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THE STATE OF WORLD FISHERIES AND AQUACULTURE 2010

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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2010

FAO Fisheries and Aquaculture Department

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FOREWORD

As the world endeavours to recover from the combined impact of a global food price crisis, financial crash and economic recession, many hundreds of millions of people are facing increased uncertainty and real hunger. It is in this context that *The State of World Fisheries and Aquaculture 2010* aims to provide all concerned with an informed, comprehensive, balanced and worldwide view of fisheries, aquaculture and related issues.

This publication reveals that the per-capita supply of fish as human food reached a new all-time high in 2008, underscoring the key role of the sector in providing income for subsistence and small-scale fishers and food for billions of consumers who benefit from an excellent source of affordable, high-quality animal protein – protein that is particularly important for mothers-to-be and young children. Although the rate of global aquaculture growth is falling, aquaculture remains the fastest-growing animal-food-producing sector, now accounting for almost half of total food fish supply. While *The State of World Fisheries and Aquaculture 2010* makes the point that world capture fisheries production has been relatively stable in the past decade, it does voice concern about the state of stocks exploited by marine capture fisheries.

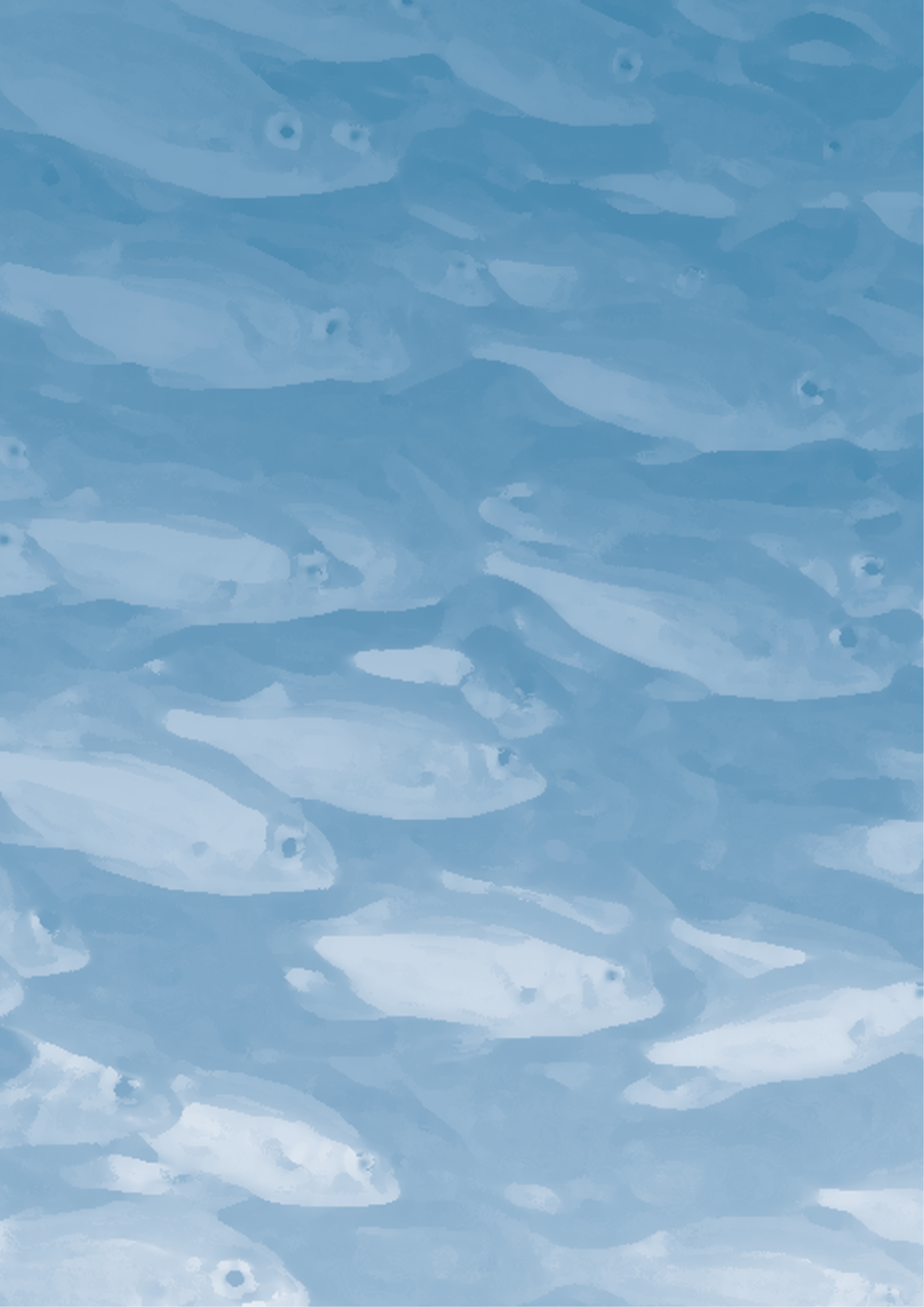
Fisheries and aquaculture are a crucial source of income and livelihood for hundreds of millions of people around the world, with the increase in employment in the sector outpacing world population growth and employment in traditional agriculture. Women play a vital role in fisheries and aquaculture, particularly in post-harvest activities. They represent almost half the people working in small-scale fisheries and this figure jumps to over 50 percent for inland fisheries. Reflecting the sector's continually increasing importance in the global market, this publication reports that exports of fish and fishery products reached record values in 2008.

Looking at broader issues in fisheries and aquaculture, *The State of World Fisheries and Aquaculture 2010* emphasizes the growing need to focus on the many facets of policy and governance, especially in relation to employment and poverty alleviation. Among other topics, it examines the impacts on the sector of climate change, biodiversity loss, quality certification and product traceability. It highlights efforts to curb IUU fishing, rent drain and the impact of derelict gear while promoting transparency in the sector, fostering an ecosystem approach to fisheries and enhancing biosecurity in aquaculture. It also points the way forward by encouraging actors at all levels in the sector to make better use of the Internet, GIS, remote sensing and other technological advances to safeguard biodiversity and ensure a sustainable future for the sector.

The Outlook section focuses on inland fisheries, which reported catches setting a new high for 2008, and their significant role in many small communities where they make a vital contribution to poverty alleviation and food security. It stresses the need for inland fisheries to be better reflected in government policies for rural development and particularly in programmes concerning the use of freshwater.

It is my hope that *The State of World Fisheries and Aquaculture 2010* will give readers an accurate and useful view of the fisheries and aquaculture sector, and that it will also provide an idea of the future the sector is likely to face and of the tools available to help people around the world put into practice and manage responsible fisheries and aquaculture.

Árni M. Mathiesen
Assistant Director-General
FAO Fisheries and Aquaculture Department



CONTENTS

PART 3
HIGHLIGHTS OF SPECIAL STUDIES

PART 4
OUTLOOK

TABLES

FIGURES

BOXES

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), X. Zhou (aquaculture), S. Vannuccini (fishers, utilization and consumption), F. Jara and S. Tsuji (fishing fleets), P. Barros, G. Bianchi and Y. Ye (marine resources), J. Jorgensen, U. Barg, D. Bartley and G. Marmulla (inland resources), and S. Vannuccini and H. Josupeit (trade and commodities). In the section on governance, contributions were provided by R. Willmann (small-scale fisheries), L. Ababouch and W. Emerson (trade and traceability), H. Watanabe and F. Poulain (RFBs), D. Doulman (IUU fishing), F. Chopin (bycatch and discards), and N. Hishamunda and R. Subasinghe (aquaculture policy). S. Montanaro and S. Vannuccini prepared most of the figures and tables.

Contributors to Part 2, Selected issues in fisheries and aquaculture, included W. Emerson (trade measures against IUU fishing), M. Reantaso (maintaining biosecurity in aquaculture), J. Toppe (benefits and risks of fish consumption), and M. Kuruc, S. Driscoll and F. Jara (fisheries sector transparency).

For Part 3, Highlights of special studies, contributors included T. Bahri, C. De Young and D. Soto (climate change implications for fisheries and aquaculture), R. Willmann (rent drain in capture fisheries), F. Chopin (abandoned, lost or otherwise discarded gear), L. Ababouch and S. Washington (private standards and certification), N. Hishamunda (aquaculture development in Southeast Asia), C. De Young (human dimensions of the ecosystem approach to fisheries), J. Kapetsky and J. Aguilar (GIS, remote sensing and mapping for marine aquaculture), R. Subasinghe (review of aquaculture development), and S. Garcia (using the Internet for fisheries policy and management advice).

Part 4, Outlook, was prepared by G. de Graaf, D. Bartley, J. Jorgensen, G. Marmulla and U. Wijkström. Elements of this chapter drew upon a driver review of inland fisheries prepared for the United Kingdom Government Office for Science's Foresight Project on Global Food and Farming Futures under the leadership of Sir John Beddington.

The individuals who provided text boxes included: P. Barros and G. Bianchi (1); G. de Graaf (5, 20 and 21); C. De Young (15); C. De Young and T. Bahri (12); D. Doulman (9 and 10); J. Fitzgerald (13 and 14); A. Harris (8); J. Jorgensen and G. de Graaf (17); H. Josupeit (3); S. Kennelly (11); M. Kuruc and J. Sanders (6 and 7); A. Lem (2); G. Marmulla (19); S. Vannuccini (4); U. Wijkström and G. de Graaf (18); and U. Wijkström and J. Jorgenson (16).

The FAO Fisheries and Aquaculture Department, under the supervision of T. Farmer, coordinated the editing, design and production of *The State of World Fisheries and Aquaculture 2010*.

ABBREVIATIONS AND ACRONYMS

ACC
Aquaculture Certification Council

ACP COUNTRIES
African, Caribbean and Pacific countries

ALDFG
abandoned, lost or otherwise discarded fishing gear

APEC
Asia-Pacific Economic Cooperation

CBD
Convention on Biological Diversity

CCAMLR
Commission on the Conservation of Antarctic Marine Living Resources

CCRF
Code of Conduct for Responsible Fisheries

CITES
Convention on International Trade in Endangered Species of Wild Fauna and Flora

COFI
Committee on Fisheries

EAF
ecosystem approach to fisheries

EAFM
ecosystem approach to fisheries management

EEA
European Economic Area

EEZ
exclusive economic zone

EU
European Union

FAD
fish aggregating device

FDA
Food and Drug Administration (United States of America)

FIGIS
FAO Fisheries Global Information System

FIRMS
Fishery Resources Monitoring System

FSMS
food safety management scheme

GDP
gross domestic product

GEF
Global Environment Facility

GIS
geographic information system

HACCP
Hazard Analysis and Critical Control Point (system)

ICCAT
International Commission for the Conservation of Atlantic Tunas

IMO
International Maritime Organization

IOC
Intergovernmental Oceanographic Commission

IPOA-IUU
FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing

ITQ
individual transferable quota

IUU
illegal, unreported and unregulated fishing

LIFDC
low-income food-deficit country

LOA
length overall

MARPOL
International Convention for the Prevention of Pollution from Ships

MCS
monitoring, control and surveillance

MPA
marine protected area

MSE
management strategies evaluation

NAFO
Northwest Atlantic Fisheries Organization

NAMA
Northwest Atlantic Marine Alliance

NASCO
North Atlantic Salmon Conservation Organization

NEAFC
North East Atlantic Fisheries Commission

NEI
not elsewhere included

NGO
non-governmental organization

NPOA
national plan of action

OECD
Organisation for Economic Co-operation and Development

OIE
World Organisation for Animal Health

RAC
Regional Advisory Council

RFB
regional fishery body

RFMO
regional fisheries management organization

RSN
Regional Fishery Body Secretariats Network

SPS AGREEMENT
Agreement on the Application of Sanitary and Phytosanitary Measures

SSB
spawning stock biomass

TAC
total allowable catch

TBT AGREEMENT
Agreement on Technical Barriers to Trade

UNDP
United Nations Development Programme

UNFSA
United Nations Fish Stocks Agreement

UVI
unique vessel identifier

VME
vulnerable marine ecosystem

VMS
vessel monitoring system

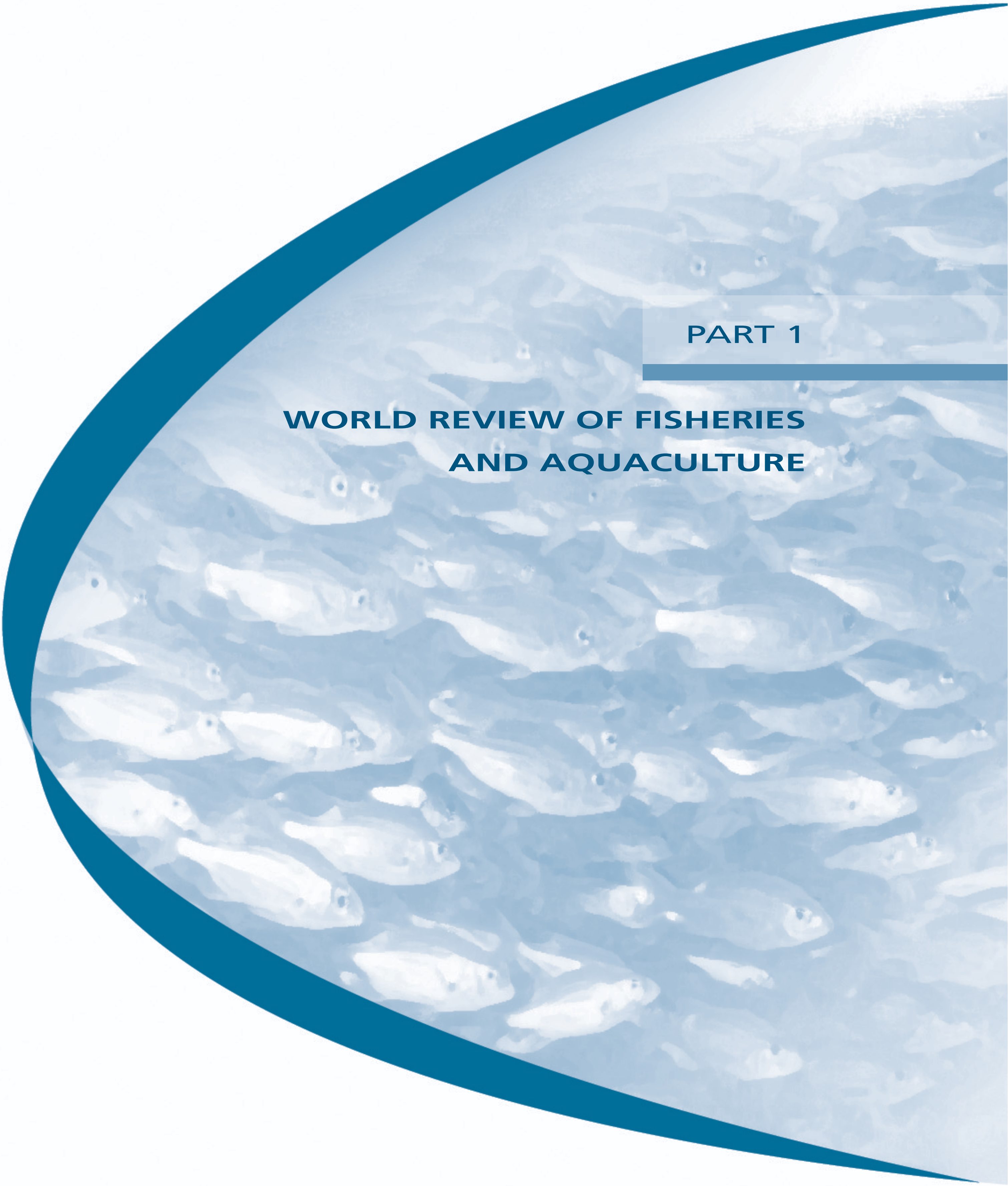
WHO
World Health Organization

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 142 million tonnes of fish in 2008 (Table 1 and Figure 1; all data presented are subject to rounding). Of this, 115 million tonnes was used as human food, providing an estimated apparent per capita supply of about 17 kg (live weight equivalent), which is an all-time high (Table 1 and Figure 2). Aquaculture accounted for 46 percent of total food fish supply, a slightly lower proportion than reported in *The State of World Fisheries and Aquaculture 2008* owing to a major downward revision of aquaculture and capture fishery production statistics by China (see below), but representing a continuing increase from 43 percent in 2006. Outside China, per capita supply has remained fairly static in recent years as growth in supply from aquaculture has offset a small decline in capture fishery production and a rising population (Table 2). In 2008, per capita food fish supply was estimated at 13.7 kg if data for China are excluded. In 2007, fish accounted for 15.7 percent of the global population's intake of animal protein and 6.1 percent of all protein consumed. Globally, fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and 3.0 billion people with at least 15 percent of such protein. In 2007, the average annual per capita

Table 1
World fisheries and aquaculture production and utilization

	2004	2005	2006	2007	2008	2009
			(Million tonnes)			
PRODUCTION						
INLAND						
Capture	8.6	9.4	9.8	10.0	10.2	10.1
Aquaculture	25.2	26.8	28.7	30.7	32.9	35.0
Total inland	**33.8**	**36.2**	**38.5**	**40.6**	**43.1**	**45.1**
MARINE						
Capture	83.8	82.7	80.0	79.9	79.5	79.9
Aquaculture	16.7	17.5	18.6	19.2	19.7	20.1
Total marine	**100.5**	**100.1**	**98.6**	**99.2**	**99.2**	**100.0**
TOTAL CAPTURE	**92.4**	**92.1**	**89.7**	**89.9**	**89.7**	**90.0**
TOTAL AQUACULTURE	**41.9**	**44.3**	**47.4**	**49.9**	**52.5**	**55.1**
TOTAL WORLD FISHERIES	**134.3**	**136.4**	**137.1**	**139.8**	**142.3**	**145.1**
UTILIZATION						
Human consumption	104.4	107.3	110.7	112.7	115.1	117.8
Non-food uses	29.8	29.1	26.3	27.1	27.2	27.3
Population (*billions*)	6.4	6.5	6.6	6.7	6.8	6.8
Per capita food fish supply (*kg*)	16.2	16.5	16.8	16.9	17.1	17.2

Note: Excluding aquatic plants. Data for 2009 are provisional estimates.

apparent fish supply in developing countries was 15.1 kg, and 14.4 kg in low-income food-deficit countries (LIFDCs). In LIFDCs, which have a relatively low consumption of animal protein, the contribution of fish to total animal protein intake was significant – at 20.1 percent – and is probably higher than that indicated by official statistics in view of the underrecorded contribution of small-scale and subsistence fisheries.

China remains by far the largest fish-producing country, with production of 47.5 million tonnes in 2008 (32.7 and 14.8 million tonnes from aquaculture and capture fisheries, respectively). These figures were derived using a revised statistical methodology adopted by China in 2008 for all aquaculture and capture fishery

Figure 1

World capture fisheries and aquaculture production

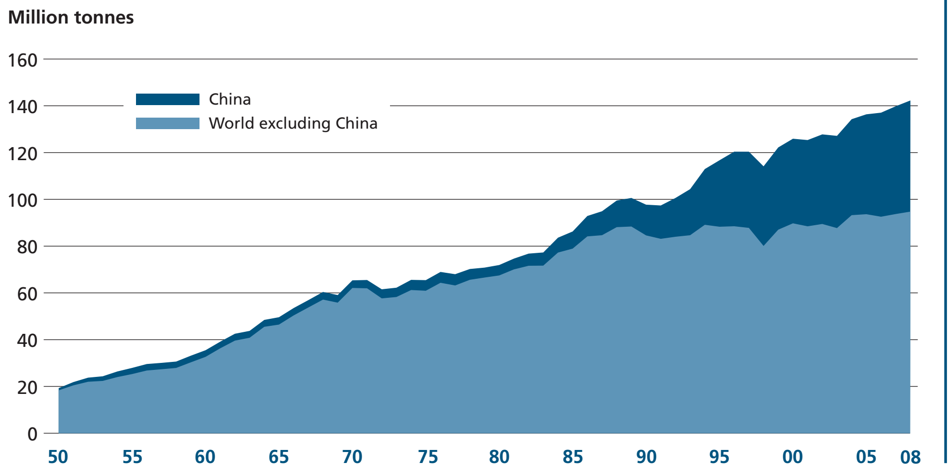


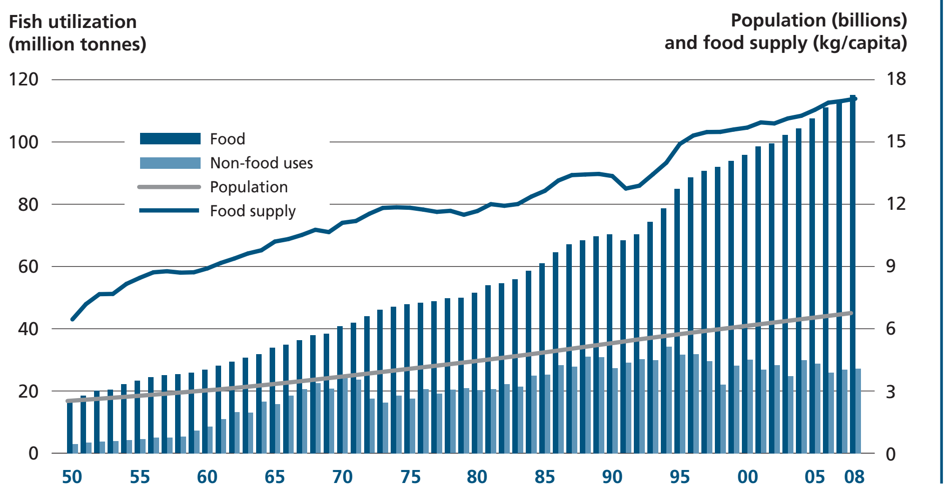
Table 2
World fisheries and aquaculture production and utilization, excluding China

	2004	2005	2006	2007	2008	2009
	(Million tonnes)					
PRODUCTION						
INLAND						
Capture	6.5	7.2	7.6	7.7	8.0	7.9
Aquaculture	8.9	9.5	10.2	11.0	12.2	12.9
Total inland	**15.4**	**16.7**	**17.7**	**18.7**	**20.1**	**20.8**
MARINE						
Capture	71.4	70.3	67.5	67.5	67.0	67.2
Aquaculture	6.5	6.7	7.3	7.5	7.6	8.1
Total marine	**77.9**	**77.0**	**74.8**	**75.0**	**74.6**	**75.3**
TOTAL CAPTURE	**77.9**	**77.5**	**75.1**	**75.2**	**74.9**	**75.1**
TOTAL AQUACULTURE	**15.3**	**16.2**	**17.5**	**18.5**	**19.8**	**21.0**
TOTAL FISHERIES PRODUCTION	**93.2**	**93.7**	**92.6**	**93.7**	**94.8**	**96.1**
UTILIZATION						
Human consumption	68.8	70.4	72.4	73.5	74.3	75.5
Non-food uses	24.5	23.2	20.2	20.2	20.5	20.5
Population (*billions*)	5.2	5.2	5.3	5.4	5.4	5.5
Per capita food fish supply (*kg*)	13.4	13.5	13.7	13.7	13.7	13.7

Note: Excluding aquatic plants. Data for 2009 are provisional estimates.

Figure 2

World fish utilization and supply



production statistics and applied to statistics for 2006 onwards. The revision was based on the outcome of China's 2006 National Agricultural Census, which contained questions on fish production for the first time, as well as on results from various pilot sample surveys, most of which were conducted in collaboration with FAO. While revisions varied according to species, area and sector, the overall result was a downward correction of fishery and aquaculture production statistics for 2006 of about 13.5 percent. FAO subsequently estimated revisions for its historical statistics for China for 1997–2005. Notice of the impending revision by China had been given in *The State of World Fisheries and Aquaculture 2008*. Because of the major importance of China in the global context, China is in some cases discussed separately from the rest of the world in this publication.

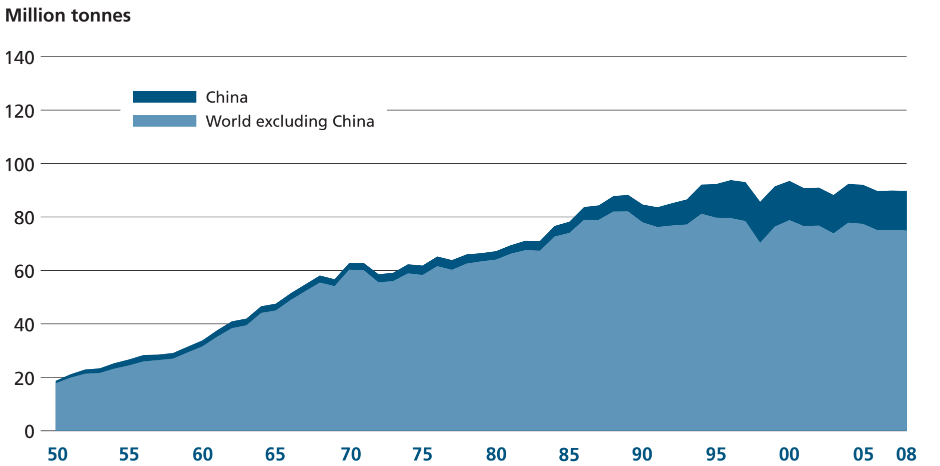
Global capture fisheries production in 2008 was about 90 million tonnes, with an estimated first-sale value of US$93.9 billion, comprising about 80 million tonnes from marine waters and a record 10 million tonnes from inland waters (Table 1 and Figure 3). World capture fisheries production has been relatively stable in the past decade (Figure 3), 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. Fluctuations in other species and regions tend to compensate for each other to a large extent. In 2008, China, Peru and Indonesia were the top producing countries. China remained by far the global leader with production of about 15 million tonnes.

Although the revision of China's fishery statistics reduced reported catches by about 2 million tonnes per year in the Northwest Pacific, this area still leads by far the ranking of marine fishing areas, followed by the Southeast Pacific, the Western Central Pacific and the Northeast Atlantic. The same species have dominated marine catches since 2003, with the top ten species accounting for about 30 percent of all marine catches. Catches from inland waters, two-thirds of which were reported as being taken in Asia in 2008, have shown a slowly but steadily rising trend since 1950, owing in part to stock enhancement practices and possibly also to some improvements in reporting, which still remains poor for inland water fisheries (with small-scale and subsistence fisheries substantially underrepresented in the statistics).

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 2008, an average annual growth rate of 6.6 percent.

Figure 3

World capture fisheries production



It is set to overtake capture fisheries as a source of food fish. While aquaculture production (excluding aquatic plants) was less than 1 million tonnes per year in the early 1950s, production in 2008 was 52.5 million tonnes, with a value of US$98.4 billion. Aquatic plant production by aquaculture in 2008 was 15.8 million tonnes (live weight equivalent), with a value of US$7.4 billion, representing an average annual growth rate in terms of weight of almost 8 percent since 1970. Thus, if aquatic plants are included, total global aquaculture production in 2008 amounted to 68.3 million tonnes with a first-sale value of US$106 billion. World aquaculture is heavily dominated by the Asia–Pacific region, which accounts for 89 percent of production in terms of quantity and 79 percent in terms of value. This dominance is mainly because of China's enormous production, which accounts for 62 percent of global production in terms of quantity and 51 percent of global value.

Growth rates for aquaculture production are slowing, reflecting the impacts of a wide range of factors, and vary greatly among regions. Latin America and the Caribbean showed the highest average annual growth in the period 1970–2008 (21.1 percent), followed by the Near East (14.1 percent) and Africa (12.6 percent). China's aquaculture production increased at an average annual growth rate of 10.4 percent in the period 1970–2008, but in the new millennium it has declined to 5.4 percent, which is significantly lower than in the 1980s (17.3 percent) and 1990s (12.7 percent). The average annual growth in aquaculture production in Europe and North America since 2000 has also slowed substantially to 1.7 percent and 1.2 percent, respectively. The once-leading countries in aquaculture development such as France, Japan and Spain have shown falling production in the past decade. It is expected that, while world aquaculture production will continue to grow in the coming decade, the rate of increase in most regions will slow.

The fish sector is a source of income and livelihood for millions of people around the world. Employment in fisheries and aquaculture has grown substantially in the last three decades, with an average rate of increase of 3.6 percent per year since 1980. It is estimated that, in 2008, 44.9 million people were directly engaged, full time or, more frequently, part time, in capture fisheries or in aquaculture, and at least 12 percent of these were women. This number represents a 167 percent increase compared with the 16.7 million people in 1980. It is also estimated that, for each person employed in capture fisheries and aquaculture production, about three jobs are produced in secondary activities, including post-harvest, for a total of more than 180 million jobs in the whole of the fish industry. Moreover, on average, each jobholder provides for three dependants or family members. Thus, the primary and secondary sectors support the livelihoods of a total of about 540 million people, or 8.0 percent of the world population.

Employment in the fisheries sector has grown faster than the world's population and than employment in traditional agriculture. The 44.9 million people engaged in the sector in 2008 represented 3.5 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide, compared with 1.8 percent in 1980. The majority of fishers and aquaculturists are in developing countries, mainly in Asia, which has experienced the largest increases in recent decades, reflecting in particular the rapid expansion of aquaculture activities. In 2008, 85.5 percent of fishers and fish farmers were in Asia, followed by Africa (9.3 percent), Latin America and the Caribbean (2.9 percent), Europe (1.4 percent), North America (0.7 percent) and Oceania (0.1 percent). China is the country with the highest number of fishers and fish farmers, representing nearly one-third of the world total. In 2008, 13.3 million people were employed as fishers and fish farmers in China, of whom 8.5 million people were full time. In 2008, other countries with a relatively high number of fishers and fish farmers were India and Indonesia.

Although the highest concentration of people employed in the primary sector is in Asia, average annual production per person there is only 2.4 tonnes, whereas it is almost 24 tonnes in Europe and more than 18 tonnes in North America. This reflects the degree of industrialization of fishing activities, and, in Africa and Asia, also the key social role played by small-scale fisheries. The differences are even more evident in the aquaculture sector, where, for example, fish farmers' average annual production in Norway is 172 tonnes per person, while in Chile it is about 72 tonnes, in China 6 tonnes and in India only 2 tonnes.

Although capture fisheries continue to provide by far the greater number of jobs in the primary sector, it is apparent that the share of employment in capture fisheries is stagnating or decreasing and increased opportunities are being provided by aquaculture. According to the estimates based on the available data for 2008, fish farmers accounted for one-quarter of the total number of workers in the fisheries sector, totalling almost 11 million people. Since 1990, fish farmers have experienced the greatest increases in their numbers, with most of the growth occurring in Asia, particularly in China, where the number of fish farmers increased by 189 percent in the period 1990–2008.

Employment in fishing is decreasing in capital-intensive economies, in particular in most European countries, North America and Japan. This is the result of several factors, including decreased catches, programmes to reduce fishing capacity and increased productivity through technical progress. It is estimated that about 1.3 million people were employed in fisheries and aquaculture in developed countries in 2008, a decrease of 11 percent compared with 1990.

Analyses indicate that the global fishing fleet is made up of about 4.3 million vessels and that this figure has not increased substantially from an FAO estimate of a decade ago. About 59 percent of these vessels are powered by engines. The remaining 41 percent are traditional craft of various types, operated by sails and oars, concentrated primarily in Asia (77 percent) and Africa (20 percent). These unmotorized boats are engaged in fishing operations, usually inshore or on inland waters. The estimated proportion of non-powered boats is about 4 percent lower than that obtained in 1998. Of the total number of fishing vessels powered by engines, the vast majority (75 percent) were reported from Asia and the rest mostly from Latin America and the Caribbean (8 percent), Africa (7 percent) and Europe (4 percent). The proportion of countries where the number of vessels either decreased or remained the same (35 percent) was greater than that of those where it increased (29 percent). In Europe, 53 percent of the countries decreased their fleet and only 19 percent of countries increased it. There was no increase in North America, while in the Pacific and Oceania region the fleet size either remained the same or decreased in a larger proportion of countries. In the Near East, 6 out of 13 countries (46 percent) increased the number of vessels in their fleets. In Latin America and the Caribbean, Asia and

Africa, an even greater proportion of countries increased their national fleets in terms of number of vessels.

The proportion of marine fish stocks estimated to be underexploited or moderately exploited declined from 40 percent in the mid-1970s to 15 percent in 2008, whereas the proportion of overexploited, depleted or recovering stocks increased from 10 percent in 1974 to 32 percent in 2008. The proportion of fully exploited stocks has remained relatively stable at about 50 percent since the 1970s. In 2008, 15 percent of the stock groups monitored by FAO were estimated to be underexploited (3 percent) or moderately exploited (12 percent) and able to produce more than their current catches. This is the lowest percentage recorded since the mid-1970s. Slightly more than half of the stocks (53 percent) were estimated to be fully exploited and, therefore, their current catches are at or close to their maximum sustainable productions, with no room for further expansion. The remaining 32 percent were estimated to be either overexploited (28 percent), depleted (3 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum potential production owing to excess fishing pressure, with a need for rebuilding plans. This combined percentage is the highest in the time series. The increasing trend in the percentage of overexploited, depleted and recovering stocks and the decreasing trend in underexploited and moderately exploited stocks give cause for concern.

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, are fully exploited. The two main stocks of anchoveta (*Engraulis ringens*) in the Southeast Pacific and those of Alaska pollock (*Theragra chalcogramma*) in the North Pacific and blue whiting (*Micromesistius poutassou*) in the Atlantic are fully exploited. Several Atlantic herring (*Clupea harengus*) stocks are fully exploited, but some are depleted. Japanese anchovy (*Engraulis japonicus*) in the Northwest Pacific and Chilean jack mackerel (*Trachurus murphyi*) in the Southeast Pacific are considered to be fully exploited. Some limited possibilities for expansion may exist for a few stocks of chub mackerel (*Scomber japonicus*), which are moderately exploited in the Eastern Pacific, while the stock in the Northwest Pacific was estimated to be recovering. In 2008, the largehead hairtail (*Trichiurus lepturus*) was estimated to be overexploited in the main fishing area in the Northwest Pacific. Of the 23 tuna stocks, most are more or less fully exploited (possibly up to 60 percent), some are overexploited or depleted (possibly up to 35 percent) and only a few appear to be underexploited (mainly skipjack). In the long term, because of the substantial demand for tuna and the significant overcapacity of tuna fishing fleets, the status of tuna stocks may deteriorate further if there is no improvement in their management. Concern about the poor status of some bluefin stocks and the difficulties in managing them led to a proposal to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 2010 to ban the international trade of Atlantic bluefin. Although it was hardly in dispute that the stock status of this high-value food fish met the biological criteria for listing on CITES Appendix I, the proposal was ultimately rejected. Many parties that opposed the listing stated that in their view the International Commission for the Conservation of Atlantic Tunas (ICCAT) was the appropriate body for the management of such an important commercially exploited aquatic species. Despite continued reasons for concern in the overall situation, it is encouraging to note that good progress is being made in reducing exploitation rates and restoring overfished fish stocks and marine ecosystems through effective management actions in some areas such as off Australia, on the Newfoundland–Labrador Shelf, the Northeast United States Shelf, the Southern Australian Shelf, and in the California Current ecosystems.

Inland fisheries are a vital component in the livelihoods of people in many parts of the world, in both developing and developed countries. However, irresponsible fishing practices, habitat loss and degradation, water abstraction, drainage of wetlands, dam construction and pollution (including eutrophication) often act together, thus compounding one another's effects. They have caused substantial declines and other changes in inland fishery resources. Although these impacts are not always reflected by a discernable decrease in fishery production (especially when stocking is practised), the fishery may change in composition and value. The poor state of knowledge on inland fishery resources and their ecosystems has led to differing views on the actual status of many resources. One view maintains that the sector is in serious trouble because of the multiple uses of and threats to inland water ecosystems. The other view holds that the sector is in fact growing, that much of the production and growth has gone unreported and that stock enhancement through stocking and other means has played a significant role. Irrespective of these views, the role of inland fisheries in poverty alleviation and food security needs to be better reflected in development and fisheries policies and strategies. The tendency to undervalue inland fisheries in the past has resulted in inadequate representation in national and international agendas. In recognition of this, the “Outlook” section of this publication focuses on inland fisheries in an effort to improve awareness of their role and importance.

As a highly perishable commodity, fish has specific requirements and a significant capacity for processing. Almost 81 percent (115 million tonnes) of world fish production in 2008 was destined for human consumption, while the rest (27 million tonnes) was used for non-food purposes such as fishmeal and fish oil (20.8 million tonnes), culture, bait, and pharmaceutical uses as well as for direct feeding in aquaculture and for fur animals.

In 2008, 39.7 percent (56.5 million tonnes) of total world fish production was marketed as fresh, while 41.2 percent (58.6 million tonnes) of fish was frozen, cured or otherwise prepared for direct human consumption. Since the mid-1990s, the proportion of fish used for direct human consumption has grown as more fish is used as food and less for producing fishmeal and fish oil. Of the fish destined for direct human consumption, fish in live or fresh form was the most important product, with a share of 49.1 percent, followed by frozen fish (25.4 percent), prepared or preserved fish (15.0 percent) and cured fish (10.6 percent). Live and fresh fish grew in quantity from 45.4 million tonnes in 1998 to 56.5 million tonnes in 2008 (live weight equivalent). Processed fish for human consumption increased from 46.7 million tonnes in 1998 to 58.6 million tonnes in 2008 (live weight equivalent). Freezing represents the main method of processing fish for human consumption and it accounted for a 49.8 percent share of total processed fish for human consumption and 20.5 percent of total fish production in 2008. Anchoveta and other small pelagics are the main species used for reduction, and the production of fishmeal and fish oil is strictly linked to the catches of these species.

Trade in fish represents a significant source of foreign currency earnings, in addition to the sector’s important role in employment, income generation and food security. In 2008, trade in fish and fishery products represented a share of about 10 percent of total agricultural exports and 1 percent of world merchandise trade in value terms. The share of fishery and aquaculture production (live weight equivalent) entering international trade as various food and feed products increased from 25 percent in 1976 to 39 percent in 2008, reflecting the sector’s growing degree of openness to, and integration in, international trade. In 2008, exports of fish and fishery products reached a record value of US$102.0 billion, 9 percent higher than in 2007, almost double the US$51.5 billion corresponding value in 1998. In real terms (adjusted for inflation), fishery exports grew by 11 percent in the period 2006–08 and by 50 percent between 1998 and 2008. In the period from late 2006 to mid-2008, international agricultural prices (particularly of basic foods) surged to record levels in nominal terms owing to several factors including a tightening in own supplies, the intertwining of global markets, exchange rate fluctuations, and rising crude oil prices and freight rates. These soaring prices affected large population segments, in particular among the poor in many developing countries. Prices of fish and fishery products were also affected by the food price crisis, following the general upward trend in all food prices. The FAO Fish Price Index indicates an increase of 37 percent between February 2007 and September

2008, when it reached a record high. Prices for species from capture fisheries increased more than those for farmed species because of the larger impact from higher energy prices on fishing vessel operations than on farmed species. The FAO Fish Price Index showed a drastic drop from September 2008 to March 2009 with the global financial crisis and recession, after which it recovered somewhat. Preliminary estimates indicate that trade in fish and fishery products declined by 7 percent in 2009 compared with 2008. Available data for the first few months of 2010 indicate that there have been increasing signs that fish trade is recovering in many countries, and the long-term forecast for fish trade remains positive, with a growing share of fish production entering international markets.

China, Norway and Thailand are the top three fish exporters. Since 2002, China has been by far the leading fish exporter, contributing almost 10 percent of 2008 world exports of fish and fishery products, or about US$10.1 billion, and increasing further to US$10.3 billion in 2009. China's fishery exports have grown considerably since the 1990s, and a growing share of these exports consists of reprocessed imported raw material. Developing countries, in particular China, Thailand and Viet Nam, accounted for 80 percent of world fishery production in 2008 with their exports accounting for 50 percent (US$50.8 billion) of world exports of fish and fishery products in value terms. Low-income food-deficit countries are playing an active and growing role in the trade in fish and fishery products, with their fishery exports reaching US$19.8 billion in 2008. World imports of fish and fish products reached the new record of US$107.1 billion in 2008, growing by 9 percent compared with previous year. Preliminary data for 2009 point to a 9 percent decrease, as a consequence of the economic downturn and the contraction in demand in key importing countries. Japan, the United States of America and the European Union (EU) are the major markets, with a total share of about 69 percent in 2008. Japan is the world's largest single national importer of fish and fishery products, with imports valued at US$14.9 billion in 2008, a growth of 13 percent compared with 2007, although its imports decreased by 8 percent in 2009. The EU is by far the largest market for imported fish and fishery products with imports in 2008 worth US$44.7 billion, up 7 percent on 2007, and representing 42 percent of total world imports. However, if intraregional trade among EU countries is excluded, the EU imported US$23.9 billion from non-EU suppliers. This still makes the EU the largest market in the world, with about 28 percent of the value of world imports (excluding intra-EU trade). Figures for 2009 indicate a downward trend in EU imports, with a 7 percent decrease in value recorded. The Latin America and the Caribbean region continues to maintain a solid positive net fishery exporter role, as do the Oceania region and the developing countries of Asia. By value, Africa has been a net exporter since 1985, but it is a net importer in quantity terms, reflecting the lower unit value of the imports (mainly small pelagics). Europe and North America are characterized by a fishery trade deficit. High-value species such as shrimp, prawns, salmon, tuna, groundfish, flatfish, seabass and seabream are highly traded, in particular as exports to more affluent economies, and low-value species such as small pelagics are also traded in large quantities. Products derived from aquaculture production are contributing an increasing share of total international trade in fishery commodities, with species such as shrimp, prawns, salmon, molluscs, tilapia, catfish, seabass and seabream.

Governance of small- and large-scale fisheries and of aquaculture is receiving increasing attention. Latest estimates indicate that small-scale fisheries contribute more than half of the world's marine and inland fish catch, almost all of which is destined for direct human consumption. These fisheries employ more than 90 percent of the world's 35 million capture fishers and they support another 84 million people employed in jobs associated with fish processing, distribution and marketing. There are also millions of other rural dwellers, particularly in Asia and Africa, involved in seasonal or occasional fishing activities with few alternative sources of income and employment. Almost half of the people employed in the primary and secondary sectors associated with small-scale fisheries are women. More than 95 percent of small-scale fishers and related workers in post-harvest sectors live in developing countries. In spite of their economic, social and nutritional benefits, as well as their contribution to societal and cultural values, small-scale fishing communities often face precarious and vulnerable living and working conditions. Poverty remains widespread for millions of fishing people, especially in sub-Saharan Africa and South and Southeast Asia. Overfishing and potential depletion of fishery resources constitute a real threat to many coastal communities relying on small-scale fisheries, but social structures and institutional arrangements also play a central role in engendering poverty. Critical factors that contribute to poverty in small-scale fishing communities include: insecure access rights to fishery resources; poor or absent health and educational services; lack of social safety nets; vulnerability to natural disasters and climate change; and exclusion from wider development processes owing to weak organizational structures and inadequate representation and participation in decision-making. These factors all have important consequences for the governance of small-scale fisheries. Addressing poverty requires that marginalized groups be included in the institutional processes related to their development including fishery management through new institutional approaches. A human rights approach has been proposed that requires strengthening the capacity of fishing communities to be aware of, claim and exercise their rights effectively. It also requires all duty-bearers, including states, to fulfil their human rights obligations, including through legislation. Devolved management responsibilities and comanagement arrangements with strong involvement of local resource users together with the state have a role to play, but these require human capacity at the local level as well as legal, practical and community-based arrangements.

The role and obligations of regional fishery bodies (RFBs), and particularly those with a management remit, in international fisheries governance are growing steadily, but strengthening their performance still remains the major challenge. Most RFBs consider illegal, unreported and unregulated (IUU) fishing, effective implementation of monitoring, control and surveillance (MCS) and overcapacity in fishing fleets as being the main challenges to their performance. Most RFBs have reported an inability to control IUU fishing and highlighted the impact that this has on undermining attempts at effective fisheries management, although there have been some notable successful developments in this regard. Difficulties in implementation of the ecosystem approach to fisheries (EAF), the control of bycatch and the promotion of economic development in member countries are also widespread among RFBs. A new inland fishery body, the Central Asian and the Caucasus Fisheries and Aquaculture Commission, is in the process of development with the objective to promote the development, conservation, rational management and best utilization of living aquatic resources, including the sustainable development of aquaculture. A convention has been adopted for the proposed South Pacific Regional Fisheries Management Organisation, which, when it enters into force, will close a gap that exists in the international conservation and management of non-highly migratory fish stocks and protection of biodiversity in the marine environment extending from the easternmost part of the South Indian Ocean through the Pacific Ocean towards the exclusive economic zones (EEZs) of South America. The RFBs share information of joint interest through the Regional Fishery Bodies Secretariat Network (RSN).

The RFBs are at the forefront in the fight against IUU fishing. The tuna RFBs have demonstrated the benefits of more rigorous interregional collaboration and harmonization of activities to address IUU fishing, and this provides a basis for wider collaboration among non-tuna RFBs. A certification scheme to stem the flow of IUU-caught fishery products into the EU market was introduced in 2010. The preparation of national plans of action to combat IUU fishing, as called for in the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU) of 2001, has stalled after the development of about 40 such national plans, despite their undoubted value. The FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal Unreported and Unregulated Fishing was finalized in 2009 and its application will serve to reduce the effects of IUU fishing.

Problems persist with the high levels of unwanted and often unreported bycatch and discards in many fisheries around the world, including the capture of ecologically important species and juveniles of economically valuable species. The latest estimate of global discards from fishing is about 7 million tonnes per year. Apart from the mortality discarding inflicts on the commercial fishery resources, there are also issues about the mortalities of rare, endangered or vulnerable species and socio-economic considerations about the non-utilization of discarded bycatch. To respond to concerns about this raised in the FAO Committee on Fisheries (COFI) and the United Nations General Assembly, FAO will lead the development of international guidelines on bycatch management and reduction of discards.

FAO Guidelines were adopted in 2008 to assist states and regional fisheries management organizations (RFMOs) in sustainably managing deep-sea fisheries in the high seas and are increasingly being implemented. The Guidelines provide advice on topics vital to fisheries management such as data and reporting, enforcement and compliance, management measures, conservation-related aspects, criteria for identification of vulnerable marine ecosystems (VMEs) and impact assessment.

Consumers of fish, particularly in the world's richer economies, are increasingly demanding that retailers guarantee that the fish they offer is not only of high quality and safe to eat but also that it derives from fisheries that are sustainable. For retailers to provide such guarantees, they must receive, together with the fish, certificates that guarantee the wholesomeness of the product, that the product label correctly identifies the species, that the fish originates in sustainable fisheries and that the chain of custody is unbroken. As a consequence, several large-scale retailers are demanding certification to their own private standards schemes in the areas of both food safety and quality and sustainability. Public administrations in importing countries are also in the process of responding to consumer demands while regulating the industry to reduce fraudulent practices. One of the main strategies for doing this is to impose product traceability schemes on the industry that verify the integrity of the supply chain and take measures when that integrity is broken. Traceability initiatives, whether implemented by non-governmental organizations (NGOs), governments or RFBs, are becoming increasingly prevalent. Recent initiatives include the adoption of or progress with the development of ecolabelling or certification guidelines for marine fisheries, inland fisheries and aquaculture.

In the past two decades, considerable progress has been made in addressing aquaculture governance issues through national and international corporate efforts with the common goal of sustainability of the sector. Approaches have varied from top-down, command and control of the sector's development with little or no consultation with stakeholders, through a "market-driven" approach where government policy is to let the private sector largely lead aquaculture development, to "participatory governance" involving industry self-regulation, comanagement by industry representatives and government regulators, or community partnerships. Participatory governance is increasingly becoming the norm. Where aquaculture governance has proved fruitful, it appears that governments have followed four main guiding principles, namely: accountability, effectiveness and efficiency, equity, and predictability. Accountability would be reflected in timely decisions and would imply stakeholder participation in decision-making processes. Effectiveness and efficiency consist of making the right decisions and implementing them effectively in a cost-effective way. Equity requires that all groups, particularly the most vulnerable ones, have opportunities to improve or maintain their well-being through the guaranteeing of procedural fairness, distributional justice and participation in decision-making. Predictability relates to fairness and consistency in the application of laws and regulations and in the implementation of policies. While there have been laudable efforts throughout the sector, aquaculture governance remains an issue in many countries. There are still conflicts over marine sites, disease outbreaks, negative public perceptions of aquaculture in certain countries, an inability of small-scale producers to meet foreign consumers' quality requirements and inadequate development of the sector in certain jurisdictions despite favourable demand and supply conditions.

CAPTURE FISHERIES PRODUCTION

Total capture fisheries production

In the early 1970s, an FAO study compiled by Gulland[1] estimated the potential fish (excluding invertebrates) harvest of resources of the oceans at close to 100 million tonnes but, considering it unlikely that all stocks could be exploited at the optimal level, set also a more realistic forecast at 80 million tonnes. However, even this lower estimate has never been approached, and global marine fish catch production peaked in 1996 at 74.7 million tonnes. Since the mid-1990s and throughout the 2000s, several studies[2] have predicted the rapid decline of marine fisheries worldwide. Paradoxically, a glance at the total global capture statistics collated by FAO almost 40 years after those analysed by Gulland prompts a word that has very rarely been used to describe catch trends: stability.

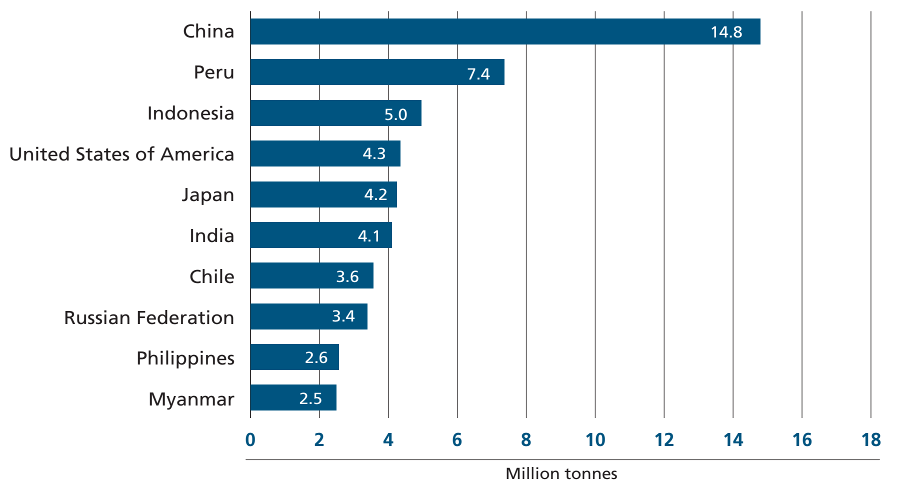
In fact, despite a marked variability in the annual total catch by several countries, fishing areas and species (the three fields included in the FAO capture database), the world total (marine and inland) capture production for the period 2006–08 was very steady at about 89.8 million tonnes (Table 1 and Figure 3). In those years, a minor decrease in global marine catches was compensated for by an increase of 0.2 million tonnes in total inland waters capture production for both 2007 and 2008. Even the usually highly variable anchoveta catches, which caused the drop in total marine catches between 2005 and 2006, remained fairly stable for three subsequent years (2006–08) for the first time since 1970.

Collation by FAO of national fishery statistics encountered more difficulties in 2009 than in previous years. The number of non-reporting countries increased, and, on average, a worsening of the quality of capture statistics submitted was also noted. As for other activities depending on public funding, it is probable that some schemes to collect national fishery data were cut or reduced owing to the global economic crisis. However, national administrations should consider as a priority maintaining data collection systems that, despite reduced budgets, would continue to enable reliable trend studies on national and international fishery production.

The most significant change in the ranking of the top ten producers (Figure 4) was the gaining of a position by two Asian countries (i.e. Indonesia and India), which surpassed two American countries (i.e. the United States of America and Chile) whose total capture production decreased by 10 and 15 percent, respectively, in comparison with 2006. In addition to the performance of the Asian countries mentioned above,

Figure 4

Marine and inland capture fisheries: top ten producer countries in 2008



other major Asian fishing countries (i.e. Bangladesh, Myanmar, Philippines and Viet Nam) have been reporting regularly increasing capture statistics in the last ten years despite well-known cases of local overfishing and natural disasters, such as the December 2004 tsunami and cyclones, that have occurred in this area in recent years.

World marine capture fisheries production

Although the revision of China's fishery statistics reduced reported catches by about 2 million tonnes per year in the Northwest Pacific, this area still leads by far the ranking of marine fishing areas (Figure 5). As already stated, 2006–08 global marine production was practically stable although individual fishing areas showed distinct catch trends.

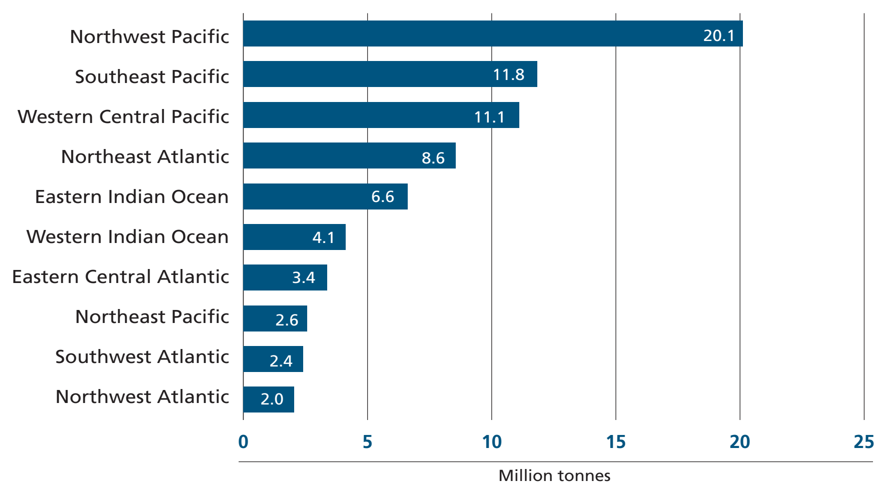
In the Northwest, Northeast and Western Central Atlantic, capture production reached recent peaks in 2004, 2001 and 2000, respectively, but in the following years catches consistently decreased with overall reductions of 13, 23 and 30 percent, respectively. In the Mediterranean and Black Seas, catches decreased by 12 percent in 2008 in comparison with the high catches of the previous year, a negative result shared by all five major fishing countries. Catch trends in the Atlantic areas did not vary much in 2006–08.

Growth in total catch in the Indian Ocean has been sustained since 1950, but in 2007 and 2008 this trend reversed in the Western Indian Ocean whereas it kept its pace in the Eastern Indian Ocean. The catch decrease in the Western Indian Ocean is mostly due to a reduction in tuna catches for both local and distant waters fleets.

Among the six very large and highly diverse fishing areas into which the Pacific Ocean is divided, recent changes in catch trends have occurred in the Northeast, Southwest and Eastern Central Pacific areas. In the Northeast Pacific, a catch decline has been noted since 2006 for both Canada and the United States of America, the only two countries catching significant quantities in this area. In the Southwest Pacific, the catch has decreased since 2006. In this area, New Zealand's share of total catch was 73 percent in the period but it is noteworthy that 23 percent was caught by European and North Asian vessels, which travel to this distant area to target pelagic and demersal fish and cephalopods. Starting in the 1980s, total catch in the Eastern Central Pacific has been fluctuating around an average of 1.6 million tonnes but a positive trend since 2005 has produced an overall 20 percent catch increase.

Figure 5

Capture fisheries production: principal marine fishing areas in 2008



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

For the Southern Ocean (Antarctic) areas, FAO derives catch statistics from information produced by the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR). Owing to the strict and effective management regime applied by this RFB, catch variations in this region are usually small, but a marked increase in krill catches was registered in 2008.

The dominant species in marine fishery catches (Figure 6) have been the same since 2003 and only a few changes in the ranking have occurred in the last six years, another sign of a relative stability. The share of the top ten species in global marine catches has varied little, oscillating between 29 and 33 percent. However, there are differences among the trend trajectories of the various species groups and the most striking are described below.

Growth of tuna fisheries halted in 2008 as catches of this species group decreased by 2.6 percent after the 2007 global record of almost 6.5 million tonnes (Figure 7). While maximum tuna catches in the Pacific Ocean (which represents about 70 percent of the global catches) and in the Indian Ocean were reached in 2007 and 2006, respectively, the peak of Atlantic tuna catches dates back to 1993. Shark catches decreased by almost 20 percent from their 2003 peak at 0.9 million tonnes. It is hoped that this reduction is partially due to the effectiveness of the management measures (e.g. finning ban) implemented at the national and regional levels to regulate both fisheries targeting sharks and shark bycatch, rather than to stock decline resulting from overfishing of sharks.

The decline of the gadiformes (“cods, hakes, haddocks” in Figure 7) seems relentless. In 2008, catches of this species group as a whole did not total 8 million tonnes, a level that had been until then consistently exceeded since 1967 and that reached a peak of almost 14 million tonnes in 1987. In the last decade, catches of Atlantic cod, the iconic species of this group, have been somewhat stable in the Northwest Atlantic at about 50 000 tonnes (very low by historical standards), but in the Northeast Atlantic catches have further decreased by 30 percent.

Cephalopod catches set a new record in 2008, although their growth seems to have levelled off. This is the species group that has shown the strongest performance in recent years, with a gain of more than 1 million tonnes since 2002 (Figure 7). Crabs are another group of invertebrates that reached a maximum in 2008, with overall catches growing by one-quarter in the last six years. On the other hand, shrimp catches have

Figure 6

Marine capture fisheries production: top ten species in 2008

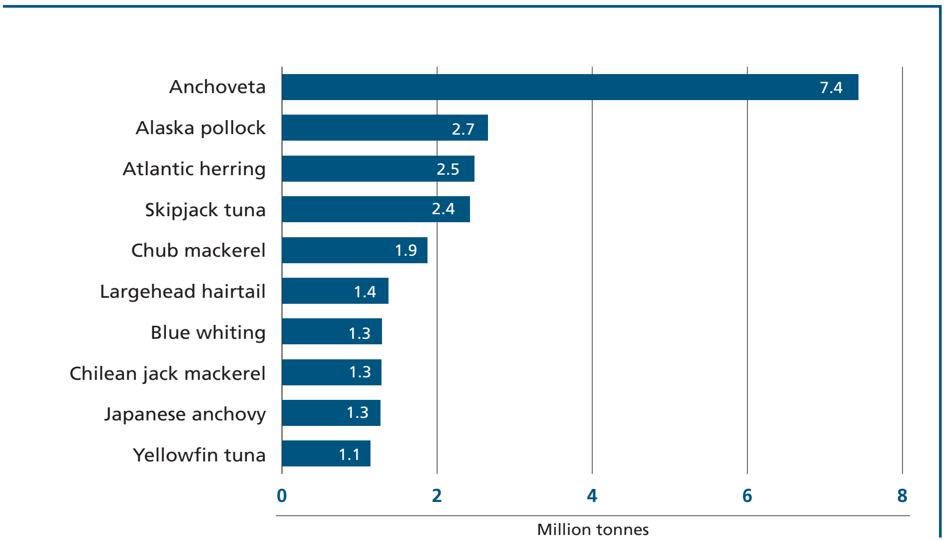


Figure 7

Catch trends by valuable marine species groups

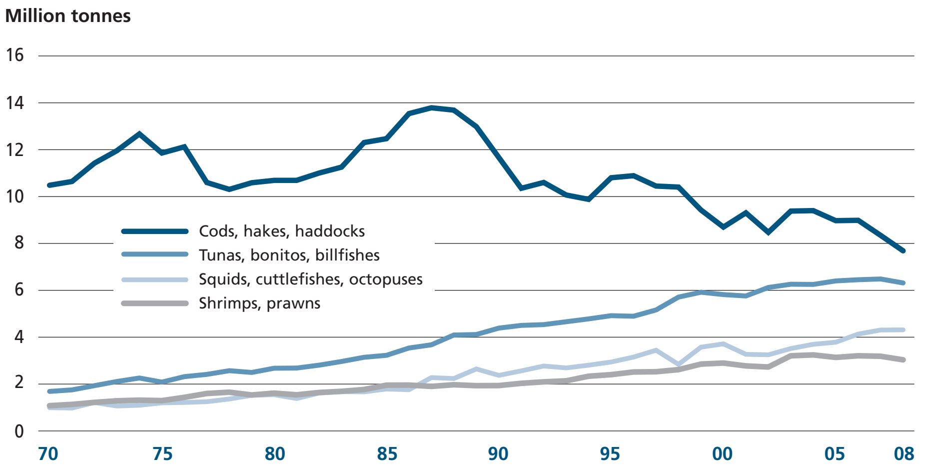
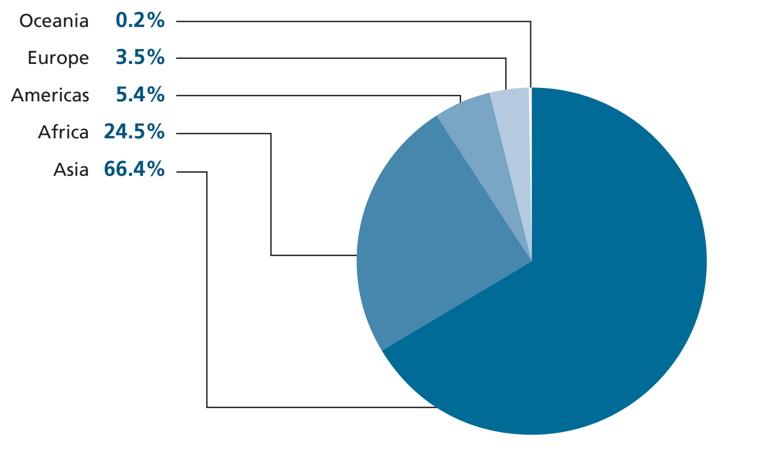


Figure 8

Inland capture fisheries by continent in 2008



Note: World inland capture fisheries production amounted to 10.2 million tonnes in 2008.

decreased slightly but remained at more than 3 million tonnes in 2008 (Figure 7). The four groups of bivalves as a whole were very steady in 2005–08, although different trends are shown by the groups. Oyster and mussel catches have been declining since 2000, whereas scallops and clams have recently recovered from previously negative trends.

World inland capture fisheries production

Global inland capture fisheries production was fairly stable between 2000 and 2004 at about 8.6 million tonnes, but in the following four years it showed an overall increase of 1.6 million tonnes, reaching 10.2 million tonnes in 2008 (Table 1). Asia accounted for two-thirds of the world production (Figure 8).

Table 3 shows the variations between 2004 and 2008 for the 14 countries with catches of more than 200 000 tonnes each in 2008 and which together represented about 78 percent of the 2008 world catches. The unexpected recent growth in global total production, despite increasing concern about environmental conditions of

Table 3
Inland capture fisheries: major producer countries

Country	2004 (Tonnes)	2008 (Tonnes)	Variation 2004–2008 (Tonnes)	Variation 2004–2008 (Percentage)
China	2 097 167 [1]	2 248 177	151 010	7.2
Bangladesh	732 067	1 060 181	328 114	44.8
India	527 290	953 106	425 816	80.8
Myanmar	454 260	814 740	360 480	79.4
Uganda	371 789	450 000 [1]	78 211	21.0
Cambodia	250 000	365 000	115 000	46.0
Indonesia	330 879	323 150	–7 729	–2.3
Nigeria	182 264	304 413	122 149	67.0
United Republic of Tanzania	312 040	281 690	–30 350	–9.7
Brazil	246 101	243 000 [1]	–3 101	–1.3
Egypt	282 099	237 572	–44 527	–15.8
Thailand	203 200	231 100	27 900	13.7
Democratic Republic of the Congo	231 772 [1]	230 000 [1]	–1 772	–0.8
Russian Federation	178 403	216 841	38 438	21.5

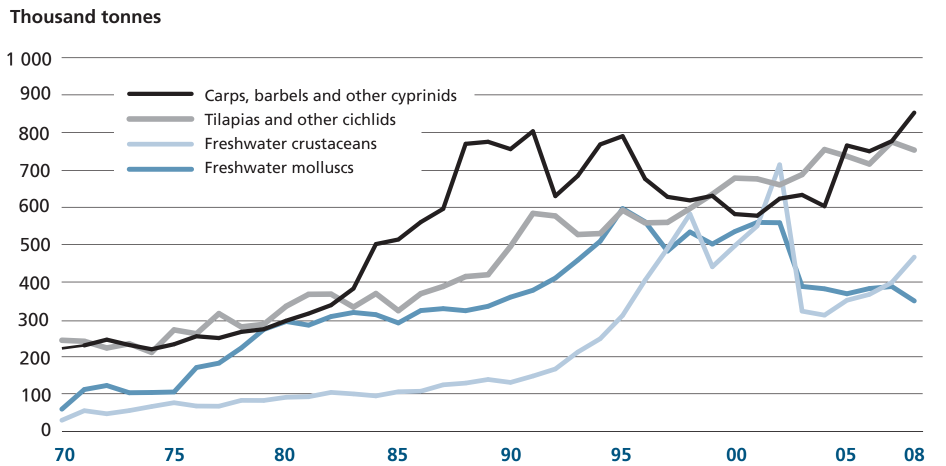
[1] FAO estimate.

inland waterbodies and their fish stocks, was the consequence of the considerable rise in catches reported to FAO by several major inland fishing countries (i.e. China, Bangladesh, India, Myanmar, Uganda, Cambodia, Nigeria and Russian Federation), as the total of all other catches varied very little between 2004 and 2008. Statistics provided by these countries merit a closer and case-by-case analysis given that a striking increment in inland waters catch could be the consequence of sound fishery management (including re-stocking of wild populations), improved coverage within the data collection systems, or a tendency to report continuously increasing production.

Inland water fishing is often a subsistence or recreational activity with fishing sites geographically scattered, making gathering information very difficult. In many countries, national administrations do not manage to secure adequate funding for the collection of reliable inland catch statistics. About one-third of the countries do not submit any information on inland waters catch statistics, forcing FAO to estimate the national production. Although several countries have made efforts in the last decade

Figure 9

Catch trends by major inland waters species groups



to improve the quality of inland catch statistics and report a finer breakdown of species composition, the global level of unidentified catches remains very high – exceeding half of the total inland waters catch production.

Figure 9 shows catch trends since 1970 by major species groups caught in inland fisheries. In 2005, cyprinids returned as the dominant group after being exceeded for some years by the tilapias group (and in 2002 also by freshwater crustaceans). Catches of freshwater molluscs have decreased significantly since 2002, and this may be due to their extreme vulnerability to habitat degradation, overexploitation, and predation by alien species.[3] It is noteworthy that catch trends for inland water species groups present several more abrupt ups and downs than those of marine species groups (compare Figures 7 and 9). Rather than being explained by highly variable catches, this is mostly the result of some major inland water fishing countries varying throughout the years the attribution of aggregated catches between "freshwater fishes not elsewhere included (NEI)" and major groups such as "cyprinids NEI". This can be seen as another indication of the poor quality of inland water catch statistics reported to FAO.

AQUACULTURE

World production of food fish

Aquaculture remains a growing, vibrant and important production sector for high-protein food. The reported global production of food fish from aquaculture, including finfishes, crustaceans, molluscs and other aquatic animals for human consumption, reached 52.5 million tonnes in 2008. The contribution of aquaculture to the total production of capture fisheries and aquaculture continued to grow, rising from 34.5 percent in 2006 to 36.9 percent in 2008. In the period 1970–2008, the production of food fish from aquaculture increased at an average annual rate of 8.3 percent, while the world population grew at an average of 1.6 percent per year. The combined result of development in aquaculture worldwide and the expansion in global population is that the average annual per capita supply of food fish from aquaculture for human consumption has increased by ten times, from 0.7 kg in 1970 to 7.8 kg in 2008, at an average rate of 6.6 percent per year.

Production from aquaculture is mostly destined for human consumption. Globally, aquaculture accounted for 45.7 percent of the world's fish food production for human consumption in 2008, up from 42.6 percent in 2006. In China, the world's largest aquaculture producer, 80.2 percent of fish food consumed in 2008 was derived from aquaculture, up from 23.6 percent in 1970. Aquaculture production supplied the rest of the world with 26.7 percent of its food fish, up from 4.8 percent in 1970.

Despite the long tradition of aquaculture practices in a few countries over many centuries, aquaculture in the global context is a young food production sector that has grown rapidly in the last 50 years or so. World aquaculture output has increased substantially, from less than 1 million tonnes of annual production in 1950 to the 52.5 million tonnes reported for 2008, increasing at three times the rate of world meat production (2.7 percent from poultry and livestock together) in the same period. In contrast to world capture fisheries production, which has almost stopped growing since the mid-1980s, the aquaculture sector maintained an average annual growth rate of 8.3 percent worldwide (or 6.5 percent excluding China) between 1970 and 2008. The annual growth rate in world aquaculture production between 2006 and 2008 was 5.3 percent in volume terms. The growth rate in the rest of the world (6.4 percent) from 2006 to 2008 was higher than that for China (4.7 percent).

The value of the world aquaculture harvest, excluding aquatic plants, is estimated at US$98.4 billion in 2008. The actual total output value from the entire aquaculture sector should be significantly higher than this level, because the value of aquaculture hatchery and nursery production and that of the breeding of ornamental fishes are yet to be estimated and included.

If aquatic plants are included, world aquaculture production in 2008 was 68.3 million tonnes, with an estimated value of US$106 billion.

World production of aquatic plants

Aquaculture produced 15.8 million tonnes (live weight equivalent) of aquatic plants in 2008, with a total estimated value of US$7.4 billion. Of the world total production of aquatic plants in the same year, 93.8 percent came from aquaculture. The culture of aquatic plants has enjoyed a consistent expansion in production since 1970, with an average annual growth rate of 7.7 percent. The production is overwhelmingly dominated by seaweeds (99.6 percent by quantity and 99.3 percent by value in 2008).

Countries in East and Southeast Asia dominate seaweed culture production (99.8 percent by quantity and 99.5 percent by value in 2008). China alone accounted for 62.8 percent of the world's aquaculture production of seaweeds by quantity. Other major seaweed producers are Indonesia (13.7 percent), Philippines (10.6 percent), Republic of Korea (5.9 percent), Japan (2.9 percent) and Democratic People's Republic of Korea (2.8 percent). In 2007, Indonesia replaced the Philippines as the world's second-largest seaweed producer and remained so in 2008. In value terms, Japan maintained its position as the second-most important producer because of its high-valued Nori production. In East Asia, almost all cultured seaweed species are for human consumption, although Japanese kelp is also used as a raw material for the extraction of iodine and algin. In contrast, seaweed farming in Southeast Asia, with *Eucheuma* seaweeds as the major species, is mainly producing raw material for carrageenan extraction.

Chile is the most important seaweed culturing country outside Asia, producing 21 700 tonnes in 2008. Africa also harvested 14 700 tonnes of farmed seaweeds in 2008, with the United Republic of Tanzania (mainly Zanzibar), South Africa and Madagascar as the leading producers. Farmed seaweed production in the United Republic of Tanzania and in Madagascar, mostly *Eucheuma* seaweeds for export, was much underreported previously. In South Africa, cultured seaweeds are harvested mainly as feed for the culture of perlemoen abalone (*Haliotis midae*).

In 2008, the highest production of cultured seaweed was of Japanese kelp (*Laminaria japonica*, 4.8 million tonnes), followed by *Eucheuma* seaweeds (*Kappaphycus alvarezii* and *Eucheuma* spp., 3.8 million tonnes), Wakame (*Undaria pinnatifida*, 1.8 million tonnes), *Gracilaria* spp. (1.4 million tonnes) and Nori (*Porphyra* spp., 1.4 million tonnes).

According to the national reports received by FAO, the production of algae culture in freshwater was 68 400 tonnes in 2008, and virtually all the production was of *Spirulina* from China (62 300 tonnes) and Chile (6 000 tonnes). Worldwide, *Spirulina* spp. are cultured in many countries, predominantly in cement tanks, as an ingredient in animal feeds and as a nutrition supplement for people.[4] Production is both large-scale as a commercial business and small-scale for consumption by local communities. Production data are not systematically collected and reported worldwide. In recent years, the culture of the freshwater alga *Haematococcus pluvialis* has been developed in a few countries (e.g. Chile, China, India, Japan and the United States of America) for the extraction of astaxanthin, a natural pigment and strong antioxidant used in many fields including aquaculture feeds. In addition, the culture of lipid-rich species of freshwater algae for biofuel production, still in its initial stages, is the latest development in freshwater algae culture. Compared with seaweed farming, the culture of freshwater algae is generally poorly reported worldwide.

Production by region: growth patterns and top producers

Asia has retained its progressively dominant position in world aquaculture production. Asia accounted for 88.8 percent of world aquaculture production by quantity and 78.7 percent by value in 2008, while China alone accounted for 62.3 percent of world aquaculture production by quantity and 51.4 percent by value in the same year (Table 4).

Table 4
Aquaculture production by region: quantity and percentage of world production

Selected groups and countries		1970	1980	1990	2000	2006	2008
Africa	**(tonnes)**	**10 271**	**26 202**	**81 015**	**399 788**	**754 406**	**940 440**
	(percentage)	***0.40***	***0.60***	***0.60***	***1.20***	***1.60***	***1.80***
Sub-Saharan Africa	(tonnes)	4 243	7 048	17 184	55 802	154 905	238 877
	(percentage)	*0.20*	*0.10*	*0.10*	*0.20*	*0.30*	*0.50*
North Africa	(tonnes)	6 028	19 154	63 831	343 986	599 501	701 563
	(percentage)	*0.20*	*0.40*	*0.50*	*1.10*	*1.30*	*1.30*
America	**(tonnes)**	**173 491**	**198 850**	**548 200**	**1 422 637**	**2 367 320**	**2 405 166**
	(percentage)	***6.80***	***4.20***	***4.20***	***4.40***	***5.00***	***4.60***
Caribbean	(tonnes)	350	2 329	12 169	39 692	36 610	40 054
	(percentage)	*0.00*	*0.00*	*0.10*	*0.10*	*0.10*	*0.10*
Latin America	(tonnes)	869	24 590	179 367	799 235	1 640 001	1 720 899
	(percentage)	*0.00*	*0.50*	*1.40*	*2.50*	*3.50*	*3.30*
North America	(tonnes)	172 272	171 931	356 664	583 710	690 709	644 213
	(percentage)	*6.70*	*3.70*	*2.70*	*1.80*	*1.50*	*1.20*
Asia	**(tonnes)**	**1 786 286**	**3 540 960**	**10 786 593**	**28 400 213**	**41 860 117**	**46 662 031**
	(percentage)	***69.60***	***75.20***	***82.50***	***87.60***	***88.40***	***88.80***
Asia excluding China	(tonnes)	1 021 888	2 211 248	4 270 587	6 821 665	11 831 528	13 717 947
	(percentage)	*39.80*	*47.00*	*32.70*	*21.00*	*25.00*	*26.10*
China	(tonnes)	764 380	1 316 278	6 482 402	21 522 095	29 856 841	32 735 944
	(percentage)	*29.80*	*28.00*	*49.60*	*66.40*	*63.10*	*62.30*
Near East	(tonnes)	18	13 434	33 604	56 453	171 748	208 140
	(percentage)	*0.00*	*0.30*	*0.30*	*0.20*	*0.40*	*0.40*
Europe	**(tonnes)**	**510 713**	**770 200**	**1 616 287**	**2 072 160**	**2 209 097**	**2 366 354**
	(percentage)	***19.90***	***16.40***	***12.40***	***6.40***	***4.70***	***4.50***
Non-EU countries	(tonnes)	39 431	49 985	582 305	676 685	925 664	1 088 594
(+ Cyprus and Israel)	*(percentage)*	*1.50*	*1.10*	*4.50*	*2.10*	*2.00*	*2.10*
EU countries (27)	(tonnes)	471 282	720 215	1 033 982	1 395 475	1 283 433	1 277 760
	(percentage)	*18.40*	*15.30*	*7.90*	*4.30*	*2.70*	*2.40*
Oceania	**(tonnes)**	**8 421**	**12 224**	**42 005**	**121 312**	**160 126**	**172 214**
	(percentage)	***0.30***	***0.30***	***0.30***	***0.40***	***0.30***	***0.30***
World	**(tonnes)**	**2 566 882**	**4 705 841**	**13 074 100**	**32 416 110**	**47 351 066**	**52 546 205**

Notes: Data exclude aquatic plants. Data for 2008 contain provisional data of some countries.

The growth patterns in aquaculture production are not uniform among the regions, as illustrated in Figure 10. Latin America and the Caribbean shows the highest average annual growth (21.1 percent), followed by the Near East (14.1 percent) and Africa (12.6 percent). China's aquaculture production increased at an average annual growth rate of 10.4 percent in the period 1970–2008. However, in the new millennium, China's growth rate declined to 5.4 percent, which is significantly lower than in the 1980s (17.3 percent) and 1990s (12.7 percent). The average annual growth in production in Europe and North America since 2000 has slowed substantially to 1.7 percent and 1.2 percent, respectively. The once-leading countries in aquaculture development, e.g. France, Japan and Spain, have shown falling production in the most recent decade. It is expected that, while world aquaculture production will continue to grow, the rate of increase in most of the regions will slow in the coming decade.

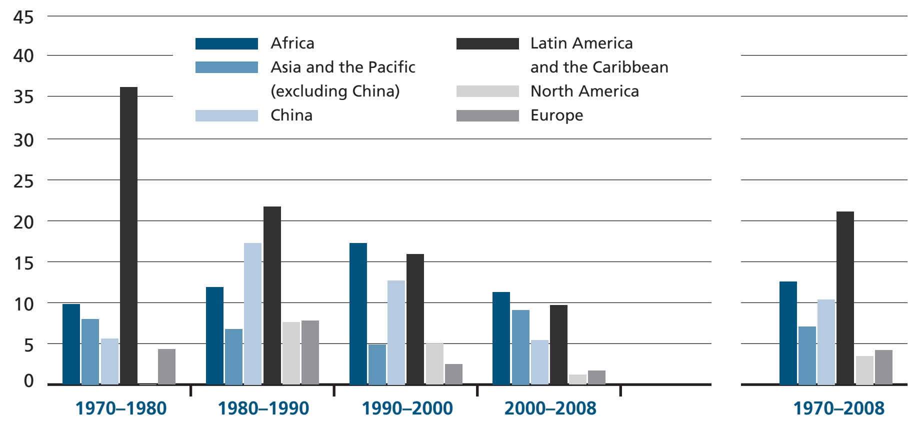
In 2008, the top 15 producers listed in Table 5 harvested 92.4 percent of total world production of food fish from aquaculture. Indonesia replaced Thailand as the fourth-largest producer.

By economic class, aquaculture in all developing countries in 2008 produced 48.63 million tonnes of food fish valued at US$84.03 billion, accounting for 92.5 percent and 85.4 percent of world aquaculture production quantity and value,

respectively. However, the combined share of the least-developed countries remains very low in terms of world aquaculture production quantity (3.6 percent) and value (3.1 percent). Aquaculture production of 1.9 million tonnes in 2008 for the least-developed countries was dominated by Bangladesh (52.8 percent) and Myanmar (35.5 percent), followed by the Lao People's Democratic Republic (4.1 percent), Uganda (2.7 percent), Cambodia (2.1 percent) and Nepal (1.4 percent). Developed countries produced only 3.92 million tonnes, accounting for 7.5 percent of world aquaculture production in terms of quantity, but the value of their production was 14.6 percent of the world total (Table 6).

Figure 10

World aquaculture production: annual growth by region since 1970



Note: Data exclude aquatic plants.

Table 5
Top 15 aquaculture producers by quantity in 2008 and growth

	Production			Average annual rate of growth		
	1990	2000	2008	1990–2000	2000–2008	1990–2008
	(Thousand tonnes)			*(Percentage)*		
China	6 482	21 522	32 736	12.7	5.4	9.4
India	1 017	1 943	3 479	6.7	7.6	7.1
Viet Nam	160	499	2 462	12.0	22.1	16.4
Indonesia	500	789	1 690	4.7	10.0	7.0
Thailand	292	738	1 374	9.7	8.1	9.0
Bangladesh	193	657	1 006	13.1	5.5	9.6
Norway	151	491	844	12.6	7.0	10.0
Chile	32	392	843	28.3	10.1	19.8
Philippines	380	394	741	0.4	8.2	3.8
Japan	804	763	732	–0.5	–0.5	–0.5
Egypt	62	340	694	18.6	9.3	14.4
Myanmar	7	99	675	30.2	27.1	28.8
United States of America	315	456	500	3.8	1.2	2.6
Republic of Korea	377	293	474	–2.5	6.2	1.3
Taiwan Province of China	333	244	324	–3.1	3.6	–0.2

Note: Data exclude aquatic plants.

Table 6
Aquaculture production quantity and value by economic class in 2008

	Quantity		Value	
	(Million tonnes)	*(Percentage)*	*(US$ billions)*	*(Percentage)*
Developed countries	3.92	7.50	14.42	14.60
Least-developed countries	1.90	3.60	3.01	3.10
Other developing countries	46.72	88.90	81.03	82.30
World	**52.55**	**100.00**	**98.45**	**100.00**

Note: Data exclude aquatic plants.

Production by environment and species group

Aquaculture production using freshwater contributes 59.9 percent to world aquaculture production by quantity and 56.0 percent by value. Aquaculture using seawater (in the sea and also in ponds) accounts for 32.3 percent of world aquaculture production by quantity and 30.7 percent by value. Aquaculture in seawater produces many high-value finfish, crustaceans and abalone species, but also a large amount of oysters, mussels, clams, cockles and scallops. Although brackish-water production represented only 7.7 percent of world production in 2008, it accounted for 13.3 percent of total value, reflecting the prominence of relatively high-valued crustaceans and finfishes cultured in brackish water.

In 2008, freshwater fishes continued to dominate with a production of 28.8 million tonnes (54.7 percent) valued at US$40.5 billion (41.2 percent), followed by molluscs (13.1 million tonnes), crustaceans (5 million tonnes), diadromous fishes (3.3 million tonnes), marine fishes (1.8 million tonnes) and other aquatic animals (0.6 million tonnes) (Figure 11).

The production of freshwater fishes in 2008 was dominated by carps (*Cyprinidae*, 20.4 million tonnes, or 71.1 percent). A small portion (2.4 percent) of freshwater fishes was cultured in brackish water, including tilapia farmed in Egypt. In 2008, the largest producer of all carps was China (70.7 percent) followed by India (15.7 percent). Another 10.2 percent of all carps were produced by Bangladesh, Myanmar, Viet Nam, Indonesia and Pakistan. Growth in the production of pangas catfish (*Pangasius* spp.) in Viet Nam has been dramatic in recent years, with 1.2 million tonnes produced in 2008.

The main components of mollusc production in 2008 were oysters (31.8 percent), carpet shells and clams (24.6 percent), mussels (12.4 percent) and scallops (10.7 percent). While mollusc production as a whole grew at a average annual rate of 3.7 percent in the period 2000–08, production of the "luxury" group of abalones increased from 2 800 tonnes to 40 800 tonnes in the same period, at an annual growth rate of 39.9 percent.

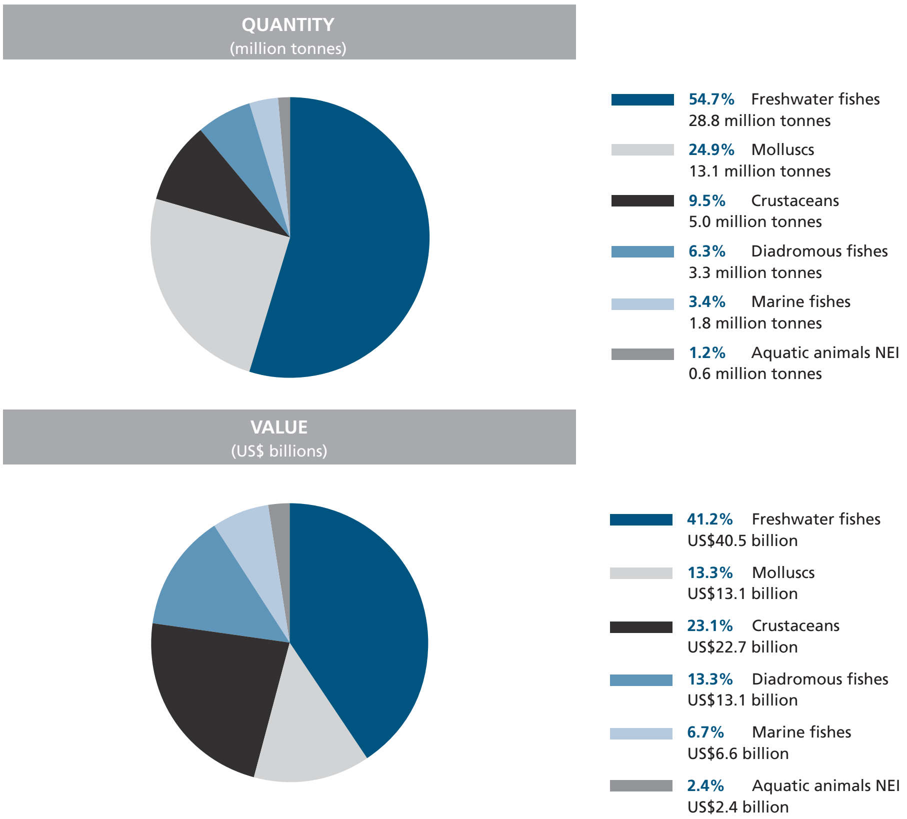
World production of crustaceans was relatively even in distribution among brackish water (2.4 million tonnes, or 47.7 percent), freshwater (1.9 million tonnes, or 38.2 percent) and marine water (0.7 million tonnes, or 14.1 percent). Crustaceans farmed in freshwater include more than 0.5 million tonnes of the marine species white leg shrimp (*Penaeus vannamei*) produced by China, which was previously reported as production from brackish water.

Diadromous fish production in 2008 was dominated by Atlantic salmon (1.5 million tonnes, or 44 percent), milkfish (0.68 million tonnes, or 20.4 percent), rainbow trout (0.58 million tonnes, or 17.4 percent) and eels (0.26 million tonnes, or 7.9 percent – *Anguilla japonica* and *A. anguilla* combined). Norway and Chile are the world's leading aquaculture producers of salmonids, accounting for 36.4 percent and 28 percent of world production, respectively. Other European countries produced another 18.9 percent, while Asia and North America contributed only 7.9 percent and 7.4 percent, respectively. Atlantic salmon (*Salmo salar*) production in Chile was hit hard by a disease outbreak in 2009, leading to the loss of half of the production.

With regard to marine fishes, flatfish production increased significantly from 26 300 tonnes in 2000 to 148 800 tonnes in 2008, with China and Spain being the

Figure 11

World aquaculture production: major species groups in 2008



Note: NEI = not elsewhere included.

leading producers. The major species concerned are turbot (*Psetta maxima*), bastard halibut (*Paralichthys olivaceus*) and tongue sole (*Cynoglossus semilaevis*). Norway's production of Atlantic cod (*Gadus morhua*) grew significantly in the period 2000–08.

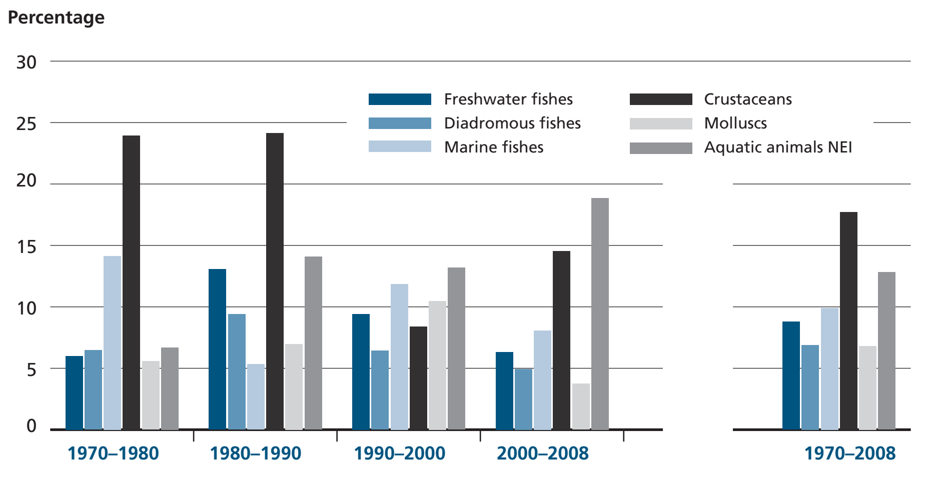
More than half the volume (0.35 million tonnes, or 57 percent) of miscellaneous aquatic animals are produced in freshwater. The most important species are soft-shelled turtles followed by frogs. Production in marine water (0.27 million tonnes, or 43 percent) includes jellyfishes, Japanese sea cucumbers and sea squirts as major species.

Aquaculture production of all major species groups continued to increase in the period 2000–08 (Figure 12), although finfish and mollusc production grew more slowly than in the period 1990–2000. In contrast, crustacean production grew at an average annual rate of almost 15 percent in this period, faster than in the previous decade. The rapid increase in crustacean production largely reflects the dramatic increase in white leg shrimp culture in China, Thailand and Indonesia. Figure 13 presents world aquaculture production by major species group in the period 1970–2008.

The contribution from aquaculture to global total production of major species groups has increased markedly since 1950, except for marine fishes. In 2008, aquaculture accounted for 76.4 percent of global freshwater finfish production, 64.1 percent of molluscs, 68.2 percent of diadromous fishes and 46.4 percent of crustacean production (Figure 14). Although cultured crustaceans still account for less than half of the total crustacean global production, the culture production of penaeids (shrimps and prawns) in 2008 was 73.3 percent of the total production. While

Figure 12

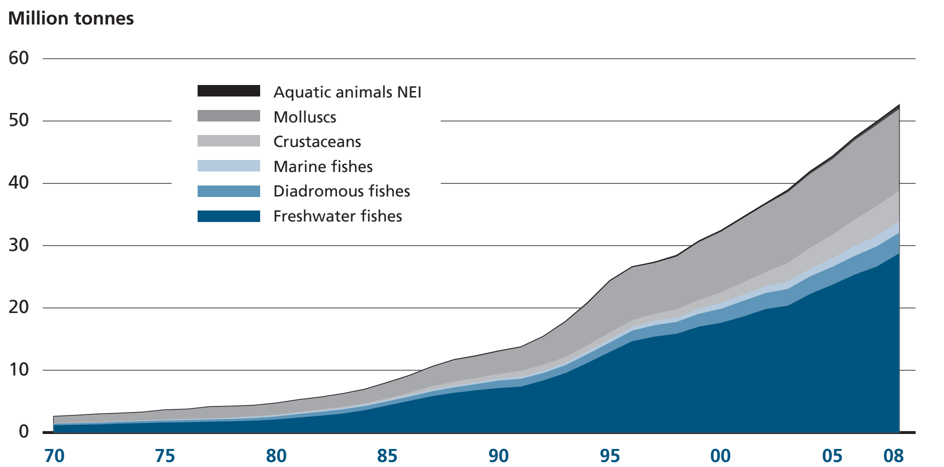
Trends in world aquaculture production:
average annual growth rate for major species groups 1970–2008



Note: NEI = not elsewhere included.

Figure 13

Trends in world aquaculture production: major species groups



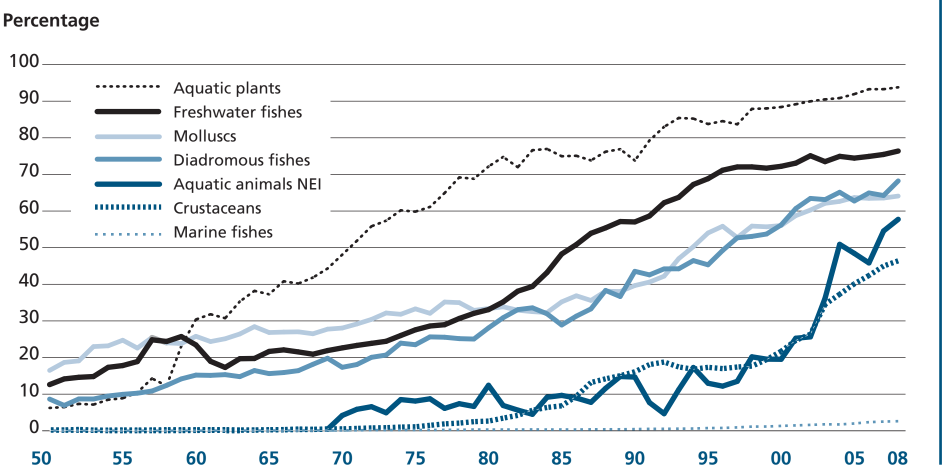
Note: NEI = not elsewhere included.

the overall share of aquaculture in total production of marine fishes was as low as 2.6 percent, aquaculture does dominate production for some species, e.g. flathead grey mullet, gilthead seabream, silver seabream, European seabass, turbot, cobia, red drum and bastard halibut. For many species now produced through aquaculture, the farmed production is substantially higher than the highest catch ever recorded.

Culture in earthen ponds is the most important farming method in Asia for finfish and crustacean production in freshwater and brackish water. In China, 70.4 percent of aquaculture production in freshwater relied on pond culture in 2008, while the rest of the production came from artificial reservoirs (11.7 percent), natural lakes (7.7 percent), rice paddy fields (5.6 percent), canals (2.7 percent) and other facilities (2.6 percent). The

Figure 14

Contribution of aquaculture to global production: major species groups



Note: NEI = not elsewhere included.

average yield of pond culture in China was 6.8 tonnes per hectare in 2008. Rice–fish culture, often operating at family scale with renovated paddy fields, has expanded rapidly among rice farmers in China in recent decades, and the total area of rice fields used for aquaculture was 1.47 million hectares in 2008, with an average yield of 0.79 tonnes of food fish per hectare. Rice fields produced 1.2 million tonnes of food fish in 2008, up 15 percent on 2006. Egypt produced 27 900 tonnes of food fish from rice in 2008, accounting for 4 percent of the total production in the country.

While aquaculture production is almost completely destined for human consumption, a special situation is observed in China in the culture of high-value Mandarin fish (*Siniperca chuatsi*; 230 000 tonnes), which is estimated to have consumed about 1 million tonnes of low-price carps purposely cultured in small sizes as live "feed fish" in 2008.

Production of introduced species and hybrids

Similar to other agriculture subsectors, the use of introduced species has played an important role in aquaculture production, particularly in Asia. Tilapia production outside Africa totalled 2.4 million tonnes in 2008, representing 8 percent of all finfish produced in freshwater and brackish water outside Africa. The production of tilapias in the Philippines, Indonesia, Thailand, Malaysia and China accounted for 34.7 percent, 19.5 percent, 15.3 percent, 14.3 percent and 3.4 percent of their respective national aquaculture production. The culture of white leg shrimp, introduced from America, reached a total of 1.8 million tonnes outside America in 2008. This accounted for 80.7 percent of the global aquaculture production of this species and 40.7 percent of the production of all cultured crustaceans outside America. Largemouth black bass, introduced from America, is now an important species in freshwater aquaculture in China, and its production in 2008 was almost 160 000 tonnes. China also produced 51 000 tonnes of introduced red drum in 2008, accounting for 7 percent of total production of cultured finfish from marine waters in the country. In China, aquaculture production of turbot, native to Europe, has reached an annual level of 50 000–60 000 tonnes in recent years, which is about seven times the total culture production of turbot in Europe. Of the world production of 0.46 million tonnes of channel catfish in 2008, only about half was cultured in its native country (the United States of America), while the other half was grown in China and several other countries. Native to the Yangtze River basin in China, the Mandarin fish introduced to the Pearl

River basin in southern China accounted for more than 0.1 million tonnes in 2008, or 44 percent of the total production of this species. Piarapatinga (*Piaractus brachypomus*) and pacu (*Piaractus mesopotamicus*) introduced from South America are now widely farmed in China, Myanmar, Thailand and Viet Nam. East Asian countries like China have been importing European eel seed stock collected from the wild for aquaculture. China produced more than 0.2 million tonnes of cultured eels in 2008, of which a significant portion was European eel. However, new regulations in Europe on this species will result in reduced exports of European eel seed stock to Asia.

The introduction of white leg shrimp to Asia has given rise to a boom in farming of this species in China, Thailand, Indonesia and Viet Nam in the last decade, resulting in an almost complete shift from the native black tiger shrimp (*Penaeus monodon*) to this introduced species in Southeast Asia. The ban on the introduction and culture of white leg shrimp was lifted in 2008 in India, and this will have a major impact on the marine shrimp farming sector in India in years to come. The giant river prawn (*Macrobrachium rosenbergii*) has been introduced from South and Southeast Asia to China and some countries in South America for culture. In 2008, China alone produced 128 000 tonnes of giant river prawn, accounting for 61.5 percent of the total production of this species. Red swamp crayfish (*Procambarus clarkii*), unintentionally introduced from North America to China several decades ago, is now the third-most important crustacean species cultured in freshwater in China, with a reported production of 365 000 tonnes in 2008.

Introduced from America, Atlantic bay scallop (*Argopecten irradians*) is now widely cultured in China – estimated to account for more than half of the country's total production of 1.1 million tonnes of scallops in 2008. Pacific cupped oyster (*Crassostrea gigas*) has been introduced widely in many countries for aquaculture.

Although the use of hybrids in aquaculture is very common for certain desirable traits, the statistical data available so far do not provide a clear picture of the production level of all hybrids in aquaculture worldwide. A considerable number of hybrids are used in various countries for aquaculture. Out of the 1.1 million tonnes of production reported from China as Nile tilapia, about one-quarter is a hybrid between Nile tilapia (*Oreochromis nilotica*) and blue tilapia (*O. aureus*). Thailand produces about 136 000 tonnes of hybrid catfish (between *Clarias gariepinus* and local *C. macrocephalus*), which was 9.9 percent of the country's total aquaculture production. A significant portion of the 324 100 tonnes of snakehead produced in China in 2008 was the hybrid between *Channa argus* and *C. maculate,* which is reported to accept formulated feeds more readily in farming. The hybrid of *Piaractus mesopotamicus* and *Colossoma macropomum* is farmed in Brazil, with production levels exceeding 10 000 tonnes in recent years. The United States of America has cultured hybrid striped bass, *Morone chrysops* x *M. saxatilis*, for two decades and its production was about 5 000 tonnes in the period 2000–08.

FISHERS AND FISH FARMERS

The fish sector is a source of income and livelihood for millions of people around the world. Linked to the strong increase in fish production, employment in capture fisheries and aquaculture has grown substantially in the last three decades, with an average rate of increase of 3.6 percent per year since 1980. According to the most recent estimate, in 2008, 44.9 million people were directly engaged, full time or, more frequently, part time, in capture fisheries or in aquaculture. This number represents a 167 percent increase compared with the 16.7 million people in 1980. Employment in the fisheries sector has grown faster than the world's population and than employment in traditional agriculture. The 44.9 million in 2008 represented 3.5 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide, compared with 1.8 percent in 1980.

The majority of fishers and aquaculturists are in developing countries, mainly in Asia, which has experienced the largest increases in recent decades, reflecting the rapid expansion of aquaculture activities. In 2008, 85.5 percent of fishers and fish

farmers were in Asia, followed by Africa (9.3 percent), Latin America (2.9 percent), Europe (1.4 percent), North America (0.7 percent) and Oceania (0.1 percent) (Table 7). China is the country with the largest number of fishers and fish farmers, representing nearly one-third of the world total. In 2008, 13.3 million people were employed as fishers and fish farmers in China, of whom 8.5 million people were full time. In 2008, other countries with a significant number of fishers and fish farmers were India and Indonesia (Table 8).

Table 9 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 Asia, but average annual production per person there is only 2.4 tonnes, whereas it is almost 24 tonnes in Europe and more than 18 tonnes in North America. The high figure for Oceania (23 tonnes) 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, in Africa and Asia, also the key role played by small-scale fisheries. The differences are even more evident in the aquaculture sector, where, for example, fish farmers in Norway have an average annual production of 172 tonnes per person, while in Chile the figure is about 72 tonnes, in China 6 tonnes and in India only 2 tonnes.

The national statistics available to FAO are often too irregular and lacking in enough detail to permit a more in-depth analysis of the employment structure at the world level. However, it is apparent that, in the most important fishing nations systematically providing this information, the share of employment in capture fisheries is stagnating or decreasing and increased opportunities are being provided by aquaculture. According to the estimates based on the available data for 2008, fish farmers accounted for one-quarter of the total number of workers, totalling almost 11 million people. However, these figures are indicative and they underestimate the real number as many countries still do not collect employment data separately for the two sectors. Since 1990, fish farmers have experienced the greatest increases in their numbers, with most of the growth occurring in Asia, particularly in China, where the number of fish farmers increased by 189 percent in the period 1990–2008.

Table 7
World fishers and fish farmers by continent

	1990	1995	2000	2005	2008
			(Thousands)		
Africa	1 832	1 950	3 657	3 683	4 187
Asia	23 736	28 096	35 242	36 860	38 439
Europe	626	466	746	662	641
Latin America and the Caribbean	1 104	1 104	1 250	1 271	1 287
North America	385	376	343	338	337
Oceania	55	52	49	54	56
World	**27 737**	**32 043**	**41 287**	**42 868**	**44 946**
Of which fish farmers[1]					
Africa	1	11	78	120	123
Asia	3 698	6 692	6 647	9 828	10 143
Europe	14	12	66	78	80
Latin America and the Caribbean	68	86	187	438	443
North America	...	...	...	...	...
Oceania	1	1	5	4	4
World	**3 783**	**6 803**	**6 983**	**10 467**	**10 793**

Note: ... = data not available.
[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.

On the other hand, employment in fishing is decreasing in capital-intensive economies, in particular in most European countries, North America and Japan. This is the result of several factors combined, including decreased catches, capacity reduction programmes and increased productivity due to technical progress. For example, in Norway, employment in the fisheries sector has been declining for several years. In 1990, about 27 500 people were employed in marine fishing, but this number had decreased by 53 percent to 12 900 people in 2008. In Japan, the number of marine fishery workers decreased from 549 000 in 1970 to 370 600 in 1990 and then continued falling to reach a low of about 200 000 in 2008.

Estimates indicate that in 2008 about 1.3 million people were employed in fisheries and aquaculture in developed countries, representing a decrease of 11 percent compared with 1990. A characteristic of the fishers and fish farmers in more developed

Table 8
Number of fishers and fish farmers in selected countries

Country	Fishery		1990	1995	2000	2005	2008
WORLD	FI + AQ	(number)	**27 737 435**	**32 043 098**	**41 287 272**	**42 868 290**	**44 945 985**
		(index)	***67***	***78***	***100***	***104***	***109***
	FI	(number)	23 954 755	25 240 316	34 304 228	32 400 874	34 153 137
		(index)	*70*	*74*	*100*	*94*	*100*
	AQ	(number)	3 782 680	6 802 782	6 983 044	10 467 416	10 792 848
		(index)	*54*	*97*	*100*	*150*	*155*
China	FI + AQ	(number)	11 173 463	11 428 655	12 935 689	12 902 777	13 327 846
		(index)	*86*	*88*	*100*	*100*	*103*
	FI	(number)	9 432 464	8 759 162	9 213 340	8 389 161	8 288 287
		(index)	*102*	*95*	*100*	*91*	*90*
	AQ	(number)	1 740 999	2 669 493	3 722 349	4 513 616	5 039 559
		(index)	*47*	*72*	*100*	*121*	*135*
Iceland	FI + AQ	(number)	6 951	7 165	6 265	5 265	4 665
		(index)	*111*	*114*	*100*	*84*	*74*
Indonesia	FI + AQ	(number)	3 323 135	4 177 286	4 776 713	4 719 390	4 692 020
		(index)	*70*	*87*	*100*	*99*	*98*
	FI	(number)	1 700 839	2 072 464	2 633 954	2 212 776	2 342 020
		(index)	*65*	*79*	*100*	*84*	*89*
	AQ	(number)	1 622 296	2 104 822	2 142 759	2 506 614	2 350 000
		(index)	*76*	*98*	*100*	*117*	*110*
Japan[1]	FI + AQ	(number)	370 600	301 440	260 200	222 160	204 000
		(index)	*142*	*116*	*100*	*85*	*78*
Norway	FI + AQ	(number)	24 979	21 776	18 589	18 848	17 800
		(index)	*134*	*117*	*100*	*101*	*96*
	FI	(number)	20 475	17 160	14 262	14 626	12 904
		(index)	*144*	*120*	*100*	*103*	*90*
	AQ	(number)	4 504	4 616	4 327	4 222	4 896
		(index)	*104*	*107*	*100*	*98*	*113*
Peru[1]	FI + AQ	(number)	43 750	62 930	66 361	70 036	72 410
		(index)	*66*	*95*	*100*	*106*	*109*
	FI	(number)	...	60 030	63 798	66 395	68 660
		(index)	...	*94*	*100*	*104*	*108*
	AQ	(number)	...	2 900	2 563	3 641	3 750
		(index)	...	*113*	*100*	*142*	*146*

Note: FI = fishing, AQ = aquaculture; index: 2000 = 100; ... = data not available.
[1] Data for 2008 are FAO estimates.

Table 9
Fishery production per fisher or fish farmer in 2008

Continent	Production (capture + aquaculture)[1]	Percentage of production	Number of fishers and fish farmers	Percentage of persons	Production per person
	(Tonnes)	*(%)*	*(No.)*	*(%)*	*(Tonnes/year)*
Africa	8 183 302	5.8	4 186 606	9.3	2.0
Asia	93 579 337	65.8	38 438 646	85.5	2.4
Europe	15 304 996	10.8	640 676	1.4	23.9
Latin America and the Caribbean	17 703 530	12.4	1 287 335	2.9	13.8
North America	6 170 211	4.3	336 926	0.7	18.3
Oceania	1 286 340	0.9	55 796	0.1	23.1
Total	**142 287 124**	**100.0**	**44 945 985**	**100.0**	**3.2**

[1] Production excludes aquatic plants. Data for total production also include 59 408 tonnes of "others not elsewhere specified", which are not included in any aggregate by continent.

economies is their advancing average age, mainly resulting from the profession's decreasing appeal to younger generations. For many young people, neither the pay nor the quality of life aboard fishing vessels compares favourably with those of land-based industries. Moreover, widespread concerns about the status of some 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. For example, in Europe, fishers from the economies in transition or from developing countries are starting to replace local fishers.

Fishers are often employed in marine and inland waters part time or as an occasional occupation. In 2008, in addition to the estimated 45 million part-time and full-time fishers, about 6 million occasional fishers and fish farmers were reported to FAO (of whom 2.8 million in India and 1.2 million in China). Among the main reasons explaining this phenomenon are: the variation in seasonal resource availability, seasonal weather fluctuations, limits on year-round activity (e.g. closures of selected fisheries at certain times of the year and quotas on catches of selected species) or on the number of commercial licences and the number of fish caught per trip. Increasingly, operators are having to turn to other activities for supplementary income.

In many countries, especially in developing countries, most fishers and their families work in coastal artisanal fisheries and associated activities. It is also estimated that the great majority of fishers work on small vessels. However, it is very difficult to obtain exhaustive statistics for these activities as well as to measure their socio-economic importance. Nonetheless, it is undeniable that they are important in terms of their contribution to production, income and food security for the coastal communities.

The number of people employed in direct production in the fisheries and aquaculture sector cannot be taken as the only indicator of the magnitude of fisheries to the national economy. In addition to fishers and fish farmers, people engage 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 linked with the fisheries sector. No official data are available on the estimated numbers of people involved in these other activities. Some estimates indicate that, for each person employed in capture fisheries and aquaculture production, about three jobs are produced in the secondary activities, including post-harvest, for a total of more than 180 million jobs in the whole of the fish industry. Moreover, on average, each jobholder 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 540 million people, or 8.0 percent of the world population.

THE STATUS OF THE FISHING FLEET

Introduction: general weakness of data quality

In 2009, FAO obtained data on national fishing fleets (either through direct reporting or through disseminated statistics) from 137 countries, which represent about 67 percent of the countries involved in capture fisheries. This number represents an improvement as in 2007 information from only 97 countries was available to FAO. Nonetheless, the quality of data varies widely from fragmented records to long time series of consistent and continuous statistics. Data reported to FAO are sometimes based on national registers and/or other administrative records. These registers often do not cover small boats, especially those used in inland waters, as such craft are often not subject to compulsory registration. Even where they are, the registers concerned are often managed by provincial or municipal authorities, and they are easily overlooked in reporting at the national level. Moreover, registers and administrative records often include non-operational units. This means that the number of fishing vessels is generally underreported in global analyses.

In addition to the above-mentioned available datasets, alternatives and supporting information were vigorously sought and used in this analysis, and, hence, data from a further 50 countries were estimated based on the best available information. It should be noted that the reliability of estimates of the global size of fishing fleet is problematical.

However, the national reports (from 137 countries) together represent the vast majority (96 percent) of the global fishing fleet of decked and undecked vessels; the 50 countries for which derived estimates were made added just 4 percent to the total number of fishing vessels.

Estimate of global fleet and regional distribution

The analysis indicates that the global fishing fleet is made up of about 4.3 million vessels and that this figure has not increased substantially from an earlier FAO estimate a decade ago.

About 59 percent of these vessels are powered by engines. The remaining 41 percent are traditional craft of various types, operated by sails and oars, concentrated primarily in Asia (77 percent) and Africa (20 percent). This large number of unmotorized boats are engaged in fishing operations, usually inshore or on inland waters. The estimated proportion of non-powered boats is about 4 percent lower than that obtained in 1998. Although the quality of this estimate is uncertain for the reasons described above, this reflects a worldwide trend towards the motorization of small and medium-sized artisanal craft worldwide.

Of the total number of fishing vessels powered by engines, the vast majority (75 percent) were reported from Asia (Figure 15). The rest were mainly reported from Latin America and the Caribbean (8 percent), Africa (7 percent) and Europe (4 percent).

While the numbers of vessels have been decreasing in some parts of the world in recent years, they have being increasing in others. As a result, the global fleet size in net terms has not changed substantially in the last decade. Figure 16 illustrates the pattern of change in fleet size by examining the proportion of countries whose fleet size increased, decreased or remained unchanged between 2006 and 2009.

Globally, the proportion of countries where the number of vessels either decreased or remained the same (35 percent) was greater than that of those where it increased (29 percent). However, the data available did not allow the trend to be determined for a substantial proportion (36 percent) of countries. The best-documented situation was that of Europe, where 53 percent of the countries reduced their fleet and only 19 percent of countries increased it. There was no increase in North America, while in the Pacific and Oceania region the fleet size either remained the same or decreased

Figure 15

Distribution of motorized fishing vessels by region in 2008

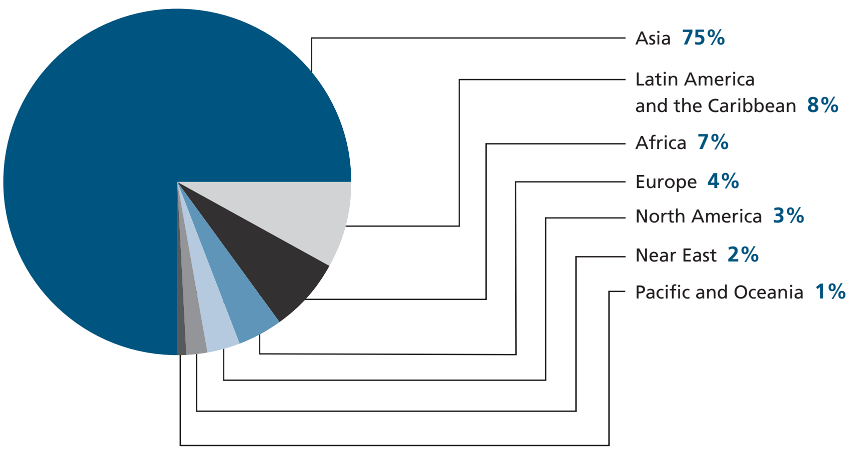
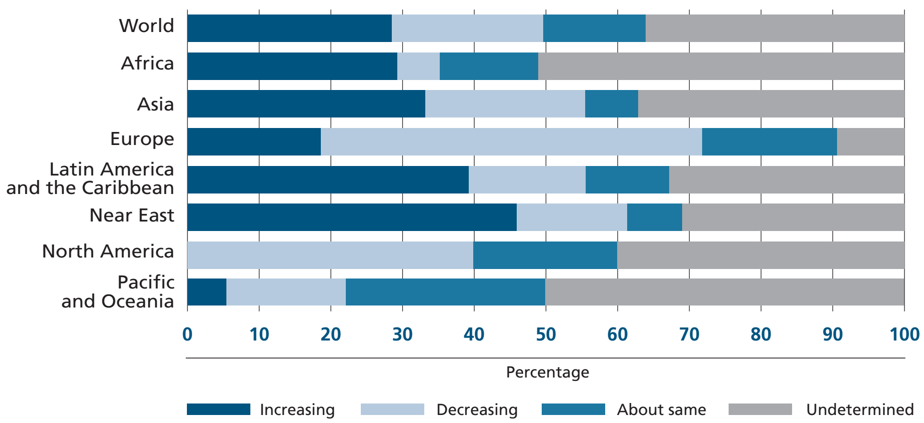


Figure 16

Changes in vessel numbers: proportion of countries by region, 2006–2009



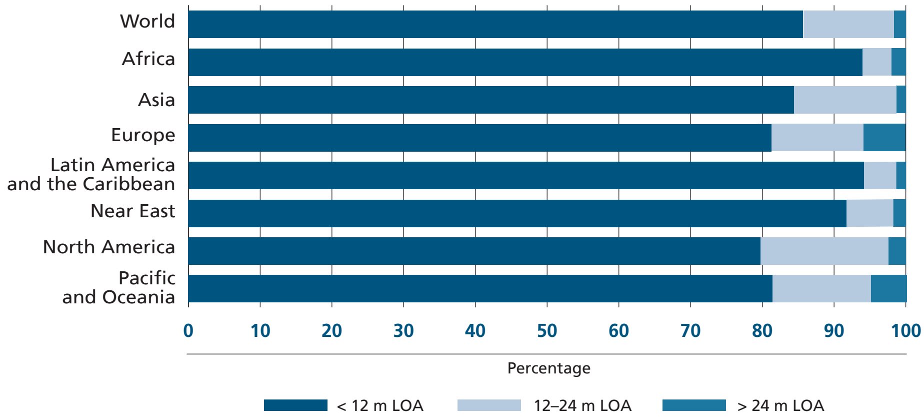
in a larger proportion of countries. In the Near East, 6 out of 13 countries (46 percent) increased the number of vessels. In Latin America and the Caribbean, Asia and Africa, an even greater proportion of countries increased the number of vessels in their national fleets. However, the results should be viewed with caution given the large uncertainty implied by the high proportion of countries for which it was not possible to indicate any trend. Nevertheless, the general tendencies observed here seem to be consistent with other observations.

Size distribution – importance of small boats

About 86 percent of the motorized fishing vessels in the world are less than 12 m in length; such vessels dominate everywhere, particularly in Africa, Latin America and the Caribbean, and the Near East (Figure 17). Less than 2 percent of all motorized fishing craft correspond to industrialized fishing vessels of more than 24 m in length (with a gross tonnage [GT] of generally more than 100 GT); this percentage is higher in Europe (6 percent), the Pacific and Oceania (5 percent), North America and Africa.

Figure 17

Size distribution of motorized fishing vessels



Note: LOA = length overall.

As indicated above, the bulk of the global fishing fleet is considered to be small vessels for which data are not readily available. This is particularly the case in Africa, parts of Asia and the Americas. In many cases, this category of the fleet is not even registered, or information on it resides in local registries to which few have access. As the inland fishing fleets usually consist of vessels of less than 12 m length overall (LOA), much of the fleet is not registered and is most likely omitted from most analyses involving the global number of fishing vessels, particularly in developing countries.

The EU Fleet Register for the European Economic Area (EEA) is the largest and most detailed fishing vessels database that is publicly accessible. At the end of 2009, the EU Fleet Register listed some 84 800 fishing vessels, of which 4 percent were more than 100 GT and a further 3 percent were between 50 and 100 GT, but the vast majority (93 percent) were less than 50 GT. In terms of LOA, 4 percent were longer than 24 m, another 4 percent were between 18 and 24 m, 3 percent were between 15 and 18 m, and a further 6 percent were between 12 and 15 m. Again, the vast majority (83 percent) were less than 12 m LOA (defined as small-scale under EU Council Regulation [EC] No. 2792/1999).

The structure of the fleets in terms of average power and average tonnage differs within the EEA. For example, Greece has the most fishing vessels (17 255 vessels in 2009) but they are of a comparatively small size (87 917 total GT, and 0.5 million total kW). However, the United Kingdom and Norway, with very similar numbers (about 6 510 fishing vessels each), have fleets with, respectively, two to four times the capacity of Greece's fishing fleet (206 945 total GT for the United Kingdom, 367 688 total GT for Norway), and they have considerably greater power (0.83 million total kW for the United Kingdom, 1.25 million total kW for Norway).

Table 10 provides examples from selected nations illustrating the importance of small vessels in various fleets. The proportion of vessels of less than 100 GT is well over 90 percent in most cases. Therefore, if measures are taken to limit fleet capacity, choices will have to be made between reductions in the industrial or the small-scale fleets. When deciding on such policies, many nations face difficult dilemmas as not only resources but also social and political issues are involved. Regarding engine power, the fleets from different nations differ more widely in terms of the proportion of vessels below 50 horsepower (HP) (37 kW). Within the EU, marked differences exist between fleets from different nations depending on their areas of operations. For example, while more than 82 percent of the vessels in Greece's fishing fleet have engines of 50 HP or less, the corresponding figure for Sweden is only about 38 percent.

In terms of the areas of operation of the small Asian vessels, about 38 percent of them are dedicated to fishing on inland waters. In Africa and in Latin America and the Caribbean, small vessels constitute that vast sector of artisanal and subsistence fisheries on which the livelihoods of a great number of fisher households depend. In this context, efforts are being made in Africa as well as Central America to establish vessel registers as part of fishery resources management plans and policies.

Effect of overcapacity reduction efforts

Several countries have tried to resolve the issues of overcapacity by establishing reduction targets. However, data from other countries indicate a continuing expansion of their fleets. For example, the number of motorized fishing vessels in Cambodia increased by 16 percent from 38 253 in 2006 to 44 420 in 2008. Indonesia's fleet of motorized fishing vessels increased by 15 percent from 337 188 in 2005 to 387 178 in 2007. Viet Nam reported a 6 percent increase in offshore fishing vessels (those with engines of more than 90 HP) from a total of 21 232 in 2006 to 22 529 in 2008, and Malaysia reported an 8.6 percent increase in licensed fishing vessels from 23 376 to 25 376 for the same period. The case of Sri Lanka illustrates the potential for overshoot in efforts to re-establish a fishing fleet partly destroyed by the tsunami that swept the region in 2004. Sri Lanka had a pre-tsunami fishing fleet of 15 307 motorized vessels, which according to official reports was reduced to about 6 700 vessels (a 44 percent reduction) by the tsunami. By 2007, the fishing fleet numbered 23 464 motorized

Table 10
Percentage of small vessels in selected nations with reference to engine power and tonnage

Country	Date of data	Powered vessels	< 50 horsepower	< 50 gross tonnage	< 100 gross tonnage
		(Number)		(Percentage)	
Cambodia[1]	2008	44 420	98.9	–	99.0
Chile[1]	2008	6 801	–	–	97.8
Egypt[1]	2007	4 543	43.1	–	80.7
Indonesia[2]	2007	387 178	–	97.8	98.9
Japan[3]	2007	296 576	–	–	99.6
Thailand[1]	2007	13 056	–	71.0	97.0
Viet Nam[4]	2008	130 377	77.0	–	89.0
EU (selected)[5]					
Denmark	2009	2 861	57.7	92.3	95.5
Finland	2009	3 253	64.6	98.6	99.5
Greece	2009	17 255	82.1	97.9	99.0
Ireland	2009	2 098	57.3	85.9	92.0
Italy	2009	13 625	50.3	92.2	97.1
Portugal	2009	8 565	73.3	96.4	97.5
Spain	2009	11 143	64.7	87.5	91.9
Sweden	2009	1 454	37.8	89.8	93.1

[1] Response to FAO questionnaire 2008, national authorities.
[2] Ministry of Marine Affairs and Fisheries and Japan International Cooperation Agency. 2009. *Indonesian Fisheries Statistics Index 2009* (available at www.dkp.go.id/upload/jica/book_file/02_statindex2009.pdf).
[3] Fisheries Agency, Government of Japan. 2008. *Statistic Tables of Fishing Vessels.* General Report No. 60.
[4] National Directorate of Aquatics and Resource Exploitation and Protection. 2009. *Briefing document on the current status of Viet Nam's fishery sector.* DECAFIREP official figures, from POSMA, FSPS II. Prepared by the Post-Harvest and Marketing Component of the Fishery Sector Programme Support Phase II.
[5] Fleet Register On the Net (available at ec.europa.eu/fisheries/fleet/index.cfm?method=Download.menu).

vessels, and by 2008 the number had increased even further to 23 555 motorized fishing vessels.

Viet Nam incorporated a fleet reduction target of 40 000 small fishing boats as part of its 2006–2010 fisheries master plan. The number of small fishing boats was considered too high and partly responsible for overfishing in inshore waters. Therefore, fishers were encouraged to use larger and better-equipped fishing vessels and to fish further offshore, and a subsidy programme has been in effect towards this end. Whether the reduction target will be achieved remains to be seen.

China's 2003–2010 marine fishing vessel reduction plan has aimed to achieve a marine fishing fleet of 192 390 vessels with a total combined power of 11.4 million kW. The latest available information (2007) reports a total of 288 779 marine fishing vessels with a total combined power of 14.7 million kW. Japan has applied various schemes in order to reduce its fishing fleet. From 1981 to 2004, a total of 1 615 mid- to large-scale fishing vessels were scrapped under a government scheme of direct payment assistance for fishing fleet reduction. The historical data series of the number of motorized marine fishing vessels confirms the downward trend. In 2005, Japan had 308 810 registered marine fishing vessels with a combined total power of 12.44 million kW. By 2007, the number of vessels had dropped to 296 576 with a combined total power of 12.84 million kW. Thus, while the number of vessels declined, mean engine power increased, rising from 40.3 kW in 2005 to 43.3 kW in 2007. This is generally the case when decommissioning programmes are set in place as usually the first vessels to leave tend to be the most inefficient, while the most efficient vessels tend to remain active the longest.

In the EU, policies have been directed to ensuring sustainable fishing over a long period within a sound ecosystem through the appropriate management of fisheries while offering stable economic and social conditions to those involved in the activity. The restructuring of the European fishing fleet to achieve a sustainable balance between the fleet and the available fishery resources has been a major goal of such policies. Indeed, the evolution of the combined number, tonnage and power of Europe's fishing vessels does indicate downward tendencies in the last decade. For example, the fishing fleet of the EEA18 (which comprises the combined fleets from Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom) contracted from 90 573 vessels at the end of 2006 to 85 676 vessels at the end of 2008, a net reduction of 5.4 percent. In the same period, total tonnage decreased from 2.3 million GT to 2.2 million GT (a net reduction of 4.8 percent), while total power decreased from 8.44 million kW to 8.05 million kW (a net reduction of 4.6 percent). Notwithstanding such downward trends for the combined data of the EEA18 fishing fleet, similarly to the Japanese case, average power has actually increased. Thus, the mere reduction in the number of fishing vessels does not clearly reduce the actual fishing capacity of the fleet, as defined in terms of tonnage and engine power.

The EU tried to deal with this problem by establishing ceilings for total tonnage and total power for the fleets of each member state. Later, the measures were revised to limit the effort, defined as the product of the total number of vessels multiplied by the total tonnage (or total power) multiplied by the number of days at sea (or other measure of actual fishing activity).

Notwithstanding efforts aimed at reducing fleet capacity, high fuel prices seem an even more powerful force to reduce fishing activities – up to one-third of the small boats in Viet Nam have been reported as confined to port since 2008. Rising prices of fuel oil in 2007 and 2008 have also been thought to have a major impact and have prevented fishing operations in countries as diverse as Guatemala, Japan, Namibia, Philippines, and Sao Tome and Principe. There is some evidence that, at least in the United States of America, the current high fuel prices are reducing the use of high-powered fishing vessels.

THE STATUS OF FISHERY RESOURCES

Marine fisheries

Global production of marine capture fisheries reached a peak of 86.3 million tonnes in 1996 and then declined slightly to 79.5 million tonnes in 2008, with great interyear fluctuations. In 2008, the Northwest Pacific had the highest production of 20.1 million tonnes (25 percent of the global marine catch), followed by the Southeast Pacific, with a total catch of 11.8 million tonnes (15 percent), the Western Central Pacific with 11.1 million tonnes (14 percent) and the Northeast Atlantic, with 8.5 million tonnes (11 percent) (Figure 18).

The proportion of stocks estimated to be underexploited or moderately exploited declined from 40 percent in the mid-1970s to 15 percent in 2008 (Figure 19). In contrast, the proportion of overexploited, depleted or recovering stocks increased from 10 percent in 1974 to 32 percent in 2008. The proportion of fully exploited stocks has remained relatively stable at about 50 percent since the 1970s, with scattered, slightly lower levels between 1985 and 1997. In 2008, 15 percent of the stock groups monitored by FAO were estimated to be underexploited (3 percent) or moderately exploited (12 percent) and, therefore, able to produce more than their current catches. This is the lowest percentage recorded since the mid-1970s. Slightly more than half of the stocks (53 percent) were estimated to be fully exploited and, therefore, their current catches are at or close to their maximum sustainable productions, with no room for further expansion. The remaining 32 percent were estimated to be either overexploited (28 percent), depleted (3 percent) or recovering from depletion (1 percent) and, thus, yielding less than their maximum potential production owing to excess fishing pressure in the past, with a need for rebuilding plans. This combined percentage is the highest in the time series. While the degree of uncertainty about these estimates may be great (Box 1), the apparently increasing trend in the percentage of overexploited, depleted and recovering stocks and the decreasing trend in underexploited and moderately exploited stocks do give cause for concern.

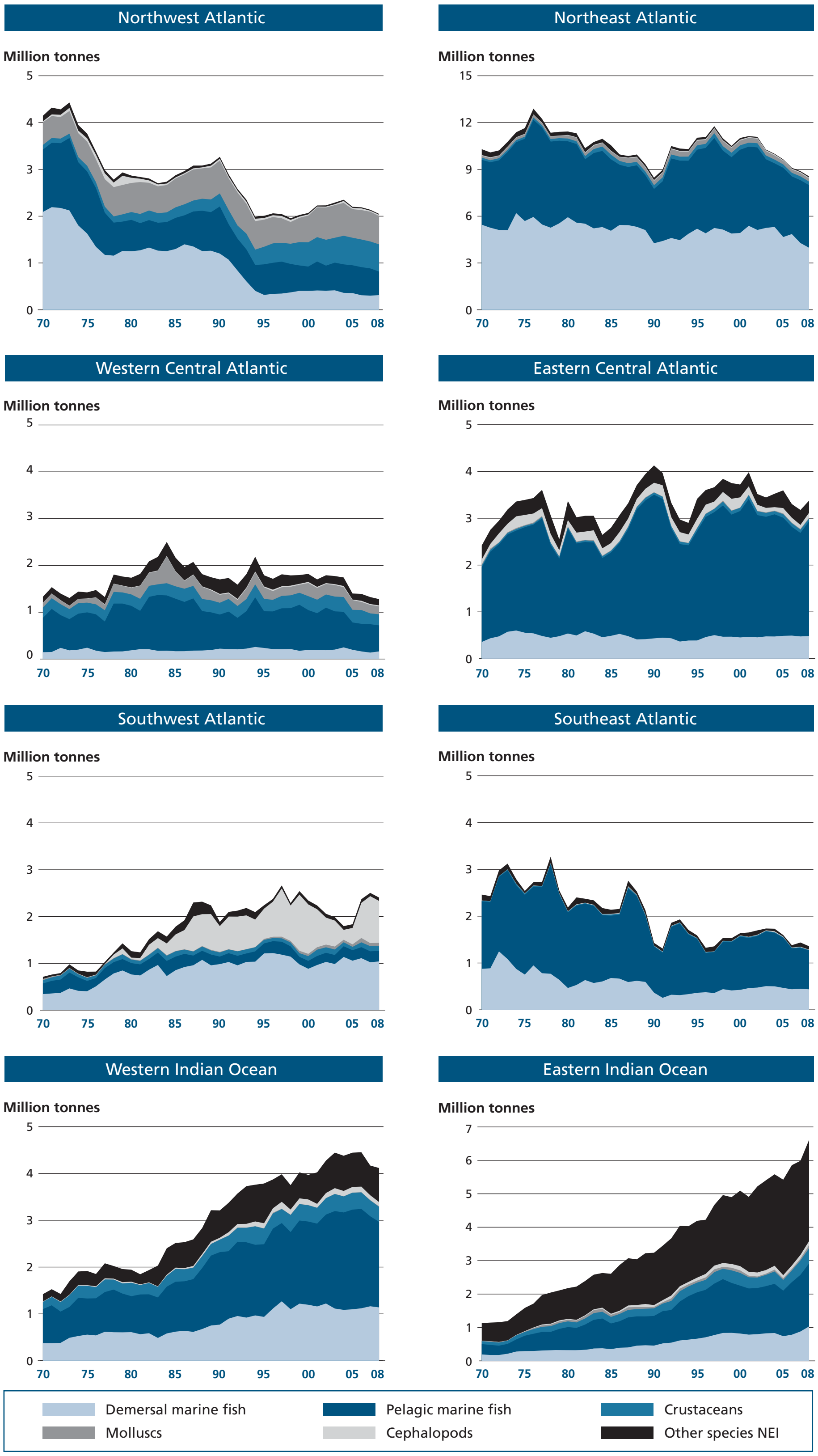
Most of the stocks of the top ten species, which account in total for about 30 percent of the world marine capture fisheries production in terms of quantity (Figure 6), are fully exploited and, therefore, have no potential for increased production, while some stocks are overexploited and increases in their production could only be possible with effective rebuilding plans in place. The two main stocks of anchoveta (*Engraulis ringens*) in the Southeast Pacific and those of Alaska pollock (*Theragra chalcogramma*) in the North Pacific and blue whiting (*Micromesistius poutassou*) in the Atlantic are fully exploited. Several Atlantic herring (*Clupea harengus*) stocks are fully exploited, but some are depleted. Japanese anchovy (*Engraulis japonicus*) in the Northwest Pacific and Chilean jack mackerel (*Trachurus murphyi*) in the Southeast Pacific are considered to be fully exploited. Some limited possibilities for expansion may exist for a few stocks of chub mackerel (*Scomber japonicus*), which are moderately exploited in the Eastern Pacific, while the stock in the Northwest Pacific was estimated to be recovering. In 2008, the largehead hairtail (*Trichiurus lepturus*) was estimated to be overexploited in the main fishing area in the Northwest Pacific.

The total catch of tuna and tuna-like species was about 6.3 million tonnes in 2008. The principal market tuna species – albacore, bigeye, bluefin (three species), skipjack and yellowfin – contributed 4.2 million tonnes, a decline of about 0.2 million tonnes from the peak in 2005. About 70 percent of that catch was taken from the Pacific. The skipjack was the most productive tropical market tuna (contributing about 57 percent to the 2008 catch of principal tunas) and yellowfin and bigeye were the other productive tropical species (contributing about 27 and 10 percent, respectively).

Of the 23 tuna stocks, most are more or less fully exploited (possibly up to 60 percent), some are overexploited or depleted (possibly up to 35 percent) and only a few appear to be underexploited (mainly skipjack). However, an increase in skipjack catches is not desirable at present as it may negatively affect bigeye and

Figure 18

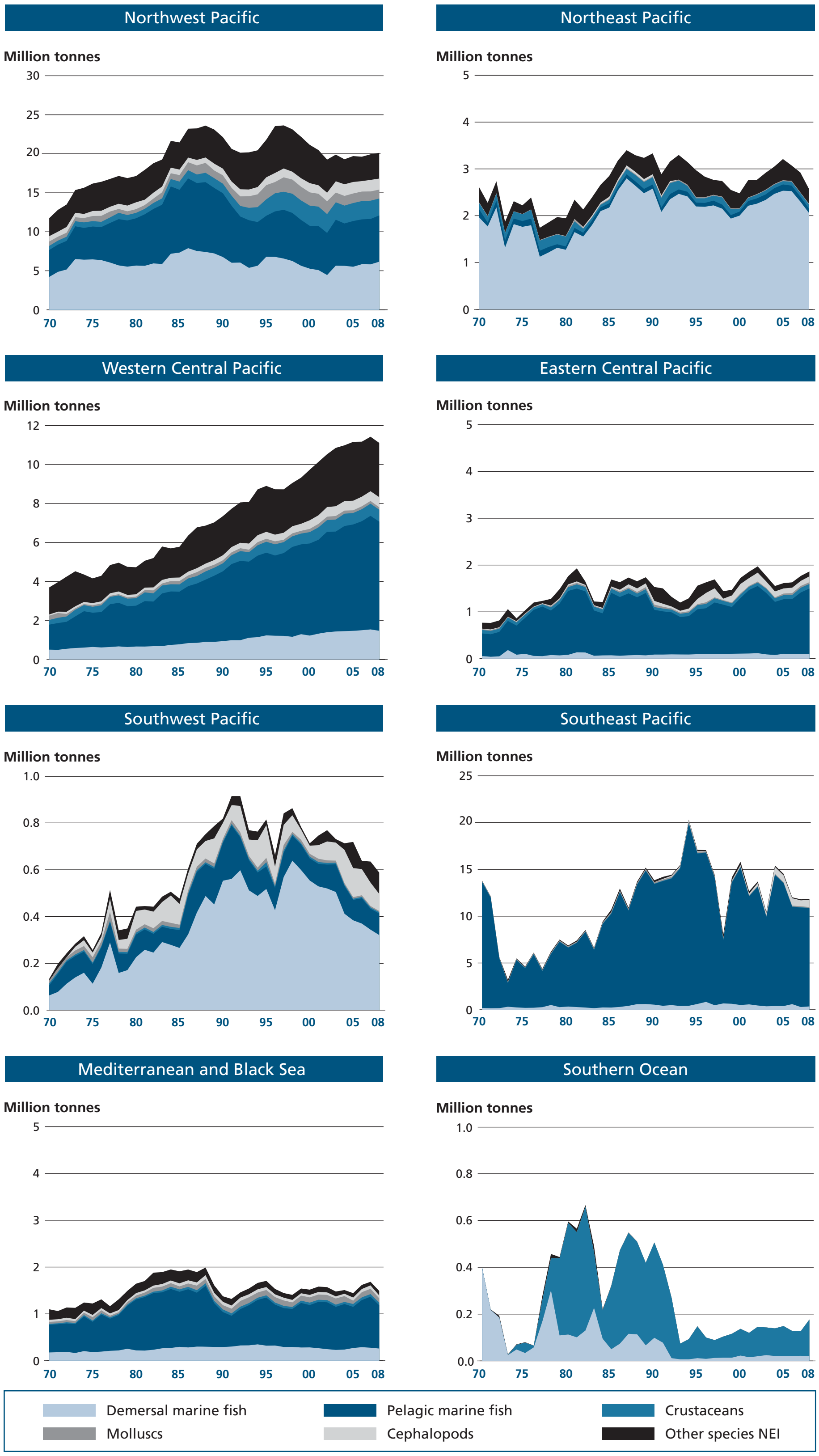
Capture fisheries production in marine areas



(Continued)

Figure 18 *(cont.)*

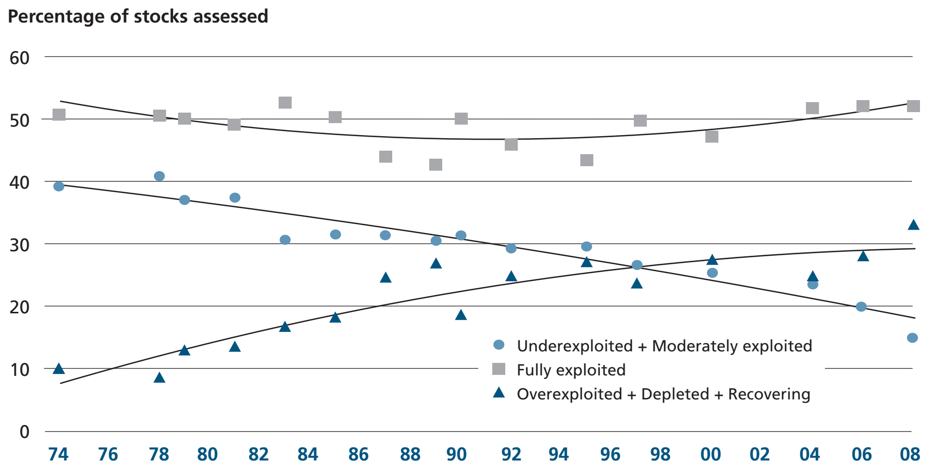
Capture fisheries production in marine areas



Note: NEI = not elsewhere included.

Figure 19

Global trends in the state of world marine stocks since 1974



yellowfin tunas. Only for very few stocks of principal tunas is their status unknown or very poorly known. In the long term, because of the substantial demand for tuna and the significant overcapacity of tuna fishing fleets, the status (and consequently catches) of tuna stocks may deteriorate further if there is no improvement in their management.

The concern about the poor status of some bluefin stocks and the difficulties facing many tuna management organizations in managing these stocks effectively led to a proposal by Monaco in 2010 to ban the international trade of Atlantic bluefin under the CITES. Although it was hardly in dispute that the stock status of this high-value food fish met the biological criteria for listing on CITES Appendix I, the proposal was ultimately rejected. Many parties that opposed the listing stated that in their view the ICCAT was the appropriate body for the management of such an important commercially exploited aquatic species.

In the Northwest Pacific, small pelagics are the most abundant category, with Japanese anchovy providing about 1.9 million tonnes in 2003, but having since declined to 1.2 million tonnes in 2008. Other important contributors to the total catch in the area 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 Eastern Central and Southeast Pacific, there have been no major changes in the state of stock exploitation, while there have been some improvements regarding the assessment and management of some key fish stocks at both the national and international levels. Regarding international cooperation, after 3–4 years of intense negotiations, some of the member parties of the proposed South Pacific Regional Fisheries Management Organization (Chile, Colombia, Cook Islands, New Zealand and Peru) adopted the Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean, in Auckland, New Zealand, on 14 November 2009. This convention promotes the international conservation and management of non-highly-migratory fisheries and protection of biodiversity in the area extending from the easternmost part of the South Indian Ocean through the Pacific towards the EEZs of South America. Central American countries have also improved regional cooperation for the assessment and management of important coastal fisheries resources in their area. In addition, a moderate El Niño developed in 2009 and continued throughout the equatorial Pacific in the early months of 2010. Deep tropical convection remained enhanced across central and eastern parts of the

tropical Pacific, with relatively mild impacts reported on the state of stocks and fisheries in the eastern Pacific.

Total production in the Western Central Pacific grew continuously to a maximum of 11.4 million tonnes in 2007 and then decreased slightly in 2008. This area contributes about 14 percent of global marine production. Despite this apparently positive situation, there are reasons for concern regarding the state of the resources, with most stocks being either fully exploited or overexploited (many also depleted), particularly in the western part of the South China Sea. The high catches have probably been maintained through expansion of the fisheries to new areas, and possible double counting in the transshipment of catches between fishing areas, which leads to bias in estimates of production, potentially masking negative trends in stock status.

In the Northeast Atlantic, the blue whiting stock has recovered since the 1990s with current catches of about 1 million tonnes, although a managed decline in the short term is probable owing to recent low recruitment. Fishing mortality has been reduced in cod and plaice, with recovery plans in place for the major stocks of these species. The Arctic cod spawning stock was particularly large in 2008, having recovered from the low levels observed from the 1960s to the 1980s. Similarly, the Arctic saithe and haddock stocks have increased to high levels, although stocks elsewhere remain fully exploited or overexploited. The largest stocks of sand eel and capelin remain overexploited. Concern remains for redfishes and deep-water species for which there are limited data and which are likely to be vulnerable to overfishing. The northern shrimp stocks are generally in good condition, but there are indications that some stocks are being overexploited. Harvest control rules based on a more consistent maximum sustainable yield policy have been, or are being, developed for many stocks, including blue whiting, mackerel, Arctic haddock, Arctic cod, and the larger herring and plaice stocks.

Although fishery resources in the Northwest Atlantic continue to be under stress from previous and/or current exploitation (with some 35 percent of stocks estimated to be depleted in 2008), some overexploited and depleted stocks have recently shown signs of recovery in response to an improved management regime in the past decade (e.g. Greenland halibut, yellowtail flounder, Atlantic halibut, haddock and spiny dogfish). However, this is not the case for Atlantic cod, once the most important and abundant commercial fish species in the Northwest Atlantic, which dramatically collapsed in the early 1990s and has not recovered yet.

There have been several important changes in the status of the stocks in the Southeast Atlantic since the last assessment in 2006. The important hake resources remain fully exploited to overexploited. However, there are signs of some recovery in the deepwater hake stock (*Merluccius paradoxus*) off South Africa and in the shallow-water Cape hake (*Merluccius capensis)* off Namibia as a consequence of good recruitment years and of the strict management measures introduced since 2006. The status of most stocks of coastal fishes remains fully exploited or overexploited, some being 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, a situation that was already evident in the last review in 2008. In contrast, the status of Southern African anchovy has continued to improve from fully to moderately exploited, due especially to a series of years with good recruitment conditions, while Whitehead's round herring continues to be underexploited to moderately exploited. The condition of Cape horse mackerel and Cunene horse mackerel stocks has deteriorated, particularly off Namibia and Angola, where both species are currently overexploited. Sardinellas (*S. aurita* and *S. maderensis*) off Angola are still moderately to fully exploited. The condition of the perlemoen abalone stock continues to be worrying. Exploited heavily by illegal fishing, it is currently overfished and probably depleted.

Another area of concern is the Southwest Atlantic, where more than half of the 16 assessed species were deemed to be depleted or overfished, among them Argentina hake (*Merluccius hubbsi*), southern blue whiting (*Micromesistius australis*), Patagonian toothfish (*Dissostichus eleginoides*) and the Argentine shortfin squid (*Illex argentinus*).

In the Eastern Central Atlantic, total catches were about 3.4 million tonnes in 2008, slightly below the 2000–08 average of about 3.5 million tonnes. The small pelagic species constitute the bulk of the landings, followed by the miscellaneous coastal fishes. The single most important species in terms of landings is sardine (*Sardina pilchardus*), with annual landings in the range of 600 000–800 000 tonnes in the last nine years. In the area from Cape Boujdor southwards to Senegal, the sardine is still considered moderately exploited, otherwise most of the pelagic stocks are considered fully exploited. Some are considered overexploited, such as the sardinella stocks off Northwest Africa and in the Gulf of Guinea. To a large extent, the demersal fish

Box 1

Assessment of data-poor fisheries

The statistics presented in *The State of World Fisheries and Aquaculture 2010* on the status of marine fisheries are frequently referred to in international policy documents and in the media to draw attention to the issue of the sustainability of the world's fisheries. While this information represents a unique effort to provide a global overview on the state of fishery resources, it should be noted that the stocks included in this analysis, and for which assessments are available, represent only a fraction of the total number of exploited stocks around the world. The proportion of the exploited stocks that are subject to some sort of formal assessment is highest for the fisheries operated by developed countries, particularly in high-latitude areas, and lowest for tropical multispecies fisheries exploited by fleets from developing countries or by distant-water fleets.

A conservative estimate is that probably only 10 percent of the exploited fish stocks are assessed, but not always regularly. Although these assessed stocks include the largest single-species stocks and account for almost 80 percent of the total declared landings, it is clear that for the large majority of the exploited fish stocks there is no or little information on their status. In addition to the difficulty of developing a reliable global overview of the state of fish stocks, this situation also undermines the ability of states to manage their fisheries sustainably. The FAO Code of Conduct for Responsible Fisheries requires that all fisheries should be managed using the "best available knowledge", and for most fisheries this information should necessarily include stock status and an understanding of the impacts of fishing on the target species and their supporting ecosystem. Growth in the international trade in fishery products, combined with increasing consumer awareness about sustainability issues, often results in the adoption of ecolabeling schemes, which requires documentation on the state of exploited fish stocks for the application of certification procedures.

To ensure the long-term sustainability of fishery resources, it is essential that exploited stocks be regularly assessed and that the results of these assessments be incorporated into the fisheries management process. In most of the industrialized large-scale fisheries, states regularly collect biological and statistical data and monitor stock status through

resources are fully exploited to overexploited in most of the area, and the white grouper stock (*Epinephelus aeneus*) off Senegal and Mauritania remains in a severe condition. The status of some of the deepwater shrimp stocks seems to have improved and they are now considered moderately exploited, whereas the other shrimp stocks in the region range from fully exploited to overexploited. The commercially important octopus (*Octopus vulgaris*) and cuttlefish (*Sepia* spp.) stocks remain overexploited.

In the Mediterranean Sea, the overall situation has remained stable but difficult since the last global assessment. All hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*) stocks are considered overexploited, as are probably also the main stocks of sole and most seabreams. The main stocks of small pelagic fish (sardine and anchovy) are assessed as either fully exploited or overexploited.

In the Black Sea, the situation of small pelagic fish (mainly sprat and anchovy) has recovered somewhat from the drastic decline suffered in the 1990s, probably as a

mathematical modelling. However, the collection of such data is often quite expensive, requires a stable research and monitoring system and calls for specialized expertise that is not always available (or is scarce) in many countries or regions. Therefore, this approach may not be applicable to many of the world's fisheries.

It has become clear that there is a need to identify or develop methods and procedures that are less data-demanding, but which can be used to assess the status of fish stocks and to provide the information necessary for designing effective management plans. To increase the awareness of these methods among a wider audience, including the advantages and disadvantages of the different approaches, FAO is preparing a set of guidelines for the assessment of fish stocks in data-poor situations. These guidelines will lay out the main principles as regards the use of these tools, with the precautionary principle as the overarching reference. These methods require fewer data in comparison with traditional stock assessments, but they make more explicit use of local knowledge and informal approaches. Assessments of uncertainty and risk will be a key part of such methods. The assessment procedure will be more closely linked to fisheries management and the decision-making process.

The trade-offs between intensity of exploitation and data availability will be made clearer, in that intensively exploited fisheries will require more intensive and frequent data collection and monitoring than moderately exploited ones. Guidance as regards other criteria that may be relevant in deciding the level of cost and complexity of the assessment (and of management) will also be provided. This will help to ensure that costs are commensurate with the value of the fishery, and that the level of complexity matches the capacity available in the given context.

With this and other similar initiatives, it is expected that the coming years will see a clear increase in the number of assessed stocks, and also a strengthening of the link between stock assessment and fisheries management under a risk assessment framework. This work is fully consistent with, and is an aspect of, implementing an ecosystem approach to fisheries.

consequence of unfavourable oceanographic conditions, but they are still considered fully exploited to overexploited.

The Eastern Indian Ocean is still experiencing a high growth rate in catches, with a 10 percent increase from 2007 to 2008, now totalling 6.6 million tonnes. The Bay of Bengal and Andaman Sea regions have seen total catches increasing steadily, and there are no signs of the catch levelling off. However, a very high percentage (about 42 percent) of the catches in this area are attributed to the category "marine fishes not identified", which is a cause of concern as regards the need for monitoring stock status and trends. Increased catches may in fact be due to the expansion of fishing to new areas or species. Declining catches in the fisheries within Australia's EEZ can partly be explained by a reduction in effort and in catches following a structural adjustment and a ministerial direction in 2005 aimed at ceasing overfishing and allowing overfished stocks to rebuild. The economics of fishing in this area are expected to improve in the medium and long terms, but higher profits can also be expected for individual fishers in the short term because fewer vessels are operating.

In the Western Indian Ocean, total landings reached a peak of 4.45 million tonnes in 2006, but dropped to 4.12 million tonnes in 2008. Tuna and tuna-like species are the largest catch contributor among other species groups – 0.88 million tonnes or 21 percent of the total landings of the area in 2008. Recent assessments have shown that stocks of narrow-barred Spanish mackerel (*Scomberomerus commerson*) are overfished. Catch data in this area are often found not to be detailed enough for stock assessment purposes. However, the South West Indian Ocean Fisheries Commission conducted stock assessments for 140 species in its mandatory area in 2008 based on best-available data and found that 29 percent are overexploited or depleted, 53 percent are moderately or fully exploited and 18 percent are underexploited, which is higher than the global average.

It should be noted that the declining global catch in the last few years, together with the increased percentage of overexploited, depleted or recovering stocks and the decreased proportion of underexploited and moderately exploited species around the world, strengthens the likelihood that the production of wild capture fisheries will not be able to increase unless effective management plans are put in place to rebuild overfished stocks. The situation seems more critical for some highly migratory, straddling and other fishery resources that are exploited solely or partially in the high seas. The United Nations Fish Stocks Agreement (UNFSA), which entered into force in 2001, should be used as a legal basis for management measures for the high seas fisheries.

It is encouraging to note that good progress is being made in reducing exploitation rates and restoring overfished fish stocks and marine ecosystems through effective management actions in some areas. For example, among the fish stocks managed by Australia, the number of fish stocks classified as overfished and/or subject to overfishing fell from 24 in 2005 to 18 in 2008; in contrast, the number of stocks classified as fully fished and underfished increased from 19 to 39 in the same period.[5] Since the 1990s, the Newfoundland–Labrador Shelf, the Northeast United States Shelf, the Southern Australian Shelf, and the California Current ecosystems have shown substantial declines in fishing pressure, such that they are now at or below the modelled exploitation rate that gives the multispecies maximum sustainable yield of the ecosystem.[6]

Inland fisheries

Inland fisheries are a vital component in the livelihoods of people in many parts of the world, in both developing and developed countries. Inland fisheries provide high-quality protein, essential nutrients and minerals that are often difficult to obtain from other food sources. In developing areas, inland fisheries provide economic opportunities and a "safety net" that allows for continued food production when other sectors may fail. In developed countries, and in an increasing number of

developing countries, inland fisheries are used for recreation rather than for food production, another avenue to economic development and growth.

However, the status of inland fishery resources and the ecosystems that support them is generally poorly known. This has led to differing views on the actual status of many resources. One view maintains that, because of the multiple uses of and threats to inland water ecosystems, the sector is in serious trouble. The other view holds that the sector is in fact growing and that much of the production and growth has gone unreported. The statistics reported to FAO indicate an overall increase of 1.6 million tonnes in the period 2004–08, and in 2008 the sector contributed 10.2 million tonnes to global capture fisheries production – a record contribution. For further details on inland water catch trends, see the "World inland capture fisheries production" section (on page 16) and the discussion below on these statistics.

The simple phrase "inland fisheries" belies the extremely diverse nature of this subsector, and thus makes assessment of the state of inland fishery resources extremely difficult. Inland fisheries include a range of fishing techniques in a variety of inland waterbodies. Inland fisheries exist in natural areas such as streams, rivers, swamps, lakes and inland seas, in temporary waterbodies such as floodplains and seasonal ponds, and also in artificial and modified habitats such as irrigation systems, rice paddies, reservoirs and enclosed natural waterbodies (e.g. ox-bow lakes). Fishing techniques also range from small hand-held nets in rice paddies to industrial-scale trawlers on inland seas. In remote rural areas, fishery management, monitoring and reporting are difficult and often non-existent.

The reluctance by public administrations to spend resources on monitoring inland fisheries, to which the high cost of collecting information is a contributing factor, leads to a poor state of knowledge on inland fisheries and their resources. This in turn hinders the formulation of comprehensive and appropriate policies for the sector.

The assessment of inland fishery resources is generally done by each country on its own, even for watersheds shared with neighbouring countries. This is in spite of the fact that most inland fishery scientists recommend the "watershed" as the appropriate unit for fishery management and resource assessment. They do so because biological, ecological and physiochemical processes within the watershed are interdependent and will determine fishery production.

Although irresponsible fishing practices can and do affect the state of inland fishery resources, factors external to the fishery are often more important for the status of the stocks. Habitat loss and degradation, water abstraction, drainage of wetlands, dam construction, and pollution and eutrophication often act together, thus compounding one another's effects. They have caused substantial declines and/or changes in inland fishery resources. Although these impacts are not always reflected by a discernable decrease in fishery production (especially where stocking is practised), the fishery may change in composition and value.

In response to the above impacts on inland fisheries, enhancement programmes have been initiated in many areas of the world. One common form of enhancement is the stocking of early life-history stages produced in aquaculture hatcheries. Thus, fishery production may be maintained not by natural recruitment but by the release of hatchery-raised individuals. Reporting on the contribution of hatchery-produced stock is often poor (or even absent), and resource assessments based primarily on catch from a stocked fishery could be misleading, particularly where there is significant natural recruitment.

There is a growing appreciation of the need to improve inland fishery statistics. This is principally because inland fisheries provide significant food and income to many rural areas in developing countries. Even in peri-urban areas and industrialized countries, inland fisheries provide significant employment and income-generating opportunities through recreational and fishing and environmentally related activities. Where in-depth analysis has been undertaken, it has revealed that officially reported inland fishery production has underestimated actual production by as much as 1 000 percent in some areas.[7] Focused studies on inland fishery production have demonstrated that officially reported production has underestimated the true amount by an average of about 40 percent.[8] On the other hand, the constant increases in inland water catch production reported by several major fishing countries (Table 3) seem somewhat unrealistic given the environmental conditions of inland waterbodies. In some cases, these increases may be due largely to improvements in the data collection system. Studies have examined existing information to look for reporting irregularities and novel approaches are being tried,[9] such as including a question on inland fisheries in periodic national agriculture census.

The role of inland fisheries in poverty alleviation and food security needs to be better reflected in development and fisheries policies and strategies. The tendency to undervalue inland fisheries has resulted in inadequate coverage in national and international agendas. In recognition of this, the "Outlook" section of *The State of World Fisheries and Aquaculture 2010* focuses on inland fisheries in an effort to improve awareness of their role and importance.

FISH UTILIZATION AND PROCESSING

Fisheries production is rather diversified where species and product forms are concerned. As a highly perishable commodity, fish has specific requirements and a significant capacity for processing. The many options for preparing fish allow for a wide range of presentations, making fish a very versatile food commodity. It is generally distributed as 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.

In 2008, nearly 81 percent (115 million tonnes) of world fish production was destined for human consumption, while the rest (27 million tonnes) was used for non-food purposes. Seventy-six percent of world fish production destined for non-food purposes (20.8 million tonnes) was reduced to fishmeal and fish oil; the remaining 6.4 million tonnes was largely utilized as fish for ornamental purposes, for culture (fingerlings, fry, etc.), for bait, for pharmaceutical uses as well as raw material for direct feeding in aquaculture, for livestock and for fur animals.

In 2008, 39.7 percent (56.5 million tonnes) of world fish production was marketed as fresh, while 41.2 percent (58.6 million tonnes) of fish was frozen, cured or otherwise prepared for direct human consumption.

Since the mid-1990s, the proportion of fish used for direct human consumption has grown. This tendency has come about as more fish is used as food and less for producing fishmeal and fish oil.

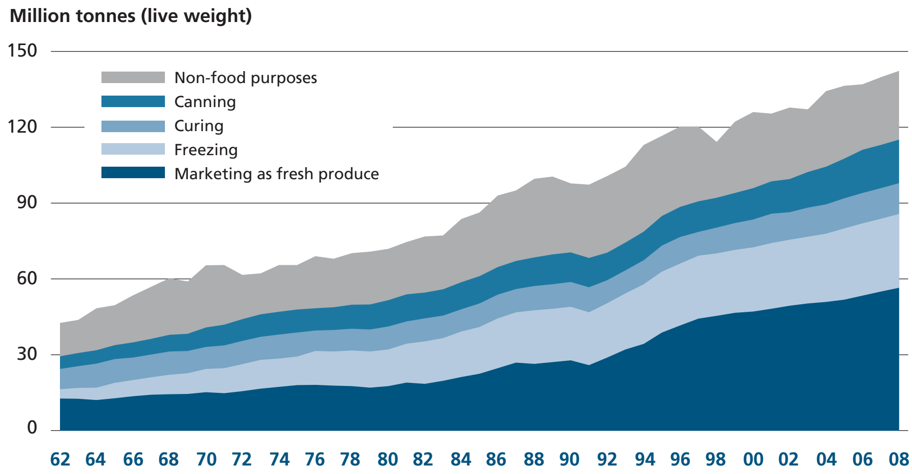
Small pelagics, in particular anchoveta, are the main groups of species used for reduction, and the production of fishmeal and fish oil is strictly linked to the catches of these species. The El Niño phenomenon has considerable effects on catches of anchoveta, which has experienced a series of peaks and drastic drops in the last few decades. Fishmeal production peaked in 1994 at 30.2 million tonnes (live weight equivalent) and has followed a fluctuating trend since then. In the last three years, it has experienced minimum variations (20.8 million tonnes in 2008) as catches of anchoveta have been rather stable.

Of the fish destined for direct human consumption, fish in live or fresh-fish form was the most important product, with a share of 49.1 percent, followed by frozen fish (25.4 percent), prepared or preserved fish (15.0 percent) and cured fish (10.6 percent). Live and fresh fish increased in quantity from 45.4 million tonnes in 1998 to 56.5 million tonnes in 2008 (live weight equivalent). Processed fish for human consumption increased from 46.7 million tonnes in 1998 to 58.6 million tonnes in 2008 (live weight equivalent). Freezing represents the main method of processing fish for human consumption, and it accounted for a 49.8 percent share of total processed fish for human consumption and 20.5 percent of total fish production in 2008 (Figure 20).

These general data mask significant differences. The utilization of fish and, more significantly, the processing methods vary according to the continent, region, nation

Figure 20

Utilization of world fisheries production (breakdown by quantity), 1962–2008



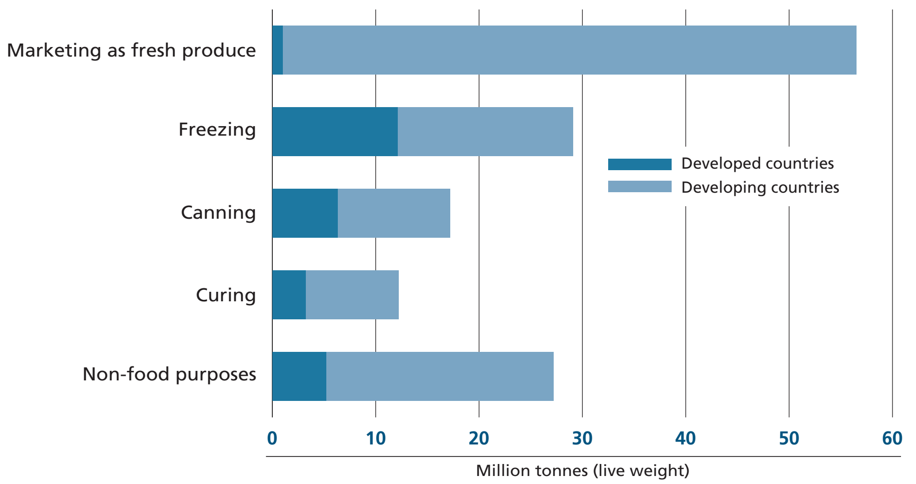
and even within countries. The highest percentage of fishmeal is produced by Latin American countries (47 percent of the total). The proportion of cured fish is higher in Africa (14 percent of the total) compared with other continents (the world average is 8.6 percent). In Europe and North America, more than two-thirds of fish used for human consumption is in frozen and canned forms.

In Africa, but also significantly in Asia, a large proportion of fish is marketed in live or fresh forms. Live fish is particularly appreciated in Asia (especially by the Chinese population) and in niche markets in other countries, mainly among immigrant Asian communities. However, it is not possible to determine the exact amount of fish marketed in live form from available statistics. Live fish are valuable but difficult to market and transport. They are often subject to stringent health regulations and quality standards. In some parts of Southeast Asia, and particularly in China, the commercialization and trade are not formally regulated but based on tradition. However, in markets such as the EU, live fish have to comply with requirements *inter alia* concerning animal welfare during transportation. Commercialization of live fish has increased in recent years as a result of technological developments, improved logistics and increased demand. An elaborate network of handling, transport, distribution, display and holding facilities has been developed to support the marketing of live fish. New technological systems include specially designed or modified tanks and containers, as well as trucks and other transport vehicles equipped with aeration or oxygenation facilities to keep fish alive during transportation or holding and display. Major innovations in refrigeration, ice-making and transportation are also permitting the distribution of more fish in fresh form.

However, notwithstanding technical changes and innovations, many countries, especially developing countries, still lack adequate infrastructure, including hygienic landing centres, electric power supply, potable water, roads, long supply chains as well services such as ice, ice plants, cold rooms and refrigerated transport. These factors, linked with tropical temperatures, cause a high percentage of post-harvest losses and quality deterioration, with consequent risk to the health of consumers. 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 in developing countries is traded primarily in live or fresh form (representing 60.0 percent of fish destined for human consumption in 2008) or after curing through drying, smoking or fermentation (9.8 percent in 2008). However, in the last few years, developing countries have experienced a growth in the share of frozen products (18.4 percent in 2008, up from 7.7 percent in 1998) and of

Figure 21

Utilization of world fisheries production (breakdown by quantity), 2008



prepared or preserved forms (11.8 percent in 2008, compared with 7.8 percent in 1998) (Figure 21).

In developed countries, most fish is retailed either as a frozen or as a prepared or preserved product. The share of frozen fish has been increasing in the last four decades and it represented 43.5 percent of total production in 2008. In many developed countries, processors are often facing reduced margins owing to increased competition from low-cost processing countries. Processors that operate without strong brands are also experiencing growing problems linked to the scarcity of domestic raw material and they are being forced to import fish for their business. Processors of traditional products, in particular of canned products, have been losing market share to suppliers of fresh and frozen products as a result of long-term shifts in consumer preferences as well as in changes in processing and in the general fisheries industry.

The fish industry is dynamic by nature and in the last two decades the utilization and processing of fish production have diversified significantly, particularly into high-value fresh and processed products, fuelled by changing consumer tastes and advances in technology, packaging, logistics and transport. Processing is becoming more intensive, geographically concentrated, vertically integrated and linked with global supply chains. 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 the 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, for which shelf-life and transportation time are important, 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.

Improved processing technology enables higher yields and results in a more lucrative product being derived from the available raw material for fish for human consumption as well as for the production of fishmeal and fish oil. In developed countries, innovation in value addition 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 require 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 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 of providing livelihood support to 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.

Improved processing technologies are also important in the utilization of fish waste derived from the fish-processing industry. Chitin and chitosan obtained from shrimp and crab shells have a variety of uses, such as in water treatments, cosmetics and toiletries, food and beverages, agrochemicals and pharmaceuticals. Fish skin is used as a source of gelatine as well as leather in making clothing, shoes, handbags, wallets, belts and other items. Larger fish are more suited to leather production owing to the size of the skins. Common sources of leather include shark, salmon, ling, cod, hagfish, tilapia, Nile perch, carp and seabass. Shark cartilage is used in many pharmaceutical preparations and reduced in powder, creams and capsules, as are other parts of sharks, e.g. ovaries, brain, skin and stomach. Fish collagen is used in the pharmaceutical industry, as are carotenoids and astaxanthins – pigments that can be extracted from crustacean wastes. Fish silage and fish protein hydrolysates obtained from fish viscera are finding applications in the pet feed and 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. In addition, shark teeth are used in handicrafts; similarly, the shells of scallops and mussels can be used in handicrafts and jewellery, and for making buttons. Calcium carbonate for industrial use can be obtained from mussel shells. Oyster shells are used in some countries as a raw material in the construction of buildings and for the production of quicklime (calcium oxide). Small fish bones, with a minimum amount of meat, are also consumed as snacks in some Asian countries. Procedures for the industrial preparation of biofuel from fish waste as well as from seaweeds are being developed.

FISH TRADE AND COMMODITIES

Fish and fishery products are highly traded. They have long been commercialized, and in the period 1976–2008 the fishery trade grew significantly, at an average annual rate of increase of 8.3 percent in value terms. This rise was aided by structural changes in the fishery sector, including the growing globalization of the fisheries and aquaculture value chain, and by the outsourcing of processing to countries where comparatively low wages and production costs provide a competitive advantage. In addition, increasing consumption of fishery commodities, trade liberalization policies, globalization of food systems and technological innovations furthered the overall increase in international fish trade. Improvements in processing, packaging, transportation and changes in distribution and marketing significantly changed the way fishery products were prepared, marketed and delivered to consumers. All these factors facilitated and increased the movement of production in relative terms from local consumption to international markets. The share of production (live weight equivalent) entering international trade as various food and feed products increased from 25 percent in 1976 to 39 percent in 2008 (Figure 22), reflecting the sector's growing degree of openness to, and integration in, international trade.

Until 2008, increasing fish exports coincided with an impressive global trade expansion. According to the United Nations Comtrade database, real merchandise exports increased by 27 percent between 2006 and 2008, well above the average annual rate of growth of 11 percent in the period 1998–2008. Among important factors explaining this increase, there was the influence exerted by price movements and exchange rates on trade flows, also 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) *vis-à-vis* the US dollar.

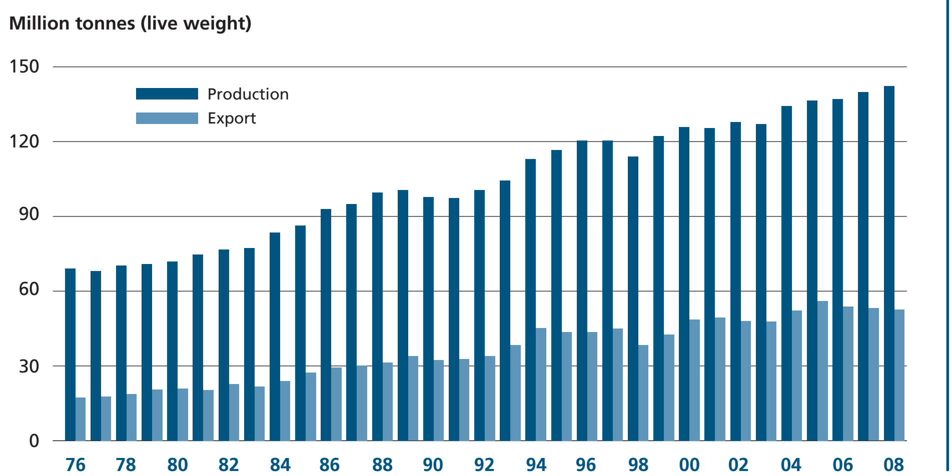
Trade in fish and fishery products is characterized by a wide range of product types and participants. In 2008, 197 countries reported exports of fish and fishery products. The role of fishery trade varies among countries and is important for many economies, in particular for developing nations. Trade in fish represents a significant source of foreign currency earnings, in addition to the sector's important role in employment, income generation and food security. In 2008, trade in fish and fishery products represented about 10 percent of total agricultural exports (excluding forest products) and 1 percent of world merchandise trade in value terms.

In 2008, exports of fish and fishery products reached a record of US$102.0 billion, 9 percent higher than 2007, nearly doubling the US$51.5 billion corresponding value in 1998. In real terms (adjusted for inflation), fishery exports grew by 11 percent in the period 2006–08, by 50 percent between 1998 and 2008 and by 76 percent between 1988 and 2008. In quantity terms (live weight equivalent), exports reached a peak at 56 million tonnes in 2005, representing an increase of 28 percent since 1995 and of 104 percent since 1985. Thereafter, export volumes decreased, accounting for 55 million tonnes in 2008. This decline was mainly because of a fall in production of and trade in fishmeal (down 10 percent in the period 2005–08), but also to the first signs of contraction in demand, and therefore of trade, as a consequence of the food price crisis, which affected consumer confidence in major markets.

In the period from late 2006 to mid-2008, international agricultural prices (particularly of basic foods) escalated to record levels in nominal terms. A series of long-

Figure 22

World fisheries production and quantities destined for export



and short-term factors contributed to this growth. They included the tightening in own supplies and the intertwining of global markets, exchange rate fluctuations, and rising crude oil prices and freight rates. These soaring prices affected large population segments, in particular among the poor in many developing countries. Prices of fish and fishery products were also affected by the food price crisis, following the general upward trend in all food prices. The FAO Fish Price Index (for more information on this issue, see Box 2) indicates an increase from 93.6 in February 2007 to 128.0 in September 2008. This represents the highest value reached during the period covered by the index (from 1994 to the present, with the base year 1998–2005 = 100). Prices for species from capture fisheries increased more than those for farmed species (which reached 137.7 versus 117.7 in September 2008, with 2005 as base year = 100) because of the larger impact from higher energy prices on fishing vessel operations than on farmed species. Aquaculture also experienced higher costs, in particular for feedstuffs.

In late 2007, a global financial crisis began. This crisis erupted into a full-blown economic recession in September 2008, representing the greatest financial and economic challenge since the Second World War. With the crisis, food prices fell dramatically. The FAO Fish Price Index reported a drastic drop from 128.0 in September 2008 to 112.6 in March 2009, after which it recovered to 119.5 in November 2009. Virtually no country has escaped the impact of the widening crisis, whose effects are likely to be felt through to 2011. Global gross domestic product (GDP) declined by 2.2 percent in 2009, and trade flows contracted sharply, with a drop of 14.4 percent in world merchandise trade in 2009. Preliminary estimates indicate that trade in fish and fishery products declined by 7 percent in 2009 compared with 2008.

Although the most acute phase of the global financial crisis seems to have passed and GDP growth rates are starting to improve, the outlook for the global economy remains uncertain and the recovery is fragile and slow. According to the World Bank's Global Economic Prospects 2010 report,[10] the world economy is expected to recover, with GDP projected to grow by 2.7 percent in 2010 and 3.2 percent in 2011. World trade volumes are forecast to expand by 4.3 percent in 2010 and 6.2 percent in 2011. Available data for the first few months of 2010 indicate that there have been increasing signs that fish trade is recovering in many countries, and the long-term forecast for fish trade remains positive, with a growing share of fish production entering international markets.

Table 11 shows the top ten exporters and importers of fish and fishery products in 1998 and 2008. China, Norway and Thailand are the top three exporters. Since 2002, China has been by far the leading fish exporter, contributing almost 10 percent of 2008 world exports of fish and fishery products, or about US$10.1 billion, and increasing further to US$10.3 billion in 2009. China's fishery exports have grown considerably since the 1990s, although at present they represent only 1 percent of its total merchandise exports. A growing share of fishery exports consists of reprocessed imported raw material. China has experienced a significant increase in its fishery imports, up from US$1 billion in 1998 to US$5.1 billion in 2008, when it was the sixth-largest importer. However, imports declined by 3 percent in 2009 to US$5.0 billion. With the exception of 2009, this increase in imports reflects the lowered import duties following China's accession to the World Trade Organization (WTO) in late 2001, the rising imports of raw material for reprocessing, as well as the growing domestic consumption of high-value species that are not available from local sources.

Viet Nam has also experienced significant growth in its exports of fish and fish products, up from US$0.8 billion in 1998 to US$4.6 billion in 2008, when it became the fifth-largest exporter in the world. Its growing exports are linked to its flourishing aquaculture industry, in particular to the production of *Pangasius* and of both marine and freshwater shrimps and prawns.

In addition to China, Thailand and Viet Nam, many other developing countries play a major role in global fisheries. In 2008, developing countries accounted for 80 percent of world fishery production. Their exports accounted for 50 percent (US$50.8 billion) of world exports of fish and fishery products in value terms and 61 percent

(33.8 million tonnes in live weight equivalent) in terms of quantity. Fishmeal represents a significant share of their exports (36 percent by quantity, but only 5 percent by value in 2008). Developing countries have an important segment of world exports of non-food fish exports (75 percent in 2008 in terms of quantity). However, developing countries have also considerably increased their share of the quantity of world fish exports destined for human consumption, from 46 percent in 1998 to 55 percent in 2008.

Box 2

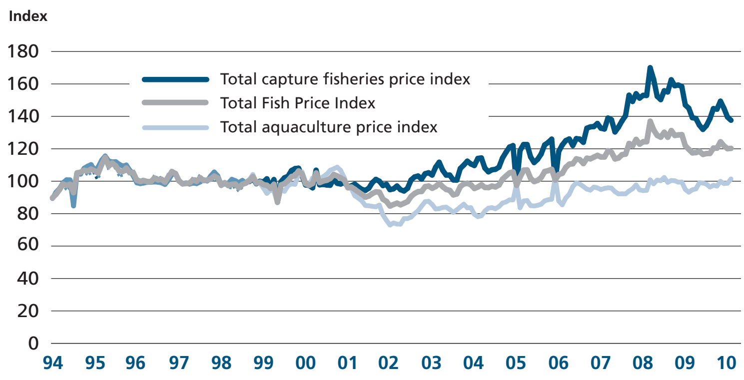
FAO Fish Price Index

With the development of the FAO Fish Price Index and its regular publication in the FAO Food Outlook,[1] fish is for the first time receiving similar coverage to the main groups of terrestrial food products.

FAO has long been publishing price indices on non-fish food commodities, such as wheat, grains, corn, rice, livestock, dairy products, poultry and pork. With the development of a similar index also for fish, world policy-makers now have access to an additional tool in the planning and management of current and future food supply. Specifically, the FAO Fish Price Index creates a new tool for the analysis of global seafood production from capture fisheries as well as from aquaculture, and from different species groups and regions. The index has been developed in collaboration between FAO, the University of Stavanger (Norway) and the Pontifical Catholic University of Peru, with data support from the Norwegian Seafood Export Council.

The FAO Fish Price Index starts its coverage with 1994 (see accompanying figure); in its current version, it represents about 57 percent of all fish traded internationally. Given the market interactions and substitution effects between traded and non-traded fish, the index can be expected to provide guidance on fish price development and also on domestic markets for many non-traded products. Separate underlying indices are generated for the most important commodities as well as for capture fisheries and for aquaculture.

Trends in the FAO Fish Price Index and underlying indices



Note: 1998–2000 = 100.

The fishery industries of developing countries rely heavily on 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 2008, in value terms, 75 percent of the fishery exports of developing countries were directed to developed countries. A growing share of these exports consisted of processed fishery products prepared from imports of unprocessed fish to use as raw material for further processing

The main objective of the FAO Fish Price Index is to indicate long-term price trends, reflecting global demand and supply changes in international seafood trade. With this in mind, the index uses international import data from the world's largest importing countries – as these data are easily accessible, qualitatively reliable and fairly up-to-date. This means that, in theory, fish that is not traded internationally (e.g. a large part of freshwater aquaculture production in Asia is destined for domestic markets) is not covered. However, in reality, there are clear interactions between traded and non-traded products, as consumers choose protein from different sources based on availability, price, quality, origin, etc., with domestic non-traded products competing with imported products. This makes the index relevant for both traded and non-traded products.

The basis for the index is a so-called Fisher price index, a weighted index of the Laspeyres and the Paasche indices. The base period is 1998–2000 and the values used are quantities and nominal import prices (unit values) for a number of species groups converted into US dollars. Variation in the index is caused by actual price changes (trends and seasonal volatility) and compositional effects.

The FAO Fish Price Index will play a role in the joint work by the Organisation for Economic Co-operation and Development and FAO on supply and demand projections for food (the Aglink-CO.SI.MO. system) and the planned inclusion of fish in their joint *Agricultural Outlook* publication. In addition, the growing role of aquaculture and the interactions between farmed and non-farmed species, as well as with other food sectors, are highlighting the utility of an index in making comparisons and projections. The FAO Fish Price Index will also facilitate the work of documenting the linkages of fishmeal and fish oil with other non-fish commodities.

One interesting aspect highlighted by the FAO Fish Price Index is the emerging divergence in price trends for capture and aquaculture products since about 2000. The main causes for the different price developments appear to be on the supply side and in the respective cost structures. Aquaculture has benefited to a greater degree from cost reductions through productivity gains and economies of scale, whereas capture fisheries have at times suffered from rising energy costs.

[1] Food Outlook is available at www.fao.org/giews/english/fo/index.htm.

Table 11
Top ten exporters and importers of fish and fishery products

	1998	2008	APR
	(US$ millions)		(Percentage)
EXPORTERS			
China	2 656	10 114	14.3
Norway	3 661	6 937	6.6
Thailand	4 031	6 532	4.9
Denmark	2 898	4 601	4.7
Viet Nam	821	4 550	18.7
United States of America	2 400	4 463	6.4
Chile	1 598	3 931	9.4
Canada	2 266	3 706	5.0
Spain	1 529	3 465	8.5
Netherlands	1 365	3 394	9.5
TOP TEN SUBTOTAL	23 225	51 695	8.3
REST OF WORLD TOTAL	28 226	50 289	5.9
WORLD TOTAL	**51 451**	**101 983**	**7.1**
IMPORTERS			
Japan	12 827	14 947	1.5
United States of America	8 576	14 135	5.1
Spain	3 546	7 101	7.2
France	3 505	5 836	5.2
Italy	2 809	5 453	6.9
China	991	5 143	17.9
Germany	2 624	4 502	5.5
United Kingdom	2 384	4 220	5.9
Denmark	1 704	3 111	6.2
Republic of Korea	569	2 928	17.8
TOP TEN SUBTOTAL	39 534	67 377	5.5
REST OF WORLD TOTAL	15 517	39 750	9.9
WORLD TOTAL	**55 051**	**107 128**	**6.9**

Note: APR refers to the average annual percentage growth rate for 1998–2008.

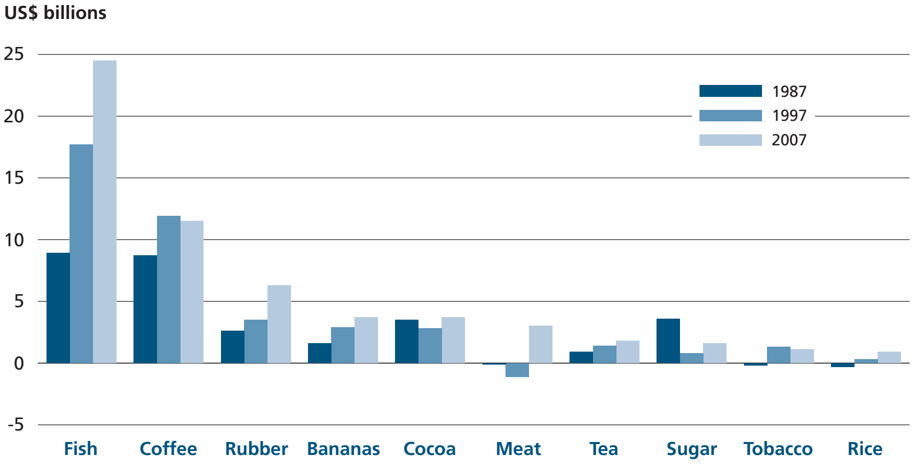
and re-export. In 2008, in value terms, 40 percent of the imports of fish and fishery products by developing countries originated from developed countries.

Net exports of fish and fish products (i.e. the total value of fish exports less the total value of fish imports) are particularly important for developing countries, being higher than those of several other agricultural commodities such as rice, meat, sugar, coffee and tobacco (Figure 23). They have increased significantly in recent decades, growing from US$2.9 billion in 1978 to US$9.8 billion in 1988, to US$17.4 billion in 1998, and reaching US$27.2 billion in 2008. Low-income food-deficit countries are playing an active and growing role in the trade of fish and fishery products. In 2008, their net export revenues were US$11.5 billion, while their fishery exports reached US$19.8 billion.

World imports of fish and fish products reached a new record of US$107.1 billion in 2008, up 9 percent on the previous year and up 95 percent with respect to 1998. Preliminary data for 2009 point to a 7 percent decrease, as a consequence of the economic downturn and the contraction in demand in key importing countries. Japan, the United States of America and the EU are the major markets, with a total share of about 69 percent in 2008. Japan is the world's largest single national importer of fish and fishery products, with imports worth US$14.9 billion in 2008, a growth of 13 percent compared with 2007. In 2009, its imports decreased by 8 percent. The EU is by far the largest market for imported fish and fishery products. However, it is

Figure 23

Net exports of selected agricultural commodities by developing countries



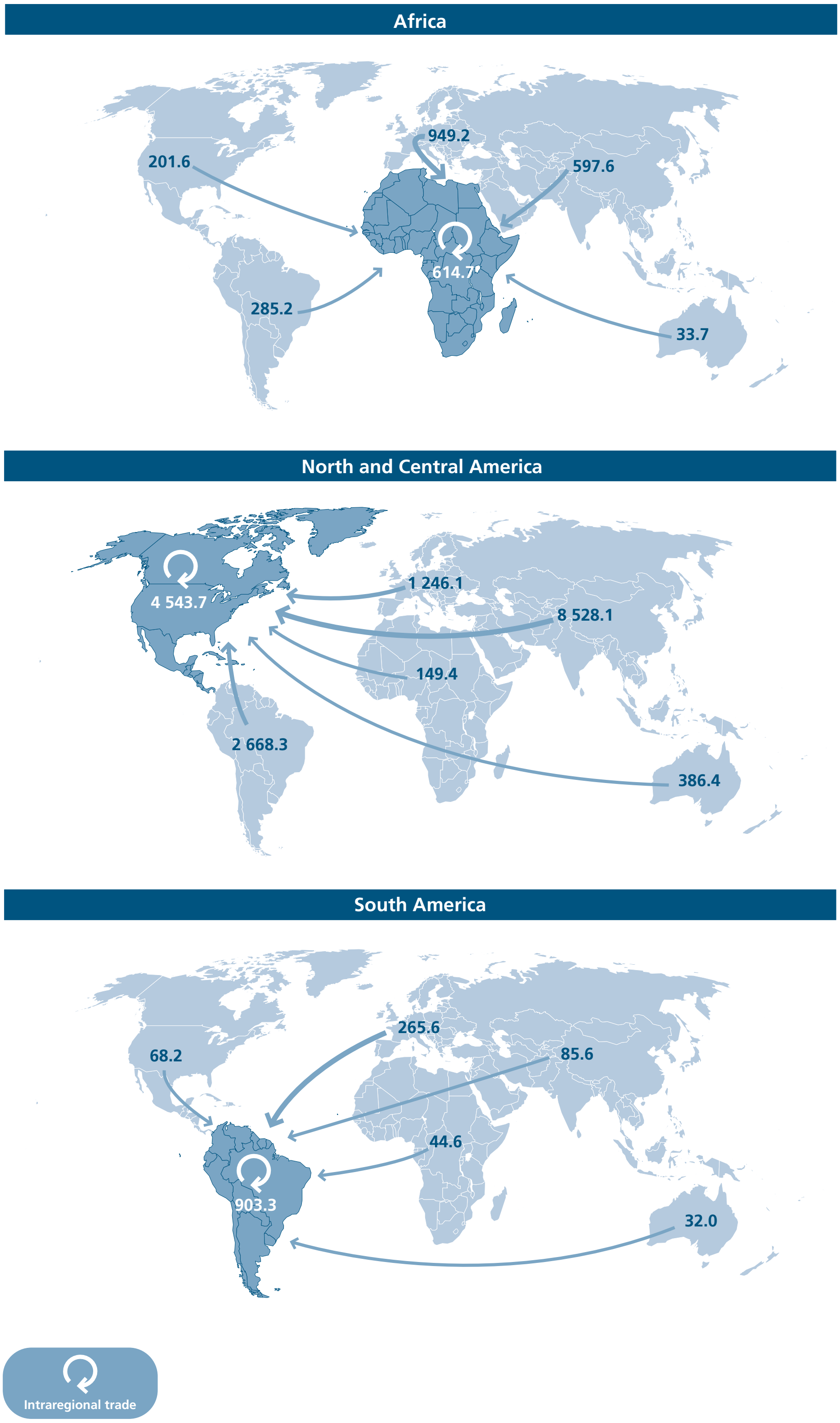
extremely heterogeneous, with markedly different conditions from country to country. In 2008, imports by the EU reached US$44.7 billion, up 7 percent from 2007, and representing a share of 42 percent of total world imports. However, if intraregional trade among EU countries is excluded, the EU imported US$23.9 billion from non-EU suppliers. This still makes the EU the largest market in the world, with about 28 percent of the value of world imports (excluding intra-EU trade). Figures for 2009 indicate a downward trend in EU imports, with a 7 percent decrease in value recorded.

Developed countries as a whole are now responsible for 78 percent of the total import value of fish and fishery products. In volume (live weight equivalent), their share is significantly less, 58 percent, showing the higher unit value of commodities imported by developed countries. Owing to stagnating domestic fishery production, developed countries have to rely on imports and/or on aquaculture to cover their increasing domestic consumption of fish and fishery products. This may be one reason for rather low import tariffs on fish in developed countries, albeit with a few exceptions, i.e. for some value-added products. As a consequence, in the last few decades, developing countries have been able to increasingly supply fishery products to developed-country markets without facing prohibitive custom duties. In 2008, about 50 percent of the import value of developed countries originated from developing countries. At present, the principal barriers facing developing countries in increasing their exports (beyond the physical availability of product) are the stringent quality- and safety-related import standards, together with the importing countries' requirements that production processes and products meet international animal health and environmental standards and social responsibility requirements. In addition, the rising power of large retail and restaurant chains in seafood distribution and sales is shifting negotiating power towards the final stages in the value chain, and retailers are also imposing more and more private- or market-based standards and labels on exports from developing countries. All the above are making it more difficult for small-scale fish producers and operators to penetrate international markets and distribution channels.

The maps in Figure 24 summarize trade flows of fish and fishery products by continent for the period 2006–08. It is important to mention that the overall picture presented by these maps is not exhaustive as data are not available for all countries, in particular for several African countries. However, the quantity of data available is sufficient to establish general trends. The Latin America and the Caribbean region continues to maintain a solid positive net fishery exporter role, as do the Oceania region and the developing countries of Asia. By value, Africa has been a net exporter since 1985, but it is a net importer in quantity terms, reflecting the lower unit value of

Figure 24

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2006–08)



(Continued)

Figure 24 *(cont.)*

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2006–08)

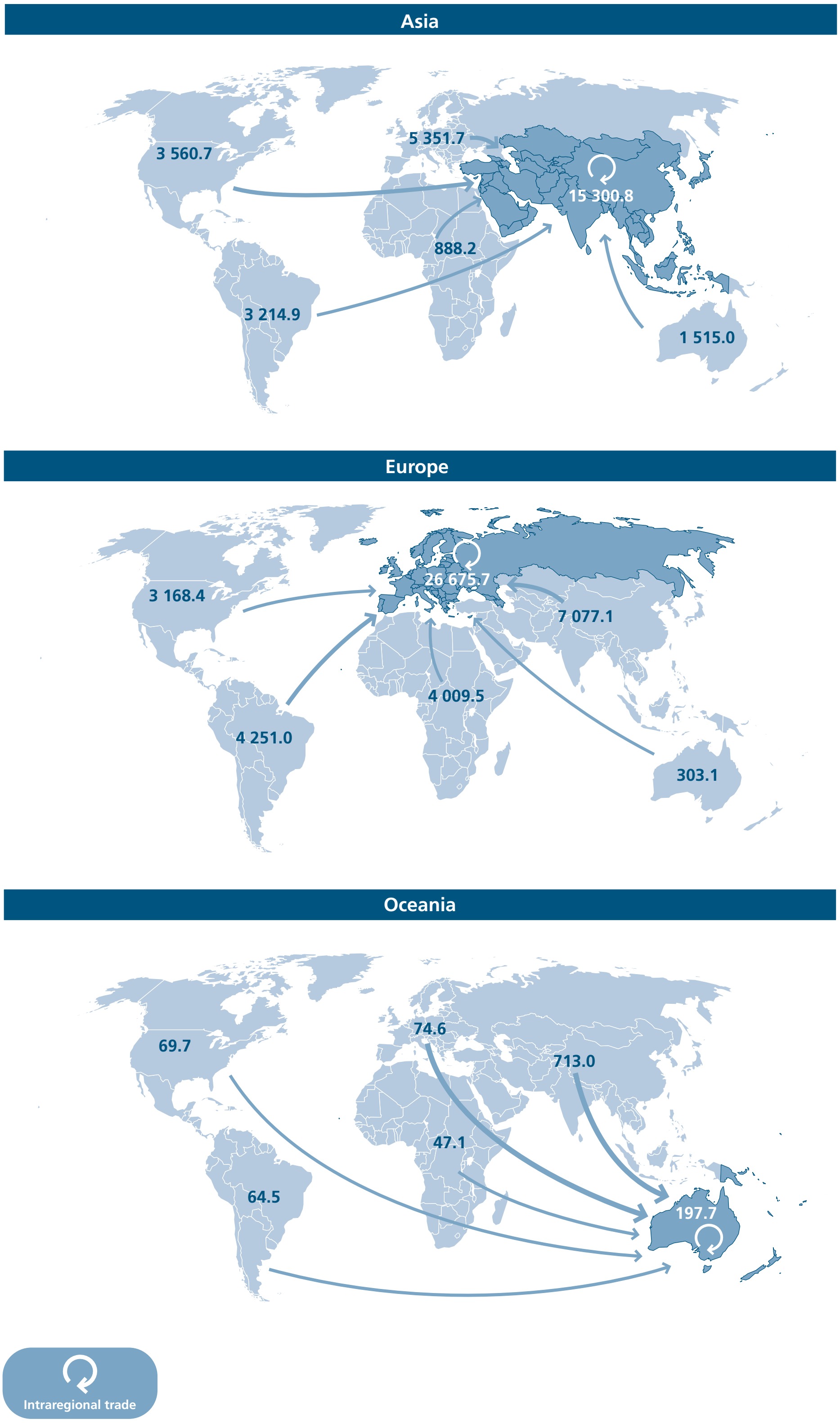
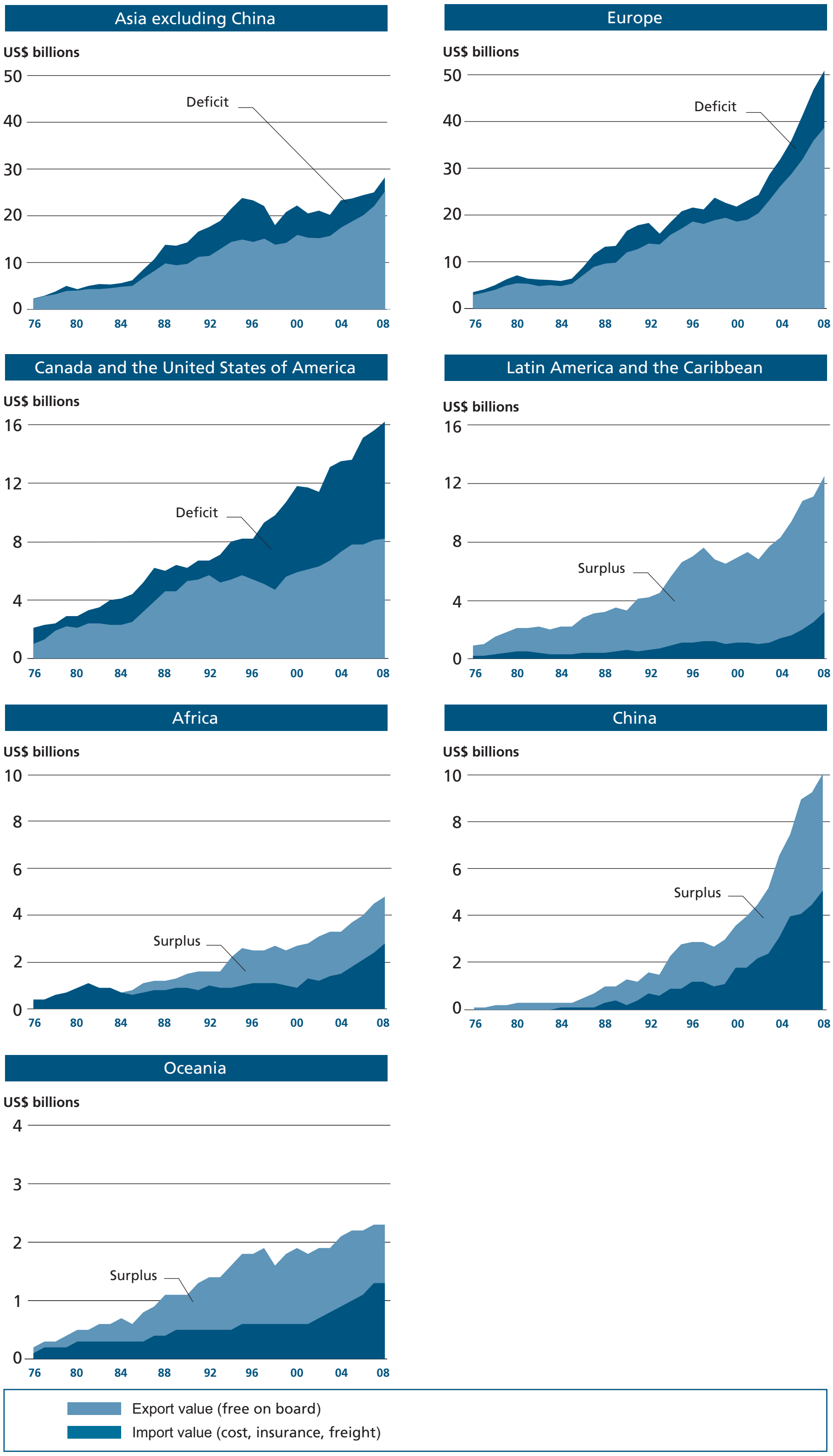


Figure 25

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



the imports (mainly small pelagics). Europe and North America are characterized by a fishery trade deficit (Figure 25).

In recent decades, there has been a tendency towards increased fishery trade within regions. Most developed countries trade more with other developed countries. In 2008, in value terms, some 85 percent of fishery exports from developed countries were destined for other developed countries, and about 50 percent of developed-country fishery imports originated in other developed countries. In contrast, the trade in fish between developing countries represents only 25 percent of the value of their fishery exports. Over time, the trade in fish and fish products between developing countries is likely to increase in the wake of the expansion of the middle classes in emerging economies, gradual trade liberalization and a reduction of the high 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.

Some of the major issues concerning international trade in fishery products in the past biennium, and which continue to affect international trade, are:

- the introduction of private standards, including for environmental and social purposes, and their endorsement by major retailers;
- certification of aquaculture in general;
- concern in exporting countries about the impact on their fish exports of the introduction in 2010 of new traceability requirements in EU markets to prevent IUU fishing;
- continuation of trade disputes related to catfish species and shrimp;
- the growing concern of the general public and the retail sector about overexploitation of certain fish stocks, in particular of bluefin tuna;
- the multilateral trade negotiations in the WTO, including the focus on fisheries subsidies;
- climate change, carbon emissions and their impacts on the fisheries sector;
- energy prices and the impact on fisheries;
- rising commodity prices in general and the impact on producers as well as on consumers;
- prices and margins throughout the fisheries value chain;
- the need for competitiveness compared with other food products;
- perceived risks and benefits from fish consumption.

Commodities

High-value species such as shrimp, prawns, salmon, tuna, groundfish, flatfish, seabass and seabream are highly traded, in particular as exports to more affluent economies. However, low-value species such as small pelagics are also traded in large quantities in the other direction to feed low-income consumers in developing countries. Products derived from aquaculture production are contributing an increasing share of total international trade in fishery commodities, with species such as shrimp, prawns, salmon, molluscs, tilapia, catfish (including *Pangasius*), seabass and seabream. Many of the species that have registered the highest export growth rates in the last few years are produced by aquaculture. Aquaculture is expanding in all continents in terms of new areas and species, as well as intensifying and diversifying the product range for species and product forms that respond to consumer needs. However, it is difficult to determine the extent of this trade because the classification used internationally to record trade statistics for fish does not distinguish between products of wild and farmed origin. Hence, the exact breakdown between products of capture fisheries and aquaculture in international trade is open to interpretation.

Accurate and detailed trade statistics are essential for monitoring the fishery sector and to help provide a basis for appropriate fisheries management. However, notwithstanding the improvements in the overall coverage of national trade statistics, many countries provide little breakdown of information by species in their reporting of

Box 3

Forensic technologies and fish species identification

When fish species cannot be identified with accuracy and there is a need for certainty, especially to investigate suspected illegal activity, forensic technologies are used with increasing frequency to test the authenticity of fishery products.

Forensic techniques are relatively commonplace today and are used in solving crimes involving humans and increasingly utilized in cases involving non-humans. The growth and applications of scientific and research techniques to law enforcement and monitoring, control and surveillance (MCS) work are likely to expand, and the use of chemical and genetic techniques in fisheries enforcement is following this tendency.

For identification purposes, these forensic tests might include DNA analysis. Species differ in their DNA sequences, and the unique portion of the sequences (likened to a DNA barcode) can be used to match individual specimens to species upon comparison of a sample with a known genetic reference. A number of genetic reference databases exist, such as the Barcode of Life Initiative, which contains a fish section known as FISH-BOL (www.fishbol.org) that currently includes barcoding for 7 700 fish species, and FishPopTrace (maritimeaffairs.jrc.ec.europa.eu/web/fishpoptrace/).

It is possible to sample fish catches or shipments, or extract biological materials from processed or mixed products, and then send samples to appropriately equipped facilities for testing. A number of countries have laboratories dedicated to fisheries issues. They work closely with investigative authorities and continue to develop procedures needed for successful applications.

Some enquiries are more difficult than others, and not all questions about all species can currently be answered, but the results of such testing have been successfully used as evidence in court cases. This forensic evidence has also been used to obtain admissions of guilt in advance of formal proceedings in court, which eliminates the need for a lengthy and costly trial. While portable test kits or online applications would be most useful for testing fish in the field, they are not yet available.

their international trade in fish. This is linked to the difficulties that customs authorities have in dealing with fish. On the one hand, they lack reliable methods for identifying species and, on the other hand, the standard classifications used to collect trade statistics are outdated – they do not provide opportunities to identify "new" species and products. However, technologies for species identification (Box 3) are being improved and a more appropriate classification scheme for internationally traded seafood items (Box 4) is being developed. These developments will improve the accuracy of the data that customs authorities provide on international trade in fish and fish products.

Owing to the high perishability of fish and fishery products, in quantity terms (live weight equivalent), 90 percent of trade in fish and fishery products consists of processed products (i.e. excluding live and fresh whole fish). Fish are increasingly traded as frozen food (39 percent of the total quantity in 2008, compared with 28 percent in 1978). In the last four decades, prepared and preserved fish have doubled their share in total quantity, going from 9 percent in 1978 to 18 percent

Box 4

Improved coverage of fish and fishery products in the Harmonized Commodity Description and Coding System: HS2012

Developed, introduced and maintained by the World Customs Organization (WCO), the Harmonized Commodity Description and Coding System, commonly referred to as the Harmonized System (HS), is used as a basis for the collection of customs duties and international trade statistics by more than 200 countries and economies. More than 98 percent of the merchandise in international trade is classified in terms of the HS. At present, about 130 six-digit codes cover fish and fishery commodities.

Fish is widely traded, and detailed trade statistics are important to help in monitoring the fishery sector and for the good management of fisheries. It is possible to pursue such aims only if the trade statistics are precise and show, to the extent possible, the specification of the species. This possibility is lacking in the current version of the HS as the codes for fish and fishery products do not provide sufficient details on the level of processing of the traded products or on the classification of species originating in developing countries or in the southern hemisphere. Neither do they provide satisfactory data on the level of processing of traded products. Therefore, many of these species are recorded in generic groups.

This deficiency was also communicated to FAO by several countries and, in 2003, the Twenty-fifth Session of the Committee on Fisheries gave clear instructions to FAO to work on improving the HS classification for fish and fishery products. The need to improve the HS classification for monitoring the entire agricultural trade was also emphasized by other Departments of FAO. Hence, in 2007, FAO submitted a joint proposal to the WCO for the revision of the codes related to agriculture, forestry and fishery products. After two years of intensive work and close collaboration between FAO and the Harmonized System Review Sub-Committee and the Harmonized System Committee of the WCO, 320 amendments on agricultural and fisheries commodities were made to the HS. The new version of the HS classification, HS2012, will enter into force on 1 January 2012.

The FAO modifications for HS codes of fish and fishery products try to improve the quality and precision of fish trade coverage through an improved specification for species and product form. Within the limits of the available codes, the classification has been restructured according to main groups of species of similar biological characteristics. About 190 amendments have been implemented and about 90 new commodities (species by different product form) have been introduced. The choice of the added species was based on their present and future economic importance as well as on the monitoring of potentially endangered species. Among the species introduced are turbot, hake, seabass, seabream, Alaska pollock, cobia, jack and horse mackerel, rays and skates, Norway lobster, coldwater shrimps, clams, cockles, arkshells, abalone, sea urchin, sea cucumber and jellyfish. Several splits by more product forms for several species have also been introduced, in particular for meat and fillets, as well as the introduction of shark fins in cured form, the separation of caviar from other substitutes, the separation of molluscs from other aquatic invertebrates, and the distinction between seaweeds for human consumption and for other purposes. This last introduction will be very useful in calculating the FAO Food Balance Sheets, which will now be able to finally take seaweeds into consideration.

in 2008. Notwithstanding their perishability, trade in live, fresh and chilled fish has also increased, representing a 10 percent share of world fish trade in 2008 (6 percent in 1978), reflecting improved logistics and increased demand for unprocessed fish. Trade in live fish also includes ornamental fish, which is high in value terms but almost negligible in terms of quantity traded. In 2008, 71 percent of the quantity exported consisted of products destined for human consumption. Much fishmeal and fish oil is traded because, generally, the major producers (South America, Scandinavia and Asia) are distant from the main consumption centres (Europe and Asia).

Shrimp

Shrimp continues to be the largest single commodity in value terms, accounting for 15 percent of the total value of internationally traded fishery products (2008). Cultured shrimp plays an important role in the market, but it experienced a decline in production in 2009 for the first time since it entered international trade in the 1980s. In 2009, shrimp trade was affected by the economic crisis. While export volumes remained stable, average shrimp prices declined substantially in the course of the year (Figure 26). In value terms, the major exporting countries are Thailand, China and Viet Nam. The United States of America continues to be the main shrimp importer, followed by Japan. Apart from Spain, all major European countries have experienced a stable or increasing trend for shrimp imports.

Salmon

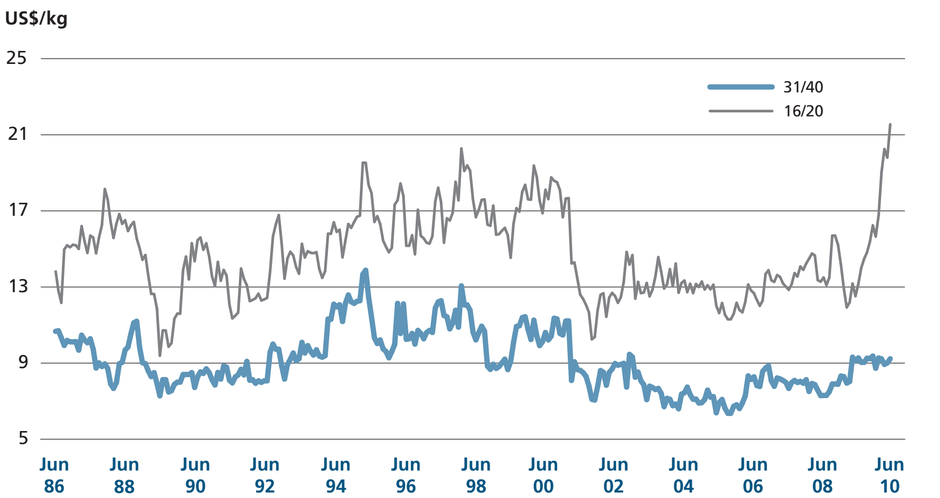
The share of salmon (including trout) in world trade has increased considerably in recent decades and now stands at 12 percent. However, 2009 was overshadowed by lower salmon production in Chile, owing to disease, resulting in a decline in cultured salmon output for the first time. Higher salmon output from Norway failed to offset this decline. Salmon prices reached record high levels in all markets.

Groundfish

Groundfish species represented about 10 percent of total fish exports (by value) in 2008. Groundfish prices went down in 2009 as a result of good supply from capture

Figure 26

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.

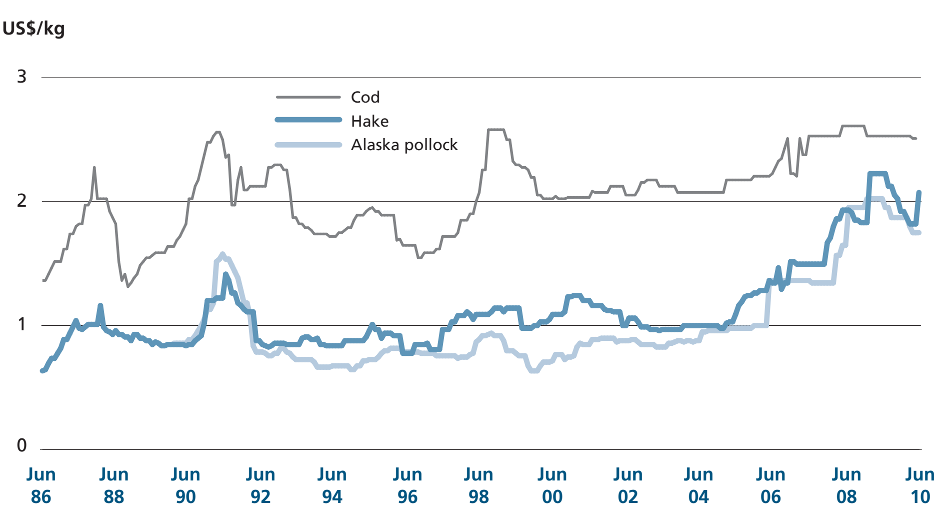
fisheries and strong competition from farmed species such as *Pangasius* on the market (Figure 27). Some marine fish stocks had recovered, and governments and regional fisheries commissions recommended higher catch quotas, which kept the market well supplied.

Tuna

The share of tuna in total fish exports in 2008 was about 8 percent. Tuna markets were rather unstable owing to large fluctuations in catch levels. Tuna prices were on average

Figure 27

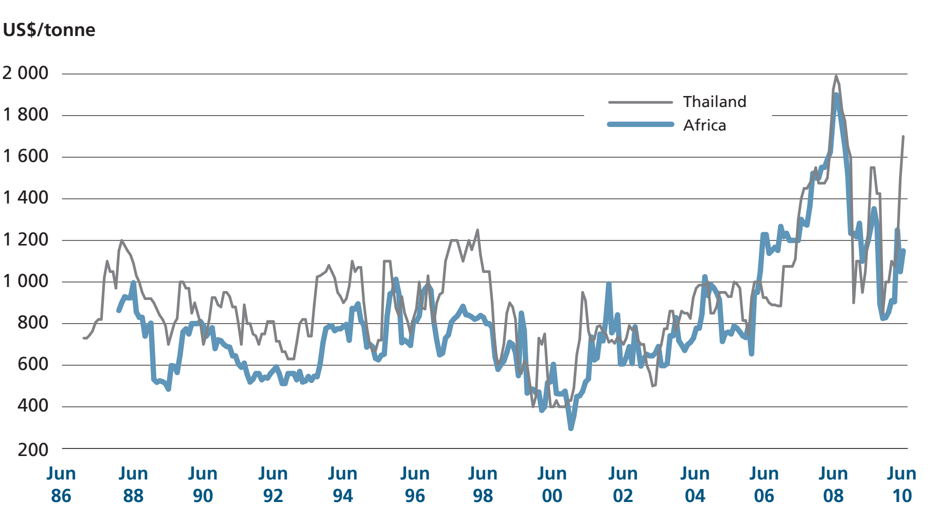
Groundfish prices in the United States of America



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

Figure 28

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.

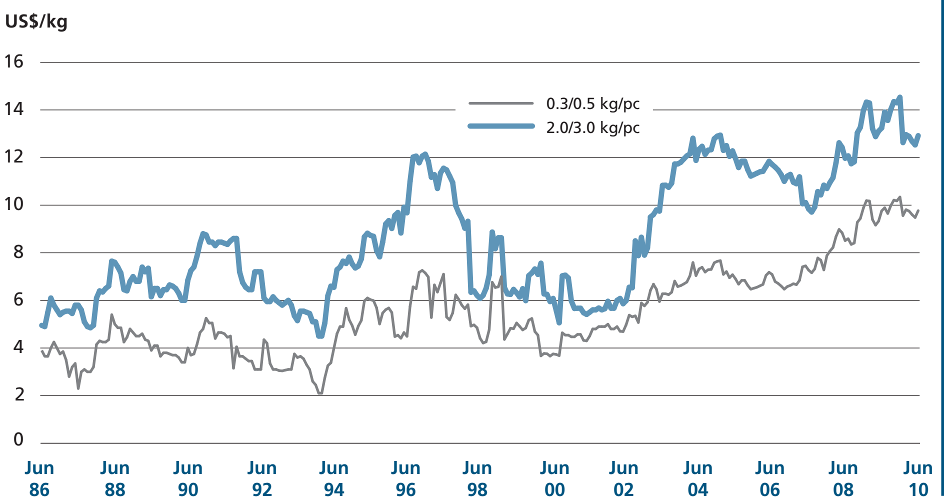
US$550/tonne lower in the course of 2009 compared with 2008. This was because of lower fuel prices and increased landings. As a result, canning became more profitable again after a difficult 2008 (Figure 28). Traders were able to lower prices, which led to stronger demand in the market during a challenging year with regard to consumer preferences.

Cephalopods

The share of cephalopods (squid, cuttlefish and octopus) in world fish trade was 4 percent in 2008. Spain, Italy and Japan are the largest consumers and importers

Figure 29

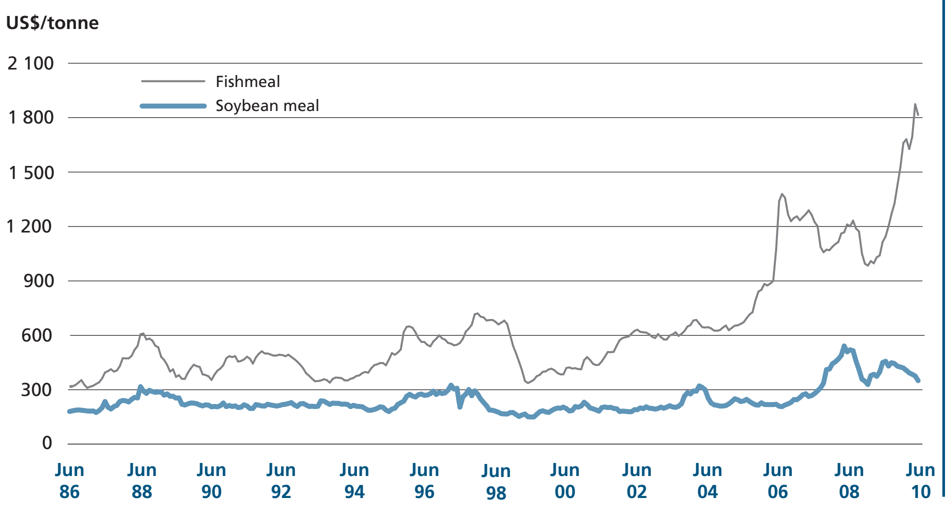
Octopus prices in Japan



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

Figure 30

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.

of these species. Thailand is the largest exporter of squid and cuttlefish, followed by Spain, China and Argentina, whereas Morocco and Mauritania are the principal octopus exporters. Low squid catches worldwide and increased prices characterized 2009. On the other hand, octopus was in good supply with reduced price levels (Figure 29).

Pangasius

Pangasius is a freshwater fish, and relatively new in international trade. However, with production of about 1.2 million tonnes, mainly in Viet Nam and all going to the international markets, this species is playing an important role as a source of cheap fish. The EU is the main market for *Pangasius,* with 215 000 tonnes imported in 2009, or one-third of total Vietnamese exports. Many countries report increasing imports of this species, displacing domestic fish production. *Pangasius* prices were very low in 2009, with no recovery foreseen for 2010.

Fishmeal

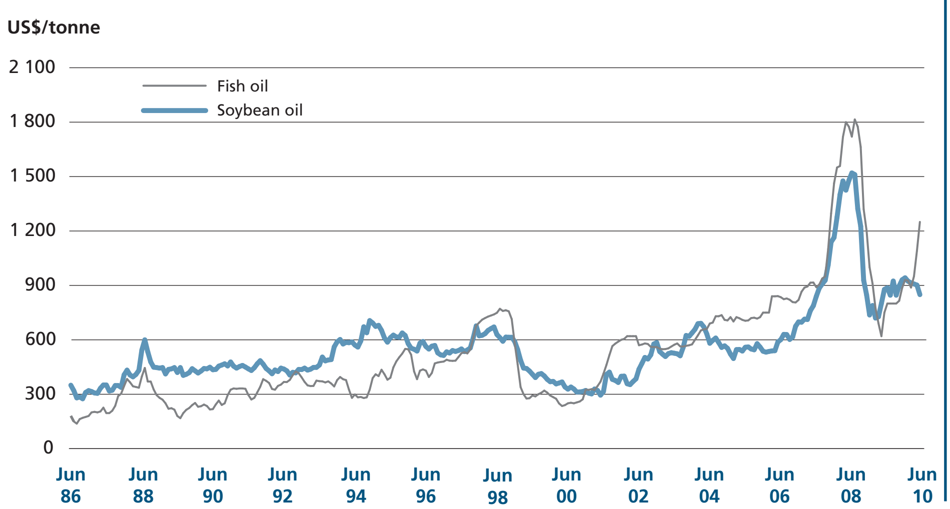
Catches for reduction purposes have been declining continuously in recent years. However, fishmeal production has remained stable as more fishmeal is produced from offal derived from the fish processing industry. Demand for fishmeal was strong in 2009, leading to sharply higher fishmeal prices in that year (Figure 30). China remains the main market for fishmeal.

Fish oil

In 2009, total fish oil production by the five main exporting countries (Peru, Chile, Iceland, Norway and Denmark) was 530 000 tonnes, a decline of 100 000 tonnes compared with 2008. Fish-oil prices reached US$950/tonne in March 2010, which was 50 percent higher than a year earlier (Figure 31). For fish oil, the share going to aquaculture is even greater than for fishmeal, with almost 85 percent of production being used as an ingredient in fish and shrimp feeds.

Figure 31

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.

FISH CONSUMPTION[11]

The fishery sector plays a key role in food security, not only for subsistence and small-scale fishers who rely directly on fishery for food, incomes and services, but also for consumers who profit from an excellent source of affordable high-quality animal protein. A portion of 150 g of fish[12] provides about 50–60 percent of the daily protein requirements for an adult. Fish is also a source of essential micronutrients, including various vitamins and minerals. With a few exceptions for selected species, fish is usually low in saturated fats, carbohydrates and cholesterol.

In 2007, fish accounted for 15.7 percent of the global population's intake of animal protein and 6.1 percent of all protein consumed (Figure 32). Globally, fish provides more than 1.5 billion people with almost 20 percent of their average per capita intake of animal protein, and 3.0 billion people with 15 percent of such protein (Figure 33). In terms of a world average, the contribution of fish to calories is rather low at 30.5 calories per capita per day (2007 data). However, it can reach 170 calories per capita per day in countries where there is a lack of alternative protein food and where a preference for fish has been developed and maintained (e.g. Iceland, Japan and several small island states).

Total and per capita fish food supplies have expanded significantly in the last five decades. Total food fish supply has increased at an annual rate of 3.1 percent since 1961, while the world population has increased by 1.7 percent per year in the same period. Annual per capita fish consumption grew from an average of 9.9 kg in the 1960s to 11.5 kg in the 1970s, 12.6 kg in the 1980s, 14.4 kg in the 1990s and reached 17.0 kg in 2007. Preliminary estimates for 2008 indicate a further increase in annual per capita consumption to about 17.1 kg. In 2009, as a consequence of uncertain economic conditions, demand remained rather sluggish and per capita consumption is expected to have remained stable.

The general growth in fish consumption has had different impacts among countries and regions. Countries that have experienced dramatic growth in their per capita fish consumption in recent decades diverge from those where consumption has remained static or decreasing, such as some countries in the sub-Saharan Africa region. In addition, the countries of the former Soviet Union in Eastern Europe and Central Asia experienced major declines in the 1990s. The most substantial increases in annual per capita fish consumption have occurred in East Asia (from 10.8 kg in 1961 to 30.1 kg in 2007), Southeast Asia (from 12.7 kg in 1961 to 29.8 kg in 2007) and North Africa (from 2.8 kg in 1961 to 10.1 kg in 2007). China, in particular, has seen dramatic growth in its

Figure 32

Total protein supply by continent and major food group (average 2005–2007)

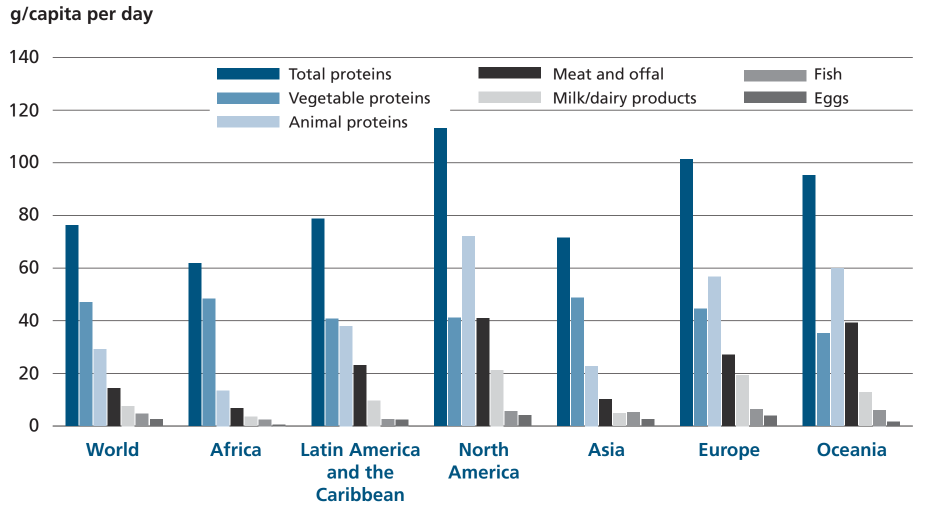
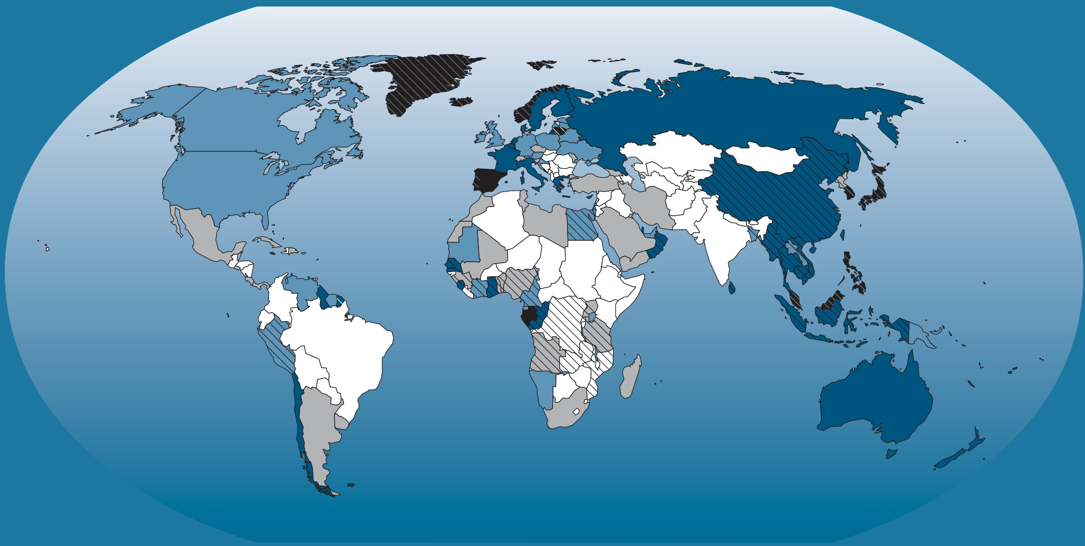


Figure 33

Contribution of fish to animal protein supply (average 2005–2007)



Fish proteins (per capita per day)

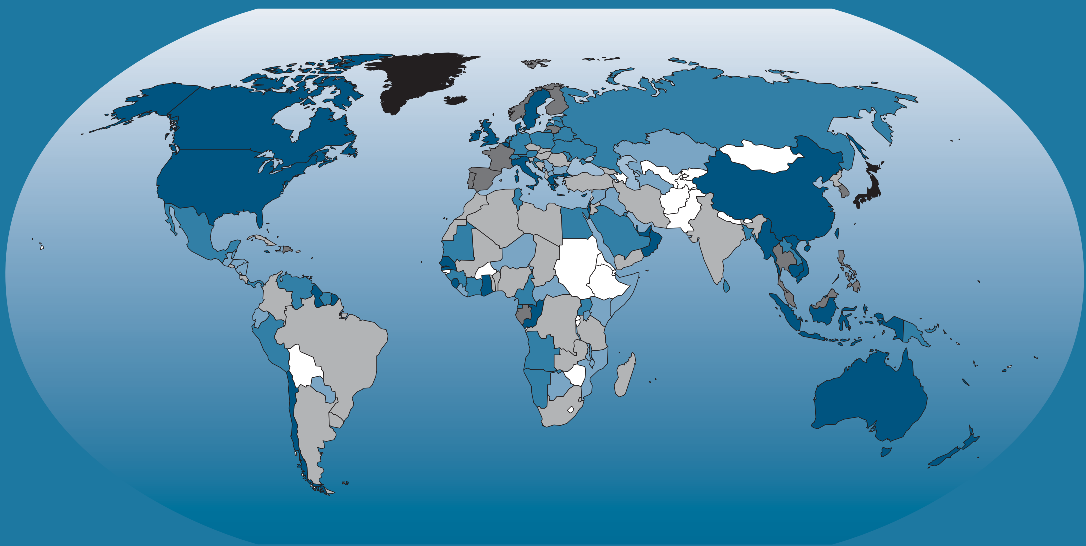
< 2 g
2–4 g
4–6 g
6–10 g
> 10 g

Contribution of fish to animal protein supply

> 20%

Figure 34

Fish as food: per capita supply (average 2005–2007)



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

per capita fish consumption, with an average growth rate of 5.7 percent per year in the period 1961–2007. China accounted for most of the global increase in per capita consumption owing to the substantial increase in its fish production, mainly from the growth of aquaculture. Its estimated share of world fish production grew from 7 percent in 1961 to 33 percent in 2007, when China's annual per capita fish supply was about 26.7 kg. If China is excluded, in 2007, annual per capita fish supply was about 14.6 kg, slightly higher than the average values of the mid-1990s, and lower than the maximum levels registered in the mid-1980s.

Table 12 summarizes per capita consumption by continent and major economic groups. The total amount of fish consumed and the species composition of the food supply vary according to regions and countries, reflecting the different levels of availability of fish and other foods, including the accessibility of aquatic resources in adjacent waters, as well as diverse food traditions, tastes, demand, income levels, prices and seasons. Annual per capita apparent fish consumption can vary from less than 1 kg in one country to more than 100 kg in another (Figure 34). Differences are also evident within countries, with consumption usually higher in coastal areas. Of the 111 million tonnes available for human consumption in 2007, consumption was lower in Africa (8.2 million tonnes, with 8.5 kg per capita), while Asia accounted for two-thirds of total consumption, with 74.5 million tonnes (18.5 kg per capita), of which 39.6 million tonnes was consumed outside China (14.5 kg per capita). The corresponding per capita consumption figures for Oceania, North America, Europe, Central America and the Caribbean, and South America were 25.2, 24.0, 22.2, 9.4 and 9.1 kg, respectively.

Differences in fish consumption exist between the more-developed and the less-developed countries. In developed countries, apparent fish supply rose from 16.7 million tonnes (live weight equivalent) in 1961 to 33.0 million tonnes in 2007. A significant share of this supply consisted of imported fish. Developed countries have become increasingly dependent on fish imports to satisfy their demand. Forecasts indicate that this dependence will grow owing to their decreasing fisheries production (down 16 percent in the period 1998–2008). Apparent fish consumption in developed countries grew from 17.2 kg per capita per year in 1961 to 24.3 kg in 2007. However, the share of fish to animal protein intake, after consistent growth up to 1984, declined from 13.3 percent in 1984 to 12.0 percent in 2007, while consumption of other animal proteins continued to increase. In 2007, for industrialized countries, apparent fish

Table 12
Total and per capita food fish supply by continent and economic grouping in 2007

	Total food supply	Per capita food supply
	(million tonnes live weight equivalent)	*(kg/year)*
World	**113.1**	**17.0**
World (excluding China)	78.2	14.6
Africa	8.2	8.5
North America	8.2	24.0
Latin America and the Caribbean	5.2	9.2
Asia	74.5	18.5
Europe	16.2	22.2
Oceania	0.9	25.2
Industrialized countries	27.4	28.7
Other developed countries	5.5	13.7
Least-developed countries	7.6	9.5
Other developing countries	72.6	16.1
LIFDCs[1]	61.6	14.4
LIFDCs (excluding China)	26.7	9.0

[1] Low-income food-deficit countries.

consumption was 28.7 kg per capita per year and the share of fish in animal protein intake was 13.0 percent.

In 2007, the average annual per capita apparent fish supply in developing countries was 15.1 kg, and 14.4 kg in LIFDCs. However, if China is excluded, these values become 11.3 kg and 9.0 kg, respectively. Although annual per capita consumption of fishery products has grown steadily in developing regions (from 5.2 kg in 1961) and in LIFDCs (from 4.5 kg in 1961), it is still considerably lower than in the more developed regions, even though the gap is narrowing. In addition, these figures may be higher than indicated by official statistics in view of the unrecorded contribution of subsistence fisheries. Despite these relatively low levels of fish consumption, the contribution of fish to total animal protein intake in 2007 was significant at about 18.3 percent for developing countries and 20.1 percent for LIFDCs. However, as seen for developed countries, also in developing countries and LIFDCs, this share has declined slightly in recent years owing to the growing consumption of other animal proteins.

In the last two decades, before the food and economic crises,[13] the global food market, including the fish market, experienced unprecedented expansion and a change in global dietary patterns, with a shift towards more protein. This change was the result of complex interactions of several factors, including rising living standards, population growth, rapid urbanization, increased trade and transformations in food distribution. A combination of these factors has driven demand for animal protein, especially from meat, milk, eggs and fish products, as well as vegetables in the diet, with a reduction in the share of basic cereals. Protein availability has increased in both the developed and developing world, but growth 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. Annual global per capita consumption of meat almost doubled in the period 1961–2007, rising from 23 kg to 40 kg. The growth was particularly impressive in the most rapidly growing economies of developing countries and LIFDCs. Having attained a high level of consumption of animal protein, more developed economies have been increasingly reaching saturation levels and are less reactive to income growth and other changes than are low-income countries. Developing countries increased their annual per capita meat consumption from 9 kg in 1961 to 29 kg in 2007, with the corresponding values for LIFDCs increasing from 6 kg to 23 kg in the same period.

In addition, world food markets have become more flexible, with new products entering the markets, including value-added products easier to prepare for the consumer. Before the global economic crisis, as a consequence of good economic conditions, many individuals ate more and better than previously. Growing urbanization is one of the factors modifying patterns of food consumption, which has also had an impact on demand for fishery products. People living in urban areas tend to eat out of the home more frequently, and larger quantities of fast and convenience foods are purchased. Supermarkets are also emerging as a major force, particularly in developing countries, offering consumers a wider choice, reduced seasonal fluctuation in availability and, often, safer food. Several developing countries, especially in Asia and Latin America, have experienced a rapid expansion of supermarkets, which are not only targeting higher-income consumers but also lower- and middle-income consumers.

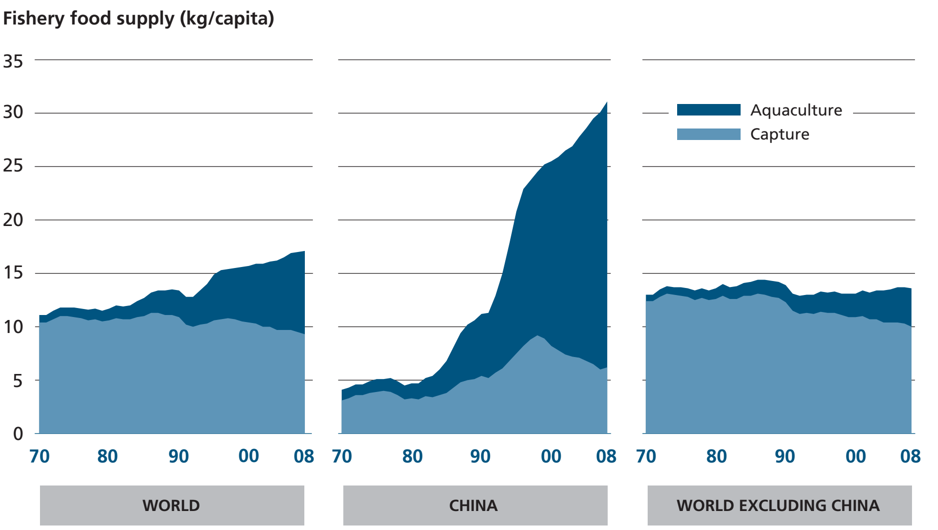
In the last two decades, the consumption of fish and fishery products has also been considerably influenced by globalization in food systems and by innovations and improvements in processing, transportation, distribution, marketing and food science and technology. These have led to significant improvements in efficiency, lower costs, wider choice and safer and improved products. Owing to the perishability of fish, developments in long-distance refrigerated transport and large-scale and faster shipments have facilitated the trade in and, therefore, consumption of an expanded variety of species and product forms, including live and fresh fish. In addition, there has been a greater focus on marketing, with producers and retailers attentive to consumer preferences and attempting to anticipate market expectations in terms of quality, safety standards, variety, value addition, etc. Especially in the more affluent markets, consumers are increasingly requiring high standards of food freshness, diversity, convenience and safety, including quality assurances such as traceability, packing requirements and processing controls. Consumers demand guarantees that their food has been produced, handled and sold in a way that is not dangerous to their health, respects the environment and addresses various other ethical and social concerns. Health and well-being are among other factors increasingly influencing consumption decisions. Fish has a particular prominence in this respect, following mounting evidence confirming the health benefits of eating fish.

In the last decade, the surging demand for fish and fishery products has mainly been met by aquaculture production, as capture fisheries have been rather stagnant or even declining in some countries. In 2008, aquaculture contributed about 46 percent of the fishery output for human consumption (Figure 35). Aquaculture has pushed the demand for, and consumption of, species that 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, such as shrimps, salmon and bivalves, as well as tilapia and *Pangasius*. Aquaculture also has a role in food security, for the significant production of some low-value freshwater species, which are mainly destined for domestic production also through integrated farming.

The increasing production of species from aquaculture can also be seen by examining fish consumption by major groups. Consumption of crustaceans and molluscs, being high-priced commodities, tends to be concentrated in affluent economies. However, between 1961 and 2007, owing to the increasing production of shrimps, prawns and molluscs from aquaculture and the relative decline in their price, annual per capita availability of crustaceans grew substantially from 0.4 kg to 1.6 kg and that of molluscs (including cephalopods) from 0.8 kg to 2.5 kg. The increasing production of salmon, trouts and selected freshwater species has led to a significant growth in annual per capita consumption of freshwater and diadromous species, up from 1.5 kg in 1961 to 5.5 kg in 2007. In the last few years, no major changes have been experienced by the other broader groups. Consumption of demersal and pelagic fish species has stabilized at about 3.0 kg per capita per year. Demersal fish continue to be among the main species favoured by consumers in Northern Europe and in North America (8.5 kg and 7.0 kg per capita per year, respectively, in 2007), whereas cephalopods are mainly preferred by Mediterranean and East Asian countries. Of the

Figure 35

Relative contribution of aquaculture and capture fisheries to food fish consumption



17.0 kg of fish per capita available for consumption in 2007, about 75 percent came from finfish. Shellfish supplied 25 percent (or about 4.1 kg per capita), subdivided into 1.6 kg of crustaceans, 0.6 kg of cephalopods and 1.9 kg of other molluscs. Freshwater and diadromous species accounted for about 36.4 million tonnes of the total supply. Marine finfish species provided about 48.1 million tonnes, of which 20.4 million tonnes were pelagic species, 20.0 million tonnes were demersal fish, and 7.7 million tonnes were unidentified marine fish.

Notwithstanding the growth in the consumption of fish and food in general and the positive long-term trends in nutritional standards, undernutrition (including inadequate levels of consumption of protein-rich food of animal origin) remains a huge and persistent problem. This is especially the case in many developing countries, with the bulk of undernourished people living in rural areas. The number of undernourished people declined significantly in the 1970s, 1980s and early 1990s, in spite of rapid population growth. The proportion of undernourished people in the developing countries fell from one-third in 1970 to less than 20 percent in the 1990s and to 13 percent in 2004–06. However, the incidence of hunger and undernourishment in the world has been dramatically affected by the two successive crises – the food crisis first, with basic food prices beyond the reach of millions of poor, and then the economic recession. These crises have had very severe consequences for millions of people, pushing them into hunger and undernourishment. For the first time in decades, there has been an increase in both the absolute number and in the proportion of undernourished people. FAO's current estimate of the number of undernourished people in the world in 2008 is 1.02 billion people, which represents more hungry people than at any time since 1970.

At the same time, many people in countries around the world, including developing countries, suffer from obesity and diet-related diseases. This problem is caused by excessive consumption of high-fat and processed products, as well as by inappropriate dietary and lifestyle choices.

The outlook for the global food sector remains uncertain. It is facing various challenges related to the recovering economy and demographic issues, including growing urbanization. Since 2008, demand for food, including fish products, has remained sluggish compared with past years, but the long-term forecast for demand for food remains positive, also driven by population growth and urbanization. In particular, demand for fish products is expected to continue to rise in the coming decades. However, future increases in per capita fish consumption will depend on the availability of fishery products. With capture fisheries production stagnating, major increases in fish food production are forecast to come from aquaculture. Taking into account the population forecast, an additional 27 million tonnes of production will be needed to maintain the present level of per capita consumption in 2030. However, future demand will be determined by a complex interaction of several factors and elements. The global food sectors, including the fishery sector, will have to face several challenges stemming from demographic, dietary, climatic and economic changes, including reduced reliance on fossil energy and increasing constraints on other natural resources.

In particular, the future supply and demand of food commodities, including fisheries, will be affected by population dynamics and the location and rate of economic growth. The increase in world population is expected to slow in the next decade, in all regions and continents, with the fastest population increases continuing to be experienced by developing countries. According to the United Nations Population Division,[14] the world population is projected to reach 7 billion early in 2012, up from the current 6.8 billion, and exceed 9 billion people by 2050. Most of the growth will occur in developing countries, where the population is projected to increase from 5.6 billion in 2009 to 7.9 billion by 2050. In contrast, the population of the more developed regions is expected to change minimally, going from 1.23 billion to 1.28 billion, and would decline to 1.15 billion were it not for the projected net migration from developing to developed countries, which is forecast to average 2.4 million people per year from 2009 to 2050.

Urbanization also plays a major role in changing patterns of food consumption. According to the United Nations Population Division,[15] 50.5 percent (3.5 billion people) of the world's population live in urban areas. Disparities in the levels of urbanization persist among countries and regions of the world, with highly urbanized countries having an urban share of up to 82 percent, in particular in North America, Latin America, Europe and Oceania, while others remain mostly rural (in particular in Africa and Asia) with a share of about 40 percent. However, in these latter countries, a vast movement of the population towards the cities is taking place. An additional 250 million to 310 million people are expected to become urbanized by 2015, with the bulk of the increase in urban areas expected in Asia and Africa. By 2050, the shares of urban population will be 62 percent in Africa and 65 percent in Asia, although this will still be significantly less than most other continents. The rural population is expected to decline in every major area except in Africa, where it is forecast to continue rising until 2040.

GOVERNANCE AND POLICY

Small-scale fisheries

Latest estimates indicate that small-scale fisheries contribute more than half of the world's marine and inland fish catch. Nearly all of this is used for direct human consumption. These fisheries employ more than 90 percent of the world's 35 million capture fishers (Box 5). Moreover, they support another 84 million people employed in jobs associated with fish processing, distribution and marketing.[16] There are also millions of other rural dwellers, particularly in Asia and Africa, involved in seasonal or occasional fishing activities. They often have few other alternative sources of income and employment, and they are not recorded as "fishers" in official statistics.

Almost half of the people employed in small-scale fisheries are women. The importance of the small-scale fisheries sector is of global reach. Its diversity in technology, culture and traditions is part of humankind's heritage. More than 95 percent of small-scale fishers and related workers in post-harvest sectors live in developing countries.[17]

In spite of their economic, social and nutritional benefits, as well as their contribution to societal and cultural values, small-scale fishing communities often face precarious and vulnerable living and working conditions. Poverty remains widespread for millions of fishing people, especially in sub-Saharan Africa and South and Southeast Asia.

Poverty is now better understood and recognized as a complex issue with socio-institutional factors generally being more important than pure economic or biological aspects. It is undeniable that overfishing and potential depletion of fishery resources constitute a real threat to many coastal livelihoods and small-scale fisheries. However, there are other conditions related to social structures and institutional arrangements that play a more central role in engendering poverty by the way they control how and by whom fishery and other resources can be accessed and used. Critical factors that contribute to poverty in small-scale fishing communities include: insecure rights to both land and fishery resources; poor or absent health and educational services; lack of social safety nets; vulnerability to natural disasters and climate change; and exclusion from wider development processes owing to weak organizational structures and inadequate representation and participation in decision-making.

These insights into the factors of poverty have important consequences for the governance of small-scale fisheries. It has become evident that addressing poverty requires that marginalized groups be included in the institutional processes related to resource management and that, in order to achieve this, new institutional approaches are needed. However, for new approaches to be effective, the wider facets of poverty need to be addressed first (or simultaneously with resource management) as fishing

Box 5

Improving information in small-scale fisheries

There is a general lack of coherent, reliable and accessible information on the small-scale fisheries sector. This hinders the formulation of relevant policies for the sector. Addressing these knowledge gaps, particularly in developing countries, can help justify additional efforts by policy-makers and planners to maintain and improve the contribution by the sector to food security, poverty alleviation and employment.

The severity of the situation has been recognized globally and in particular by the United Nations General Assembly, which in 2003 endorsed a global strategy for improving information on status and trends in capture fisheries. Subsequently, the World Bank, WorldFish Center and FAO started: (i) a global reassessment of employment and production of small-scale fisheries; and (ii) a critical review of data-gathering methods employed for small-scale fisheries.

Preliminary results from this study[1] show that 33 million people worldwide are employed as fishers full time or part time. Adding employment – full-time and part-time – in the post-harvest sector indicates that 119 million people are directly dependent on capture fisheries for their livelihoods. Some 97 percent of them live in developing countries (116 million) and more than 90 percent are involved in the small-scale fisheries sector. Inland water fisheries are particularly important in developing countries, and more than half (60 million) of those employed in fisheries in developing countries work in small-scale inland fisheries. In developing countries, almost 56 million jobs are held by women.

Reviews[2] of data gathering for small-scale fisheries indicate that both catches and employment in small-scale fisheries tend to be greatly underreported. The major reasons are:

- the dispersed characteristics of small-scale fisheries;
- in many developing countries, a poor institutional capacity;
- the adoption by developing countries of data collection approaches that originate in developed countries and are difficult to apply in the multispecies, multigear environment of small-scale fisheries.

Reviews also show that data gathering for small-scale fisheries requires new innovative approaches:

- A main priority is the sample frame. Data collection on small-scale fisheries will probably be cheaper and more robust if undertaken as part of statistical surveys carried out for other purposes, e.g. population size or agriculture production.
- Appropriate assessment methods need to be developed for data-poor fisheries.
- Once obtained, data and information should be easily available, and to this end international information-sharing arrangements should be strengthened and/or developed.

[1] The "Global Big Numbers Project", executed by FAO and WorldFish Center and sponsored by the World Bank in 2008.
[2] The FAO "FishCode-STF Project" (ongoing since 2004), funded by the Governments of Japan, Norway and Sweden.

people, facing the immediate daily challenge to meet their most basic needs, often lack the capacity and incentives to participate in resource management.

It is in this context, but also in its own right, that there is a call for the adoption of a human rights approach towards the sustainable development of small-scale fisheries.[18] The Global Conference on Small-Scale Fisheries (Bangkok, 2008) identified several critical ways forward for securing sustainable small-scale fisheries that integrate social, cultural and economic development, address resource access and use-rights issues guided by human rights principles, and recognize the rights of indigenous peoples. The conference reaffirmed that human rights are critical to achieving sustainable development.

The human rights approach stresses the importance of removing obstacles, such as illiteracy, ill health, lack of access to resources, and lack of civil and political freedoms, that prevent people from doing legitimate activities that they want to do. As an overarching governance framework, the human rights approach provides a strong basis for citizens to make claims on their states, and for holding states accountable for fulfilling their duties. At a fundamental level, in this case, it requires strengthening the capacity of fishing communities to be aware of and to claim and exercise their rights effectively. It also requires all duty-bearers, including states, to fulfil their human rights obligations.[19]

In welcoming the outcome of the Global Conference on Small-Scale Fisheries by the Twenty-eighth Session of the COFI, many Members expressed the need for an international instrument on small-scale fisheries that would guide national and international efforts to secure sustainable small-scale fisheries and create a framework for monitoring and reporting.[20]

Legislation is often crucial to promote human rights and ensure that specific economic and social rights are enshrined for small-scale fishers and fishworkers, and to ensure that such rights cannot be eroded through social, economic and political marginalization. Processes for legislative development are different in different countries. Better compliance can be fostered by legislation that involves all stakeholders in its development, permitting them to then claim ownership over such laws.[21]

At the sector level, the challenges of sustainable resource use in small-scale fisheries are not adequately addressed by the standard methods of management applied to large commercial fisheries. The difficulties often include, for example, widely dispersed landing sites, multispecies nature of resources, and fishery resources shared with other communities and sectors. The current trend is towards devolved management responsibilities and comanagement arrangements with strong involvement of local resource users together with the state. This would appear to be the appropriate governance approach for addressing the existing challenges. However, this approach requires not only human capacity at the local level but also legal, practical and community-based prerequisites in support of decentralized and shared management.[22]

There are generally high interdependences of small-scale fisheries with other sectors, usually best addressed through cross-sector planning and coordination processes and mechanisms. In fact, past experience[23] indicates that cross-sectoral integrated planning processes can be a very powerful means for raising the profile of small-scale fisheries in the policy arena, especially also in relation to the effective integration of fisheries into poverty reduction and food security initiatives.

Fish trade and traceability

The fisheries sector operates in an increasingly globalized environment. Nowadays, fish can be produced in one country, processed in a second and consumed in a third. The process of globalization has created substantial opportunities for the sector. However, hand in hand with the opportunities created by globalization are the risks inherent in such a widespread sector. For example, a common fraudulent practice is species substitution, which can be unintentional or intentional for tax evasion, for laundering illegally caught fish or for selling one fish species for a higher-priced species. Traceability systems are increasingly being used to mitigate these risks by establishing a tool to verify the integrity of the supply chain and to remedy failure when a supply chain's integrity is broken.

Traceability systems trace fish and fish products from the point of production to the consumer. Traceability is becoming an increasingly common feature in the fisheries sector, especially in the case of fish and fish products that are traded internationally. It is used for food safety purposes, to verify legal provenance of fish or to meet national security and public safety objectives. It is required by:

- importing markets to ensure that food safety and authenticity objectives are met. The United States of America and the EU have mandatory traceability requirements. Japan has no mandatory traceability requirements for seafood products, but it does have a number of other legal obligations that have the effect of requiring businesses to have effective traceability capacity.
- regional fisheries management organizations that have implemented documentation systems that enable contracting parties and cooperating states to verify that certain sensitive fish products have been caught in compliance with the requirements of the RFMOs and, therefore, should be granted access to international markets.
- the catch certificates required by the EU to verify that all wild caught fish and shellfish traded to the EU can be traced back to the vessel that caught it and that all vessels used to supply wild captured fish to the EU were legally authorized at the time of fishing. Chile is in the process of implementing similar legislation.
- ecolabelling schemes that certify products are sourced from well-managed fisheries. Ecolabelling schemes are mainly private although public ones are being developed.

Challenges

The implementation of traceability requirements has created challenges for exporting countries. Failure to meet these requirements may result in fish and fish products being denied market access. As traceability systems are generally not integrated, separate traceability systems need to be introduced to meet safety, legality and sustainability objectives. This is a challenge for developing countries that often lack the resources to meet such requirements. The introduction of traceability requirements has also created additional costs for the fishing industry.

Solutions

Technological developments. Technologies based on the application of unique product numbering, whether proprietary or compliant with transparent public standards, can enable businesses and regulators to track and trace products through the value chain. These technologies may be adopted to assist food suppliers to meet enhanced regulatory requirements, as for example proposed in the United States of America, requiring food suppliers to demonstrate the full provenance of their products at any point as they pass through the supply chain.

In recent decades, businesses have adopted standardized product numbering, using barcoding to identify goods for a variety of purposes as they move through supply chains from producer to consumer. Primarily used for inventory control purposes, barcoding provides a proprietary technical solution for delivering traceability.

More portable and secure technologies are available through the development of an international standard for electronic product coding and its application through radio frequency product identification (RFID), with unique traceability data encoded using an internationally standardized and secure system on products to enable their identification as they pass along the supply chain. Such proprietary systems require significant investment by companies in systems development and internal documentation. While the unit cost of applying a barcode or RFID tag is very small, the investment costs for infrastructure development, system development and internal controls, and related training can be high.

Producing official certificates electronically can also provide a greater level of assurance of document integrity – especially if the documents exist solely in cyber-space accessed only through secure access arrangements. The United Nations Centre for Trade Facilitation and Electronic Business has released a standard for electronic certification (eCert) that allows governments to exchange electronic export certificates for agriculture and food commodities, including fish and fisheries products.

Another prominent area of research is species identification, especially using DNA-based techniques (Box 3). Advances in polymerase chain reaction methodology have reduced both the quantity of DNA needed for analysis as well as the time required for rapid testing. Specific genetic markers for fish, molluscs and other aquatic species enable species differentiation.

Integration. Traceability and fish identification have matured. What started as a programme to increase the safety, quality and legality of fish products has expanded to fish branding for marketing purpose. It is becoming a powerful economic tool that affects truthfulness in advertising as well as being part of a supply chain that ties the end consumer to the harvesting ground through the genetic code.

The integration of traceability systems may result in cost savings. However, care should be taken to ensure that the benefits of integration outweigh their costs. The integration of certification for different objectives with different information needs should be based on a platform that offers the greatest security or integrity. As noted above, this may run the risk of adding costs and barriers for some users to a greater extent than may be strictly necessary.

Private traceability standards should, to the extent possible, be adapted to official standards. This can offer cost savings to the businesses concerned, as compared with having to develop and implement duplicate proprietary systems.

Regional fishery management organizations

The role and obligations of regional fishery bodies (RFBs), and notably regional fisheries management organizations (RFMOs), in fisheries governance are growing steadily. Simultaneously, strengthening RFBs and their performance still remains the major challenge facing international fisheries governance. This is reflected in various international fora and in particular in the United Nations General Assembly and the COFI.

A recent FAO enquiry[24] shows that most RFBs consider IUU fishing (including effective implementation of MCS and overcapacity) as being the main challenge to their performance. Most respondents reported an inability to control IUU fishing and highlighted the impact that this has on undermining attempts at effective fisheries management. More encouragingly, three RFBs claimed to be addressing IUU fishing successfully: the Northwest Atlantic Fisheries Organization (NAFO), the North Atlantic Salmon Conservation Organization (NASCO) and the North East Atlantic Fisheries Commission (NEAFC). Indeed, the NEAFC noted that it was achieving considerable success in combating IUU fishing through IUU fishing vessel lists and a port state control system. Similarly, the NAFO also claimed to have a relatively effective MCS scheme that addresses IUU fishing through at-sea inspections, 100 percent observer coverage, a vessel monitoring system (VMS) and obligatory port inspections. The NASCO has noted a significant decrease in the level of unreported catches owing to improved surveillance and exchange of data.

A second commonly expressed fisheries management problem was difficulty in the implementation of the EAF. Other fisheries management problems reported by RFBs included bycatch (particularly of turtles, sharks and birds) and specific management issues in aquaculture and inland fisheries. Everywhere, there were problems of legal and illegal overcapacity leading to too much fishing effort. The need for more and better scientific data was noted by many RFBs.

Financial support for the RFB was cited as a primary issue of concern by a number of RFBs. Numerous RFBs also noted the need for greater cooperation between member states and the need to reform their legal and institutional framework.

Furthermore, RFBs are frustrated by their inability to promote economic development in member countries. This is important as the membership of many

Box 6

International Guidelines for the Management of Deep-sea Fisheries in the High Seas

The FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas[1] (the Guidelines) were adopted in 2008. They are a response to a request from the FAO Committee on Fisheries (COFI) at its twenty-seventh session (2007) to assist states and regional fisheries management organizations/arrangements (RFMO/As) in sustainably managing deep-sea fisheries and in implementing United Nations General Assembly Resolution 61/105 (2006). The Guidelines were developed owing to increased international concern regarding the management and potential impact of deep-sea fisheries on vulnerable marine ecosystems (VMEs) in the high seas, particularly regarding low-productivity species targeted by some of these fisheries and sensitive deep-sea habitats.

Although there is no standard definition of “deep sea” because of regional variations in habitat, fisheries and species, these fisheries are generally conducted at depths of more than 200 m, on continental slopes or isolated oceanic topographic structures such as seamounts, ridge systems and banks. Deep-sea fisheries *in the high seas* are relatively new. Although trawl fisheries for deep-sea species developed in the mid-1950s, they only began to expand into areas beyond national jurisdiction in the 1970s after the extension of national maritime claims.

The main objective of the management of these fisheries, according to the Guidelines, is “to promote responsible fisheries that provide economic opportunities while ensuring the conservation of marine living resources and the protection of marine biodiversity”. As such, the Guidelines constitute a unique voluntary international instrument, adopted by more than 70 FAO Members, that combines recommendations for the management of fisheries while also focusing on the conservation of marine biodiversity. Although non-binding, the Guidelines are one of the few tools to assist those responsible for managing marine living resources, as well as protecting vulnerable marine ecosystems in the high seas – which is no easy task. Guidance is provided on topics vital to fisheries management, such as data and reporting, enforcement and compliance, and management measures. In addition, conservation-related aspects are included, such as criteria for the identification of VMEs and key components of an impact assessment.

These Guidelines, which were elaborated through a multistakeholder process, are now being implemented by RFMOs mandated to manage discrete deep-sea stocks in the high seas, as well as by some FAO Members. FAO is now in the process of producing technical support tools to assist RFMO/As, states, the deep-sea fishing industry and others to achieve full implementation of the Guidelines.

[1] FAO. 2009. *International Guidelines for the Management of Deep-sea Fisheries in the High Seas*. Rome. 73 pp.

Box 7

Marine protected areas

Closed areas in fisheries are nothing new. Various types of spatial measures, such as closed areas or areas with particular gear or other restrictions, have been used for centuries as traditional management measures in artisanal fisheries around the world. These measures are also an integral part of "conventional" fisheries management. However, the term "marine protected area" (MPA) is a more recent concept and is usually more directly associated with biodiversity conservation than fisheries management. The use of MPAs and international imperatives to reach targets for the establishment of MPAs have risen rapidly in the last decade or so. This has created much confusion as to what constitutes an MPA, which is also referred to as a closed area, marine reserve, no-take area, marine sanctuary or countless other types of spatially explicit areas that enjoy some form of protection within a restricted boundary. Confusion persists not only in regard to terminology, but also in relation to how such areas fit into fisheries management. In particular, there is also confusion as to what the potential fisheries management benefits and costs are. Owing to the conflicting and confusing information on MPAs in a fisheries context and the absence of adequate guidance on this topic, the FAO Committee of Fisheries, at its twenty-sixth session, requested FAO to develop technical guidelines on the design, implementation and testing of MPAs in relation to fishing.

Marine protected areas have an important role to play, not only within the conservation community but also within fisheries management, and particularly in an ecosystem approach to fisheries. Therefore, they can serve as a tool for helping to achieve multiple objectives from different sectors. As practices and interests between the communities converge – owing to an awareness among conservation groups that human needs and interests cannot be ignored in conservation, and a complementary awareness among fishery scientists and managers that sustainable fisheries are only possible in healthy ecosystems – such tools will become even more important to the management of aquatic systems. Nonetheless, it is also important to remember that MPAs, however defined, are one type of tool to achieve certain objectives and that they are not an end in themselves. It is vital that attention be focused on reaching overall goals and achieving effective management of resources.

The FAO MPA Guidelines[1] provide information and advice on MPAs in the context of fisheries management, but also discuss the implementation of MPAs with multiple objectives, i.e. when fisheries management is one, but not the only, objective. The MPA Guidelines seek to clarify the potential effects of MPAs on fisheries, the fishery resource and the ecosystem, including biological, physical and socioeconomic aspects. The importance of using spatial management tools such as MPAs within a reconciled framework (i.e. where fisheries management objectives exist in tandem with other sectoral objectives) and of their integration into overall policy frameworks is stressed. Guidance on MPA design, implementation, monitoring and adaptation is provided, and the main challenges and opportunities relevant to these processes are discussed.

[1] FAO. (forthcoming). *Fisheries management. 4. Marine protected areas and fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 4. Rome.

RFBs consists solely or predominantly of developing states, and poverty clearly affects the ability to manage fisheries at all levels in society. In particular, it affects the ability to improve the livelihoods of subsistence and artisanal fishers.

A new generic area of concern for RFBs, compared with a previous FAO study,[25] is the environment. As areas of main concern, a large number of RFBs listed issues relating to climate change, habitat protection, including VMEs (Box 6), marine protected areas (MPAs, see Box 7) and seamounts, and the worldwide problem of depleted fish stocks.

New regional fisheries bodies

A new inland fishery body is in the process of development. The Central Asian and the Caucasus Fisheries and Aquaculture Commission was approved by the Hundred and Thirty-seventh Session of the FAO Council in October 2009. It will become active as soon as at least three countries ratify or accede to the Agreement.

Its objectives are to promote the development, conservation, rational management and best utilization of living aquatic resources, including the sustainable development of aquaculture. A five-year programme of work has been prepared and will be submitted for discussion and adoption by the Third Intergovernmental Meeting on the Establishment of a Central Asian and Caucasus Fisheries and Aquaculture Commission, which is scheduled to take place in late 2010.

The mandate of the new body includes the inland waters within the territorial boundaries of Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkey, Turkmenistan and Uzbekistan. Management of fisheries in the transboundary water basins bordering these states will be undertaken in collaboration with the Interstate Commission for Water Coordination of Central Asia and with other RFBs, particularly the European Inland Fisheries Advisory Commission.

The international consultations on the proposed South Pacific Regional Fisheries Management Organisation concluded with the adoption of the Convention on the Conservation and Management of the High Seas Fishery Resources of the South Pacific Ocean in Auckland, New Zealand, in November 2009. The convention opened for signature on 1 February 2010 and will remain open for 12 months. It will enter into force 30 days after the deposit of the eighth instrument of ratification, accession, acceptance or approval (of which three must be coastal states and three non-coastal states). When the convention enters into force, it will close a gap that exists in the international conservation and management of non-highly migratory fish stocks and protection of biodiversity in the marine environment extending from the easternmost part of the South Indian Ocean through the Pacific Ocean towards the EEZs of South America.

Preparatory discussions are under way for the establishment of a regional fishery mechanism for the coastal states of the Red Sea and Gulf of Aden. Such discussions were requested at the Twenty-eighth Session of the COFI.

Regional Fishery Body Secretariats Network

Since 1999, RFBs have met biannually to share information of joint interest. At their fourth meeting in 2005, participants agreed that their meetings should be referred to as the Regional Fishery Body Secretariats Network (RSN).

The RSN met in March 2009 and reviewed a large number of subjects of joint interest. Among these were: decisions and recommendations relating to RFBs made by the COFI; IUU fishing; overcapacity; United Nations General Assembly Resolution 61/105; management of marine ecosystems; and the status of the Fisheries Resources Monitoring System and that of the Coordination Working Party on Fishery Statistics. The Secretary of the NEAFC was elected as the new Chairperson of the RSN.

The RSN also discussed RFMO performance reviews. It noted the many similarities in the procedures set up by the different organizations but also that each RFB is in a unique position with respect to the parties involved, their interaction with the RFB, the species managed, the NGO community and other stakeholders involved, and the nature of its remit. However, provided that there is a real element of independent outside review of what the organization is achieving, or not achieving, the RSN concluded that the approaches to performance review needed to be flexible and it agreed that each performance review could have its own characteristics.

Management of tuna fisheries

The world's five tuna RFMOs[26] consult periodically. Following their first meeting in Kobe, Japan, in January 2007, the Second Joint Meeting of Tuna Regional Fisheries Management Organizations was held in San Sebastian, Spain, from 29 June to 2 July 2009. The meeting reviewed progress in performance reviews of RFMOs, scientific work programmes and cooperation in data collection, in particular how to avoid the creation of gaps in data series. Concrete actions to ensure that fishing capacity is commensurate with available fishing opportunities were also discussed. A number of immediate actions as well as a work plan for 2009–2011 were agreed.

Performance reviews of RFMOs

The Review Conference on the UNFSA held in New York, the United States of America, in May 2006 discussed the need to modernize the mandates of RFMOs in order that they can fulfil their functions as described in the UNFSA. At the conference, proposals were made for a systematic review and assessment of RFMO performance. In the course of the conference, states agreed specific measures to be taken by states individually and/or by RFMOs in order to strengthen international cooperation. Among the agreed actions were performance reviews of RFMOs.[27]

In 2007, the Committee for Fisheries of the Organisation for Economic Co-operation and Development (OECD) embarked on a review of the experiences of a number of RFMOs[28] that had undergone recent changes to their mandates and/or modes of operation. The objective of the review was to identify the key lessons from these experiences. In May 2009, the OECD Committee for Fisheries agreed to release the report[29] under the responsibility of the Secretary-General of the OECD.

By early 2009, six RFMOs had reported that they had already concluded performance reviews, and many others had started the process. At that time, the NAFO had finalized a comprehensive reform process and planned to review its performance after most elements of the reform had been implemented. The South East Atlantic Fisheries Organization conducted its performance review during its sixth Annual Meeting in October 2009.

The performance review of the NASCO was undertaken in 2004–05 by stakeholders and NGOs. During dedicated meetings, they gave feedback on their perception of how well the NASCO was performing in different areas. Opportunities were also provided to question contracting parties about implementation of, and compliance with, NASCO measures.

The NEAFC used an independent panel for its 2006 review. The review panel included representatives of NEAFC members and non-members. They conducted the performance review according to criteria agreed in advance. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) and the Indian Ocean Tuna Commission (IOTC) conducted their performance reviews using the method employed by the NEAFC.

FAO reform and regional fishery bodies

As part of the reform process, there has been a consensus that FAO statutory bodies, such as Article XIV fishery bodies, wishing to do so, should be encouraged to assume greater autonomy for their activities and finance, while remaining within the framework of FAO and maintaining a reporting relationship with it.

Despite positive developments with some Article XIV fishery bodies, many of them remain seriously challenged in terms of effectively carrying out their mandates. This situation is principally caused by ongoing and serious constraints in terms of financial, technical and human resources. Most of these bodies do not have dedicated secretariats and, as a consequence, in practice function as part-time organizations.

Dealing with IUU fishing

Illegal, unreported and unregulated (IUU) fishing continues to threaten the long-term sustainable management of world fisheries. This situation was reconfirmed by the COFI at its twenty-eighth session in 2009. Its position has since been substantiated with the publication of a study concerning the role and work of RFBs.[30] It showed, *inter alia,* that IUU fishing remained a priority concern and that most RFBs were struggling with it. The study reported that only a small number of RFBs were making headway in curtailing IUU fishing.

However, most RFBs are striving to implement measures to counteract IUU fishing. Measures being adopted and strengthened include: the promotion of awareness-building programmes, the creation and use of vessel lists, the implementation of catch documentation schemes, the implementation of port state measures, enhanced MCS, increased at-sea vessel inspection, complete fleet observer coverage, improved exchange of information, and the deployment of VMSs. Moreover, some RFBs reported that they had used their performance reviews to examine options to address IUU fishing.

The RFBs are at the forefront in the fight against IUU fishing. The tuna RFBs have demonstrated the benefits of more rigorous interregional collaboration and harmonization of activities to address IUU fishing. Further consolidation and intensification of their efforts is needed for the fuller implementation of agreed common measures and approaches. Cooperation among these RFBs provides a template for wider collaboration among non-tuna RFBs.

A notable and forward-looking development to stem the flow of IUU-caught fisheries product into the European market was taken on 1 January 2010 with the implementation of the certification scheme developed by the EU. Covering all imports of fishery products, it will require unprocessed products to have documents certified by the flag state of the fishing vessel, while imports of processed products require a statement issued by the processing company of the exporting country. This statement must include information establishing a connection between the processed product, the fish used as raw material and its origin.

Despite widespread publicity about the introduction of the scheme and the requirements that would have to be met, some countries have experienced difficulty in complying with the new EU requirements. While there has been a degree of flexibility in the introduction of the scheme in order to accommodate the concrete and specific situations of countries, the longer-term impact of the certification scheme should be positive. Generally, industry groups and authorized fishers have welcomed the scheme, although the increased bureaucratic workload for exporting countries is likely to be significant. In addition, the scheme could exert upward pressure on EU fish prices if it restricts import flows.

Civil society works to promote action against IUU fishing in many areas and at different levels. Generally, there is an increasing trend towards blending of interests among civil-society groups with respect to IUU fishing. Essentially, to satisfy a growing demand in the marketplace for sustainably harvested and non-IUU-caught product, industry groups have embraced sustainability and environmental goals, reducing the traditional demarcation among civil-society players. This convergence is having a positive effect on reducing IUU fishing as traders and processors opt not to purchase fish, irrespective of its source, that does not meet their self-imposed standards.

The 2001 FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing called for states to elaborate national plans of action (NPOAs) by mid-2004 and to review them every four years at least. There are fewer than 40 NPOAs on IUU fishing worldwide, and subregions have few if any. Information shows that the preparation of such NPOAs has stalled despite their undisputable value in promoting coherent and transparent national action against IUU fishing. Countries that have not elaborated NPOAs on IUU fishing find themselves at a disadvantage in addressing the problem because they lack a clear platform on which to base their operations.

Human resource development and institutional strengthening are high priorities in the fight against IUU fishing. Developing countries require assistance to enable them

Box 8

SADC mobilization against illegal, unreported and unregulated (IUU) fishing

The countries of southern Africa have been mobilizing in the fight against illegal, unreported and unregulated (IUU) fishing. In September 2007, a forum for national heads of operation of monitoring, control and surveillance (MCS) hosted by Mozambique, considered that illegal fishing should be raised at the highest level within the Southern African Development Community (SADC). Subsequently, the SADC held a ministerial conference on 4 July 2008 in Windhoek, Namibia, at which fisheries ministers from coastal states considered and signed a statement of commitment to stop illegal fishing. Among several resolutions, the ministers committed to closing their ports to all illegal vessels.

At the SADC ministerial conference, the Minister of Fisheries and Marine Resources of Namibia, Dr Abraham Iyambo, placed the issue in regional context: "It is not an exaggeration to state that the plague of illegal fishing is one of the largest environmental crimes of our time. In this context, we may well be the last generation of decision-makers with an opportunity to prevent this scandal and to bring to an end the troubling destruction of our oceans and the hardship it brings to our people."

Following the signing of the SADC statement of commitment, SADC countries took action with vessel arrests, revoking or reviewing some of the foreign fishing agreements, and enforcing measures on vessels flying their flag and fishing outside of their exclusive economic zones.

Regional cooperation in monitoring and surveillance increased significantly, with joint training at sea and operations between member countries of the Indian Ocean Commission (IOC) and the SADC. In a series of patrols along the coast of southern and east Africa, some countries were able to apprehend illegal fishing vessels for the first time and, through bilateral exchange of staff and advisors, proceed to prosecute the owners successfully and confiscate the vessels.

Early in 2009, Mozambique hosted a second regional forum of heads of operation of MCS, where the elements of an action plan against illegal fishing were identified, including the possibility of a regional MCS centre. With South Africa as chair, the SADC Fisheries Technical Committee finalized the action plan and set up several working groups ahead of negotiations on a global port state measures agreement that were scheduled for later in the year. At the negotiations, SADC members actively participated in a coordinated African approach to obtain concessions in relation to the special situation of developing countries and small island states.

The SADC action plan against illegal fishing was approved at a ministerial meeting in Zimbabwe on 16 July 2010. Mozambique will be hosting a global fisheries enforcement conference in 2011. The African Union (New Partnership for Africa's Development [NEPAD]) is proceeding to support similar initiatives by other regional economic communities in Africa.

Regional and international organizations and partners that have contributed to this southern African effort led by the SADC include: the Department for International Development (United Kingdom), FAO, the Indian Ocean Tuna Commission, INFOSA, the IOC, the NEPAD, the Norwegian Agency for Development Co-operation, the Pews Foundation, the South East Atlantic Fisheries Organisation, the Southwest Indian Ocean Fisheries Commission, Stop Illegal Fishing, and the Swedish International Development Cooperation Agency.

Box 9

FAO Agreement on port state measures to combat IUU fishing

Following a year of intense negotiations,[1] the FAO Conference in November 2009 approved the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (the Agreement) as an Article XIV instrument under the FAO Constitution. Immediately following its approval, the Agreement opened for signature and it will remain open for one year. It will enter into force 30 days after the date of the deposit of the twenty-fifth instrument of ratification, acceptance, approval or accession with the Depositary, the Director-General of FAO.

The Agreement seeks to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing through the implementation of port state measures as a means of ensuring the long-term conservation and sustainable use of living marine resources and marine ecosystems. The intention is that the Agreement will be applied by parties, in their capacities as port states, for vessels[2] not entitled to fly their flags. It will apply to these vessels when seeking entry to parties' ports or while they are in port. Certain artisanal fishing craft and container vessels will be exempt.

The real-time exchange of information is a key aspect of the Agreement. Indeed, its success will hinge, to a large degree, on the extent to which parties are prepared to, and capable of, exchanging information relating to vessels suspected of engaging, or found to have engaged, in IUU fishing. The Agreement specifies procedures for vessels to follow when requesting port entry and, conversely, for port states in relation to vessel inspections and other responsibilities such as the transmittal of inspection results. The annexes, an integral part of the Agreement, specify the advance information to be provided by vessels seeking entry to parties' ports as well as guidelines for inspection procedures, the handling of inspection results, information systems and training requirements.

Central to the Agreement is the article concerning the requirements of developing states. Focusing on the issue of capacity building, this article recognizes the need to ensure that all parties, irrespective of their geographic location and development status, have the human and material means to implement the Agreement. These provisions reflect a fundamental concern as lack of capacity among port states parties could seriously hamper the effectiveness of the Agreement in meeting its objectives.

The Agreement, on its own, cannot be expected to solve the world's IUU fishing problems. They must be addressed comprehensively and in different yet mutually reinforcing ways. However, blocking the movement of IUU-caught fish into ports and onto national and international markets, as well as making the operations of vessels engaged in IUU fishing more difficult, should cost-effectively reduce the incentive for fishers to take part in such fishing and related activities.

[1] FAO. 2009. *Report of the Technical Consultation to Draft a Legally-binding Instrument on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing*. FAO Fisheries and Aquaculture Report No. 914. Rome. 77 pp.
[2] The Agreement defines a "vessel" as any vessel, ship of another type or boat used for, equipped to be used for, or intended to be used for, fishing or fishing-related activities.

to develop, implement and improve policies and measures to combat IUU fishing. Moreover, they need more and accurate information about the negative effects on sustainability of flags and ports of non-compliance. While some countries need international support to develop strategies to stop the sale of flags as a revenue-raising activity, others may need assistance in order not to permit their ports to be used by vessels without appropriate entry and exit checks. However, in order to be effective,

Box 10

Flag state performance

A number of participants in the 2007 session of the FAO Committee on Fisheries (COFI) spoke about "irresponsible flag states". It was proposed that criteria be developed for assessing the performance of flag states and that possible actions against vessels flying the flags of states not meeting the criteria be examined. Following an Expert Workshop convened by Canada with the support of the European Commission and Iceland's Law of the Sea Institute, the matter of flag state performance was addressed again in 2009 by the COFI. As agreed by the COFI, an Expert Consultation was held in June 2009, to be followed by a Technical Consultation before the 2011 COFI session.

The task assigned to the Expert Consultation was quite ambitious. Participants used as a starting point and general reference a number of technical papers relating to the issues to be discussed as well as the outcomes of the Canadian Expert Workshop. In their deliberations, they were to consider and make recommendations on: criteria for assessing the performance of flag states; possible actions against vessels flying the flags of states not meeting the criteria identified; the role of national governments, regional fisheries management organizations, international institutions, international instruments and civil society in implementing the criteria and actions for flag state performance; and assistance to developing countries to help them in meeting the criteria, taking actions and fulfilling their respective roles as appropriate.

The Expert Consultation agreed to recommend to a technical consultation that international guidelines be developed on criteria for assessing the performance of flag states and possible actions against vessels flying the flags of states not meeting such criteria.[1] An assessment process would be an important part of such guidelines. Noting the basis provided by international law for such assessments, the Expert Consultation agreed on the need for two processes: one for self-assessment, and another for international or multilateral assessment. The latter assessment should be undertaken in a spirit of international cooperation, consistent with the 1982 United Nations Convention on the Law of the Sea. The Expert Consultation further agreed upon draft criteria for flag state performance, processes for conducting assessments, post-assessment actions, and assistance to developing countries to improve their performance as flag states.
The experts considered that these criteria and actions should form an appropriate framework for review by a technical consultation.

[1] FAO. 2009. *Expert Consultation on Flag State Performance*. FAO Fisheries and Aquaculture Report No. 918. Rome. 94 pp.

capacity-building measures must be matched by the political will to address IUU fishing (Box 8) and by a willingness to rein in corrupt practices that both facilitate and feed off IUU fishing.

FAO is focusing considerable attention on IUU fishing and related activities. In 2009, in line with international calls to conclude negotiations, FAO finalized the 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal Unreported and Unregulated Fishing (Box 9) and commenced work, possibly to involve the development of guidelines, on the elaboration of criteria and follow-up action for flag state performance (Box 10). The broader, if not universal, application of the above agreement will serve to reduce the effects of IUU fishing, as will the specification of criteria to enhance flag state performance.

Emerging issue – international guidelines on bycatch management and reduction of discards

Notwithstanding the emphasis given to bycatch and discards by several intergovernmental organizations in the past, there remain significant concerns with respect to effective management of bycatch and reduction of discards in capture fisheries. Previous efforts to address these issues have included the development of international plans of action for seabirds and sharks[31] and guidelines to reduce sea turtle mortality in fishing operations.[32] However, problems persist with the high levels of unwanted and often unreported bycatch and discards in many fisheries around the world, including the capture of ecologically important species and juveniles of economically valuable species. Total global bycatch is difficult to quantify because of incomplete information and because different states define it differently. Nevertheless, the latest published estimate of global discards from fishing (a subset of bycatch under any definition) is of about 7 million tonnes (Box 11).[33] However, issues other than the actual tonnages of bycatch and discards are also important – such as the mortalities of rare, endangered or vulnerable species, and the socio-economic impacts of utilizing bycatch instead of decreasing its capture.

Calls for action on bycatch and discards have also been raised at the United Nations General Assembly. For example, at the sixty-third session of the United Nations General Assembly in 2008, states, subregional and regional fisheries management organizations and arrangements (RFMO/As) and other relevant international organizations were urged to reduce or eliminate bycatch, catch by lost or abandoned gear, discards and post-harvest losses, and support studies and research that will reduce or eliminate bycatch of juvenile fish.[34]

In 2009, at the Twenty-eighth Session of the COFI (COFI 28), it was noted that, in poorly managed fisheries, unreported and unregulated landings of bycatch, discards, and pre-catch losses are issues of major concern.[35] To respond to these concerns and those raised at the United Nations General Assembly, COFI 28 requested FAO to lead the development of international guidelines on bycatch management and reduction of discards through the process of an Expert Consultation[36] (held in late 2009) followed by a Technical Consultation (scheduled for December 2010).[37] The proactive stance proposed by COFI 28 was welcomed by the United Nations General Assembly.[38]

Aquaculture policy and governance

In the last two decades, aquaculture has recorded significant and rapid growth among the food-producing sectors and has developed into a globally robust and vital industry. However, this level of development has varied widely across nations, with a positive bias towards countries where entrepreneurs have been successful – an indication that this development has come about largely because of the private sector.

One of the reasons, and perhaps the most important reason, why entrepreneurs flourish in some jurisdictions but not others is governance.[39] In the past two decades, considerable progress has been made in addressing aquaculture governance issues. This progress has been made possible by an international corporate effort and by several nations that have pushed the aquaculture agenda forwards in an orderly and

Box 11

Monitoring and reporting on discards in the world's fisheries

Most fisheries professionals recognize that, despite three decades of excellent work by researchers and practitioners in developing technologies to reduce discards throughout the world, many problems persist with high levels of unwanted and often unreported bycatch and discards in many fisheries. Of particular concern are not only the capture and mortality of threatened species, like turtles, dolphins and seabirds, but the consequences of killing and discarding huge quantities of juveniles of economically valuable fish species.

In the fisheries context, "discard" means fish that are thrown away after being taken aboard the fishing vessel or slipped from the net in the water. However, quantifying fisheries discards on a global scale is not simple either, because of incomplete information for many fisheries and countries. Nevertheless, in 1994, global discards from fishing were estimated at about 27 million tonnes.[1] In 2004, this figure was updated and revised to 7 million tonnes.[2] However, these latest estimates suffer as comprehensive and accurate data on the world's capture fisheries are not available.

In the past decade or so, many countries have increased their efforts to collect information about discards and bycatch. Many countries collect discard information on an ongoing basis in varying formats and reporting styles, some by law, some voluntarily, and there exist unprecedented numbers of observer programmes of excellent quality (well accepted as the best way of gathering discard information). Moreover, while some countries do not have observer programmes, some are about to introduce them, and virtually all have an appreciation of the need to do so. Indeed, the experience generated by recent approaches to the collection of information on discards will probably help to develop the "International Guidelines on Bycatch Management and Reduction of Discards" that FAO is currently compiling at the request of the FAO Committee on Fisheries.

However, many observers believe that to account properly for the scale and complexity of fishery discards throughout the world, it is time to introduce a global, far-reaching process along similar lines to those used to assemble and collate capture fisheries landings data.

[1] D.L. Alverson, M.H. Freeberg, S.A. Murawski and J.G. Pope. 1994. *A global assessment of fisheries bycatch and discards*. FAO Fisheries Technical Paper No. 339. Rome, FAO. 233 pp.
[2] K. Kelleher. 2005. *Discards in the world's marine fisheries. An update*. FAO Fisheries Technical Paper No. 470. Rome, FAO. 152 pp.

sustainable fashion through good governance. Means and processes of governing the sector have varied with traditions and values, which precludes a universal template, but there are enough common features for an overall lesson.[40]

One feature is the common goal that countries have pursued with aquaculture governance – sustainability of the sector. Sustainability requires environmental neutrality and social acceptability of the industry. It also requires, for the industry as a whole, revenues that, on the one hand, provide compensation for risks associated with aquaculture and, on the other, ensure long-run profitability of aquaculture activities. In practice, the governance regimes followed by different governments to achieve sustainability of the sector are fluid, with no clear-cut demarcation between them. However, analysis of the processes by which collective action is taken and decisions are implemented reveals three main types of aquaculture governance.

At one extreme is "hierarchical governance". This is a top-down, command and control of the sector development with little or no consultation with stakeholders. Often, the authorities facilitate and formulate policies for aquaculture management and development, but leave farmers to make production decisions. The danger with this approach is that, more often than not, enforcement will be inadequate and producers non-compliant. Thus, in many cases, there has been devolution to industry, with more self-regulation using voluntary codes of practice. Governance through voluntary codes of practice obviates the need for restrictive regulations; the incentive for compliance is mutual benefits. However, with these benefits come concerns about efficiency. There are prevailing arguments that, in the absence of mandatory legal obligations (especially those that regulate access to resources and ensure environmental safeguards), self-regulation by the aquaculture industry relying on voluntary codes of practice is an ineffective form of governance.

Some countries have also adopted a "market-driven" approach to governance. With this approach, government policy is to let the private sector largely lead aquaculture development, with the government adopting a *laissez-faire* attitude. This type of governance has resulted in impressive sectoral growth. However, as exemplified by early-movers in aquaculture in many places, such policies have resulted in environmental degradation, especially in mangrove destruction in many instances, and in the near collapse of some aquaculture industries around the world. Having learned from this experience, other countries with market-driven governance now accept the need to intervene to correct market failures. They use regulations on environmental protection, fish health, and safety of aquaculture products to mitigate these failures.

Governments also attempt to achieve sustainability in aquaculture through "participatory governance". Participatory governance extends from industry self-regulation, to comanagement of the sector by industry representatives and government regulators and to community partnerships. This form of governance is increasingly becoming the norm, be it at the local, national or regional level. At the local level, neighbouring and competing farmers would work together to coordinate environmental and production measures. Compliance is enforced by peer pressure. There are instances where the industry is self-managed although some aspects such as animal welfare are comanaged; the industry undertakes most inspections, with governments checking only periodically. At the national level, codes of practice also exist as part of industry self-regulation in many countries. While most of these codes are general in scope (incorporating feed, drugs and environmental protection aspects), many are issue-specific. The incentive for farmers' self-compliance with these codes is certification of quality. However, industry organizations also have the ability to exclude those who do not comply. At the regional level, there are associations of aquaculture producers. These usually have codes of practice that may cover environmental, consumer, husbandry and socio-economic issues as well as the public image of the industry.

Where aquaculture governance has proved fruitful, it appears that governments have followed four main guiding principles, namely: accountability, effectiveness and efficiency, equity, and predictability.

Accountability means the acknowledgment and assumption of responsibility for actions, decisions, policies and products by officials. It implies greater openness of administrations, so that officials are answerable to the public and to their institutional stakeholders for their actions. It also implies performance-based standards for officials, and mechanisms for reporting, auditing and enforcement. In practice, accountability would be reflected in timely decisions and would imply stakeholder participation in decision-making processes. It would also mean that, for example, decisions on licences to farm are open to appeal and that the criteria for their granting are transparent. This would increase predictability for aquaculture producers and other stakeholders.

In simple terms, effectiveness consists of doing the right thing; it is a measure of the quality and decency of actions undertaken. Efficiency is about doing things properly, in a cost-effective way; it measures the speed and the cost at which things are done. Effective and efficient government services have played an important role in ensuring good governance in aquaculture. However, balancing the two has not always been easy for policy-makers; yet, this balance is crucial for the development of the industry.

Equity has been critical for sustainability. A society's well-being depends on ensuring that all its members feel that they have a stake in it and are a part of the mainstream of society. This requires that all groups, particularly the most vulnerable ones, have opportunities to improve or maintain their well-being. In practice, this will mean guaranteeing procedural fairness, distributional justice and participation in priority-setting and decision-making processes to men and women alike. The sharing of power leads to equity in resource access and use.

Predictability relates to fairness and consistency in the application of laws and regulations and in the implementation of policies. In many instances, governments have ensured predictability by making credible commitments and persuading the private sector that decisions will not ultimately be reversed because of political uncertainty. This has been done through participation. By giving stakeholders a voice, stakeholders have been able to express their preferences. With predictability, farmers have been protected from arbitrary decisions and have been able to retain their produce, while property owners or users have had the right to exclude others from the property. Moreover, with predictability, property rights have become fungible, easing access to loans because farmers can use property as collateral. Such security of tenure, whether freehold or usufruct, has become an important target for government policy also because it influences investment decisions. Predictability has also worked in the reverse direction; it has reduced the risk that property be subject to arbitrary confiscation and taxation. Grounds for expropriation of land, non-renewal of licences, and taxation have become transparent.

While there have been laudable efforts throughout the sector, aquaculture governance remains an issue in many countries. There are still: (i) conflicts over marine sites; (ii) disease outbreaks; (iii) negative public perception of aquaculture in certain countries; (iv) inability of small-scale producers to meet foreign consumers' quality requirements; and (v) inadequate development of the sector in certain jurisdictions despite favourable demand and supply conditions. This last issue is likely to become more important as the world strives to feed its ever-growing population.

Experts agree that most future aquaculture expansion will occur in the seas and oceans, certainly further offshore, perhaps even as far as the high seas. However, aquaculture governance is already facing serious limitations in marine waters under national jurisdiction. Should aquaculture operations be undertaken in the high seas, the problem is likely to become a challenge as existing relevant principles of public international law and treaty provisions provide little guidance on the conduct of aquaculture operations in these waters. There seems to be a regulatory vacuum for aquaculture in the high seas.

NOTES

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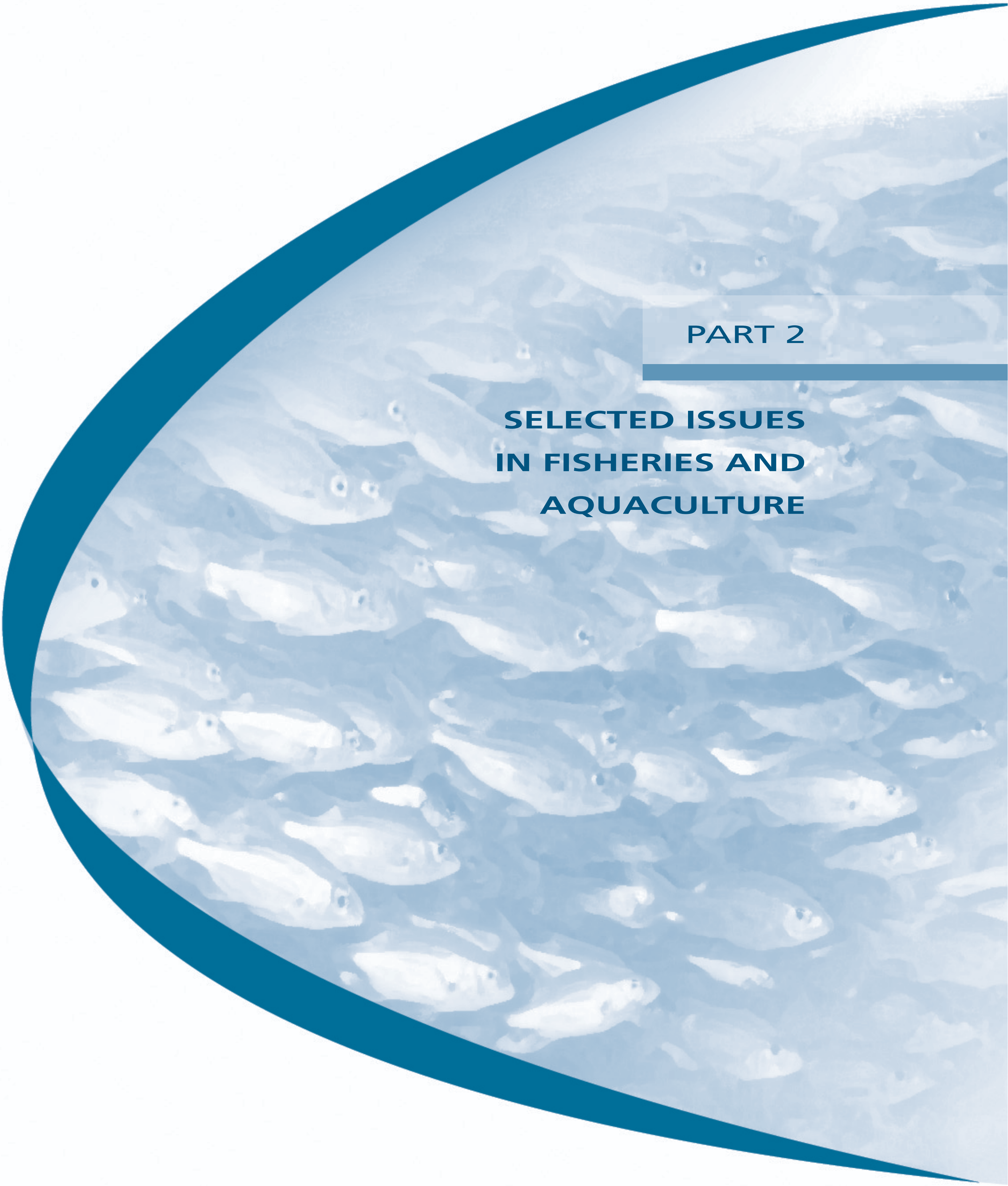


PART 2

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

Trade measures against IUU fishing

THE ISSUE

Trade measures are increasingly being used to combat illegal, unreported and unregulated (IUU) fishing.[1] The aim of these measures is to prevent IUU-sourced fish and fish products from entering into international trade. The increasingly stringent implementation of trade-related measures often poses a significant challenge, especially for fish and fish products originating from small-scale fisheries in developing countries. These countries often lack the resources and infrastructure needed to meet the requirements. As a result, they may be excluded from participating in the international trade in fish and fish products, regardless of whether their product is of legal origin or not. In other words, legally sourced fish and fish products may be excluded from international trade because developing countries are not in a position to implement the administrative requirements associated with the trade measures. This may also pose a problem for the processing sector in importing countries that rely on imports of raw material from developing countries to supply their processing plants.

IUU fishing

Now a global problem, IUU fishing occurs in virtually all capture fisheries, ranging from fisheries under national jurisdiction to high seas fisheries. It is increasingly recognized that IUU fishing undermines national and international fisheries conservation and management measures and leads to resource depletion. This, in turn, weakens the ability of the fisheries sector to meet national and global economic, social and environmental objectives and threatens the livelihoods of people who depend on fishing. However, given the importance of developing countries in the international fish trade,[2] measures to reduce IUU fishing will fail if developing countries are not active participants in the fight to ensure legal and sustainable fishing practices.

A recent study estimates the cost of illegal and unreported fishing alone at US$10–23.5 billion per year.[3] In 2006, global capture fisheries had an estimated first-sale value of US$91 billion.[4] Even at the low end of the IUU cost estimate spectrum, the losses due to IUU fishing are substantial relative to the total value of the fisheries sector.

Trade measures against IUU fishing

Trade-based measures consist of actions directed toward products originating from IUU fishing and may include banning products from states found to be undermining fishery conservation and management measures, or rejecting individual shipments that lack required documentation of their legal provenance. As approximately 37 percent of the global fish harvest enters into the international trade, international regulations or measures that ensure that internationally traded fish does not originate from IUU fishing can be powerful instruments. However, caution must be exercised in their application to ensure that they do not create unnecessary or unjustifiable barriers to trade.

Until recently, trade measures to combat IUU fishing were mainly implemented by regional fisheries management organizations (RFMOs)[5] managing high seas fisheries. However, trade measures have now been developed to be implemented at the national level by Chile, the United States of America and the European Union (EU).

Chile

In December 2009, Chile introduced new requirements for imports of aquatic species or by-products into Chile. Imports require a certificate of legal origin certifying that the imported species were captured or harvested pursuant to national and international regulations applicable in the country of origin, and in the case of fisheries products, that the aquatic species or raw material used and their manufacturing process are in accordance with the above regulations.

United States of America

Since January 2007,[6] the United States of America has produced a biennial report of nations identified as having vessels engaged in IUU fishing. The report includes a description of efforts taken by listed nations to take appropriate corrective action and a report of progress at the international level to strengthen the efforts of international fishery management organizations against IUU fishing. The United States of America also seeks to strengthen international fishery management organizations to address IUU fishing through the adoption of IUU vessel lists, stronger port state controls, market-related measures and other actions.

Once a nation has been identified as having vessels engaged in IUU fishing, the United States of America will work with and encourage the identified nation to take appropriate corrective action to address IUU fishing. The absence of steps by identified nations to address IUU fishing may lead to prohibitions on the importation of certain fisheries products into the United States of America.

European Union

The EU Regulation to prevent, deter and eliminate IUU fishing (the EU IUU Fishing Regulation) entered into force in January 2010.[7] It aims to ensure that any individual or business wishing to import fish and fish products into the EU can only do so if the country under whose flag the fish was caught can show that it has in place, and enforces, laws and regulations to conserve and manage its marine resources. Among other measures, the EU IUU Fishing Regulation allows EU member states to ban fish imports if they:

- are not accompanied by a catch certificate;
- were caught by a vessel that has been found to engage in IUU fishing;
- were caught by a vessel included in the EU IUU fishing list; or
- were caught by a vessel flying the flag of a non-cooperating third country.

The catch certificate that must accompany any imports of fish and fish products caught by third-country fishing vessels is a central element of the EU IUU Fishing Regulation. The certificate is issued by the flag state of the vessel that originally caught the fish. Catch certificates of a given flag state will only be accepted once that country has confirmed to the European Commission that "it has in place national arrangements for the implementation, control and enforcement of laws, regulations and conservation and management measures".[8] Trade sanctions can also be imposed on fish caught by vessels found to have engaged in IUU fishing. European Union member states can ban imports as an immediate enforcement measure if a vessel has been caught fishing illegally. The European Commission can also add a vessel engaged in IUU fishing to an IUU vessel list if the flag state has failed to take action. Imports of fish and fish products from listed vessels to the EU are prohibited.

Vessels included in IUU lists of RFMOs will automatically be added to the EU list. A country can also be put on the list if it is found to have failed to implement adequate measures to address recurrent IUU fishing activities involving vessels flying its flag, fishing in its waters or using its ports. It must also have adequate measures in place to prevent access for illegally caught fisheries products to its market. In addition, the EU can implement short-term emergency measures if actions by a third country are deemed to undermine the conservation and management measures of RFMOs.

The EU IUU Fishing Regulation will recognize certain RFMO schemes as complying with its requirements, although fish from unrecognized RFMO schemes will have to provide both RFMO and EU documentation.

The EU IUU Fishing Regulation is much broader in scope than previously implemented trade-related measures. It applies to imports originating from waters under national jurisdiction (exclusive economic zones [EEZs]) as well as from the high seas. The EU is the world's largest importer of fish and fish products, with imports valued at US$49 billion in 2008 (including intra-EU trade). All imports of fish and fish products into the EU will be subject to the requirements of the EU IUU Fishing Regulation, which means it will significantly affect international fish trade. The EU IUU Fishing Regulation has a provision for catch documents issued under certain RFMO catch documentation schemes to be accepted in lieu of the catch certificates required by the regulation. However, some developing countries have raised concerns about their capacity to meet the requirements set out in the EU IUU Fishing Regulation. In response, the EU has foreseen the possibility of providing assistance and capacity building in developing countries to help them implement the EU IUU Fishing Regulation.

Implications for developing countries: the case of EU regulations

For some developing countries, especially those with limited administrative infrastructures, the challenges of meeting the requirements associated with the implementation of trade measures may prove difficult.

The two main challenges created by the EU IUU Fishing Regulation for developing countries are related to their capacity to:

- develop national arrangements for the implementation, control and enforcement of laws, regulations and conservation and management measures that deal with the problem of IUU fishing;
- implement the reporting requirements associated with the EU IUU Fishing Regulation.

The EU IUU Fishing Regulation is quite comprehensive and, in particular, requires that a catch certificate accompany all shipments. Recognizing the capacity constraints for the implementation of the certification scheme, the EU has developed a simplified catch certificate for small fishing vessels. The simplified certificate is intended to lighten the reporting requirement. However, the major hurdle for small-scale fisheries will be the cost of collecting and compiling catch certificates from individual vessels. Small-scale fisheries in developing countries typically depend on many small vessels, each supplying a relatively small quantity of fish. Because a catch certificate is required for each vessel, the compliance cost is much heavier than for industrial fleets. In addition, developing countries do not have access to electronic reporting systems. This requires the establishment of a paper trail for each vessel from the point of capture.

The EU regulations also pose challenges for shipments of fresh fish. Owing to the perishability of the product, it is imperative that the product move rapidly through the value chain in order to fetch a maximum price. These factors are of critical importance in a sector that operates on thin profit margins. Delays caused by reporting requirements will have a negative effect on the market for fresh fish. In many instances, individual shipments are composed of small, line-caught catches originating from a range of vessels operated by artisanal fishers.

As the EU applies a different set of rules to address IUU fishing by EU vessels, some countries have also questioned whether the EU IUU Fishing Regulation is inconsistent with the national treatment provisions of the World Trade Organization (WTO).[9] The EU has argued that its Control Regulation[10] has the same effect as the EU IUU Fishing Regulation and that there is therefore no discrimination.

POSSIBLE SOLUTIONS

Trade measures against IUU fishing include two main components. The first consists of the administrative procedures associated with the trade measure (identifying a competent authority, developing traceability systems, etc.). The second component relates to the development of national arrangements for the implementation, control and enforcement of laws, regulations and conservation and management measures.

Under existing international agreements, it is incumbent on various international organizations and other relevant bodies to consider providing technical and financial assistance to developing countries to assist them in adhering to international agreements, particularly those contained in the WTO agreements and the FAO International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA-IUU).[11] This means *inter alia* helping developing countries in the implementation of the two main components of trade measures against IUU fishing.

FAO adopted the IPOA-IUU in 2001. The IPOA-IUU specifically calls upon states to develop additional internationally agreed market-related measures to prevent, deter and eliminate IUU fishing. Such measures must be interpreted and applied in accordance with the principles, rights and obligations established by the WTO and implemented in a fair, transparent and non-discriminatory manner.

The IPOA-IUU also commits states, with the support of FAO and relevant international financial institutions and mechanisms, to support training and capacity building and to consider providing financial, technical and other assistance to developing states so that they can more fully meet their commitments under the IPOA-IUU and obligations under international law.

RECENT ACTIONS

In 2009, the EU organized regional seminars in Cameroon, Colombia, New Caledonia, South Africa and Viet Nam to introduce the requirements of the EU IUU Fishing Regulation. In addition, the EU will take into account the capacity of developing countries and will assist them in implementing the EU IUU Fishing Regulation and combating IUU fishing. The constraints of developing countries in the field of monitoring, control and surveillance (MCS) of fishing activities will also be taken into account. The EU issued a statement prior to adoption of the EU IUU Fishing Regulation where it undertook to assist third countries in the implementation of the EU IUU Fishing Regulation and the EU catch certification scheme.[12]

FAO has carried out several regional workshops where participants have had the opportunity to: (i) gain a better understanding of the requirements associated with the United States' IUU approach and the EU's new IUU legislation; and (ii) exchange experiences at the national level in relation to the implementation of the EU's IUU regulations. A questionnaire has also been developed to identify the aspects of the IUU regulations that are creating difficult challenges for exporting countries. The feedback received from the questionnaire will help FAO to determine how best to provide technical assistance to affected countries.

The EU's IUU regulations and other similar measures are also discussed by the FAO Committee on Fisheries (COFI) Sub-Committee on Fish Trade. Every two years, this event brings together all the market, coastal and flag states and provides a forum where these issues are debated by policy-makers.

FUTURE PERSPECTIVES

Improvements to existing schemes and the development of new trade measures are likely in order to fulfil the requirements of the EU and other nations. Where possible, they will probably be designed so as not to create unnecessary burdens for fish trade flows. However, in the future, the private sector may also seek additional assurances that it is sourcing fish and fish products from legal fisheries. The private sector will probably be encouraged, to the extent possible, to build on and support initiatives implemented by national governments.

Given the expected difficulties of developing countries in the implementation of trade measures, development agencies and donors are likely to monitor the situation closely and to assist countries in the implementation of IUU regulations and associated trade measures, particularly in developing the capacity required to comply with the regulations.

The trade measures described above can be particularly effective in preventing IUU fish and fish products from entering regulated markets. However, they have little or no effect on fish and fish products harvested for domestic consumption or for unregulated markets. It seems plausible that, in the future, nations will be encouraged to implement trade measures that target both fisheries supplying the international trade and fisheries that supply domestic markets.

In addition, a prerequisite for combating IUU fishing is good governance of the harvesting sector. Therefore, in order to deal effectively with IUU fishing, most countries, including developing countries, will need to strengthen national arrangements for the implementation, control and enforcement of laws and regulations intended to ensure the conservation and management of living marine resources.

Maintaining biosecurity in aquaculture

THE ISSUE

While aquaculture offers relief to many of the food security issues facing the world's growing population, the sector is also in direct conflict (invariably overlapping other economic, environmental and social interests) with other users of aquatic habitats and coastal and riparian areas. A better and more widely used structure and programme for biosecurity may be one way of reducing conflicts between aquaculture and other water users.

More than 360 species are produced in aquaculture worldwide; some 25 of these are of high value and traded globally. A successful harvest can be very profitable, and this has spurred the expansion of aquaculture production in terms of area and geographical range. When done in a haphazard manner, species movement for farming can be one of the many sources of biological threats to the well-being of farmed aquatic animals as well as to humans and ecosystems. As aquaculture intensifies and diversifies, the biological hazards and risks to farmed animals, people and ecosystems also increase in number and diversity, with potentially serious consequences. Some of these hazards are infectious diseases, animal pests, public health concerns on residues and resistance of antimicrobial agents, zoonosis,[13] invasive alien species, release of genetically modified organisms and biosecurity risks posed by climate change. The growing number, complexity and seriousness of these risks have driven the development of the concept of biosecurity and its increasing application. An integrated strategy to manage biosecurity, business, environmental and social risks will better promote sustainable growth of the aquaculture sector.[14]

Biosecurity can be understood as the management of biological risks (such as those mentioned above and others that may yet arise) in a comprehensive and systematic manner to protect the health and well-being of animals, plants and people, and to maintain the functions and services of ecosystems. Through this integrated and comprehensive approach, biosecurity can safeguard animal and human health, protect biodiversity, promote environmental sustainability and ensure food safety. It can stimulate increased market supply and private investments by enabling farmers to produce healthy products that can be highly competitive in the market. It makes adherents and users responsible trading partners. Through biosecurity, developing countries can grow more food efficiently, increase their incomes and, thus, improve their resilience, reduce their vulnerability and enhance their ability to respond to the impacts of higher food prices and other threats to food security.

Examples of biosecurity risks in aquaculture

Transboundary aquatic animal diseases

Highly contagious aquatic animal diseases or pathogens, transboundary aquatic animal diseases (TAADs) can spread very rapidly anywhere and cause serious losses and long-lasting damage. Increases in trade increase the potential of facilitating new mechanisms by which pathogens and diseases may be introduced and spread to new areas together with host movement. Examples of serious TAADs affecting aquaculture are: (i) epizootic ulcerative syndrome (EUS), a fungal disease of finfish that has recently expanded its geographic range to southern Africa, affecting wild fish populations; (ii) white spot disease of black tiger shrimp, probably the most serious viral disease of cultured shrimp and responsible for the collapse of the shrimp culture industry in many countries; and (iii) koi herpes virus (KHV), another viral pathogen affecting an important food fish (common carp) and a high-value ornamental fish (koi carp).[15] Domestic and international movements of infected broodstock and seed are proven pathways for the entry and spread of these pathogens. Infectious diseases are constraining the development and sustainability of the industry through direct losses (in many cases, costing millions of US dollars), increased operating costs, closure of aquaculture operations, unemployment, restrictions on trade, and impacts on biodiversity.[16]

Public health risks from the use of veterinary medicinal products

Veterinary medicinal products are substances (such as antimicrobial agents, chemotherapeutants, disinfectants and vaccines) used during production and processing to treat or prevent disease, carry out medical diagnosis, or restore, correct or modify physiological functions in animals.[17] Overall, veterinary substances have raised production efficiency and have been taken up rapidly by the aquaculture industry with improved learning and better understanding of health management and biosecurity application to aquaculture. The benefits are also well recognized from a wide range of applications, including, in addition to the above, development of new species for farming, alternatives to failed preventive strategies, development of culture technology, and animal welfare. However, there are also increasing concerns about veterinary medicinal products in terms of their limitations and the potential harm they may cause. These are related to bacterial resistance, antimicrobial agent residues in tissues of food products, the cost of remedying unintended effects, and the reliability of their efficacy under various aquatic environments. Along with widespread use comes growing concern about irresponsible use, such as the covert use of banned products, misuse because of incorrect diagnosis and abuse owing to a lack of professional advice. That said, there are still not enough approved products for a range of species and diseases in aquaculture.

Biological invasions

Biological invasion, a broad term that refers to human-assisted introductions and natural range expansions,[18] is a major cause of global biodiversity loss. An example is the golden apple snail, which was intended for use as a food crop, an aquarium pet or a biological control agent. However, it became a pest in rice fields and native ecosystems in the Asian countries in which it was introduced. Aquaculture can be a source of risk from biological invasions in a number of ways, e.g. bringing in non-native species for farming and the use of non-native, fresh or frozen feedstocks. These can have adverse effects on biodiversity, including decline or elimination of native species – through competition, predation, or transmission of pathogens – and the disruption of local ecosystems and ecosystem functions. The global spread of many marine organisms through shipping has been a major marine biosecurity concern in the last decade. Ballast water[19] may transport all groups of marine organisms. The transport of toxic algae in ballast water has had a profound effect on aquaculture activities, such as closure of farms during blooms. Hulls, on the other hand, can become carriers of encrusting organisms (e.g. macro-algae, bivalve molluscs, barnacles, bryozoans, sponges and tunicates), which may not only introduce novel pathogens but more seriously foul ports, coasts and aquaculture facilities, thus adding costs (for treatment and clearing) and weakening the economic viability of marine farms.

Climate change scenarios that will affect biosecurity
Many aquaculture operations located in riparian and coastal systems will be vulnerable to climate change effects, such as sea-level rise, increased incidence of storm surges and land-based runoffs, as well as extreme weather events resulting in flooding, drought and perturbations such as rise in sea temperature.[20] In the tropics, warmer air and water temperatures and rising water levels may drive species from their tropical habitats to subtropical regions. Assessments of the impacts of climate change have generally concurred that global warming could increase the range of pests and pathogens, or intensify their occurrence or increase the vulnerabilities of farmed animals to diseases. Extension in the range of diseases, particularly non-host-specific pathogens, will be induced by species movement. In addition, major losses of stocks and infrastructure are likely to result from increased incidence of storm events. Higher temperatures could increase the likelihood of the occurrence of pathogen, food safety, public health and ecological risks.

POSSIBLE SOLUTIONS

Policy options (including regulatory and implementation frameworks)

The rapid expansion of the aquaculture sector has spawned a diverse set of international, regional, national and local regulatory frameworks. A number of international agreements, organizations and programmes are part of a loose international framework on biosecurity, reflecting the historically sectoral approach to regulation in this area. Actions may include: identifying a competent authority and oversight bodies and agreeing on interagency coordinating responsibilities; making biosecurity an element of national aquaculture development programmes; establishing regulatory processes and the appropriate infrastructure to enforce them; and enhancing compliance with regional and international treaties and instruments through effective implementation of national strategies and national policies.

Knowledge base

At the heart of modern approaches to biosecurity is the application of risk analysis. It offers an effective management tool whereby, despite limited information, pragmatic decisions can be made that provide a balance between competing environmental and socio-economic interests. Its application can improve the ability of aquaculture managers in identifying risks and deciding on mitigation or management strategies to deal with risks. However, this tool needs research, databases and other vital sources of information and knowledge so that it can effectively support biosecurity assessments, surveillance, diagnostics, early warning, emergency preparedness and contingency planning. These are needed in order to: identify, understand and analyse the risks and their possible routes (or pathways); describe the individual steps and critical events leading to an introduction; and draw up effective risk mitigation measures. In addition, information from the risk analysis and on options for risk mitigation should be communicated clearly, carefully and rapidly.

Capacity building

Dealing with biosecurity risks is a common responsibility that should be shared among relevant authorities and stakeholders along the aquaculture value chain. Thus, capacity building in risk analysis and adaptive management[21] at all levels – from farms to oversight bodies of the public and private sectors – should be part of the overall programme so that threats and uncertainties from new species and innovations can be assessed rapidly. Fish farmers need reliable and timely information and effective tools. Extension and diagnostic services at primary production levels should be revitalized, and the operational effectiveness of oversight bodies to respond effectively to biosecurity emergencies needs to be maintained. Investing in capacity building for designing and implementing surveillance programmes and for preparing for, and coping with, emergencies will pay dividends. It will be less costly to detect, identify and prevent the emergence or spread of diseases and pests than to contain them. It will cost less and minimize human suffering if such risk does not turn into an emergency, or, if it does, is met with a rapid and appropriate response.

Investment in infrastructure, capacity, regulatory frameworks and partnerships

Effective, coordinated and proactive biosecurity systems are the product of science-based knowledge and practices used within effective regulatory frameworks backed by sufficient resources for enforcement. More investment is needed in: biosecurity infrastructure; human capacity for assessing, managing and communicating risks; regulatory frameworks for controlling risks; and public and private sector partnerships for identifying, monitoring and evaluating risks. A crucial consideration is how to deal with "unknowns". This suggests the need to forge an effective regional and international cooperation to pool resources and share expertise and information. At the global, regional or national levels, the institution mandated to ensure biosecurity would be well served by putting emergency preparedness with advanced financial planning as its core function.

RECENT ACTIONS

The main regulatory instrument governing biosecurity is the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) of the WTO.[22] It advocates the use of risk analysis as the basis for taking any sanitary and phytosanitary measures. The three main international organizations and standards are: (i) the FAO/WHO Codex Alimentarius Commission, concerned with food safety; (ii) the World Organisation for Animal Health (OIE), concerned with animal (including aquatic animal) life and health; and (iii) the International Plant Protection Convention, concerned with plant life and health. With regard to international trade in aquatic animals, different obligatory international treaties and agreements and other voluntary guidelines are involved. Examples of binding international agreements are the aforementioned SPS Agreement, the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and related legislation and directives of the EU. Examples of voluntary agreements and guidelines include that of the International Council for the Exploration of the Sea,[23] the codes of practice of the European Inland Fisheries Advisory Commission[24] and the FAO Code of Conduct for Responsible Fisheries[25] and a number of supporting technical guidelines.[26] These international agreements have added to the responsibilities of competent authorities in dealing with biosecurity risks. In many instances, voluntary international guidelines are incorporated into national legislations and, thus, become mandatory at the national level.

The OIE Aquatic Animal Health Code (the Aquatic Code),[27] a reference document for use by competent authorities, import/export services and all those involved in the international trade of aquatic animals and their products, assures the sanitary safety of such trade. The OIE Manual of Diagnostic Tests for Aquatic Animals (the Aquatic Manual)[28] provides a standardized approach to the diagnosis of diseases listed in the Aquatic Code to facilitate health certification of trade in aquatic animals and aquatic animal products. Both the Aquatic Code and Aquatic Manual are updated on a regular basis with available new information. For example, in 2007, the Aquatic Code updated the list of aquatic diseases and included KHV as a reportable and notifiable finfish disease.

Countries producing foods of animal origin and wishing to export them to the EU market must satisfy certain animal health, public health, veterinary certification and residues requirements, which are published and updated regularly as EU legislation and directives.[29]

The International Day for Biological Diversity, an annual event arranged by the Secretariat of the CBD to increase understanding and awareness of biodiversity issues, was celebrated on 22 May 2009 with the theme "Biodiversity and Invasive Alien Species".[30]

GloBallast Partnerships, a five-year (October 2007 to October 2012) joint project of the International Maritime Organization (IMO), the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), member governments and the shipping industry, is aimed at assisting vulnerable developing states and regions to implement sustainable, risk-based mechanisms for the management and control of ballast water and sediments in order to minimize the adverse impacts of aquatic invasive species transferred by ships.[31]

Examples of recent actions by FAO on biosecurity include: (i) technical assistance in the investigation of EUS incursion in southern Africa (2007)[32] and emergency response to KHV in Asia (2003);[33] (ii) pioneering work in promoting the application of risk analysis to aquaculture production,[34] which has now expanded to other regions (e.g. Western Balkans,[35] Persian Gulf,[36] Pacific Islands); and (iii) the organization, in December 2009, of an expert workshop on improving aquatic biosecurity through prudent and judicious use of veterinary medicinal products. This expert workshop was supported by the EU, OIE and World Health Organization (WHO) and FAO Member Governments. All these actions support the development of the knowledge base and enhance human and technical capacity on biosecurity.

FUTURE PERSPECTIVES

The recent global crisis in food prices has put pressure on both governments and the international community to ensure an adequate supply of food for a growing population. Many challenges lie ahead in terms of: continuing trade globalization; intensification and diversification of farming practices; further advancement in technological innovations in food production; changing human behaviour and ecological systems; heightened awareness for biodiversity protection; greater demand for public health and environmental protection; and increasing concerns on animal welfare and impacts of climate change. These challenges will lead to greater attention and commitments on improving biosecurity and the wider application of risk analysis and adaptive management as valuable decision-making tools. In the absence of appropriate and effectively implemented biosecurity measures, risks from biological hazards will continue to threaten the aquaculture sector, inflicting losses and requiring more resources to mitigate them.

It is not possible to know and predict precisely every potential source of harm and its pathways. Thus, it is important that the use of risk analysis as a concept be understood and embraced rather than shied away from because of the seeming complexity of the process. Effective application of risk analysis will require enabling structures and mechanisms, such as capacity building, efficient planning and governance, better institutional coordination, a programme to address issues associated with globalization and trade, a programme to manage the use of limited natural resources,[37] and a national-level strategy to deal with the social and biological impacts of climate change.

Which fish to eat: enjoying the benefits while minimizing the risks

THE ISSUE

While the consumption of seafood has well-established nutritional and health benefits, some fish species can be harmful when they accumulate contaminants. The question is how to maximize the positive consequences of seafood consumption while minimizing the concurrent negative consequences.

The risks of consuming potentially contaminated foods have traditionally received greater attention than the benefits of eating them. However, there is now a growing focus on the risks of *not* consuming certain foods, and among them fish products, given their potential beneficial components. Nutritional benefits derive not only from the long-chain polyunsaturated fatty acids (LCPUFAs) – docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) – but also from amino acids, micronutrients (vitamins, minerals) and possibly from other nutrients (e.g. taurine), all found in fish.

The fact that fish consumption helps prevent coronary heart disease (CHD) has been well known for some time. There is now an increasing focus on fish as a source of DHA and iodine, which are essential for the early development of the brain and neural system. These nutrients are almost exclusively found in foods from the aquatic environment. The role of fish in mitigating mental disorders, such as depression and dementia, is also receiving increased attention from scientists.

However, the presence of contaminants in some fish and fish products and other foods is of increasing concern to consumers. Some fish products are known to contain contaminants such as methyl mercury (mercury in its most toxic form) and dioxins (all dioxin-like compounds).

In general, it is believed that the levels of such contaminants in seafood are well below the maximum levels established for their safe intake. Nevertheless, in fish caught in polluted waters or in large, long-lived predator species, the levels of contaminants might exceed the levels regarded as safe for consumption.

It is well known that ingested mercury might have a negative impact on the development of the neural system of children and that some fish species can be the main source of mercury in many diets. Fish can also be a source of dioxins in populations that consume fish frequently. However, the occurrence of dioxins among individuals in these populations is generally not higher than in populations having low fish consumption.[38] Therefore, reducing the consumption of fish might reduce the exposure to mercury in human diets, but the exposure to dioxins will probably be the same for individuals even if they significantly reduce their consumption of fish.

When consumption of a food can be associated with both potential health risks and benefits, risk managers try to identify an intake level that minimizes risks and maximizes benefits. It is particularly important to establish such levels when consumption levels are close to levels that should not be exceeded.[39]

Advice on limiting the consumption of fish for vulnerable groups, such as children and pregnant women, is being given by many public health authorities. While the intention is only to limit consumption of products believed to have elevated levels of contaminants, the effect in some cases has been a significant reduction in seafood consumption. However, a reduction in seafood consumption could result in a diet that might not ensure an optimal intake of essential nutrients. Both children and adults run this risk. As LCPUFAs are essential in the early development of the brain and neural system in children, advice aiming to limit the consumption of contaminated fish must be couched in such terms that not all fish is given a "bad name". Similarly, as seafood consumption reduces cardiovascular diseases among the adult population, messages intended to reduce the exposure of fish products to contaminants should go hand in hand with the promotion of safe fish products.

POSSIBLE SOLUTIONS

Most informed observers would probably agree that the solution to this issue consists of sound, science-based advice that weighs the benefits and costs for human health of consuming fish. Although much work has been done in this field, the subject is not exhausted and conclusions reached to date have not obtained universal endorsement.

Addressing this issue is a complex and resource-demanding scientific task that includes: (i) an assessment of the health risks associated with the consumption of fish and other seafood; (ii) an assessment of the health benefits associated with the consumption of fish and other seafood; and (iii) a subsequent comparison of the health risks and health benefits.

Some studies[40] have tried to balance the positive and negative sides of consuming foods of high nutritional value but that are also a source of contaminants. However, to date, the procedures used have been controversial, and experts in this field maintain that new procedures need to be developed in order to carry out quantitative assessments of the risks and benefits to human health of consuming fish and other seafood.[41] Once the methodology has been developed, the required data will need to be obtained. The new procedures should make it possible to compare nutritional benefits with the possibility of adverse effects while accounting for the uncertainties – this should be possible for all groups in the population. In addition, scientists should be able to make quantitative comparisons of the human health risks and benefits of seafood consumption.

RECENT ACTIONS

In order to assist governments in giving advice to vulnerable population groups on the potential risks and benefits of consuming fish and seafood, the Codex Alimentarius Commission requested FAO and the WHO to hold an expert consultation on health risks associated with mercury and dioxins in fish and the health benefits of fish consumption.

The Expert Consultation on the Risks and Benefits of Fish Consumption was held from 25 to 29 January 2010 at FAO Headquarters, Rome, Italy.[42] Seventeen experts in nutrition, toxicology and risk-benefit assessment discussed the risks and benefits of fish consumption. The experts agreed that consumption of fish provides energy, protein and a range of essential nutrients, and that eating fish is part of the cultural traditions of many peoples. In some populations, fish and fishery products are a major source of food and essential nutrients, and there may be no alternative and affordable food sources for these nutrients.

Among the general adult population, consumption of fish, and in particular oily fish, lowers the risk of CHD mortality. There is an absence of probable, or convincing, evidence of mercury causing CHD. Although there is a risk that dioxins may cause cancer, the risk is comparatively small and seems to be outweighed by reduced CHD mortality for those who eat fish. Weighing the benefits of LCPUFAs against the risks of mercury for women of childbearing age, it is established that, in most circumstances, fish in the diet lowers the risk of women giving birth to children with suboptimal development of the brain and neural system compared with women not eating fish.[43]

At levels of maternal dioxin intake (from fish and other dietary sources) that do not exceed the established long-term tolerable intakes of dioxins, the risk of suboptimal neural development is negligible.[44] If the maternal dioxin intake (from fish and other dietary sources) exceeds the established long-term tolerable intakes of dioxins, this risk may no longer be negligible. Among infants, young children and adolescents, evidence is insufficient to derive a quantitative framework of health risks and benefits. However, healthy dietary patterns that include fish established early in life influence dietary habits and health during adult life.

To minimize risks in target populations, the Expert Consultation recommended that states should acknowledge that fish is an important food source containing energy, protein and a range of essential nutrients as well as being part of the cultural traditions of many peoples. States should therefore emphasize: (i) that fish consumption reduces CHD mortality in the adult population; and (ii) that fish consumption improves the neurodevelopment of foetuses and infants and is therefore important for women of childbearing age, pregnant women and nursing mothers. In order to provide sound advice to different population groups, it will also be important to develop, maintain and/or improve regional databases of the specific nutrients and contaminants in the fish available for consumption. Risk management and communication strategies that aim to minimize risks and maximize benefits from eating fish should be developed and evaluated.

FUTURE PERSPECTIVES

Mental illness

Mental illness and depression are increasing globally. Some experts predict that they will become a major burden in terms of global health, especially in the developed world.[45] In 2004, mental health overtook heart disease as the leading health problem in

Europe and was estimated to cost €386 billion a year.[46] More recent studies suggest that consumption of seafood and in particular long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFAs) may also have a positive impact on dementia[47] and Alzheimer's disease, with the most promising evidence for the benefits on mood and depression.[48] However, such benefits should be considered as emerging, as they are not as well established as reductions in CHD deaths and improved early neurodevelopment.

Sustainability and alternative sources of LC n-3 PUFAs

Although there is no association between resource sustainability and health, the issue of sustainability must be considered if proven health benefits lead to greatly increased demand for seafood. With the known wide range of benefits from seafood consumption, it is pertinent to consider whether increased production is possible. For the last 20 years, global landings from capture fisheries have been stagnant at around 89–93 million tonnes. Even with the widespread failure to manage fishery resources properly, which has resulted in a situation where some 28 percent of stocks are overexploited, there is general scientific agreement that significantly more cannot be produced from wild fish populations.

However, total global fish production has continued to rise, amounting to about 142 million tonnes in 2008.[49] The balance is made up by production from aquaculture, which now amounts to 52.5 million tonnes, accounting for almost 46 percent of all fish for human consumption.

Global fish consumption has gradually increased, regardless of the increasing world population, and stood at 17.0 kg of fish (live weight equivalent) per capita per year in 2008.[50] A widespread recognition of the benefits of seafood consumption would inevitably lead to additional demand. If the recommendations of authorities in the United Kingdom of two meals of 140 g of fish per week[51] were followed, then annual per capita consumption would have to rise to 23.3 kg. This translates into an additional production of 40 million tonnes for 2008, rising to 82 million tonnes in 2050.

Aquaculturists are optimistic that far more fish can be produced, but there are issues of nutritional quality using land-based feeds. It would be necessary to incorporate LC n-3 PUFAs into the feeds. Intensive research is required on how this could be achieved, including on production from hydrocarbons by yeast fermentation, extraction from algal sources[52] and/or genetic modification of plants to become LC n-3 PUFA producers. However, for now and probably for the new decade, the source of LC n-3 PUFAs will remain marine capture fisheries.

Fisheries sector transparency

THE ISSUE

Fishing vessel registration and the maintenance of a comprehensive record of fishing vessels are fundamental pillars for effective fisheries management and enforcement at the national level and essential for collaborative effort at the regional and global levels. Their importance has been recognized in most major international fisheries instruments of recent years. However, despite this, comprehensive data on the world's fishing fleets are not readily available. In particular, the technical guidelines on the implementation of the IPOA-IUU recognize that there is no single and complete database or record of fishing vessels in the world – a situation that creates opportunities for IUU fishing vessels to escape detection.[53]

The IPOA-IUU provides the strategic framework through which states can fulfil their obligations as responsible international citizens in the fisheries context, and it has the single objective to prevent, deter and eliminate IUU fishing through effective and transparent measures. Its operational principles stress the essential nature of close and effective national, regional and international coordination and collaboration, the sharing of information, cooperation to ensure measures are applied in an integrated

manner, and transparency. Overall, the IPOA-IUU scheme underlines the fact that IUU fishing is an international, transboundary phenomenon that cannot be effectively addressed through disconnected national efforts alone. In particular, the IPOA-IUU calls on all states to maintain a record of fishing vessels entitled to fly their flag and, by strong inference, to share that record widely – in the interests of cooperation, collaboration and transparency.

POSSIBLE SOLUTION

In seeking a solution to the global lack of transparency, the proposed Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (the Global Record) could be the essential tool currently missing from the existing IUU toolbox. The reduced effectiveness of current tools and measures stems from a lack of real-time quality information and the transparency that improved information availability would create. The Global Record would not only create a detailed record of all included fishing vessels, it would also create a reliable mechanism through which a wide variety of vessel-related information could be displayed. Through a single source, it would have the potential to provide a complete information picture and be the catalyst for significantly improved transparency and collaboration at all levels. No such information tool currently exists.

Today, IUU fishing is a global issue prevalent both within EEZs and on the high seas; and markets are global in nature, ensuring the international movement of vast quantities of fish and fish product. It is clear that the effective management of fishing vessels and their activity is essential to overcoming the IUU problem. Most countries maintain a register or record of larger industrial fishing vessels and carrier vessels, although many do not maintain any records of smaller fishing vessels. Regional registers and records also make an important contribution within the regional context. However, they often lack many of the characteristics necessary for effective global application and they usually do not provide the wider information picture envisaged by the Global Record.

RECENT ACTIONS

The 2005 Rome Declaration by Ministers on IUU Fishing called for the development within FAO of a comprehensive global record of fishing vessels, including refrigerated transport vessels and supply vessels. As a result, the Twenty-seventh and Twenty-eighth Sessions of the COFI in 2007 and 2009 endorsed a programme of work to explore the concept further so that the findings could be presented to a Technical Consultation.

The EU's Fleet Register[54] provides an example of a comprehensive fleet record, publicly available and searchable online without cost. It provides an excellent description of each vessel although it does not display ownership and operator details. The inclusion of such information would enhance its overall value and provide a model for states that would significantly improve sector-wide transparency and enhance compliance with international obligations.

However, no country outside the EU appears to provide publicly available data in this way, making it impossible to scrutinize commitments made to sustainability measures and fleet capacity reductions. Nor is it possible for practitioners of MCS to identify and assess vessels with any degree of accuracy without direct inspection and lengthy investigation. Traceability schemes also rely heavily on the ability of state parties to verify supplied data. However, without basic transparency in the sector, this is impossible, raising significant questions about the reliability of information in these schemes.

This lack of basic transparency could be seen as an underlying facilitator of all the negative aspects of the global fisheries sector – IUU fishing, fleet overcapacity, overfishing, ill-directed subsidies, corruption, poor fisheries management decisions, etc. A more transparent sector would place a spotlight on such activities whenever they occur, making it harder for perpetrators to hide behind the current veil of secrecy and requiring immediate action to be taken to correct the wrong.

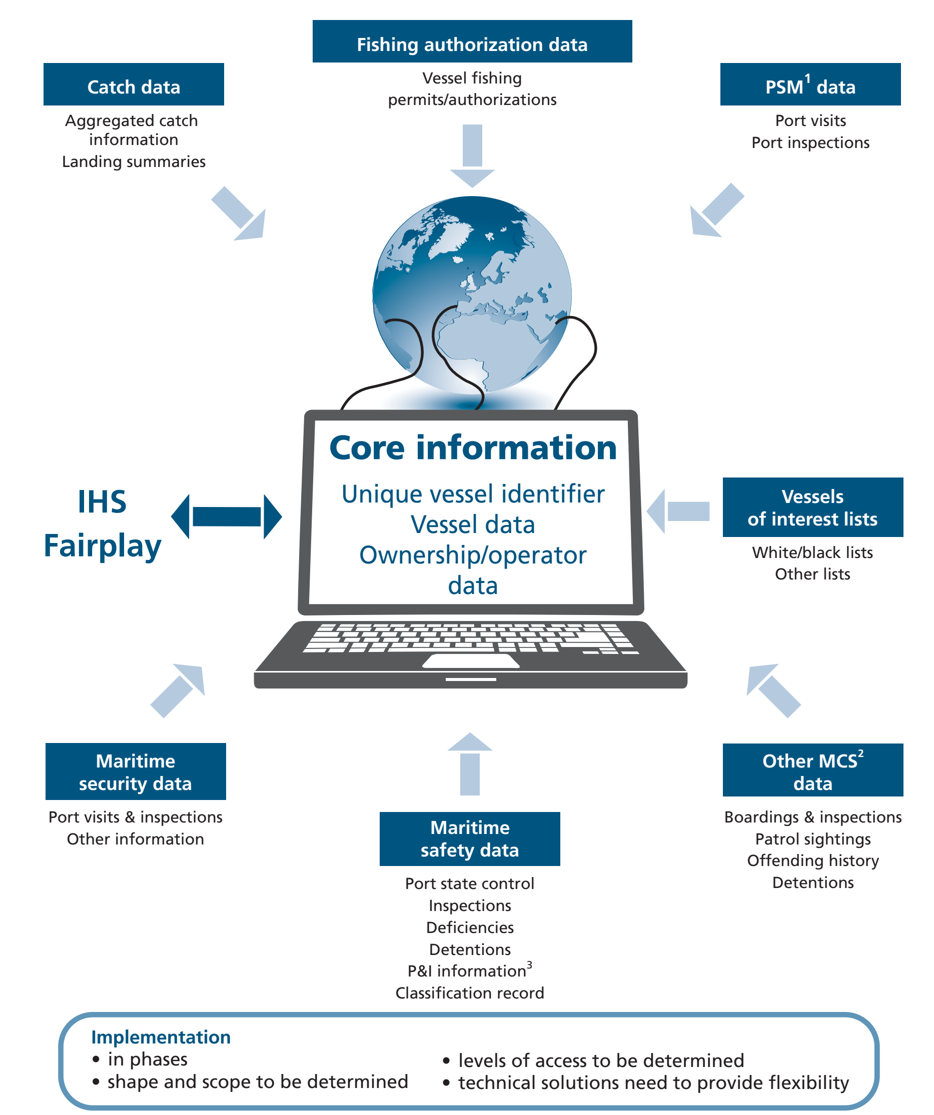
FUTURE PERSPECTIVES

The proposed "Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels" (the Global Record) is intended to be the catalyst around which global transparency in the fisheries sector can be improved. Other important recent initiatives such as the Port State Measures Agreement to combat IUU fishing and the proposed guidelines on flag state responsibility are essential additions to the strategic framework to combat IUU fishing, but they will never achieve their potential impact without a more transparent environment in which to operate. The proposed Global Record can help create that environment and, in doing so, act as a force-multiplier for all other tools and initiatives employed in the fight against IUU fishing.

The Global Record is envisaged as a global repository (database) designed primarily to provide reliable identification of vessels authorized to engage in fishing or fishing-

Figure 36

Examples of data modules as part of a comprehensive global record of fishing vessels



[1] Port state measures.
[2] Monitoring, control and surveillance.
[3] Protection and indemnity information.

Source: Based on IHS Fairplay (formerly known as Lloyd's Register-Fairplay).

Table 13
Numbers of fishing vessels by type with IHS-F (IMO) numbers

	Number of vessels[1]
Fishing vessels	12 842
Fish carriers	616
Trawlers	9 513
Fishing support vessels	397
Fish factory ships	68
Total	**23 436**

[1] Figures as supplied by IHS Fairplay (formerly known as Lloyd's Register-Fairplay) as of 30 November 2009.

Table 14
Top ten flag states with fishing vessels carrying IHS-F (IMO) numbers

	Number of vessels[1]
European Union (22 states)	3 879
United States of America	3 372
Russian Federation	1 465
Japan	1 234
Republic of Korea	1 136
Peru	714
Norway	469
China	462
Philippines	444
Morocco	425
Total (top ten states)	**13 600**

[1] Figures as supplied by IHS Fairplay (formerly known as Lloyd's Register-Fairplay) as of 30 November 2009.

related activity. An essential element will be the assignment of a unique vessel identifier (UVI) to each vessel so that, regardless of ownership or flag changes over time, the UVI will remain constant. This will provide certainty to the vessel record and facilitate the accurate association of vessel-related information so that a comprehensive information picture can be developed. Once the core vessel record has been established, it will be possible to associate a wide range of information modules and provide a comprehensive information picture on all aspects of the vessel's operation (Figure 36).

It is envisaged that the Global Record will be Web-based with simple, user-friendly search facilities making it accessible to a wide variety of users. Nevertheless, despite the underlying desire for openness and transparency, it will be possible to provide varying levels of access where appropriate. The Global Record's use of UVIs will provide a high degree of accuracy, and careful analysis is being undertaken as to the best options available to facilitate this. Administered by IHS Fairplay (formerly known as Lloyd's Register-Fairplay), the "International Maritime Organization (IMO) numbering system" that is used for merchant vessels of more than 100 GT tonnes offers an ideal model, with 23 436 active fishing vessels having already obtained IHS-F numbers (Table 13). This existing involvement in the IMO numbering scheme comes from 165 individual states, with 10 states accounting for 58 percent of the vessels (Table 14). Overall, it is believed that the global fishing fleet consists of about 140 000 vessels of more than 100 GT or 24 m length overall (LOA), and so current representation in the scheme is about 17 percent.

This relatively high level of voluntary uptake suggests confidence in the scheme and provides an excellent platform from which all flag states should be encouraged to adopt it for all qualifying fishing vessels. The IHS-F (IMO) number should be viewed as adding value to national and regional vessel registration processes and in no way replaces national or regional vessel registration numbers – it simply adds the essential international dimension needed for global fisheries sector transparency.

A number of RFMOs – and in particular the five tuna RFMOs – have demonstrated outstanding sector leadership in their drive to create a harmonized global record of tuna vessels incorporating the IHS-F (IMO) number as the UVI for each vessel. The development process for this work is providing important insights for the Global Record, and these partnerships are valued by FAO. At a Technical Consultation held at FAO in November 2010, Member States discussed the scope, shape and management of the Global Record.

NOTES

1 *Illegal* fishing is fishing that takes place when vessels operate in violation of the applicable laws and regulations. *Unreported* fishing is fishing that has been unreported or misreported in contravention of applicable laws and regulations. *Unregulated* fishing is fishing in areas where there are no conservation and management measures in place.

2 They account for about 50 percent of the fish and fish products that enter into the international trade.

3 D.J. Agnew, J. Pearce, G. Pramod, T. Peatman, R. Watson, J.R. Beddington and T.J. Pitcher. 2009. Estimating the worldwide extent of illegal fishing. *PLoS ONE*, 4(2): e4570 (available at www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0004570;jsessionid=604D72E332D75382B5EC14CB81197ADD). The study estimated the worldwide cost of illegal and unreported fishing by using detailed reports from published scientific literature and in-country specialist studies. The source studies used a number of different methods to estimate the level of illegal and unreported fishing, including surveillance data, trade data, stock assessments based on fishery-dependent data and expert opinion.

4 FAO. 2009. *The State of World Fisheries and Aquaculture 2008*. Rome. 176 pp.

5 Documentation schemes have been implemented by the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), the Indian Ocean Tuna Commission (IOTC), the Inter-American Tropical Tuna Commission (IATTC), and the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR).

6 Title IV of the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (MRSA).

7 European Commission. 2008. *Council Regulation (EC) No 1005/2008 of 29 September 2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing, amending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and repealing Regulations (EC) No 1093/94 and (EC) No 1447/1999* (available at eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:286:0001:0032:EN:PDF).

8 Ibid.

9 The WTO requires that foreign origin product "shall be accorded treatment no less favourable than that accorded to like products of national origin in respect of all laws, regulations and requirements affecting their internal sale" (Article III of the General Agreement on Tariffs and Trade).

10 European Commission. 2009. *Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy* (available at www.illegal-fishing.info/item_single.php?item=document&item_id=689&approach_id=16).

11 FAO. 2001. *International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing*. Rome. 24 pp.

12 European Commission. 2009. *Handbook on the practical application of Council Regulation (EC) No. 1005/2008 of 29 September 2008 establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing*. Mare A4/PS D(2009) A/12880. (available at dtn.go.th/dtn/tradeinfo/Oct%2009_handbook%20on%20the%20practical%20application%20of%20the%20IUU%20regulation.pdf).

13 Zoonosis refers to diseases that can be transmitted between animals and humans.

14 J.R. Arthur, M.G. Bondad-Reantaso, C. Hewitt, M.L. Campbell, C.L. Hewitt, M.J. Phillips and R.P. Subasinghe. 2009. *Understanding and applying risk analysis in aquaculture: a manual for decision-makers*. FAO Fisheries and Aquaculture Technical Paper No. 519/1. Rome, FAO. 113 pp.

15 M.G. Bondad-Reantaso, A. Lem and R.P. Subasinghe. 2009. International trade in aquatic animals and aquatic animal health: What lessons have we learned so far in managing the risks? *Fish Pathology*, 44(3): 107–114.
16 M.G. Bondad-Reantaso, R.P. Subasinghe, J.R. Arthur, K. Ogawa, S. Chinabut, R. Adlard, Z. Tan and M. Shariff. 2005. Disease and health management in Asian aquaculture. *Veterinary Parasitology*, 132: 249–272.
17 European Commission. 2001. *Directive 2001/82/EC of the European Parliament and of the Council of 6 November 2001 on the Community code relating to veterinary medicinal products* (available at ec.europa.eu/enterprise/sectors/pharmaceuticals/files/eudralex/vol-5/dir_2001_82/dir_2001_82_en.pdf).
18 Within the scope of this definition, the following terms are also used: alien species, aquatic nuisance species, exotic species, non-native species, foreign species, non-indigenous species, invasive species. See also J.T. Carlton. 2001. *Introduced species in U.S. coastal waters: environmental impacts and management priorities*. Arlington, USA, Pew Oceans Commissions.
19 Water carried by ships to ensure stability, trim and structural integrity.
20 Op. cit., see note 14.
21 Adaptive management, also known as adaptive resource management, is a structured, iterative process of optimal decision-making in the face of uncertainty that aims to reduce such uncertainties over time via system monitoring. In this way, decision-making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. Adaptive management is often characterized as "learning by doing".
22 World Trade Organization. 1994. Agreement on the Application of Sanitary and Phytosanitary Measures. *In: The Results of the Uruguay Round of Multilateral Trade Negotiations: The Legal Texts, General Agreement on Tariff and Trade (GATT)*, pp. 69–84. Geneva, Switzerland.
23 International Council for the Exploration of the Sea. 2005. *ICES Code of practice on the introductions and transfers of marine organisms 2005*. Copenhagen.
24 G. Turner, ed. 1988. *Codes of practice and manual of procedures for consideration of introductions and transfers of marine and freshwater organisms*. EIFAC Occasional Paper No. 23. Rome, FAO. 49 pp.
25 FAO. 1995. *FAO. Code of Conduct for Responsible Fisheries*. Rome. 41 pp.
26 FAO. 2008. *Aquaculture development. 5. Genetic resource management*. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 3. Rome. 125 pp.
FAO. 2007. *Aquaculture development. 2. Health management for responsible movement of live aquatic animals*. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 2. Rome. 31 pp.
FAO and NACA. 2000. *Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy*. FAO Fisheries Technical Paper No. 402. Rome. 53 pp.
27 World Organisation for Animal Health. 2009. *Aquatic Animal Health Code 2009*. Paris (also available at www.oie.int/eng/normes/fcode/en_sommaire.htm).
28 World Organisation for Animal Health. 2009. *Manual of Diagnostic Tests for Aquatic Animals 2009*. Paris (also available at www.oie.int/eng/normes/fmanual/A_summry.htm).
29 EU legislation and directives on animal health are available at europa.eu/legislation_summaries/food_safety/animal_health/index_en.htm.
30 Information on this event is available at www.cbd.int/idb/2009/.
31 Information on GloBallast Partnerships is available at globallast.imo.org/index.asp?page=GBPintro.html&menu=true.
32 FAO. 2009. *Report of the International Emergency Disease Investigation Task Force on a Serious Finfish Disease in Southern Africa, 18–26 May 2007*. Rome. 70 pp.

33 M.G. Bondad-Reantaso, A. Sunarto and R.P. Subasinghe. 2007. Managing the koi herpesvirus disease outbreak in Indonesia and the lessons learned. *In* B. Dodet and OIE Scientific and Technical Department, eds. *The OIE Global Conference on Aquatic Animal Health*, pp. 21–28. Developments in Biologicals Vol. 129. Basel, Karger.

34 M.G. Bondad-Reantaso, J.R. Arthur and R.P. Subasinghe, eds. 2008. *Understanding and applying risk analysis in aquaculture*. FAO Fisheries and Aquaculture Technical Paper No. 519. Rome, FAO. 304 pp.

35 M.G. Bondad-Reantaso, J.R. Arthur and R.P. Subasinghe, eds. 2009. *Strengthening aquaculture health management in Bosnia and Herzegovina*. FAO Fisheries and Aquaculture Technical Paper No. 524. Rome, FAO. 83 pp.

36 FAO and Regional Commission for Fisheries. 2008. *Report of the Regional Technical Workshop on Aquatic Animal Health. Jeddah, Kingdom of Saudi Arabia, 6–10 April 2008*. FAO Fisheries and Aquaculture Report No. 876. Rome. 119 pp.

37 Op. cit., see note 14.

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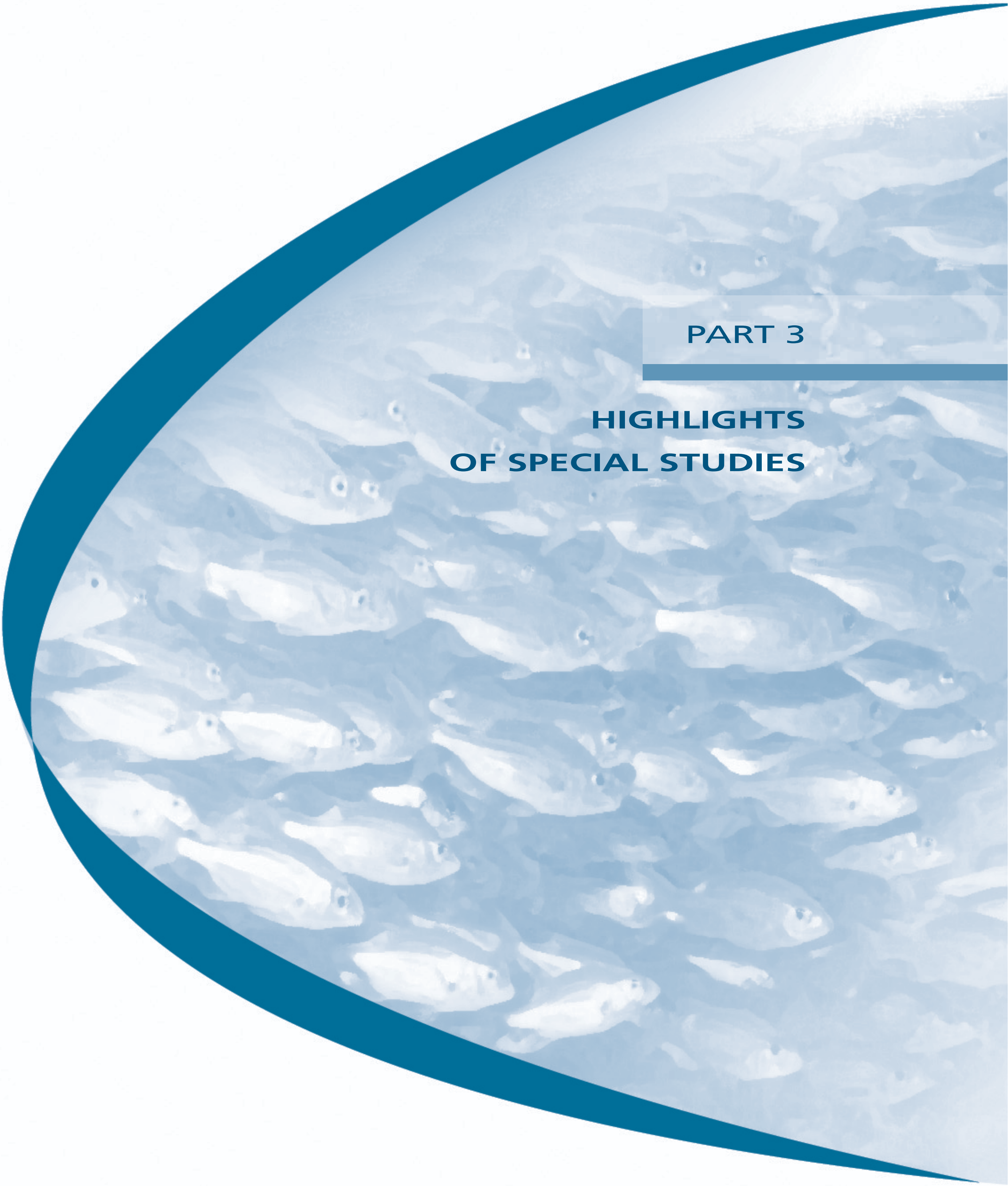


PART 3

HIGHLIGHTS OF SPECIAL STUDIES

HIGHLIGHTS OF SPECIAL STUDIES

Climate change implications for fisheries and aquaculture: overview of current scientific knowledge

Climate change is bringing substantial changes to the world's capture fisheries, which are already under stress from overfishing and other anthropogenic influences. Inland fisheries – most of which are in developing African and Asian countries – are at particularly high risk, threatening the food supply and livelihoods of some of the world's poorest populations. There are also consequences for aquaculture, which is especially significant for populations in Asia. States need to act to ensure that the people who depend on fish for food and livelihoods have the capacity, new policies and resources to adapt to the changing waters.

The effects of climate change on the world's capture fisheries and aquaculture resources and the people who depend on them for their food and livelihoods are examined in a recent technical paper published by FAO.[1] In three parts (each written by leading experts), the technical paper reviews: the physical effects of climate change and their impacts on marine and inland capture fisheries and aquaculture; the consequences of these changes for fishers and their communities; and the consequences for aquaculture. The latter two parts investigate options for adaptation as well as mitigation in the subsectors. The technical paper represents a synthesis of about 500 technical reports and articles on the subject and presents a comprehensive picture of what is known about the effects of climate change on fisheries and aquaculture (Figure 37).

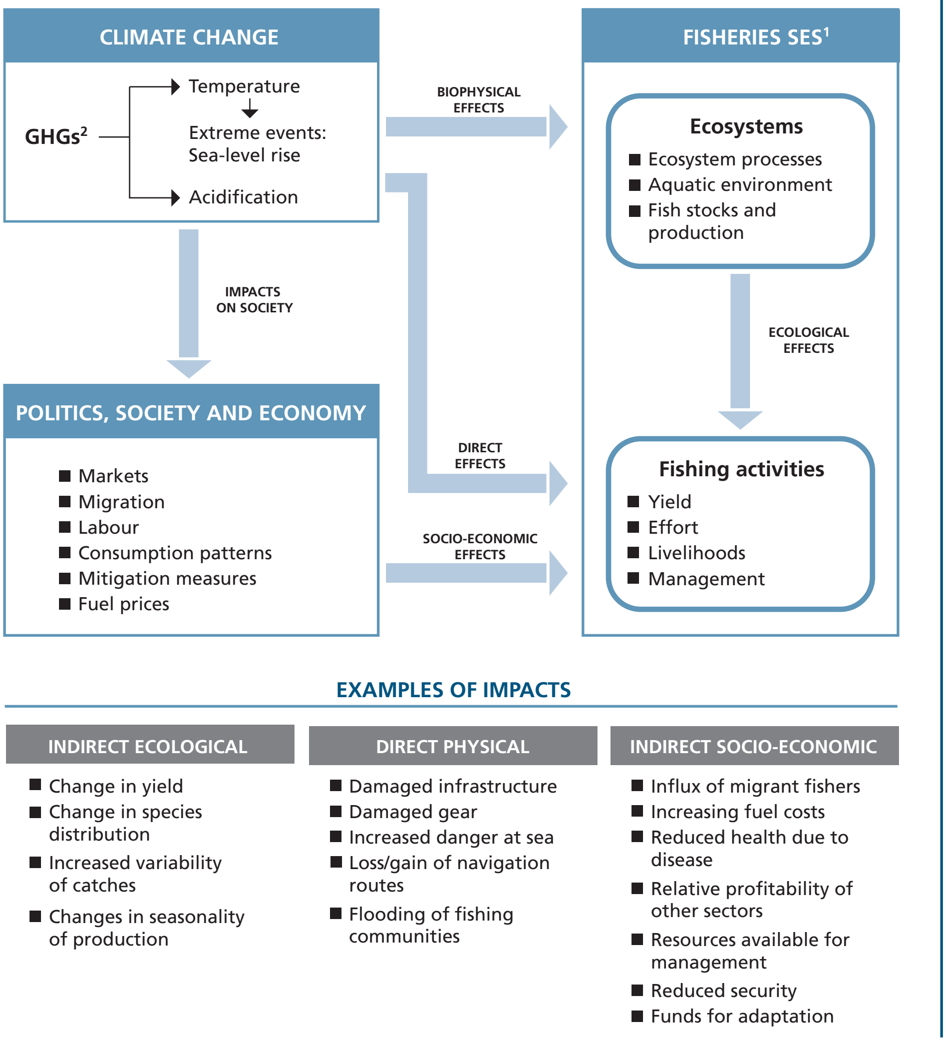
ECOLOGICAL AND PHYSICAL IMPACTS OF CLIMATE CHANGE

Under climate change, the oceans are warming but this warming is not geographically homogeneous. The combined effect of temperature and salinity changes caused by climate warming is expected to reduce the density of surface waters and thus increase vertical stratification. These changes are likely to reduce nutrient availability in the surface layer and, therefore, primary and secondary production in a warmed world. Moreover, there is evidence that upwelling seasonality may be affected by climate change, with impacts across the food web. The consequences of climate change will probably affect community composition, production and seasonality processes in plankton and fish populations. Increasing acidity (decreasing pH) of the world's oceans is a significant and pervasive longer-term threat to coral reefs. In the short term, increased temperatures linked to coral bleaching may lead to steady degradation of reefs and other ecosystems. In the long term, increasing water acidification and a weakening of the structural integrity of reefs is forecast. The potential for coral reef systems to adapt to these environmental stresses is uncertain.

As temperatures warm, marine fish populations at the poleward extents of their ranges will increase in abundance whereas populations in more equatorward parts of their range will decline in abundance. In general, climate change is expected to drive the ranges of most terrestrial and marine species towards the poles, expanding the range of warmer-water species and contracting that of colder-water species. The most rapid changes in fish communities will occur with pelagic species that are expected to shift to deeper waters to counteract rising surface temperatures. Moreover, the timing of many animal migrations will be affected. Ocean warming will also alter the predator–prey matches because of the differential responses between plankton components (some responding to temperature change and others to light intensity).

Figure 37

Examples of direct and indirect pathways of climate change



[1] Social-ecological systems.
[2] Greenhouse gases.
Source: T. Daw, W.N. Adger, K. Brown and M.-C. Badjeck. 2009. Climate change and capture fisheries: potential impacts, adaptation and mitigation. *In* K. Cochrane, C. De Young, D. Soto and T. Bahri, eds. *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge,* pp. 107–150. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp.

There is evidence that inland waters are also warming but that there are differential impacts of climate change on the river runoff that feeds these waters. In general terms, high-latitude and high-altitude lakes will experience reduced ice cover, warmer water temperatures, a longer growing season and, as a consequence, increased algal abundance and productivity. In contrast, some deep tropical lakes will experience reduced algal abundance and declines in productivity, probably owing to reduced supply of nutrients. Regarding freshwater systems in general, there are also specific concerns over changes in timing, intensity and duration of floods, to which many fish species are adapted in terms of migration, spawning and transport of spawning products, as a result of climate change.

The technical paper also summarizes the consequences of climate change along “rapid”, intermediate and long time scales. These encompass impacts on physiology of fish (including consequences for aquaculture), ecology of short-lived species and changes in species distributions and abundance. Information is lacking for the long time scale and there are considerable uncertainties and research gaps that the paper outlines.

FISHERS AND THEIR COMMUNITIES

Fisheries-dependent economies, coastal communities and fisherfolk are expected to experience the effects of climate change in a variety of ways. These include: displacement and migration of human populations; effects on coastal communities and infrastructure due to sea-level rise and changes in the frequency, distribution or intensity of tropical storms; and less stable livelihoods and changes in the availability and quantity of fish for food.

The vulnerability of fisheries and fishing communities depends on their exposure and sensitivity to change, but also on the ability of individuals or systems to anticipate and adapt. This adaptive capacity relies on various community assets and can be constrained by culture, current institutional and governance frameworks or marginalized access to adaptive resources. Vulnerability varies between countries and communities and between demographic groups within society. Generally, poorer and less empowered countries and individuals are more vulnerable to the effects of climate change, and the vulnerability of fisheries is likely to be higher where the resources already suffer from overexploitation, the ecosystems are degraded and the communities face poverty and lack sufficient social services and essential infrastructure.

Fisheries are dynamic social-ecological systems and are already experiencing rapid change in markets, exploitation and governance. The combined effects of these changes and the biophysical and human impacts of climate change make it difficult to predict the future effects of climate change on fisheries social-ecological systems.

Human adaptation to climate change includes reactive or anticipatory actions by individuals or public institutions. These range from abandoning fisheries altogether for alternative occupations to developing insurance and warning systems and changing fishing operations. Governance of fisheries will need the flexibility to account for changes in stock distribution and abundance. Governance aimed towards equitable and sustainable fisheries, accepting inherent uncertainty and based on an ecosystem approach is generally thought to be the best approach to improve the adaptive capacity of fisheries.

Greenhouse gas contributions of fisheries and related supply chain features are small when compared with other sectors but, nevertheless, can be reduced with identifiable measures already available. In many instances, climate change mitigation could be complementary to and reinforce existing efforts to improve fisheries sustainability (e.g. reducing fishing effort and fleet capacity in order to reduce energy consumption and carbon emissions). Technological innovations could include energy reduction in fishing practices and more efficient post-harvest and distribution systems. There may also be important interactions for the sector with respect to environmental services (e.g. maintaining the quality and function of coral reefs, coastal margins, inland watersheds), and potential carbon sequestration (Box 12) and other nutrient management options, but these will need further research and development.

AQUACULTURE

Aquaculture now accounts for almost 50 percent of fish consumed by humans, and this share is expected to increase further to meet future demand. Of considerable concern is the long-term ability of capture fisheries production to produce the fishmeal and fish-oil supplies used as feed components in aquaculture. Alternatives, such as soybean, corn meal, rice bran and others, have not been perfected according to fish requirements, and the increased demand for these agricultural products created by expanding aquaculture could also have consequences.

Box 12

Blue carbon: the role of healthy oceans in binding carbon

The facts

Black and brown carbon emissions from fossil fuels, biofuels and wood burning are major contributors to global warming. Green carbon, the carbon stored in plants and soils, is a vital part of the global carbon cycle. Blue carbon is the carbon captured by the world's oceans and represents more than 55 percent of the green carbon. The carbon captured in living organisms in oceans is stored in the form of sediments from mangroves, salt marshes and seagrasses.

In addition to absorbing heat and regulating the earth's climate, oceans are the largest long-term sink for carbon (see figure). Oceans store some 93 percent of the earth's carbon dioxide (CO_2) and capture more than 30 percent of the CO_2 released annually. Most of the carbon captured is stored not for decades or centuries but rather for millennia. Importantly, restoration of green and blue carbon habitats alone could mitigate emissions by up to 25 percent.

Blue carbon sinks are also central to the productivity of coastal zones, which provide a wide range of benefits to humans (e.g. as buffers against pollution and extreme weather events, as sources of food and livelihood security and social well-being) and services estimated at more than US$25 trillion per year. Approximately 50 percent of the world's fisheries stem from these coastal waters.

The threats

The annual rate of loss of coastal marine vegetal ecosystems (2–7 percent) is up to four times that of rainforests and is caused *inter alia* by unsustainable natural resource use, poor coastal development practices, and poor watershed and waste management.

Surface water temperatures are increasing, decreasing the amount of CO_2 that can be dissolved in water. Combined with changes in acidification, water circulation and mixing and loss of blue carbon habitats, this means that the oceans' ability to absorb and store CO_2 is decreasing.

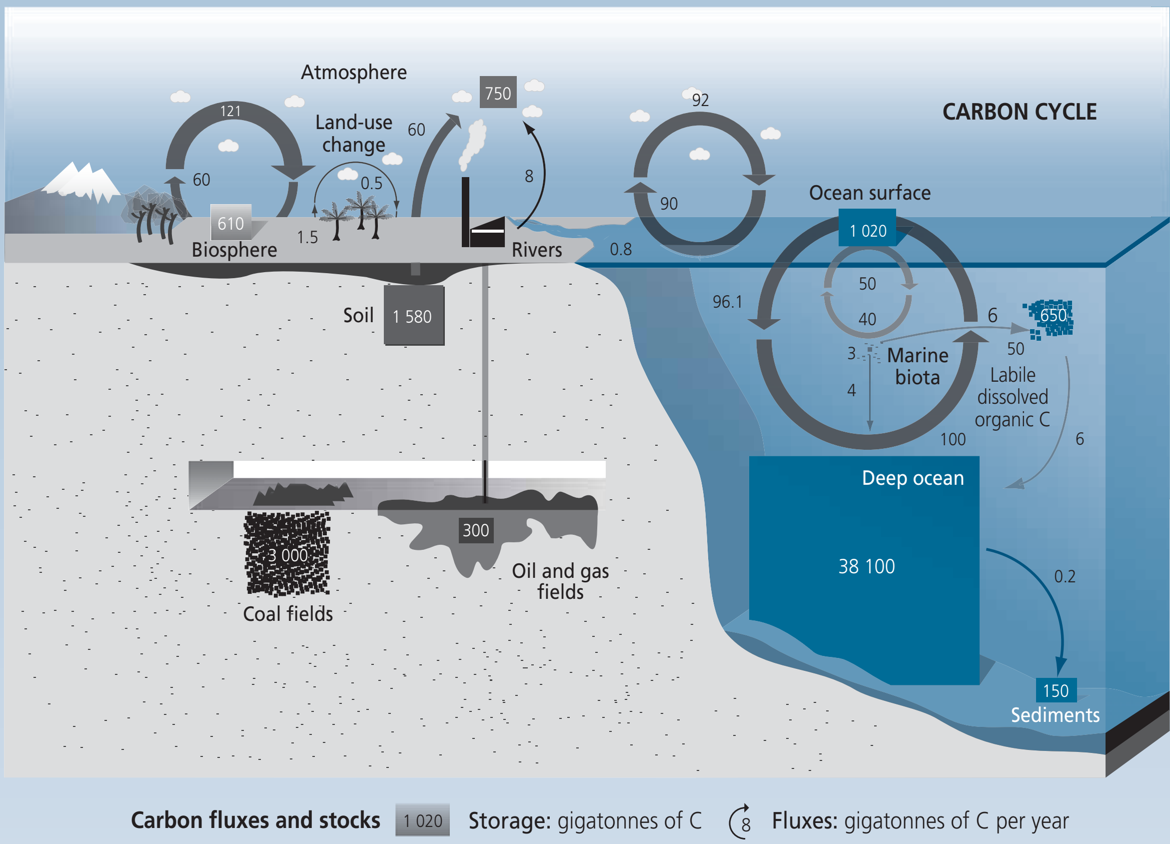
Coastal populations are in the front line of climate change and often the most vulnerable to its effects. Climate change will have impacts across all dimensions of food security as well as increasing risks at sea and the threat of damage to or loss of infrastructure and housing.

While coastal populations are growing, inflexible institutional frameworks persist in limiting adaptation strategies. In addition, monitoring and early-warning systems are deficient, and emergency and risk planning are not integrated into sectoral development.

The options

1. Establish a global blue carbon fund for the protection and management of coastal and marine ecosystems and ocean carbon sequestration.
2. Immediately and urgently protect seagrass meadows, salt marshes and mangrove forests through effective management.
3. Initiate management practices that reduce and remove threats, and that support the robust recovery potential inherent in blue carbon sink communities.
4. Maintain food and livelihood security from the oceans by implementing comprehensive and integrated ecosystem approaches to increase the resilience of human and natural systems to change.
5. Implement win–win mitigation strategies in the ocean-based sectors, including efforts to:
    - improve energy efficiency in marine transport, fishing and aquaculture sectors as well as marine-based tourism;

THE WORLD'S CARBON CYCLE



Source: Intergovernmental Panel on Climate Change.

- encourage sustainable, environmentally sound ocean-based production, including algae and seaweed;
- curtail activities that negatively affect the oceans' ability to absorb carbon;
- ensure that investment for restoring and protecting the capacity of the oceans' blue carbon sinks to bind carbon and provide food and incomes is prioritized in a manner that also promotes business, jobs and coastal development opportunities;
- catalyse the natural capacity of blue carbon sinks to regenerate by managing coastal ecosystems for conditions conducive to rapid growth and expansion of seagrass, mangroves and salt marshes.

Source: C. Nellemann, E. Corcoran, C.M. Duarte, L. Valdés, C. De Young, L. Fonseca and G. Grimsditch, eds. 2009. *Blue carbon: the role of healthy oceans in binding carbon.* A Rapid Response Assessment. Nairobi, United Nations Environment Programme, and Arendal, Norway, GRID-Arendal (also available at www.grida.no/publications/rr/blue-carbon/).

Global aquaculture is concentrated in the world's tropical and subtropical regions, with Asia's inland freshwaters accounting for 65 percent of total production. Significant aquaculture activities occur in the delta areas of major rivers. Sea-level rise in the coming decades will increase salinity intrusion further upstream, affecting brackish-water and freshwater culture practices. Adaptation would involve moving aquaculture practices further upstream or shifting to more salinity-tolerant strains of cultured species. Such measures are costly, with significant effects on the socio-economic status of the communities involved. On the other hand, aquaculture in temperate zones will be more affected by water warming to levels that will exceed the limit for many farmed species and will require changes in farmed species.

The increase in extreme weather events may affect aquaculture in several ways: physical destruction of aquaculture facilities, loss of stock and spread of disease. The risks will be larger in more open exposed sites.

Climate change is expected to affect static waters profoundly by increasing the concentration of some chemicals in the water to toxic levels and by changing the stratification of the waters, leading to increased depletion in oxygen and increasing mortality of cultured stocks. However, adaptive measures can be applied if careful monitoring and suitable strategies are in place.

Climate change also offers opportunities for aquaculture. Some inland waters could experience an increase in the availability of phytoplankton and zooplankton, which would boost aquaculture production. While increased salinity in deltas will push some aquatic farming upstream, it could also provide additional areas for shrimp farming, often a higher-value commodity, albeit one with higher energy consumption.

Unlike land-based animal husbandry, which accounts for 37 percent of all human-induced methane emissions, farmed aquatic species emit no methane. Aquaculture of molluscs and the expanding seaweed culture make a minimum contribution, if any at all, to carbon dioxide emissions, while they could contribute to carbon sequestration to some extent and also provide raw material for biofuels (algae). This enhances the value of aquaculture as an important source of animal protein with a smaller carbon footprint and relevant potential for additional mitigation of carbon release into the atmosphere.

Semi-intensive pond aquaculture constitutes one of the most widespread farming systems in Asia and these ponds can be highly productive. If well managed, these ponds can enhance carbon capture and could make a significant contribution to the sequestration of carbon in freshwater and brackish-water systems.

From drain to gain in capture fisheries rents: a synthesis study

Over the last three decades, the difference between the potential and actual economic benefits from marine fisheries has grown dramatically. The joint World Bank/FAO report, *The Sunken Billions,*[2] argues that the world's capture fishery resources are non-performing assets with rates of return, or yields, not exceeding zero – costing the world economy an estimated US$50 billion per year in forgone resource rent. Now, FAO Fisheries and Aquaculture Technical Paper No. 538[3] provides a synthesis of case studies on resource rent losses in the world's capture fisheries. It draws upon case studies in the literature as well as 17 case studies commissioned by the World Bank's PROFISH Global Program on Fisheries and FAO as part of the "Rent Drain" study project. The commissioned cases studies support the conclusions in *The Sunken Billions* and show that economic overexploitation of capture fishery resources is spread throughout the world, to be found both within developed and developing fishing states regardless of their economic systems.

How did the world's capture fishery resources end up as non-performing assets? By the middle of the twentieth century, fishery managers in industrialized countries, realizing that stocks were being overexploited, attempted to improve the design and enforcement of resource management measures. However, it became apparent that introducing harvest controls through the implementation of total allowable catches (TACs), or the equivalent thereof, alone generally led to the emergence of excess fleet capacity and severe economic waste. Subsequently, TACs were complemented with "limited entry schemes". However, even if the numbers of vessels were effectively controlled, technological advances in fishing technology meant that fishing capacity increased and resource depletion, economic waste (in the form of excess vessel capital) and lost economic rents (the result of exploiting standing stocks much below optimal stock sizes) continued to grow, exacerbated by fishery subsidies. The extension of economic zones, in the 1980s, followed by the 1995 United Nations Fish Stocks Agreement (UNFSA), did not improve the institutional framework for resource management to such an extent that resource investment occurred and economic waste disappeared, in part because of the problems associated with shared stocks.

FAO Fisheries and Aquaculture Technical Paper No. 538 attempts to identify what needs to be done to ensure that the world's capture fishery resources make their full potential contribution to the world economy. The paper concludes that massive resources need to be invested in the overexploited fish stocks. In this case, as with any positive investment, costs and sacrifices must be borne first in the hope of an economic return in the future. Establishing effective resource investment programmes within the exclusive economic zones (EEZs) of coastal states will be difficult, particularly in the developing world. How to go about such investment programmes is at the core of this study.

TYPES, OR LEVELS, OF FISHERIES IN NEED OF ECONOMIC REFORM

The root cause of the rent drain in capture fisheries lies in the perverse (from society's point of view) incentive structure confronting fishers in "common pool" types of fisheries. The fishers are given every incentive to regard the fishery resources as non-renewable resources to be mined. If measures are taken to restrict harvesting (in order to conserve the fishery resources) but nothing effective is done to limit fleet access to the fishery, the restricted harvest, TAC or the equivalent, becomes the "common pool", with the inevitable emergence of excess fleet and human capital, leading to resource rent dissipation. Unless the fishers are effectively blocked from responding to the perverse incentives, or the incentives themselves are altered, reversing the rent drain becomes an all but hopeless task.

Realizing the goal of maximizing resource rent requires that the perverse incentive problem be resolved. However, in many capture fisheries, this on its own will not be enough. As explained below, a major rebuilding of the resources will need to be undertaken if the goal is to be achieved. Given these two requirements, one can think of fisheries requiring reform as being at three levels. Level 1 consists of fisheries in which the resource managers have, by some means, succeeded in maintaining the stocks at, or building the stocks up (resource investment) to, the optimal level, but in which, through continued existence of perverse fisher incentives, the resource rent has been allowed to drain away. Resource investment is not required, but the correction of fisher incentives is. For these fisheries, the reversal of the rent drain, while not without its difficulties, is a simpler undertaking than is the case in Level 2 and Level 3 fisheries.

Level 2 consists of fisheries that are essentially the reverse of Level 1 fisheries. The perverse fisher incentive problem has been effectively addressed. Resource rent is being generated, but not maximized, because the resource is well below the optimal level owing to past overexploitation. Rebuilding the resource to the optimal level is an exercise in investment in natural capital in the form of fishery resources. Any investment in real capital, be the capital produced or natural, is a costly, and possibly lengthy and uncertain, undertaking. The fact that the incentive problem has been dealt with may mean that the required resource investment programme can be undertaken with some reasonable hope of success.

Level 3 consists of fisheries in which the perverse fisher incentives are unaddressed, in which the resource is well below the optimal level, and in which any resource investment that is occurring is negative (the average biomass is falling). The first objective of management in such fisheries must be to ensure that the rate of resource investment is no lower than zero.

Resource rent capture in fisheries with effective resource management but with perverse incentives – case studies of Level 1 fisheries

Pacific halibut is a good example of a shared (transboundary) stock that was saved from significant depletion and is therefore a strong candidate for inclusion in the Level 1 category. The fishery stands as one of those rare instances in which the fishing industry demanded the implementation of government fisheries regulation before serious damage had been done to the stock.

The Government of Canada was also aware of the consequences of harvest controls unaccompanied by controls over fleet size. Indeed, it had pioneered the introduction of limited entry schemes, commencing with the British Columbia salmon fishery. The implementation of the Canadian EEZs gave the Government of Canada the opportunity to introduce limited entry schemes in both its sablefish fishery and in Canada's segment of the Pacific halibut fishery. It had seized these opportunities by the early 1980s. However, both limited entry schemes were accompanied by what can be described as an Olympic-style TAC, i.e. the vessels granted access to the fishery were to compete for shares of the TAC. This was standard practice for limited entry schemes at that time.

What one can conclude from this Level 1 fishery experience is:

- The incentive-blocking approach to resource management, as it pertained to fleet and human capacity, was completely ineffective. The inability to control capacity led to a rent-destroying, non-cooperative game among the fishers.
- The subsequent introduction of catch shares in the form of individual transferable quotas (ITQs) did, in these instances, lead to a resource-rent-creating cooperative game among the fishers. That said, one must guard against concluding from this experience that ITQs offer the only route to achieving cooperative games among fishers. There will be many cases in which ITQs are inappropriate. However, alternatives exist. In their detailed paper on small-scale fisheries in developing fishing states, Kurien and Willmann[4] argue that ITQs are indeed inappropriate for many, if not most, of these fisheries. The desired results – turning fisher competition into cooperation – can, they argue, be achieved through the establishment of community-based fisheries management schemes. Public authorities would continue to play an important management role, so that the schemes might best be described as comanagement schemes. In order to effect the transformation of fisher competition into cooperation, substantial management capacity is demanded of the resource managers. To take one example, if the resource managers in the Canadian case described had proved to be incapable of establishing an effective monitoring scheme, the ITQ schemes would have degenerated into non-cooperative fisher games, with all that that implies.

A question not hitherto considered is: Could the same results produced by catch-rights-based management be achieved through the traditional incentive-adjusting technique of taxes (positive and negative)? No answer is immediately available. It is noted that, for reasons good or ill, taxes have been little used in fisheries management.

The Canadian Level 1 experience leads to a further implicit conclusion. Let it be supposed that resource rebuilding is called for, and that a successful resource investment programme is implemented. If this resource investment programme is not accompanied by a management scheme designed to prevent the emergence of excess capacity, the return on the resource investment – expressed as an increase in sustainable resource rent – will equal zero. Thus, it is all but pointless, from an economic perspective, to undertake a resource investment programme until the incentive problem has been resolved.

Resource rent capture in fisheries with ineffective resource management but with appropriate incentives – case studies of Level 2 fisheries

The Icelandic cod fishery can be seen as the archetypal Level 2 fishery. The fishery is the most valuable of the Icelandic demersal fisheries, with a potential annual landed value of US$1 billion. An ITQ scheme was introduced into the fishery in 1984, and then strengthened in 1991.[5] The perverse fisher incentive problem appears to have been dealt with successfully. The fishery is currently generating significant rents, estimated to be in the order of US$240 million per year as of 2005.[6]

However, that said, the fishery had been heavily overexploited prior to the introduction of ITQs. The introduction of ITQs, combined with reductions in the TAC, has brought overexploitation of the resource to a halt, but it has not succeeded in rebuilding the resource. It is estimated that the biomass is less than 60 percent of the optimal stock size. It is estimated further that the rent forthcoming from the fishery is no more than 36 percent of the maximum.[7] Thus, if one accepts the estimates, one is forced to the conclusion that the potential return on investment in the resource is substantial. The problem is how to put into effect an effective resource investment programme.

One can now consider the feasible set of fishery resource investment opportunities and two issues that need to be addressed. The issues prove to be closely related. The first pertains to the optimal resource investment programme, which, in turn, is concerned in the first instance with the optimal rate of positive resource investment. The most rapid rate of positive resource investment is achieved by declaring an outright harvest moratorium until the optimal biomass level is achieved. As a general rule of thumb, once the target stock of capital (of any form) has been identified, one should move towards the target with all possible speed unless there are penalties associated with rapid rates of investment. The second issue pertains to the incentive structure that must be in place for the relevant fishers in order for the resource investment programme to have any reasonable chance of success.

Concerning the second issue, the optimal rate of positive resource investment, an example is provided by a case study on the Lake Victoria Nile perch fishery.[8] The biomass of the resource is estimated to be between 37 and 50 percent of the optimal biomass, depending on whether the logistic or the Fox biological model is used. The study examines the possible resource investment programmes, and compares the one that would maximize the present value (PV) of rent from the resource through time with what the author of the study terms a "reasonable" investment programme. The PV-maximizing programme involves declaring a harvest moratorium for about three years until the optimal biomass level, or close to the optimal biomass level, is achieved. In other words, the PV-maximizing resource investment programme consists of investing in the resource at the maximum rate of speed. The "reasonable" resource investment programme calls for some harvesting during the resource investment phase. In so doing, it calls, in turn, for a slower rate of investment in the resource.

One could ask whether investing in the resource at the most rapid rate would not cause severe disruption to the fishing industry, and to the communities dependent upon the industry for employment. The answer depends critically on what economists term the "malleability" of the produced capital in the fishing fleet and the human capital involved in the fishery. The malleability of such capital concerns the ease with which it can be shifted into and out of the fishery, with perfectly "malleable" fleet and human capital being capital that can be easily and costlessly shifted in and out of the fishery. This is clearly not the case in the Lake Victoria Nile perch fishery.

From all of this, an obvious conclusion follows. The optimal resource investment programme must be expected to vary from fishery to fishery in both Level 2 and Level 3 fisheries. The resource managers must design an incentive scheme that will give the fishers an incentive to invest in the resource. The first question is whether the fishers are to be called upon to bear all or part of the cost of the resource investment. If the fleet and human capital is perfectly malleable, then the problem does not arise. In the many cases in which the fleet and human capital is less than perfectly malleable, one could, in the first instance, think of a scheme in which the state bore the cost of investment by compensating the fishers for temporarily reduced harvest opportunities.[9] However, such schemes could be accompanied by the threat of possibly severe moral hazard issues.

If the fishers are to bear a part or all of the cost of the resource investment, then the incentive-adjusting schemes discussed in the context of Level 1 fisheries carry a much greater burden. Eliminating the "race for the fish" is not enough. The design must be such that the fishers are assured a significant share of the investment payoff, with the proviso that the payoff be contingent upon the success of the resource investment. Thus, it would seem to be obvious that, if harvest rights are employed, they should be long in term, in fact (if not in strict law), and the harvest shares should be expressed as a percentage of the TAC.

The fishers should also have a considerable degree of certainty about future resource management policy. If, for example, the resource managers' policy is perceived by fishers as being capricious, then the fishers will, if rational, heavily discount all future returns from the resource investment.

Beyond this, one can say little about the optimal incentive scheme other than that it will require a great deal of planning and thought and that it is certain to vary from fishery to fishery.

Resource rent capture in fisheries with ineffective resource management and with perverse incentives – case studies of Level 3 fisheries

Level 3 fisheries, in which the fisher incentives have not been corrected and in which negative resource investment is still occurring, constitute the ultimate challenge in terms of rent restoration. The vast majority of the world's capture fisheries, including most developing countries' small-scale fisheries that are so critical to food security and poverty alleviation, continue to remain in this category. Among the case studies, mention can be made of the Thai demersal and pelagic fisheries in the Gulf of Thailand, the Chinese fisheries in the Bohai and Yellow Seas, and the Vietnamese fisheries in the Gulf of Tonkin.

The Arafura shrimp fishery

While posing tremendous management challenges and difficulties, the case studies indicate that progress can nonetheless be achieved in developing, as well as developed, fishing states. One of the more dramatic cases of success is that of the Indonesian Arafura shrimp fishery.[10]

Up until early in this decade, the fishery was plagued with rampant non-compliance and poaching by Indonesians and foreigners, with consequent overexploitation of the resource and dissipation of the resource rent. It is estimated that, in 2000, the biomass was no more than 50 percent of the optimal level. The resource rent was positive, but was equal to less than 6 percent of the optimal level.[11] Under new fisheries legislation promulgated in 2004, surveillance and enforcement were greatly strengthened, and the right incentives were created by devolving management authority upon the provincial government, which, in turn, gained the active support and cooperation of the relevant fishing communities.

By 2005, the biomass had increased to almost 75 percent of the optimal level, and the resource rent was estimated to be more than 90 percent of the optimal level. As the shrimp resource is a fast-growing one, quick payoffs to resource investment are to be expected. Nonetheless, the results are remarkable.

Management of internationally shared fisheries

The greatest difficulties in attaining effective cooperation are encountered in the management of internationally shared fishery resources. These are either discrete high seas stocks, often highly migratory, or stocks that are found in the EEZs and adjacent high seas, i.e. straddling stocks. Under the terms of the UNFSA, highly migratory and straddling stocks are to be managed through regional fisheries management organizations (RFMOs) that are to have both coastal states and relevant distant-water fishing states as members.[12] The Northwest Atlantic Fisheries Organization (NAFO), the Northeast Atlantic Fisheries Commission, and the Western and Central Pacific Fisheries Commission are all examples of such RFMOs.

The case studies present an example of an RFMO that is working reasonably well, the Northeast Atlantic Fisheries Commission managing the Norwegian spring-spawning herring, and one that provides an example of a Level 3 fishery, namely the RFMO governing the Northeast Atlantic and Mediterranean bluefin tuna fishery. The RFMO for this bluefin tuna fishery takes the form of the International Commission for the Conservation of Atlantic Tunas (ICCAT).

The bluefin tuna fishery

When in a healthy state, the Northeast Atlantic and Mediterranean bluefin tuna fishery ranges from the Canary Islands to Norway and through the Mediterranean to the Black Sea. The harvested fish are some of the most valuable in the world, with an individual fish being able to command a price of up to US$100 000.

At present, some 25–30 states are involved in the fishery. At the peak of the fishery, up to 50 states were involved. The number of active states involved in the fishery has been substantially reduced because, argues Bjørndal,[13] the resource has been severely depleted. Bjørndal maintains that the resource-rent-maximizing spawning stock biomass (SSB) is in the order of 800 000 tonnes. The current SSB is estimated to be in the order of 100 000 tonnes. This is the lowest SSB for the resource in recorded history. Indeed, the resource faces a significant risk of outright collapse.[14]

The current resource rent is actually positive, being estimated by Bjørndal at about US$35 million per year. However, the continuation of this level of rent is uncertain given the parlous state of the biomass. The US$35 million per year can be compared with Bjørndal's estimate of annual resource rent, under optimal conditions, of about US$550 million.

The root of the problem is straightforward enough. The cooperative game that is the ICCAT-based RFMO governing the tuna resources has degenerated into a competitive game. According to Bjørndal, the management advice provided by the ICCAT is largely ignored. The economics of non-cooperative management of shared fishery resources predicts that the shared fishery can readily take on all of the characteristics of a pure open-access one. Bjørndal maintains that the fishery is to all intents and purposes just that. The steady, almost inexorable, decline in the SSB in the past 30 years is entirely consistent with a pure open-access fishery.

With the support of the EU, the ICCAT has called for the implementation of a resource recovery programme, i.e. a programme of resource investment. However, given the severely reduced state of the biomass, MacKenzie, Mosegaard and Rosenberg[15] argue that recovery may take many years even if fishing mortality is drastically reduced. In other words, the states currently exploiting the resource will be called upon to bear heavy investment costs.

The Norwegian spring-spawning herring

A stark contrast is provided by the case of Norwegian spring-spawning herring. The resource has historically been one of the largest and most valuable in the Northeast Atlantic. When healthy, the resource migrates from its spawning grounds in Norwegian waters as far west as Iceland. In so doing, the resource passes through international waters, which means that it is to be classified as a straddling stock.

The resource crashed in the late 1960s and early 1970s, and its SSB was reduced to 2 000 tonnes, 0.08 percent of the critical minimum level of 2.5 million tonnes. Massive resource re-investment was called for and it did occur. Today, the resource is healthy, with the SSB at more than 6.5 million tonnes.[16] So what went right?

First, the remnants of the resource were confined to Norwegian waters. Thus, it ceased, for the time being, to be a shared fishery resource. Second, as indicated above, the Norwegian fleet and human capital involved in the fishery was highly malleable with respect to the fishery. It was politically easy for the Norwegian resource managers to declare a harvest moratorium, which more or less remained in place for 20 years. Finally, there was an element of luck in that environmental conditions allowed for a recovery of the resource from its desperately low state.

While not without its periodic difficulties, the cooperative game in the form of the Norwegian spring-spawning herring cooperative management arrangement has over time proved to be stable and effective in terms of both conservation and resource rent generation. In contrast to the Northeast Atlantic and Mediterranean bluefin tuna cooperative resource management arrangement, the number of "players" was small (a cooperative straddling stock fishery game with only five "players" is small indeed). There were no would-be new members appearing on the horizon. One can conjecture that the absence of a new-member problem was not unconnected with the fact that two of the "players" were, and are, politically very powerful – the EU and the Russian Federation.

Bjørndal demonstrates that the resource rent from the fishery could be increased by fine tuning the harvesting arrangements. Nonetheless, the resource rent is very substantial and would have seemed unachievable 35 years ago.

Abandoned, lost or otherwise discarded fishing gear

INTRODUCTION

Fishing gear has been lost, abandoned or discarded[17] for many centuries since fishing began. However, increases in the scale and technologies used in fishing operations in recent decades mean that the extent and impact of abandoned, lost or otherwise discarded fishing gear (ALDFG) has increased significantly with the use of synthetic materials, the overall increase in fishing capacity and the targeting of more distant and deepwater grounds. Growing concern over ALDFG reflects the numerous negative impacts, particularly its ability to continue to fish (often referred to as "ghost fishing") with associated impacts on fish stocks, and potential impacts on endangered species and benthic environments. It is also a concern because of its potential to become a navigational hazard at sea, with associated safety risks.

The issue of ALDFG has been raised at the United Nations General Assembly on several occasions, and as ALDFG is part of a wider problem of marine pollution, it comes under the remit of the International Maritime Organization (IMO). The mandate of the IMO includes the International Convention for the Prevention of Pollution from Ships (MARPOL), and the IMO's Marine Environmental Protection Committee established a correspondence group in 2006, which includes FAO, to review Annex V of the MARPOL (Box 13). The United Nations Environment Programme (UNEP) is also dealing with the issue of ALDFG as part of a broader Global Initiative on Marine Litter, which is being implemented through the UNEP Regional Seas Programme.

The FAO Committee on Fisheries (COFI) considers marine debris and ALDFG an area of major concern. The FAO Code of Conduct for Responsible Fisheries (CCRF) encourages states to tackle issues associated with fishing impact on the marine environment. Article 8.7 of the CCRF specifically addresses the requirements of the MARPOL.

At the regional level, the Asia-Pacific Economic Cooperation (APEC) has recognized the problem of ALDFG. In seeking solutions to the problem, the Bali Plan of Action (September 2005) agreed to support efforts "to address derelict fishing gear and derelict vessels, including the implementation of recommendations from research already undertaken in the APEC context". At the national level, some countries have taken unilateral action against ALDFG components of marine litter. The Marine Debris Research, Prevention, and Reduction Act came into law in late 2006 in the United States of America. It establishes programmes to identify, assess, reduce and prevent marine debris and its effects on the marine environment and navigation safety. Some states

in the United States of America also have their own laws addressing the problem of marine debris, while other states have made substantial progress through voluntary programmes.

In 2009, a joint FAO/UNEP report,[18] to which this article refers, examined the magnitude and composition of ALDFG, its impacts and its causes. In order to establish an appropriate response to the problem of ALDFG, the report gathered and presented available information and examples from around the world on existing measures to address ALDFG, and recommended actions to be taken.

In order to establish an appropriate response to the problem of ALDFG, the report provides available information and examples from around the world on the following aspects of ALDFG in particular and marine litter in general:

- the magnitude and composition of ALDFG;
- the impacts of ALDFG and the associated financial costs;
- the reasons why fishing gear is abandoned, lost or otherwise discarded;
- the measures being taken to combat ALDFG and the degree of success achieved in mitigating ALDFG impacts.

Box 13

Review of MARPOL Annex V and related guidelines

The Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) is currently conducting a review of Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) and its guidelines for the application of the regulations within the Annex. The MEPC has established a correspondence group (CG), of which FAO is a member, to carry out the review. Whereas the CG is considering a wide range of issues related to abandoned, lost or otherwise discarded fishing gear (ALDFG), Annex V is only specific in relation to the prohibition of disposal into the sea of all plastics including, but not limited to, synthetic ropes and synthetic fishing nets. It also provides exceptions to the rule that include “the accidental loss of fishing nets, provided that all reasonable precautions have been taken to prevent such loss”. Although Annex V takes due account of the possibility that gear may have to be discarded for safety or environmental reasons, the guidelines may have to address traditional and small-scale fisheries, particularly in relation to the location, retrieval, identification and how and where to dispose of such gear so retrieved. In this regard, more emphasis is likely to be placed on the availability of shore-based facilities for the disposal of fishing gear and garbage arising from the operation of fishing vessels.

With regard to the identification of lost fishing gear, the guidelines for the application of Annex V contain pertinent references for the need to consider the development of technology for more effective fishing gear identification systems. Although progress has been made, many systems of marking currently in use fall short of identifying the ownership of ALDFG, and this is one of the issues being addressed in the process of reviewing and amending Annex V of the MARPOL. In addition, the matter was again brought to the attention of the Committee on Fisheries (COFI) in 2007, at which time there was widespread support within the COFI to address the issue further.

MAGNITUDE OF MARINE LITTER AND ALDFG

Marine litter is either sea-based or land-based, with fishing activity just one of many different potential sources. The report concludes that there is no overall figure for the contribution of ALDFG to marine litter. A number of estimates suggest very different contributions of fishing activity to total marine litter based on locality. Close to or on the shore, the majority of litter originates from land-based sources.

When considered on a global basis, and including litter that does not wash up on beaches, it appears likely that merchant shipping contributes far more to marine litter than does ALDFG from fishing vessels. There are also significant differences in terms of the weight and the type of impacts on the environment of marine litter from merchant shipping and synthetic forms of ALDFG. Attempts at broad-scale quantification of marine litter enable only a crude approximation of ALDFG, which is likely to comprise less than 10 percent of global marine litter by volume, with land-based sources being the predominant cause of marine debris in coastal areas, and merchant shipping the key sea-based source of litter.

Table 15 summarizes ALDFG indicators from a number of fisheries around the world.[19] The table demonstrates the wide variability of loss rates from different fisheries and also highlights the patchiness of data on ALDFG. Reports of gear loss do not necessarily equal the same volume of ALDFG remaining in the environment indefinitely, as some may subsequently be retrieved by other operators in the fishery.

Abandoned, lost or otherwise discarded fishing gear tends to accumulate and often reside for extended periods in ocean convergence zones. Mass concentrations of marine debris in areas such as the equatorial convergence zone are of particular concern, as they may create "rafts" of assorted debris, including various plastics, ropes, fishing nets and cargo-associated wastes. It should be noted that literature on marine litter in general and ALDFG in particular uses a mixture of volume, abundance and weight, complicating global estimates and compromising their robustness.

The UNEP Global Programme of Action[20] estimates that as much as 70 percent of the entire input of marine litter to the world's oceans sinks to the bottom and is found on the seabed, both in shallow coastal areas and in much deeper parts of the oceans. Accumulation of litter in offshore sinks may lead to the smothering of benthic communities on soft and hard seabed substrates.

IMPACTS OF ALDFG

The ability of ALDFG to "ghost fish" is one of its most significant impacts and is highly specific to a number of factors. These include the gear type (whether it has been abandoned as a set gear maximized for fishing or discarded or lost where it is less likely to fish effectively) and the nature of the local environment (especially in terms of currents, depth and location). Environmental impacts of ALDFG can be grouped as follows:

- *Continued catch of target and non-target species.* The state of the gear at the point of loss is important. For example, some lost nets may operate at maximum fishing efficiency and will thus have high ghost fishing catches, whereas ALDFG that collapses immediately and has lower fishing efficiency will probably have less ghost fishing potential. Fish dying in nets may attract scavengers that are subsequently caught in the nets, resulting in cyclical catching by the fishing gear. Furthermore, ghost fishing of gill and entangling nets and traps is probably higher than other ALDFG.
- *Interactions with threatened or endangered species.* Especially when made of persistent synthetic material, ALDFG can affect marine fauna such as seabirds, turtles, seals and cetaceans through entanglement or ingestion. Entanglement is generally considered to be the more likely cause of mortality.
- *Physical impacts on the benthos.* It is likely that ALDFG has little impact on the benthic fauna and the bottom substrate unless dragged along the bottom by strong currents and wind or when physically dragged during retrieval, potentially harming fragile organisms like sponges and corals.
- *Accumulation of synthetic material into the marine food web.* Modern plastics can last up to 600 years in the marine environment, depending upon water conditions, ultraviolet light penetration and the level of physical abrasion. However, the impact

of synthetic fragments and fibres in the marine environment, which result from the degradation of larger items, is not known. Thompson *et al*.[21] examined the abundance of microplastics in beaches, estuarine and subtidal sediments and found them to be particularly abundant in subtidal sediments.

- *Accidents and loss of life.* A key socio-economic impact is the navigational threat of ALDFG to marine users. It is very difficult to rate or compare the magnitude

Table 15
Summary of gear loss, abandonment and discard indicators from around the world

Region/fishery	Gear type	Indicator of gear loss (data source)
North Sea & NE Atlantic	Bottom-set	Gillnets 0.02–0.09% nets lost per boat per year (FANTARED 2, 2003)
English Channel & North Sea (France)	Gillnets	0.2% (sole & plaice) to 2.11% (sea bass) nets lost per boat per year
Mediterranean	Gillnets	0.05% (inshore hake) to 3.2% (sea bream) nets lost per boat per year (FANTARED 2, 2003)
Gulf of Aden	Traps	20% lost per boat per year (Al-Masroori, 2002)
ROPME Sea Area United Arab Emirates	Traps	260 000 lost per year in 2002 (G. Morgan, personal communication, 2007)
Indian Ocean Maldives	Tuna longline	3% loss of hooks/set (Anderson & Waheed, 1998)
Australia (Queensland)	Blue swimmer crab trap	Fishery 35 traps lost per boat per year (McKauge, undated)
NE Pacific Bristol Bay	King crab trap fishery	7 000–31 000 traps lost in the fishery per year (Stevens, 1996; Paul, Paul & Kimker, 1994; Kruse & Kimker, 1993)
NW Atlantic	Newfoundland cod gillnet fishery	5 000 nets per year (Breen, 1990)
	Canadian Atlantic gillnet fisheries	2% nets lost per boat per year (Chopin *et al.*, 1995)
	New England lobster fishery	20–30% traps lost per boat per year (Smolowitz, 1978)
	Chesapeake Bay	Up to 30% traps lost per boat per year (NOAA Chesapeake Bay Office, 2007)
Caribbean Guadeloupe	Trap fishery	20 000 traps lost per year, mainly in the hurricane season (Burke & Maidens, 2004)

Sources: Based on:
G. Macfadyen, T. Huntington and R. Cappell, R. *Abandoned, lost or otherwise discarded fishing gear.* UNEP Regional Seas Reports and Studies No. 185; FAO Fisheries and Aquaculture Technical Paper No. 523. Rome, UNEP/FAO. 2009. 115 pp.
FANTARED 2. 2003. *A study to identify, quantify and ameliorate the impacts of static gear lost at sea 2003.* EC contract FAIR-PL98-4338.
H.S. Al-Masroori. 2002. *Trap ghost fishing problem in the area between Muscat and Barka (Sultanate of Oman): an evaluation study.* Sultan Qaboos University, Oman. (MSc thesis)
R.C. Anderson and A. Waheed, A. 1988. *Exploratory fishing for large pelagic species in the Maldives. Main Report.* BOBP/REP/46 – FAO/TCP/MDV/6651. Madras, India, Bay of Bengal Programme. 59 pp.
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G.H. Kruse and A. Kimker. 1993. *Degradable escape mechanisms for pot gear: a summary report to the Alaska Board of Fisheries.* Regional Information Report 5J93-01. Kodiak, USA, Alaska Department of Fish and Game.
P.A. Breen. 1990. A review of ghost fishing by traps and gillnets. *In* R.S Shomura and M.L. Godfrey, eds. *Proceedings of the 2nd International Conference on Marine Debris, 2–7 April 1989, Honolulu,* pp. 561–599. NOAA Technical Memorandum 154. Washington, DC, US Department of Commerce, NOAA, National Marine Fisheries Services.
F. Chopin, Y. Inoue, Y. Matsushita and T. Arimoto. 1995. Sources of accounted and unaccounted fishing mortality. *In* B. Baxter and S. Keller, eds. *Proceedings of the Solving Bycatch Workshop on Considerations for Today and Tomorrow,* pp. 41–47. University of Alaska Sea Grant College Program Report No. 96–03. Fairbanks, USA, University of Alaska.
R.J. Smolowitz. 1978. Trap design and ghost fishing: an overview. *Marine Fisheries Review,* 40(5–6): 2–8.
NOAA Chesapeake Bay Office. 2007. *Derelict fishing gear study fact sheet, July 2007* (available at chesapeakebay.noaa.gov/).
L. Burke and J. Maidens. 2004. *Reefs at risk in the Caribbean.* Washington, DC, World Resources Institute (also available at www.wri.org/biodiv/pubs_description.cfm?PubID=3944).

of the wide range of socio-economic costs as literature is very scarce and there are particular problems in quantifying and comparing social costs. Estimating the costs associated with compliance, rescue and/or research associated with ALDFG is complex, and it does not seem to have been attempted to date.

CAUSES OF ALDFG

It is important to recognize that, owing to the environment in which fishing takes place and the technology used, some degree of ALDFG is inevitable and unavoidable. As with the magnitude of ALDFG, the causes of ALDFG vary between and within fisheries. When one considers that gear may be abandoned, lost or discarded, it is clear that some ALDFG may be intentional and some unintentional. Correspondingly, the methods used for reducing ALDFG need to be matched to the causes.

Direct causes of ALDFG can also result from a variety of pressures on fishers, including: enforcement pressures causing those operating illegally to abandon gear; operational pressures (including those resulting from hazardous weather conditions) resulting in gear being abandoned or discarded; economic pressure leading to dumping of unwanted fishing gear at sea rather than disposal onshore; and spatial pressures resulting in the loss or damage of gear through gear conflicts. Indirect causes include the unavailability of onshore waste disposal facilities as well as their accessibility and cost of use.

MEASURES TO ADDRESS ALDFG

Measures to address ALDFG specifically can be broadly divided into measures that prevent (avoid the occurrence of ALDFG in the environment), mitigate (reduce the impact of ALDFG in the environment) and cure (remove ALDFG from the environment). Experience to date illustrates that many of these measures can be applied at a variety of levels (international, national, regional, local) and through a variety of mechanisms. To reduce the problem of ALDFG successfully, and more generally to reduce its contribution to marine debris, it is likely that actions and solutions will need to address all three types of measures, i.e. preventive, mitigating and curative.

Some measures may need to be supported by a legal requirement, while others may be just as effective if introduced on a voluntary basis and when incentives are provided. Therefore, the likely success of introduced measures may depend strongly on whether the correct approach is taken with regard to a mandatory or voluntary, incentivized approach.

Preventive measures

Preventive measures are identified as the most effective way of tackling ALDFG as they avoid the occurrence of ALDFG and its associated impacts. Such measures include: gear marking; the use of onboard technology to avoid loss or improve the location of gear; and the provision of adequate, affordable, accessible onshore port reception and collection facilities. It is also acknowledged that effort reduction measures, such as limits on the amount of gear that can be used (e.g. pot and trap limits) or the soak-time (the length of time gear can remain in the water), could reduce operational losses. Spatial management (e.g. zoning schemes) is also a useful tool in addressing gear conflict, which can be a significant cause of ALDFG.

The implementation of the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated (IUU) Fishing[22] when it enters into force will be critical in addressing IUU fishing, which is also a significant contributor to ALDFG as illegal fishers are unlikely to comply with regulation including any measures to reduce ALDFG. Furthermore, the agreement can be used to strengthen requirements for gear marking.

The provision of appropriate collection facilities is a preventive measure as it can reduce the likelihood that a fisher will discard unwanted gear at sea. Annex V Regulation 7 of the MARPOL[23] stipulates: “the Government of each Party to the

Convention undertakes to ensure the provision of facilities at ports and terminals for the reception of garbage, without causing undue delay to ships, and according to the needs of the ships using them." However, scale and capacity issues have prevented the provision of adequate reception facilities at many fishing ports and harbours, and these need to be addressed.

The increasing use of the Global Positioning System (GPS) and seabed mapping technology by fishing vessels affords benefits in terms of both reducing initial gear loss and improving the location and subsequent recovery of lost gear. Transponders are now a common feature in many large-scale fisheries, with the satellite tracking of vessels for safety and for monitoring, control and surveillance (MCS) purposes. The use of transponders on gear such as marker buoys or floats to improve the ability to locate lost gear is becoming more widespread. Small-scale fishers should also be encouraged to make wider use of available technology so that they can better identify the position of static gear.

In the revision process of Annex V of the MARPOL, mentioned above, reporting procedures have been discussed, including the fact that currently all ships of 400 GT and above have to keep a garbage record book. However, this does not apply to smaller ships. Furthermore, there is no direct instruction to report ALDFG to the flag state or to any coastal state in whose waters the ship (fishing vessel) may be operating. It has therefore been suggested that existing reporting requirements such as catch reporting systems (e.g. logbooks) and observer programmes should be extended to include the reporting of ALDFG, possibly as a mandatory requirement. A "no-blame" approach could be incorporated into any such requirements with respect to liability for losses and their impacts and any related recovery costs.

Spatial management can avoid ALDFG by actively segregating marine users or, more commonly, by better ensuring that marine users are aware of the likely presence of fishing gear in the water. This reduces the navigational hazard of fishing gear and thus reduces the likelihood that gear will be damaged or moved. Spatial management at the local level may reduce ALDFG through fostering a stewardship approach to an area, especially when such management is based on a community or comanagement approach.

The use of fishing effort and output restrictions will also have impacts on the incidence of ALDFG. For static gear, the amount of gear in the water and the time it is left in the water (soak-time) both influence the probability that gear will be lost or discarded, and restrictions on effort can thus reduce ALDFG.

Mitigation measures

Mitigation measures to reduce the impact of ALDFG are limited in their extent and application as many may increase costs through reduced effectiveness of gear or higher gear prices. Consequently, the development of innovative materials has been slow and the return to biodegradable netting by the industry has been very limited. Trials are continuing on net materials that increase sound reflectivity and hence could reduce the bycatch of non-target species such as cetaceans (Box 14). These and other innovative solutions are being encouraged through initiatives such as the International Smart Gear Competition of the World Wide Fund for Nature (WWF).

Curative measures

Curative measures are inevitably reactive to the presence of ALDFG in the environment and will therefore always be less effective than avoiding ALDFG in the first instance. However, curative measures have been shown to be cost-effective when considering the costs of leaving the ALDFG *in situ*. Measures can be seen to be broadly sequential in the identification, removal from the environment and appropriate disposal of ALDFG. They include: efforts to locate lost gear using various technologies, such as the side scan sonar for seabed surveys; the introduction of systems to report lost gear; gear recovery programmes; and the disposal or recycling of ALDFG material.

Awareness

Raising awareness of the ALDFG problem is a cross-cutting measure that can aid the development and implementation of any of the measures described above. It can target fishers themselves, port operators, marine users or the general public through local, national, regional or international campaigns. Education can, if effective,

Box 14

The role of technology in mitigating abandoned, lost or otherwise discarded fishing gear

Degradable escape panels and "rot cords" can be used to reduce ghost fishing by traps and are required in some fisheries, although they are less evident in net fisheries. The spiny lobster fishery in Florida (United States of America) has had such a requirement since 1982,[1] and the fisheries management plan for king and tanner crab in the Bering Sea states that "an escape mechanism is required on all pots; this mechanism will terminate a pot's catching and holding ability in case the pot is lost".[2] In Canada, recreational fishing traps require features "to ensure that if the trap is lost, the section secured by the cord will rot, allowing captive crabs to escape and to prevent the trap from continuing to fish".[3] Also in Canada, the 2008 Pacific Region Integrated Fisheries Management Plan for crab traps includes various requirements related to biodegradable escape mechanisms.

There have been some efforts to develop biodegradable and oxydegradable plastics for use in the fishing industry. For example, the Australian and New Zealand Environment Conservation Council was instrumental in promoting the use of biodegradable materials in bait bag manufacture and supporting the development of biodegradable ice bags.[4]

Mitigating against ghost fishing of bycatch and non-target species (cetaceans, turtles, seabirds, etc.) by abandoned, lost or otherwise discarded fishing gear can be supported using the same measures as in the active fishery, e.g. acoustic beacons ("pingers") and reflectors in gillnet and set net fishing gear. Trials are also progressing with substances that reflect sound, such as barium sulphate, with such substances being added to nylon nets during production. The additive does not affect the performance or the look of the net in any way, but it reflects sound waves in ranges used by echo-locating animals.[5] Other developments, such as those supported by the World Wide Fund for Nature (WWF) through its International Smart Gear Competition, have produced weak ropes that are operationally sound but break with the action of marine mammals, and magnets attached to longlines to repel sharks.

[1] T.R. Matthews and S. Donahue. 1996. *By-catch in Florida's spiny lobster trap fishery and the impact of wire traps*. Report submitted to the South Atlantic Fishery Management Council.
[2] North Pacific Fishery Management Council. 2008. *Fishery Management Plan for Bering Sea/ Aleutian Islands King and Tanner Crabs* (available at www.fakr.noaa.gov/npfmc/fmp/crab/ CRAFMP2008.pdf).
[3] Fisheries and Oceans Canada. 2007. *Pacific region recreational fishing – recreational fishing gear* (available at www.pac.dfo-mpo.gc.ca/recfish/Law/gear_e.htm).
[4] I. Kiessling. 2003. *Finding solutions: derelict fishing gear and other marine debris in Northern Australia*. Hobart, Australia, Charles Darwin University, National Oceans Office.
[5] G. Schueller. 2001. Nets with porpoise in mind. *Environmental News Network*, 19 February 2001 (available at www.eurocbc.org/page523.html).

facilitate a change in behaviour and result in self-policing by stakeholders, and it has the potential to extend beyond those directly targeted to change behaviour in society.

In many fisheries, operational losses resulting from extreme weather events may to some extent be prevented if the level of awareness to approaching rough weather can be raised through, for example, radio and, where practical, the use of cellular phones or other information dissemination methods to allow precautionary measures to be put in place to minimize risk to fishers, installations and gear in advance of appraoching bad weather.

CONCLUSIONS

Many of the measures to address ALDFG can be applied at a variety of geographic scales (international, national, regional, local) and through a variety of mechanisms, from legal requirements through to voluntary schemes. Measures to address ALDFG must be tailored to reflect the need for differing solutions for gear that is: (i) abandoned, (ii) lost, or (iii) discarded. They must also deal with the wide range of different causes as discussed above. Thus, actions must reflect a high degree of specificity of causes across different fishing methods and fisheries. While some generalized and international measures are certainly appropriate and necessary, it is also likely that great care will need to be taken in specifying solutions that adapt and tailor possible measures to the specificities of the particular fishery concerned.

In order for the issue of ALDFG to be tackled effectively, it is critical that there be greater education and awareness of the extent of the problem, its impacts and causes, and of the wide variety of measures that can be used to reduce ALDFG. This article is itself an attempt to foster such awareness and to build on growing concern at the level of the United Nations General Assembly and among many international and regional organizations, as well as among states, the fishing industry and civil society. Greater education and awareness will serve to foster much-needed collaborative efforts between institutions and stakeholders to address the problem of ALDFG more effectively.

More research is urgently needed on many aspects of ALDFG, including a quantification of the scale involved, the contribution of different fisheries to ALDFG, and the potential technological solutions to the problem. Also of special importance is the need to understand better why certain measures are effective in certain situations and why others are not; reasons may be strongly correlated with their relevance, acceptability and enforcement in specific locations but have not been well studied. Another significant gap in knowledge results from the lack of cost–benefit analyses conducted of particular measures, or of how to prioritize among them. However, it would appear likely that “prevention is better than cure”. Preventive measures are likely to be preferable to curative ones because, by preventing gear loss, they can prevent many of the potentially high costs associated with ALDFG once it has entered the environment (e.g. ghost fishing, navigational risks), which *ex-post* measures are less able to do.[24] What is clear is that there are very many measures, be they preventive, mitigating or curative, that can and should be taken now to address ALDFG so as to reduce the significant environmental, economic and social impacts, even if current knowledge of ALDFG is not as comprehensive as it should be.

Private standards and certification in fisheries and aquaculture: current practice and emerging issues

INTRODUCTION

Private standards and related certification are becoming significant features of international fish trade and marketing. In 2009, FAO reported on the range of market-based standards and labels in fisheries and aquaculture.[25] However, there is scant empirical evidence on the market significance of private standards. A recent FAO study[26] analyses two main types of private standards that affect fish trade and marketing in order to shed light on the overall implications for fisheries and aquaculture. It focuses on:

- "ecolabels" or private standards and certification schemes related to the sustainability of fish stocks;
- private standards and certifications related to food safety and quality, from retailers' in-house specifications to international food safety management schemes (FSMSs) designed for food generally but increasingly applied to fish and seafood.

The FAO study analyses implications of private standards in fisheries and aquaculture for a range of stakeholders. It asks:

- What role do private standards play in overall governance for fisheries sustainability and food safety? Do they complement, duplicate or undermine public regulatory frameworks?
- Do they impose deadweight compliance costs for the various stakeholders in the supply chain or can they facilitate market opportunities? How are the costs and benefits distributed among stakeholders?
- How do they affect developing countries and small-scale producers and processors? Can they help facilitate international trade by encouraging good practices and by compensating for local institutional shortfalls or, instead, do they amount to a significant barrier to trade that threatens to undermine the internationally agreed mechanisms of the World Trade Organization (WTO)?

ECOLABELS AND MARINE CAPTURE FISHERIES

It is difficult to estimate the volume of ecolabelled certified products on the international market. The two largest international schemes (both sponsored by non-governmental organizations [NGOs]), the Marine Stewardship Council (MSC) and Friend of the Sea (FOS), claim to cover 7 percent and 10 percent, respectively, of the world's capture fisheries. However, together this amounts to less than one-fifth of wild capture landed product. Probably only a small percentage of certified raw material ends up as a labelled product. Of the MSC's 6 million tonnes of seafood landed from certified fisheries, only about 2.5 million tonnes ends up carrying the MSC label.[27] Ecolabelled fish and seafood is also highly concentrated in certain species. While the MSC claims to cover 42 percent of the world's global salmon catch and 40 percent of the "prime whitefish" catch, the Alaskan salmon and pollock fisheries account for more than half (56 percent) of MSC products on sale. About 80 percent of FOS-certified fish is Peruvian anchovy.[28] Despite the exponential growth in the number of ecolabelled products on the market overall, they are also concentrated in certain markets only. The main demand for ecolabelled products appears to be in pockets of the European market (Germany, Netherlands, United Kingdom) and in the United States of America (especially in the food service industry). FAO research[29] suggests that markets conducive to sales of ecolabelled fish and seafood typically have:

- an environmentally aware population with a strong civil society active in the environmental or sustainability area;
- retail of fish and seafood products dominated by supermarkets (typically large retailers in highly competitive markets) rather than fresh fish markets;
- consumption patterns based on a traditionally limited range of fish and seafood species leading to lower substitutability of product;
- strong tradition and presence of highly processed fish and seafood products.

The costs and benefits of ecolabelling and certification accrue differently to different stakeholders. Retailers are the main drivers of the ecolabelling phenomenon and reap the most rewards in terms of value-addition to their brand and reputation, risk management, ease of procurement, and potential price premiums, at relatively little or no cost (relating to chain of custody certification or licence fees). In contrast, fishers assume the main cost burden. The actual costs of certification, including experts' fees, can range from a few thousand US dollars to up to US$250 000 depending on the size and complexity of the fishery and on the scheme chosen. One research study has confirmed that the fishing industry itself usually foots the bill for certification.[30] In terms of benefits, there is some evidence of more secure supply relationships based on certification, consolidation of position in existing markets, and of new niche markets for environmentally friendly products. However, there is only spotty evidence of price premiums accruing to certified fish and seafood.[31] Reported price premiums are typically associated with more secure supply relationships, either with food services (and to a lesser extent, supermarkets) or access to niche markets.

To date, fisheries in developing countries represent a small minority of certified fisheries, most of which are large-scale. Developing countries' underrepresentation is due to three main factors:

- There is a lack of an economic imperative for certification. Developing countries have a limited presence in the markets, species, types of products and supply chains where pressure to be certified is greatest. Despite some exceptions, developing country fishers (especially small-scale fragmented fisheries environments) are less linked into direct supply relationships with large-scale buyers where the pressure for certification is most intense.
- Ecolabelling schemes do not translate well into the typical conditions of the fisheries environment in developing countries (insufficient fisheries management regimes, data deficiencies, small-scale multispecies fisheries).
- The high costs of certification are often prohibitive for small-scale or resource-poor operators.

However, developing countries might be missing out on the potential opportunities that certification has to offer. As demand for ecolabelled products grows and spreads to fisheries in species relevant to developing country capture fishers (such as shrimp[32] and other tropical species), developing country producers might feel more pressure to participate in ecolabelling schemes.

PRIVATE STANDARDS AND CERTIFICATION FOR FOOD SAFETY AND QUALITY IN FISHERIES AND AQUACULTURE

National and international regulatory frameworks to ensure food safety systems that function across national borders are well entrenched. The joint FAO/WHO Codex Alimentarius Commission is the global reference for national food safety strategies. However, fish exporters still face safety and quality control regimes that vary from one jurisdiction to the next, as well as a growing proliferation of standards being introduced by the private sector. In addition to their firm-specific product and process specifications, many large retailers, commercial brand owners and food service industry firms require their suppliers to be certified:

- For processed fish and seafood: To a national or international FSMS, such as the British Retail Consortium (BRC), International Food Standard (IFS), Safe Quality Food Institute (SQF) or Global Gap. These are designed for food generally but are increasingly applied to fish and seafood products. They are based on the Hazard Analysis and Critical Control Point (HACCP) system and are the most important schemes in terms of the impacts of private standards on the food industry generally.
- For aquaculture: To one or other of the schemes that merge quality and safety with environmental protection, animal health and even social development, such as the Aquaculture Certification Council (ACC). Global Gap is also active in aquaculture while the WWF has set up (in 2010) the Aquaculture Stewardship Council, following its "aqua dialogues" and standards development for 12 aquaculture species.

A few public safety and quality certification schemes also exist. For example, Thai Quality Shrimp is a public certification verifying the safety and environmental credentials of Thai shrimp farmers. A relatively new development is the use of private voluntary standards in public food safety policy frameworks. For example, the United States Food and Drug Administration (FDA) has a pilot programme to evaluate third-party certification schemes for imported farmed shrimp – including the ACC and Thai Quality Shrimp – which might eventually allow products from facilities certified by those bodies expedited entry into the United States of America. In this way, governments are using market mechanisms as tools to gain traction in their own food safety policy frameworks.

The pressure on producers (fish farmers) and processors (of both wild capture and farmed fish) to comply with private standards depends on the market, how that market is structured, and the type of product being sold. As in the ecolabels arena, large-scale retailers and food firms are not equally demanding of all their suppliers or product lines. Requirements are more stringent for private-label and highly processed fish and seafood products than for basic commodity fish and seafood. For fish and seafood processors producing brand products or private-label products, certification would be essential. The pressure to comply with private standards is more intense for suppliers to markets in northern Europe, where a higher proportion of fish and seafood is sold in supermarkets, where there is a greater predominance of processed and value-added products, and where there are more private-label products. In terms of requirements for certified aquaculture, the United States market is also important. The pressure is lower in southern Europe (overall the biggest European seafood consumers), where whole fish and fresh fish remain standard fare. The more direct the supply relationship is and the more integrated the supply chain is, the more private standards are likely to enter the equation – there is relatively more integration in aquaculture, where there is scope to produce to specification.

Although the costs of certification are difficult to determine with precision, estimated costs need to be weighed against the potential benefits, which might include:

- access to new markets where certification offers access to an integrated value chain and long-term contractual supply relationships as well as access to more sophisticated market segments (private-label, high-value-added products);
- improved quality management and products, and subsequent reductions in costly rejections based on poor sanitary status or inferior quality and in the costs of recalls and the negative publicity they cause;
- more stable supply relationships – probably meaning less price volatility (although there is no evidence of a price premium generally).

COMMON POLICY AND GOVERNANCE ISSUES

The impact of private standards – ecolabels, safety and quality or aquaculture certifications – is not uniform across markets, species or types of products. Demands for ecolabelled fish and seafood, and certified aquaculture products, are currently concentrated in certain species and in certain markets. The demands for fish and seafood to be certified to a private FSMS increase according to the level of value-addition involved, and affect products destined for sale in supermarkets and/or as commercial brand and private-label products.

However, the impact of private standards in the trade and marketing of fish and seafood is likely to increase as supermarket chains consolidate their role as the primary distributors of fish and seafood products, and as their procurement policies move away from open markets towards contractual supply relationships. As the leading retail transnationals extend their global reach, their buying strategies will probably progressively influence retail markets in Africa, East Asia, Eastern Europe and Latin America. Key issues related to the overall impact of private standards in fisheries and aquaculture and how they affect various stakeholders require resolution.

Assessing the quality and credence of private standards and related certification

The proliferation of private standards causes confusion for many stakeholders – fishers and fish farmers trying to decide which certification scheme will bring most market returns, buyers trying to decide which standards have most credence in the market and will offer returns to reputation and risk management, and governments trying to decide whether to take a "hands off" or "hands on" approach to private certification schemes. Transparency and good governance in private voluntary schemes are imperative. A mechanism for judging the quality of schemes is required.

CHALLENGES AND OPPORTUNITIES FOR DEVELOPING COUNTRIES

Fish and seafood are important income earners for many developing countries. Developing countries are crucial for current and future global supplies of fish and seafood products. They account for about half by value, and about 60 percent by volume, of all seafood traded internationally. Furthermore, they produce more than 80 percent of aquaculture products, which currently supply 47 percent of global fish food, up from a mere 7 percent in the early 1970s.

As noted above, certification to private standards schemes can be problematic for many developing countries. Some private certification schemes have taken these concerns on board and have attempted to develop ecocertification methodologies more suited to data-deficient small-scale fisheries and fish farms. However, developing country operators remain underrepresented particularly among the ranks of certified fisheries (ecolabels) and certified fish processors (FSMSs). They are becoming better represented in aquaculture, where there have been proactive strategies to organize small-scale farmers into associations or "clusters".[33] In general, certified operators from developing countries tend to be those that are large-scale and involved in more integrated supply chains with direct links to developed country markets (through equity or direct supply relationships).

While some developing countries have argued that private standards pose a barrier to trade, there is no solid evidence of markets "drying up" as a result of demands for certification. Demands for certified products tend to be concentrated in markets and species that are not the main species traded by developing countries. Moreover, evidence suggests that meeting mandatory public standards in developed country markets currently poses more of a barrier to trade than do requirements to meet private standards. For developing countries to take advantage of the opportunities presented by private standards, they must first be able to meet the requirements of mandatory regulatory requirements in importing countries. This would create the foundations for future responses to private standards, if and when demand spreads to typical developing country species. Any technical cooperation in developing countries would be best focused on ensuring that the public systems are appropriate.

While certification is problematic for many developing country fishers, farmers and processors, it might also provide a tool for engagement with large-scale buyers. The challenges and costs of certification need to be weighed against the potential opportunities to access high-value or niche markets in key importing countries, and to participate in direct supply relationships, with less price volatility than selling through traditional auction markets. There is also potential for more value-addition in developing countries that have a competitive advantage in lower labour costs.

Developing countries are a crucial part of international fish and seafood supply chains. Any attempts to further develop global governance for food safety or fisheries and aquaculture sustainability will fail if developing countries are not an integral part of the equation.

Impacts on international trade and WTO mechanisms

The impact of private standards on international trade has been raised for discussion in relation to two WTO agreements: the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical Barriers to Trade (TBT Agreement). Ongoing concerns of WTO member countries in relation to private standards include those related to:

- the content of private standards and their consistency with international WTO obligations;
- the discriminatory costs of and access to private certifications;
- a lack of clarity about the jurisdiction over private-sector actors;
- the changing interface between public and private standards.

Some countries have argued that private standards go beyond relevant international public standards and that those related to food safety include product and process specifications (non-safety and quality criteria) that have no particular scientific rationale and are, therefore, inconsistent with the obligations of the SPS Agreement. In terms of ecolabels, some countries fear that the allowance of non-product-related process and production methods could open the door to developed countries to impose their domestic policy frameworks related to either fishing methods and/or other standards (social responsibility), thereby giving further grounds for discrimination against developing country products. Further analysis is required in order to determine the consistency or not of private standards with international standards and obligations of both the SPS Agreement and the TBT Agreement.

While governments have the right to challenge the actions of other governments within the context of the WTO, the grounds for challenging non-governmental actors are less clear. Requirements for only ecolabelled fish and seafood could mean that products can be excluded from certain markets owing to perceptions of the buyer or retailer about whether governments (from exporting countries) have lived up to their obligations for good fisheries management. What recourse governments have to challenge these assessments and their implications is still largely unknown. Jurisdiction over non-governmental actors, transnational firms or coalitions of firms is problematic. The SPS Agreement and the TBT Agreement offer little direction on this front and "there is no jurisprudence on this matter".[34]

Other trade-related issues are emerging. For example, could public-sector financial support for ecolabel certification be considered a "subsidy" and/or notifiable in the context of WTO mechanisms? If a government pays outright for certification, is that a subsidy to its industry? If it leads to a trade advantage or improved market access, then should it be notifiable? As the boundaries between public and private standards and requirements start to blur, there are implications for trade that need to be closely monitored.

Some countries have argued that private standards help to expand trade. Others counter that they discriminate against developing countries. Further enquiry and evidence of the actual effects of private standards on trade opportunities, especially for developing countries, are needed. While volumes of certified fish products remain modest, the impact on trade is likely to be slight. However, it is a fast-moving area that needs to be closely monitored. Work continues in the area at both the WTO and FAO.

Aquaculture development in Southeast Asia: the role of policy

INTRODUCTION

Fish is important in the diet of much of Southeast Asia (here considered to consist of Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Viet Nam). It is a major source of animal protein in a region where levels of animal protein in human diets are below the world average.

The region has a long history of aquaculture, but rapid expansion began only after 1975. Before then, total output was still less than half a million tonnes. By 1987, the region was producing one million tonnes, excluding aquatic plants. Thereafter, each decade has seen a doubling of output, with production of food fish exceeding five million tonnes in 2005. By 2005, the region already produced a significant proportion of world aquaculture output: 10 percent by volume and 12 percent by value, excluding aquatic plants. Moreover, the region's share of world volume has been growing.

Accounting for one-quarter of all food fish produced in the region, aquaculture is an important contributor to food security. It also provides rural employment and income. For example, more than half a million people are employed in aquaculture in Viet Nam; capture fisheries do not employ as many people. Furthermore, it is a major contributor to countries' economies and a sector with promising export potential. In 2005, the value of the seven countries' aquaculture production combined was almost US$10 billion, only a small proportion of which (2.7 percent) came from aquatic plants.

However, these attributes are not uniform among the region's seven countries; the level and pace of the sector's development have varied across national boundaries.

The aim of the study[35] summarized here was to understand the reasons for these differences. In a region that has experienced such a rapid expansion of aquaculture output and where aquaculture development is uneven, there are successes and failures that can provide invaluable lessons from which countries within and outside the region can learn as they strive to develop aquaculture. For a sector playing such an essential role in the region's food security, rural livelihoods and foreign exchange, it was felt equally important to ascertain whether or not the growth of the sector is likely to continue in the future.

POLICY LESSONS

The analysis of the history of development of aquaculture in the region reveals that the rapid expansion of the sector occurred in response to market demand and profit opportunities, with some government involvement. Governments were more enabling than proactive; they endorsed aquaculture as a source of livelihood or export earnings, but they did not provide generous incentives to farmers. It is only recently that, motivated by the sector's contribution to economic development, food security and the balance of payments, some governments have been proactive, deliberately promoting the sector with such incentives. Having learned from earlier mistakes in the region, most governments also intervene with regulations to limit *laissez-faire* excesses. It seems, therefore, that differences in national government policies could explain much of the difference in countries' aquaculture growth.

Myanmar, for example, has demonstrated the usefulness of aquaculture legislation in promoting the sector in a more orderly fashion. By legalizing aquaculture in 1998, the legislation encouraged farms to register. While water rights in agriculture still have priority over aquaculture, farmers have been permitted to convert rice paddies in the Irrawaddy Delta to shrimp farms. The result has been a rapid expansion in area devoted to shrimp farming and in output. From almost zero a decade earlier, shrimp output reached almost 49 000 tonnes in 2005. However, in terms of leases for aquaculture farms, Viet Nam appears to have developed the most effective policies. The leases are for long periods, ranging from 20 to 50 years; they are also transferable. In Myanmar, they may be for only three years; too brief to provide an incentive to improve property. In Viet Nam, officials are obliged to process applications for permits within 90 days of the application; otherwise, the permit is assumed granted.

Seed production and seed quality have also been a focus of policies and regulations in the region. All seven countries have public hatcheries that undertake research, training and technology dissemination and produce fingerlings. Some fingerlings are destined to small-scale farmers at subsidized prices, as in the Philippines; others are oriented to particular regions, as in Viet Nam. Public hatcheries may also concentrate on particular species deemed to have potential commercial value, as in Malaysia. However, in all countries except Cambodia, public hatcheries have been outnumbered by private hatcheries. The latter have developed in parallel with the industry. Indonesia's experience with public shrimp hatcheries has demonstrated the dynamism of the private sector. By the time public stations had been constructed, they were already redundant because of the appearance of private hatcheries.

Some countries have deliberately encouraged private hatcheries by providing incentives to domestic and foreign investors. These incentives, which consist of soft loans or tax exemptions and which have succeeded in increasing seed production, can be oriented to particular species. To improve seed quality from the private sector, regulations and inspections are used in Indonesia and Thailand. However, monitoring and enforcement are expensive; they also require skilled personnel that may be unavailable, as in Cambodia. The Philippines has improved culture traits of farmed species by encouraging collaborative research with universities.

Among the policies used to lower feed expenses, the most important cost in fish farming, are reductions in tariffs on imported feed; this helps domestic producers to become more efficient. Viet Nam has enticed foreign investment into the feed sector, which has increased feed availability and lowered costs. The availability and low cost of feed have increased its demand from farmers and stimulated investment in domestic feed industries. To lower the foreign exchange burden of imported fishmeal, Indonesia and Malaysia are actively conducting research in the use of local ingredients. In some countries, feed standards are controlled by regulations, but as with seed quality, monitoring can be constrained by lack of financial resources or skilled personnel.

A further policy that has been selectively used to promote investment in aquaculture is the provision of incentives to potential investors. Indonesia and the Philippines have offered subsidized credit, sometimes focused on small-scale farmers. The Philippines has abandoned this policy as it gave undue advantages to large-scale farmers. Provision of loans without collateral to small-scale farmers has been a successful policy in Malaysia. In Myanmar, policies focusing on carp farmers have not worked; not only is collateral required, but loan limits are also very low.

Fiscal exemptions and foreign investment have also been successfully used to encourage development in aquaculture. A number of countries offer tax holidays, exemptions or reductions on income tax, land taxes, sales taxes and import duties. Such incentives are not unique to aquaculture; they may be granted to other food-producing sectors, as in Malaysia. They can be species-specific or location-specific, as in Myanmar and Viet Nam. In Myanmar, foreign investment can take the form of joint ventures exclusively, while in the Philippines there are maximum limits on foreign participation. A minimum requirement for these policies to be successful is to guarantee capital and profit repatriation. While foreign investment in aquaculture within the seven countries is generally low, foreign participation in Viet Nam has been increasing rapidly. In Viet Nam, incentives also have a regional bias; the aim is to entice aquaculture development to the mountainous regions where fish protein is most needed.

MAJOR STRENGTHS AND WEAKNESSES

The region provides several lessons to learn from, but it has also generated problems of its own, which could limit the expansion of aquaculture output.

With the possible exception of Indonesia, the major constraint on aquaculture expansion in the region is a shortage of land. Different governments have taken different approaches to tackling this problem. The Government of Thailand has limited the brackish-water area available for marine shrimp. In the Philippines, no official limit has been set, but no additional land is available either; less than one-third of the original 400 000 ha of mangroves remain, but they are protected against encroachment. Development in the mid-1980s occurred in agricultural land, primarily in sugar plantations. Because land area cannot be increased, a solution is to intensify land-based production. Another option is to move to marine cage culture. Already, more seabass and grouper farming occurs in sea cages than in ponds, with higher returns. The Philippines is also moving to sea cage culture of milkfish.

Except in Indonesia and Malaysia, availability of freshwater is the second-most important constraint. In addition to agriculture and the farming of freshwater aquaculture species, freshwater is used in brackish-water shrimp culture to reach optimal salinity levels. Its use in aquaculture is frequently regarded as a loss for agriculture. In Myanmar, agriculture has been given priority for water-allocation rights.

A third constraint is the availability and cost of feed. Carnivorous species such as grouper or quasi-carnivorous species including shrimp require fish protein. Fishmeal has to be imported, often from as far away as South America, which can be costly. Substantial quantities of fresh fish are also often used to feed carnivorous species, which adds to the negative image of aquaculture. Ecologically, there are arguments that demand for fish to feed fish will put much pressure on the wild species, and the practice may not be sustainable. Socially, there are claims that the aquaculture industry transforms low-value protein sources that could be used to feed the poor into an expensive commodity for the wealthy. For this reason, Cambodia prohibited the culture of snakehead in 2004.

Low seed-quality standards could further limit the success of the industry in the region. Unavailability of quality seed encouraged the establishment of public fish stations to provide subsidized fingerlings to the poor, improve broodstock and supply fish for restocking public waters. In the Philippines, some public stations offer seeds that are below industry standards, which forces private hatcheries to lower their standards to remain competitive. The issue is not unique to the Philippines. In most countries, there is pressure for ensuring seed standards by compulsory certification of hatcheries.

Another constraint is the supply of adequate energy. Intensification often requires pumping and aeration and, hence, energy. Recirculation systems and wind-powered pumps are in use on a limited scale in freshwater aquaculture, but their capital cost is high. An inability to design a low-cost, high-volume pump for saltwater shrimp farming has also restricted their use. Solar-powered pumps suffer from the same problems.

The region also suffers from pollution and environmental degradation problems. The most severe form of pollution takes a direct toll on the species being raised owing to high levels of toxicants. The excessive use of inputs and poor husbandry practices led to severe production setbacks in Indonesia, Philippines and Thailand. Damage may also occur from urbanization and industrialization, both of which are increasing in Southeast Asia. A less severe form of pollution may not kill the harvest but may make it unfit for human consumption.

Limited expertise among officials as well as farmers is a serious hindrance to development in some countries. Policies and regulations may be enacted, but unless there are sufficient government personnel with adequate skills to monitor and enforce them, they will remain ineffective. Similarly, technology dissemination requires personnel who have the expertise to undertake research and extension. Cambodia and Myanmar, for example, lack sufficient capacity in these areas.

FUTURE DIRECTIONS

Despite the above caveats, aquaculture will in all likelihood remain important for the region in the near and medium-term future. On the supply side, the region already produces a significant proportion of the world's aquaculture output; this trend has strengthened in recent years. The region as a whole has adequate technical expertise and brackish-water and freshwater species whose culture is both technically feasible and economically viable.[36] Most countries have sufficient coastline for marine fish farming with considerable potential for cage culture of marine finfish; mariculture is the fastest growing aquaculture environment in the region.

Although expansion of certain species such as seabass and groupers remains constrained by seed availability and feed costs, other species (including milkfish) offer high returns – their upward production trend is likely to continue. With the exception of Cambodia and Myanmar, governments in the region have actively supported aquaculture by providing research and, in many cases, incentives[37] and have ambitious plans for aquaculture development. There is no indication that this policy will change. In most countries in the region, an enabling investment environment, through good governance, is in place and has resulted in production increases.

On the demand side, markets for farmed species are well established, and the region's population is projected to grow by 16 percent by 2015. Per capita incomes and urbanization, two of the robust determinants of fish demand, are increasing rapidly in most of the region's countries. Therefore, domestic demand for fish is likely to continue growing. Because production from the capture fisheries has reached its maximum sustainable yields in most countries, aquaculture supply is likely to expand in order to meet this growing demand. Furthermore, the region as a whole has a comparative advantage in a number of species, including shrimp, which augurs well for continued expansion of these species, particularly for export markets.

In addition to freshwater fish and shrimp, other species such as grouper also enjoy strong demand. While there are concerns about the use of trash fish to feed these species, the culture of such high-value species offers a means of raising the living standards of the poor. The profit margins on grouper are much higher than those on milkfish.

Human dimensions of the ecosystem approach to fisheries[38]

INTRODUCTION

Management of fisheries has always taken place in the context of societal goals and aspirations. In the first half of the twentieth century, those goals were dominated by a desire to increase landings. However, in the second half of the century, it became apparent that many fish stocks were being overexploited and that the relationship between fisheries and the ecosystems in which they were found could not be ignored. From this growing awareness came the ecosystem approach to fisheries (EAF). The EAF is an integrated approach to fisheries management, striving to balance diverse societal objectives (Box 15), with its basis in the CCRF.

Although the EAF has reached a point of general acceptance, difficulties are being encountered in its application in many areas. Some fisheries managers have seen the EAF as requiring extensive additional research and as adding costly complications that could not be funded with available budgets. The FAO Technical Guidelines for Responsible Fisheries No. 4.2[39] provided insights into the principles and concepts underlying the EAF, but further guidance was requested regarding the human dimensions of EAF and their manifestations in the form of policies, legal frameworks, social structures, cultural values, economic principles and institutional processes.

The FAO Fisheries Technical Paper No. 489 aims to facilitate the introduction of the EAF in the day-to-day work of fishery administrations by providing this additional information. It consolidates a range of available concepts, tools and experiences relevant to EAF implementation from social, economic and institutional viewpoints, and examines how these aspects are an integral part of EAF application.

The paper covers key issues facilitating the implementing of the EAF: (i) defining the boundaries, scale, scope and context of the EAF at hand; (ii) the various benefits and costs involved in the EAF, from social, economic, ecological and management perspectives, and the decision-making tools that can assist EAF implementation; (iii) internal incentives and institutional arrangements that can be created or used for promoting, facilitating and funding the adoption of EAF management; and (iv) external (non-fisheries) approaches for financing EAF implementation. A companion document to the FAO Technical Guidelines for Responsible Fisheries No. 4.2.2[40] on the same theme, it includes a wide range of tools and examples from around the world that may serve as starting points for solving practical problems linked to the introduction of the EAF.

THE HUMAN CONTEXT FOR AN EAF

In any given fishery in which implementation of EAF management is being planned, it is important to understand the current state of the fishery and its natural and human environment – the context in which the EAF is being developed.

For example, knowing the context will help clarify if the particular EAF will be incremental or a complete overhaul of an exisitng management approach, intersectoral or intrasectoral, local or international, involving intensive scientific research or relying on the best available information, etc. Establishing this EAF context will involve not only understanding the fishery and ecosystem from both the natural science and human perspectives, but also society's goals and values with respect to ecosystem goods and services, the social and economic context (at the micro and macro levels) in which the fishery operates, the policy and institutional frameworks in place, as well as the political realities and power dynamics affecting the governance of resources.
A good understanding of these issues and other realities surrounding the use of

Box 15

Ecosystem approaches for natural resource management – similarities and differences in starting points and focuses

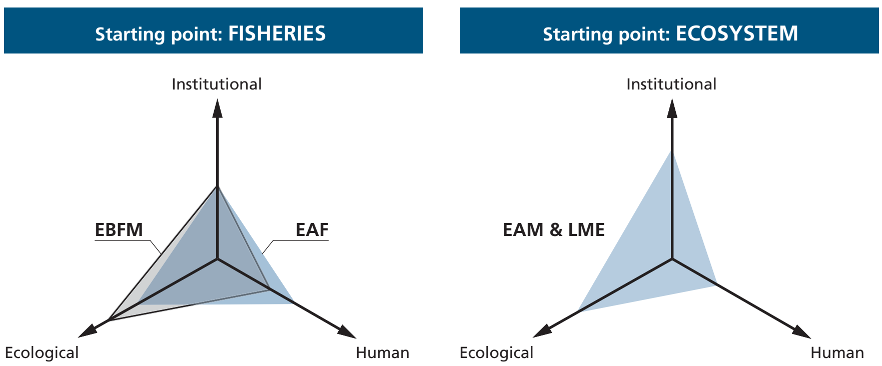
Differences are found among the many ecosystem approaches to natural resource management being implemented by different organizations around the world today. It is difficult to quantify these nuances or to provide a scale on which the approaches could be placed. One notable distinction that could be made refers to whether the process starts from a fisheries perspective or from a more holistic ecosystem overview. The ecosystem approach to fisheries (EAF) and ecosystem-based fisheries management (EBFM) have their focus in fisheries management while, for example, the ecosystem approach to management (EAM) and large marine ecosystem (LME) approaches tend to start from a defined ecosystem in which fisheries is one sector among several others.

Another distinction that could be made concerns the discipline-centred perspective of the different approaches:

- institutional – governance aspects including cross-sectoral coordination and collaboration;
- human – socio-economic well-being and attainment of economic societal objectives;
- ecological – health of biological ecosystem components and environmental sustainability.

In line with their ecosystem-based starting point and holistic outlook, EAM and LME generally have a stronger explicit focus on ecological and – particularly with regard to LME – institutional aspects than the fisheries-based approaches EAF and EBFM. Comparing EAF and EBFM, the latter could be regarded as relatively more inclined towards ecology than the former, which seeks to balance human and societal economic needs with ecological functions. The figures below attempt to illustrate these nuances in focus and perspective.

Ecosystem approaches for natural resource management



Sources: G. Bianchi. 2008. The concept of the ecosystem approach to fisheries in FAO. *In* G. Bianchi and H.R. Skjoldal, eds. *The ecosystem approach to fisheries*, pp 20–38. Rome, FAO. 363 pp.
P. Christie, D.L. Fluharty, A.T. White, L. Eisma-Osorio and W. Jatulan. 2007. Assessing the feasibility of ecosystem-based fisheries management in tropical contexts. *Marine Policy* 31(3): 239–250.

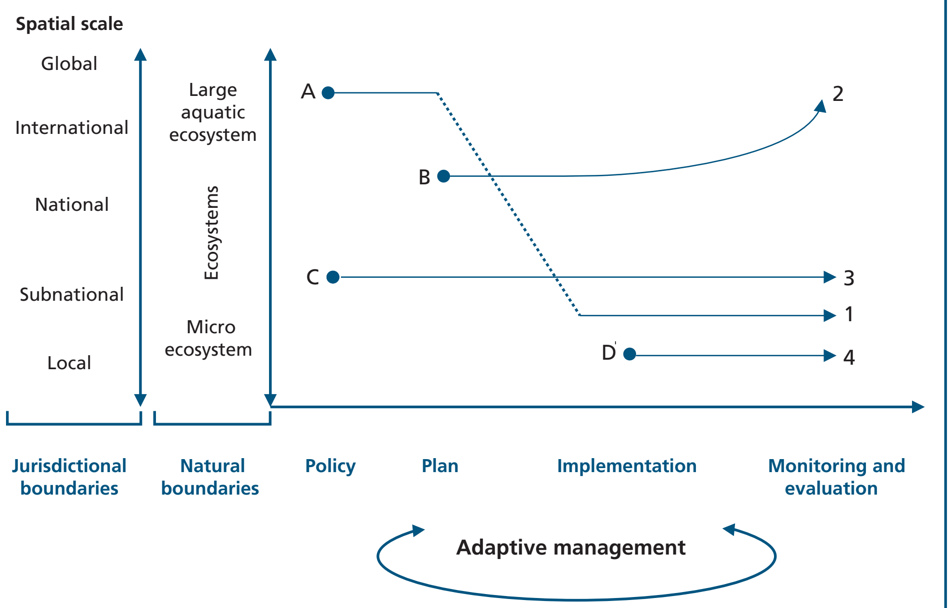
aquatic resources is essential to guide EAF policies, objectives and plans – in their absence, policies and plans may very likely fail to assist in the move towards sustainable fisheries.

The human aspects that play a role in determining the nature and effectiveness of an EAF include the power and governance structures in place, the economic “push” and “pull” mechanisms driving the fishing activities, the sociocultural values and norms associated with fishing, and the external contexts (e.g. global markets, natural phenomena, emergencies and political changes) that affect the ability to manage fisheries.

Social, economic and institutional aspects contribute as much to the set of complexities faced within fishery management as do those relating to fish species and the aquatic environment itself. For example, a fishery typically faces the complexities of: (i) multiple and conflicting objectives; (ii) multiple groups of fishers and fishing fleets, and conflicts among them; (iii) multiple post-harvest stages; (iv) complex social structures, and sociocultural influences on the fishery; (v) institutional structures,

Figure 38

Example entry points and paths for an ecosystem approach to fisheries (EAF)



PATH

A → 1 Starting from an international commitment to define aquatic resource policy at the level of a large marine ecosystem, leading to integrated natural resource management planning at this level; however, implementation of these plans occurs at the national level (within marine areas under national jurisdiction, including exclusive economic zones), with subnational adaptations of fisheries management plans within the internationally defined policies and plans.

B → 2 Starting from the revision of existing fisheries management at the national level to incorporate EAF principles and approaches, leading to a subregional agreement among two or more nations to adopt an EAF for shared or transboundary aquatic resources.

C → 3 Starting with national policy revisions to incorporate an EAF, leading to more holistic, integrated and participatory approaches to managing waters in the territory of a country, including inland waters, following EAF principles, including fully functioning monitoring and evaluation mechanisms, and adaptive management.

D → 4 Starting as a response to a crisis within the fishery such as a bycatch problem in a single fishery that is corrected by a technical measure (e.g. a turtle exclusion device); potentially leading to a revision of policy and management within this fishery and elsewhere that incorporates EAF principles.

Source: FAO. 2009. *Fisheries management. 2. The ecosystem approach to fisheries. 2.2 The human dimensions of the ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2, Add. 2. Rome. 88 pp.

and interactions between fishers and regulators; and (vi) interactions with the socio-economic environment and the larger economy.

DRIVING FORCES FOR AN EAF

The list of potential factors driving fisheries managers, a community or a society to adopt the EAF is as extensive and varied as the list of potential reactions to these drivers. The initiation of an EAF may take place at various stages of the EAF process, may target different scales and may evolve differently along the EAF path. Figure 38 presents four example starting points (A–D) and paths (1–4) of EAF initiation and implementation.

COSTS AND BENEFITS OF APPLYING AN EAF

The widespread support for the EAF reflects its potential to produce a range of ecological and social benefits (Table 16). It should cause an increase in sustainable employment and income generation, a reduction in the risk of fishery collapses, and various aesthetic benefits. At the same time, there are potential costs involved in implementing an EAF, ranging from direct costs of implementation (e.g. increased management costs) to possible indirect or induced costs, resulting from how the EAF is implemented (e.g. reduced employment or revenues in the short term). It is important to understand the range of such benefits and costs involved in EAF implementation – be they ecological, management administration, economic or social – together with their likelihood of occurrence, and their potential impacts.

Figure 39

Total value of a fisheries ecosystem

TOTAL VALUE OF A FISHERIES ECOSYSTEM

Use value | **Non-use value**[1]

Total value categories	**Direct use value** Consumptive, non-consumptive	**Indirect use value**	**Option and quasi-option** Bequest value	**Existence**
Example: fisheries ecosystem services	• Capture/recreational/ aquarium fishing (food, income) • Ornamental resources • Medicinal resources • Tourism/recreation • Culture/heritage/ spiritual • Science and education	• Habitats and biological regulation • Employment/livelihoods • Food chain/global life support • Transportation • Local/national/ international relations	• Preservation for future uses • Stewardship • Precautionary or risk/uncertainty reduction • Future knowledge potentials	• Intrinsic preservation • Biodiversity • Social identity • Religious and cultural identities
Common valuation method	M, P, HP, TC, CV, CJ, ranking	AC, P, CV, CJ, ranking	AC, CV, CJ, ranking	CV, CJ, ranking

[1] The dotted line indicates the overlap between direct use values and future, potential use values, i.e. some people and societies value these services today because of their potential to be used in the future.

Notes: M = market methods; P = production approaches; HP = hedonic pricing; TC = travel cost; CV = contingent valuation; CJ = conjoint analysis; AC = avoidance cost.

Sources: Adapted from Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being. A Framework for Assessment. Chapter 6: Concepts of ecosystem value and valuation approaches.* Island Press, Washington, DC.
S. Farber, R. Costanza, D.L. Childers, J. Erickson, K. Gross, M. Grove, C.S. Hopkinson, J. Kahn, S. Pincetl, A. Troy, P. Warren and M. Wilson. 2006. Linking ecology and economics for ecosystem management. *BioScience,* 56(2): 121–133.

A crucial matter to consider in any management action, and particularly in the implementation of as profound a shift as the introduction of EAF management, is that of the distributional impacts of the changes. Managers need to consider: (i) To whom do the various benefits and costs accrue? (ii) When do the various benefits and costs occur? (iii) At what scale do the benefits and costs occur?

Table 16
Benefits and costs of implementing an ecosystem approach to fisheries (EAF)

Type	Benefits	
Ecological	■ Healthier ecosystems (directly or with EAF linkages to effective integrated coastal and ocean management [ICOM]) ■ Increased global production of goods and services from aquatic ecosystems (a global benefit) ■ Improved fish stock abundance (due to healthier ecosystems) ■ Reduced impact on threatened/ endangered species ■ Reduced bycatch of turtles, marine mammals, etc.	■ Less habitat damage (due to more attention to fishing impacts) ■ Lower risk of stock or ecosystem collapse ■ Reduced contribution of fisheries to climate change (if EAF leads to lower fuel usage) ■ Improved understanding of aquatic systems
Management	■ Better integration in management across fisheries, other uses, etc. ■ Clearer expression of management objectives, leading to greater societal benefits ■ Better balancing of multiple objectives	■ Better balancing of multiple uses, leading to increased net benefits ■ More robust management owing to broadening from single-species tools ■ Improved compliance owing to more "buy-in" to management, through better participation
Economic	■ Increase in benefits to fishers per fish caught (bigger fish from a healthier ecosystem) ■ Increased catches (especially in long term) ■ Increased contribution to the economy (especially long term) ■ Reduced fishing costs (if EAF results in reduced bycatch) ■ Increased net economic returns (if EAF involves reduced fishing effort, towards maximum economic yield)	■ Higher-value fishery (if increased availability of food to top predators increases stock sizes) ■ Greater livelihood opportunities for fishers (e.g. in tourism, if abundance of charismatic species increases through EAF) ■ Increased non-use (e.g. cultural) and existence values (the latter resulting from appreciation of healthier aquatic systems and a greater abundance of aquatic life, etc.)
Social	■ Positive impacts on food supply in long term (if greater catches become possible) ■ Synergistic positive effect of coordinated EAF across fisheries and/or nations (large marine ecosystem) ■ Greater resilience (if there is emphasis on multiple sources of fishery livelihoods)	■ Greater resilience (if increased bycatch results in more livelihood opportunities) ■ Reduced conflict (if EAF processes deal effectively with interfishery issues)

Source: C. De Young, A. Charles and A. Hjort. 2008. *Human dimensions of the ecosystem approach to fisheries: an overview of context, concepts, tools and methods.* FAO Fisheries Technical Paper No. 489. Rome, FAO. 152 pp.

In addition, managers need to be familiar with the values used to express benefits and costs and associated valuation methods. The various benefits and costs of EAF implementation reflect the range of human values of fisheries social-ecological systems from the local level to the global level. Therefore, it is important to recognize that the benefits could arise in various forms. Figure 39 provides examples of the use and non-use services of relevance to fisheries ecosystems as well as a few of the common

Table 16 (cont.)

Type	Costs	
Ecological	■ Decreased fish stocks (if fishery management is now less effective than previously) ■ Increased habitat damage (if management is now less effective or creates induced impacts) ■ Shift in fishing effort to unprotected areas, leading to a loss of genetic biodiversity	■ Greater highgrading/dumping, and thus more wastage (if catch and/or bycatch is restricted) ■ Reduced fish catches (if more predators, e.g. seabirds, seals, because of better protection
Management	■ Increased cost of management ■ Increased cost of research ■ Increased cost of data collection and data management ■ Increased cost of coordination across fisheries and aquatic uses ■ Increased cost of additional and more participatory meetings ■ Increased cost of monitoring, observers, etc.	■ Increased risk of non-compliance (if regulations too complex or unacceptable) ■ Increased risk of collapse of management system (if too demanding of resources) ■ Risk of management failure (if excessive faith placed in "new" EAF paradigm) ■ Poor management results and loss of support (if EAF imposed or implemented improperly)
Economic	■ Reduced catches (especially in short term) ■ Loss of income to negatively affected fishers ■ Increased income disparity among fishers (if EAF impacts are uneven) ■ Reduction in government revenues from licences, etc. (if there is reduced effort)	■ Reduction in benefits to fishers (if lower government support) ■ Reduced contribution to economy (short term) ■ Reduced employment in short term and possibly long term
Social	■ Negative impacts on food supply in short term (and risk of this also in long term) ■ Greater inequity (if EAF favours those able to invest in appropriate technology) ■ Greater inequity (if there is misplaced allocation of responsibility for EAF costs)	■ Increased poverty among those adversely affected by EAF (short term, long term, or both) ■ Reduced benefits to fishers (if EAF linked to ICOM, and trade-offs detrimental to fishers) ■ Greater conflict (if EAF leads to enforced interaction among a larger set of societal and/or economic players)

methods used to evaluate these services. Such valuation methods would provide nominal or relative value estimates, which would then be incorporated into a broader evaluation or into decision-making mechanisms, such as cost–benefit analyses, indicator frameworks, national accounting systems, asset mapping, and bioeconomic models. These mechanisms would allow decision-makers and stakeholders to better understand the social, environmental and economic trade-offs related to any management alternatives.

INSTRUMENTS FOR EAF IMPLEMENTATION

Institutional arrangements

In moving from conventional fisheries management towards an EAF, some changes to current institutional and legal frameworks will probably be necessary.[41] These changes include ways of taking account of, and dealing with, the increased scope of this management approach, conveying the need for:

- coordination, cooperation and communication within and among relevant institutions and resource user groups, in the fishery sector and outside, in the planning process and in implementation;
- information regarding the ecosystem and the factors affecting it;
- incorporation of uncertainties into the decision-making;
- ways of involving the broadened definition of stakeholders in decision-making and management.

Legal frameworks

The long-term prospects of applying an EAF will be enhanced by clear and facilitating legal arrangements, supporting the corresponding policy frameworks and institutional frameworks. A supporting legal framework can provide the legal backbone for implementing an EAF and its relevant principles and policies by:

- providing mechanisms for coordination and integration between the fisheries administration and other institutions in charge of ecosystem maintenance and use;
- defining roles and responsibilities clearly and transparently, including the management and regulatory powers of the responsible authorities;
- providing legal mechanisms for conflict management;
- providing mechanisms for stakeholder involvement in decision-making;
- establishing or confirming management and user rights;
- decentralizing decision-making and management responsibilities and establishing mechanisms for comanagement;
- providing for spatial and temporal control on fishing activities.

A legal framework should furthermore provide for the establishment of EAF management plans and clearly designate the institutions responsible for implementing and enforcing such plans. To that effect, the legislation should clarify:

- the decision-making entities at various jurisdictional levels;
- the geographical area that the EAF policy covers;
- the stakeholders bound by the policy;
- the institutions responsible for implementing and enforcing the management plan;
- how institutional and jurisdictional disputes will be resolved.

Capacity building

Developing organizational capacity may be a prerequisite for the introduction of an EAF, and it is likely to be a requirement throughout the process. In an EAF, stakeholders need to understand human–system relationships in relation to the resource system. In many cases, capacity may be built fairly easily and quickly if stakeholders engage in collaborative activities in which complementary skills transfer occurs. Learning by doing within partnerships is an approach well suited to strengthening EAF institutions and one that is usually cost-effective.

Adaptive management

A fundamental consideration that must be dealt with in fisheries management is the reality of uncertainty. Adaptive management takes the view that resource management policies may be treated as careful "experiments" from which managers can learn and then adapt or change. To make the process effective, it is essential that the experiments and their results be appropriately documented. In this way, the use of adaptive management and learning processes will allow EAF systems to adjust and improve over time as new experiences and knowledge become available.

Information for an EAF

Ecosystem approaches are often perceived as being data-intense, analytically complex, requiring large amounts of information and extremely costly. This may be true in some cases, but there are many options and entry points for initiating and establishing an EAF that are no more onerous than conventional fisheries management. For example, the "best available [scientific] information" in low-value fisheries could, in some cases, be confined to traditional knowledge and basic fishery assessment. Inadequacy of scientific data should not hinder the application of an EAF, but the implications of uncertainty need to be taken into account through the precautionary approach.

Because EAF information systems need to be manageable and sustainable, it is critical that the research and data collection be linked to what is essential for decision-making. Often, available information will come from various types of knowledge systems (e.g. scientific and traditional) and include both qualitative and quantitative information, which may cause problems of integration. However, tools for and examples of such integration exist.

Incentives as part of the EAF toolbox

There may be a need to create or introduce appropriate incentives, whether institutional, legal, economic or social, that individuals will factor into their decision-making, to induce support for EAF implementation.

Institutional incentives refer to motivations created by institutional arrangements that promote transparency, cooperation, trust and participation on behalf of stakeholders. Adequate institutional arrangements are key to successful management outcomes. Institutional failures – combined with inadequate legal frameworks – have been identified as main obstacles to effective conventional fisheries management.

Legal incentives include effective legislation that creates positive incentives as well as negative ones in the form of significant penalty structures with effective enforcement capability. Clear and enabling legal arrangements that support the corresponding policy and institutional frameworks are key to successful EAF implementation. The legal framework should provide support for: (i) coordination and integration, including roles and responsibilities of different parties; (ii) framework for management processes; (iii) legal status of rights systems; (iv) pro-poor legislation; (v) international norms and agreements; and (vi) conflict resolution.

Economic incentives, or financial incentives, arise from the need to address market failures and aim to establish a situation where economic actors and individuals choose to make more socially correct choices. These financial measures can be divided into two categories: market-based incentives (e.g. ecolabelling and tradable rights) and non-market-based incentives (e.g. taxes and subsidies). The distinction is made to reflect the idea that, in the former, a buyer and seller interact in the market to determine the price of a good or service, whereas, in the latter, it is the governmental authority defining and imposing changes to the profit function of the fishery.

Social incentives relate to the ways group behaviour and group interactions occur and form the context in which an individual makes decisions. Such incentives include: moral structures, religious beliefs, peer pressure, gender relations, policy, social preferences, norms, rules, ethics, traditional value systems, social recognition, trust among the various stakeholders, and common interests.

Perverse incentives are, from an EAF point of view, any policy or management measures that incite people or groups to act in a way that negatively affects an ecosystem's ability to provide services or, in other words, that lead to inefficient use of ecosystem resources. Examples of perverse incentives include subsidies leading to overinvestment in fishing capacity in a fishery in which management is unable to control fishing effort. The removal of perverse incentives is a necessary condition for a successful EAF.

CONCLUSIONS

A wide range of social, economic and institutional considerations are relevant to the implementation of an EAF because: (i) the EAF must take place in the context of societal or community objectives, which inherently reflect human aspirations and values; (ii) as the EAF takes into account interactions between fisheries and ecosystems, this includes a wide range of complexities relating to human behaviour, human decision-making, human use of resources, and so on; and (iii) implementing the EAF is a human pursuit, with implications in terms of the institutional arrangements that are needed, the social and economic forces at play, and the carrots and sticks that can induce actions compatible with societal objectives.

Such processes take place in a world of complexity, and the EAF can provide an effective vehicle to better recognize and address the wide range of complexities in fisheries, complexities that bear directly on the success of fisheries management.

Geographic information systems, remote sensing and mapping for the development and management of marine aquaculture

INTRODUCTION

This article presents a summary of the FAO Fisheries Technical Paper No. 458,[42] whose objective is to bring to light applications of geographic information systems (GIS), remote sensing and mapping to improve the sustainability of marine aquaculture. The perspective is global, and developing countries are the focus. The underlying purpose is to stimulate the interest of individuals in government, industry and in the educational sectors of marine aquaculture to make more effective use of these tools.[43]

Marine aquaculture is becoming increasingly important in the fisheries sector in terms of both production and value. Of 202 maritime countries and territories, 93 had a mariculture output in the period 2004–08. Of those, 15 countries accounted for 96 percent of the world output. Thus, there appear to be ample opportunities for the expansion of marine aquaculture among those countries not yet producing, or producing relatively little at present. Countries have jurisdiction over development and management of all kinds within their EEZs, and most countries possess vast EEZ areas associated with their homelands or territories. Thus, a lack of space does not at first glance appear to be an impediment to the expansion of marine aquaculture at present.

Marine aquaculture can be viewed as occupying three environments – coastal, off-the-coast and offshore in waters that are “sheltered” by land, “partially exposed” and “exposed” in the unsheltered waters of the open ocean. The development of nearshore aquaculture appears to be impeded by a number of issues relating to competing uses and the environment. Offshore aquaculture shares the same issues in kind, but to a lesser degree, and is currently impeded by a lack of open-ocean technologies and an enabling framework for development.

Geographic information systems, remote sensing and mapping have a role to play in the development and management of marine aquaculture because all of the issues have geographic and spatial components that can be addressed by spatial analyses. Satellite, airborne, ground and undersea sensors acquire much of the required data, especially data on temperature, current velocity, wave height, chlorophyll-a concentration and land and water use. A GIS is used to integrate, manipulate and analyse spatial and attribute data from all sources. It is also used to produce reports in map, database and text format to facilitate decision-making.

The first GIS was the Canada Geographic Information System and it marked the inception of worldwide efforts to formalize and automate geographic principles to solve spatial problems. After more than 40 years of development, GIS are now a mainstay for addressing geographic problems in a wide variety fields apart from natural resources.[44]

METHODOLOGY

The approach used in the technical paper was to employ example applications that have been aimed at resolving many of the important issues in marine aquaculture. The focus was on the ways spatial tools have been employed for problem solving, not on the tools and technologies themselves. A brief introduction to spatial tools and their use in the marine fisheries sector preceded the example applications. The most recent applications were selected to be indicative of the state of the art, allowing readers to make their own assessments of the benefits and limitations of use of these tools in order to resolve their own issues. Other applications were selected in order to illustrate the evolution of the development of the tools. The applications were organized according to the main realms of marine aquaculture: culture of fishes in cages, culture of shellfishes and culture of marine plants. Because data availability is a prerequisite for a GIS and one of the prime issues in the use of spatial tools in marine aquaculture, a section was devoted to describing various kinds of data. Similarly, because the ultimate purpose of a GIS is to aid decision-making, a section on decision support tools was also included.

Given that spatial aspects of marine aquaculture have an economic underpinning, it is noteworthy that there is a dearth of GIS applications to the economic aspects of marine aquaculture development and management. This is despite the fact that some existing economic studies and models clearly lay out geographically related cost variables. It has been suggested that a GIS could be applied to several elements of these economic studies to improve choices of trade-offs mainly by spatially hindcasting environmental variables. The few applications of GIS in socio-economics are mainly global studies that encompass all of aquaculture.

Although there is much room for refinement as well as for the expansion of applications to address issues more fully and broadly, it is safe to say that GIS can be advantageously deployed to improve the sustainability of marine aquaculture, particularly for estimating potential for development, siting, zoning and identifying and quantifying competing, conflicting and complementary uses. Put another way, the use of GIS, remote sensing and mapping has reached the point of becoming an essential step in providing the enabling environment for the development of marine aquaculture. A noteworthy gap is that spatial analyses have been little applied to the culture of marine plants, by weight the most important output of marine aquaculture.

A case study was included in the technical paper to illustrate how freely downloadable data (i.e. EEZ boundaries, bathymetry, sea surface temperature, and chlorophyll-a) can be used to estimate marine aquaculture potential. The study was of open-ocean aquaculture potential in the eastern EEZs of the United States of America. It clearly illustrated that it is possible to create a simple GIS to make a first approximation of offshore aquaculture potential for any country wishing to do so.

The techniques used to conduct the spatial analysis were basic to GIS and included: (i) data collection; (ii) selection and assessment of data collected; (iii) data importing; (iv) data standardization (e.g. projection); (v) GIS spatial representations (e.g. interpolation); (vi) thresholding; (vii) overlaying; (viii) querying; and (ix) verification of results.

In order to ensure that the case study would provide a realistic example using an approach that would have wide applicability, it was to decided to select species already being cultured in nearshore waters in many countries and for which there are well-established world markets. The cobia *(Rachycentron canadum),* a top predator in nature, is a warm-water fish that provides an example of "fed aquaculture" in that it requires formulated feeds in culture. In contrast, the blue mussel *(Mytilus edulis),* is a cold-water, filter-feeding shellfish and in this latter regard provides an example of "extractive aquaculture". The former is cultured in cages and the latter using several types of suspended devices including longlines.

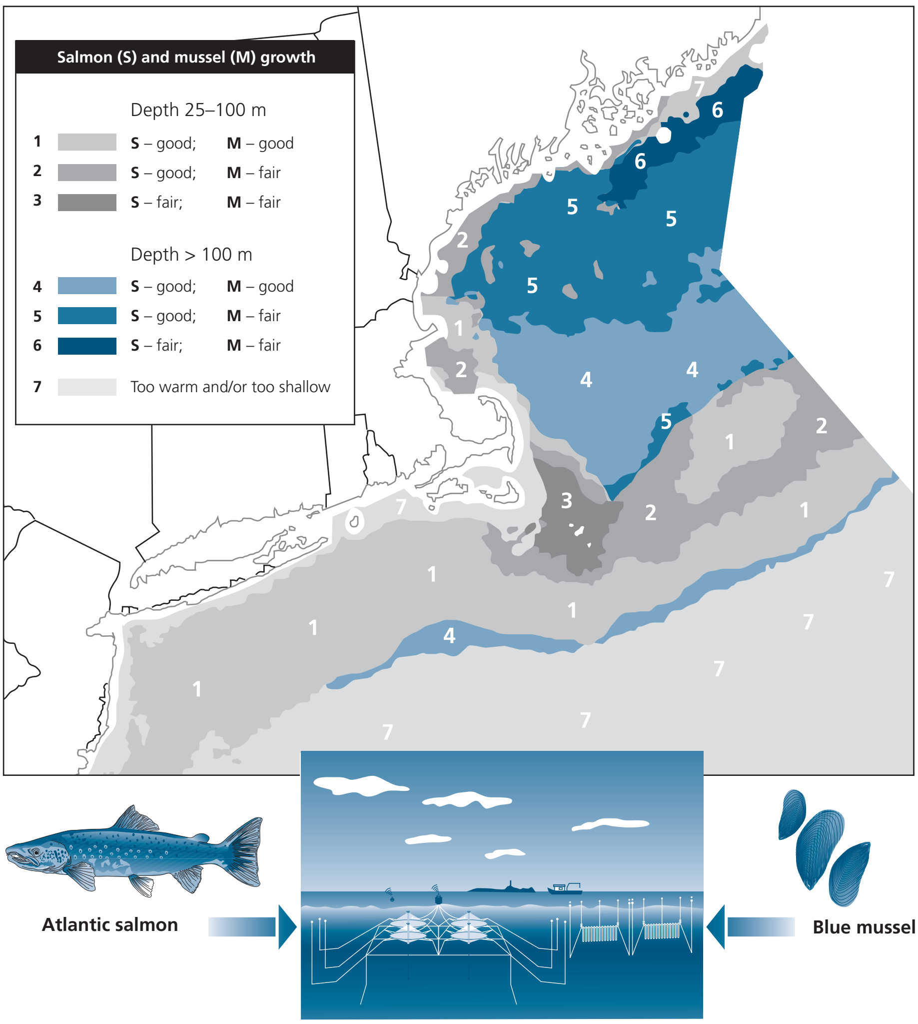
Setting thresholds was one of the most important steps in the case study. Examples are temperature thresholds relating to the growth rates of all cultured organisms, and chlorophyll-a relating to the growth of filter feeders such as the blue mussel. Other thresholds relate to minimum and maximum depths suitable for cages and longlines. An important consideration is that it may take a long time to identify, compile and synthesize attribute data to set thresholds on production factors such as depth of cages – this is because of the need for extensive searches of the scientific literature and the Internet as well as for correspondence with experts. Additional variables can be added as they become available, and it may be necessary to modify threshold ranges as new information is obtained from culture practice.

RESULTS

Since publication of the technical paper, the case study analyses have been extended to include an additional species, the Atlantic salmon, *Salmo salar.* The Atlantic salmon was selected because of its global economic importance in cool-water aquaculture. Moreover, it was an attractive candidate because its culture methods are well

Figure 40

Differing potentials for integrated multitrophic aquaculture in the Western Atlantic Ocean[1]



[1]According to depths suitable for anchored (25–100 m) and free-floating (> 100 m) culture installations off the northeast coast of the United States of America (from Maine to New Jersey).

Sources: Cooperative Institute for New England Mariculture and Fisheries, National Oceanic and Atmospheric Administration, and University of New Hampshire.

established. Thus, the main technological challenge to its culture in the open ocean is one of durable, economic structures in which to contain it. With an average annual sea surface temperature of 20 °C or higher in 87 percent of the EEZ study area, there is relatively little area that is suitable for a cold-water species like the salmon. However, expansion of the study to include the Atlantic salmon offered an opportunity to examine the potential for integrated multitrophic aquaculture in combination with the blue mussel, another cool-water species. Chopin[45] and Soto[46] see trophic diversification in offshore aquaculture as an advantage from an environmental and economic perspective, with "service species" from lower trophic levels (mainly seaweeds and invertebrates) performing the ecosystem balancing functions while representing value-added crops. The spatial analysis of the salmon–mussel combination explores this opportunity in the open ocean.

In this analysis, suitability maps for salmon and mussel were first integrated and all combinations reported. Most of the eastern EEZ area of the United States of America is unsuitable for either mussel or salmon in each of the depth zones. However, there are nearly 49 000 km^2 where good growth of salmon and mussel would occur together in the 25–100 m zone and, correspondingly, 19 000 km^2 for the same growth conditions in the > 100 m zone.

Figure 40 shows areas with potential for good growth of Atlantic salmon and blue mussel that are within cage depth limits and adjacent to ports in the Atlantic Ocean. This is an environmentally aware, integrated approach in the sense that the mussels consume some of the waste from the salmon. It is economically efficient because, on the one hand, output now includes mussels and not only salmon, and, on the other, capital and operation costs are shared.

The underlying purpose of the case study was to test the approach for later use in a reconnaissance of open-ocean aquaculture potential worldwide using a country-by-country assessment.[47] The basis for such studies is sufficient spatial data with global coverage that are freely available for download from the Internet. Attribute data have to be identified, compiled and synthesized according to the culture systems and species.

As an example of a more specific kind of analysis, the potential for the culture of cobia in the open ocean is being examined. The limits of the study areas are the outer EEZ boundaries while the inner limits are the shorelines of the coastal countries.

The preliminary results for the cobia indicate a total area of 2.9 million km^2 that nominally would be within the limits of present cage technologies in terms of depth, 25–100 m, and that would result in good growth in terms of temperature, 26–32 °C. Forty-nine countries or territories possess more than 1 000 km^2 in this class and, of those, 28 countries possess more than 10 000 km^2 in this class, predominately developing countries. Correspondingly, the total area suitable for blue mussel that would be within present technology limits and provide the best growth in consideration of temperature and chlorophyll-a concentration is 1.1 million km^2. There are 38 countries that possess at least 1 000 km^2 and, of those, 22 countries that have more than 10 000 km^2. Although the surface areas that are suitable seem very large, there may be competing and conflicting uses for the same space. Furthermore, access in terms of time and distance from shore support facilities to culture sites also limits the area available for development. Both of these considerations will be addressed in future studies. However, these results are speculative because offshore aquaculture potential has been estimated in areas that have yet to be developed. Therefore, opportunities for validation based on locations of existing installations are very limited.

CHALLENGES

A legitimate question is: Despite the many varieties of applications presented herein, why is the use of GIS, remote sensing and mapping in aquaculture not more common and widespread as in other disciplines such as water resources? Part of the answer may be a lack of information about the capabilities of these tools among administrators and managers and a lack of experience among practitioners, especially in developing countries. This technical paper represents one solution. GISFish (the FAO Internet gateway to GIS, remote sensing and mapping as applied to fisheries and aquaculture)[48] and an FAO overview on the potential of spatial planning tools to support the ecosystem approach to aquaculture[49] are complementary resources to this technical paper.

However, other possible constraints on the use of spatial tools need to be considered. One is that there is too little opportunity for formal education in GIS that should accompany undergraduate and graduate studies in all fields of natural resource research and management. Another is lack of access to computer equipment, software and the bandwidth in order to operate on the Internet effectively, especially with regard to communicating and acquiring data, and especially in developing countries. The impediments to more effective and widespread use of spatial tools in aquaculture need to be examined.

Possibilities for next steps in this direction include the formation of an international working group to address specific items such as:

- a review of the aquaculture sector's present and future needs for spatial analyses;
- a critical analysis of why GIS has not taken off;
- the role of GIS, remote sensing and mapping for the management and development of aquaculture and in strategic and operational decision-making.

From the viewpoint of organization and implementation of GIS, it is clear that marine fisheries and marine aquaculture share common needs for environmental and economic data, and many of the species are both cultured and captured. Furthermore, spatial analytical procedures are the same or similar in marine aquaculture and fisheries. Therefore, it would seem that there is much to be gained by cooperation between, or integration of, GIS activities in aquaculture and fisheries at national government levels and among academic institutions.

CONCLUSIONS

To date, the GIS applications in marine aquaculture have been very specific. That is to say, they have usually been aimed at resolving single issues. However, GIS, serving as the backbone of an aquaculture management information system, could help resolve pressing issues. The benefits would accrue in many ways, but perhaps the most important would be that diverse data and different perspectives on a problem would be integrated, a development that could lead to comprehensive solutions to the advantage of all stakeholders.

Global review of aquaculture development 2000–2010

Global aquaculture production (excluding plants) increased from 32.4 million tonnes in 2000 to 52.5 million tonnes in 2008, while the contribution of aquaculture to global food fish consumption rose from 33.8 percent to 45.7 percent in the same period. It is estimated that aquaculture will meet more than 50 percent of global food fish consumption by 2012.

The aquaculture sector has further expanded, intensified and diversified in the past decade. The expansion has mainly been due to research and development breakthroughs, compliance with consumer demands and improvements in aquaculture policy and governance, as identified in the 2000 Bangkok Declaration and Strategy.[50] Efforts to develop the sector's full potential and increase seafood supplies have been aggressively pursued in recent years, often under regulatory regimes that support industry expansion and growth. Much of the aquaculture sector has developed sustainably in keeping with principles of an ecosystem approach to management and in accordance with the CCRF. However, these trends have not occurred consistently throughout all regions.

The environmental performance of the aquaculture sector has continued to improve as a result of a combination of appropriate legislation and governance, technological innovations, risk reductions and better management practices. There is also evidence in most regions of efforts to apply the ecosystem approach to aquaculture development. In many countries, sea-farming activities have expanded, as has promotion of multitrophic aquaculture, causing reduced environmental impact. Aquaculture networking has improved and communication has been amplified. Technology has strengthened, several new species have emerged (striped catfish, tuna, cod, etc.) and some have reached production volumes sufficient for stable markets to develop. The quantity and quality of seed and feed have increased globally as producers have responded both to consumers' concerns and to the availability of resources. Significant improvements in feed conversion have been recorded and the reliance on fishmeal has been reduced for several species. In general, aquaculture health management and biosecurity have improved, although sporadic outbreaks of transboundary diseases have occurred in most regions. The use of veterinary drugs and antimicrobials has come under increased scrutiny, and legal frameworks for controlling their use have been established in many countries. However, effective enforcement of such laws is still constrained by a shortage of financial and human resources.

In the past decade, the Asia–Pacific region has witnessed the highest overall growth and development of aquaculture. The small-scale farming sector in Asia has endeavoured to comply with consumer demands in importing countries. Application of a cluster management approach to farming and adoption of better management practices have been evident in many countries. This has meant improved food quality and safety for small-scale farmers' aquaculture products and improved access to markets. However, many countries still do not benefit fully from the opportunities offered by international trade as their aquaculture products have difficulty satisfying the import requirements of some of the leading markets.

The Asia–Pacific region has exhibited two interesting developments in the last decade. Within the space of a few years, an almost complete shift has occurred in marine shrimp production – away from the indigenous black tiger shrimp (*Penaeus monodon*) to the exotic white leg shrimp (*P. vannamei*). There has also been an explosive growth in striped catfish (*Pangasius hypophthalmus*) farming in Viet Nam (the Mekong Delta), where production reached a million tonnes in 2009.

In Europe, research and development achievements in aquaculture have been remarkable, in particular the improvements in the efficiency of production systems and the quality of the fish produced therein, while mitigating environmental impacts. Examples of new technologies include: the development of underwater surveillance to manage feeding and biomass; the upscaling of recirculation systems; the development of cages and nets that can be used in higher energy locations; and the development of integrated multitrophic production systems. However, in spite of undeniable technological progress, Europe remains a net importer of fish, possibly a consequence of increasingly stringent regulations for aquaculture and dwindling access to water resources and land suitable for aquaculture.

In Latin America, aquaculture has advanced well. Brazil, Mexico, Ecuador and Chile, the leading aquaculture producers, have spearheaded this development, producing growing quantities of salmon, trout, tilapia, shrimp and molluscs. Commercial and industrial-scale aquaculture still dominates in Latin America. However, there is significant potential for small-scale aquaculture development. Initiatives to develop such aquaculture are under way in the Amazon Basin, one of the largest aquatic environments in the world and with significant aquaculture potential. However, Latin American aquaculturists have also encountered difficulties. Recently, Chilean aquaculturists have experienced dramatic losses of revenue as almost 50 percent of their Atlantic salmon production has been infected by a virus (infectious salmon anaemia). The recovery from this catastrophe is slow and difficult, demanding more research and better governance. Export markets are becoming less accessible and, therefore, regional and local markets are being promoted, especially as an outlet for small producers.

In North America, aquaculture has evolved into two broad industry types: finfish production and shellfish production. Finfish production is dominated by salmon, catfish and, to a lesser degree, trout, while aquaculture of shellfish primarily includes oysters, mussels and clams. The finfish industry is still at the forefront of the sector, with salmon taking the lead in Canada and channel catfish in the United States of America.

In Africa, aquaculture production increased by 56 percent in volume and more than 100 percent in value between 2003 and 2007. This growth was due to increasing prices for aquatic products along with the emergence and spread of small and medium enterprises, and to a significant investment in cage culture accompanied by the expansion of larger commercial ventures, some producing high-value commodities for overseas markets. Egypt has continued to dominate production in Africa. In the Near East and North Africa, some countries have invested heavily in capacity building and infrastructure development for aquaculture. Several countries in sub-Saharan Africa, including Angola, Ghana, Mozambique, Nigeria, Uganda and United Republic of Tanzania, have also experienced good growth in aquaculture. In other countries in sub-Saharan Africa, growth has been held back by persistent bottlenecks such as access to good-quality inputs and markets. However, African governments have demonstrated increasing support for aquaculture, presumably anticipating benefits to economic growth, food supply and security as well as in the form of poverty alleviation.

Almost 40 percent (live weight equivalent) of the total annual production of fish (capture fisheries and aquaculture) has entered international trade in the last decade. Farmed shrimp, salmon, trout, tilapia, catfish and bivalves have contributed significantly to this trade. This increase in trade in aquaculture produce has been accompanied by increased concern in the public and private sectors about: (i) environmental impacts of aquaculture; (ii) consumer protection and food safety requirements; (iii) animal health and animal welfare; (iv) social responsibility; and (v) traceability and consumer information along the aquaculture supply chain. Non-governmental organizations have initiated or strengthened these concerns and developed strategies to wield influence over consumers' purchasing decisions and especially over the procurement policies of major buyers and retailers of fish. These developments have resulted in the proliferation of aquaculture standards and certification schemes designed to trace the origin of fish, its quality and its safety, and the environmental and/or social conditions prevailing during aquaculture production, processing and distribution of fish and feed.

Although precise figures on some aspects of the impact of aquaculture are lacking, it seems clear that its contribution to poverty alleviation, food security, employment, trade and gender opportunities has increased in the past decade. In part, this growing contribution has been caused simply by the growth in volume and value of production and by the expanding worldwide presence of aquaculture products in retail trade and as raw material to the processing sector. However, aquaculture's contribution to society has also come about through features such as: ownership by beneficiaries; people-centred approaches; the use of species that feed low on the food chain; sharing benefits and employment among household members; use of methodologies originating in farmer field schools; and technologies that have been developed to fit the local context, and this using local networks.

Unlike many other sectors of the economy worldwide, aquaculture has generally been resilient in the face of the various economic crises of the last decade. However, an extended global crisis could damage the sector's growth, especially by limiting funds available for research and for support to vulnerable groups such as small-scale farmers. Experience during the past decade indicates that governments, especially in developing countries, will have difficulties in finding the necessary funds unless they have sound macroeconomic and public-sector management programmes in place. Governments, perhaps in collaboration with donors, will also need to engage in long-term planning in order to have safety nets in place for vulnerable groups, including those engaged in aquaculture activities, to allow them to adapt to the possible impacts of climate change.

The global aquaculture sector's long-term ability to achieve economic, social and environmental sustainability depends primarily on continued commitment by governments to provide and support a good governance framework for the sector. It is encouraging that the experience of the past decade indicates that many governments remain committed to good governance for the sector and that involving stakeholders, particularly producer associations, in strategic policy decisions is becoming an accepted practice. In the past decade, governments have strengthened their capability to monitor and manage environmental and social consequences of aquaculture, and they have made conscious efforts to address these in a transparent manner, backed by scientific evidence. One of the main difficulties has been not to overreact at the expense of aquaculture producers, particularly small-scale farmers, for example by framing legislation that would be costly, time-consuming and difficult to implement.

Although aquaculturists have scored many successes in the past decade, there is no room for complacency. Increasingly strict market and environmental standards continuously challenge the sector to achieve its full potential. However, as the new decade unfolds, it would appear that a stronger and more confident aquaculture sector stands ready to face and overcome these challenges and move further along the sustainability path.

Using the Internet for fisheries policy and management advice

INTRODUCTION

In the early 2000s, the EAF and the ecosystem approach to fisheries management (EAFM) received global recognition and endorsement. Broadening the objectives of, and constraints to, management, the approaches increased the amount of data and the related analytical capabilities needed by those providing policy and management advice in fisheries. Because of the need to broaden the types and sources of information and to compare knowledge on similar ecosystems in different regions, the practice of sharing information via the Internet has grown in importance. Nonetheless, the formidable potential offered by the Internet for enhancing the implementation of the EAF (including through capacity building) is still only partially and unevenly used, suggesting that more regional and global initiatives are needed.

A recent FAO study[51] reviews the complexity of the EAF and the information needed for effective management and describes the types of data and information that can be found under publicly or privately maintained Internet sites. The following sections are taken from the study.

CURRENT SITUATION

Although it is probably impossible to obtain, through a desk-study, a complete picture of the use of the Internet in the formulation and use of fisheries policy and management, essential aspects of that picture will appear from a review of three key areas of information-related needs in relation to science-based decision-making: (i) access to basic or reference data; (ii) availability of tools for data processing; and (iii) diffusion of results beyond the strict decision and publication processes.

Expertise

Finding the expertise needed for assessment and management is a problem. The Web-based registry *OceanExpert*[52] (of the Intergovernmental Oceanographic Commission [IOC] of the United Nations Educational, Scientific and Cultural Organization [UNESCO]) could potentially be a useful source of information, but the registration of fisheries expertise in this database is still very limited. A database of fisheries expertise would be very helpful.

Bibliographic records

Bibliographic information is available on many commercial sites. However, acquiring information may be very costly, especially for individuals and organizations in developing countries. *Aquatic Sciences and Fisheries Abstracts*, developed with FAO, has the advantage that it offers good economic conditions to users in developing countries. The *Aquatic Commons* repository covers marine, estuarine and freshwater environments as well as the science, technology, management and conservation of these environments and their resources with their economic, sociological and legal aspects. It has the significant advantage that it contains grey literature (e.g. policies, plans, stock assessment reports). The *OceanDocs* system from the IOC is also a free-access library of non-copyrighted material or material whose distribution has been authorized. These efforts are valuable and should be pursued.

Ocean bottom data

Bathymetric data is also available at various resolutions, for example on the *GEBCO* Web site. The *Virtual Ocean* platform allows the online generation of user-defined bathymetric, geological and hydrological maps online. Other bottom-related information of importance to fisheries, such as bottom types or habitats, does not seem to be available. Considering that pressures are highest in the coastal zone, these facilities need to be continued and others developed, improving the availability of high-resolution bathymetry and other information about these areas.

Hydrographical data

The International Oceanographic Data and Information Exchange (*IODE*) programme of the IOC is the centre of a very active global network for the exchange of oceanographic and atmospheric data. For example, the database of the International Comprehensive Ocean-Atmosphere Data Set (*International COADS*) contains 220 years of data, easily accessible and constantly updated. This system is an example and needs to be connected to biological information. This might come with the recent entry of the Ocean Biogeographic Information System (OBIS – see below) into the IODE. In the near future, more oceanographic data will be collected directly by marine animals, equipped for this purpose (see below).

Biological information

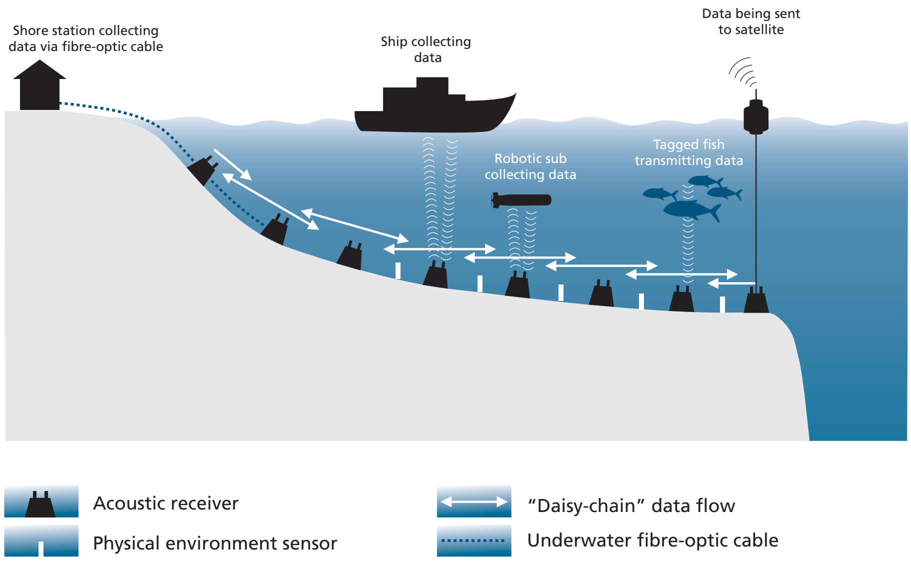
A large amount of information on the biological parameters of fisheries resources is also available through FAO's Fisheries Global Information System (*FIGIS, FAO Fisheries and Aquaculture Department*) as well as in other systems such as *FishBase* (with FAO collaboration) and *SeaLifeBase*: images, taxonomy, biology, ecology, distribution, diseases, diet, and life history parameters. Financial support is needed to ensure the survival and updating of these fundamental sources of biological reference data, particularly considering the growing potential impact of climate change on these parameters. At the moment, the life parameters are only accessible by individual species, and the system could usefully be modified to enable transversal access to all biological parameters in order to allow meta-analyses.

As fisheries management moves towards a more ecosystemic approach, biodiversity data become important. A project of the Census of Marine Life, *OBIS* already has more than 20 million records (compiled from almost 100 databases) and is connected to the World Register of Marine Species (*WoRMS*), *Global Biodiversity Information Facility*, *FishBase*, Encyclopedia of Life (*EOL*), etc. and offers online mapping facilities. The taxonomic records of OBIS need to be enriched with more detailed information on species, probably through more connections with dedicated databases such as FishBase and FIGIS. With its network of regional nodes, OBIS is a good example of the types of Web infrastructures that would be useful to support an enlarged fishery community in the future.

Information on the distribution and migration of marine animals and on the environment they cross during those migrations is being collected and made available on maps by the *Ocean Tracking Network* (OTN) (Figure 41). Fish and marine mammals

Figure 41

Listening array of the Ocean Tracking Network



Source: R.K. O'Dor, M. Stokesbury and G.D. Jackson. 2007. Tracking marine species: taking the next steps. *In* J.M. Lyle, D.M. Furlani and C.D. Buxton, eds. *Cutting edge technologies in fish and fisheries science,* pp. 6–12. Workshop Proceedings, Hobart, Tasmania, August 2006. Australian Society for Fish Biology (available at www.asfb.org.au).

(from 20 g to 20 tonnes) and other marine animals are tagged with acoustic and archival electronic devices, which collect geolocated information on the oceanic environment, and in some cases, on other tagged fish they meet on the way. The tagged animals are passively or actively tracked as they travel, and the information collected is downloaded either to satellites (when the animal comes to the surface), fish aggregating devices (FADs), underwater vehicles, or large-scale telemetry arrays of radio-listening devices installed on the bottom of the continental shelf in many places around the world. The information allows the analysis of the oceanographic conditions under which migration takes place, as well as the mapping of fish movements. This sort of information (which can be made accessible to the public through *Google Ocean*) may soon become more easily available and therefore more usable to provide information for management, particularly on highly migratory species like tuna, salmon, sharks and marine mammals.

Fishery statistics

FAO statistics are available at the national, regional and global levels with different degrees of accessibility and practically no interoperability between systems. Global statistics since 1950 are available and are accessible through the statistics section of the *FAO Fisheries and Aquaculture Department.* The database can be queried online and the outputs can be graphed but not yet mapped. This limitation might be overcome in the future by the D4Science-II *Integrated Capture Information System* project. In general, however, access to fishery statistics at the national and subnational levels (including at fishery level) remains problematic except when RFMOs have established relevant databases. A facility to upload the national statistics into regional and global systems through the World Wide Web, in a semi-automatic manner, would be a major improvement and an effective incentive to data providers.

Financed by the European Union (EU) in Northwest Africa, the Improve Scientific and Technical Advices for Fisheries Management project (with its regional Web platform, *ISTAM*) organizes regional fisheries monitoring. It improves national statistical systems, develops common standards and sharing protocols, validates datasets and provides assessment methods and training with a view to improving stock assessment and management practices (particularly of shared stocks) as well as general diffusion of scientific assessments on the Internet. Such systems are probably part of the solution to improve national systems and global accessibility to statistics as well as capacity building.

The *Fishery Resources Monitoring System* (FIRMS) launched by FAO has expanded that approach to the whole world. It aims at a global systematic inventory of the world stocks, fisheries and management systems developed by FIRMS partners with FAO support. FIRMS is powered by FIGIS, and the information contained in its database is published in the form of standardized fact sheets. This system provides the various data owners with tools to ensure controlled dissemination of high-quality and updated information. As for FishBase, the system could be usefully modified to allow transversal access to all parameters for meta-analyses of stocks or fisheries. It could also be completed by a system of reference data on the characteristics and performance of fishing vessels.

Data processing platforms

A number of fishery modellers and analysts use *The R Project for Statistical Computing* (also called GNU) for analysis and visualization of data, and it is a good example of the sort of open-source software development platform that is needed in fishery science. The fishery community has already reacted positively to the opportunity that the R platform represents:

- The FLR library (*FLR*) is the result of an open collaborative effort by researchers from a number of laboratories and universities in various countries (under the leadership of the International Council for the Exploration of the Sea) to develop a collection of tools in the R statistical language. It is a generic toolbox specifically suited for the construction of simulation models, such as bioeconomic or ecosystem models and other models usable, for example, for fisheries management strategies evaluations (MSEs).
- Similarly, the AD Model Builder (*ADMB*) is a high-level software suite. It is an environment for non-linear statistical modelling, enabling rapid model development, numerical stability, fast and efficient computation, and high-accuracy parameter estimates. The ADMB Project promotes wider application of the ADMB to practical fishery problems and assists ADMB users to become more proficient.

Much more effort in this direction is needed, particularly to enhance the capacity of the developing world to use these tools and, for example, to test the robustness of the simpler, less demanding models. There is also a need to develop tools better suited to data-poor and low-capacity conditions.

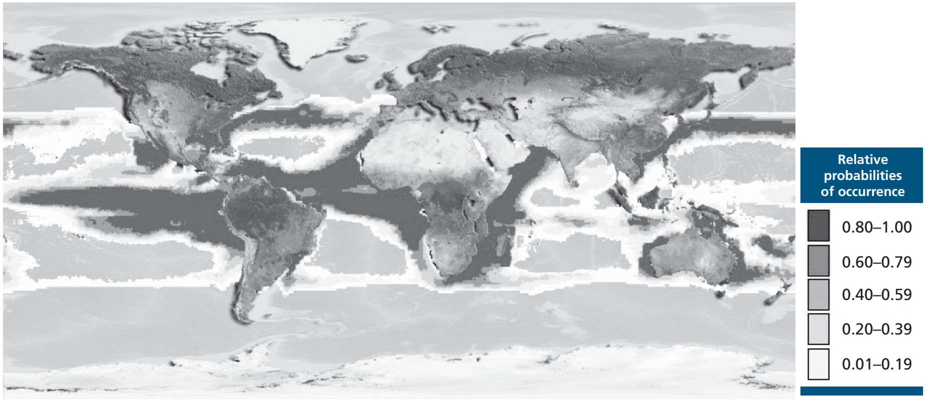
Interactive mapping

The capacity of online interactive mapping is rapidly improving. The United Nations Environment Programme–World Conservation Monitoring Centre (UNEP–WCMC) has developed interactive mapping services, and the Interactive Map Service (*IMapS*) is an authoritative source of environmental data that can freely be accessed, downloaded if needed, and mapped online to user requirements. It can be used for environmental impact assessment. A number of thematic or regional applications exist on the UNEP–WCMC Web site (e.g. on the Caspian Sea watershed). Jointly developed by FishBase and SeaLifeBase, *AquaMaps* is another example of the substantial progress made in online interactive mapping (Figure 42). The facility has been used to generate model-based probability distributions of species based on their ecological requirements and known distribution.

Regional data integration is a crucial level of collaboration for the development of any global system and should be a priority for systems development. Such platforms could very usefully improve the work of regional fishery bodies (RFBs).

Figure 42

An example of AquaMap output for distribution of the whale shark (*Rhincodon typus*)



Source: Based on a screenshot from AquaMaps (available at www.aquamaps.org).

Global communication

The pressure and incentives are growing to make the information on fisheries and their resources more widely available to the actors and the public. This is usually done through conventional institutional portals offered by institutions and projects focused on core business. The Web sites of FAO (*FAO*) and The WorldFish Center (*WorldFish*) are extremely rich examples. Some portals are rather specific. For example, that of the Global Ocean Ecosystem Dynamics project (*GLOBEC*) deals with the impact of climate change on recruitment, abundance, diversity and productivity of marine populations. GLOBEFISH (see below) is an international network of regional institutions established by or with the assistance of FAO and specialized in fish trade. The Web site of the FAO FishCode project (*FishCode*), aiming at supporting numerous aspects of the implementation of the CCRF in the bioecological as well as socio-economic arenas is more diversified. Such portals are now routinely offered, and numerous ones deal with marine resources and fisheries. However, they are usually static and one-way, with little or no interaction with the users yet.

The *UN Atlas of the Oceans* is a more dynamic and interactive portal developed by FAO on behalf of its sister UN Agencies competent in ocean matters and their partner institutions. It is an excellent example of collaborative effort in coordinated information diffusion. *OneFish* is another fisheries information portal maintained by FAO. Both OneFish and the UN Atlas of the Oceans offer users the possibility to establish virtual offices, i.e. specific sub-Web sites that can be used as platforms to organize collaboration, working groups, etc. Once established, such interactive Web sites (whose contents are controlled and published directly by the content producers in a decentralized manner) can be maintained at low cost.

Google Ocean (see above) is a unique publication platform in which large quantities of data can be made freely available to a large potential audience in the form of images, videos, sound files, connection to specific sites, etc. The OBIS, OTN and other Census of Marine Life projects already use Google Ocean for information diffusion. Another important knowledge-federating output is the emerging *EOL* (see above). These global platforms should probably always be used in the future to make selected information available to the public.

The contribution of industry

Missing from the above panorama of Web usage by the world fishery community is the industry “voice”, taken here in the broad sense of the private sector, in large-scale and small-scale fisheries. The role of the sector in modern, inclusive, participative governance is essential. However, the Internet is still not the channel most used by industry to communicate its concerns or policy or management proposals. Confidentiality of data is the default rule in this arena. A variety of Web sites are found when using the search term "fishing industry websites": (i) numerous sport fishing sites; (ii) single company or consortium sites advertising fishing technology or fishery products; (iii) private companies offering a range of services (e.g. consultancies, training, general information);[53] and (iv) sites from industry NGOs (fishers associations) delivering information of relevance to their constituency. The latter tend to be the ones dealing more frequently with management issues.

Of the many Web sites available, *GLOBEFISH* and *FISHINFOnetwork* warrant special mention. GLOBEFISH is an international collaborative effort of the fishing industry, fostered by FAO to collect store, organize, share and distribute fish trade information. It coordinates and is an integral part of the FISHINFOnetwork, consisting of seven independent intergovernmental and governmental organizations.[54] Created to assist the fishery sector, particularly in developing countries and countries in transition, the network provides services to private industry and to governments. FISHINFOnetwork executes multilateral and bilateral projects, produces and distributes a number of publications, and organizes conferences, workshops and training seminars. It has more than 70 full-time staff members and works with more than 100 additional international consultants in all fields of fisheries. Fifty national governments have signed international agreements with the different FISHINFOnetwork services and are using the expertise of these services to develop the fishery sector worldwide.

The New Zealand seafood industry Web site (*New Zealand Seafood Industry Gateway*) provides a wide range of information to its members. A section on this site deals specifically with global aspects of sustainability issues put in a local perspective. This seems to stimulate debate on local "burning" issues. The Web site of the New Zealand Seafood Industry Council (*Seafood Industry Council*) has a science group and a policy group and offers contributions to the policy debate. The Web site of the Queensland Seafood Industry Association (*Queensland Seafood*) has debates on partnerships with management institutions on the issue of climate change, showing that the industry is concerned about long-term environmental issues and open to debate on them.

A few sites may indicate a movement towards more interaction among the actors of the sector. For example, the Northwest Atlantic Marine Alliance (*NAMA*), created in 1995 in New England (United States of America) is an independent, non-profit organization dedicated to pursuing community-based management to restore and enhance more resilient, diverse and abundant resources and uses. Advocating self-organization and self-governance, the institution also tries to provide an interface between scientists and fishers. That cooperation is also one of the keys aims of *FishResearch.org.*

Numerous governmental sites exist whose purpose seems to be to inform and/or educate fishers and the industry about the issues, the decisions and their implications, reaching out from the state to the industry. For example, the Web site of the New South Wales Department of Primary Industries (*Fishing and Aquaculture*) offers considerable information on protected species, threatened habitats, fishery science and management issues. However, the level of interaction possible with the site is minimal. Government sites are not discussion platforms, as this form of interaction takes place through other more conventional channels involving the government, scientists and fishers associations.

There are also a few hybrid sites, such as *Seafish*, independent but supported by the Government of the United Kingdom. It provides information on a responsible fishing scheme and is financed by a levy paid by industry. It intends to prepare the constituency for a fishery world in which ecolabelling and accreditation will be the rule. The critiques seem to indicate that the interaction between fishers and the fishery management authority is still unsatisfactory.

The EU's seven newly established Regional Advisory Councils (RACs)[55] provide a strong and structured interface between the industry and the European Commission and European Parliament. Their present role is only advisory, but an evolution towards more involvement in decision-making is to be expected.

An Internet search on small-scale fisheries reveals that many Web sites deal with small-scale fisheries in one way or another. These sites may be connected to other sites belonging to developed countries' aid programmes, international organizations, environmental NGOs, etc. However, the number of sites exclusively dedicated to small-scale fisheries seems to be limited. The International Collective in Support of Fishworkers (*ICSF*) is an important exception. This aims of this NGO are to: (i) monitor issues that relate to the life, livelihood and living conditions of fishworkers around the world; (ii) disseminate information on these issues, particularly among fisherfolk; (iii) prepare guidelines for policy-makers that stress fisheries development and management of a just, participatory and sustainable nature; and (iv) help create the space and momentum for the development of alternatives in the small-scale fisheries sector. The ICSF is very active in the international fisheries management processes and publishes in multiple national and local languages. Established by commercial fishers in New Delhi, in 1997, the *World Forum of Fish Harvesters and Fishworkers*, also focuses on small-scale and medium-scale fishing, coastal sustainable fishing, coastal fishery livelihoods and relations with the WTO. Its degree of activity is hard to evaluate. The Web site of the Confederación Nacional de Pescadores Artesanales de Chile (*CONAPACH*), is an example of a national Web site dedicated to small-scale fisheries. Established in 1990 by all the small-scale fisheries unions of Chile, CONAPACH aims to represent the interests of the small-scale fishers regarding their rights and their living conditions. It also provides services such as training materials and information. *Collectif Pêche et Développement* is an NGO under French law that also seeks to connect artisanal fishers of the world to promote solidarity and sustainability in the fishery sector.

A few other sites offer services. *The Courier* is an online magazine established by EuropeAid of the European Commission, acting on behalf of the African, Caribbean and Pacific (ACP) countries. It offers information and communication on management and development issues in small-scale fisheries in the ACP countries. The *Safety for Fishermen* Web site is a gateway to information and material related to safety at sea, hosted by FAO and managed by a selected group of experts contributing information and material on safety at sea in the fisheries sector with a focus on small-scale fisheries.

CONCLUSIONS

The World Wide Web is developing at an accelerating rate, offering potential for progressively more powerful and effective global collaborations. Scientists are embracing the opportunity. Fishers are joining in only slowly, but with time more and more are likely to use the Internet, at least in communities that have the infrastructure and capacity and where the practice is common in other areas of economic and social life.

The above sections indicate that a substantial amount of information and some tools of high relevance to the implementation of the EAF are already available on the World Wide Web. However, these elements are still little used by fishery analysts, and some very interesting examples of use are limited to a few experts in a very few countries. The reasons have not been studied but may include all or some of the following: (i) the sites are not known; (ii) the scale of information provided is not detailed enough; (iii) the coverage is too incomplete; (iv) Internet access is too limited; and (v) the competence needed to use these systems properly is not available. In any case, an effort is needed to upgrade the capacity to use the World Wide Web to facilitate the emergence of a global and interactive fishery science.

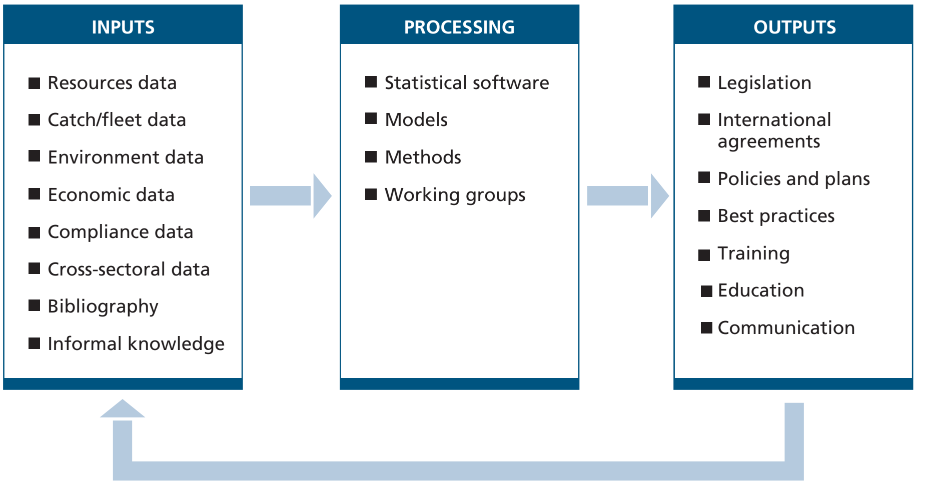
The brief and probably partial overview of the industry Web sites provided above offers no clue as to how active or effective the Web sites are or what their audience really is. Some are very active (e.g. that of the ICSF), others seem to be more confidential. Most are a one-way channel of communication trying to reach out to fishers who have access to and use the World Wide Web, governments and other NGOs. The degree of interactivity between the Web sites and the fishers and the extent to which the sites represent the fishers' views are also not clear. The Web culture is only developing now[56] and extending progressively from advertisement and provision of corporate services to policy and management issues and the collaborative defence of fishers' livelihoods. In the process of integrating the World Wide Web into communication strategies, large-scale fishers seem better equipped than small-scale ones, and associations better positioned than individuals. The situation is evolving more rapidly in countries where Internet usage is common (e.g. Australia, Iceland, New Zealand) and the industry is eager to receive more information via the Internet and keen to be effectively involved in the decision process regarding resource allocation, taxation schemes, subsidies, protected areas, etc. However, it is likely that the voice of the small-scale fishers will only be sufficiently heard if efforts are made by governments and NGOs to catalyse their communication. Important efforts are already ongoing in this direction.

More focused and more interactive portals are needed to support regional or global communities of practice on fisheries assessment, policy and management. There is also a need to better interconnect or federate the scattered initiatives currently on the World Wide Web. In order to function effectively, the recurrent process of assessment and decision for adaptive management needs a wide range of formal and informal inputs regarding resources, fleets, fisherfolk, environment, economic performance, compliance, interaction with other sectors, etc. The process results in a range of outputs such as new legislation, policies, plans, best practices, training, education and communication material. Indeed, many of these outputs are cross-checked and recycled as knowledge inputs in the successive assessment and decision loops (Figure 43).

The wide range of information needed should ideally be further organized in interoperable databases and knowledge bases, ontologies,[57] glossaries, open bibliographic libraries (with as free access as possible) and information repositories. For data processing, scientists should have access to analytical tools such as statistical and modelling software and other assessment tool boxes, and to open-source platforms to develop these tools. Facilities are also necessary to organize the assessment-and-decision process, including e-meeting facilities, "wikis",[58] catalogues of contacts and

Figure 43

Data inputs, processing and outputs for fisheries management



expertise (for joint reporting), and e-training for on-the-job competence building. Much of this information can be organized in interactive and dynamic portals.

As stated above, many facilities exist but they tend to be scattered, non-comprehensive, not interoperational and weakly interactive. More use of dedicated social network services[59] would facilitate the emergence of more effective regional or global epistemic communities. Depending on the context, the expectations[60] of fishery communities range from very basic to very sophisticated. They include:

- improved access to authoritative, federated regional data systems;
- generalization of georeferencing of fishery data, starting with FAO statistics;
- access to three-dimensional displays, as depth is essential in oceans;
- tools visualizing uncertainty, particularly on maps and charts;
- more dynamic representations;
- more Google Ocean applications;
- platforms for collaborative development of multidisciplinary atlases;
- standardized publication platforms for a federated and federating publication process;
- case studies and catalogues of best practices;
- availability of e-training, particularly for assessment, modelling and management.

Future information systems in support of science-based policy-making should ideally have the following properties:

- multisource, harvesting data from multiple providers;
- multipurpose, allowing use by many different types of users;
- multidisciplinary, integrating various types of knowledge;
- multicultural and multilingual, accessible to users with different national and social backgrounds;
- multi-output and multimedia, producing statistics, maps, graphs, briefs and fact sheets as well as videos, sound bites, etc.;
- multiscale in space and time, scalable up and down depending on the decision level;
- interactive, i.e. piloted both by users and providers;
- interoperable, to federate efforts and data and facilitate the crossing of information from different sources using common standards;
- nested, e.g. connecting local, national, regional and global systems;
- evolutive, with the capacity to adapt to changing demands and changing technology;
- authoritative, providing verified information with traceable pedigree;
- affordable, with low maintenance cost;
- flexible, e.g. allowing on-line processing as well as downloading for offline work;
- providing capacity building, training, repositories of best practices, mentoring, etc.;
- action-oriented, i.e. built, maintained and connected to decision-making;
- end-user-oriented as opposed to technology-driven or supply-oriented;
- ethical, acknowledging the complex web of data providers and system developers and respecting confidentiality requirements.

The need to involve fishers more directly in the assessment and advisory process calls for better connection between the sites developed by scientists and by industry, and major efforts are needed in this direction. For example, the RACs might provide the opportunity and incentive to do so in Europe.

A development that possibly would encapsulate most needs is if information and communication technologies were used to foster the development of a global *community of practice* around fishery science and management, with perhaps many interconnected smaller (possibly regional) and more specialized communities around subsectors (e.g. artisanal fisheries) or themes (e.g. ecosystem simulation or ecosystem-based management). Within such efforts, the development of open source platforms is needed to accelerate the collaborative development and diffusion of interdisciplinary bioeconomic, behavioural and ecosystem models as well as participatory role games in which the industry must be called to participate. A global community of practice might also allow the development of the collaborative *cloud computing* capacity needed to run large, complete-fishery system models.

This review indicates that a significant increase in collaboration for fisheries management is possible with little additional cost through increased and more effective use of the World Wide Web. FAO, and other international organizations, could help in the effort to link the international fishery community's expectations and the potential offered by the Internet.[61] This would help avoid a digital divide in fisheries science developing between nations.

List of Web sites mentioned in this article

ADMB	www.admb-project.org/
AquaMaps	www.aquamaps.org
Aquatic Commons	aquacomm.fcla.edu/
Aquatic Sciences and Fisheries Abstracts	www.fao.org/fishery/asfa/en
Collectif Pêche et Développement	pechedev.free.fr/
CONAPACH	www.conapach.cl/home/
EOL	www.eol.org/
FAO	www.fao.org
FAO Fisheries and Aquaculture Department	Fact sheets: www.fao.org/fishery/factsheets/en Statistics: www.fao.org/fishery/statistics/en
FishBase	www.fishbase.org
FishCode	www.fao.org/fishery/fishcode/en
Fishery Resources Monitoring System	firms.fao.org/firms/en
FISHINFOnetwork	www.fishinfonet.com/
Fishing and Aquaculture	www.dpi.nsw.gov.au/fisheries
FishResearch.org	www.fishresearch.org/default.asp
FLR	www.flr-project.org/
GEBCO	www.gebco.net/
Global Biodiversity Information Facility	www.gbif.org/
GLOBEC	www.globec.org
GLOBEFISH	www.globefish.org/
Google Ocean	earth.google.com/ocean/
ICSF	www.icsf.net/icsf2006/jspFiles/icsfMain/
IMapS	www.unep-wcmc.org/imaps/IMapS_about.aspx
Integrated Capture Information System	www.d4science.eu/icis
International COADS	icoads.noaa.gov/
IODE	www.iode.org/
ISTAM	www.projet-istam.org/
NAMA	namanet.org/about/about-nama
New Zealand Seafood Industry Gateway	www.seafood.co.nz/
OBIS	www.iobis.org/
Ocean Tracking Network	oceantrackingnetwork.org/news/index.html
OceanDocs	www.oceandocs.org/
OceanExpert	www.oceanexpert.net/
OneFish	www.onefish.org/global/index.jsp
Queensland Seafood	www.qsia.com.au/future-proofing-industry.html
Safety for Fishermen	www.safety-for-fishermen.org/en/
Seafish	www.seafish.org/indexns.asp
Seafood Industry Council	www.seafoodindustry.co.nz/n392,67.html
SeaLifeBase	www.sealifebase.org/
The Courier	www.acp-eucourier.info/Partners.14.0.html
The R Project for Statistical Computing	www.r-project.org/
UN Atlas of the Oceans	www.oceansatlas.org/index.jsp
Virtual Ocean	www.virtualocean.org/
World Forum of Fish Harvesters and Fishworkers	www.pcffa.org/wff.htm
WorldFish	www.worldfishcenter.org
WoRMS	www.marinespecies.org/

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52 The Web sites indicated in italics are listed together at the end of this article.

53 For example, the Southern Fish Industry Training Association (www.sfita.co.uk/) offers courses in sea survival, firefighting, first aid, fishing practice, food hygiene, fish trade, fish processing, etc.

54 EUROFISH (Eastern and Central Europe), INFOFISH (Asia and Pacific region), INFOPECHE (Africa), INFOPESCA (South and Central America), INFOSA (Southern Africa), INFOSAMAK (Arab countries) and INFOYU (China).

55 The seven RACs are: Baltic Sea Regional Advisory Council (www.bsrac.org/mod_inc/?P=itemmodule&kind=front), Mediterranean Regional Advisory Council, North Sea Regional Advisory Council (www.nsrac.org/), North Western Waters Regional Advisory Council (www.nwwrac.org/), South Western Waters Regional Advisory Council (www.ccr-s.eu/EN/index.asp), Pelagic Regional Advisory Council (www.pelagic-rac.org/), and Long Distance Fleet Regional Advisory Council (www.ldrac.eu/content/view/12/29/lang,en/).

56 An example of the developing Web culture is the growing use of the Internet by fishing captains for formal transmission of data about their fishing activity.

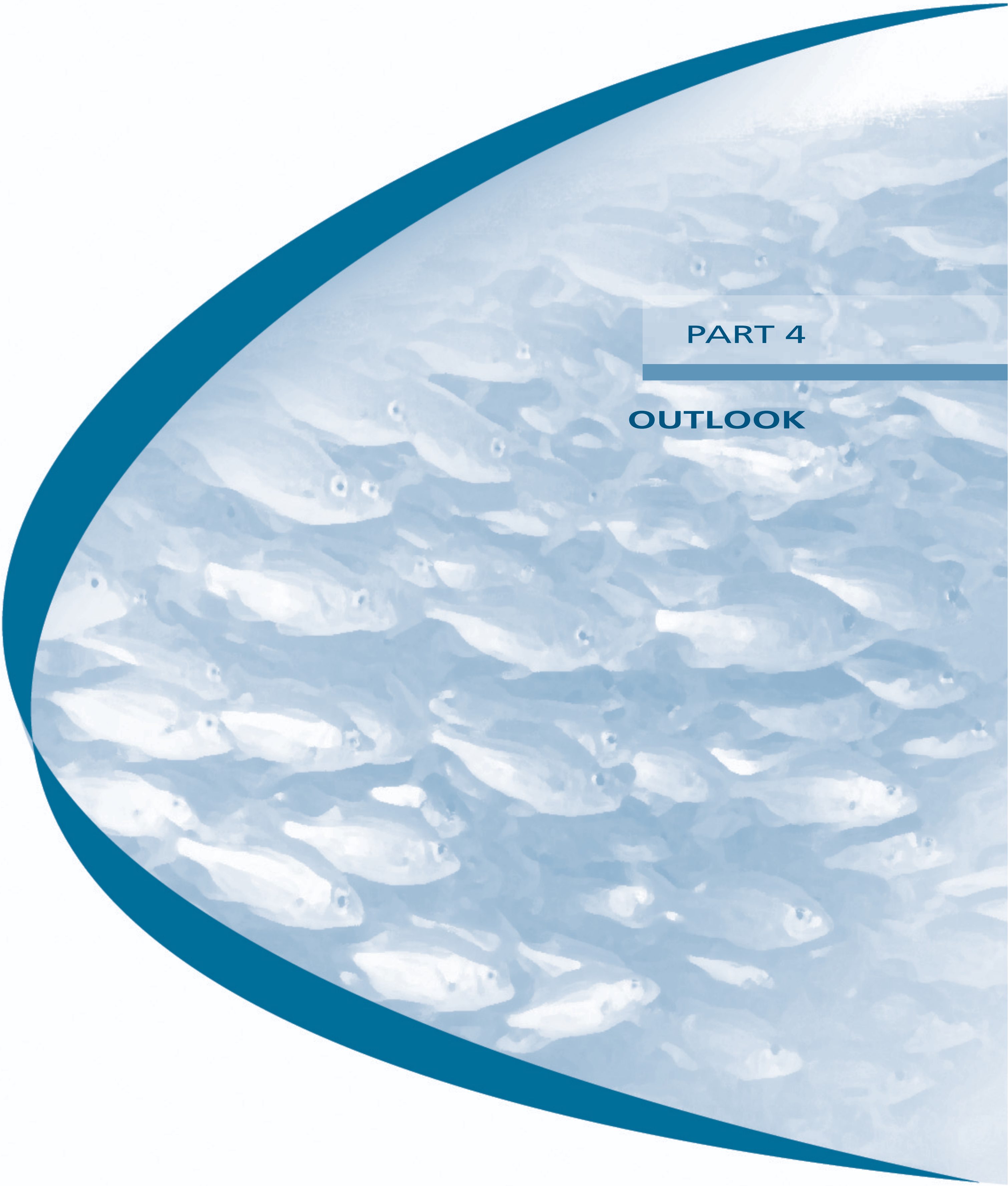
57 An ontology is a system that contains terms and the definitions of those terms, and the specification of relationships among those terms. It can be thought of as an enhanced thesaurus – it provides all the basic relationships inherent in a thesaurus, plus it defines and enables the creation of more formal and more specific relationships. It is designed to serve as a central focal point for the vocabulary of a particular domain, and to codify and standardize the knowledge within that domain. It enables better communication within and across domains, and structures meaning contained in the domain. (Agricultural Ontology Service Workshop, Rome, November 2001).

58 A "wiki" is a Web site (or a function in a site) that facilitates joint creation and editing of interlinked Web pages, usually under some system of authorities. Wikis are often used in collaborative Web sites.

59 The social network services referred to here can be used to build a social network and enhance social relations among people who share fishery management interests and/or activities. They consist of a representation of each user (often a profile), his/her social links, and a variety of additional services. They provide means to interact over the Internet, such as e-mail and instant messaging as well as common information resources and tools, and facilities to organize electronic meetings and jointly write or edit documents. They may empower groups of experts, e.g. in modelling, reef assessment or marine protected areas.

60 Obtained from a selection of 19 very experienced fishery scientists with a strong background in modelling and information systems.

61 An example of such collaboration is the EU's D4Science-II project, with which the FAO Fisheries and Aquaculture Department collaborates.



PART 4

OUTLOOK

OUTLOOK

What future for inland fisheries?

ANCIENT ORIGINS, CURRENT ISSUES

Origin, importance and nature of inland fisheries

Fisheries[1] had their origin in inland waters. Long before people started to grow crops or raise livestock, they went fishing, initially in rivers, ponds, wetlands and lagoons. Many decades passed before people ventured onto the open waters of large lakes, or onto the sea, in purpose-built craft.

Several centuries ago, marine fisheries overtook inland fisheries as the major supplier of fish protein on a global scale. Since FAO started collecting fisheries statistics in 1950, inland fisheries have contributed between 5 and 10 percent to annual capture fisheries production globally as reported by FAO. However, this apparently low proportion can be misleading and this share does not reflect adequately the importance of inland fisheries in today's society.

Inland capture fisheries are rooted in socially and culturally complex societies (Box 16), operate in a large variety of environments and are characterized by an

Box 16

The many uses of inland fish: food, currency, religion and mythology

In ancient Egypt, the fish of the Nile River was an important part of people's diet; fish was used as a means of payment, a reward and considered as part of national revenue. The connection of fish with the cyclical life-giving forces of the Nile River became an image in the Egyptian conception of the world. Mullets, having travelled from the Mediterranean Sea to the first cataract, were honoured as heralds of the flood god, Hapi. The mouth-brooding habits of certain cichlids were associated with the god Atum, who took seed into his mouth and spat out the world. The Nile catfish, *Clarias* sp., which favours muddy waters, was believed to guide the solar boat through the dark river of the underworld at night.[1]

Fish and fisheries were central to life in the ancient Khmer Empire. Bas-reliefs showing fish and other aquatic animals and fisheries-related activities are found on centuries-old temples in Cambodia. The local currency, the riel, is probably named after the most abundant fish species, trey riel, and an indication of its traditional importance to the economy.

In the Lao People's Democratic Republic, giant catfish have traditionally been associated with spirits, royalty and sacrifice. Near Vientiane, every February, people used to gather to catch giant catfish. The first one caught belonged to the spirits and to the old man who was in contact with them.[2]

[1] I. Feidi. 2001. Gift of the Nile. *Samudra*, 28: 3–7.
[2] Mekong River Commission. 2003. Lao legends. *Catch and culture*, 9(1): 11.

extremely diverse range of gear. Inland fisheries are generally labour-intensive and, in most cases, do not easily lend themselves to mechanization and industrialization. They are thus typically driven by individual human effort and the overall number of people in the fishery. As a result, they are typically not great wealth creators for individual fishers, but may in their aggregate sense be massive suppliers of food and income. As such, inland fisheries can be considered significant contributors to rural food security and income generation, providing a diverse set of livelihood benefits to some of the poorest households in the rural sector. However, they do not usually provide an opportunity for taxation and levies and, hence, awareness of their socio-economic importance is often lacking in government development programmes. There are some notable exceptions, such as sturgeon fisheries in the Caspian Sea, lot and dai fisheries in the Tonle Sap, and Nile perch fisheries in Lake Victoria (see below).

Today, there are probably more individuals involved in inland fisheries than ever before. While fishing provides working opportunities and income in less affluent societies, relatively few people in richer countries fish to make a living but millions go fishing for fun.

Major issues in inland fisheries

Inland fisheries often appear to be undervalued and inadequately addressed in national and international policies or priorities for development. There is a critical need to improve the information on inland fishery resources and on the people that use and depend on them.

Another major issue is how to maintain ecosystem integrity and mitigate impacts on aquatic ecosystems. These ecosystems, so essential for inland fisheries, suffer as hydroelectricity generation and abstraction of freshwater resources for agriculture and other purposes are often given higher priorities. These other sectors, combined with growing populations and ease of travel and trade, are putting pressures on inland fisheries resources that are stronger and more widespread than at any time in history. Inland capture fisheries are also being affected by developments within the sector itself, such as increasing fishing pressure and illegal fishing. However, the majority of the impacts originate from outside the fisheries sector (see below).

Rich economies can mitigate influences on inland fish resources through legislation and technical measures to protect aquatic environments. Developing countries have fewer resources for such tasks, or have other priorities to invest resources in. Thus, those who have most need of inland fisheries, in particular rural populations in developing countries, are particularly at risk from these pressures and a lack of policies.

In a changing world, it will be a major challenge to sustain the different functions of inland fisheries, such as their role in food security and poverty alleviation and other ecosystem services.

THE STATUS OF INLAND FISHERIES

Inland waters and global landings

The waters

Globally, lakes, reservoirs and wetlands important for inland fisheries cover a total area of about 7.8 million km^2 (Table 17). Relatively high proportions of land are covered with surface waters in Southeast Asia, North America, east and central West Africa, the northern part of Asia, Europe and South America.

Global production

In 1950, inland fisheries produced about 2 million tonnes in terms of fish landings. The figure was about 5 million tonnes in 1980, and, after steady growth of 2–3 percent per year, 10 million tonnes in 2008 (Figure 44). This growth occurred mainly in Asia and Africa, with Latin America making a small contribution. Asia and Africa regularly account for about 90 percent of reported landings. The remaining 10 percent is split between North and South America and Europe. However, much uncertainty surrounds both the trend in and the level of production (see below).

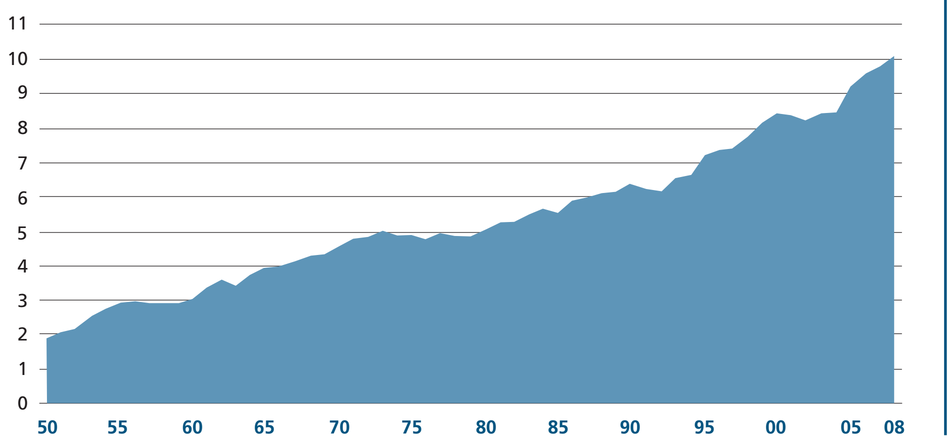
Table 17
Distribution by continent of major surface freshwater resources

	Surface area								Share of total
	Lakes	Reservoirs	Rivers	Floodplain	Flooded forest	Peatland	Intermittent wetland	Total	
	(km^2)								*(Percentage)*
Asia	898 000	80 000	141 000	1 292 000	57 000	491 000	357 000	**3 316 000**	42
South America	90 000	47 000	108 000	422 000	860 000	–	2 800	**1 529 800**	20
North America	861 000	69 000	58 000	18 000	57 000	205 000	26 000	**1 294 000**	17
Africa	223 000	34 000	45 000	694 000	179 000	–	187 000	**1 362 000**	17
Europe	101 000	14 000	5 000	53 000	–	13 000	500	**186 500**	2
Australia	8 000	4 000	500	–	–	–	112 000	**124 500**	2
Oceania	5 000	1 000	1 000	6 000	–	–	100	**13 100**	0
Total	**2 186 000**	**249 000**	**358 500**	**2 485 000**	**1 153 000**	**709 000**	**685 400**	**7 825 900**	**100**

Source: B. Lehner and P. Döll. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. *Journal of Hydrology,* 296(1–4): 1–22.

Figure 44

Production in inland fisheries reported by FAO since 1950



Source: FAO. 2010. FishStat Plus – Universal software for fishery statistical time series (online or CD–ROM) (available at: www.fao.org/fishery/statistics/software/fishstat/en).

Trends and role

Characteristics of the sector

The inland fisheries sector is extremely diverse. It deploys a wide variety of fishing techniques, ranging from simple hand-held gear to small trawls or purse seines operated by commercial fishing vessels. Moreover, the term "fisheries" means not only the harvesting of fish[2] – the actual fishing operations – but also includes processing and other post-harvest and supporting activities. These related activities add further layers of complexity to the sector.

Inland fisheries include commercial and industrial fisheries, small-scale fisheries and recreational fisheries, each with a different economic and social structure. Commercial, small-scale and recreational fisheries are difficult to define at the global level. Still, some general attributes can be used to give a broad definition.

Commercial and industrial inland fisheries. Income is a primary motivation for many fishers, including at the small-scale level. This group is thus not limited to the commercial and industrial sector, as modern small-scale fisheries can be economically efficient and produce high-value products, also for international markets.

Commercial inland fisheries produce significant quantities of fish at localized sites. They often require specialized catch preservation and distribution, usually involving high-capital-input gear and often using significant inputs of professional labour. Commercial fisheries are usually found where resource availability and access to markets justify significant investment (financial, human resources and/or in the construction of gear) and where access can be controlled. Key fishing sites or opportunities are often allocated through well-developed licensing and auction systems. Commercial and industrial inland fisheries are mainly known from lake fisheries in developed countries, from the Great Lakes in Africa and from sturgeon fisheries in the Caspian Sea. However, some impressive commercial and industrial river fisheries occur in Southeast Asia, such as the "fishing lots" and the dai or bagnet fisheries of Cambodia, the "fishing inns" of Myanmar and reservoir marketing concessions. In Latin America, industrial fisheries for migratory catfish are carried out in the Amazon and for sábalo (*Prochilodus* spp.) in the Plate River.

Small-scale inland fisheries.[3] These constitute a dynamic and evolving sector employing labour-intensive harvesting, processing and distribution technologies to exploit the fisheries resources. The activities are conducted: full time,[4] part time, often targeted on supplying fish and fishery products to local and domestic markets, or occasionally. Occasional fishers are a complex group. They fish for cash when the opportunities are there and for subsistence home consumption; they often outnumber full-time and part-time fishers. However, pure subsistence fisheries are rare as excess production would be sold or exchanged for other products or services even in the smallest fishery. When referring to subsistence fishing, a more household-centred rather than commercial activity is implied. The definition "subsistence fisher" is more often concerned with lack of opportunity to derive income rather than a deliberate livelihood strategy. Even where fish is not sold but consumed locally, it has a value because it contributes to family, local or regional welfare and food security. Subsistence fisheries are a subset of occasional small-scale fisheries.

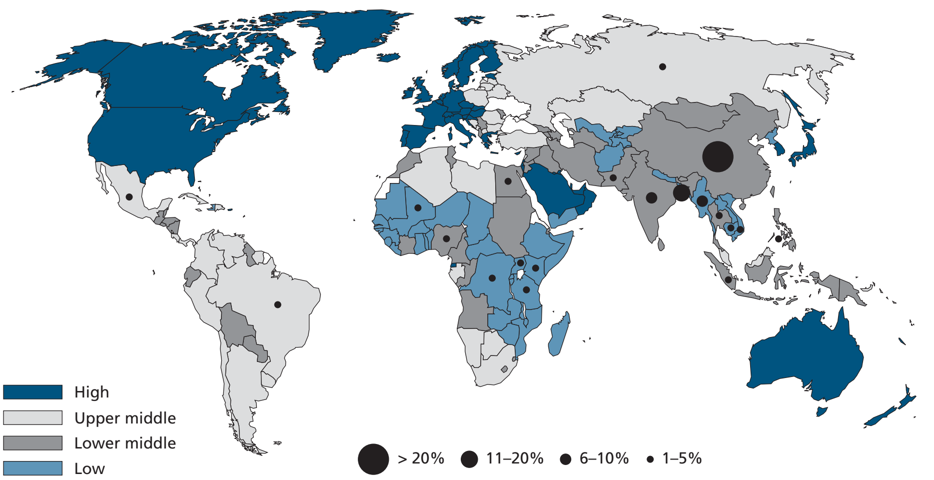
Recreational fisheries. These exist where fishing is for pleasure or competition, with a possible second objective to catch fish for own consumption. Recreational fishing is a popular activity and pastime in many developed countries around the world (e.g. Western Europe, Australia, Canada, New Zealand and the United States of America) and also occurs in countries such as Argentina, Botswana, Brazil, Chile, Mexico, South Africa and Thailand (in some of which it has started to develop recently). Recreational fishing is by definition not a commercial activity – the catch is usually not sold. The fish may be returned to the water, used as a trophy, eaten or sold, but the latter two are not the main motivation for capture. However, the subsector can contribute substantially to local and national economies through employment in secondary sectors.

Inland fisheries in developing countries

Small-scale fisheries. The bulk (about 90 percent) of inland fish is caught in developing countries and 65 percent is caught in low-income food-deficit countries (LIFDCs) (Table 18 and Figure 45). In most rural areas of many developing countries, especially landlocked ones, inland fisheries are more important than marine fisheries for food security and income generation. A recent study[5] estimates that about 1 million people are employed in larger-scale commercial inland fisheries and 60 million in small-scale inland fisheries, and the majority of them (41 million) live in Asia (Table 19). It thus seems that a total of 61 million people (of whom more than 50 percent are women) are involved in fishing and associated post-harvest activities, such as fish processing and trading, in the inland fisheries sector in developing countries. This is more than the 55 million people who are engaged in the marine fisheries sector in developing countries.

Figure 45

Distribution of global inland capture fisheries production in relation to development status of countries



Country	World Bank development status	Percentage of global inland fish production
China	Lower middle	22
Bangladesh	Low	11
India	Lower middle	9
Myanmar	Low	8
Uganda	Low	4
Cambodia	Low	4
Indonesia	Lower middle	3
Nigeria	Lower middle	3
United Republic of Tanzania	Low	3
Thailand	Lower middle	2

Country	World Bank development status	Percentage of global inland fish production
Brazil	Upper middle	2
Democratic Republic of the Congo	Low	2
Russian Federation	Upper middle	2
Egypt	Lower middle	2
Philippines	Lower middle	2
Viet Nam	Low	1
Kenya	Low	1
Mexico	Upper middle	1
Pakistan	Lower middle	1
Mali	Low	1

Note: Values for countries accounting for less than1 percent of global inland fish production are not shown.

Table 18
Distribution of inland fisheries catch in developing and developed countries

	Production 2008	Production	Water area	Water surface
	(Tonnes)	*(Percentage)*	*(km^2)*	*(Percentage)*
LIFDCs[1]	6 528 000	65	1 967 000	25
Non-LIFDCs	3 557 000	35	5 862 000	75
World Bank income status				
Low	4 175 000	41	1 222 000	16
Lower middle	4 903 000	49	1 589 000	20
Upper middle	812 000	8	3 493 000	45
High	194 000	2	1 516 000	19
World Bank development status				
Developing	9 078 000	90	2 811 000	36
Developed	1 006 000	10	5 009 000	64

[1] Low-income food-deficit countries.
Sources: FAO FishStat Plus 2010 (available at www.fao.org/fishery/statistics/software/fishstat/en);
FAO list of LIFDCs 2010 (available at www.fao.org/countryprofiles/lifdc.asp); World Bank country list 2010 (available at data.worldbank.org/about/country-classifications/country-and-lending-groups).

Inland fishers catch less fish per individual and year than do small-scale fishers employed in marine fisheries. This is because a large number of rural households, although living close to waterbodies, engage in fishing activities for only a few weeks or a few months in the year. The use of passive gear (traps, gillnets, etc.) allows the fishers to spend most of their time on other activities, which explains why fishing in inland waters is often, if not predominantly, a component of a mixed livelihoods strategy.

It is clear that for millions of households in developing countries, small-scale inland fisheries play an important role in their livelihood (Box 17). The bulk of inland fisheries production is usually consumed locally, and it is important to rural populations for food and nutritional security, cash income, alternative livelihoods and as a safety net for the poor. There are, however, large differences in the characteristics at the local, national or regional levels.

Commercial fisheries. Where commercial inland fisheries are licensed, licence fees can be significant sources of income at a local or even national level. For example, in the 1990s, the Government of Cambodia collected US$2 million in licence fees from dai and lot leases. This subsequently decreased to US$1.2 million after the fisheries reform in 2001.

Products from inland fisheries can also be important export commodities. For example, in the recent past, more than 90 percent of the world's caviar production came from the Caspian Sea at a value of US$90 million per year. In Argentina, sábalo was once the fourth-most-exported fish – 40 000 tonnes per year (with a value of US$40 million). Catch limits have since been reduced to protect the stocks, and production is about 10 000 tonnes. The Nile perch fisheries in Lake Victoria are valued at US$250 million per year.

Commercial inland fisheries can be a significant source of employment on a seasonal basis both in the primary industry and in the post-harvest sector. In large-scale operations, the owners do not usually do the fishing themselves but rely on a number of labourers.

Commercial inland fisheries in rivers often target migratory fish either on their path towards the spawning grounds or on their way to their dry season refuges when the floodwaters recede. In lakes and reservoirs, commercial inland fisheries usually target schooling pelagic species.

The development of commercial fisheries depends *inter alia* on possibilities of marketing the products. This can be a major challenge as infrastructure is poorly developed in many rural areas. High-value fish are usually bought by intermediaries

Table 19
Employment in inland fisheries in developing countries

	Inland small-scale		Inland commercial		Total
	Fishers	Other employment	Fishers	Other employment	
	(No. of people)				
Africa	5 634 000	11 832 000	213 000	85 000	17 764 000
Americas	519 000	1 091 000	34 000	14 000	1 658 000
Asia	13 146 000	27 607 000	534 000	216 000	41 503 000
Oceania	9 000	19 000	500	500	29 000
Total by category	**19 308 000**	**40 549 000**	**781 500**	**315 500**	**60 954 000**
Total employment by subsector	**59 857 000**		**1 097 000**		**60 954 000**
Total female employment by subsector	**32 921 000**		**342 000**		**33 263 000**

Source: World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries.* Washington, DC, World Bank.

Box 17

Livelihood strategies that include inland fisheries

In rural markets, fish can readily be converted into cash or bartered and, importantly, the cash can be obtained for as long as the fishing season lasts, sometimes all year round. For example, data suggest that in the Zambezi floodplain the contribution of inland fisheries to household cash income is greater than cattle rearing and sometimes crop production (see table).

Floodplain fisheries in Bangladesh are dominated by part-time and subsistence fishers, catching about 75 percent of the production (about 8–20 kg/fisher/year).[1] Fish is one of many resources that become relatively more important during the flood season when other sources of income are at their annual low.

Fishing households at the Great Lake of the Tonle Sap in Cambodia obtain more than half their household income from fishing. People fishing mainly in the Mekong mainstream acquire about one-fifth of their total income from fish sales. A wide range of factors (including market access) decides how much of the income is derived from fish.

Contribution of fishery to households' income in different parts of the Zambezi Basin compared with other activities

Category	Barotse floodplain		Caprivi-Chobe wetlands		Lower Shire wetlands		Zambezi Delta	
	(US$/household/year)							
Cattle	120		422		31		0	
Crops	91		219		298		121	
Fish	**180**	43%[1]	**324**	28%	**56**	13%	**100**	39%
Wild animals	6		49		1		0	
Wild plants	24		121		48		29	
Wild foods	0		11		7		4	
Clay	2		0		8		0	

[1] Percentage of total household income.

Source: J. Turpie, B. Smith, L. Emerton and J. Barnes. 1999. *Economic valuation of the Zambezi basin wetlands.* Report prepared for IUCN Zambezi Basin Wetlands Conservation and Resource Utilization Project. Harare, IUCN – The World Conservation Union Regional Office for Southern Africa.

In a survey of upland fisheries of Luang Prabang, a rugged mountainous province in the north of the Lao People's Democratic Republic, 83 percent of households were engaged in capture fisheries, although rice and livestock farming were the most important activities. Ninety percent of the catches came from rivers and small streams, 7 percent from rice fields and 3 percent from ponds. Fish and other aquatic animals provided about 20 percent of total animal protein intake, ranking equally with beef and pork.[2]

In the Brazilian Amazon, floodplain households obtain about 30 percent of their income from fishing.[3]

[1] G.J. de Graaf, B. Born, K.A. Uddin and F. Marttin. 2001. *Floods fish and fishermen*. Dhaka, The University Press Limited.

[2] J.G. Sjorslev, ed. 2000. *Luangprabang fisheries survey*. Vientiane, AMFC/MRC and LARReC/NAFRI.

[3] O. Almeida, K. Lorenzen and D. McGrath. 2002. *Impact of co-management agreements on the exploitation and productivity of floodplain lake fisheries in the Lower Amazon.* Paper presented at the Ninth Biennial Conference of the International Association for the Study of Common Property IASCP at Victoria Falls, Zimbabwe, 17–21 June 2002.

and transported to urban centres where they can be sold at a high price or exported – one example is the catfish fisheries in the Amazon. Low-value products may be sold locally to the extent that the local market can absorb the fish. In the peak season, most of the fish will be processed and stored for use later in the year (this is the case with the riel [*Henicorhynchus* spp.] caught in the dai fisheries in Cambodia).

Inland fisheries in developed countries

Small-scale and commercial fisheries. About 1 million tonnes of fish is caught in the inland waters of developed countries by 100 000 fishers (Table 20), where the total number of people employed in the sector is estimated at 307 000. Most of these people are involved in small-scale fisheries. However, the small-scale sector is technologically more advanced and obtains higher catches per fisher than in the developing countries. Women make up about 44 percent of the workforce, employed mainly in the post-harvest sector.

Recreational fisheries. In the last century, the number of commercial fishers has decreased considerably, and recreational fishing has become a major activity in the inland waters of developed countries. This move away from food fisheries towards recreational fisheries has been accompanied by a shift in economics and interests, and recreational interests have become a major driver of habitat and water use (Box 18).

In countries such as Belarus, Bulgaria, Georgia, Republic of Moldova, Romania, Turkey and Ukraine, recreational fishing is often not just a hobby activity. Many people go fishing after work and at weekends to help their households meet their food security needs.

Although only partially covered in the FAO statistics, there is today a realization that sport and recreational fishing is important in many developed countries. In 2004, the Government of Mexico and the National Commission of Aquaculture and Fishing developed an action plan, partly based on the FAO Code of Conduct for Responsible Fisheries (CCRF), that stresses the importance of recreational fisheries as environmental stewards for the sustainable conservation of fish habitats. In 2008, the FAO European Inland Fisheries Advisory Commission developed the European Code of Practice for Recreational Fisheries.

Recreational fishers can contribute to fish and habitat conservation through their desire to protect the particular fisheries and environments they value. However, recreational fisheries can also have serious impacts on natural habitats through the introduction of non-native species that may become invasive. Moreover, conflicts may arise between recreational and commercial fishers over catch allocations and access to fishing grounds

Utilization of inland captures

In developing countries, most of the catch from inland fisheries goes for domestic consumption, and most of the processing is done in small-scale or medium-scale units,

Table 20
Estimated employment in inland fisheries in developed countries

Category	Small-scale	Commercial/ industrial	Total
Number of fishers	98 000	2 000	100 000
Post-harvest employment	206 000	1 000	207 000
Total employment	**304 000**	**3 000**	**307 000**
Share of women in total workforce (*percentage*)	44	29	41

Source: World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries.* Washington, DC, World Bank.

where handling and hygienic practices often are inadequate. Trade in inland fish and products is constrained by lack of infrastructure (e.g. hygienic landing centres, roads, electric power supply, potable water) and facilities needed to establish and operate cold chains (e.g. ice plants, cold rooms, refrigerated trucks). This often results in high post-harvest losses, especially quality losses, that can amount to up to 40 percent of the landings. Owing to the remoteness and isolated nature of many inland fishing

Box 18

Recreational fisheries

Recreational fisheries have grown to involve millions of people and generate billions of dollars in developed countries; the activity is also emerging in developing countries.

A change to recreational fishing

Fishing by commercial and sport fishers in the inland waters of the Netherlands changed structurally after 1900. At the beginning of the 1900s, there were about 4 500 active commercial inland fishers. Today, they number only a few hundred. Seining, previously done intensively by about 300 crew, is now carried out by a crew of 15. In the same period, the number of sport fishers has increased from a few thousand to 1.5 million.[1]

A popular pastime

Recreational fishing is the most important activity in nature for the people of Finland. About 40 percent of the Finnish population, more than 2 million people, fish at least once a year. The catch from recreational fishing accounts for about one-third of the total catch of fish in Finland; in inland waters, its share in the catch is almost 90 percent. The annual catch of recreational fishing totals about 50 000 tonnes consisting mostly of perch, pike and roach. However, almost half of the landings are caught by nets, and thus probably the fish is also used for significant home consumption.[2]

A source of income and jobs

In the European Union, more than 3 000 companies (manufacturers and wholesalers) trade in recreational fishing tackle, providing 60 000 jobs. It is estimated that the total expenditure by recreational fishers in Europe on their hobby and related lodging and transportation add up to more than US$33 billion annually.[3]

In Queensland, Australia, fishers are estimated to spend about US$870 each per year on fishing activities, including tackle, boats, travel and accommodation. Using these estimates, the contribution to the Queensland economy is about US$766 million per year.[4]

[1] B. Steinmetz. 1983. Developments in fishery management in the Netherlands. *Aquatic Ecology,* 17(1): 67–69.
[2] Ministry of Agriculture and Forestry. *Recreational fishing* (available at www.mmm.fi/en/index/frontpage/Fishing,_game_reindeer/Recreational_fishing.html).
[3] B. Dillon. 2004. *A bio-economic review of recreational angling for bass (*Dicentrachus labrax*).* UK, Scarborough Centre for Coastal Studies, University of Hull.
[4] J. Robinson. 2001. *The economic value of Australia's estuaries: a scoping study*. Australia, University of Queensland (available at www.ozcoasts.org.au/pdf/CRC/economic_value estuaries.pdf).

communities and the high abundance of fish on a seasonal basis, large amounts of fish from inland capture are cured. However, given the localized demand and relatively limited post-harvest industries in inland fisheries, as compared with marine fisheries, most of the operations are on a small or medium scale and most of the post-harvest operators are self-employed.

In Africa, the fish processing methods vary according to region and even subregion. Drying and smoking, and to a very small extent fermenting, are the main methods. Some processed freshwater products are considered a delicacy in some countries and are higher priced than similar products prepared using marine fish, e.g. in Ghana, where fresh and salted dried tilapia as well as smoked catfish or perch (*Lates*) are highly preferred. Fish smoking has been under scrutiny for the past few years owing to the occurrence of the carcinogenic compounds belonging to the group of polycyclic aromatic hydrocarbons, e.g. benzo(*a*)pyrene, which are process-related human health hazards.

In Asia, a significant proportion of inland fish goes into fish sauce and fish paste. In Cambodia for example, the bulk of the fish caught from the Mekong River in the dai fishery is used for making fish paste (prahoc) and fish sauce. Here, there are food safety issues involved with the presence of parasites in raw or lightly fermented fish or fish products, or in products that have been improperly frozen. Live parasites are rare in well-fermented fish, and parasites do not usually survive when fish are well frozen.

Addressing the above deficiencies requires more capacity building and training in good hygienic practices, focusing more effort on research work (e.g. in systematic loss assessment for sustainable loss-reduction strategies and aspects related to [live] fish handling, post-mortem attributes and technological processes) for the development of value addition of fish from inland capture. With a reduction in the losses, more fish would be available for human consumption and/or some pressure could be taken off the aquatic resource.

The role of women

Fishers are most commonly portrayed as men going out on boats to catch the fish while women work as fish sellers and processors on land. This generalization of the professional roles of men and women is largely correct, but a closer examination of gender in fisheries reveals a more complex situation depending on the cultural context. In some countries, such as Benin, Cambodia, Congo, Mali, Nepal and Thailand, women actively fish or collect fish. In other countries, such as Uganda, it is taboo for women to be on board a fishing vessel, but they can own boats and hire men as crew. As fish buyers, it is not unusual for women to provide the working capital for fishing trips against a guaranteed supply of fish when the catch is landed. In Bangladesh, fishing was traditionally a low-caste Hindu occupation and only the men in fishing communities engaged in catching fish. While still relatively few women work in fisheries today – an estimated 3 percent of the total female workforce is involved in the fisheries sector – shrimp fry is caught in coastal areas by significant numbers of poor women, irrespective of their religion, age or marital status. In Lake Liangzihu (China), some of the small-scale fishing vessels are operated by women.

Worldwide, there are more women (33 million) than men employed (28 million) in the inland fisheries sector when post-harvest activities are included (Tables 19 and 20).

Statistics, information and data collection

Since 1950, FAO has requested its Member States to report inland fisheries capture statistics as a separate part of their fisheries reporting in order to enable the tracking of trends in global inland fisheries production. From these reported data, there is an apparent increasing trend in the production from global and regional inland fisheries in the period 1950–2008. In 2003, FAO Member States committed themselves to improving such statistics by adopting the Strategy for Improving Information on the Status and Trends of Capture Fisheries, and this strategy was subsequently endorsed by the United Nations General Assembly.

The significance of current reported trends in catches is difficult to assess. In most countries, it is assumed that actual catches have been at a maximum level for some time. Analyses of reported catches in Southeast Asia indicate that large year-to-year increases in reported catches are a relatively common occurrence and are due to the deliberate revision of statistics rather than a sudden change in the status of a fishery.[6] Owing to the high contribution of Asian countries to global inland fisheries landings, improved reporting at the national level can influence also the global trends. The implications of this are that for the world as a whole the baseline is being re-adjusted while in some countries a possible decline in one or more fisheries is being masked (in the reporting to FAO) by the aggregation of catches from several fisheries.

The individual catch per fisher may well be declining, but the aggregate catch can still increase because, overall, the total number of fishers may be increasing. Therefore, an increase in total capture production is not a contradiction to decreasing individual catches. For example, the catch in the Tonle Sap (Cambodia) approximately doubled between 1940 and 1995, but at the same time the number of fishers tripled.[7] Thus, the catch per fisher in 1995 was lower than it was in 1940 although the overall landings were higher. Nevertheless, among fishers, the impression is that resources are declining, although this may not be the case.

In addition, it has frequently been reported, by those working closely with inland fisheries, that catches of individual species or species groups are declining, e.g. in the sturgeon fisheries of the American Great Lakes and the Caspian Sea, the Murray cod fisheries of Australia and the large species of the Mekong River. Often, such details are difficult to obtain from the information on reported landings that countries provide to FAO.

Coates[8] noted that national inland fisheries statistics for a number of countries in the Asia-Pacific region did not show the variations typically expected for inland fisheries as a result of variations in the annual monsoon rains, seasonal effects and dry versus wet years, all of which are known to affect fisheries productivity through year-on-year variations in the areas inundated that influence primary productivity, migration, breeding and recruitment success. In well-monitored fisheries, these significant annual variations in catch as a result of seasonal and climate factors are clearly observed. National fisheries statistics reported to FAO tend not to show these variations.

Estimating the yield from the inland fisheries by using the same approaches as in marine fisheries is extremely difficult. The majority of inland fisheries are not licensed; they operate at commercial, semi-commercial and subsistence levels and are widely dispersed along the lengths of all rivers and streams as well as in a variety of waterbodies and wetlands. There are often no centralized landing ports or major markets where data can be easily collected, and a large part of the catch is bartered locally or consumed by the fishers and their households. Catch size and composition, gear used and the number of fishers vary greatly seasonally. Ideally, data should therefore be collected several times per year, but poorly developed infrastructure in remote areas makes data collection time-consuming and expensive.

Furthermore, as few fees or taxes can be levied on these fisheries, there is little incentive to invest already scarce human and financial resources in collecting the data. The institutional capacity to collect and analyse the data remains low in many countries, and one of the results is that trends in catches become suppressed because data are aggregated across basins and species. Often, landings are recorded for some indicative fisheries and these are subsequently extrapolated up to a national figure, with large errors occurring if structural data (numbers of gear, fishers and households involved) are unreliable.

To improve the situation, alternative approaches to data collection are needed that, in addition to the traditional catch and effort surveys, should include population censuses (for structural data), agriculture surveys, consumption studies (including household surveys), market surveys, georeferenced information, habitat classification and measurement, and establishment of comanagement or fishery user groups.

Freshwater aquatic resources: species and stocks and their environment

The ecosystem services provided by inland waters include food and water supply, water purification, biodiversity habitat, fibre and raw materials, climate regulation, flood protection, and recreational opportunities. Biodiversity has an important role in aquatic habitats, a large number of aquatic plants and animals are important ecosystem components, essential in sustaining fisheries and other uses of aquatic ecosystems. Where biodiversity is maintained and ecosystem processes remain largely undisturbed, also the adaptive capacity of the ecosystem is retained, meaning, *inter alia*, that it retains its ability to buffer or absorb perturbations, including exploitation by the fishery.

Fish assemblages of tropical floodplain rivers and waterbodies with a floodpulse are highly dynamic as a result of seasonal shifts in availability of food, habitats and mortality. Nutrient pulses induced by the floods lead to cycles of explosive population growth followed by high mortality when the aquatic environment contracts. Fish populations in these environments are therefore adapted to high mortality and

Box 19

Atlantic salmon: disappearance and rehabilitation – an example from the Rhine Basin

Atlantic salmon (*Salmo salar* L.) were abundant in the Rhine River and its tributaries until the middle of the nineteenth century and provided the basis for a valuable fishery. The decrease in the salmon population was triggered mainly by the construction of weirs and dams, loss of spawning habitat and water pollution. Since ancient times, people have built water diversion structures, canals and aqueducts to provide drinking-water and water for irrigation, to fill public baths and to harness water power. With the intensification of agriculture that also involved clearing forests, increased silt runoff led to greater alluvial deposits and clogging of gravel river bottoms. During the Industrial Revolution, the use of land and water along the Rhine River intensified even more dramatically. River channels were straightened and deepened, and vast canal networks were constructed together with dams and weirs to serve navigation and hydropower production. Vast floodplains, side arms and backwaters were lost and, thus, valuable aquatic habitat was destroyed. In addition, increasing amounts of industrial and domestic wastes poured into rivers as towns and factories proliferated and grew. However, unsustainable fishing also contributed to the decline of the Rhine salmon.

In an attempt to remedy the situation, intensive stocking with salmon fry and fingerlings was carried out in the second half of the nineteenth century. In Germany alone, several million were released annually.[1] Even an international "salmon treaty"[2] was concluded that led to the first international stocking programme for the Rhine River from 1886 onwards. However, stocking alone failed to maintain the stock and the salmon, together with the sea trout (*Salmo trutta trutta* L.), disappeared from the Rhine Basin. The last salmon was caught in the late 1950s.

When the water pollution in the Rhine River became critical in the 1960s and 1970s, sewage stations for treating industrial and domestic wastewater were built throughout the basin. Old smokestack industries like steelworks and tanning factories shut down because of the radical restructuring of Europe's industry and cleaner technology was applied. In addition, better pollution monitoring was implemented. As a consequence, the water quality in the Rhine River and its tributaries improved remarkably, and sea trout returned to the Sieg River (a tributary of the Rhine River in North Rhine–Westphalia) in the early 1980s. However, it was only after a chemical are extremely resilient to exploitation by fisheries, and capable of persevering even under extreme exploitation levels. However, the pressure on the fish stocks exerted by the fishery does not act in isolation. Impacts on the aquatic environment and habitats arising from non-fishery uses reduce the adaptive capacity of the fish populations. Therefore, decisions on the management of the fishery should consider any activity that, directly or indirectly, may affect the ecosystem and thus the fish stocks of concern.

The estimated global trend of increasing global production may encourage an immediate conclusion that inland fisheries have not yet been fished to their fullest extent. However, overfishing may be taking place in inland fisheries but is often

accident in Switzerland in 1986, when toxic water spilled into the Rhine River and killed tonnes of fish, that the riverine states initiated a comprehensive programme for the rehabilitation of the Rhine River and its tributaries. The aim was to improve the Rhine Basin ecosystem to such an extent that sensitive species like salmon and other migratory species could live and reproduce there again.[3]

Within the framework of the "Rhine Action Programme" under the control of the International Commission for the Protection of the Rhine, assessments of potential salmon spawning and feeding habitats were carried out and the accessibility of such habitats evaluated in the entire Rhine Basin. This showed that the basin was still suitable for salmon. *In-situ* tests to evaluate the potential success of natural spawning were carried out, and salmon fry and fingerlings were released. Where possible, aquatic habitat was protected and, where appropriate and feasible, actively restored. Atlantic salmon eggs were imported from trusted and certified sources that provided material that was genetically the closest to that originally present in the Rhine Basin. A programme for constructing fish passage facilities was intensified and monitoring programmes initiated.

The first record of returning salmon in the Rhine Basin since the species disappeared was in 1991, and in 1994 natural reproduction occurred again in the Sieg River.[4] Since then, hundreds of salmon have come back into the Rhine River and migrated far upstream, as is documented by monitoring results from the fish passes in Iffezheim and Gambsheim. Salmon are now again reproducing successfully in the Rhine Basin system.

[1] P.F. Meyer-Waarden. 1970. *Aus der deutschen Fischerei: Geschichte einer Fischereiorganisation*. Berlin, H. Heenemann.
[2] F. Bürger. 1926. Die Fischereiverhältnisse im Rhein im Bereich der preußischen Rheinprovinz. *Zeitschrift für Fischerei*, 24: 217–398.
[3] Internationale Kommission zum Schutz des Rheins (HG.). 1987. *Aktionsprogramm "Rhein"*. APR-Bericht No. 1. Strasbourg, France and Koblenz, Germany.
[4] J. Lehmann, M. Schenk, G. Marmulla, F. Stürenberg and A. Schreiber. 1995. Natural reproduction of recolonizing Atlantic salmon, *Salmo salar*, in the rhenanian drainage system (Nordrhein-Westfalen, Germany). *Naturwissenschaften*, 82(2): 92–93.

masked by the fact that total catches remain stable over a range of fishing pressures. This is referred to as "assemblage overfishing" and is related to the resilience of inland fish communities and the opportunistic behaviour of the fishers. In healthy inland multispecies fisheries, a small part of the fish community consists of large fish, with a high value. These species grow slowly and start to reproduce when they are three to four years old or even older. The majority of the fish consist of small rapid-growing fish reproducing early in their life. With increasing fishing pressure, the large fish will be reduced by fishing and may ultimately suffer recruitment

Box 20

Changes in fish communities in the Danube Delta Biosphere Reserve and their relation to nutrient loads

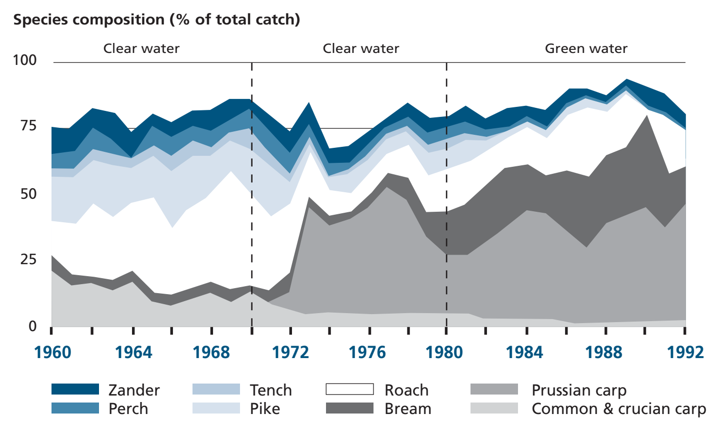
The degree of eutrophication (phosphorus and nitrogen content) is an important factor in deciding which fish species can be found in a waterbody. The evolution of the species composition of the fish catch and eutrophication in the Danube Delta (Romania) in the period 1960–1992 is shown in the accompanying figures.

From 1960 until the mid-1970s, the nutrient load in the Danube Delta was rather low, the water was clear, and macrophytes were frequent and provided shelter for the predatory pike. The vegetation near the embankments provided breeding and nursing places for tench and pike. The abundance of common and crucian carp was in decline, but species like pike, perch and tench were abundant.

In the mid-1970s, the phosphorus load increased gradually until it reached a very high level of 0.1–0.15 mg/litre, the water turned green due to algae growth, and the submerged vegetation disappeared. The habitat favoured by pike and tench was destroyed, and bream, roach, zander and stocked Prussian carp became dominant in the system.

From 1980 onwards, owing to, *inter alia,* reduced water clarity, changes in zooplankton composition and intensive stocking programmes, the Prussian carp stock increased rapidly, partly replacing the roach. Pike, which is a visual

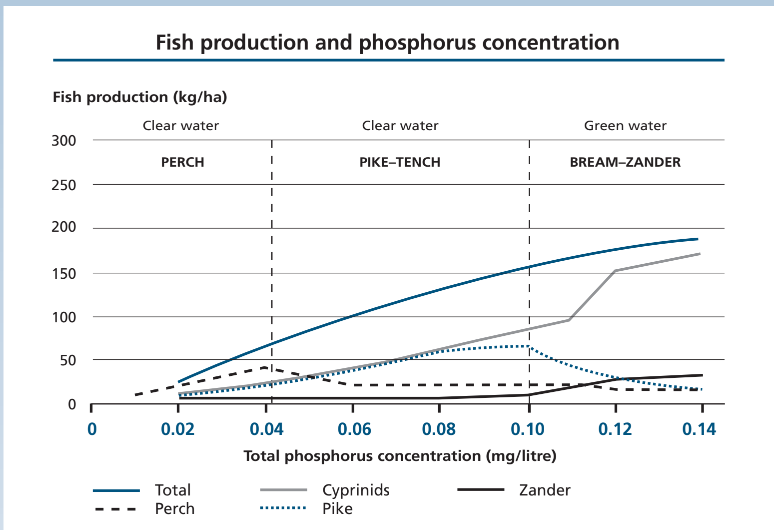
Trends in species composition in the Danube Delta

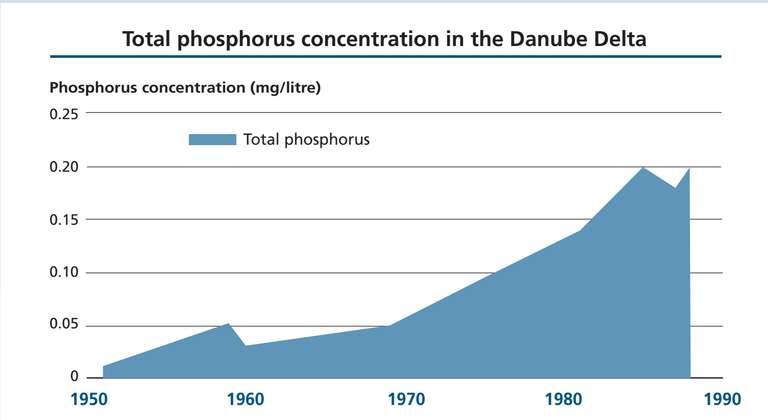


failures. In response, the fishers will gradually shift their effort to other species of the assemblage by using different gear. As the mean size of individuals and species in the assemblage becomes smaller, the fishers will reduce the mesh size of gear they use. This will result in a fishery mainly consisting of the smaller species, with a more rapid life cycle, and often based on the young of the year, but it will remain very productive, at least for a while.

The fishing-down process is illustrated in Figure 46, which shows the trend in catch composition in the Tonle Sap (Cambodia). In 1940, the total catch from the Tonle Sap

predator, was replaced by zander (which are less reliant on vision). With the disappearance of pike (the largest predator in the system), the abundance of bream and other cyprinids increased substantially.





of 125 000 tonnes consisted mainly of large and medium-sized fish, while the 1995–96 catch of 235 000 tonnes contained hardly any large fish and was dominated by small fish.

Assemblage overfishing is most common in tropical areas with high species diversity and where local communities depend on a diverse inland fish harvest. It is an indication of the resilience of inland fisheries, but it also creates the misleading impression that inland fisheries resources are limitless. This is especially the case if catches are not reported by species or species groups and internal processes in the fisheries are masked.

In Asia, most inland fisheries are heavily fished to a degree that substantially alters species size and composition, and also the abundance and ecology of the fish communities. In these situations, there is probably little room for any substantial increases in catch. Fishing pressures in South America and parts of Africa do not appear to have reached these levels, as catches usually still include large species, and here there is probably some room for increases.

Where fish resources in lakes or rivers are reserved for recreational purposes, it is common for the fish assemblages to remain reasonably pristine, except where alien sport fish have been introduced and become established or where habitats have been modified to suit particular species. Nevertheless, many recreational fisheries exist in highly modified habitats, e.g. urban parks or specially constructed waterbodies where native and alien species provide food and recreation. In these fisheries, conservation of biological diversity is not an objective.

However, also in the developed world, inland fisheries resources have changed considerably in recent decades, mainly owing to developments outside the sector. Well-known examples are the decline of many salmon populations and the disappearance of clear water systems in Europe because of eutrophication. Considerable resources have been, and continue to be, invested in reversing this trend, with some success (Box 19).

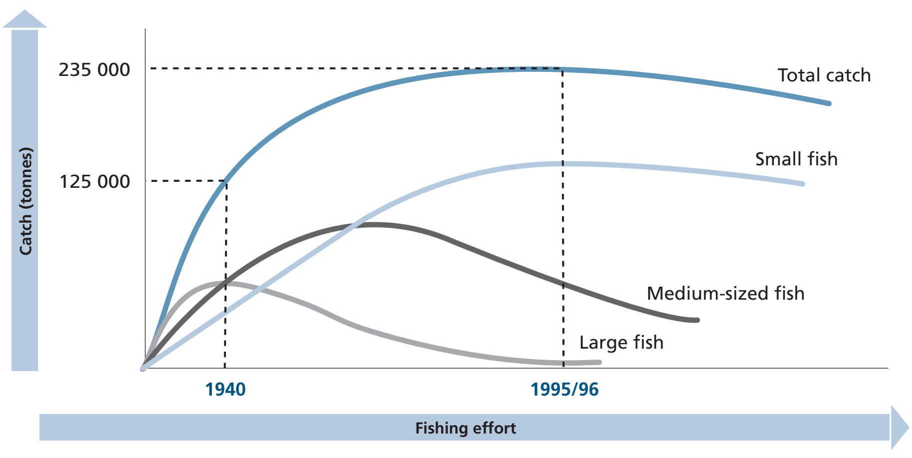
Where overfishing exists, alien species are introduced and habitats are degraded, in particular through changes in water- and land-use practices, the species composition of inland fishery catches will continue to change (Box 20).

Threats

Major threats to inland fisheries come from outside the sector. Environmental degradation and increasing land and water scarcity in most regions of the world are threatening inland fish production. Industrialization, urbanization, deforestation,

Figure 46

Catch composition in the Tonle Sap, Cambodia



Source: FAO. 2003. *New approaches for the improvement of inland capture fishery statistics in the Mekong Basin. Ad-hoc expert consultation.* RAP Publication 2003/01. Bangkok, Erewan Press. 145 pp.

mining and agricultural land and water use often cause degradation of aquatic environments, which is the greatest threat to inland fish production. Some major threats from outside the sector and their impacts are summarized below.

Agriculture is responsible for draining wetlands, abstracting a tremendous amount of water through irrigation and disrupting the connectivity between rivers and floodplains. Floodplains are some of the most productive inland fishery habitats, especially in tropical areas. Agricultural expansion is leading to a progressive modification of floodplains. For example, more than 40 percent of the floodplains of Bangladesh, which themselves cover more than 69 percent of the country, have been modified and impoldered for rice growing, and more than 60 percent of the water flow of the Ganges Basin is abstracted for irrigation and other purposes, and while some water is returned, its quality has suffered.

Excessive agricultural effluents, e.g. agrochemicals and harmful waste, can cause pollution and eutrophication of inland waters and affect growth and mortality of aquatic species, or toxins may accumulate in fish and be passed on to consumers. To a lesser extent, effluents from irresponsible aquaculture may pose some of the same threats to inland waters. Introduction of pathogens and alien species are two potential threats of irresponsible aquaculture that could also affect inland fisheries.

Hydropower generation through the creation of dams changes the quality and quantity of water available to inland fisheries. The dams often create impassable barriers to fish that result in fragmented habitats where access to critical areas is unavailable to the fish.

Development, land clearing and deforestation cause increased erosion and siltation in the watershed. Trees often provide shade and even habitat and food for many inland fisheries. Rivers are often "channelized" to suit the needs of urban populations. Increased human populations require more water to be used for industrial and municipal uses rather than being available for fish.

The effects of climate change are hard to predict but are expected to result in an increase in the variability of environmental conditions, including temperature, precipitation and wind patterns. Rising sea levels and increased temperatures will change the distribution and composition of inland fishery resources (see below).

The above threats are not new. In the past, they have together had a variety of impacts on inland fisheries. Their combined effects have resulted in changes in the natural flow patterns of inland waters, which in turn have caused the species composition to change. Where species cannot adapt, they simply disappear. It seems that these threats will continue to have serious impacts on the viability of inland fishery resources. Eutrophication and increased temperatures may initially increase production of some species, but beyond thresholds production will decline. However, habitat fragmentation, direct loss of fish through pollution or entrapment at water and turbine intakes, predation by introduced species and loss of critical habitat for spawning or feeding will result in a reduction in inland fishery resources.

Policies and regulatory environment[9]

In light of the external threats cited above, there exists a great need for policies on inland fisheries to be closely integrated with those of other stakeholders and sectors. In general, these policies are lacking, or where present they may not be easily enforced. Policies and regulations are more developed concerning access to fishing grounds and fishing practices than for regulation of other threats to fish resources and their ecosystems. However, these will be insufficient if the quantity and quality of water necessary to sustain inland fisheries are not ensured.

There are a number of international agreements that can guide governments towards improving governance of natural resources, and the focus in all of these is on sustaining benefits to people. In addition to the CCRF, they include the Ramsar Convention, the Convention of Biological Diversity, the Convention on Migratory Species, and the World Heritage Convention.

As reported on in *The State of World Fisheries and Aquaculture 2006,*[10] a range of regional frameworks provide advice on, or deal directly with, the management of inland waters and living aquatic resources. However, the governance system remains incomplete as only 44 percent of international basins are subject to one or more agreements. Many of these do not focus on fishery resources but on water as a resource, i.e. the allocation of water for irrigation, flood protection, navigation or hydropower generation. Nevertheless, the agreements normally have a mandate in environmental matters, which could be extended to include fisheries, although these are often not specifically mentioned.

A wide range of different access regimes and fishing rights systems are observed in inland fisheries. In most cases, inland fisheries remain public resources, but the responsibilities of the management and the access rights to the resource are increasingly being devolved to private individuals or groups and local communities in recognition of the limited capacities of the central state (in particular in developing countries) to enforce management regulations.

It is frequently stated that small-scale fisheries in the developing world are "open access". However, very few inland fisheries are de facto open access; the right to fish is usually linked to some form of formal or informal, symbolic or substantial management system generally established at the local or community level. In Africa, these community-based arrangements are still largely under the influence and/or control of local traditional authorities. However, in Asia and Latin America, decentralization reforms have led to situations where the control of access to inland fisheries has been increasingly devolved to local government or decentralized institutions, often in collaboration with fishers organizations, under what are known as fisheries comanagement systems. While the top-down approach to fisheries management has largely failed, comanagement, to be effective, requires that local communities and other partners be given greater influence over the management of the environment upon which the fishery is based.

Comanagement is not the only major type of reform that has been introduced in inland fisheries in recent years. In some countries where reservoirs and lake fisheries are mainly managed through leasing systems, the central government has decided to abolish the existing arrangement that favoured local fishing cooperatives, and instead to allow individual private "entrepreneurs" to bid during the leasing process. The basis for this reform is frequently the assumption that these waterbodies are likely to be more effectively managed and exploited by private investors than by local collective groups or cooperatives. In India, one factor driving this policy reorientation is the hope that these privately exploited waterbodies will increase the capacity of the sector to produce a fish surplus and, thereby, to respond to the increasing demand generated by the country's growing urban population. Experiences elsewhere have shown that sustainability is closely linked to the length of the lease periods – a long lease period creates an incentive to manage the fishery sustainably.

Production-oriented policies to increase fish production through aquaculture development and culture-based fisheries in waterbodies that previously sustained capture fisheries have been introduced in a number of countries. Although fish production *per se* may in many cases have increased as a result of this type of intervention, the benefits may not be socially and environmentally sustainable if the intervention overly restricts access and creates conflicts among the different stakeholders.

In most developed countries, policies governing inland fisheries have evolved from an initial emphasis on food production, through a growing interest in recreation, and with aesthetic and nature conservation interests emerging last. In many areas, however, the main uses of inland waters continue to be for non-fishery related development.

Sustainable fisheries require that key habitats be protected. For species with strict ecological requirements, their spawning grounds and nursery areas are especially sensitive. However, most importantly, ecosystem processes and functions must be maintained or restored where they have been lost, and ecosystem connectivity

throughout the basin must be ensured and habitat fragmentation avoided. By maintaining biodiversity, the ecosystem stands the best chance of being able to adapt on its own to the changes that are already happening. Sustaining biodiversity and habitats is equivalent to sustaining ecosystem services and, therefore, sustaining human well-being.

Biodiversity loss has seriously inequitable outcomes – usually greatly disadvantaging inland fishers. To achieve a more balanced and sustainable development, an "ecosystem services" approach to policy and decision-making needs to be adopted, instead of sector-based approaches, which tend to lead to disparities in service delivery and inequities in benefits. For this to happen, greater awareness of the role of biodiversity

Box 21

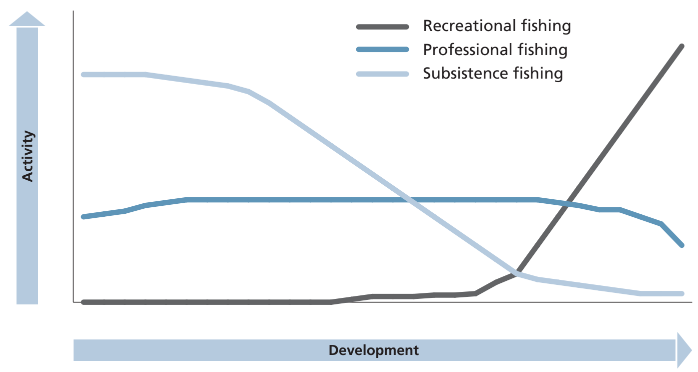
Economic development and its influence on inland fisheries – some relationships

Economic growth will generate improved employment opportunities outside the fisheries sector as well as leading to increasing income levels and purchasing power for rural populations. Most likely, this will mean that fewer households will need to rely on subsistence fisheries for the supply of food, and some occasional or subsistence and part-time fishers will abandon the fishery (see figure).

Professional inland fishing may continue over a long period. Transport and communication infrastructure will improve, as will fishing technology, leading to a strengthening of the sector's competitive position in fish markets. However, economic and social development will increase the threats from outside the sector and may lead to reduced ecosystem services and degradation of water resources, and reduction in income opportunities from fishing.

Aquaculture and fisheries enhancements will increase fish supply globally and will partly meet the demand for fish. With increased development, people in developing countries will become less dependent on supply from wild inland fisheries except in productive and profitable inland fisheries supported by appropriate policies and regulations. As living standards improve, recreational fisheries will become increasingly common also in developing countries.

Evolution of inland fisheries



is necessary, together with more transparent, informed and impartial decision-making processes involving the rural people who depend directly on the biodiversity resources.

THE OUTLOOK

In spite of the trend of gradually increasing inland catches, it is reported that the abundance of inland water species populations declined by 28 percent between 1970 and 2003.[11] Action is required to secure conservation of aquatic ecosystems and safeguard the resources that form the basis for inland fisheries. A range of factors will directly or indirectly drive the development of the sector. However, there is the possibility to mitigate some negative impacts through technological advances, wealth creation and better management.

Drivers of inland fisheries

A general scenario

For inland fisheries to have a future, there must be fish resources that can be exploited to satisfy people's needs for food, income and/or recreation.

Those now engaged in inland fisheries have fundamentally different reasons to be involved. Commercial, full-time and part-time fishers pursue fisheries because they see the activity as one of their best possibilities to secure a livelihood for themselves and their families. Occasional and subsistence fishers go fishing for additional income or to add fish to their meals, and recreational fishers do so because it is for most of them a leisure-time occupation. However, the sector is highly dynamic with possibilities for people to enter or leave it or increase or decrease their participation in response to developments and available opportunities inside and outside fisheries.

The status of the fisheries resources depends to some extent on the number of fishers and how they are regulated. However, the threats coming from outside the fisheries sector are often more important and can lead to fishers being deprived of their resources and their livelihoods. General social and economic development is a major force influencing the drivers within and outside the fisheries sector, in both a positive and negative manner (Box 21).

Need for more food

According to the projections by the United Nations Population Division,[12] the world population will increase from 6.8 billion today to 9 billion by 2050. As stated above, 65–90 percent of the inland capture fish production takes place in the developing and low-income food-deficit countries. The World Bank's forecast for 2020 suggests that 826 million people, or 12.8 percent, of developing country citizens will be living on US$1.25 a day or less and that there will be almost 2 billion poor people living at or below the US$2 a day poverty line.[13] The growing population will need significant increases in food production at affordable prices.

More land (including wetlands) will be used, and some will be used more intensively, as agricultural food production expands during coming decades. This will result in increased use of agrochemicals with serious negative consequences for inland fisheries.

The demand for water for both irrigation and domestic purposes will continue to increase, leading to reduced water availability for fisheries, especially during the dry season. There will be attempts to transfer water between separate basins, with unpredictable consequences for biodiversity. There are also already plans to connect large rivers and transform them into shipping lanes linking distant cities, provinces and countries in areas with poorly developed rail and road infrastructure. There is expected to be increased demand for energy, including hydropower – leading to further damming of rivers.

The need for animal protein, including fish, will increase. Most marine fish stocks are already fully exploited. Notwithstanding increases in aquaculture production, fishing pressure will increase on inland fish stocks, and there will probably be a rise in unsustainable fishing methods, such as the use of explosives and poison, electrofishing and dry pumping of small natural waterbodies. These methods are all capable of killing large amounts of fish indiscriminately.

Aquaculture will continue to grow, and high-value species and products will increasingly come from farms rather than wild stocks. This may reduce capture fishing pressure. In developing countries, improvements in aquaculture technology will allow more fish to be sold more cheaply but, in some markets, cultured species will have problems competing with wild fish because of the need for feed based on fishmeal and fish oil. However, progress is being made on developing feed alternatives derived from locally available animal-waste products or using plant-based proteins instead of animal protein. Where water is available, culture-based and enhanced fisheries will become increasingly important in poor countries with rapidly growing populations because of the lower levels of investment and running costs, but they will require hatcheries to provide the seed. This development will tend to concentrate access to fishing among fewer groups, and the role of fishing as a safety net for the poorest of the poor is likely to be threatened.

Economic development

In an economic growth scenario, income per capita is expected to increase. In order to achieve such an increase in income from fisheries, it is necessary to achieve either a higher price per kilogram of fish or a higher catch per unit of effort. In most countries, the majority of inland fisheries products are low-priced compared with other sources of animal protein and there is little reason to expect this situation to change. For high-value products (e.g. caviar), there will be increased competition from aquaculture. As economies develop and diversify, more jobs will be created in cities, causing a migration from rural areas to urban ones, and fishing for food will become a less important source of employment. Reduced fishing pressure – as fishers leave the industry – may lead to a growth in the standing biomass of commercial species and higher catches per unit of effort, provided that the habitat remains viable. This may slow the decline of the industry provided it is possible to increase the landings or their value with the available technologies. In some inland fisheries, the cost of inputs such as fuel and gear will also increase. However, the low level of technology in most cases is likely to continue, as the return on any investment to improve technology will be comparatively low.

At the same time, with the increasing amount of leisure time, the tendency of recreational fisheries to become more important will continue. This will change the visibility of the recreational fishery subsector. Government income from the subsector will rise and so will its political leverage. The dynamics of the fishery will change and the management requirements will be fundamentally different from a fishery geared to providing food. The transition from a fishery for food towards “fishing for fun” has already occurred in developed countries around the world, and many transition economies are now following a similar course. Development should ensure that recreational fisheries are conducted responsibly.

With increased economic development, people are freed from the fear of starvation and can devote more time to activities other than the pursuit of food. Better-educated people often have the leisure time and opportunities to become more aware of the general value of biodiversity and ecosystems, and “environmental ethics” and conservation issues tend to take a higher priority. Consequently, there will also be a higher demand for the protection of natural ecosystems for recreation as well as sustainably produced food.

Technological development

Most inland waters require labour-intensive methods to fish them efficiently and, apart from in the largest lakes and reservoirs, there is limited scope to apply labour-saving technologies. Recreational fisheries will continue to develop new gear, tackle, baits and methods.

Technological advances have the potential to reduce pollution from both agriculture and industries. In the future, pesticides will, for example, target particular pests much more specifically and so be used in smaller amounts. Pollution from industries can be reduced with technologies that treat or recycle water and prevent pollution.

There will also be new techniques to mitigate the impacts of water-using sectors on aquatic habitats, and new methods to rehabilitate already-affected aquatic environments, e.g. fish pass technologies, ecological engineering, and reconnection of rivers and floodplains. Although these technologies may initially be available mainly in developed countries, they will increasingly be adopted by other countries driven by the move towards conservation.

Climate change and climate variability

Climate change has the potential to become the most important driver of change in inland aquatic ecosystems. It will affect societies and economies, and increase pressures on all livelihoods and food supplies. Inland water ecosystems and, thus, inland fisheries are affected by more or less regular natural variations in the physical environment. However, an expected characteristic of global climate change is a probable increase in the variability of environmental conditions, including temperature, precipitation and wind patterns.

Inland fisheries have a strong reliance on resources harvested from natural ecosystems. How climate change affects these fisheries will depend on the capacity of the ecosystem to adapt to change, which in turn is heavily dependent on the extent of degradation of the ecosystem from other human activities. Therefore, while climate change will almost certainly influence inland fisheries in significant ways, both directly, e.g. as a result of changes in rainfall patterns and rising sea levels, and indirectly, e.g. through shifts in the demand for and trade in commodities, the exact nature of these changes cannot be easily established.

Impacts will occur as a result of both gradual warming and associated physical changes as well as from changes in the frequency, intensity and location of extreme events. Wetlands and shallow rivers are susceptible to changes in temperature and precipitation, and prolonged periods of drought will reduce available habitat to fish, especially during the dry season. Overall, a global temperature increase of 1 °C is associated with a 4 percent increase in river runoff. However, rainfall will not be evenly distributed geographically, and while river runoff is expected to increase at higher latitudes, it is predicted to decrease in parts of West Africa, southern Europe and southern Latin America.[14] In rivers with reduced discharge, up to 75 percent of local fish biodiversity could be headed towards extinction by 2070 because of combined changes in climate and water consumption. Fish-loss in these scenarios would fall disproportionately on poor countries.[15] Measures implemented to ensure continuous water supply for irrigation and domestic purposes by storing more water will further escalate impacts on aquatic ecosystems.

The melting of glaciers and changed rainfall patterns will potentially affect river flows and flood hundreds of kilometres downstream in large catchments, leading to changes in flood areas, timing and duration. As the life cycles of fish species are closely adapted to the rhythmic rise and fall of the water level, changes to this pattern may cause fish to spawn at the wrong time of the year, with loss of eggs and fry as a result. Flash floods may wash eggs and fry out of their normal habitats, thereby increasing the chances that they will die from starvation or predation.

Variations in temperature and wind could affect stratification of waterbodies and circulation of water masses in large lakes and reservoirs. They may also lead to changes in productivity and shifts in the relative abundance of species throughout the foodchains and cause deoxygenation in bottom layers. To date, there has been no global assessment of warming of inland waters, but many lakes have shown moderate to strong warming since the 1960s. There are particular concerns regarding Africa, where temperatures are predicted to rise and rainfall to decrease.

Increased temperatures will affect fish physiological processes and, thus, their ability to survive and reproduce. Increased temperatures will therefore also change the distribution of species. Unlike the marine environment, where many species can move to more suitable water conditions, many inland fish species are constrained by physical boundaries that would prevent them changing their distribution. There could also be an increased risk of species invasions and of the spread of vector-borne diseases.

Lack of information

In most cases, the information available on inland fisheries is insufficient to allow an assessment of the potential for future development and the elaboration of the necessary policies and strategies. To create the necessary awareness for inland fisheries to be taken seriously into account when planning, better data on the size and importance of the fisheries are required. The failure to understand how inland ecosystems work and how many people depend on them has greatly affected inland fisheries throughout the world. Appropriate management must be guided by data on which to base an assessment of the status and trends for the stocks concerned.

New approaches to gathering and analysing information are needed that include individual fishers, households and communities, and proxy measures of fishery yield. In addition to the traditional catch and effort surveys, approaches to improve information on inland fisheries include: population censuses (for structural data), agriculture surveys, consumption studies (including household surveys), market surveys, georeferenced information, habitat classification and measurement, and the involvement of comanagement or fishery user groups in data collection.

Geographic information systems (GIS) constitute a very powerful analytical tool for inland fisheries managers because they can incorporate a variety of information from different sources at the same time, thereby revealing patterns that may otherwise be difficult to discern. For example, they can be used to analyse and illustrate migration patterns, fish occurrences and spawning grounds in relation to physical data such as water quality, substrates, current and the presence of physical obstacles. By combining environmental data with population statistics, a GIS can also yield information about the status of fisheries, people's dependence on aquatic resources and their vulnerability to environmental change.

There are encouraging signs that information on inland fisheries can improve.[16] The implementation of the FAO Strategy for Improving Information on Status and Trends of Capture Fisheries[17] is making progress, and proxy measures for yield, such as fish consumption measures, are being developed. Regional and subregional mechanisms for exchange of information, especially for the small-scale sector, are also making progress. An analysis of inland fishery statistics from key countries in Africa is under way. Its aim is to help identify data needs and shortcomings.

As the special information needs of inland fisheries are being realized, it can be expected that the new approaches mentioned above, the development of fisheries information systems and easier Web-based communications will generate improved information.

CONCLUSIONS

Inland fisheries are an important source of cash and high-quality protein, particularly in poorer countries where their products are readily available to the population. Ninety percent of inland fishery production comes from developing countries, and 65 percent comes from LIFDCs. As shown above, inland fisheries provide employment for some 60 million people, especially women, in both developed and developing countries. Although the figures given are only best estimates, it is clear that the inland fishery sector involves a tremendous workforce, producing food where it is greatly needed.

In a changing world, it will be a major challenge to sustain the different functions of inland fisheries, such as their role in food security and poverty alleviation and other ecosystem services. It is apparent that many of the drivers of inland fisheries originate from outside the sector. Many of them are associated with the economic development and industrialization that compete for water resources and can negatively affect inland waters and the living aquatic resources therein. Therefore, fisheries need to be taken into due consideration, and integrated basin planning needs to be brought forward. However, development may also provide alternative livelihoods for fishers, technology to mitigate negative impacts, and improved food security that will allow people to fish for recreation rather than for livelihood. Technological interventions that will help maintain ecosystem function and biodiversity (e.g. wetland rehabilitation, pollution control, and construction of well-designed fish passes) can accompany development and thereby maintain viable inland fisheries. Thus, the future of the inland fishery sector depends very much on responsible development in other sectors.

However, also within the sector, changes are needed. Improved fish-processing technologies and investment in post-harvest infrastructure can help reduce post-harvest losses and increase the quality of inland fish and fish products for better market access (as is the case for marine fisheries and aquaculture). Considering the importance of inland fisheries for the rural poor, reduction of fishing pressure where the resources are threatened by overexploitation, although extremely difficult, is often the only option. Ways to reduce the fishing pressure should be developed with all stakeholders involved.

The shift away from fisheries as a food source to providing recreation in developed countries may also be followed in developing countries as they develop economically. This shift will depend on the level of food security, education, economic development and available infrastructure to support conservation and recreational activity. In addition, there will be increased competition from aquaculture as that sector continues to grow. However, aquaculture is not commonly an activity or source of food for the poorest of the poor – for these people, inland fisheries will continue to be important.

While many impacts resulting from development or climate change appear unavoidable, countries have options on how to respond if the political will is present and resources are made available. In many developed countries, the desire to protect inland waters and fisheries exists and the necessary resources will be available. However, in other areas, economic considerations of the more influential sectors that are perceived to be more profitable are expected to take precedence.

It is often the case that policies and strategies for the management and development of the water sector are formulated, and water development projects implemented, with incomplete information on the extent of inland fishery production, the number of people involved and the significance of inland fisheries for their livelihoods. This usually results in serious negative consequences for aquatic ecosystems and, hence, inland fisheries. If the inland fishery sector can become better integrated with other users of inland waters and food production sectors, it will facilitate the collection and exchange of the information necessary to help protect inland waters and to assess and manage the status of inland fisheries. This information should be used to develop and implement holistic land-use policies that emphasize user participation and an ecosystem-based approach to management in order to conserve biodiversity and ecosystem services, and so ensure the continued availability of aquatic resources for the benefit of human populations. Thus, economic development of the water sector should include measures that maintain viable fisheries that serve local populations as a source of food, money and/or recreation, or measures that provide alternative economic opportunities for those displaced from inland fisheries.

NOTES

1 This "Outlook" section does not deal with aquaculture, except as it interacts with inland fisheries. Inland fisheries take place in inland waters existing inland of the coastline, including lakes, ponds, streams, rivers, wetlands, artificial watercourses and reservoirs, coastal lagoons and artificial waterbodies.

2 The term "fish" includes finfish, crustaceans and molluscs. Unless stated otherwise, aquatic plants are not included.

3 Although the term "small-scale fisheries" is commonly used in international fisheries literature and discussions, this classification is rarely explicitly defined. This could be considered a significant oversight that relates to the fact that the conceptualization in one place could be considered large scale in another. While there are common attributes, there is hence no all-encompassing global definition.

4 Full-time fishers receive at least 90 percent of their livelihood from, or spend at least 90 percent of their working time on, fishing. Part-time fishers receive at least 30 percent but less than 90 percent of their livelihood from fishing, or spend at least 30 percent but less than 90 percent of their working time in that occupation. Occasional fishers receive less than 30 percent of their income from fishing or spend less than 30 percent of their working time on fishing. (Definition from the FAO Fisheries and Aquaculture Department, available at www.fao.org/fishery/cwp/handbook/K/en).

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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2010

Against a backdrop of global economic uncertainty, this issue of *The State of World Fisheries and Aquaculture* highlights the major role and challenges facing fisheries and aquaculture worldwide. With a steadily rising demand for fish and fish products, the supply of fish as human food hit a record high in 2008, underlining its significance in contributing to food security and nutrition as a source of high-quality, affordable animal protein in particular. International trade in fish also topped previous values, pointing to the sector's continued important contribution to economic expansion and human well-being. Aquaculture, despite a falling growth rate in recent years, remains the fastest-growing animal-food-producing sector and is set to overtake capture fisheries as a source of food fish. Overall production of the sector continues to grow.

This publication analyses and reviews the latest available global statistics and trends in fisheries and aquaculture. It explores the important, yet often underestimated, role of inland fisheries, particularly in many small communities where they make a vital contribution to poverty alleviation and livelihood security. A broader look at the issues affecting fisheries and aquaculture emphasizes the growing need to focus on the many facets of policy and governance and examines the impacts of climate change, biodiversity loss, quality certification and product traceability on the sector.

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