007, WTO and UNCTAD organized a workshop on private and commercial standards. At the workshop, presentations were made on: the "good agricultural practices" (GAPs) of GlobalGAP; the approaches of the retailer-driven Global Food Safety Initiative; and "the food safety management system standard ISO 22000". Studies on the development, impact and implications of private standards were also presented by UNCTAD, the Secretariat of the Committee on Technical Barriers to Trade, the Organisation for Economic Co-operation and Development (OECD) and FAO.

This is rather a new issue for the SPS Committee, which generally deals with standards set by international standard-setting bodies and the mandatory regulations imposed by governments. The debates examined whether private standards could be considered within the scope of the SPS Agreement and whether the SPS Committee was the right forum for discussing this issue, bearing in mind that many private standards are much broader than SPS (sometimes including environmental or labour provisions).

While several sanitary and phytosanitary provisions of the SPS Agreement apply directly to private standards, others do not. For example, Article 1.1 states that the SPS Agreement applies to "all sanitary and phytosanitary measures which may, directly or indirectly, affect international trade" without explicitly limiting this application to measures taken by governmental authorities. Similarly, the definition of a sanitary or phytosanitary measure in Annex A(1) and the accompanying illustrative list of measures do not explicitly limit these to governmental measures. On the other hand, other provisions of the SPS Agreement, including the basic rights and obligations in Article 2, explicitly refer to the rights and obligations of "Members".

Some private standards fall within the scope of the WTO Agreement on Technical Barriers to Trade (the TBT Agreement). The legal definitions given for standards, conformity assessment procedures and non-governmental bodies in Annex 1 to the TBT Agreement are of particular relevance in this regard (see also Article 3 of the TBT Agreement).

The debates at the SPS Committee have highlighted various concerns. Some members support private standards as a tool that can help suppliers to improve the quality of their products and gain access to markets. However, the majority, especially developing countries, argue that the proliferation of non-science-based standards set without consultation poses a challenge for their exports. These private standards often conflict with those set by governments or international organizations, are costly to comply with, and can become compulsory because non-complying suppliers are excluded from the market. Other issues raised were: the relationship between private and international standard-setting bodies; what governments might do to meet their obligation to ensure that private bodies comply with the SPS Agreement; the relationship with other areas of WTO work (such as TBT); and "equivalence".

Driven by members' concerns, the forthcoming sessions of the SPS Committee will probably debate the issue further, and several developing countries propose to bring concrete examples to the SPS Committee. In particular, the SPS Committee will discuss what reasonable measures members can take in order to ensure compliance by non-governmental entities with the SPS Agreement (as there is no jurisprudence on this matter). It will also examine what further actions it might take on this issue.

In FAO, private standards and certification schemes have been discussed at the Committee on Fisheries (COFI), in particular by its two subcommittees on aquaculture and on fish trade, respectively.

The Sub-Committee on Aquaculture, while recognizing the value of better management practices (BMPs) and certification for increasing public and consumer confidence in aquaculture production practices and products, has noted that many non-governmental certification schemes have resulted in higher costs for producers

without delivering significant price benefits to small-scale producers. It has pointed out that such schemes are disadvantageous to small-scale producers because they add to the costs of market access. It also recognizes that small-scale and large-scale producers have different needs and that these differences should be adequately addressed. The Sub-Committee on Aquaculture has commented that the emergence of a wide range of certification schemes and accreditation bodies is creating confusion among producers and consumers alike. It has stated that there is a need for more globally accepted norms for aquaculture production. These norms could provide better guidance and serve as a basis for improved harmonization by facilitating the mutual recognition and equivalence of such certification schemes.

Within the context of the application of the Code of Conduct for Responsible Fisheries (CCRF), the Sub-Committee on Aquaculture has requested FAO to organize an expert consultation to:

- make recommendations regarding the development of harmonized shrimp farming standards;
- review certification procedures for global acceptance and transparency.

The expert consultation should also help to elaborate norms and review the diverse options and relative benefits of its proposals. In this regard, the Sub-Committee on Aquaculture has encouraged FAO to play a lead role in facilitating the preparation of guidelines for the development of national and regional aquaculture standards. Several members of the subcommittee, as well as a number of intergovernmental organizations, have offered to cooperate at national, regional and international levels, and requested FAO to provide a platform for such collaboration. The subcommittee has also requested FAO to set up an expert group specifically to review certification of shrimp farming systems.

Since 2006, FAO and the Network of Aquaculture Centres in Asia–Pacific (NACA) have organized six consultative workshops in Asia, Europe, North America and South America to develop draft guidelines for aquaculture certification. These will be submitted to the FAO Committee on Fisheries, Sub-Committee on Aquaculture, for discussion and decision at its Fourth Session to be held in Puerto Varas, Chile, in October 2008.

The Tenth Session of the Sub-Committee on Fish Trade, held in Santiago de Compostela, Spain, in June 2006, also recommended that work be done on certification and harmonization. The subcommittee encouraged FAO to: (i) widen and expand the implementation of the safety and quality systems based on the Hazard Analysis and Critical Control Point (HACCP) system and the use of risk assessment as the basis for the development of fish standards; (ii) promote equivalence and harmonization; and (iii) monitor the border sanitary and quality controls used to regulate, restrict or prohibit trade (including their economic consequences). FAO was also requested to broaden the perspective and discussion to include:

- how developed countries could support the integration of small-scale fisheries into international trade through, for example, standard setting;
- intermediation, including financing issues;
- potential loss of bargaining power of small-scale fishers in obtaining fair prices for their products;
- traceability and ecolabelling;
- value chain analysis.

At its Eleventh Session (Bremen, Germany, 2–6 June 2008), the Sub-Committee on Fish Trade considered the trade implications of private standards and certification in fisheries and aquaculture. It provided guidance on how to address transparency, harmonization and complementarity of private and government standards. It requested FAO to undertake studies on the use of certification and ecolabelling in fisheries and aquaculture, including cost–benefit implications (especially for small-scale operations) and their applicability and credibility in adhering to FAO guidelines.

OUTLOOK AND FUTURE PERSPECTIVE

Several recent developments are likely to lead to an expanded use of private standards and certification schemes in fisheries and aquaculture. These include:

- the increasing influence and concerns of civil society in relation to health, social and environmental issues;
- legal requirements for companies to demonstrate "due diligence" in the prevention of food safety risks;
- growing attention to "corporate social responsibility" and a drive by companies to minimize "reputational risks";
- "globalization" of supply chains and a trend towards vertical integration through the use of direct contracts between suppliers and retailers;
- expansion of supermarkets in food retailing both nationally and internationally.

However, the extent of these developments and their implications for the governance of the international fish trade are not yet known and need to be studied. The ongoing work in FAO and WTO, organizations that provide an international framework to ensure transparency, will continue to promote the development of science-based standards, harmonization and equivalence in conformity with WTO trade measures and the standards of international standard setters such as the Codex Alimentarius Commission and the OIE. This may lead to an environment in which private standards and certification schemes complement and add value to the work of governments rather than duplicating it. If supported with appropriate technical assistance, such developments are likely to have positive economic implications, especially for small-scale fisheries and aquaculture producers in developing countries.

Marine genetic resources in areas beyond national jurisdiction as related to marine biodiversity and the sustainable use of living marine resources

THE ISSUE

During the process that led to the convening of the Third United Nations Conference on the Law of the Sea, and at the Conference itself, the negotiations related to the regime of the seabed beyond the limits of national jurisdiction focused mainly on the mineral resources in these areas, based on the assumption that these resources were the only ones of economic interest or consequence. Significantly, while the 1970 UN Declaration of Principles Governing the Sea-Bed and the Ocean Floor, and the Subsoil Thereof, beyond the Limits of National Jurisdiction did refer to "resources" in general, the 1982 UN Convention on the Law of the Sea, in its Article 133 defines the "resources" of the "Area" as: "all solid, liquid or gaseous mineral resources *in situ* in the Area at or beneath the seabed, including polymetallic nodules". It further specifies that "resources, when recovered from the Area, are referred to as 'minerals'".

The negotiators of the UN Convention on the Law of the Sea could hardly have anticipated the extent of the scientific and technological development that was soon to open new perspectives on the potential uses of marine biodiversity, including in the seabed of areas beyond national jurisdiction (ABNJ).[19] Therefore, it is unlikely that the term "living marine resources" in the text of the 1982 convention was ever meant to encompass marine genetic resources (MGRs).[20] It was only later that the potential benefits of MGRs became known and appreciated beyond a specialized scientific community. Today, hydrothermal vents, seamounts and other deep seabed ecosystems rich in genetic biodiversity in ABNJ are being identified and studied with the support of the latest developments in technology, and the knowledge of these resources and of their potential uses continues to grow.

Marine genetic resources include genetic material from all living organisms in the oceans, such as mammals, fish, invertebrates, plants, fungi, bacteria, archaea and viruses.[21] These resources are components of marine biodiversity and, from a

commercial standpoint, basic raw material for the production of food, pharmaceuticals, cosmetics, etc.[22] However, a real appreciation of the breadth of uses and applications of MGRs for commercial activities is only now emerging. Uses vary from food additives to medicines. Hence, MGRs are coming to be seen as a potential source of financial wealth. Although the scope of these benefits is yet to be fully grasped, debates at international level have reflected the concerns of some states that activities aimed at generating said benefits might threaten sustainable use and disregard equity.

Activities such as bioprospecting for MGRs have progressed beyond simple observation of benthic fauna by submersible vessels to the sampling of this fauna and the installation of scientific instruments in the deep seabed.[23] At present, there is no comprehensive and specific mechanism that governs bioprospecting for MGRs[24] in ABNJ. Regulation of these activities has been on the agenda of the international community for some years, but no substantive and concrete steps have been taken, especially in terms of developing a regime for sustainable use. However, it is becoming increasingly urgent to find ways to address this challenge as bioprospecting activities are currently being undertaken on a first-come first-served basis. They have eclipsed commercial interest in mining for deep seabed minerals, as illustrated by the continuously expanding list of patents involving MGRs from the deep seabed.[25]

According to some countries, these MGRs, at least those of the seabed, should be fully assimilated to the resources regulated under Part XI of the 1982 Convention on the Law of the Sea as they are regarded as the common heritage of humankind.

However, other countries maintain that MGRs cannot be considered analogous to mineral resources but rather as belonging to the category of living marine resources. Thus, they would be subject to the legal regime applicable to these resources in the high seas, without the need for further distinction between MGRs that may be found on the seabed or in the superjacent waters. Those who hold this view argue that the principle of freedom of collecting and sampling MGRs in ABNJ should prevail, provided that these activities are carried out in accordance with international law and following approaches and strategies applicable to the protection of marine biodiversity in general.

POSSIBLE SOLUTION

Against this background, discussions at international level have focused on a number of options, including the possible elaboration of a new legal regime for MGRs in ABNJ to be built upon the 1982 Convention on the Law of the Sea or developed taking into account the International Treaty on Plant Genetic Resources for Food and Agriculture (the Treaty) adopted by FAO.

Because of the specificity of the MGRs and the fact that the present provisions of the 1982 Convention on the Law of the Sea are clearly focused on fisheries, even when referring in general to living marine resources, the elaboration of a new legal regime may warrant further study.

The FAO Commission on Genetic Resources for Food and Agriculture (CGRFA)[26] was established in 1983 by the FAO Conference.[27] It was conceived as a permanent forum in which to reach international consensus on matters relating to the conservation and sustainable use of genetic resources and the fair and equitable sharing of benefits arising out of their use. Its extensive mandate now covers all biodiversity components of relevance to food and agriculture.[28] As a consequence, the CGRFA has recently adopted a Multi-Year Programme of Work – a ten-year road-map for the development of policies on crop, forest, farm animal, aquatic and micro-organism genetic resources.[29] The FAO Fisheries and Aquaculture Department is cooperating closely with the CGRFA on matters related to aquatic[30] genetic resources.

The Treaty,[31] which was negotiated through the CGRFA, pursues the conservation and sustainable use of plant genetic resources for food and agriculture as well as the fair and equitable sharing of the benefits arising from their use. Under the Treaty, benefits (which include transfer of technology, capacity building, exchange of information, and funding) must be shared on a multilateral basis. Anyone who

obtains commercial profit from the use of genetic resources administered multilaterally is obliged, by a standard material transfer agreement, to pay a percentage of the benefits to the multilateral mechanism used by the governing body of the Treaty. These funds are then used to mobilize support for priority activities, plans and programmes, particularly in developing countries.

The Treaty could be considered as one option and serve as a useful reference point to address MGRs in ABNJ, as it might provide a practical and working framework for multilateral benefit sharing within the UN system, as witnessed by the more than 90 000 transfers of genetic material in its first seven months of operation.[32]

RECENT ACTIONS

The issue has been addressed by the United Nations General Assembly and its Ad Hoc Open-ended Informal Working Group as part of efforts to study issues relating to the conservation and sustainable use of marine biodiversity in ABNJ. These fora have been debating *inter alia* a perceived governance and regulatory gap for MGRs in ABNJ, [33] including whether there is a need for a new legal regime. They have been studying the way forward concerning policies[34] as well as options on how to guarantee the sustainable, and possibly equitable, use of MGRs.

Early in 2008, delegations acknowledged that the legal impasse on the status of MGRs in ABNJ should not prevent the development of practical measures to ensure their sustainable use. In addition to matters related to their sustainable use, it was suggested that the development of rules for access and benefit sharing should also be considered. This is particularly important in the interests of equity and, indeed, this issue is a prime concern for many developing countries.

At its Eleventh Regular Session (Rome, 11–15 June 2007), the CGRFA agreed to include aquatic genetic resources within the remit of its Multi-Year Programme of Work. It requested that "coverage of aquatic genetic resources under the Multi-year Programme of Work should be undertaken in collaboration with, *inter alia;* the FAO Committee on Fisheries, the Convention on Biological Diversity, the United Nations Convention on the Law of the Sea, the United Nations Informal Consultative Process on Oceans and the Law of the Sea, regional and international fisheries organizations and networks, and industry".[35] The CGRFA then pointed to the need for developing those elements of the FAO CCRF that may be relevant for the conservation and sustainable use of aquatic genetic resources.

FAO is working to develop a set of international guidelines for the management of deep-sea fisheries in the high seas with the aim of *inter alia* protecting vulnerable marine ecosystems and ensuring the sustainable use of their fisheries.[36] It is also undertaking relevant work on marine protected areas.

Finally, the UN General Assembly has invited FAO to contribute within its area of competence to the consideration of conservation and sustainable use of marine biodiversity in ABNJ.[37]

FUTURE PERSPECTIVES

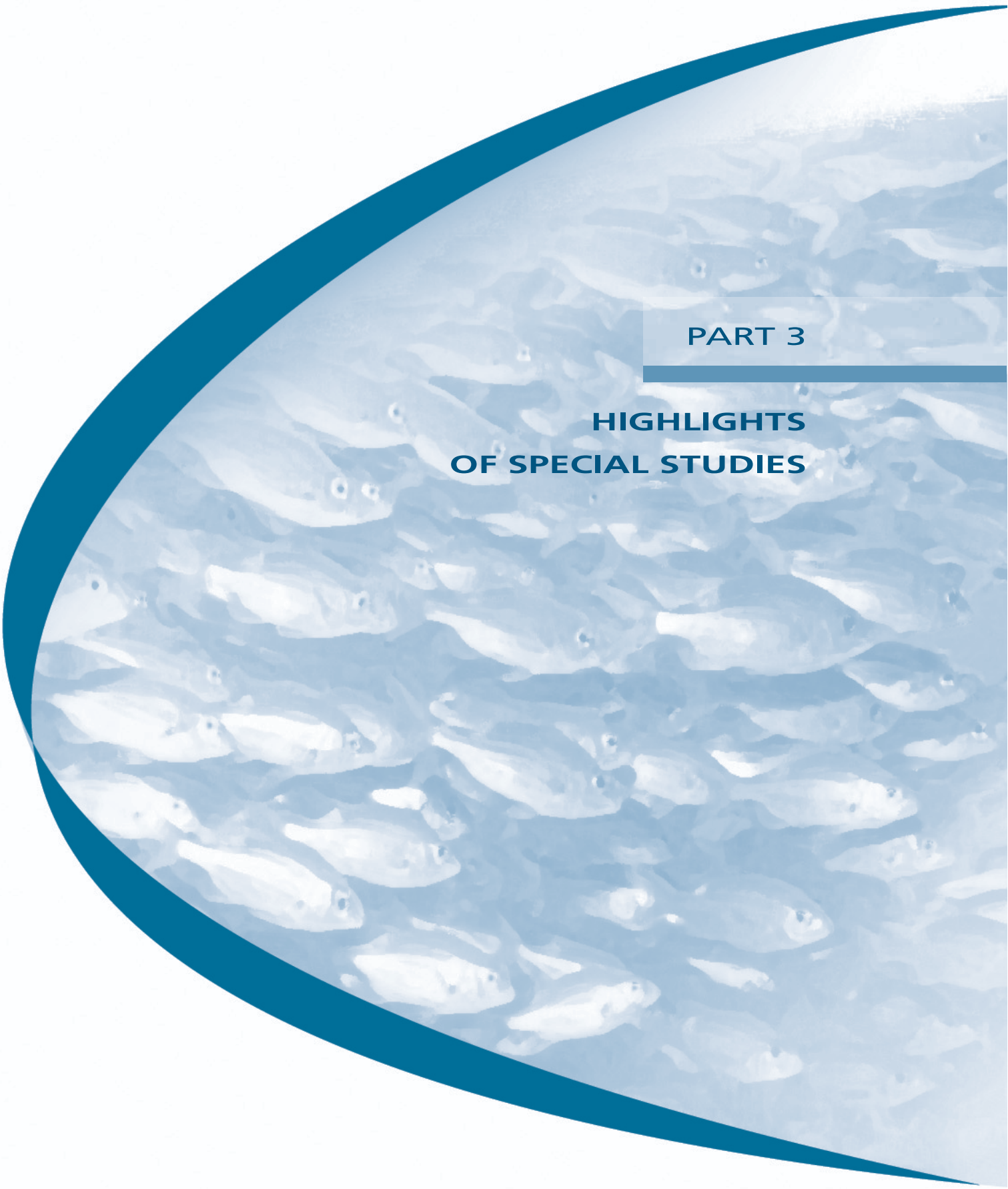
In response to the recent call by the UN General Assembly, a positive contribution, might be expected from the FAO, acting through the CGRFA and the COFI. The COFI in particular might decide to: (i) stimulate the development of the elements of the FAO CCRF that target maintaining genetic diversity, including MGRs; and (ii) foster discussions on the equitable sharing of benefits.

NOTES

1. International Labour Organization. 1999. *Tripartite Meeting on Safety and Health in the Fishing Industry, Geneva, 13–17 December 1999*. Geneva, Switzeland.
2. W.J. Uberti. 2001. Operation safe return: a nontraditional approach to improving commercial fishing vessel safety. *Proceedings of the Marine Safety Council*, 58(2): 35.
3. J.-E. Sverre. 1989. Accidents in the Norwegian fishing fleet: preventive measures and resources in the event of man overboard. *In: International Symposium on Safety and Working Conditions aboard Fishing Vessels, Proceedings,* p.39. Rimouski, Canada, Université du Québec à Rimouski.
4. The Code of Conduct for Responsible Fisheries refers to safety in paragraphs: 6.17; 8.1.5–8.1.8; 8.2.5; 8.3.2; and 8.4.1.
5. An IPOA is a voluntary instrument elaborated within the framework of the FAO Code of Conduct for Responsible Fisheries. In implementing IPOAs, states are required to carry out a set of activities in conjunction with relevant international organizations and conduct a comprehensive assessment to determine if a problem exists. Where a problem exists, states should adopt a national plan of action (NPOA) to mitigate the problem. States that determine that an NPOA is not necessary should review that decision on a regular basis and implement an NPOA if a problem has arisen. States should report on the progress of their NPOA as part of their biennial reporting to FAO on the Code of Conduct for Responsible Fisheries.
6. FAO. 2001. *Safety at sea as an integral part of fisheries management*, by G. Petursdottir, O. Hannibalsson and J.M.M. Turner. FAO Fisheries Circular No. 966. Rome.
   FAO. 1993. *Safety at sea – a safety guide for small offshore fishing boats*, by O. Gulbrandsen and G. Pajot. BOBP/MAG/16. Madras, India.
   FAO and Ministry of Marine Affairs and Fisheries. 2005. *Boat building in the tsunami affected areas of Aceh and Nias: fishing vessel quality issues,* by M. Savins and R. Lee. Jakarta.
7. Existing binding instruments pertaining to the safety of fishing vessels and fishers are the Torremolinos Protocol, the STCW-F Convention, and the Work in Fishing Convention.
8. FAO. 2007. *The State of World Fisheries and Aquaculture 2006*. Rome.
9. World Trade Organization.1994. *Agreement on the Application of Sanitary and Phytosanitary Measures*. Geneva.
10. World Organisation for Animal Health (OIE). 2008. *Considerations relevant to private standards in the field of animal health, food safety and animal welfare. Submission to the World Trade Organization* (available at http://docsonline.wto.org/DDFDocuments/t/G/SPS/GEN822.doc).
11. Op. cit., see note 9.
12. World Wide Fund for Nature. 2007. *Benchmarking study. Certification programmes for aquaculture. Environmental impacts, social issues and animal welfare*. Zurich, Switzerland, and Oslo, Norway.
13. M. Phillips, R. Subasinghe, J. Clausen, K. Yamamoto, C.V. Mohan, A. Padiyar and S. Funge-Smith. 2007. Aquaculture production, certification and trade: challenges and opportunities for the small scale farmer in Asia. *In* FAO. *Global trade conference on aquaculture*, edited by R. Arthur and J. Nierentz. FAO Fisheries Proceedings No. 9, pp. 165–169. Rome.
14. An ecolabel is a tag or label certifying that the fish product was produced in an environmentally friendly way. It provides information at the point of sale that links the product to the production process.
15. FAO. 2008. *Ecolabels and marine capture fisheries: current practices and emerging issues*, by S. Washington. Globefish Research Programme. Volume 91. Rome.

16. See Web article by the World Wildlife Fund. Aquaculture dialogues overview (available at http://www.worldwildlife.org/cci/aquacultureoverview.cfm).
17. See Web news item by the World Trade Organization. 2008. *Members set to agree on regionalization, improved SPS transparency* (available at http://www.wto.org/english/news_e/news08_e/sps_apr08_e.htm).
18. World Trade Organization. 2007. *Private standards and the SPS Agreement. Note by the Secretariat* (available at http://docsonline.wto.org/DDFDocuments/t/G/SPS/GEN746.doc).
19. F. Millicay. 2007. A legal regime for the biodiversity of the Area. *In* M.H. Nordquist, R. Long, T.H. Heidar and J.N. Moore, eds. *Law, science and ocean management*, p. 771. Leiden, Netherlands, and Boston, USA, Martinus Nijhoff Publishers.
20. According to the Convention on Biological Diversity, Article 2, "genetic resources" means genetic material of actual or potential value.
21. H. Cohen. 2007. *Conservation and sustainable use of marine genetic resources: current and future challenges*. Presentation at the VIII United Nations Informal Consultative Process on the Law of the Sea (available at http://www.un.org/Depts/los/consultative_process/documents/8_cohen.pdf).
22. Op. cit., see note 19.
23. R. Warner. 2008. Protecting the diversity of the depths: environmental regulation of bioprospecting and marine scientific research beyond national jurisdiction. *Ocean Yearbook*, 22: 416.
24. There is currently no international agreed definition of bioprospecting. The term is used both in connection with the sampling of MGRs for scientific research and their commercial exploitation.
25. Op. cit., see note 23.
26. Further information on the CGRFA is available on the Web site: http://www.fao.org/ag/cgrfa/
27. Resolution 9/83 of the twenty-second session of the FAO Conference on the "Establishment of a Commission on plant genetic resources" (available at ftp://ftp.fao.org/ag/cgrfa/Res/C9-83E.pdf).
28. The mandate of the CGRFA was reconsidered by means of Resolution 3/95 of the twenty-eighth session of the FAO Conference on "The broadening of the mandate of the FAO Commission on Plant Genetic Resources to cover genetic resources relevant to food and agriculture". At present, 168 countries and the European Community are members of the CGRFA. Membership is open to all FAO Members and Associate Members upon request.
29. Details of the Multi-Year Programme of Work of the Commission on Genetic Resource for Food and Agriculture are available online at: ftp://ftp.fao.org/ag/cgrfa/cgrfa11/r11w21a1e.pdf
30. The FAO envisages MGRs within the broader framework of aquatic genetic resources. See C. Noiville.1997. *Ressources génétiques et droit. Essai sur les régimes juridiques des ressources génétiques marines*. Monaco, Institut du Droit Économique de la Mer, and Paris, Éditions Pedone. pp. 146.
31. The full text of the International Treaty on Plant Genetic Resources for Food and Agriculture is available online at ftp://ftp.fao.org/ag/cgrfa/it/ITPGRe.pdf
32. Further information on the activities undertaken as part of the International Treaty on Plant Genetic Resources for Food and Agriculture is available at ftp://ftp.fao.org/ag/agp/planttreaty/gb2/gb2w20e.pdf
33. UN. 2007. *Oceans and the law of the sea. Report of the Secretary-General. Addendum. A/62/66/Add.2* (available at http://daccessdds.un.org/doc/UNDOC/GEN/N07/500/06/PDF/N0750006.pdf?OpenElement).
34. "It will be for States to decide on the way forward, bearing in mind that the legal framework for all activities in the oceans and seas is set out in UNCLOS." as cited in para. 334, note 8. UN. 2007. *Oceans and the law of the sea. Report of the Secretary-General. Addendum. A/62/66/Add.2* (available at http://daccessdds.un.org/doc/UNDOC/GEN/N07/500/06/PDF/N0750006.pdf?OpenElement).

35. Para 59 of the report of the Eleventh Regular Session of the CGRGFA (available at ftp://ftp.fao.org/ag/cgrfa/cgrfa11/r11repe.pdf).
36. Further information is available on the Web site for the meetings of the Technical Consultation on International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (Rome, 4–8 February and 25–29 August 2008), as well as the text of the guidelines as adopted by the Consultation (available at http://www.fao.org/fishery/nems/36380/en).
37. The invitation by the UN General Assembly to FAO to contribute within its area of competence to the consideration of conservation and sustainable use of marine biodiversity in ABNJ is expressed in General Assembly Resolution A/RES/62/215 on Oceans and the Law of the Sea, para. 103 (available at http://www.un.org/Depts/los/general_assembly/general_assembly_resolutions.htm).



PART 3

HIGHLIGHTS OF SPECIAL STUDIES

HIGHLIGHTS OF SPECIAL STUDIES

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

INTRODUCTION

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

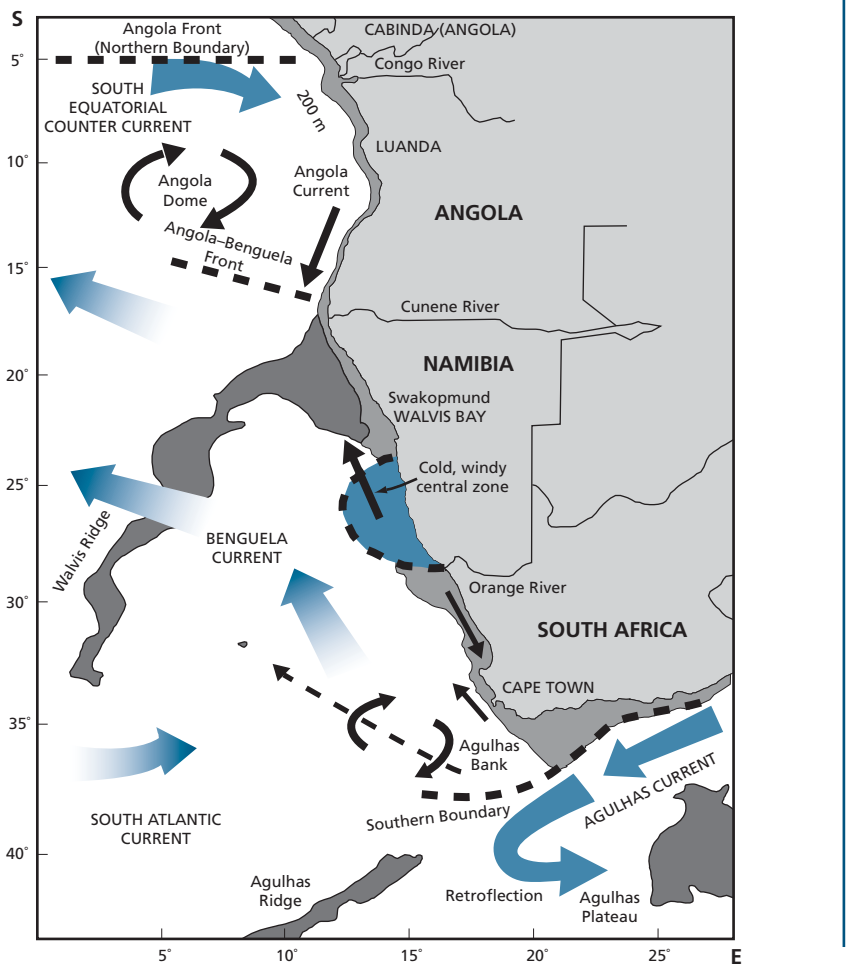
The region has a good history in ecosystem-based marine science, providing a strong knowledge-base for the development of an EAF. Fisheries management approaches and effectiveness vary across the three countries, but all three have reasonable management capacity and institutions. Therefore, the BCLME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

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

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

Figure 45

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



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

INVESTIGATING THE FEASIBILITY OF AN EAF

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

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

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

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

THE ISSUES AND PRIORITIES FOR THE BENGUELA FISHERIES

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

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

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

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

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

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

OPTIONS FOR EAF MANAGEMENT ACTION

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

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

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

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

STRENGTHENING THE SCIENTIFIC BASIS OF MANAGEMENT

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

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

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

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

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

STRENGTHENING THE DECISION-MAKING PROCESS

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

INCENTIVES FOR FACILITATING AN EAF

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

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

INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTATION OF AN EAF

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

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

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

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

RESEARCH NEEDS

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

CONCLUSIONS

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

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

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

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

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

CONCEPTS OF POVERTY, VULNERABILITY AND FOOD SECURITY

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

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

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

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

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

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

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

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

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

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

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

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

CONTRIBUTION, ROLE AND IMPORTANCE OF SMALL-SCALE FISHERIES

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

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

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

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

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

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

ENHANCING THE ROLE OF SMALL-SCALE FISHERIES

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

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

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

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

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

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

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

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

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

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

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

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

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

A global study of shrimp fisheries

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

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

THE CURRENT SITUATION OF THE WORLD'S SHRIMP FISHING INDUSTRY

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

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

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

Table 11
Catches of shrimps

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

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

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

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

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

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

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

Table 13
Some indicators of economic contributions of shrimp fisheries

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

Note: NRA = not readily available.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

MANAGEMENT OF SHRIMP FISHERIES

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

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

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

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

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

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

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

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

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

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

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

Some important enforcement issues emerged in the study:

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

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

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

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

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

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

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

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

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

INTRODUCTION

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

METHODOLOGY

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

Box 12

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

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

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

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

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

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

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

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

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

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

The report includes a CD–ROM containing excerpt questionnaires.

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

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

OCEANWIDE TRENDS

Political and legislative frameworks

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

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

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

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

State of the fisheries

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

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

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

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

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

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

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

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

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

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

Management tools in use in the largest fisheries

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

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

Figure 46

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

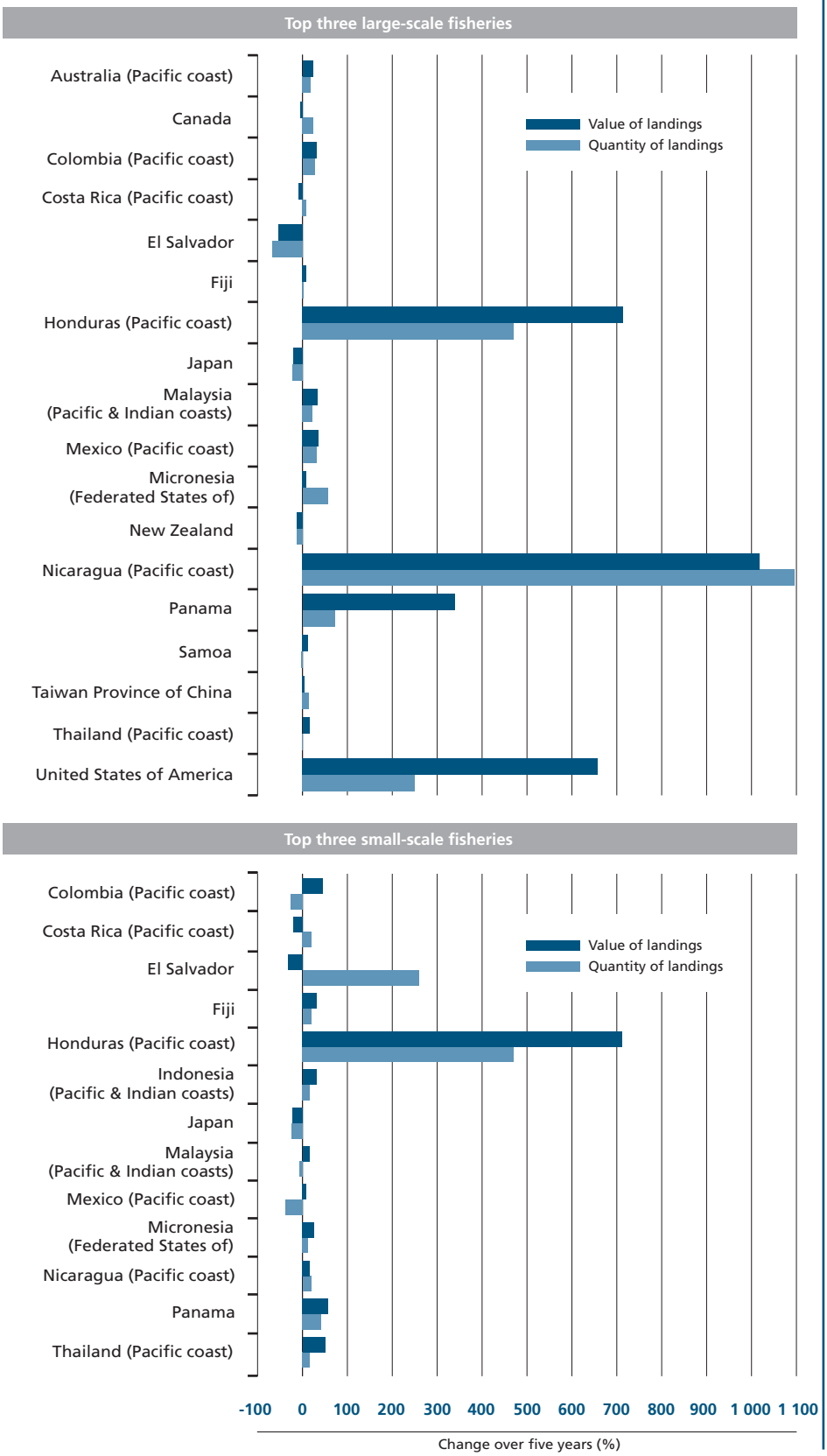
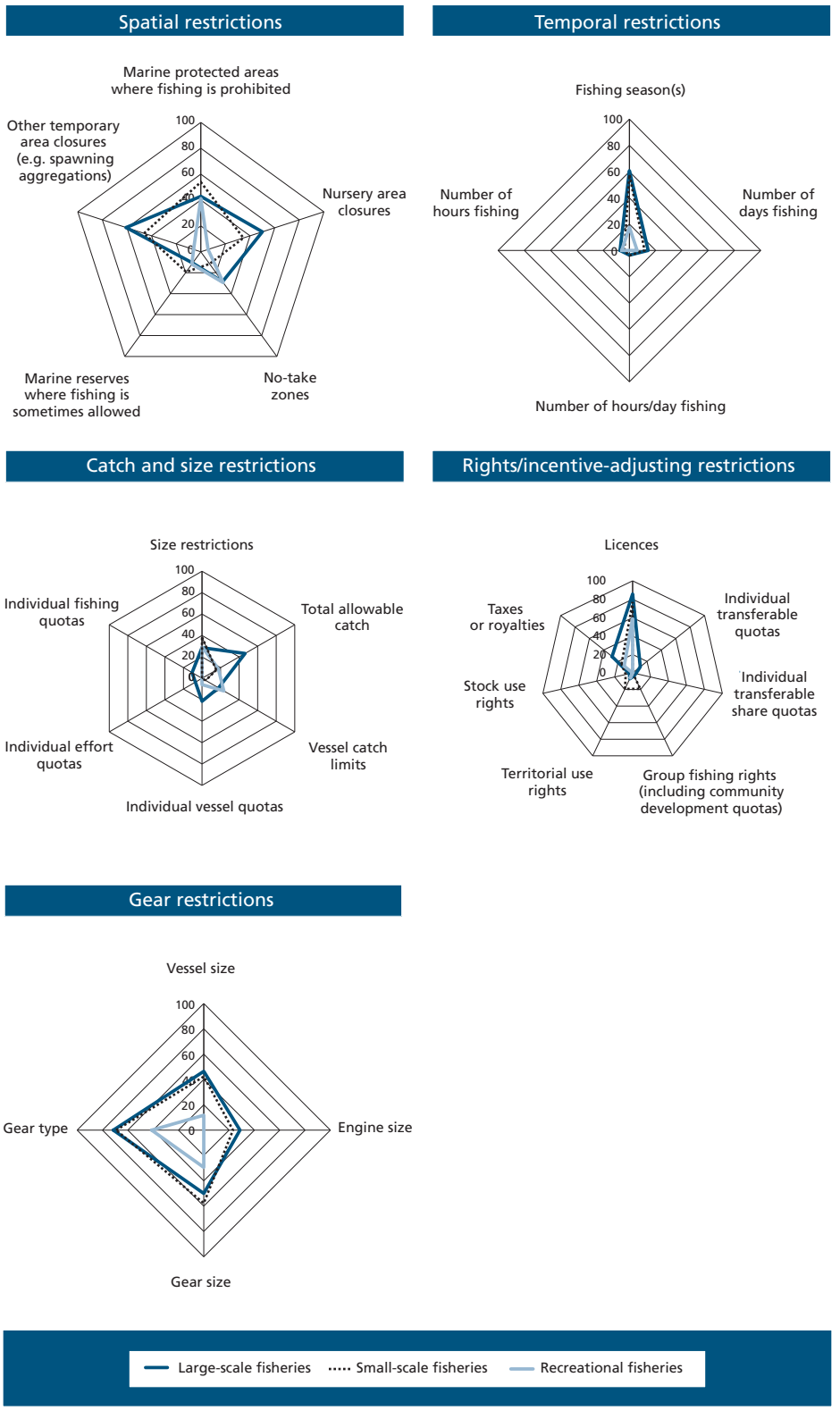


Figure 47

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



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

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

Participatory mechanisms and conflict management in the largest fisheries

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

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

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

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

Fleet capacity management within the largest fisheries

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

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

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

Costs and funding of fisheries management

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

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

Compliance and enforcement

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

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

SUMMARY AND CONCLUSIONS

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

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

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

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

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

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

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

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

Actions to address these issues may include:

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

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

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

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

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

INTRODUCTION

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

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

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

WILD STOCKS AS A SOURCE OF SEED AND BROODSTOCK

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

WILD STOCKS AS A SOURCE OF FEED

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

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

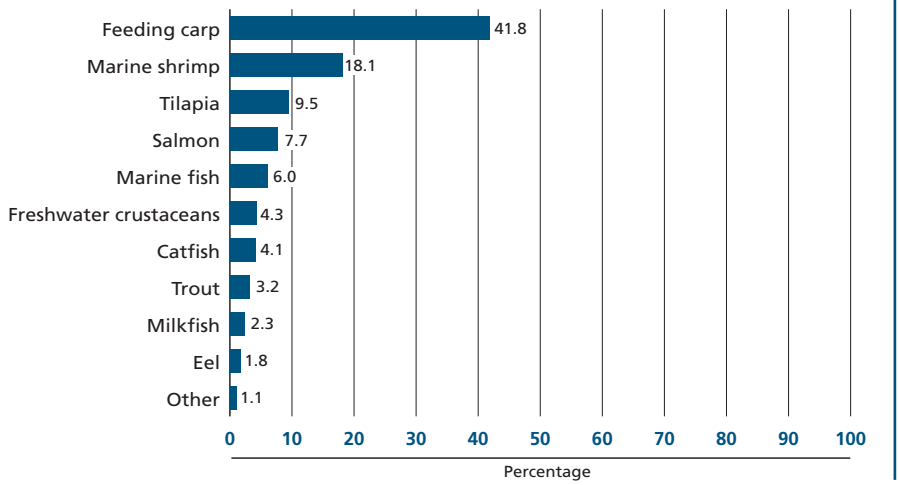
In terms of quantity of feed, the major consumers are herbivorous and omnivorous fish. An estimated 23.13 million tonnes of compound aquafeed[33] was produced in 2005, and about 42 percent of this was consumed by carps (Figure 48). In terms of absolute volume, carnivorous fish (e.g. marine finfish, salmonids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

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

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

Figure 48

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



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

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

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

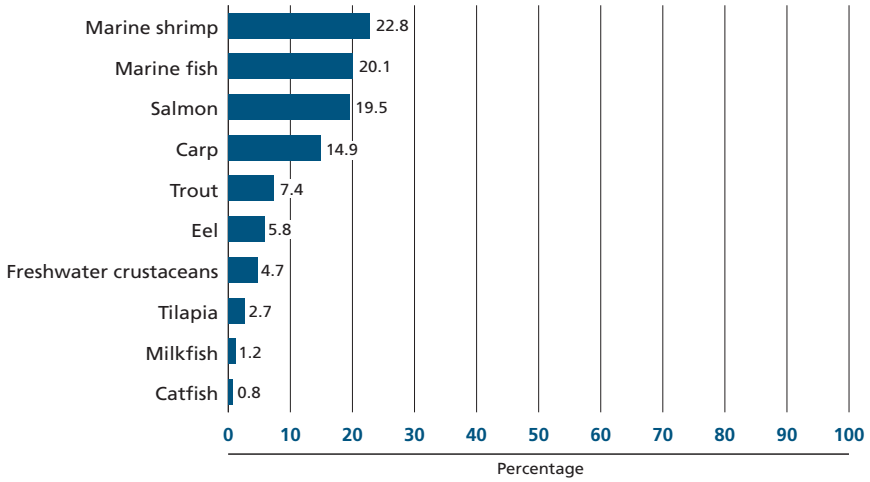
Globally, it seems clear that, in spite of the recently developed capture-based culture of yellowfin tuna (generally fed on small pelagics), the use of whole unprocessed fish as the only feed is declining. The practice is not a serious threat to wild fish stocks. However, in certain regions (e.g. the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

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

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

Figure 49

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



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

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

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

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

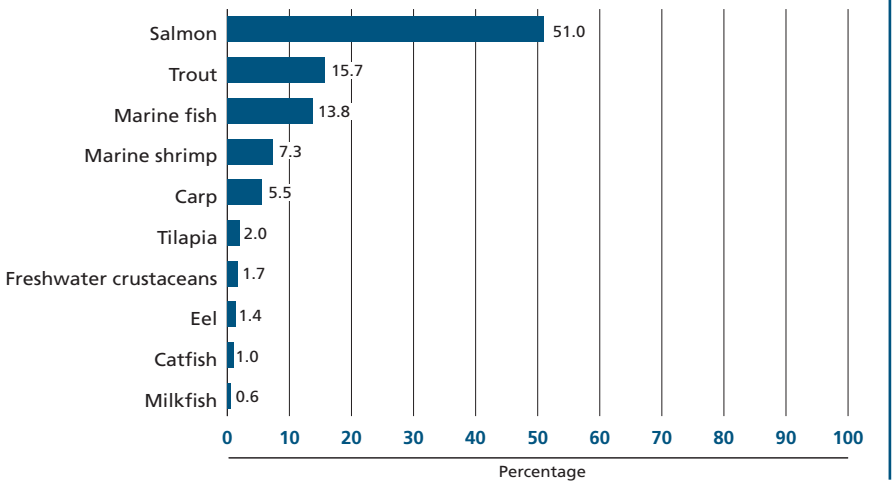
For decades, the need to provide fish as feed for other fish has been seen as an almost insurmountable obstacle given that the amount of fish that can be produced annually from the wild is finite. Thus, much research has focused on finding replacements for fishmeal and fish oil in fish feeds. Partial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

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

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

Figure 50

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



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

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

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

NOTES

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

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

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

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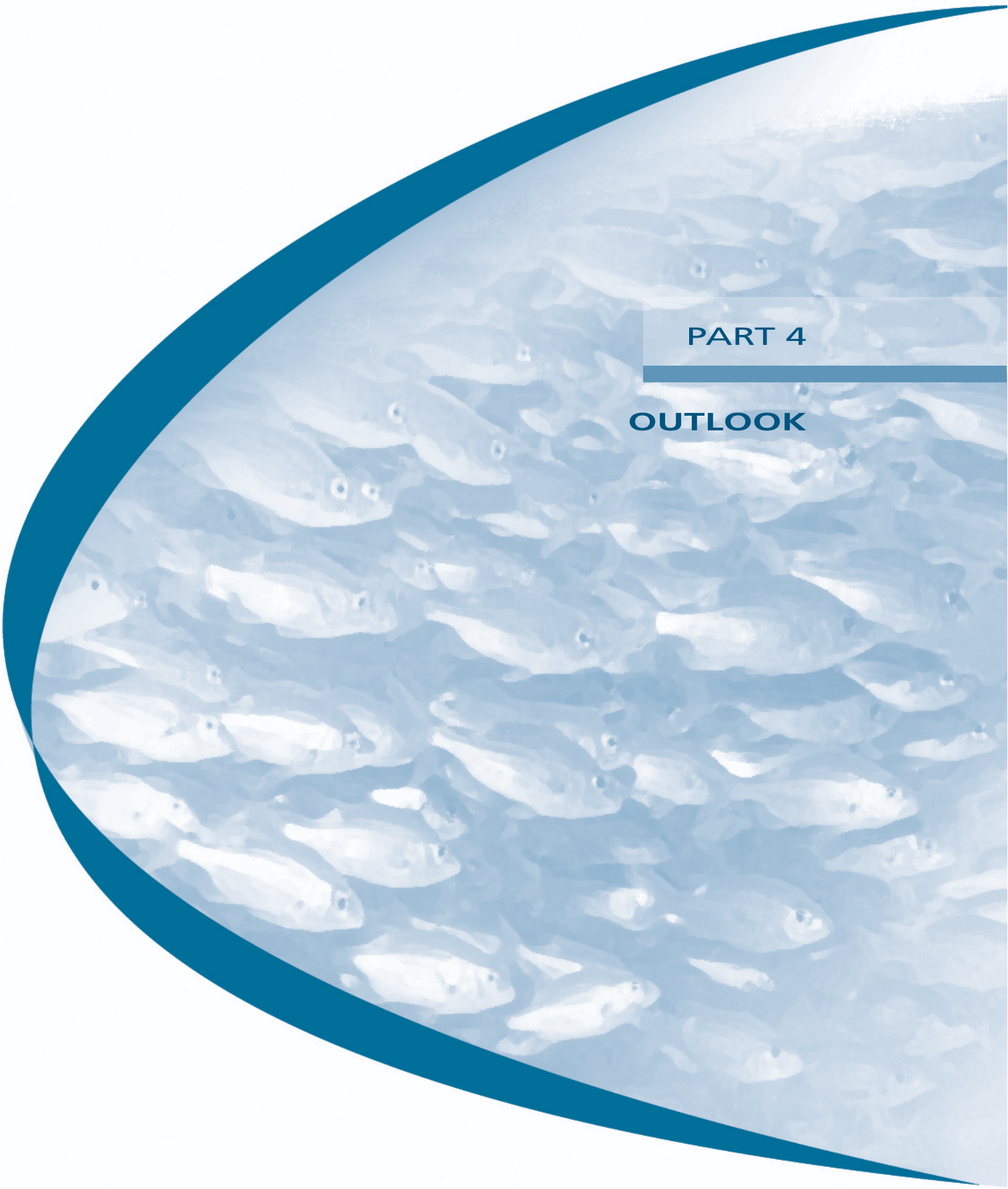

PART 4

OUTLOOK

OUTLOOK

Constraints on growth in the aquaculture sector

HAVE PER CAPITA SUPPLIES OF FISH FOR HUMAN CONSUMPTION PEAKED?

Will land and water suffice for agriculture to feed a growing human population? The question about humankind's ability to feed itself is old and recurring. However, only fairly recently has fish been included in this concern. As late as the first half of the twentieth century, the sea was considered a virtually inexhaustible reservoir of fish for people to exploit. It was only in mid-century that marine biologists started to gain an audience when they affirmed that wild fish stocks were finite and could be fished too heavily. These concerns became serious early in the second half of the century, when the capacity to overfish wild stocks became apparent. However, aquaculture started to grow at about that time and, for many, this was reassuring. It sustained the hope that there would be enough fish to eat also in the future.

In the last three decades, aquaculture has grown rapidly. In the 1970s, it accounted for about 6 percent of fish[1] available for human consumption; in 2006, the figure was 47 percent.

However, overall the rate of growth in aquaculture (measured in production volume) has started to slow. For the world as a whole, while the average yearly growth rate had been 11.8 percent in the period 1985–94, it was 7.1 percent in the following decade.

This slowdown is also reflected in the quantities of fish and fish products made available for human consumption (Table 15). Per capita availability, which grew, albeit slowly, in the 1990s and early years of the following decade, seems to be levelling off.[2] The question is whether per capita supplies of fish for human consumption will remain steady or peak in the near future and then start to fall.

The world's supply of fish available for human consumption is determined by capture fisheries production (marine and freshwater) and aquaculture production, less the share of this total withdrawn from human consumption and used for other purposes. Given the strong likelihood that fish landings will remain stagnant in capture fisheries, aquaculture remains the only apparent means to expand world supplies. So, what does the future look like for aquaculture?

In the late twentieth century, when capture fishery production levelled off and aquaculture production increased rapidly, most observers tended to conclude that any supply shortfall would be filled by aquaculture production. This opinion is still widely held (Box 13).

More serious attempts to predict future fish supplies have tended to predict capture fisheries production independently (by considering the state of stocks and fishing effort in capture fisheries) and then deduct projected landings from demand (arrived at by considering population growth and income elasticities of demand for fish) in order to arrive at the quantity that aquaculture would have to produce. There have been few attempts to predict future aquaculture production by examining the prospects for culture of various species, culture systems and economic conditions.

However, the popular assumption – that aquaculture production will grow as long as demand does, and do so in volumes that will virtually match demand growth – is unfortunate as it sends a surreptitious message that there is a considerable degree of automatism in the expected aquaculture response and, thus, little need for enabling public polices. Such a view of the seafood sector is misleading for those who formulate public policies towards aquaculture and capture fisheries. Aquaculture-enabling policies are essential for the steady and sustainable growth of the sector.

Table 15
Per capita supply of fish by groups of countries

Selected groups and countries	Per capita supply of fish (live weight equivalent)			Annual change	
	1985	1995	2005	1985–1995	1995–2005
	(Kilograms)			(Percentage)	
Africa	7.5	7.1	8.3	–0.6	1.5
Sub-Saharan Africa	7.8	7.0	7.6	–1.0	0.8
North Africa	6.4	7.6	11.9	1.8	4.6
Latin America and the Caribbean	8.3	9.1	8.7	0.9	–0.4
Latin America	7.9	9.0	8.7	1.3	–0.3
Caribbean	12.6	10.5	9.6	–1.8	–0.9
Near East	4.8	5.8	6.2	1.9	0.7
Asia and the Pacific	11.4	16.7	18.9	3.9	1.2
South Asia	3.7	4.6	5.5	2.1	1.8
East and Southeast Asia	15.8	24.4	28.0	4.4	1.4
China	6.7	20.3	26.1	11.8	2.5
Japan	69.7	71.1	61.2	0.2	–1.5
Other East and Southeast Asia	22.2	22.8	25.7	0.3	1.2
Oceania	19.7	19.9	24.5	0.1	2.1
Australia and New Zealand	17.3	19.9	24.9	1.4	2.3
Other Oceania	27.2	19.8	23.4	–3.1	1.6
Europe (+ Cyprus and Israel)	18.3	18.5	20.8	0.1	1.2
EU(27)	18.9	20.9	22.5	1.0	0.7
Non-EU countries	10.9	14.2	17.4	2.7	2.0
North America	19.0	21.9	24.1	1.4	1.0
United States of America	18.8	21.8	23.4	1.4	1.0
Canada	19.7	22.7	24.1	1.4	0.6
Other countries in North America	63.4	59.5	61.1	–0.6	0.3
World	12.6	14.9	16.4	1.7	1.0
Low-income food-deficit countries	6.8	11.6	13.8	5.5	1.8

Source: FAO Fisheries and Aquaculture Department.

Worldwide, the rate of growth in aquaculture production is slowing. Surveys of fish farmers and other aquaculturists show that, generally, the reasons for this are that those who want to expand production face various constraints and obstacles.[3] They would probably be better equipped to overcome them, and increase production, if the price levels for fish rose. However, it would seem unwise to rely only on an increase in price, which, if it happens, is likely to be in nominal rather than real terms.

The rest of this "Outlook" reports on the perceived obstacles to aquaculture growth. The purpose is to try to identify which of the various potential constraints are likely to become effective constraints in the near future. Such information should interest public administrations that use public resources to promote continued aquaculture growth.

Box 13

Will aquaculture ensure increased fish supplies?

"The aquaculture sector in developing and developed countries has witnessed spectacular production increases over the past two decades; and there is nothing to suggest that this will change." (Organisation for Economic Co-operation and Development. 2007. *Globalisation and fisheries. Proceedings of an OECD–FAO workshop.* Paris.)

"As seafood demand continues to grow, increasing demand is being satisfied from aquaculture sources in both developed and developing countries." (Ibid.)

"… aquaculture currently accounts for 43 percent of global fish production used for human consumption and is expected to grow and compensate for the predicted global shortage of supply from capture fisheries and the demands of society." (Ibid.)

"Aquaculture production has continually outstripped projections, and there is little reason to believe that it will not continue to do so." (World Bank. 2006. *Aquaculture: changing the face of the waters*. World Bank Report No. 36622-GLB. Washington, DC.)

RECENT GROWTH IN AQUACULTURE PRODUCTION

A closer look at the recent history of aquaculture growth shows that growth has not been uniform. It has been faster in some regions of the world than in others (Table 16). The same pattern appears when production is broken down by species (Table 17). For some species (trout and carp in Europe), growth has virtually stopped. For others (tilapia and catfish), growth appears high and steady, while some species either have not yet taken off (cod) or seem about to take off (cobia).

The simple explanation for these differences is that producers (aquaculturists and others who earn a living processing, transporting and selling fish) have different abilities to provide fish at prices consumers can afford. In addition, some aquatic species are easier to handle in captivity than others. The very rapid growth in production of cultured whiteleg shrimp (*P. vannamei*) in the past ten years can be attributed to the ease of obtaining seed in hatcheries from cultured broodstock, and to the fact that it is disease-free.

However, the underlying reasons for these differences are many, and several are not specific to aquaculture.

In developed economies, stagnation in production in established sectors, such as aquaculture, is usually a sign of a well-developed farming technology and a well-established market. On the one hand, consumers are aware of the product and will not consume more unless the price falls or competing products become more expensive. On the other, established producers have difficulties in modifying their methods to reduce production costs permanently. They have tailored management to their own conditions, and input and output prices have settled. Neither the individual producer nor the individual consumer can modify them. In such situations, profit margins are usually small, and new entrepreneurs are reluctant to enter the industry. In these mature industries, expansion constraints are real and effective. They can be interpreted as an indication that, for society as a whole, it is not optimal to dedicate more resources to aquaculture.

In China, on the other hand, aquaculture grew slowly prior to 1980, which could be interpreted as a sign of a mature industry – as aquaculture had been practised in China for centuries. However, aquaculture then started to expand rapidly, and

Table 16
Average yearly growth in aquaculture production by groups of countries

Selected groups and countries	Production			Annual change	
	1985	1995	2005	1985–1995	1995–2005
		(Million tonnes)		(Percentage)	
Africa[1]	0.05	0.11	0.65	7.5	19.4
Sub-Saharan Africa	0.01	0.03	0.10	12.1	11.4
North Africa	0.04	0.08	0.55	5.9	21.9
Latin America and the Caribbean	0.08	0.44	1.40	19.3	12.3
Latin America	0.07	0.41	1.37	19.4	12.8
Caribbean	0.01	0.03	0.03	17.2	0.5
Near East	0.03	0.06	0.28	8.2	16.1
Asia and the Pacific	6.21	21.69	43.34	13.3	7.2
South Asia	0.77	2.00	3.95	10.1	7.0
East and Southeast Asia	5.42	19.59	39.24	13.7	7.2
China	3.15	15.86	32.42	17.5	7.4
Japan	0.66	0.82	0.75	2.2	–0.9
Other East and Southeast Asia	1.61	2.92	6.08	6.1	7.6
Oceania	0.02	0.09	0.15	15.9	4.7
Australia and New Zealand	0.02	0.09	0.15	15.8	4.7
Other Oceania	0.00	0.00	0.00	20.0	6.5
Europe (+ Cyprus and Israel)	1.03	1.60	2.17	4.5	3.1
EU(27)	0.97	1.18	1.28	2.0	0.8
Non-EU countries	0.06	0.42	0.90	21.1	7.9
North America	0.33	0.48	0.65	3.7	3.1
United States of America	0.32	0.41	0.49	2.5	1.8
Canada	0.01	0.07	0.15	22.2	9.0
Other countries in North America	–	–	–	–	–
Others (= USSR until 1991 + others NEI)	0.29	–	–	–	–
World	8.02	24.38	48.49	11.8	7.1
Low-income food-deficit countries	4.66	19.21	39.09	15.2	7.4

Note: NEI = not elsewhere included.
[1] Egypt, Libyan Arab Jamahiriya and Sudan are also included in Near East.
Source: FAO Fisheries and Aquaculture Department.

did so at very high rates in the 1990s and into this century. The main cause was the modification of macroeconomic policies – *inter alia* in the form of weakened price controls for the aquaculture sector – that increased economic growth generally and enabled fish farmers to respond quickly and effectively to an opportunity to augment incomes by expanding production as possibilities appeared. Again, it was mainly factors exogenous to aquaculture that removed constraints and obstacles to aquaculture production. It was not the fish farmers themselves – they simply responded to an opportunity.

Table 17
Average yearly growth rates in aquaculture production by decade by groups of species

	Production			Annual change	
	1985	1995	2005	1985–1995	1995–2005
		(Million tonnes)		*(Percentage)*	
Freshwater fishes	4.35	12.94	26.05	11.5	7.2
Diadromous fishes	0.67	1.52	2.88	8.5	6.6
Marine fishes	0.22	0.53	1.65	9.0	11.9
Crustaceans	0.26	1.10	4.00	15.6	13.8
Molluscs	2.49	8.23	13.47	12.7	5.1
Aquatic animals NEI	0.03	0.06	0.44	7.1	22.9

Note: NEI = not elsewhere included.

Where aquaculture is new, growth can be rapid, particularly in developed economies. This is particularly the case in the wake of technological or management breakthroughs in the developed economies of Europe and North America, and for species that are expensive, "up-market" and well known. Modern, readily accessible means of communication and transportation make it possible to offer the product to a large market. Where the initial earnings are high, entrepreneurs are drawn into the sector, and production expands rapidly. Most mature aquaculture industries (e.g. salmon and trout worldwide; eel in Japan; oysters, seabass and seabream in Europe; milkfish in the Philippines; and catfish in the United States of America) experienced initial phases of very rapid growth.

When aquaculture becomes established in poor regions of developing countries, it is not likely to expand at a pace that is much different from that of the economy as a whole. Often, this is because poor infrastructure (especially rudimentary communication facilities and deficient transport systems) imposes large costs on any products intended for sale outside the vicinity of the fish farm. Thus, resource-poor fish farmers face constraints they can do little to circumvent. However, access to foreign capital and markets can change the situation dramatically, as has been the case in Honduras (where foreign interests have helped to develop tilapia culture for the market of the United States of America).

The growth rates for aquaculture in Africa (see Table 16) seem to contradict the above. There are several reasons for the high growth rates in Africa:

- the starting point is low absolute amounts of aquaculture production, meaning that increases that are small in absolute terms become large in relative terms;
- the inflow of foreign capital and expertise in aquaculture ventures that supply overseas markets;
- growing public support for aquaculture in regions with above-average economic growth.

Thus, the actions that have facilitated development – in a sense, removed obstacles – have come from outside the aquaculture sector. It is not the fish farmers who have created the circumstances that have made aquaculture possible.

It seems clear that aquaculture entrepreneurs have not been solely responsible for the growth of the industry and that this is likely to continue to be the case. Therefore, if governments want to ensure continued growth in aquaculture and its sustainability, they have a strong interest in actively helping the industry to remove constraints.

However, the constraints are many, and they are unlikely to all be simultaneously effective, or to be amenable to modification by all. It would seem desirable to:
(i) have an idea of which of the current constraints are likely to be effective

constraints in the coming decade; and (ii) know who should do what to alleviate them. The situation will differ by geographical region and by type of aquaculture. To a large extent, the importance of these constraints, and the associated urgency to remove them, will be decided by the expected evolution of the market for fish and fish products.

Since agriculture began, farmers have been overcoming the obstacles that nature has raised against them. However, the time when farmers removed all obstacles on their own is long gone. This is also true for aquaculture, not only for the modern aquaculture entrepreneur but also for the small-scale, commercial fish farmer in developing economies. In modern aquaculture, development is now a joint effort among farmers, investment concerns, equipment manufacturers, service suppliers, scientists and government.

CONSTRAINTS ON AQUACULTURE

Types of constraints

Constraints on aquaculture can take many forms. Active or potential fish farmers may be hindered by a lack of: (i) knowledge about how to go about the business of fish farming; (ii) access to the necessary capital or fixed assets; and (iii) access to the necessary inputs (seed, feed, fertilizer, etc.). They may also be prevented by the public administration (or in extreme cases by civil society) from engaging in an activity that seems perfectly viable from the economic point of view but is considered harmful to other interests.

Entrepreneurs, small or large, are not the only group of individuals concerned about aquaculture and its development. Scientists, administrators and policy-makers are also interested. Moreover, although a step or two removed from entrepreneurial activities, they do discuss the obstacles that in one way or another confront entrepreneurs, that is those who must suffer the consequences of such obstacles.

Entrepreneurs face constraints when they want to: (i) initiate aquaculture operations; (ii) expand an already functioning aquaculture enterprise; or (iii) streamline operations in order to reduce costs and expand market share.

As it is the farmers' perspective and needs that in the end determine what is and what is not a true constraint, it may be useful to divide constraints into categories:

- microeconomic constraints (or access to capital assets, recurrent inputs and markets);
- knowledge constraints (management and technical expertise);
- social constraints (public policies and externalities).

Neutralizing constraints

Microeconomic constraints

Worldwide, most aquaculture entrepreneurs (small or large) decide whether to start or close their farm, where to buy inputs and who to sell their products to. They are economic agents in what is usually referred to as a market economy of some kind.

They are constrained in what they do by the workings of the markets they can access. The goods and services available in these markets will determine whether the entrepreneur will be able to cover all expenses by revenues from fish farming operations and make a profit. They will do so jointly with the presence of input suppliers and the buyers of their products. However, small-scale farmers/entrepreneurs will always have to live with input and output prices over which they have little control (this is less the case for large operators). Prices may be modified by public interventions in the market, but seldom to the extent that they will cease to constitute constraints from the point of view of an individual aquaculture entrepreneur.

It is natural for fish farmers to feel constrained by the market. They would like to be paid more for their product and to pay less for the goods and services needed to run their fish farms. However, in an open-market economy, "price constraints" of this type will always exist.

However, markets are seldom perfect – in the sense of always allocating all resources where they provide the best results. Thus, public administrations may want to intervene. However, they generally do so after considering the effects on the economy as a whole and not on aquaculturists alone.

The market economy is no guarantee that all constraints, not even those that are microeconomic in nature, will be overcome or removed. The aquaculturist, or potential aquaculturist, may encounter as absolute hindrances a lack of suitable farm locations, a lack of manufactured fish feed of a certain quality or a lack of hatchery-produced fish seed.

Feed is perhaps the best-known constraint. In the 1980s, there were already discussions about the possibility of aquaculture development being slowed by a shortage of fishmeal and fish oil. However, 25 years later, it is clear that such a shortage has not been an absolute block for fish and shrimp farming. Indeed, growth in aquaculture continues to be impressive compared with that in other food-producing sectors. Thus far, fishmeal has been less of an effective constraint than many feared. However, given the difficulty in replacing fish oils, particularly in feeds for salmon, it is clear that competition for fish oil is likely to be a more serious obstacle for some sections of the aquaculture industry (Box 14).

Seed remains a constraint for many. In recent decades, aquaculture has grown rapidly, partly because this constraint was removed for some species through artificial reproduction (carp, shrimp and salmon). However, many aquaculturists still depend on wild-caught fry (or wild-caught broodstock). They include eel farmers in Europe and East Asia, most yellowtail farmers in Japan, grouper farmers in Southeast Asia and farmers of yellowfin tuna in the Mediterranean and off Australia. Thus, fortunes vary and will probably continue to do so. For many potential aquaculturists, the laws of nature, transmitted through the market mechanism, still place a definite limit as to which species can be cultured where and in what quantities. However, for some species, these laws are lenient and culture is easy, cheap and possible in many locations (e.g. whiteleg shrimp).

The market is also able to constrain entrepreneurs in other ways. Farmers who wish to expand their enterprises, and those who want to emulate successful colleagues and start fish farming, may find *inter alia* that:

- there is a lack of suitable coastal waters for fish farming (e.g. cage culture of marine finfish in China);
- there is not enough freshwater for fish farms (e.g. in Egypt);
- there is not enough land for culture sites (e.g. ponds for shrimp farming around the Bay of Bengal);
- tenure is not secure for water and/or land that is otherwise available.

In the extreme situation, a complete lack of access to culture sites or vital farming inputs may prove an insurmountable obstacle. However, often, access is possible but in another location, perhaps in another country, and often at a higher price than that paid by established entrepreneurs. The price difference may be sufficient to prevent expansion or the entry of new entrepreneurs.

However, in spite of all the valid reasons for having a market where prices are established through the interactions of so many that none has a decisive influence, fish farmers will experience them as constraints. Hence, it will be in the interest of governments to inform fish farmers about the importance and rationality of the market mechanism in order to redirect their attention to constraints that are more amenable to intervention.

As almost all the infrastructure and public goods available in an economy are not specific to aquaculture, governments that see aquaculture as important will ensure that representatives of the aquaculture industry can make their voice heard in the economy. This will be especially important in respect of economy-wide infrastructure projects but also in ensuring equivalence in conditions for national and international aquaculture entrepreneurs.

Box 14

Fishmeal and fish oil – the unpredictable long term

The world price for fishmeal remained between US$500 and US$700 per tonne in the period 2000–05. In 2006, it reached US$1 400. It has since remained above US$1 000 per tonne. The price of fish oil has also risen dramatically (see Part 1, Figures 39 and 40). Will these trends continue?

These prices result from the interaction of demand for fishmeal and fish oil (primarily from the aquaculture and livestock markets in all corners of the globe) with the supply of fish as raw material. The raw material is supplied by large dedicated fisheries and by other fisheries that supply retained non-targeted catch. Such fisheries are found in all the main oceans.

Much is happening in both the fishmeal and fish-oil markets. Aquaculture's share of fishmeal and fish oil has been growing. In 2006, this sector absorbed 56.0 and 87 percent, respectively, of world supplies. Fish and shrimp feed producers, who have seen their production costs rise, are trying to escape from dependence on fishmeal. Some success has been achieved – salmon diets now contain 30 percent fishmeal instead of the 50 percent of some years ago.[1] However, given the available commercially-adapted fish and shrimp feed technology, the demand for fishmeal from aquaculture is set to increase in the near future. In the longer term, demand will depend on the success of scientific research in reducing the use of fishmeal in fish and shrimp feeds. The global market will also be conditioned by future demand from the livestock sector and other users.

The supply of raw material for fishmeal has always fluctuated. Variations in oceanic conditions off the coast of Peru and farther out to sea mean that each season's landings of anchoveta for the fishmeal industry can differ in volume by more than 30 percent from that of the previous season. For example, in the El Niño year of 1998, anchoveta production

Knowledge constraints

Managerial constraints exist where farms are not run according to best farming practices. Best practices should *inter alia* result in:

- attaining satisfactory pollution and fish health standards;
- respecting food safety and hygiene standards;
- respecting market standards in terms of quality;
- a rate of return on investments and effort that makes the farm financially and economically sustainable.

Knowledge obstacles are often "hidden" in the sense that producers may be only partially aware of them. However, all of them can be overcome, and here the producers themselves have a large role to play. In collaboration with public authorities, fish farmers can improve their managerial performance significantly if they are made aware of their deficiencies and helped to remedy them.

Managers often consider microeconomic constraints to be the difficult ones. Having once overcome these, managers in more than one nascent aquaculture industry have not paid sufficient attention to the parameters governing the survival and health of cultured animals. Hoping to recover investments rapidly, they have increased stocking densities beyond recommended biosecurity levels (or beyond ecosystem resilience levels) with disastrous results. This happened in early Latin American shrimp culture, where such practices led to white-spot disease in Ecuador and Panama and long-term decline of the industries.

was 1.2 million tonnes (5.3 million tonnes in 1997). It went down from 8.6 million tonnes in 2002 to 5.3 million tonnes in 2003 (FISHSTAT statistics). While interseasonal variations may not be as drastic in other fisheries supplying raw material to fishmeal plants, global production volumes of fishmeal have fluctuated between 5 and 7 million tonnes irrespective of variations in demand for the final product (FISHSTAT statistics).

However, it is not only oceanographic variability that affects the supply of fish for fishmeal and fish-oil production. There are also competing uses for the fish. In the immediate future, there may be an increase in supplies. This would follow on from the rise in revenues of fishmeal plants. Following the increase in the world price of fishmeal, plants can afford prices much higher than US$100 per tonne for the raw material, which would have been unthinkable for most plants not long ago. In the immediate future, this will lead to a more intensive fishery of stocks already exploited for fishmeal, and the fishing of stocks not previously used as a source of fishmeal. Where small pelagics and miscellaneous non-target species are the food of the poor, the pressure for increased fishmeal production will create considerable controversy. Some will argue that, instead of using the fish for fishmeal, a larger share should be destined for human consumption. Such debates will be settled through political processes, the outcomes of which are virtually impossible to foresee.

[1] M. Klinkhardt. 2007. The blue revolution – feed alternatives for aquaculture. *In* FAO. *Global Trade Conference on Aquaculture, 29–31 May 2007, Qingdao, China*, edited by R. Arthur and J. Nierentz. FAO Fisheries Proceedings No. 9. Rome.

Managerial constraints are not permanent in nature. Generally, manager-owners are keen to improve farm management practices, and there is a continuous evolution of practices. In areas where aquaculture is well established, specialized expertise is often available to help deal with these issues, but it may be expensive to access.

Managerial constraints are frequent and generally slow to be overcome in regions where fish farming is not a common practice and where little private industry or government-sponsored expertise is available.

A lack of technical expertise can act as a constraint in both the short and long run.

In the short run, access to off-farm technical expertise is essential if aquaculturists are to neutralize production constraints. The need for expertise varies with the farming technology used. On the one hand, farmers engaging in simple rural pond culture may only need to discuss matters with an aquaculture generalist with knowledge of on-farm fish feeds and fish reproduction. On the other hand, farmers running modern cage or pond units producing for international markets will need access to advice from specialists in fish pathology, nutrition, feed, reproduction, etc.

In the long run, technical innovations are essential for the continued growth of the aquaculture sector. Gradually, management practices will be refined by the farmers themselves, as many of them will experiment carefully in their production units. However, fundamental breakthroughs in areas such as artificial reproduction, disease control and the use of improved feed will be achieved off-farm in laboratories run

by private industry, universities or state-run research and development centres. The building and staffing of such facilities take considerable time.

However, it is not only those at the forefront of aquaculture development who need scientific expertise in order to overcome knowledge constraints. Science-based understanding of aquaculture is equally important in regions were the sector is small or about to develop. Resident scientists in these regions should receive technical developments, adapt them to local conditions, and participate in disseminating the results to local farmers and entrepreneurs.

That said, technology transfer is not automatic even in regions with much aquaculture. Up to 75 percent of aquaculture production comes from millions of small-scale farms, most located in Asia. Although input and service providers act as conduits for transferring knowledge, given the large number of farmers, governments may find it advantageous to help farmers to organize themselves into clusters (Box 15). This will facilitate the flow of knowledge between scientists and farmers, and it will also promote adherence to best aquaculture practices if farmers are allowed to self-manage and self-regulate within clusters.

Governments that see aquaculture as important will probably place increasing emphasis on helping to neutralize the constraints caused by deficient fish-farm management and the lack of technical expertise in subjects relevant to the industry.

Social constraints

As most other agricultural or livestock activities, aquaculture affects the lives of individuals who are not directly engaged in the industry, and negative externalities occur. The most well-known effects are pollution and ecosystem disturbances originating from aquaculture production units. In some tropical coastal regions, shrimp farming has had a negative impact on marine and terrestrial environments. In some developed economies, the wider public has resisted cage culture not only because of the pollution risks but also because cages have been deemed to spoil the view.

Governments have intervened to heed these and similar concerns by regulating when, where and how aquaculture can be undertaken. Interventions started out mostly as "command and control" policies. Over time, these policies have been refined through the introduction of economic incentives and disincentives. Examples are pollution fees, environmental taxes and tradable permits. From the point of view of the entrepreneur, these regulations constitute constraints.

Such guidelines are often subjective in nature. However, unless they produce for export, aquaculturists are unlikely to face severe public regulations in economies where few regulations apply to natural-resource-based industries or activities. In these cases, the producer will have to satisfy the public and/or private standards that apply in export markets. Guidelines are likely to be more demanding in wealthy industrial economies where most economic activities are regulated in order to reduce pollution and other negative externalities. Also, where aquaculture is important for food supplies and local economies, standards are less severe than in areas where aquaculture is insignificant, which is the situation in several developed economies.

As governments regulate externalities, existing farmers are likely to face increasing costs. In order to limit such consequences, and to increase the political possibility to regulate, governments will find it advantageous to make clear to potential aquaculturists, as early as possible, their intention to regulate (as well as the legal status and the purpose of future regulations).

Farmers will generally experience aquaculture regulations as constraints and essentially be "against" them. However, in addition to regulating aquaculture, public policies can help overcome constraints that may not be apparent to those participating in nascent or rapidly expanding aquaculture activity. Constraints "hidden" to a nascent industry can include any and all of the knowledge and market constraints discussed above. Proactive public policies for aquaculture will ensure development of a strategy to help entrepreneurs overcome these obstacles when they occur.

Box 15

Globalization – obstacle or opportunity for small-scale fish farmers?

Developing countries account for about 50 percent of fish exports. A large share of this originates in the small-scale sector. This means that market access requirements in importing countries, in particular those on quality and safety, have direct implications for small-scale fish farmers, for their production and for their economic well-being.

One might argue that, because of globalization (e.g. improved communication technology and mobile-telephone networks), the world is becoming one and indivisible as far as fish and fish products are concerned, and that, therefore, the actions of small farmers are determined by what happens globally. In some measure, this may be so.

However, it is not a practical reality for most small farmers in developing countries. While they suffer or benefit, with more or less delay, from developments in the rich industrialized world, most have only a vague notion of the source and reasons for their changing circumstances. The vast majority see their livelihoods as determined above all by what goes on in the region or country where they live and operate.

Few farmers have the time and energy needed to learn about foreign markets on their own. One way of reaching out to small-scale farmers and helping them adapt to the world outside is through the use of clusters. This has had considerable success in many countries, for example, through certification of small-scale operators organized in clusters of five producers at a time. As the farmers involved have seen their yields and economic returns increase, other farmers have come forward to join in. The effect has been that thousands of small-scale fish farmers have obtained certification of their production and, thereby, gained better access also to international markets.

Globalization can also constitute an opportunity for small-scale farmers, and the better they understand the phenomenon, the better equipped they will be to exploit this opportunity. Understanding the influence and the possibilities of distant markets and societies will prepare them for necessary changes.

Small-scale farmers need the support of the public sector. As farmers become more informed about globalization and its effects, what could be an obstacle can be turned into an opportunity.

Knowledge constraints are of particular importance in this context. They can create havoc in an aquaculture industry. Moreover, it takes time to build up local expertise in aquaculture-related sciences for which academic institutions are few and the science itself evolving.

Fish genetics and fish reproduction fall into this category. The benefits achieved through selective breeding are remarkable, but probably not known to most small-scale farmers in the developing world. In a recent report, the World Bank[4] presents data indicating that selective breeding in salmonids, channel catfish, tilapia, carp, shrimps and bivalves yields increases in growth rates generally above 10 percent per generation, and that this has been sustained over several generations for some species (tilapia and salmonids). All else being equal, such improvements in growth rates enable cost reductions (without reducing production), and this expands the markets for the cultured produce.

THE GLOBAL CONTEXT OF AQUACULTURE GROWTH – IMPLICATIONS FOR CONSTRAINTS

In the second half of 2007 and early in 2008, energy costs and the prices of basic foodstuffs rose rapidly worldwide. This also affected fish prices – particularly those for wild-caught fish – which rose in real terms for the first time in many years. These increases will affect demand for fish, which is likely to suffer a setback in 2008 and 2009. However, there is no reason to believe that the rise in the retail price of fish will lead to permanent modifications in relative prices (*vis-à-vis* red meat or other substitutes). Therefore, by 2010, global demand for fish and fish products will probably continue to increase following the pattern of recent decades.

When demand growth for fish resumes, it could be satisfied if fish supplies for human consumption increased by between 1.2 and 1.5 million tonnes per year (see note 2). This amounts to an annual growth in fish supplies of between 1.1 and 1.4 percent in volume terms.

Most of this increase in demand will be caused by population growth; the remainder will be the result of gradually rising disposable incomes, particularly in developing countries.

However, the likelihood that supplies will grow at this pace differs from region to region. Some regions (North America and Western Europe) have stagnant demand and are likely to experience little economic difficulty in maintaining per capita supplies even if landings from capture fisheries fall. However, other regions, especially sub-Saharan Africa (SSA), could experience radically different scenarios. The remainder of this section reviews the scenarios for aquaculture development and the implications for growth constraints in eight geographical areas. As international trade links one region to another, what happens within the regions is also determined by what happens outside them.

The scenarios[5] are very approximate. They are developed only to the extent needed in order to provide a background for identifying market forces that might drive aquaculture in a region and, hence, provide an idea of the future types of aquaculture products and their markets. In turn, this will generate ideas about the nature and importance of the constraints confronting the aquaculture sector in the region. The purpose of developing scenarios is to derive conclusions about the situation confronting aquaculture that may serve as the starting point for the development of public policies to improve the possibilities for sustainable aquaculture by overcoming constraints. As such policies are implemented, the scenarios will be modified, and *ex-post* reviews should reveal that the scenarios, as described here, did not materialize. Thus, the scenarios should not be mistaken for "predictions of history". They are only the means to an end: better aquaculture polices.

Sub-Saharan Africa

It seems that the population of SSA would buy more fish if they had the economic means to do so. In the immediate future, given the overall rise in food prices (which will probably spread also to fish), this is unlikely to happen. However, in the medium to long run, it is probable that demand will grow rapidly. There are three main reasons for this: (i) continued rapid population growth (exceeding 2 percent per year); (ii) reasonable economic growth; and (iii) the nutritional importance of fish in the African diet. However, in the next decade, neither domestic production from capture fisheries (marine and freshwater) nor local aquaculture will be able to provide the increased quantities of fish needed for human consumption. A part of this need may be satisfied through increased imports of low-value species.

Demand growth

It seems plausible that, by 2015, total annual fish consumption in SSA could be 1.5–2.0 million tonnes higher than in 2005 if fish supplies expand at an equal pace with demand.[6] This would result from a yearly increase in the volume of fish consumed of about 3 percent in volume terms. In relative terms, this is a larger increase than that foreseen for any other comparable region of the world.

Some 70 percent of the growth in demand comes from an increase in population, which means that demand growth is steady and large. Depending on the economic situation of the region, it could increase dramatically for two fundamental reasons. First, as mentioned above, the high nutritional significance of fish products (given the relatively low levels of red-meat consumption) implies that public policies should favour the supply of cheap fish. Second, for the same reason, the income elasticity of demand is likely to remain high. Therefore, any increase in the rate of improvement in economic well-being could reflect directly in a significant increase in the demand for fish.

While fish is important in the African diet, it is neither an inferior good nor a luxury item. There are several countries in Africa where fish protein accounts for more than 30 percent of all animal protein consumed. Thus, there are good reasons for governments and the international community to try to ensure conditions that will permit African households to at least maintain their present fish consumption.

It is the average poor Africans who will account for the bulk of the population increase. Given the low economic growth postulated, there will be little if any growth in demand for luxury fish products. Demand growth is likely to be spread geographically and not be exclusive to urban areas.

Satisfying annual growth in demand

Overall, it does not seem reasonable to expect capture fisheries off Africa's coasts – or in its main lakes and rivers – to yield the growing volumes of fish (almost 0.2 million tonnes per year) demanded by a growing African population in the coming decade. In fact, in volume terms, SSA has been a net importer of fish for some time. Growing local demand will tend to increase this trade gap by pulling in more imports and retaining for local consumption some of the fish now exported.

However, it cannot be taken for granted that such changes in the international trade in fish will suffice to provide the increased quantities. There are difficulties. On the one hand, Africa is already an importer of large volumes of fish of low commercial value. The demand for this fish will increase worldwide both for human food and as raw material for making fishmeal and fish oil. This may bring international prices to such levels that African countries could only afford a limited quantity of that currently imported. The resulting demand for this category of fish by African consumers will depend on the relative increase in its price and the region's economic growth (purchasing power). On the other hand, fish that are now exported are generally sold abroad at much higher prices than they would fetch in most African markets. It seems unlikely that exporters will be willing to divert supplies to local markets as, in most cases, it would means less income for them.

Small pelagics off northwest Africa are a potential source of food. Increasing supplies of these species is not so much a technical problem as an economic one. The fish can be caught; the issue is whether they can be sold as a source of human food at a price that is interesting for producers.

The possibilities for aquaculture

Aquaculture in SSA will grow (Box 16), but probably not as fast as the market could absorb. Aquaculture for export markets will be spearheaded by international companies, while aquaculture for the national markets will be led – as now – by local, small-scale entrepreneurs.

As international aquaculture producers establish themselves in Africa, most will do so intending to supply markets in Asia, Europe and North America. Primarily, they will be interested in raising freshwater fish, with some interest in marine crustaceans and marine finfish. They will import the production inputs not available locally and, generally, export their products. Thus, at most, they will have a minor role as a supplier of fish for African consumers.

Small-scale local entrepreneurs will probably continue to expand supply at a rapid rate. They will produce tilapia, catfish and possibly other species well known in rural African markets. In volume terms, supply increases could exceed 10 percent per year. However, even at such a rate of expansion, they will only be able to contribute some

Box 16

Aquaculture and Africa – how to stimulate growth

Aquaculture is a growing investment across Africa and the subsector is currently expanding – in some countries, at a rapid pace. The 2005 FAO Regional Review of Aquaculture in Africa identified rising fish prices resulting from declining catches as a major stimulus for increased investment in aquaculture (FAO, 2006a). Improved prospects for profits are increasingly being realized by significantly revised approaches to aquaculture development. These new approaches emphasize much more private-sector involvement, with government acting less as manager and more as facilitator and monitor (FAO, 2006b). They have been integrated into the overarching Special Programme for Aquaculture Development in Africa (SPADA). The programme follows closely the priorities set by The New Partnership for Africa's Development (NEPAD) Action Plan for the Development of African Fisheries and Aquaculture (2005). It represents the FAO Fisheries and Aquaculture Department's strategic approach to addressing aquaculture development in its member countries in Africa. The goal of the SPADA is to improve economic and rural development by enhancing fish supply and distribution as well as benefiting nutrition through increased aquaculture production. This goal is to be achieved by promoting sustainable aqua-businesses at national level including the necessary public and private support services. The SPADA aims to:

- increase aquaculture production in the Africa region by at least 200 percent in the next decade;
- assist two-thirds of the countries in the Africa region in elaborating and implementing national aquaculture development strategies, with accompanying aquaculture plans, legislation and regulations;
- implement the Code of Conduct for Responsible Fisheries and best management practices as they relate to aquaculture, as well as institute monitoring and evaluation methods that ensure social and environmental soundness;
- strengthen the African Aquaculture Network to facilitate information exchange, provide technical assistance, coordinate education and research, and provide basic support to the sector while employing the latest information technology (including communications technology to facilitate networking and information exchange);

2.5–5 percent (5 000–10 000 tonnes of additional produce) of what is needed. By 2015, the annual increase in production may have reached 20 000–30 000 tonnes, but this would still be far below the potential growth in supply that the projected increase in demand could absorb.

Effective constraints

There are several operational aquaculture constraints in SSA, but they apply almost exclusively to local entrepreneurs. As many of the export-oriented firms are likely to be joint ventures between Asian entrepreneurs and local interests, the inherent African constraints on this type of activity (in the areas of management, farm technology expertise, and high-quality seed and feed) will be overcome through imports of whatever is not locally available. Thus, once established, these firms will not be held back by local constraints.

- facilitate access to inputs (e.g. feed, seed, capital, land and water) by investors while promoting intraregional trade and markets for aquatic products.

The programme will provide assistance at all geographic and administrative levels. It will be active in seven arenas:

- strengthening regional, subregional and national institutions;
- networking and outreach;
- capital and input supply;
- processing and marketing;
- research and education;
- social, economic and environmental soundness;
- monitoring and evaluation.

The programme is founded on the principle of promoting profitable and sustainable aquaculture through private–public partnerships. The application of approaches exemplified by the SPADA has already realized significant increases in growth in the aquaculture subsector in *inter alia* Kenya, Malawi, Mozambique, Nigeria, Uganda and Zimbabwe. Building on this track record, the SPADA is developing as a pan-African programme under a multilateral trust fund arrangement between FAO and donor countries and organizations to advocate and enable the expansion of responsible aquaculture across the continent.

Sources:

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FAO 2006b. *Guiding principles for promoting aquaculture in Africa: benchmarks for sustainable development*, by J.F. Moehl, R. Brummett, M.B. Kalende and A. Coche. FAO CIFA Occasional Paper No. 28. Accra, FAO Regional Office for Africa.
New Partnership for Africa's Development. 2005. *The NEPAD Action Plan for the Development of African Fisheries and Aquaculture*. NEPAD Fish for All Summit, Abuja, Nigeria, 23 August 2005.

However, from the point of view of an international investor, an aquaculture enterprise is an economic activity like any other. In Africa, the sector will have to compete for foreign capital, not only with other potential investments in Africa, but also with investment possibilities in other continents. This means that foreign-financed aquaculture investments in Africa will be made more readily in those countries with an internationally recognized record of good macroeconomic management than in those without such a record.

The situation is different for the small-scale, local, entrepreneurial sector. It is unlikely to develop as fast as the local market would want. Although access to suitable sites for ponds and cages may not constitute a major constraint, most producers will face other more serious constraints. The expansion of farming of freshwater fish in ponds and cages will be constrained by a lack of management expertise and technical skills. Moreover, there will be shortages of seed and adequate feeds.

In many parts of Africa, pollution has not been a concern of either farmers or administrators. This has been a rational approach given the prevalence of small units and low feeding intensity. However, as local entrepreneurs expand, using farm-made or industrially-produced feeds, and operations are intensified, pollution is likely to become an issue. The sooner local fishery and aquaculture administrations tackle this issue (*inter alia* through zoning and effluent management), the easier it will be overcome (and at the lowest cost for all concerned).

In strife-free areas with at least the rudiments of a market economy and an adequate infrastructure for communications and transport, the rate of aquaculture expansion will depend largely on how fast the public sector can ensure that up-to-date aquaculture research and development centres become functional.

Latin America

In respect of fish production and consumption, the situation in Latin America does not resemble that found in Africa. Latin America has a fish surplus, and its population generally prefers red meat to fish. Nevertheless, fish consumption per capita is somewhat higher than in SSA. However, it seems likely that this consumption pattern will change slowly, and that the average Latin American will eat more fish and less red meat. This development will be encouraged by the growth of modern distribution channels for fish as well as an increasing preference for health foods.

Demand growth

The projected growth in demand,[7] assuming supply will increase *pari passu* (at unchanged real prices), is relatively substantial. By 2015, the Latin American population may consume between 1.0 and 1.2 million tonnes per year more than they did in 2005 – an increase of more than 20 percent.

Some 60 percent of this increase will be generated by population growth. The share caused by income growth is relatively modest. This is not because disposable household income will not increase – it will – but because Latin Americans are assumed to continue to prefer red meat to fish. Thus, according to these exploratory calculations, by 2015, average per capita annual fish consumption in Latin America will have risen to 9.2 kg (8.7 kg in 2005).

Thus, in most of Latin America, with the exception of the population in the Andean mountain ranges, the growth in fish consumption is important more because it will stem from an increase in economic activity (capture fisheries or aquaculture) rather than because fish provides essential contributions to people's diet.

Satisfying annual growth in demand

At present, the annual increase in demand is estimated at 100 000 tonnes at most. This increase can be supplied from local fish landings if as little as 2 percent of the annual capture fishery catches of food fish is redirected to the local market. However, if this were to happen, real prices for fish would probably increase in both national and export markets by 2015.

With the exception of Brazil and a few small countries, Latin America is generally well supplied with marine fish, caught especially around the southern part of the continent.

However, the supply situation is not uniform. Coastal areas are generally very well supplied with high-quality marine fish. In the interior of Latin America, freshwater fish is highly appreciated but not in ample supply. Given the absence of large bodies of freshwater, freshwater fish are caught in the large rivers. However, the supply is limited, and it is difficult to envisage any substantial increases in supply either from improved fishing methods or better management of river fisheries.

In sum, the next decade does not seem to herald any difficulties for fish consumers in Latin America. They may be supplied with what they demand even if capture fishery production and aquaculture production remain at their present levels. However, real prices may be somewhat higher.

The possibilities for aquaculture

Aquaculturists in Latin America who want to supply the local market must be prepared to compete with capture fisheries that can produce volumes of fish far in excess of local needs.

Among the apparent opportunities for Latin American aquaculturists are local niche markets for local species and the international market for aquaculture staple products. However, in the long run, growth in the demand for fish will also result in growth for the aquaculture sector. The will be all the more so, the more successful the sector is in creating a recognizable profile among consumers.

Several species cultured in Latin America, particularly in Chile, are established in the international market. Will the aquaculture industry be able to expand their production too? The world market for trout can probably best be described as saturated, that for salmon as nearing saturation levels, and that for shrimp as growing but as uncertain. However, a saturated market is not stationary. It grows as does the economy of which it is a part. Hence, there will be some growth in the established aquaculture industries in the years ahead under most circumstances even if Atlantic salmon does not become a major item in the Chinese market.

A producer who is not satisfied with the status quo but wants to grow and sell more trout or salmon than economic growth would seem to allow – and does not see company takeovers as a way forward – will engage in what can be seen as a zero-sum game. An increase in market share for one producer, for whatever reason, will result in a loss for another producer. If the increase stems from real improvements in productivity and a resulting decrease in production costs, then, in the end, as this new technology or management practice spreads, everyone – including the consumer – will be better off.

Constraints

For aquaculture export industries, the main non-market constraints will be in the fields of farm management and fish culture technologies. Farms will continue to have better access to feed than most as Latin America is a large exporter of fishmeal and fish oil. However, as world prices for both fishmeal and fish oil are set to increase, the Chilean salmon industry may suffer more than entrepreneurs growing other species. This is because both feed ingredients are used in larger proportions in salmon feed than in most other fish or crustacean feeds. On the other hand, access to seed in well-established, export-oriented aquaculture is not a constraint.

The modern export-oriented industry will continue to have good access to developing technology. This will facilitate growth, as will public policies that adapt governance schemes to the new technologies and possible negative externalities.

The small-scale rural farmer with an interest in aquaculture will face constraints similar to those described for SSA. However, also outside the Andean range, governments will have incentives to use resources for aquaculture development, given the need to adapt new technologies to local conditions and to provide a science-based underpinning of industry regulations. Moreover, in several Latin American economies, urban-based entrepreneurs may take an interest in developing modern aquaculture operations to supply high-quality products to growing urban markets. They are likely to advocate and promote the development of local aquaculture research centres as a means to access required scientific expertise.

South Asia

Demand growth

On a per capita basis, fish consumption in South Asia is low at about 5 kg per year. However, its large population means that about 8 million tonnes of fish are consumed per year. Towards the end of this decade, consumption is likely to increase by between 150 000 and 200 000 tonnes per year if supplies are provided at present levels of real prices. In volume terms, this is an increase of slightly more than 2 percent per year. By 2015, total annual fish consumption may be some 1.5–2.0 million tonnes higher than in 2005.

Given that prevailing religious beliefs constrain consumption of red meats and fish in large parts of this region, about 70 percent of the increase in consumption will probably be generated through population growth. However, a decade from now, religious objections to fish as food may have waned and demand[8] increased. Moderate economic growth (some 2 percent per year) will nevertheless generate growth in per capita consumption, set to increase moderately from the 5.5 kg of 2005.

In certain coastal regions, particularly around the Bay of Bengal, fish is a significant source of nutrition in poor communities. Elsewhere in the region, it is less so.

Demand growth is likely to be spread throughout the various income categories. The expanding middle class is increasingly going to consume fish that is traded internationally.

Satisfying annual growth in demand

Apparent consumption in South Asia is well above that supplied by capture fisheries. The region is dependent on aquaculture for fish supplies.

Capture fisheries supplies have stabilized for the region as a whole. It seems unlikely that, in the next five to ten years, the capture fisheries sector could consistently increase its output to provide the amounts required to maintain per capita supplies. It would be even less able to contribute fish for food if there were an additional increase in demand caused by sustained economic growth.

For the region, international trade is not the apparent solution for maintaining supplies. The region is already a net importer. Local supplies will increase somewhat as a portion of what is now exported will be redirected to local urban markets. However, little of this fish will be economically accessible for the poor. Moreover, most of them will be unable to afford the prices of imported fish. Hence, a modified international trade pattern will satisfy only a part of the growing needs for fish.

The possibility for aquaculture

The situation described above implies that aquaculture will be the major source for satisfying the growing demand for fish in South Asia. Fortunately, freshwater fish culture is well established and supplying a popular product.

If aquaculture were to satisfy the full increase in demand for fish, the growth in aquaculture should be in the order of 4.3 percent per year in volume terms. Aquaculture in the region has grown faster than this in the last two decades: 10.1 percent in 1985–1994; and 7.0 percent in 1995–2004).

However, the question is whether the constraints on aquaculture are such that its growth in the decade 2005–2015 will fall below 4.3 percent per year.

Constraints

While there is a substantial shrimp farming industry in South Asia (producing mainly for external markets), there is little true mariculture. One of the main reasons for this is the geography of the subcontinent. There are few protected bays or lagoons for cage farming, possibly with the exception of those of Maldives and the Andaman Islands (India). These effective constraints are unlikely to be overcome before off-shore (possibly submerged) cage culture technology has developed. Local governments and industry do not have the strong incentive that those in North America or Europe have to develop such technology.

Aquaculture growth in the region will continue to be mostly in the form of freshwater fish culture. However, this will not be without problems. Both land and freshwater are increasingly in short supply. Small pond areas will favour culture of species that can be raised in high densities, such as catfish. However, the need to provide fish proteins as feed in one form or another will soon become an effective constraint for this type of culture by small-scale farmers. Those who increase the stocking rates of Indian major carps or Chinese carps will need to provide supplemental feeds, and energy for aeration and/or recirculation of water. Costs will rise and production expansion will slow.

It seems clear that public policies will focus on knowledge constraints. The selective breeding of carps and farm management in all its aspects are likely to become priority concerns in ensuring the continued growth of freshwater fish farming.

China

Demand growth

If fish supplies expand *pari passu* with demand, it seems likely that, by 2015, annual fish consumption in China could be 4.5–5.5 million tonnes higher than in 2005.[9] This would result from a yearly increase in the volume of fish consumed of about 1.4 percent. At the time of writing (July 2008), the annual increase is likely to be somewhere between 0.45 and 0.50 million tonnes.

The rapid economic growth in China coupled with a slow rate of population increase means that almost 60 percent of the increase comes from a projected growth in household disposable income. As annual per capita fish consumption in China at 26 kg (live weight equivalent) is already well above the world average (about 14 kg if China is excluded), it means that the growth rate is uncertain. Any change in the economic situation could reduce demand growth drastically. However, the pattern of fish consumption in China may change as increasingly affluent urban people turn away from what they perceive as low-quality products towards high-quality items. This would lead to lower growth in volume terms.

Satisfying annual growth in demand

China produces more fish than it consumes. This leaves the possibility of satisfying future increases in national demand by redirecting some of the products now regularly exported. Given the stagnation in capture fisheries production, the other way to increase production is through aquaculture.

The possibilities for aquaculture

In recent years, aquaculture production in China has grown in volume terms by 5–7 percent per year (about 2 million tonnes), significantly more than the projected annual increase in the volume of fish demanded.

China has the largest aquaculture sector in the world in terms of both the volume of aquatic animals produced and the number of species cultivated. This increases the likelihood that the sector will continue to be able to supply the local market with almost all that it will want. Some of the exotic species now in demand, such as Atlantic salmon, are not produced commercially by China's aquaculture or capture fisheries.

Constraints

Notwithstanding the foregoing, the possibilities for expansion are restricted. Reports from China say that the sites, goods and services needed by aquaculturists are also demanded by other actors in the economy – microeconomic constraints. Among these constraints are access to culture sites and availability of recurrent inputs, especially feed.

Freshwater fish culture and mariculture of molluscs and finfish are constrained by a scarcity of culture sites. Given current farming systems, the possibilities to overcome these shortages seem very limited. While research and development efforts will attempt to develop farming technologies that need less space and water, it seems plausible that Chinese aquaculture entrepreneurs will establish grow-out facilities abroad, particularly in SSA and Latin America. The added costs of transport (to bring products back to China) would be offset by lower costs for sites and recurrent inputs.

Pollution from inshore cages is a limiting factor. This is likely to continue to be an effective constraint on the growth of marine cage culture. In part to overcome this constraint, a considerable research effort is under way in China to develop off-shore and deep-water cage culture technology. However, the country's rapid economic growth, leading to an economy-wide increase in pollution, means that Chinese

aquaculture is being negatively affected. The pollution of both coastal waters and bodies of freshwater is reducing their suitability as sites for aquaculture enterprises.

A significant share of feed inputs is imported, in particular soybean, fishmeal and fish oil. Given the growing demand for fishmeal and oil (and the stagnating supplies of soybean), their price on the international market is likely to rise. An appreciation of the Chinese currency against the dollar may reduce the cost of feed and other imported inputs. However, this will probably not be sufficient to protect producers from rising costs, which in turn may slow the rate of aquaculture growth.

Southeast Asia

Demand growth

Consumption is high in absolute terms at about 18 million tonnes per year, more than double that of South Asia. By 2015, it could have increased by another 3 million tonnes, at an annual increase of between 250 000 and 300 000 tonnes if supplies keep pace with demand.[10]

Per capita fish consumption is high in Southeast Asia, and it is unlikely that continued growth in disposable incomes will cause more than a moderate increase in per capita consumption. Most of the increase in demand will come from population growth.

Satisfying annual growth in demand

Capture fisheries account for most of the fish consumed in Southeast Asia. Capture fisheries and aquaculture produce more than the region consumes, generating an annual exportable surplus of between 1.5 and 2.0 million tonnes. Although capture fisheries production is increasing moderately, it is unlikely to do so for long. Fisheries on wild stocks are reaching a limit also in this region.

Export volumes have grown but seem to have reached a plateau in the last three years. Accepting this trend as a general pattern, it seems unlikely that exports will grow significantly again (save for a sudden spurt in aquaculture production). Thus, for some time, a part of the capture fisheries production may be redirected to local markets. However, this would only cover a small share of the growing demand for fish in Southeast Asia.

The possibilities for aquaculture

In volume terms, aquaculture has grown at annual rates of 6.1 and 7.6 percent in the last two decades. As an overall demand increase of some 250 000–300 000 tonnes per year is equivalent, in volume terms, to about 4–5 percent of current aquaculture production, the continuation of present trends would seem to "resolve the problem". This means that the capture fisheries sector need not produce more for the local markets.

However, the question is whether the aquaculture sector will be able to produce this much more every year for the next five to ten years. If not, what obstacles will prevent it from doing so?

Constraints

On the one hand, aquaculturists in the region are part of vibrant, growing economies and, therefore, enjoy growing demand. On the other hand, this very success is generating obstacles in the form of increasing competition for culture sites and recurrent inputs. In addition, in foreign markets, those who feel unable to compete with imported aquaculture products from the region protest. Moreover, aquaculturists' increased dependence on wild resources is sometimes leading to unsustainable stress on wild resources.

It is evident that for some cultures (catfish, tropical spiny lobster, grouper, etc.), obtaining both broodstocks and feed from the wild will not be sustainable in the long run. As technology development is not proceeding sufficiently rapidly to overcome these problems through better hatcheries and feeds (farm-made or commercial), governments will need to intervene through regulations and enforcement. This will

subtract public resources from where they are most needed (in personnel training and technology development) and lead to slower development of the sector than might have been possible if the public sector could have concentrated fully on removing the knowledge constraints.

Europe, North America and Japan

Demand growth

On a per capita basis, Japanese fish consumption is the highest among the regions reviewed in this study, at slightly less than 60 kg per year. For North America and Europe, the corresponding quantities are 24 and 21 kg, respectively, both above the world average of about 16 kg. Combined, these developed economies consumed about 31 million tonnes of fish in 2005. Starting from these high levels, it is also necessary to consider: (i) a sign of falling per capita consumption in Japan (see Table 15); (ii) predictions of slowly falling populations in Europe and Japan; and (iii) slow to moderate economic growth for the three regions. Therefore, there will be very little, if any, increase in their combined fish consumption (in volume terms) between 2005 and 2015 as declining Japanese consumption is offset by growth in North America and a very slow increase in Europe. Thus, these three regions will consume slightly more than 20 percent of world supplies in 2015, down significantly from two decades earlier.

Satisfying annual growth in demand

Given the virtual stagnation in demand,[11] it could be expected that supplies will be made available. However, it cannot be taken as a given that capture fisheries in the region will continue to produce at present levels. Overfishing and deficient economic returns for fishing vessels may lead to a decline in effort. Neither should it be taken as a given that imports will continue at past levels. Economic growth in South Asia may cause some of the fish now exported to the industrialized world to be sold there instead.

The possibilities for aquaculture

In North America and Japan, aquaculture accounts for a minor portion of fish supplies, whereas in Europe it provides about 20 percent. However, it seems plausible that aquaculture in these three regions could expand to cover for shortfalls in capture fisheries, but it would probably face fierce competition from aquaculturists elsewhere (principally in Asia and Latin America).

It is a possible, but demanding, undertaking for aquaculturists in Europe, North America and Japan to make inroads in high-priced markets in Asia and Latin America. Thus, marketing, sales promotion and continued cost-cutting will be essential if aquaculturists in the developed world are to remain competitive.

In Europe, a segment of better-off consumers have much interest in what they eat (Box 17). There are those who prefer "slow food", or products with a regional affiliation certified by geographic denominations and labels. Such groups provide European aquaculture producers with niche markets to target through dedicated marketing efforts.

Constraints

The market for aquaculture products produced in the industrialized world will not expand rapidly at present price levels. At the current prices for salmon, trout, catfish and sea-bass, consumers in these markets seem unlikely to increase their consumption unless capture fishery supplies of similar products fall.

However, it is not unusual for agriculture commodities to pass through production cycles where the volumes produced first expand only to contract later. A frequent cause of such cycles is the time lag that occurs between producers' decisions to modify output and the subsequent effects on supply once produce is harvested. Generally, however, the long-run tendency for aquaculture products going through such production cycles, and the consequent rise and fall in volumes and prices, is one of increasing volumes and falling prices. Moreover, as production grows, the cycles flatten out.

Box 17

Balancing the risks and benefits of consuming seafood

The strong focus on contaminants in foods is increasingly attracting the attention of consumers who are becoming more aware of the potential health impacts of a contaminated food supply. Fishery products can be linked to contaminants such as methylmercury and dioxins.

The traditional focus has been on the risks of consuming potentially-contaminated foods. However, there is now a growing focus on the risks of *not* consuming such foods, given their potential beneficial components. Some studies have tried to balance the positive and negative sides of consuming foods of high nutritional value but which are also a source of contaminants. A recent study concluded that, for the Netherlands population, the health loss from consuming unhealthy food is about 100 times that from consuming chemically-contaminated foods.[1]

In general, the levels of contaminants such as methylmercury and dioxins in seafood are well below the maximum levels established. However, some fishery products from polluted areas or large predatory fish can sometimes exceed these levels.

This has persuaded some countries to issue advice on limiting the consumption of such fish, in particular for vulnerable groups such as children and pregnant women. While the intention was only to limit consumption of products known to have elevated levels of contaminants, the effect in some cases has been a significant reduction in seafood consumption. The target groups of this advice are heavily dependent on a nutritionally optimal diet to cover their needs for omega-3 fatty acids and iodine – essential in the early development of the neural system. Seafood is known to be the main natural source of these nutrients.

A more holistic approach is needed in order to give advice on balancing the risks and benefits of consuming fishery products. The existing focus on links between seafood and contaminants on one side, and between seafood consumption and health on the other, is making it increasingly relevant to provide advice to governments on how to handle such issues.

In this context, FAO and the World Health Organization are preparing an expert consultation on the risks and benefits of consuming seafood. The first phase would focus specifically on the impact of methylmercury exposure on women of childbearing age and the future development of their children with respect to neural and cardiovascular development as well as the benefits of fish and its components. The confounding effects, if any, of dioxin and dioxin-like polychlorinated biphenyls (PCBs) will also be considered, as dioxin intake is highly correlated with the intake of fatty fish, which are also significant sources of the beneficial omega-3 fatty acids.

[1] C.F. van Kreijl, A.G.A.C. Knaap and J.M.A. van Raaij, editors in chief. 2006. *Our food, our health. Healthy diet and safe food in the Netherlands*. Bilthoven, Netherlands, National Institute for Public Health and the Environment.

At present, technological constraints seem to be holding back expansion of cod and cobia culture. Recent increases in the real cost of energy will probably affect aquaculture in the industrialized world more severely than in the developing world. However, the relatively low incidence of transport costs in the price of the final aquaculture product means that the effect on international trade, and third-country processing, will be minor.

Thus, the individual entrepreneur who wants to expand aquaculture output rapidly needs to capture a larger share of the market. This can be achieved with a new species (cod or cobia) or where the new product may be sold at the expense of products already on the market (salmon and tilapia). Increasing market share can also be a matter of price competitiveness. However, the ability to maintain substantially lower prices than competitors usually requires culture technology improvements, or faster-growing or better-growing specimens compared with those generally used in the industry. Thus, the farmer has to overcome technology hurdles.

However, innovative farmers may also develop a superior business model, possibly obtaining cost advantages from integrated hatcheries, on-growing facilities and economies of scale in input procurement.

Despite the growing use of fishmeal and fish oil elsewhere, particularly in Asia, it seems unlikely that feed price increases will be large enough to reduce profit margins significantly in established industries at least in the next few years.

Aquaculture development in these three regions will be led by entrepreneurs. Governments will probably refrain from intervening in matters other than those caused by negative externalities linked to aquaculture and those related to "unfair" international competition. They will provide some support to technological development, but it is not likely to become a priority.

SUMMARY AND CONCLUSIONS

There is little doubt that worldwide aquaculture growth will slow, albeit with growth spurts for particular species and regions. The success of the industry is bringing out constraints that were only potential when it started to grow. These obstacles will not simply disappear. Persistent efforts will remove or reduce them, but then others will arise. However, it is equally true that aquaculture will continue to grow in response to demand for fish and seafood generally. It will not come to a standstill.

As aquaculture entrepreneurs – large and small, modern and artisanal – and governments increasingly collaborate to remove knowledge constraints (those they are best equipped to handle and those that yield the best returns for the effort), the aquaculture industry will start to reduce its dependence on wild stocks. Currently, its need for broodstock, seed and feeds slows development. Once this dependence has been reduced, the industry will start to benefit from gains similar to those long enjoyed by the livestock industry, in particular those of selective breeding.

NOTES

1. Unless stated otherwise, in this text, the term fish includes crustaceans and molluscs.
2. In order for the world average per capita supply of fish for food not to fall, the net annual increase in total supply must reach about 1.3 million tonnes, given the present per capita supply of 16.7 kgs and a world population growth of about 78 million per year.
3. FAO. 2007. *Study and analysis of feeds and fertilizers for sustainable aquaculture development*, edited by M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon. FAO Fisheries Technical Paper No. 497. Rome.
   FAO. 2007. *Assessment of freshwater fish seed resources for sustainable aquaculture*, edited by M.G. Bondad-Reantaso. FAO Fisheries Technical Paper No. 501. Rome.
   FAO. 2008. *Capture-based aquaculture. Global overview*, edited by A. Lovatelli and P.F. Holthus. FAO Fisheries Technical Paper No. 508. Rome.
   FAO. 2008. *Report of the FAO Expert Workshop on the Use of Wild Fish and/or Other Aquatic Species as Feed in Aquaculture and Its Implications to Food Security and Poverty Alleviation, Kochi, India, 16–18 November 2007*. FAO Fisheries Report No. 867. Rome.
4. World Bank. 2006. *Aquaculture: changing the face of the waters. Meeting the promise and challenge of sustainable aquaculture.* Report No. 36622 – GBL. Washington, DC.
5. The period considered in the scenarios is the decade starting in 2006. For each region, a scenario projects plausible developments in capture fishery production, international trade in fish, non-food use of fish and demand growth for fish. These are extrapolations of trends based on data from the UN (population), FAO (fisheries and aquaculture) and *The Economist* (economic growth). Trend modifications are described in the text. As a rule, the demand projections are conservative. The main reason is that income elasticities of demand are projected average elasticities for the decade and, thus, with the exception of SSA, well below the empirically derived elasticities generally valid for a short period. As disposable income increases, these can be expected to fall over time, especially for high-volume, low-value products.
6. For the period 2006–15, the average income elasticity of demand has been placed at 0.9 and the annual average growth in disposable real income per capita at 1 percent.
7. For the period 2006–15, the average income elasticity of demand has been placed at 0.4 and the annual average growth in disposable real income per capita at 2 percent.
8. For the period 2006–2015, the average income elasticity of demand has been placed at 0.3 and the annual average growth in disposable real income per capita at 2 percent.
9. For the period 2006–15, the average income elasticity of demand has been placed at 0.2 and the annual average growth in disposable real income per capita at 4 percent.
10. For the period 2006–15, the average income elasticity of demand has been placed at 0.3 and the annual average growth in disposable real income per capita at 1 percent.
11. For Japan, the income elasticity is negative, while for North America and Europe it has been placed at 0.3 and 0.2, respectively. Growth in average annual disposable real income per capita has been placed at 1 percent.

Please find enclosed a complimentary copy of the
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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2008

After growing steadily, particularly in the last four decades, aquaculture is for the first time set to contribute half of the fish consumed by the human population worldwide. This reflects not only the vitality of the aquaculture sector but also global economic growth and continuing developments in fish processing and trade. Until a year or so ago, production trends in aquaculture and capture fisheries were continuing without any drastic modifications – with the capture fisheries sector regularly producing between 90 and 95 million tonnes per year, and aquaculture production growing rapidly, albeit at a gradually slowing pace.

This issue of *The State of World Fisheries and Aquaculture* features some aspects of fisheries and aquaculture that may receive increasing attention. These include climate change, the use of marine genetic resources in areas beyond national jurisdiction, and the proliferation of private standards and certification schemes in the international fish trade. This report also highlights some of FAO's special studies. Among these are the use of wild-fishery resources as seed and feed in aquaculture, and reviews of the world's shrimp fisheries and of the management of marine capture fisheries in the Pacific Ocean.

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