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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2012

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THE STATE OF WORLD FISHERIES AND AQUACULTURE

2012

FAO Fisheries and Aquaculture Department

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FOREWORD

Today, the global community faces multiple and interlinked challenges ranging from the impacts of the ongoing financial and economic crisis to greater climate change vulnerabilities and extreme weather events. At the same time, it must also reconcile meeting the pressing food and nutrition needs of a growing population with finite natural resources. This edition of *The State of World Fisheries and Aquaculture* shows how these issues affect fisheries and aquaculture sector and how the sector is attempting to address them in a sustainable manner.

Fisheries and aquaculture make crucial contributions to the world's well-being and prosperity. In the last five decades, world fish food supply has outpaced global population growth, and today fish constitutes an important source of nutritious food and animal protein for much of the world's population. In addition, the sector provides livelihoods and income, both directly and indirectly, for a significant share of the world's population.

Fish and fishery products are among the most traded food commodities worldwide, with trade volumes and values reaching new highs in 2011 and expected to carry on rising, with developing countries continuing to account for the bulk of world exports. While capture fisheries production remains stable, aquaculture production keeps on expanding. Aquaculture is set to remain one of the fastest-growing animal food-producing sectors and, in the next decade, total production from both capture and aquaculture will exceed that of beef, pork or poultry.

However, in a world in which almost a billion people still suffer from hunger, it is the poor, especially those in rural areas, who are most vulnerable to the combination of threats outlined above. In many areas of sub-Saharan Africa and South Asia, their fish consumption levels remain too low and they are failing to benefit from the contributions that fisheries and aquaculture are increasingly making elsewhere in terms of sustainable food security and income.

The vital contributions from fisheries and aquaculture to global food security and economic growth remain constrained by an array of problems. These include poor governance, weak fisheries management regimes, conflicts over the use of natural resources, the persistent use of poor fishery and aquaculture practices, a failure to incorporate the priorities and rights of small-scale fishing communities, and injustices relating to gender discrimination and child labour.

The recent United Nations Conference on Sustainable Development, known as Rio+20, discussed these governance-related issues and served as a platform to renew political commitment for sustainable development, assess progress and gaps in the implementation of existing commitments, and address new challenges. Two themes underpinning Rio+20 – the institutional framework for sustainable development and the support of a green economy – were reflected in FAO's main message that improved management and efficiencies throughout the food value chain can increase food security while using fewer natural resources, i.e. achieve more with less. A special focus on oceans and coasts at Rio+20 enabled FAO to voice its recommendations on questions ranging from improving the sustainable use of marine and coastal resources through to poverty eradication, small-scale fisheries and aquaculture operations, as well as the potential contribution of small island developing States.

Promoting sustainable fishing and fish farming can provide incentives for wider ecosystem stewardship. The greening of fisheries and aquaculture requires recognition of their wider societal roles within a comprehensive governance framework. There are several mechanisms to facilitate this transition, including adopting an ecosystem approach to fisheries and aquaculture with fair and responsible tenure systems to turn resource users into resource stewards.

In addition to the efforts of government institutions, enabling fisheries and aquaculture to flourish responsibly and sustainably requires the full involvement of civil society and the private sector. Business and industry can help develop technologies and solutions, provide investment and engender positive transformation. Civil society and international and local non-governmental organizations can hold governments accountable on agreed commitments and ensure that the voices of all stakeholders are heard and represented.

Efforts to foster good governance for responsible and sustainable fisheries and aquaculture should include widespread adoption and implementation of the principles enshrined in the Code of Conduct for Responsible Fisheries, as well as of the provisions of the international guidelines currently under development for securing sustainable small-scale fisheries. It is also necessary to ensure the uptake and application of relevant international instruments, in particular the 2012 Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests, and to provide support to initiatives such as the GEF/FAO Global Sustainable Fisheries Management and Biodiversity Conservation in Areas Beyond National Jurisdiction, the World Bank's Global Partnership for Oceans and the UN Secretary-General's Ocean Compact.

To ensure that ecological well-being is compatible with human well-being, and to make long-term sustainable prosperity a reality for all, it is necessary to strike the right balance between seizing opportunities and addressing threats in the use of technology and natural resources, in applying sound economic and policy decisions and in preserving environmental integrity and social licence.

It is my sincere hope that this issue of *The State of World Fisheries and Aquaculture* will serve as a useful reference work on the sector – its status, trends, issues and outlook – and that it will contribute to a more complete understanding of the sector's key role in shaping our world.

Árni M. Mathiesen
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FAO Fisheries and Aquaculture Department

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ABBREVIATIONS AND ACRONYMS

CAC
Codex Alimentarius Commission

CACFISH
Central Asian and the Caucasus Fisheries and Aquaculture Commission

CBD
Convention on Biological Diversity

CCA
climate change adaptation

CCAMLR
Commission for the Conservation of Antarctic Marine Living Resources

CCSBT
Commission for the Conservation of Southern Bluefin Tuna

CDS
catch documentation scheme

CECAF
Fishery Committee for the Eastern Central Atlantic

CIFAA
Committee for Inland Fisheries and Aquaculture of Africa

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

CODE
Code of Conduct for Responsible Fisheries

COFI
FAO Committee on Fisheries

COP
Code of Practice

COREP
Regional Fisheries Committee for the Gulf of Guinea

CPUE
catch per unit of effort

DRM
disaster risk management

DRR
disaster risk reduction

EAA
ecosystem approach to aquaculture

EAF
ecosystem approach to fisheries

EC
European Commission

ECOSOC
United Nations Economic and Social Council

EEZ
exclusive economic zone

EIFAAC
European Inland Fisheries and Aquaculture Advisory Commission

EIFAC
European Inland Fishery Advisory Commission

FCR
feed conversion ratio

FCWC
Fishery Committee for the West Central Gulf of Guinea

GFCM
General Fisheries Commission for the Mediterranean

GHG
greenhouse gas

HACCP
Hazard Analysis and Critical Control Point (system)

HFA
Hyogo Framework for Action

HUFA
highly unsaturated fatty acid

IATTC
Inter-American Tropical Tuna Commission

ICCAT
International Commission for the Conservation of Atlantic Tunas

IMO
International Maritime Organization

IOTC
Indian Ocean Tuna Commission

ISO
International Organization for Standardization

ITQ
individual transferable quota

IUU
illegal, unreported and unregulated fishing

LDC
least-developed country

LIFDC
low-income food-deficit country

LIFE
low-impact fuel-efficient

LOA
length overall

MDG
Millennium Development Goal

MPA
marine protected area

NAFO
Northwest Atlantic Fisheries Organization

NASCO
North Atlantic Salmon Conservation Organization

NEAFC
North East Atlantic Fisheries Commission

NEI
not elsewhere included

NGO
non-governmental organization

NOAA
National Oceanic and Atmospheric Administration (the United States of America)

NPAFC
North Pacific Anadromous Fish Commission

OECD
Organisation for Economic Co-operation and Development

OSPESCA
Organization of Fishing and Aquaculture in Central America

PERSGA
Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden

RFB
regional fishery body

RFMO
regional fisheries management organization

R&D
research and development

SAR
search and rescue

SEAFO
South East Atlantic Fisheries Organisation

SIOFA
Southern Indian Ocean Fisheries Agreement

SPRFMO
South Pacific Regional Fisheries Management Organisation

SPS AGREEMENT
Agreement on the Application of Sanitary and Phytosanitary Measures

SWIOFC
Southwest Indian Ocean Fisheries Commission

TBT AGREEMENT
Agreement on Technical Barriers to Trade

UNGA
United Nations General Assembly

WCPFC
Western and Central Pacific Fisheries Commission

WHO
World Health Organization

WTO
World Trade Organization

PART 1

WORLD REVIEW OF FISHERIES AND AQUACULTURE

WORLD REVIEW OF FISHERIES AND AQUACULTURE

Status and trends

OVERVIEW

Capture fisheries and aquaculture supplied the world with about 148 million tonnes of fish in 2010 (with a total value of US$217.5 billion), of which about 128 million tonnes was utilized as food for people, and preliminary data for 2011 indicate increased production of 154 million tonnes, of which 131 million tonnes was destined as food (Table 1 and Figure 1, all data presented are subject to rounding). With sustained growth in fish production and improved distribution channels, world fish food supply has grown dramatically in the last five decades, with an average growth rate of 3.2 percent per year in the period 1961–2009, outpacing the increase of 1.7 percent per year in the world's population. World per capita food fish supply increased from an average of 9.9 kg (live weight equivalent) in the 1960s to 18.4 kg in 2009, and preliminary estimates for 2010 point to a further increase in fish consumption to 18.6 kg[1] (Table 1 and Figure 2). Of the 126 million tonnes available for human consumption in 2009, fish consumption was lowest in Africa (9.1 million tonnes, with 9.1 kg per capita), while Asia accounted for two-thirds of total consumption, with 85.4 million tonnes (20.7 kg per capita), of which 42.8 million tonnes was consumed outside China (15.4 kg per capita). The corresponding per capita fish consumption figures

Table 1
World fisheries and aquaculture production and utilization

	2006	2007	2008	2009	2010	2011
	(Million tonnes)					
PRODUCTION						
Capture						
Inland	9.8	10.0	10.2	10.4	11.2	11.5
Marine	80.2	80.4	79.5	79.2	77.4	78.9
Total capture	**90.0**	**90.3**	**89.7**	**89.6**	**88.6**	**90.4**
Aquaculture						
Inland	31.3	33.4	36.0	38.1	41.7	44.3
Marine	16.0	16.6	16.9	17.6	18.1	19.3
Total aquaculture	**47.3**	**49.9**	**52.9**	**55.7**	**59.9**	**63.6**
TOTAL WORLD FISHERIES	**137.3**	**140.2**	**142.6**	**145.3**	**148.5**	**154.0**
UTILIZATION						
Human consumption	114.3	117.3	119.7	123.6	128.3	130.8
Non-food uses	23.0	23.0	22.9	21.8	20.2	23.2
Population (*billions*)	6.6	6.7	6.7	6.8	6.9	7.0
Per capita food fish supply (*kg*)	17.4	17.6	17.8	18.1	18.6	18.8

Notes: Excluding aquatic plants. Totals may not match due to rounding. Data for 2011 are provisional estimates.

for Oceania, North America, Europe, and Latin America and the Caribbean were 24.6 kg, 24.1 kg, 22.0 kg and 9.9 kg, respectively. Although annual per capita consumption of fishery products has grown steadily in developing regions (from 5.2 kg in 1961 to 17.0 kg in 2009) and in low-income food-deficit countries (LIFDCs, from 4.9 kg in 1961 to 10.1 kg in 2009), it is still considerably lower than in more developed regions, although the gap is narrowing. A sizeable share of fish consumed in developed countries consists of imports, and, owing to steady demand and declining domestic fishery production (down 10 percent in the period 2000–2010), their dependence on imports, in particular from developing countries, is projected to grow in coming years.

China has been responsible for most of the increase in world per capita fish consumption, owing to the substantial increase in its fish production, particularly from aquaculture, despite a downward revision of China's production statistics for recent years (Box 1). China's share in world fish production grew from 7 percent in 1961 to 35 percent in 2010. Driven by growing domestic income and an increase in the diversity of fish available, per capita fish consumption in China has also increased dramatically, reaching about

Figure 1

World capture fisheries and aquaculture production

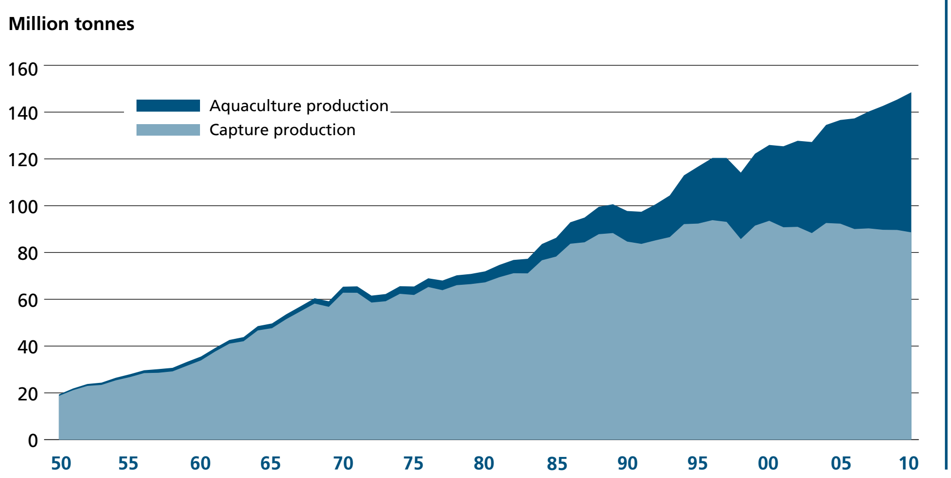
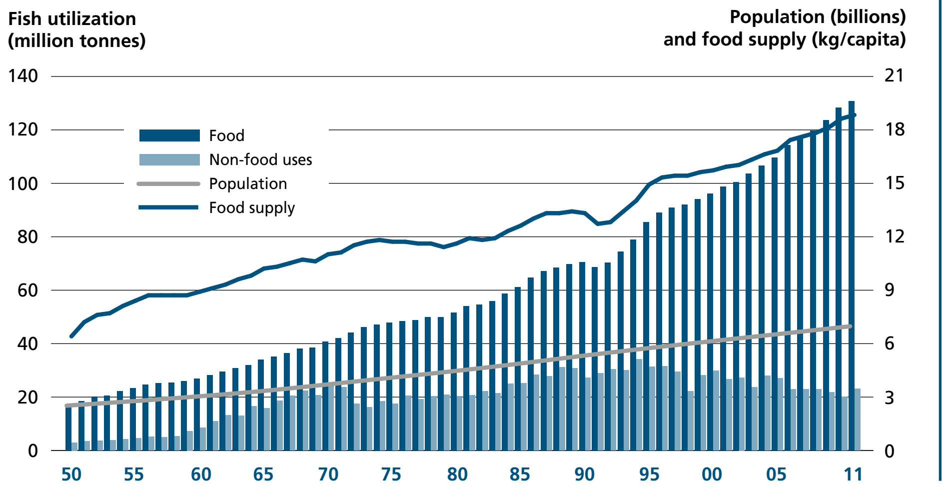


Figure 2

World fish utilization and supply

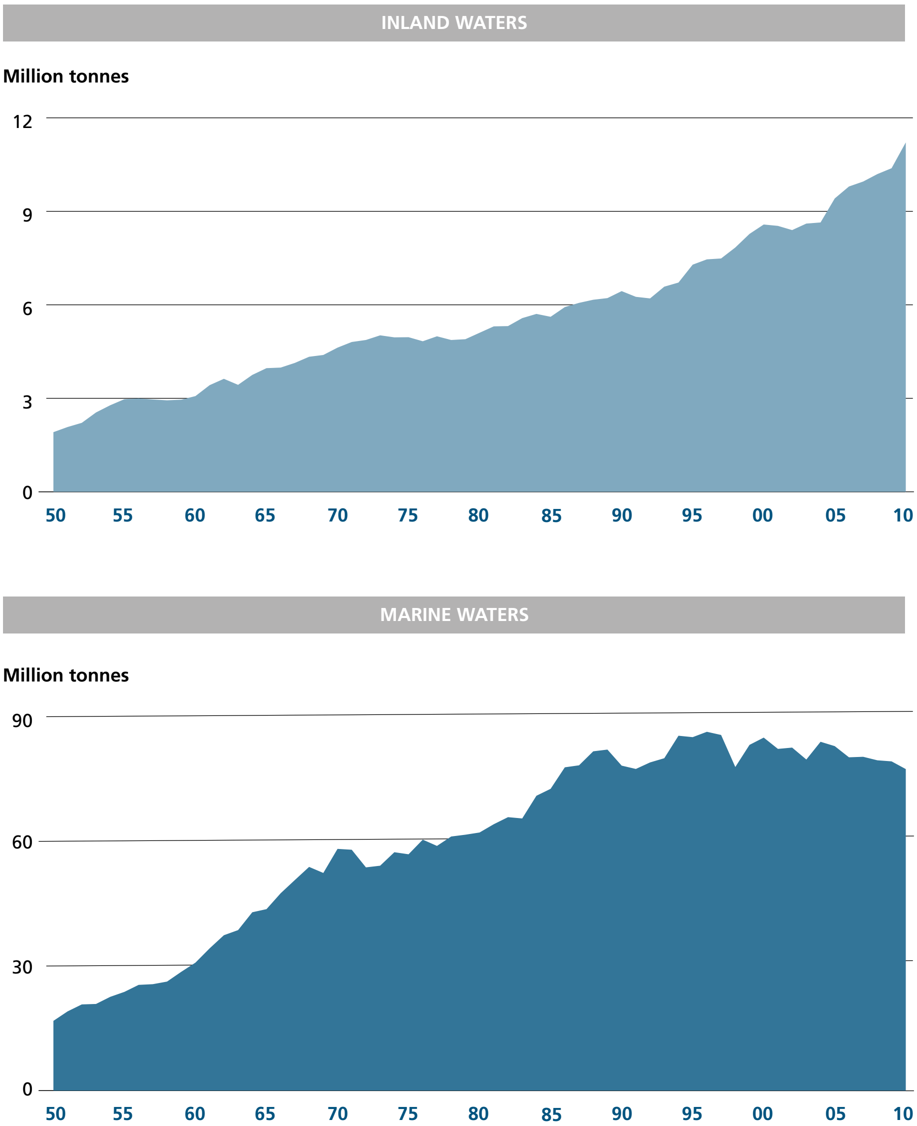


31.9 kg in 2009, with an average annual rate of 6.0 percent in the period 1990–2009. If China is excluded, annual fish supply to the rest of the world in 2009 was about 15.4 kg per person, higher than the average values of the 1960s (11.5 kg), 1970s (13.5 kg), 1980s (14.1 kg) and 1990s (13.5 kg).

Fish and fishery products represent a very valuable source of protein and essential micronutrients for balanced nutrition and good health. In 2009, fish accounted for 16.6 percent of the world population's intake of animal protein and 6.5 percent of all protein consumed. Globally, fish provides about 3.0 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein. Differences among developed and developing countries are apparent in the contribution of fish to animal protein intake. Despite the relatively lower levels of fish consumption in developing countries, the share contributed by fish was significant at about 19.2 percent, and for LIFDCs it was 24.0 percent. However, in both developing and developed countries, this share has declined slightly in recent years as consumption of other animal proteins has grown more rapidly.

Figure 3

World capture fisheries production



Box 1

Improvements in China's fishery and aquaculture statistics

As stated in previous issues of *The State of World Fisheries and Aquaculture*, China revised its production statistics for capture fisheries and aquaculture for 2006 onwards using a revised statistical methodology 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. FAO subsequently estimated revisions for its historical statistics for China for 1997–2005.

Sample surveys have been increasingly adopted in China as an efficient means of collecting data, with the possibility of tailoring them to collect more detailed information required specifically for the local situation in which they are conducted. Prior to the implementation of more systematic sample surveys, pilot surveys were undertaken to test their utility in a variety of very different situations. In addition to some undertaken independently by Chinese authorities, the following pilot sample surveys were conducted jointly by China and FAO:

- marine capture fisheries in Xiangshan County, Zhejiang Province (2002–03);
- marine capture fisheries in Putuo District, Zhoushan (China's largest fishing port), Zhejiang Province, and in Haimen City, Jiangsu Province (2004–05);
- marine capture fisheries in Laizhou City, Shandong Province (2008–09);
- inland capture fisheries at Lake Liangzi, Hubei Province (2008–09);
- inland capture fisheries at Lake Taihu, Jiangsu Province (2009–2010).

Recognizing the importance of its statistics on fisheries and aquaculture as a basis for its sectoral policy-making and management, as well as their major implications for global statistics, it is notable that China has continued to implement improvements to many aspects of its statistical systems, including the further use of sample-based surveys. Further improvements are in progress, including the disaggregation of primary-sector employment statistics between fisheries and aquaculture. Since 2009, improvement of statistics has been a priority for national fisheries and aquaculture development

Overall global capture fisheries production continues to remain stable at about 90 million tonnes (Table 1) although there have been some marked changes in catch trends by country, fishing area and species. In the last seven years (2004–2010), landings of all marine species except anchoveta only ranged between 72.1 million and 73.3 million tonnes. In contrast, the most dramatic changes, as usual, have been for anchoveta catches in the Southeast Pacific, which decreased from 10.7 million tonnes in 2004 to 4.2 million tonnes in 2010. A marked decrease in anchoveta catches by Peru in 2010 was largely a result of management measures (e.g. fishing closures) applied to protect the high number of juveniles present as a consequence of the La Niña event (cold water). This action paid dividends in 2011

and management, and additional funds have been allocated annually to strengthen the national and local capacity in collecting data and improving data quality through the following activities:

- training of enumerators and statistical officers from county to provincial levels;
- establishment of a qualification system for enumerators and a national database and communication network for enumerators and statistical officers overseen by an advisory expert panel;
- establishment of an Internet-based data reporting and validation system;
- development of field manuals for enumerators.

In addition to annual data collection and reporting, China has established monthly and mid-year data collection and reporting systems for important statistical indicators. Specialized institutes have been commissioned to use geographic information system (GIS) technologies to verify inland fishery and aquaculture areas. Parallel to the national data collection system, networks involving research institutions and fisheries authorities of key producing areas in the country have been established under the Chinese Academy of Fisheries Sciences to monitor aquaculture production of “staple species”.

The current data collection system in China covers capture production (by species, fishing area and fishing gear), fishing vessels, aquaculture production (by species, farming system and method), aquaculture areas, aquaculture seed production, fishery products processing, damage and losses in capture and aquaculture, employment and the fishery-dependent population, and fishery household-level economic indicators. China also collects and reports weekly wholesale fish prices for major marketing centres in all the provinces.

In recent years, communication between the Chinese reporting office and FAO has improved, resulting in more information becoming available on fish utilization, more detailed and accurate fishing fleet statistics, and disaggregation of primary-sector employment statistics between fisheries and aquaculture.

when anchoveta catches exceeded their 2009 level. Inland water capture production continued to grow continuously, with an overall increase of 2.6 million tonnes in the period 2004–2010 (Figure 3).

The Northwest Pacific is still by far the most productive fishing area. Catch peaks in the Northwest Atlantic, Northeast Atlantic and Northeast Pacific temperate fishing areas were reached many years ago, and total production had declined continuously from the early and mid-2000s, but in 2010 this trend was reversed in all three areas. As for mainly tropical areas, total catches grew in the Western and Eastern Indian Ocean and in the Western Central Pacific. In contrast, the 2010 production in the Western Central Atlantic decreased, with a reduction in United States catches by about

100 000 tonnes, probably mostly attributable to the oil spill in the Gulf of Mexico. Since 1978, the Eastern Central Pacific has shown a series of fluctuations in capture production with a cycle of about 5–9 years. The latest peak was in 2009, and a declining phase may have started in 2010. Both the Mediterranean–Black Sea and the Southwest Atlantic have seen declining catches, with decreases of 15 and 30 percent, respectively, since 2007. In the Southeast Pacific (excluding anchoveta) and the Southeast Atlantic, both areas where upwelling phenomena occur with strongly varied intensity each year, historical catch trends have been downward in both areas. In the Eastern Central Atlantic, production has increased in the last three years, but there are some reporting inconsistencies for this area.

Chilean jack mackerel catches have declined for this transboundary resource with a very wide distribution in the South Pacific, ranging from the national exclusive economic zones (EEZs) to the high seas. After having peaked at about 5 million tonnes in the mid-1990s, catches were about 2 million tonnes in the mid-2000s but have since declined abruptly, and the 2010 catches were 0.7 million tonnes, the lowest level since 1976. In contrast, Atlantic cod catches have increased by almost 200 000 tonnes in the last two years. In fact, in 2010, the whole group of gadiform species (cods, hakes, haddocks, etc.) reversed the negative trend of the previous three years in which it had declined by 2 million tonnes. Preliminary data for this group also report growing catches for 2011. Capture production of other important commercial species groups such as tunas and shrimps remained stable in 2010. The highly variable catches of cephalopods resumed growth after a decrease in 2009 of about 0.8 million tonnes. In the Antarctic areas, interest in fishing for krill resumed, and a catch increase of more than 70 percent was registered in 2010.

Total global capture production in inland waters has increased dramatically since the mid-2000s with reported and estimated total production at 11.2 million tonnes in 2010, an increase of 30 percent since 2004. Despite this growth, it may be that capture production in inland waters is seriously underestimated in some regions. Nevertheless, inland waters are considered as being overfished in many parts of the world, and human pressure and changes in the environmental conditions have seriously degraded important bodies of freshwater (e.g. the Aral Sea and Lake Chad). Moreover, in several countries that are important in terms of inland waters fishing (e.g. China), a good portion of inland catches comes from waterbodies that are artificially restocked. It is not clear to what extent improvements in the statistical coverage and stock enhancement activities may be contributing to the apparent increase in inland fishery production. Growth in the global inland water catch is wholly attributable to Asian countries. With the remarkable increases reported for 2010 production by India, China and Myanmar, Asia's share is approaching 70 percent of global production. Inland water capture production in the other continents shows different trends. Uganda and the United Republic of Tanzania, fishing mostly in the African Great Lakes, and Nigeria and Egypt, with river fisheries, remain the main producers in Africa. Catches in several South and North American countries have been reported as shrinking. Increased European production between 2004 and 2010 is all attributable to a rise of almost 50 percent in catches of the Russian Federation. Inland fishery production is marginal in countries in Oceania.

In the last three decades (1980–2010), world food fish production of aquaculture has expanded by almost 12 times, at an average annual rate of 8.8 percent. Global aquaculture production has continued to grow, albeit more slowly than in the 1980s and 1990s. World aquaculture production attained another all-time high in 2010, at 60 million tonnes (excluding aquatic plants and non-food products), with an estimated total value of US$119 billion. When farmed aquatic plants and non-food products are included, world aquaculture production in 2010 was 79 million tonnes, worth US$125 billion. About 600 aquatic species are raised in captivity in about 190 countries for production in farming systems of varying input intensities and technological sophistication. These include hatcheries producing seeds for stocking to the wild, particularly in inland waters.

In 2010, global production of farmed food fish was 59.9 million tonnes, up by 7.5 percent from 55.7 million tonnes in 2009 (32.4 million tonnes in 2000). Farmed food fish include finfishes, crustaceans, molluscs, amphibians (frogs), aquatic reptiles (except crocodiles) and other aquatic animals (such as sea cucumbers, sea urchins, sea squirts and jellyfishes), which are indicated as fish throughout this document. The reported grow-out production from aquaculture is almost entirely destined for human consumption. The total farmgate value of food fish production from aquaculture is estimated at US$119.4 billion for 2010.

Aquaculture production is vulnerable to adverse impacts of disease and environmental conditions. Disease outbreaks in recent years have affected farmed Atlantic salmon in Chile, oysters in Europe, and marine shrimp farming in several countries in Asia, South America and Africa, resulting in partial or sometimes total loss of production. In 2010, aquaculture in China suffered production losses of 1.7 million tonnes caused by natural disasters, diseases and pollution. Disease outbreaks virtually wiped out marine shrimp farming production in Mozambique in 2011.

The global distribution of aquaculture production across the regions and countries of different economic development levels remains imbalanced. In 2010, the top ten producing countries accounted for 87.6 percent by quantity and 81.9 percent by value of the world's farmed food fish. Asia accounted for 89 percent of world aquaculture production by volume in 2010, and this was dominated by the contribution of China, which accounted for more than 60 percent of global aquaculture production volume in 2010. Other major producers in Asia are India, Viet Nam, Indonesia, Bangladesh, Thailand, Myanmar, the Philippines and Japan. In Asia, the share of freshwater aquaculture has been gradually increasing, up to 65.6 percent in 2010 from around 60 percent in the 1990s. In terms of volume, Asian aquaculture is dominated by finfishes (64.6 percent), followed by molluscs (24.2 percent), crustaceans (9.7 percent) and miscellaneous species (1.5 percent). The share of non-fed species farmed in Asia was 35 percent (18.6 million tonnes) in 2010 compared with 50 percent in 1980.

In North America, aquaculture has ceased expanding in recent years, but in South America it has shown strong and continuous growth, particularly in Brazil and Peru. In terms of volume, aquaculture in North and South America is dominated by finfishes (57.9 percent), crustaceans (21.7 percent) and molluscs (20.4 percent). In Europe, the share of production from brackish and marine waters increased from 55.6 percent in 1990 to 81.5 percent in 2010, driven by marine cage culture of Atlantic salmon and other species. Several important producers in Europe have recently ceased expanding or have even contracted, particularly in the marine bivalve sector. In 2010, finfishes accounted for three-quarters of all European aquaculture production, and molluscs one-quarter. Africa has increased its contribution to global production from 1.2 percent to 2.2 percent in the past ten years, mainly as a result of rapid development in freshwater fish farming in sub-Saharan Africa. African aquaculture production is overwhelmingly dominated by finfishes, with only a small fraction from marine shrimps and marine molluscs. Oceania accounts for a minor share of global aquaculture production and this consists mainly of marine molluscs and finfishes, with the latter increasing owing mainly to the development of farming of Atlantic salmon in Australia and chinook salmon in New Zealand.

The least-developed countries (LDCs), mostly in sub-Saharan Africa and in Asia, remain minor in terms of their share of world aquaculture production (4.1 percent by quantity and 3.6 percent by value) with the main producers including Bangladesh, Myanmar, Uganda, the Lao People's Democratic Republic and Cambodia. However, some developing countries in Asia and the Pacific (Myanmar and Papua New Guinea), sub-Saharan Africa (Nigeria, Uganda, Kenya, Zambia and Ghana) and South America (Ecuador, Peru and Brazil) have made rapid progress to become significant or major aquaculture producers in their regions. In contrast, in 2010, developed industrialized countries produced collectively 6.9 percent (4.1 million tonnes) by quantity and 14 percent (US$16.6 billion) by value of the world's farmed food fish production, compared with 21.9 percent and 32.4 percent, respectively, in 1990. Aquaculture production has contracted or stagnated in Japan, the United States of America and several European countries. An exception is Norway, where, thanks to the farming of Atlantic salmon in marine cages, aquaculture production grew from 151 000 tonnes in 1990 to more than one million tonnes in 2010.

Freshwater fishes dominate global aquaculture production (56.4 percent, 33.7 million tonnes), followed by molluscs (23.6 percent, 14.2 million tonnes), crustaceans (9.6 percent, 5.7 million tonnes), diadromous fishes (6.0 percent, 3.6 million tonnes), marine fishes (3.1 percent, 1.8 million tonnes) and other aquatic animals (1.4 percent, 814 300 tonnes). While feed is generally perceived to be a major constraint to aquaculture development, one-third of all farmed food fish production (20 million tonnes) is currently achieved without artificial feeding, as is the case for bivalves and filter-feeding carps. However, the percentage of non-fed species in world production has declined gradually from more than 50 percent in 1980 to the present level of 33.3 percent, reflecting the relatively faster body-growth rates achieved in the culture of fed species and increasing consumer demand for higher trophic-level species of fishes and crustaceans.

Fisheries and aquaculture provided livelihoods and income for an estimated 54.8 million people engaged in the primary sector of fish production in 2010, of whom an estimated 7 million were occasional fishers and fish farmers. Asia accounts for more than 87 percent of the world total with China alone having almost 14 million people (26 percent of the world total) engaged as fishers and fish farmers. Asia is followed by Africa (more than 7 percent), and Latin America and the Caribbean (3.6 percent). About 16.6 million people (about 30 percent of the world total) were engaged in fish farming, and they were even more concentrated in Asia (97 percent), followed by Latin America and the Caribbean (1.5 percent), and Africa (about 1 percent). Employment in the fisheries and aquaculture primary sector has continued to grow faster than employment in agriculture, so that by 2010 it represented 4.2 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide, compared with 2.7 percent in 1990. In the last five years, the number of people engaged in fish farming has increased by 5.5 percent per year compared with only 0.8 percent per year for those in capture fisheries, although capture fisheries still accounted for 70 percent of the combined total in 2010. It is apparent that, in the most important fishing nations, the share of employment in capture fisheries is stagnating or decreasing while aquaculture is providing increased opportunities. Europe experienced the largest decrease in the number of people engaged in capture fishing, with a 2 percent average annual decline between 2000 and 2010, and almost no increase in people employed in fish farming. In contrast, Africa showed the highest annual increase (5.9 percent) in the number of people engaged in fish farming in the same period, followed by Asia (4.8 percent), and Latin America and the Caribbean (2.6 percent). Overall, production per person is lower in capture fisheries than in aquaculture, with global outputs of 2.3 and 3.6 tonnes per person per year respectively, reflecting the huge numbers of fishers engaged in small-scale fisheries.

Apart from the primary production sector, fisheries and aquaculture provide numerous jobs in ancillary activities such as processing, packaging, marketing and distribution, manufacturing of fish-processing equipment, net and gear making, ice production and supply, boat construction and maintenance, research and administration. All of this employment, together with dependants, is estimated to support the livelihoods of 660–820 million people, or about 10–12 percent of the world's population.

The total number of fishing vessels in the world in 2010 is estimated at about 4.36 million, which is similar to previous estimates. Of these, 3.23 million vessels (74 percent) are considered to operate in marine waters, with the remaining 1.13 million vessels operating in inland waters. Overall, Asia has the largest fleet, comprising 3.18 million vessels and accounting for 73 percent of the world total, followed by Africa (11 percent), Latin America and the Caribbean (8 percent), North America (3 percent) and Europe (3 percent). Globally, 60 percent of fishing vessels were engine-powered in 2010, but although 69 percent of vessels operating in marine waters were motorized, the figure was only 36 percent for inland waters. For the fleet operating in marine waters, there were also large variations among regions, with non-motorized vessels accounting for less than 7 percent of the total in Europe and the Near East, but up to 61 percent in Africa.

Over 85 percent of the motorized fishing vessels in the world are less than 12 m in length overall (LOA). Such vessels dominate in all regions, but markedly so in the Near East, and Latin America and the Caribbean. About 2 percent of all motorized fishing vessels corresponded to industrialized fishing vessels of 24 m and larger (with a gross tonnage [GT] of roughly more than 100 GT) and that fraction was larger in the Pacific and Oceania region, Europe, and North America.

Data from some countries indicate a recent expansion in their fleets. For example, the motorized fishing fleets in Malaysia, Cambodia and Indonesia increased by 26, 19 and 11 percent, respectively, between 2007 and 2009, and Viet Nam reported a 10 percent increase in offshore fishing vessels (those with engines of more than 90 hp) between 2008 and 2010. The case of Sri Lanka illustrates potential overshoot in efforts to re-establish a fishing fleet, of which 44 percent of the motorized vessels were destroyed by the tsunami that swept the region at the end of 2004, with the result that by 2010 there were 11 percent more motorized vessels than before the tsunami.

Many countries have policies to reduce overcapacity in their fishing fleets. China’s marine fishing vessel reduction plan for 2003–2010 did achieve a reduction by 2008 close to the target, but since then both the number of vessels and total combined power have started to increase again. Japan implemented various schemes that resulted in a net reduction of 9 percent in the number of vessels, but a net increase of 5 percent in combined power between 2005 and 2009. The evolution in the combined number, tonnage, and power of European Union fishing vessels indicates a downward tendency in the last decade and the combined EU-15 motorized fishing fleet achieved a net reduction of 8 percent in the number of vessels and of 11 percent in power between 2005 and 2010. Other important fishing nations that achieved a net reduction in fleet size in the period 2005–2010 include Iceland, Norway and the Republic of Korea.

The world’s marine fisheries increased markedly from 16.8 million tonnes in 1950 to a peak of 86.4 million tonnes in 1996, and then declined before stabilizing at about 80 million tonnes. Global recorded production was 77.4 million tonnes in 2010. The Northwest Pacific had the highest production with 20.9 million tonnes (27 percent of the global marine catch) in 2010, followed by the Western Central Pacific with 11.7 million tonnes (15 percent), the Northeast Atlantic with 8.7 million tonnes (11 percent), and the Southeast Pacific, with a total catch of 7.8 million tonnes (10 percent). The proportion of non-fully exploited stocks has decreased gradually since 1974 when the first FAO assessment was completed. In contrast, the percentage of overexploited stocks has increased, especially in the late 1970s and 1980s, from 10 percent in 1974 to 26 percent in 1989. After 1990, the number of overexploited stocks continued to increase, albeit at a slower rate. Increases in production from these overexploited stocks may be possible if effective rebuilding plans are put in place. The fraction of fully exploited stocks, which produce catches that are very close to their maximum sustainable production and have no room for further expansion and require effective management to avoid decline, has shown the smallest change over time, with its percentage stable at about 50 percent from 1974 to 1985, then falling to 43 percent in 1989 before gradually increasing to 57 percent in 2009. About 29.9 percent of stocks are overexploited, producing lower yields than their biological and ecological potential and in need of strict management plans to restore their full and sustainable productivity in accordance with the Johannesburg Plan of Implementation that resulted from the World Summit on Sustainable Development (Johannesburg, 2002), which demands that all overexploited stocks be restored to the level that can produce maximum sustainable yield by 2015, a target that seems unlikely to be met. The remaining 12.7 percent of stocks were non-fully exploited in 2009, and these are under relatively low fishing pressure and have some potential to increase their production although they often do not have a high production potential and require proper management plans to ensure that any increase in the exploitation rate does not result in further overfishing.

Most of the stocks of the top ten species, which account in total for about 30 percent of world marine capture fisheries production, are fully exploited and, therefore, have no potential for increases in production, while some stocks are overexploited and increases in their production may be possible if effective rebuilding plans are put in place. The two main stocks of anchoveta in the Southeast Pacific, Alaska pollock in the North Pacific and blue whiting in the Atlantic are fully exploited. Atlantic herring stocks are fully exploited in both the Northeast and Northwest Atlantic. Japanese anchovy in the Northwest Pacific and Chilean jack mackerel in the Southeast Pacific are considered to be overexploited. Chub mackerel stocks are fully exploited in the Eastern Pacific and the Northwest Pacific. The largehead hairtail was estimated in 2009 to be overexploited in the main fishing area in the Northwest Pacific.

Among the seven principal tuna species, one-third were estimated to be overexploited, 37.5 percent were fully exploited, and 29 percent non-fully exploited in 2009. Although skipjack tuna continued its increasing trend up to 2009, further expansion should be closely monitored, as it may negatively affect bigeye and yellowfin tunas (multispecies fisheries). In the long term, the status of tuna stocks (and consequently catches) may further deteriorate unless there are significant improvements in their management. This is because of the substantial demand for tuna and the significant overcapacity of tuna fishing fleets. Concern about the poor status of some bluefin stocks and the inability of some tuna management organizations to manage these stocks effectively led to a proposal in 2010 to ban the international trade in Atlantic bluefin tuna under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and, although the proposal was ultimately rejected, the concern remains.

The overall situation when summarized by FAO statistical areas shows three main patterns in catch trends. Areas that have demonstrated oscillations in total catch are the Eastern Central Atlantic (Area 34), Northeast Pacific (Area 67), Eastern Central Pacific (Area 77), Southwest Atlantic (Area 41), Southeast Pacific (Area 87), and Northwest Pacific (Area 61). These areas have provided about 52 percent of the world's total marine catch on average in the last five years. Several of these areas include upwelling regions that are characterized by high natural variability. The second group consists of areas that have demonstrated a decreasing trend in catch since reaching a peak at some time in the past. This group has contributed 20 percent of global marine catch on average in the last five years, and includes the Northeast Atlantic (Area 27), Northwest Atlantic (Area 21), Western Central Atlantic (Area 31), Mediterranean and Black Sea (Area 37), Southwest Pacific (Area 81), and Southeast Atlantic (Area 47). It should be noted that lower catches in some cases reflect fisheries management measures that are precautionary or aim at rebuilding stocks, and this situation should, therefore, not necessarily be interpreted as negative. The third group comprises the FAO areas that have shown continuously increasing trends in catch since 1950 and includes the Western Central Pacific (Area 71), Eastern (Area 57) and Western (Area 51) Indian Ocean. They have together contributed 28 percent of the total marine catch on average over the last five years. However, in some regions, there is still high uncertainty about the actual catches owing to the poor quality of statistical reporting systems in coastal countries.

The declining global marine catch over the last few years together with the increased percentage of overexploited fish stocks and the decreased proportion of non-fully exploited species around the world convey the strong message that the state of world marine fisheries is worsening and has had a negative impact on fishery production. Overexploitation not only causes negative ecological consequences, but it also reduces fish production, which further leads to negative social and economic consequences. To increase the contribution of marine fisheries to the food security, economies and well-being of the coastal communities, effective management plans must be put in place to rebuild overexploited 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 that entered into force in 2001 should be used as a legal basis for management measures of the high seas fisheries.

In spite of the worrisome global situation of marine capture fisheries, good progress is being made in reducing exploitation rates and restoring overexploited fish stocks and marine ecosystems through effective management actions in some areas. In the United States of America, 67 percent of all stocks are now being sustainably harvested, while only 17 percent are still overexploited. In New Zealand, 69 percent of stocks are above management targets, reflecting mandatory rebuilding plans for all fisheries that are still below target thresholds. Similarly, Australia reports overfishing for only 12 percent of stocks in 2009. Since the 1990s, the Newfoundland–Labrador Shelf, the Northeast United States Shelf, the Southern Australian Shelf, and 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. These and other successes can serve as examples to assist in more effective management of other fisheries.

The information summarizing the state of the major marine fish stocks is impossible to duplicate for the state of most of the world's inland fisheries, for which the exploitation rate is often not the main driver affecting the state of the stocks. Other drivers such as habitat quantity and quality, aquaculture in the form of stocking and competition for freshwater, influence the state of the majority of inland fishery resources much more than exploitation rates do. Water abstraction and diversion, hydroelectric development, draining wetlands, and siltation and erosion from land-use patterns can negatively affect inland fishery resources regardless of the rate of exploitation. Conversely, stock enhancement from aquaculture facilities, which is widely practised in inland waters, can keep catch rates high in the face of increased fishing and in spite of an ecosystem that is not capable of producing that level of catch through natural processes. Overexploitation also affects inland fishery resources, but the result is generally a change in species composition and not necessarily a reduced overall catch. Catches are often higher where smaller and shorter-lived species become the main component of the catch; however, the smaller fish may be much less valuable. Another issue complicating the assessment of inland fishery resources is the definition of a "stock". Very few inland fisheries have stocks that are defined precisely or are defined at the level of species. There are notable exceptions such as the Lake Victoria Nile perch and Tonle Sap dai fisheries, but many inland fishery resources are defined by watershed or river and comprise numerous species. Taking all of these considerations into account, FAO is leading efforts to improve data collection and develop new assessment methodologies for inland fishery resources that are so important but often underestimated in terms of their economic, social and nutritional benefits and contribution to livelihoods and food security. The intention is to utilize the new methodology to provide a more robust and informative summary of the state of the world's inland capture fishery resources in the future.

Concerning utilization of the world's fish production, 40.5 percent (60.2 million tonnes) was marketed in live, fresh or chilled forms, 45.9 percent (68.1 million tonnes) was processed in frozen, cured or otherwise prepared forms for direct human consumption, and 13.6 percent destined for non-food uses in 2010. Since the early 1990s, there has been an increasing trend in the proportion of fisheries production used for direct human consumption rather than for other purposes. Whereas in the 1980s about 68 percent of the fish produced was destined for human consumption, this share increased to more than 86 percent in 2010, equalling 128.3 million tonnes. In 2010, 20.2 million tonnes was destined to non-food purposes, of which 75 percent (15 million tonnes) was reduced to fishmeal and fish oil; the remaining 5.1 million tonnes was largely utilized as fish for ornamental purposes, for culture (fingerlings, fry, etc.), for bait, for pharmaceutical uses as well as for direct feeding in aquaculture, for livestock and for fur animals. Of the fish destined for direct human consumption, the most important product form was live, fresh or chilled fish, with a share of 46.9 percent in 2010, followed by frozen fish (29.3 percent), prepared or preserved fish (14.0 percent) and cured fish (9.8 percent). Freezing represents the main method of processing fish for human consumption, and it accounted for 55.2 percent of total processed fish for human consumption and 25.3 percent of total fish production in 2010.

The proportion of frozen fish grew from 33.2 percent of total production for human consumption in 1970 to reach a record high of 52.1 percent in 2010. The share of prepared and preserved forms remained rather stable during the same period, and it was 26.9 percent in 2010. Developing countries have experienced a growth in the share of frozen products (24.1 percent of the total fish for human consumption in 2010, up from 18.9 percent in 2000) and of prepared or preserved forms (11.0 percent in 2010, compared with 7.8 percent in 2000). Owing to deficiencies in infrastructure and processing facilities, together with well-established consumer habits, fish in developing countries is commercialized mainly in live or fresh form (representing 56.0 percent of fish destined for human consumption in 2010) soon after landing or harvesting. Cured forms (dried, smoked or fermented) still remain a traditional method to retail and consume fish in developing countries, although their share in total fish for human consumption is declining (10.9 percent in 2000 compared with 8.9 percent in 2010). In developed countries, the bulk of production destined for human consumption is commercialized frozen or in prepared or preserved forms.

Fishmeal is produced from whole fish or fish remains resulting from processing. Small pelagic species, in particular anchoveta, are the main contributors for reduction, and the volume of fishmeal and fish oil produced worldwide fluctuates annually according to the fluctuations in the catches of these species, which are strongly influenced by the El Niño phenomenon. Fishmeal production peaked in 1994 at 30.2 million tonnes (live weight equivalent) and has followed a fluctuating trend since then. In 2010, it dropped to 15.0 million tonnes owing to reduced catches of anchoveta, representing a decrease of 12.9 percent compared with 2009, of 18.2 percent compared with 2008, and of 42.8 percent with respect to 2000. Waste from commercial fish species used for human consumption is increasingly used in feed markets, and a growing percentage of fishmeal is being obtained from trimmings and other residues from the preparation of fish fillets. About 36 percent of world fishmeal production was obtained from offal in 2010.

Technological development in food processing and packaging is progressing rapidly. Processors of traditional products have been losing market share as a result of long-term shifts in consumer preferences as well as in processing and in the general fisheries industry. 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 large retailers controlling the growth of international distribution channels. The increasing practice of outsourcing processing at the regional and world levels is very significant, but further outsourcing of production to developing countries might be restricted by sanitary and hygiene requirements that are difficult to meet as well as by growing labour costs. 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. Processors that operate without the purchasing or sourcing power of strong brands are also experiencing increasing problems linked to the scarcity of domestic raw material, and they are being forced to import fish for their business.

Fish and fishery products continue to be among the most traded food commodities worldwide, accounting for about 10 percent of total agricultural exports and 1 percent of world merchandise trade in value terms. The share of total fishery production exported in the form of various food and feed items increased from 25 percent in 1976 to about 38 percent (57 million tonnes) in 2010. In the same period, world trade in fish and fishery products grew significantly also in value terms, rising from US$8 billion to US$102 billion. Sustained demand, trade liberalization policies, globalization of food systems and technological innovations have furthered the overall increase in international fish trade. In 2009, reflecting the general economic contraction affecting consumer confidence in major markets, trade dropped by 6 percent compared with 2008 in value terms as a consequence of falling prices and margins, whereas traded volumes, expressed in live weight equivalent, increased by 1 percent to 55.7 million tonnes. In 2010, trade rebounded strongly, reaching about US$109 billion, with an increase of 13 percent in value terms and 2 percent in volume compared with 2009. The difference between the growth in value and volume reflects the higher fish prices experienced in 2010 as well as a decrease in the production of and trade in fishmeal. In 2011, despite the economic instability experienced in many of the world's leading economies, increasing prices and strong demand in developing countries pushed trade volumes and values to the highest level ever reported and, despite some softening in the second half of the year, preliminary estimates indicate that exports exceeded US$125 billion.

Since late 2011 and early 2012, the world economy has entered a difficult phase characterized by significant downside risks and fragility, and key markets for fisheries trade have slowed sharply. Among the factors that might influence the sustainability and growth of fishery trade are the evolution of production and transportation costs and the prices of fishery products and alternative commodities, including meat and feeds. In the last few decades, the growth in aquaculture production has contributed significantly to increased consumption and commercialization of species that were once primarily wild-caught, with a consequent price decrease, particularly in the 1990s and early 2000, with average unit values of aquaculture production and trade declining in real terms. Subsequently, owing to increased costs and continuous high demand, prices have started to rise again. In the next decade, with aquaculture accounting for a much larger share of total fish supply, the price swings of aquaculture products could have a significant impact on price formation in the sector overall, possibly leading to more volatility.

As for trade, fish prices also contracted in 2009 but have since rebounded. The FAO Fish Price Index (base year 2002–04 = 100) indicates that average prices in 2009 declined by 7 percent compared with 2008, then increased by 9 percent in 2010 and by more than 12 percent in 2011. Prices for species from capture fisheries increased by more than those for farmed species because of the larger impact from higher energy prices on fishing vessel operations than on farmed species.

Since 2002, China has been by far the leading fish exporter, contributing almost 12 percent of 2010 world exports of fish and fishery products, or about US$13.3 billion, and increasing further to US$17.1 billion in 2011. A growing share of fishery exports consists of reprocessed imported raw material. Thailand has established itself as a processing centre of excellence largely dependent on imported raw material, while Viet Nam has a growing domestic resource base and imports only limited, albeit growing, volumes of raw material. Viet Nam has experienced significant growth in its exports of fish and fish products, up from US$1.5 billion in 2000 to US$5.1 billion in 2010, when it became the fourth-largest exporter in the world. In 2011, its exports rose further to US$6.2 billion, linked mainly to its flourishing aquaculture industry. In 2010, developing countries confirmed their fundamental importance as suppliers to world markets with more than 50 percent of all fishery exports in value terms and more than 60 percent in quantity (live weight). For many developing nations, fish trade represents a significant source of foreign currency earnings in addition to the sector's important role as a generator of income, source of employment, and provider of food security and nutrition. 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 or for their processing industries. In 2010, in value terms, 67 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 raw fish to be used for further processing and re-export. In 2010, in value terms, 39 percent of the imports of fish and fishery products by developing countries originated from developed countries. For LIFDCs, net export revenues amounted to US$4.7 billion in 2010, compared with US$2.0 billion in 1990.

World imports[2] of fish and fish products set a new record at US$111.8 billion in 2010, up 12 percent on the previous year and up 86 percent with respect to 2000. Preliminary data for 2011 point to further growth, with a 15 percent increase. The United States of America and Japan are the major importers of fish and fishery products and are highly dependent on imports for about 60 percent and 54 percent, respectively, of their fishery consumption. China, the world's largest fish producer and exporter, has significantly increased its fishery imports, partly a result of outsourcing, as Chinese processors import raw material from all major regions, including South and North America and Europe, for re-processing and export. Imports are also being fuelled by robust domestic demand for species not available from local sources, and, in 2011, China became the third-largest importer in the world. The European Union is by far the largest single market for imported fish and fishery products owing to its growing domestic consumption. However, it is extremely heterogeneous, with markedly different conditions from country to country. European Union fishery imports reached US$44.6 billion in 2010, up 10 percent from 2009, and representing 40 percent of total world imports. However, if intraregional trade is excluded, the European Union imported fish and fishery products worth US$23.7 billion from suppliers outside the European Union, an increase of 11 percent from 2009. In addition to the major importing countries, a number of emerging markets have become of growing importance to the world's exporters. Prominent among these there are Brazil, Mexico, the Russian Federation, Egypt, Asia and the Near East in general. In 2010, developed countries were responsible for 76 percent of the total import value of fish and fishery products, a decline compared with the 86 percent of 1990 and 83 percent of 2000. In terms of volume (live weight equivalent), the share of developed countries is significantly less, 58 percent, reflecting the higher unit value of products imported by developed countries.

Owing to the high perishability of fish and fishery products, 90 percent of trade in fish and fishery products in quantity terms (live weight equivalent) consists of processed products. Fish are increasingly traded as frozen food (39 percent of the total quantity in 2010, compared with 25 percent in 1980). In the last four decades, prepared and preserved fish have nearly doubled their share in total quantity, going from 9 percent in 1980 to 16 percent in 2010. However, trade in live, fresh and chilled fish represented 10 percent of world fish trade in 2010, up from 7 percent in 1980, 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 2010, 71 percent of the quantity of fish and fishery products exported consisted of products destined for human consumption. The US$109 billion exports of fish and fishery products in 2010 do not include an additional US$1.3 billion for aquatic plants (62 percent), inedible fish waste (31 percent) and sponges and corals (7 percent). In the last two decades, trade in aquatic plants has increased significantly, rising from US$0.2 billion in 1990 to US$0.5 billion in 2000 and to US$0.8 billion in 2010, with China as the major exporter and Japan as the leading importer.

A recent major event related to governance of fisheries and aquaculture has been the UN Conference on Sustainable Development, known as Rio+20, to renew political commitment for sustainable development, assess progress and gaps in the implementation of existing commitments, and address new challenges. The two themes of the conference were the institutional framework for sustainable development and the support of a green economy. As a concept, the green economy aims to ensure that resource exploitation contributes to sustainability, inclusive social development and economic growth, while seeking to counter the notion that sustainability and growth are mutually exclusive.

At Rio+20, FAO promoted the message that there will be no green economy without sustainable growth in agriculture (including fisheries) and that improved management and efficiencies throughout the food value chain can increase food security while using fewer natural resources. The message calls for policies that create incentives to adopt sustainable practices and behaviour and promotes the wide application of ecosystem approaches. FAO also contributed to interagency submissions to Rio+20 concerning the sustainable management of the world's oceans with a focus on the green economy as it relates to marine and coastal resources, sustainable use and poverty eradication, small-scale fisheries and aquaculture operations, and the potential contribution of small island developing States.

The dependence of the fisheries and aquaculture sectors on ecosystem services means that supporting sustainable fishing and fish farming can provide incentives for wider ecosystem stewardship. The greening of fisheries and aquaculture requires recognition of their wider societal roles within a comprehensive governance framework. There are several mechanisms to facilitate this transition, including adopting an ecosystem approach to fisheries and aquaculture with fair and responsible tenure systems to turn resource users into resource stewards.

Small-scale fisheries employ more than 90 percent of the world's capture fishers, and their importance to food security, poverty alleviation and poverty prevention is becoming increasingly appreciated. However, the lack of institutional capacity and the failure to include the sector in national and regional development policies hamper their potential contribution. Since 2003, the FAO Committee on Fisheries (COFI) has promoted efforts to improve the profile of, and understand the challenges and opportunities facing, small-scale fishing communities in inland and marine waters. It has also recommended the development of international voluntary guidelines to complement the Code of Conduct for Responsible Fisheries (the Code) as well as other international instruments with similar purposes. The preparation of the guidelines is expected to contribute to policy development and have considerable impact on securing small-scale fisheries and creating benefits, especially in terms of food security and poverty reduction. The guidelines promote good governance, including transparency and accountability, participation and inclusiveness, social responsibility and solidarity, a human rights approach to development, gender equality, and respect and involvement of all stakeholders.

Regional fishery bodies (RFBs) are the primary organizational mechanism through which States work together to ensure the long-term sustainability of shared fishery resources. The term RFB also embraces regional fisheries management organizations (RFMOs), which have the competence to establish binding conservation and management measures. As intergovernmental organizations, RFBs depend on the political will of their member Governments to implement agreed measures and undertake reform. Most RFBs are experiencing difficulties in fulfilling their mandates (many of which are outdated). However, important progress in extending the global coverage of RFBs is being made through new, strengthened and emerging bodies. In addition, numerous RFBs have been undergoing independent reviews of their performance. The 2010 United Nations Review Conference described the modernizing of RFMOs as a priority and noted that progress had been made in developing best practices for RFMOs and in reviewing their performance against emerging standards. Ten RFBs have so far undergone performance reviews. The Review Conference observed that performance reviews were generally recognized as being useful, particularly when they led to the adoption of new management measures.

Illegal, unreported and unregulated (IUU) fishing and related activities (often encouraged by corrupt practices) threaten efforts to secure long-term sustainable fisheries and promote healthier and more robust ecosystems. The international community continues to express its grave concern at the extent and effects of IUU fishing. Developing countries, often with limited technical capacity, bear the brunt of this IUU fishing, which undermines their limited efforts to manage fisheries, denies them revenue and adversely affects their attempts to promote food security, eradicate poverty and achieve sustainable livelihoods. However, there are indications that IUU fishing is moderating in some areas (e.g. the Northeast Atlantic Ocean) as policies and measures take effect.

Nonetheless, the international community is deeply frustrated by the failure of many flag States to meet their primary responsibilities under international law, which are to exercise effective control over their fishing vessels and ensure compliance with conservation and management measures. Of particular concern are those vessels flying flags of "non-compliance", which are flags belonging to States that are either unable or unwilling to exercise effective control over their vessels. As a result, the burden of controlling these rogue vessels is gradually falling on coastal States, port States, RFBs and others. This has led FAO Members to request that a Technical Consultation on Flag State Performance be convened. It is anticipated that the outcome will be a set of voluntary criteria for assessing the performance of flag States together with a list of possible actions to be taken against vessels flying the flags of States not meeting such criteria and possibly an agreed procedure for assessing compliance.

Although their achievements in terms of limiting IUU fishing vary widely, most RFBs promote and implement measures to combat IUU fishing. The measures range from more passive activities such as awareness building and dissemination of information (mainly RFBs without fisheries management functions) to aggressive port, air and surface surveillance programmes (RFMOs).

Beyond national boundaries, there is increasing need for international cooperation to improve global fisheries management of shared marine resources and to preserve the associated employment and other economic benefits of sustainable fisheries. Recognizing this, the European Union and the United States of America, as leaders in the global fish trade, undertook (in 2011) to cooperate bilaterally to combat IUU fishing by keeping illegally caught fish out of the world market. Strengthening fisheries management capacity is fundamental in developing countries in order to facilitate sustainable fisheries and to reduce the impacts of IUU fishing. Capacity development is especially important to support the full and effective implementation of existing and new global instruments such as the 2009 Port State Measures Agreement to combat IUU fishing.

Governance of aquaculture has become increasingly important and has made remarkable progress. To improve planning and policy development in aquaculture, many Governments utilize the Code as well as FAO guidelines and manuals on farming techniques promoted by industry organizations and development agencies. Several countries have adequate national aquaculture development policies, strategies, plans and laws, and use "best management practices". The insert: 2011 FAO Technical Guidelines on Aquaculture Certification constitute an additional important tool for good governance of the sector. By setting minimum substantive criteria for developing aquaculture certification standards, these guidelines provide direction for the development, organization and implementation of credible aquaculture certification schemes towards orderly and sustainable development of the sector. Long-term prosperity requires technological soundness, economic viability, environmental integrity and social licence, which, in combination, also ensure that ecological well-being is compatible with human well-being.

An important component of human well-being is employment, which in aquaculture has grown rapidly in the last three decades. More than 100 million people now depend on the sector for a living, either as employees in the producing and support sectors or as their dependants. In many places, these employment opportunities have enabled young people to stay in their communities and have strengthened the economic viability of isolated areas, often enhancing the status of women in developing countries, where more than 80 percent of aquaculture output occurs. Aquaculture has been heavily promoted in several countries with fiscal and monetary incentives and this has improved accessibility to food for many households and increased aquaculture's contribution towards the Millennium Development Goals (MDGs). However, the sector has developed at a time of growing scrutiny from

the public, improved communications and vociferous opposition groups. Although opposition groups can act as environmental and social watchdogs, putting pressure on businesses to increase transparency and improve working conditions, it is also important to consider the benefits accruing from the sector, including those related to employment.

Unfair employment practices in aquaculture, including exploitation of local labour, gender discrimination and child employment, can undermine trust in the sector, threaten the credibility of policy-makers and jeopardize markets for farmed seafood. Most countries have legislation to protect workers but compliance therewith can deter enterprises, with some opting to operate in countries with lower labour and social standards where they can gain a competitive advantage. A possible result is that Governments will be under pressure from companies to reduce labour and social standards.

Employment in aquaculture must be equitable and non-exploitative, with principled values guiding activities to induce beyond-compliance behaviour. With an ethos of corporate social responsibility, aquaculture companies would assist local communities, employ fair labour practices and demonstrate transparency. Increasingly, with rising consumer awareness, it makes good business sense for aquaculture enterprises to demonstrate that they meet the best standards. Legislation should protect labour and reflect concepts of social justice and human rights, but it needs to strike a balance as overly cumbersome regulations can make an otherwise viable business unprofitable.

CAPTURE FISHERIES PRODUCTION

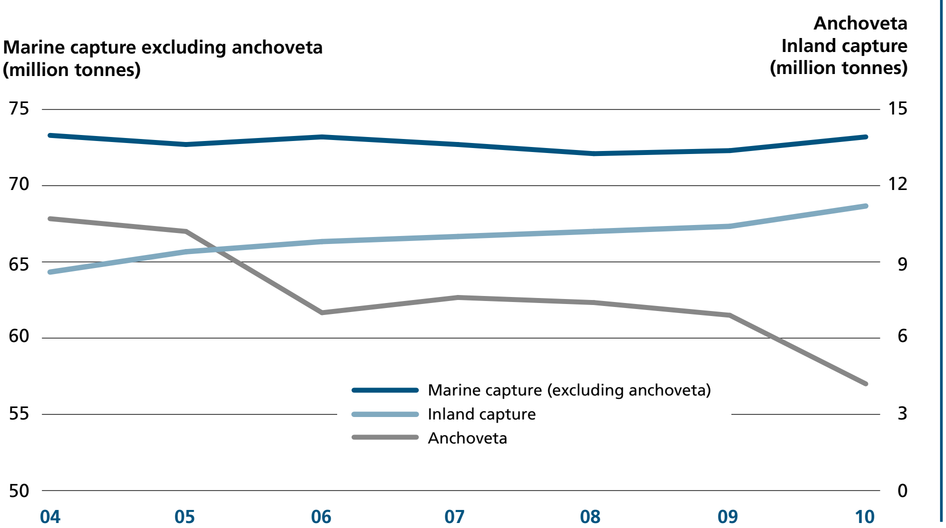
Total capture fisheries production

Overall global capture fisheries production, as derived from the FAO capture database, continues to remain stable (Table 1). This does not mean that there are no changes in catch trends by country, fishing area or species, which indeed do vary significantly throughout the years, but rather that the summation of all the annual fluctuations has been close to zero in recent years.

To analyse trends, global production can be separated into three major components: marine catches excluding anchoveta (*Engraulis ringens*); anchoveta catches; and inland water catches (Figure 4). In the last seven years (2004–2010) for

Figure 4

Recent capture fisheries production by three major components



which detailed catch statistics are available, absolute variations in comparison with the previous year of total marine catches excluding anchoveta never exceeded 1.2 percent, ranging between 72.1 and 73.3 million tonnes. However, anchoveta catches decreased from 10.7 million tonnes in 2004 to 4.2 million tonnes in 2010, and the variation on the previous year exceeded 30 percent in two cases. In the same period, inland water capture production grew continuously, with an overall increase of 2.6 million tonnes (see below).

A marked decrease in anchoveta catches by Peru in 2010 was mostly due to management measures (e.g. fishing closures) that were applied in the final quarter to protect the high number of juveniles present in the anchoveta stock as a consequence of the La Niña event (cold water), which had favoured spawning and generated a good recruitment. Thanks to this precautionary management decision, the 2011 anchoveta catches exceeded their 2009 level. Other preliminary reports from important fishing countries (e.g. the Russian Federation) show that 2011 should have been a year of increased catches. However, Japanese fishery production will probably have dropped significantly as the five prefectures hit by the earthquake and tsunami of 11 March 2011 accounted for about 21 percent of Japan's total marine fisheries and aquaculture production. Overall, preliminary information suggests that the total 2011 global catch should exceed 90 million tonnes, marking a return to 2006–07 levels (Table 1).

Notwithstanding the protracted global economic downturn, which has reduced the funds available to national administrations, the submission rates of 2009 and 2010 catch data to FAO have remained reasonably stable. However, it is well known that the quality of fishery data is very uneven among countries. An evaluation[3] of data quality in capture statistics submitted to FAO found that more than half of the countries reported inadequately. This percentage was greater for developing countries, but also about one-fourth of reports by developed countries were not satisfactory. Countries that should improve their data collection and reporting systems are mainly found in Africa, Asia and among the island States in Oceania and the Caribbean (Table 2).

World marine capture fisheries production

With the great decrease in anchoveta catches, Peru is no longer second after China in the ranking of the major marine producer countries in terms of quantity as it has been surpassed by Indonesia and the United States of America. Some major Asian fishing countries (i.e. China, India, Indonesia, Myanmar and Viet Nam) reported significant increases in 2010, but also other countries (i.e. Norway, the Russian Federation and

Table 2
Countries or territories with no adequate 2009 catch data submission

	Countries	Countries with no adequate submission	Percentage
	(Number)	*(Number)*	*(%)*
Developed	54	13	24.1
Developing	164	100	61.0
Africa	54	33	61.1
North America	37	18	48.6
South America	14	5	35.7
Asia	51	31	60.8
Europe	39	8	20.5
Oceania	23	18	78.3
Total	**218**	**113**	**51.8**

Source: Garibaldi, L. 2012. The FAO global capture production database: a six-decade effort to catch the trend. *Marine Policy*, 36(3): 760–768.

Spain) fishing in other areas and with more robust data collection systems showed growing catches after some years of sluggish production.

In particular, catches reported by the Russian Federation have grown by more than one million tonnes since the low point of 2004. According to the authorities of the Russian Federation, the recent increase is also a consequence of the management decision to remove excessive formalities on documentation of landing operations, as up until early 2010 landings by vessels of the Russian Federation in national ports were treated as imports. Moreover, an official forecast of the Russian Federation indicates further catch increases to a level of 6 million tonnes in 2020, representing an increase of more than 40 percent above present levels.

Besides decreased production by Peru and Chile as a consequence of the drop in anchoveta catches, other major fishing countries with downward trends in total marine catches in 2009 and 2010 were: Japan, the Republic of Korea, and Thailand in Asia; Argentina, Canada and Mexico in the Americas; Iceland in Europe; and to a lesser extent New Zealand. Despite variable trends, Morocco, South Africa and Senegal maintained their positions as the three major marine producers in Africa.

The Northwest Pacific is still by far the most productive fishing area. Catch peaks in the Northwest Atlantic, Northeast Atlantic and Northeast Pacific temperate fishing areas were reached many years ago (in 1968, 1976 and 1987, respectively) and total production had declined continuously from the early and mid-2000s, but in 2010 this trend was reversed in all three areas.

As for mainly tropical areas, total catches grew in the Western and Eastern Indian Ocean and in the Western Central Pacific, and, in the last two, 2010 marked a new maximum. In contrast, the 2010 production in the Western Central Atlantic decreased, driven by the reduction in United States catches by about 100 000 tonnes, probably mostly attributable to the oil spill in the Gulf of Mexico. Since 1978, the Eastern Central Pacific has shown a series of fluctuations in capture production with a cycle of about 5–9 years. The latest peak was in 2009, and a declining phase may have started in 2010.

Both the Mediterranean–Black Sea and the Southwest Atlantic seem to be areas where fisheries are in trouble as, since 2007, total catches have decreased by 15 and 30 percent, respectively. In the two areas along the southwest sides of America and Africa, upwelling phenomena occur, although their intensity varies strongly each year. In 2010, catches in the Southeast Pacific (excluding anchoveta) decreased whereas in the Southeast Atlantic they grew, but examination of historical trends from an earlier period reveals clear downward trajectories in both areas.

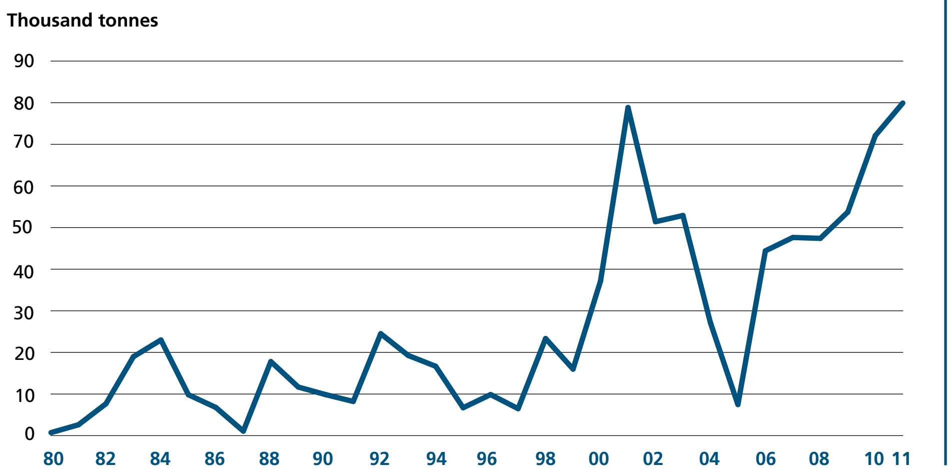
Finally, in the Eastern Central Atlantic, production has increased in the last three years. However, in this area, total capture production is significantly influenced by the activities of distant-water fleets and whether their catches are reported only by the flag States or also complemented with information by some costal countries that register foreign fleet catches in their EEZ but only make these data available to FAO intermittently.

As noted above, annual catches by fishing area, country and in particular by species very often fluctuate considerably, but all these variations combined seem to have a counterbalancing effect on the global total. A demonstration of this is that catches of more than 60 percent of the species varied by more than 10 percent in comparison with 2009 but the global total (excluding anchoveta) changed by only 1.2 percent.

It is well documented[4] that fish populations show large fluctuations in abundance, also in the absence of fishing. Although the causes are well known for some species (e.g. anchoveta – driven by changing environmental regimes), they remain unknown for many others. Besides fishes, such variations also occur in other commercial groups of species. For example, Argentina started industrial-level exploitation of *Pleoticus muelleri*, a high-value shrimp, in the 1980s. However, this species showed a major drop in 2005. Facing much reduced catches, the national authorities implemented management plans to help the species to recover. After six years, catches had rebounded tenfold reaching a new maximum recorded level in 2011 (Figure 5).

Figure 5

Catch trend for Argentine red shrimp

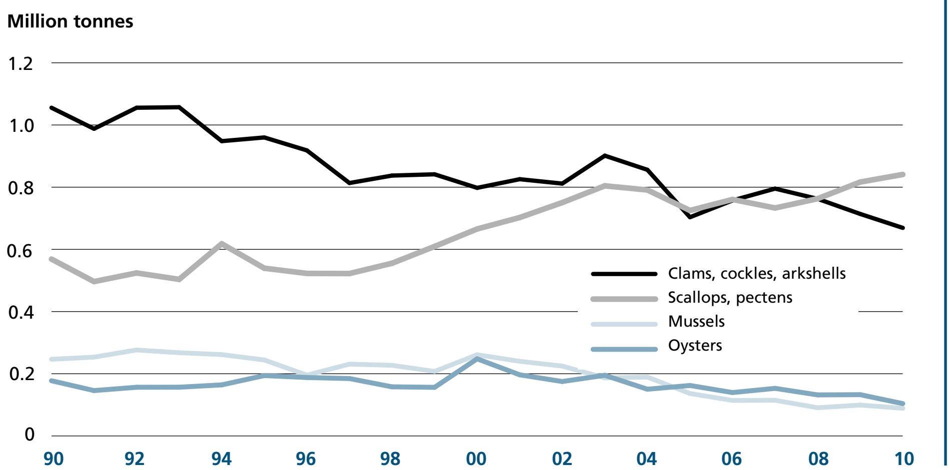


Despite the decreased 2010 catches, anchoveta is again the most-caught species. However, also in the presence of future favourable environmental regimes, yearly catches of this species should not attain the past peaks as the Government of Peru has introduced an annual quota for the whole country, subdivided by vessel, with the purpose of stabilizing the capacity of both the fleet and processing plants.

In the list of top ten species, the most evident change is the disappearance from the list of the Chilean jack mackerel (*Trachurus murphyi*), which had been sixth in 2008. This species is a transboundary resource with a very wide distribution in the South Pacific, ranging from the national EEZs to the high seas. After having peaked at about 5 million tonnes in the mid-1990s, catches were about 2 million tonnes in the mid-2000s but have since declined abruptly, and the 2010 catches were 0.7 million tonnes, the lowest level since 1976. Atlantic cod (*Gadus morhua*) has returned to the list, with a total increase of almost 200 000 tonnes in the last two years to rank tenth in 2010, a position not reached since 1998. In fact, in 2010, the whole group of gadiform species (cods, hakes, haddocks, etc.) reversed the negative trend of the previous three years in

Figure 6

Catch trends for marine bivalve species groups



which it had declined by 2 million tonnes. Preliminary data for this group also report growing catches for 2011.

Capture production of other important commercial species groups such as tunas and shrimps remained stable in 2010. The highly variable catches of cephalopods resumed growth after a decrease in 2009 of about 0.8 million tonnes. In the Antarctic areas, interest in fishing for krill resumed and a catch increase of more than 70 percent was registered in 2010.

Of the four marine bivalve groups (Figure 6), clams and cockles, which in the early 1990s contributed more than half of the overall bivalve catches, have recently accelerated their rate of decline. In 2009–2010, they were largely surpassed by scallops, which in contrast have shown a rising trend since the late 1990s. Capture production of mussels and oysters, for which reporting countries often have difficulty in separating harvest of natural populations from aquaculture production, has not varied much over the years, but an overall downward trend can be noted.

World inland capture fisheries production

Total global capture production in inland waters has increased dramatically since the mid-2000s (Figure 3). Total production, as submitted by countries and as estimated by FAO in cases of non-reporting, amounted to 11.2 million tonnes in 2010, an increase of 30 percent since 2004. Despite this growth, there are still claims that global production is much greater as some studies[5] have pointed out that capture production in inland waters is seriously underestimated in some regions. However, the little well-documented evidence available concerns a limited number of countries. On the other hand, inland waters are considered as being overfished[6] in many parts of the world, and human pressure and changes in the environmental conditions have seriously degraded important bodies of freshwater (e.g. the Aral Sea, and Lake Chad). Moreover, in several countries that are important in terms of inland waters fishing (e.g. China), a good portion of inland catches comes from waterbodies that are artificially restocked and closely monitored and, hence, it is probable that production is recorded quite carefully. Therefore, both improvements in the statistical coverage and stock enhancement activities may be contributing to the apparent increase in inland fishery production.

A closer look at the statistics shows that the growth in the global inland water catch is wholly attributable to Asian countries (Table 3). With the remarkable increases reported for 2010 production by India (up 0.54 million tonnes on 2009) and by China and Myanmar (up 0.1 million tonnes each), Asia's share is approaching 70 percent of global production. Considerable increases by some major Asian countries have seriously influenced the global total in recent years but, in some cases, they seem to be

Table 3
Inland capture fisheries production by continent and major producer

Continent/country	2004	2010	Variation 2004–2010	
	(Tonnes)	*(Tonnes)*	*(Tonnes)*	*(Percentage)*
Asia	5 376 670	7 696 520	2 319 850	43.1
China	2 097 167	2 289 343	192 176	9.2
India	527 290	1 468 757	941 467	178.5
Bangladesh	732 067	1 119 094	387 027	52.9
Myanmar	454 260	1 002 430	548 170	120.7
Africa	2 332 948	2 567 427	234 479	10.1
Americas	600 942	543 428	–57 514	–9.6
Europe	314 034	386 850	72 816	23.2
Oceania	17 668	16 975	–693	–3.9
World total	**8 642 262**	**11 211 200**	**2 568 938**	**29.7**

consequences of a tendency to report continuously increasing catches or of changes in the national data collection system.

For example, until 2009, the calculation of inland catches by Bangladesh was linked to the population increase and, as a consequence, total production grew by 67 percent between 2004 and 2009. Production reported by Myanmar has quadrupled in the last decade, increasing at an average growth rate of almost 18 percent per year, gaining 11 positions in the global ranking of major producer countries, and exceeding one million tonnes in 2010. The gathering of India's catch statistics is complex as the Ministry of Agriculture has to receive and assemble data from 28 states, which often have different systems of collecting and reporting data. It is very difficult to discern whether the dramatic growth (179 percent) in inland catches between 2004 and 2010 is ascribable to a real increase, to overestimation or to improvement in the data collection system of some of these states.

Inland water capture production in the other continents shows different trends. Uganda and the United Republic of Tanzania, fishing mostly in the African Great Lakes, and Nigeria and Egypt, with river fisheries, remain the main producers in Africa. Catches in several South American countries (e.g. Argentina, Colombia, Paraguay and Venezuela [Bolivarian Republic of]) as well as in North American ones have been reported as shrinking. Increased European production between 2004 and 2010 is all attributable to a rise of almost 50 percent in catches of the Russian Federation. Inland fishery production is marginal in countries in Oceania.

More than half of the global inland water capture production is still reported as "catches unidentified by species". However, in recent years, several countries have made efforts to improve the quality of their inland catch statistics and collect data at a finer species breakdown. In the last ten years, the increase in inland water species with statistics in the FAO database has been five times that for marine species (Table 4). Moreover, the percentage of inland water species in total species has improved, reaching 12.3 percent in 2010 – a value very close to the share (12.7 percent) of inland water catches in global catches in that year.

AQUACULTURE

Global aquaculture production has continued to grow in the new millennium, albeit more slowly than in the 1980s and 1990s. In the course of half a century or so, aquaculture has expanded from being almost negligible to fully comparable with capture production in terms of feeding people in the world (see below). Aquaculture has also evolved in terms of technological innovation and adaptation to meet changing requirements.

World aquaculture production attained another all-time high in 2010, at 60 million tonnes (excluding aquatic plants and non-food products), with an estimated

Table 4
Number of species items with statistics in the FAO capture database

	2001	2010	Variation 2001–2010
	(Number)	*(Number)*	*(Percentage)*
Inland water fish, crustaceans and molluscs	113	190	68.1
Marine and diadromous fish, crustaceans and molluscs	1 194	1 356	13.6
Total species items	**1 307**	**1 546**	18.3
Share of inland water species on total species	8.6%	12.3%	

total value of US$119 billion. One-third of the world's farmed food fish harvested in 2010 was achieved without the use of feed, through the production of bivalves and filter-feeding carps. When farmed aquatic plants and non-food products are included, world aquaculture production in 2010 was 79 million tonnes, worth US$125 billion.

About 600 aquatic species are raised in captivity worldwide for production in a variety of farming systems and facilities of varying input intensities and technological sophistication, using freshwater, brackish water and marine water. Aquaculture also contributes substantially, with hatchery-produced seeds for stocking, to culture-based capture fishery production, particularly in inland waters.

However, the stage of development and the distribution of aquaculture production remain imbalanced in all regions. A few developing countries in Asia and the Pacific, sub-Saharan Africa and South America have made considerable progress in aquaculture development in recent years and they are becoming significant or major producers in their respective regions. However, the disparity remains huge across the continents and georegions, as well as among countries of comparable natural conditions in the same region, with aquaculture in many of the LDCs yet to make a significant contribution to national food and nutrition security.

In 2010, FAO recorded 181 countries and territories with aquaculture production, and 9 countries and territories not reporting production in 2010 but with production recorded previously. Of these 190 countries and territories, about 30 percent of them, including a few major producers in Asia and Europe, had failed to report any statistics on national aquaculture production even a year after the 2010 reference year. Less than 30 percent of them were able to report national data covering grow-out production broken down by culture environment and farming method or in terms of seed production and culture areas and facilities. More than 40 percent of them reported national data in varying degrees of completeness, data quality and timeliness of reporting. To compensate for such gaps, FAO made estimates using information available from additional sources where possible.

Global statistics are still lacking on: (i) non-food aquaculture production, including live bait for fishing, live ornamental species (animals and plants) and ornamental products (pearls and shells); (ii) fishes cultured as feed for certain carnivorous farmed species; (iii) culture of biomass of many species (such as plankton, *Artemia* and marine worms) for use as feed in aquaculture hatcheries and grow-out operations; (iv) aquaculture hatchery and nursery outputs for ongrowing in captivity or stocking to the wild; and (v) inputs in terms of captured wild fish ongrown in captivity. These practices are often specialized and segmented standalone operations of local importance in many countries. There is an urgent need to improve and expand national and international aquaculture statistics collection and reporting schemes in order to have a full understanding of aquaculture in accordance with the commitments made by States in 2003 in adopting the FAO Strategy and Outline Plan for Improving Information on Status and Trends of Aquaculture.

Food fish production

In 2010, global production of farmed food fish was 59.9 million tonnes, up by 7.5 percent from 55.7 million tonnes in 2009 (32.4 million tonnes in 2000). Farmed food fish include finfishes, crustaceans, molluscs, amphibians (frogs), aquatic reptiles (except crocodiles) and other aquatic animals (such as sea cucumbers, sea urchins, sea squirts and jellyfishes) that are indicated as fish throughout this document. The reported grow-out production from aquaculture is almost entirely destined for human consumption.

In the last three decades (1980–2010), world food fish production of aquaculture has expanded by almost 12 times, at an average annual rate of 8.8 percent. Aquaculture enjoyed high average annual growth rates of 10.8 percent and 9.5 percent in the 1980s and 1990s, respectively, but has since slowed to an annual average of 6.3 percent.

Since the mid-1990s, aquaculture has been the engine driving growth in total fish production as global capture production has levelled off. Its contribution to world total fish production climbed steadily from 20.9 percent in 1995 to 32.4 percent in 2005 and 40.3 percent in 2010. Its contribution to world food fish production for human consumption was 47 percent in 2010 compared with only 9 percent in 1980.

The growth rate in farmed food fish production from 1980 to 2010 far outpaced that for the world population (1.5 percent), resulting in average annual per capita consumption of farmed fish rising by almost seven times, from 1.1 kg in 1980 to 8.7 kg in 2010, at an average rate of 7.1 percent per year.

The total farmgate value of food fish production from aquaculture is estimated at US$119.4 billion for 2010. This might be overstated considering that some countries reported values other than first-sale prices (e.g. using retail, export or processed product prices).

World aquaculture production is vulnerable to adverse impacts of natural, socio-economic, environmental and technological conditions. For example, marine cage culture of Atlantic salmon in Chile, oyster farming in Europe (notably France), and marine shrimp farming in several countries in Asia, South America and Africa have experienced high mortality caused by disease outbreaks in recent years, resulting in partial or sometimes total loss of production. Countries prone to natural disasters suffer seriously from production damage or losses caused by floods, droughts, tropical storms and, less frequently, earthquakes. Water pollution has increasingly threatened production in some newly industrialized and rapidly urbanizing areas. In 2010, aquaculture in China suffered production losses of 1.7 million tonnes (worth US$3.3 billion) caused by diseases (295 000 tonnes), natural disasters (1.2 million tonnes), pollution (123 000 tonnes), etc. Disease outbreaks virtually wiped out marine shrimp farming production in Mozambique in 2011.

Production among regions

Asia accounted for 89 percent of world aquaculture production by volume in 2010, up from 87.7 percent in 2000 (Table 5). The contribution of freshwater aquaculture has gradually increased, up to 65.6 percent in 2010 from around 60 percent during 1990s. In terms of volume, Asian aquaculture is dominated by finfishes (64.6 percent), followed by molluscs (24.2 percent), crustaceans (9.7 percent) and miscellaneous species (1.5 percent). The share of non-fed species farmed in Asia was 35 percent (18.6 million tonnes) in 2010 (compared with 50 percent in 1980). The contribution of China to world aquaculture production volume in 2010 declined to 61.4 percent from its highest level of about 66 percent in the period 1996–2000. Other major producers in Asia (India, Viet Nam, Indonesia, Bangladesh, Thailand, Myanmar, the Philippines and Japan) are among the world's top producers.

In the Americas, the share of freshwater aquaculture in total production declined from 54.8 percent in 1990 to 37.9 percent in 2010. In North America, aquaculture has ceased expanding in recent years, but in South America it has shown strong and continuous growth, particularly in Brazil and Peru. In terms of volume, aquaculture in North and South America is dominated by finfishes (57.9 percent), crustaceans (21.7 percent) and molluscs (20.4 percent). Bivalve production fluctuated between 14 and 21 percent of total aquaculture production in the 1990s and 2000s, after dropping rapidly in the 1980s from 48.5 percent.

In Europe, the share of production from brackish and marine waters increased from 55.6 percent in 1990 to 81.5 percent in 2010, driven by marine cage culture of Atlantic salmon and other species. Several important producers in Europe have recently ceased expanding or have even contracted, particularly in the marine bivalve sector. In 2010, finfishes accounted for three-quarters of all European aquaculture production, and molluscs one-quarter. The share of bivalves in total production decreased continuously from 61 percent in 1980 to 26.2 percent in 2010.

Africa has increased its contribution to global production from 1.2 percent to 2.2 percent in the past ten years, albeit from a very low base. The share of freshwater aquaculture in the region fell from 55.2 percent to 21.8 percent in the 1990s, largely reflecting the strong growth in brackish-water culture in Egypt, but it recovered in the 2000s, reaching 39.5 percent in 2010 as a result of rapid development in freshwater fish farming in sub-Saharan Africa, most notably in Nigeria, Uganda, Zambia, Ghana and Kenya. African aquaculture production is overwhelmingly dominated by finfishes (99.3 percent by volume), with only a small fraction from marine shrimps (0.5 percent) and marine molluscs (0.2 percent). In spite of some limited successes, the potential for bivalve production in marine waters remains almost completely unexplored.

Oceania is of relatively marginal importance in global aquaculture production. Production from this region consists mainly of marine molluscs (63.5 percent) and finfishes (31.9 percent), while crustaceans (3.7 percent, mostly marine shrimps) and other species (0.9 percent) constitute less than 5 percent of its total production. Marine bivalves accounted for about 95 percent of the total produced in the first half of 1980s but, reflecting the development of the finfish culture sector (especially Atlantic salmon in Australia and chinook salmon in New Zealand), they currently account for less than 65 percent of the region's total production. Freshwater aquaculture accounts for less than 5 percent of the region's production.

Table 5
Aquaculture production by region: quantity and percentage of world total production

Selected groups and countries		1970	1980	1990	2000	2009	2010
Africa	**(tonnes)**	**10 271**	**26 202**	**81 015**	**399 676**	**991 183**	**1 288 320**
	(percentage)	***0.40***	***0.60***	***0.60***	***1.20***	***1.80***	***2.20***
Sub-Saharan Africa	(tonnes)	4 243	7 048	17 184	55 690	276 906	359 790
	(percentage)	*0.20*	*0.10*	*0.10*	*0.20*	*0.50*	*0.60*
North Africa	(tonnes)	6 028	19 154	63 831	343 986	714 277	928 530
	(percentage)	*0.20*	*0.40*	*0.50*	*1.10*	*1.30*	*1.60*
Americas	**(tonnes)**	**173 491**	**198 850**	**548 479**	**1 423 433**	**2 512 829**	**2 576 428**
	(percentage)	***6.80***	***4.20***	***4.20***	***4.40***	***4.50***	***4.30***
Caribbean	(tonnes)	350	2 329	12 169	39 704	42 514	36 871
	(percentage)	*0.00*	*0.00*	*0.10*	*0.10*	*0.10*	*0.10*
Latin America	(tonnes)	869	24 590	179 367	799 234	1 835 888	1 883 134
	(percentage)	*0.00*	*0.50*	*1.40*	*2.50*	*3.30*	*3.10*
North America	(tonnes)	172 272	171 931	356 943	584 495	634 427	656 423
	(percentage)	*6.70*	*3.70*	*2.70*	*1.80*	*1.10*	*1.10*
Asia	**(tonnes)**	**1 799 101**	**3 552 382**	**10 801 356**	**28 422 189**	**49 538 019**	**53 301 157**
	(percentage)	***70.10***	***75.50***	***82.60***	***87.70***	***88.90***	***89.00***
Asia (excluding China and Near East)	(tonnes)	1 034 703	2 222 670	4 278 355	6 843 429	14 522 862	16 288 881
	(percentage)	*40.30*	*47.20*	*32.70*	*21.10*	*26.10*	*27.20*
China	(tonnes)	764 380	1 316 278	6 482 402	21 522 095	34 779 870	36 734 215
	(percentage)	*29.80*	*28.00*	*49.60*	*66.40*	*62.40*	*61.40*
Near East	(tonnes)	18	13 434	40 599	56 665	235 286	278 061
	(percentage)	*0.00*	*0.30*	*0.30*	*0.20*	*0.40*	*0.50*
Europe	**(tonnes)**	**575 598**	**916 183**	**1 601 524**	**2 050 958**	**2 499 042**	**2 523 179**
	(percentage)	***22.40***	***19.50***	***12.20***	***6.30***	***4.50***	***4.20***
European Union (27)	(tonnes)	471 282	720 215	1 033 982	1 395 669	1 275 833	1 261 592
	(percentage)	*18.40*	*15.30*	*7.90*	*4.30*	*2.30*	*2.10*
Non-European-Union countries	(tonnes)	26 616	38 594	567 667	657 167	1 226 625	1 265 703
	(percentage)	*1.00*	*0.80*	*4.30*	*2.00*	*2.20*	*2.10*
Oceania	**(tonnes)**	**8 421**	**12 224**	**42 005**	**121 482**	**173 283**	**183 516**
	(percentage)	***0.30***	***0.30***	***0.30***	***0.40***	***0.30***	***0.30***
World	**(tonnes)**	**2 566 882**	**4 705 841**	**13 074 379**	**32 417 738**	**55 714 357**	**59 872 600**

Notes: Data exclude aquatic plants and non-food products. Data for 2010 for some countries are provisional and subject to revisions. Production values for 1980 for Europe include the former Soviet Union.

The global distribution of aquaculture production across the regions and countries of different economic development levels remains imbalanced. In 2010, the top ten producing countries accounted for 87.6 percent by quantity and 81.9 percent by value of the world's farmed food fish. At the regional level, production is also concentrated in a few major producers (Table 6).

The LDCs, mostly in sub-Saharan Africa and in Asia, and home to 20 percent of the world's population (1.4 billion people), remain very small in terms of their share of world aquaculture production (4.1 percent by quantity and 3.6 percent by value). The major producers in the LDCs in 2010 include Bangladesh, Myanmar, Uganda, the Lao

Table 6
Top ten regional and world aquaculture producers in 2010

Africa	Tonnes	Percentage	America	Tonnes	Percentage	Asia	Tonnes	Percentage
Egypt	919 585	71.38	Chile	701 062	27.21	China	36 734 215	68.92
Nigeria	200 535	15.57	United States of America	495 499	19.23	India	4 648 851	8.72
Uganda	95 000	7.37	Brazil	479 399	18.61	Viet Nam	2 671 800	5.01
Kenya	12 154	0.94	Ecuador	271 919	10.55	Indonesia	2 304 828	4.32
Zambia	10 290	0.80	Canada	160 924	6.25	Bangladesh	1 308 515	2.45
Ghana	10 200	0.79	Mexico	126 240	4.90	Thailand	1 286 122	2.41
Madagascar	6 886	0.53	Peru	89 021	3.46	Myanmar	850 697	1.60
Tunisia	5 424	0.42	Colombia	80 367	3.12	Philippines	744 695	1.40
Malawi	3 163	0.25	Cuba	31 422	1.22	Japan	718 284	1.35
South Africa	3 133	0.24	Honduras	27 509	1.07	Republic of Korea	475 561	0.89
Other	21 950	1.70	Other	113 067	4.39	Other	1 557 588	2.92
Total	**1 288 320**	**100**	**Total**	**2 576 428**	**100**	**Total**	**53 301 157**	**100**

Europe	Tonnes	Percentage	Oceania	Tonnes	Percentage	World	Tonnes	Percentage
Norway	1 008 010	39.95	New Zealand	110 592	60.26	China	36 734 215	61.35
Spain	252 351	10.00	Australia	69 581	37.92	India	4 648 851	7.76
France	224 400	8.89	Papua New Guinea	1 588	0.87	Viet Nam	2 671 800	4.46
United Kingdom	201 091	7.97	New Caledonia	1 220	0.66	Indonesia	2 304 828	3.85
Italy	153 486	6.08	Fiji	208	0.11	Bangladesh	1 308 515	2.19
Russian Federation	120 384	4.77	Guam	129	0.07	Thailand	1 286 122	2.15
Greece	113 486	4.50	Vanuatu	105	0.06	Norway	1 008 010	1.68
Netherlands	66 945	2.65	French Polynesia	39	0.02	Egypt	919 585	1.54
Faroe Islands	47 575	1.89	Northern Mariana Islands	24	0.01	Myanmar	850 697	1.42
Ireland	46 187	1.83	Palau	12	0.01	Philippines	744 695	1.24
Other	289 264	11.46	Other	19	0.01	Other	7 395 281	12.35
Total	**2 523 179**	**100**	**Total**	**183 516**	**100**	**Total**	**59 872 600**	**100**

Note: Data exclude aquatic plants and non-food products. Data for 2010 for some countries are provisional and subject to revisions.

People's Democratic Republic (82 100 tonnes), Cambodia (60 000 tonnes) and Nepal (28 200 tonnes).

While aquaculture production has shown strong growth in developing countries, particularly in Asia, annual growth rates in developed industrialized countries averaged only 2.1 percent and 1.5 percent in the 1990s and 2000s, respectively. In 2010, they produced collectively 6.9 percent (4.1 million tonnes) by quantity and 14 percent (US$16.6 billion) by value of world farmed food fish production, compared with 21.9 percent and 32.4 percent in 1990. Aquaculture production has contracted or stagnated in Japan, the United States of America, Spain, France, the United Kingdom of Great Britain and Northern Ireland, Canada and Italy. An exception is Norway, where, thanks to the farming of Atlantic salmon in marine cages, aquaculture production grew from 151 000 tonnes in 1990 to more than one million tonnes in 2010, at an average growth rate of 12.6 percent in the 1990s and 7.5 percent in the 2000s.

In the recent past, some developing countries in Asia and the Pacific (Myanmar and Papua New Guinea), sub-Saharan Africa (Nigeria, Uganda, Kenya, Zambia and Ghana) and South America (Ecuador, Peru and Brazil) have made rapid progress to become significant or major aquaculture producers in their regions.

Immediately after their independence more than two decades ago, countries in the former Soviet Union were producing an annual total of almost 350 000 tonnes of food fish from aquaculture. However, production capacity in all these countries deteriorated rapidly in the 1990s to about one-third of its original level. In spite of starting to recover in the 2000s, their combined total production in 2010 amounted to only 59 percent of that in 1988. The lost capacity, especially in hatchery and nursery output, has also had a negative impact on inland culture-based capture fisheries. While Armenia, Belarus, Estonia and Republic of Moldova have exceeded their 1988 production levels, and output in Lithuania and the Russian Federation is at more than 80 percent of its original 1998 level, other countries remain at one-third or less of their 1988 production levels. In 2010, farmed fish production in Kazakhstan and Turkmenistan was less than 5 percent of that before independence.

Production with and without feed

While feed is generally perceived to be a major constraint to aquaculture development, one-third of all farmed food fish production, 20 million tonnes, is currently achieved without artificial feeding (Figure 7). Oysters, mussels, clams, scallops and other bivalve species are grown with food materials that occur naturally in their culture environment in the sea and lagoons. Silver carp and bighead carp feed on planktons proliferated through intentional fertilization and the wastes and leftover feed materials of fed species grown in the same multispecies polyculture systems. Rice–fish farming has long been a common practice, particularly in Asia (Box 2).

However, the percentage of non-fed species in world production has declined gradually from more than 50 percent in 1980 to the present level of 33.3 percent, strongly dominated by changing practices in Asia. This reflects the relatively faster growth in the fed-species culture subsector supported by, among others, the development and improved availability of formulated aquaculture feeds for finfishes and crustaceans.

Some fed species grow on a mixture of natural food proliferated from fertilization and supplementary feeds. If the non-fed portion in their total production were considered, the non-fed portion of world production of all farmed food fish would be higher than the aforesaid 33.3 percent. Owing to the unavailability of information and data needed for the calculation, the said percentage does not include: (i) the non-fed portion of production of some fed species (such as milkfish that grow partially on algal aggregates known as "lab-lab" proliferated through fertilization in culture ponds); and (ii) the non-fed filter feeding carps reported by some producers in aggregation with other species and treated wholly as fed species.

Box 2

Fish culture in rice fields

History and tradition

The capture and culture of aquatic organisms from rice fields has a long history and tradition especially in Asia, where the availability of rice and fish has been associated with prosperity and food security. Designs of rice fields with fish on ancient Chinese pottery from tombs of the Han Dynasty (206 BC–225 AD), inscriptions from a thirteenth century king of Thailand, and traditional sayings, such as one from Viet Nam – "rice and fish are like mother and children", are all testament that the combination of rice and fish has traditionally been regarded as an indicator of wealth and stability.

Status

The cultivation of almost 90 percent of the world's rice crops in irrigated, rainfed and deep-water systems equivalent to about 134 million hectares offers a suitable environment for fish and other aquatic organisms. Rice-based ecosystems provide habitats for a wide range of aquatic organisms extensively used by local people. They also offer opportunities for the enhancement and culture of aquatic organisms. The different integrations of rice and fish farming – either on the same plot, on adjacent plots where by-products of one system are used as inputs on the other, or consecutively – are all variations of production systems that aim to increase the productivity of water, land and associated resources while contributing to increased fish production. The integration can be more or less complete depending on the general layout of the irrigated rice plots and fishponds. There are many options for enhancing food production from fish in managed aquatic systems, which are ingeniously realized by farmers all over the world.[1]

As regards the general scale of rice–fish culture, China is the main producer with an area of about 1.3 million hectares of rice fields with different forms of fish culture, which produced 1.2 million tonnes of fish and other aquatic animals in 2010.[2] Other countries reporting their rice–fish production to FAO include Indonesia (92 000 tonnes in 2010), Egypt (29 000 tonnes in 2010), Thailand (21 000 tonnes in 2008), the Philippines (150 tonnes in 2010) and Nepal (45 tonnes in 2010). Trends observed in China show that fish production from rice fields has increased thirteenfold in the last two decades, and rice–fish culture is now one of the most important aquaculture systems in China, making a significant contribution to rural livelihoods and food security. A broad range of aquatic species including different carps, tilapias, catfish and breams are being farmed in rice fields. Market prices and preferences may provide important opportunities to farmers for a more diversified use of species, especially targeting eels, loaches and various crustaceans, and the sale and marketing of higher-valued organic products.[3] Also in India the practice cuts across different ecosystems from terraced rice fields in the hilly terrain to coastal lands and

deep-water rice fields, and reportedly covered an area of two million hectares in the 1990s. Rice–fish farming is being tried and practised in other countries and continents although to a lesser extent. Apart from Asia, activities have been reported from, among others, Brazil, Egypt, Guyana, Haiti, Hungary, Iran (Islamic Republic of), Italy, Madagascar, Malawi, Nigeria, Panama, Peru, Senegal, Suriname, the United States of America, Zambia, and several countries in the Central Asia and Caucasus region.[1]

Benefits, issues and challenges

Rice–fish farming provides additional food and income by diversifying farm activities and increasing yields of both the rice and fish crops. Evidence shows that although rice yields are similar, the integrated rice–fish system uses 68 percent less pesticide than rice monoculture.[4] Fish feed on rice pests, thus reducing pest pressure. Together with the fact that most broad-spectrum insecticides are a direct threat to aquatic organisms and healthy fish culture, knowledgeable farmers are much less motivated to spray pesticides. Therefore, it has been suggested that fish farming in rice and the integrated management of pests in rice production are complementary activities.[5] Similarly, complementary use of nitrogen between rice and fish resulted in 24 percent less chemical fertilizer application and low nitrogen release into the environment, suggesting positive interactions in the use of resources.[4] Fertilizers and feeds used in the integrated system are more efficiently utilized and converted into food production, and nutrient discharge to the natural environment is minimized. Rice–fish farming reduces the emission of methane by almost 30 percent compared with traditional rice farming.[6]

The challenges related to rice–fish farming are not different from those related to general aquaculture development. They include availability of and access to seed, feed and capital as well as natural risks associated with water control, disease and predation. Freshwater is rapidly becoming one of the scarcest natural resources, and competition for freshwater is among the most critical challenges facing developing countries. Sufficient and good-quality water is a key resource in rice–fish farming, which increases the productivity per unit of water used. Rice–fish farming and other forms of aquaculture in rice-based farming are one component of integrated water management approaches that produce food of high nutritional quality and, often, high economic value. Profits vary depending on production characteristics but income increases of up to 400 percent compared with rice monoculture have been reported and these may be even greater where high-value aquatic species are farmed.[3]

The use of aquatic genetic resources in rice is part of the work of the FAO Fisheries and Aquaculture Department with the Commission on Genetic Resources for Food and Agriculture as part of the preparation for *The State of the World on Aquatic Genetic Resources*. In addition, the rice–fish system has been included as one of the Globally Important Agricultural Heritage Systems under an FAO initiative supported by the Global Environment Facility.

It is the combination of efficient production and use of resources coupled with environmental benefits that has prompted recent international

Box 2 *(cont.)*

gatherings of the International Rice Commission, the Convention of Biological Diversity, and the Ramsar Convention to recommend that rice-producing countries promote the further development of integrated rice and fish systems as a means of enhancing food security and sustainable rural development. In addition, some countries with a long tradition in integrated rice–fish systems are giving renewed attention to the complex rice ecosystem with a focus on its role in biodiversity conservation, as in the Japanese *satoyama* landscape initiative.

The way forward

An increase in integrated farming of rice and fish is possible and would benefit farmers, consumers and the environment worldwide. Several organizations, active in global policies for food production and/or environmental sustainability, have become aware of this, and key policy-makers have formulated and disseminated relevant recommendations to governments, institutions and stakeholders. This is encouraging and, given the benefits of rice–fish farming, it is important to give priority to its continued promotion.

Taking China, the main producer, as an example, with currently 15 percent of the suitable rice area under integrated rice–fish cultivation, there is considerable scope for expansion.[3] The same is true for many rice-producing countries around the globe. Similarly, there is much room for intensification of existing systems. Capacity building with increased knowledge and improved management techniques will be critically important, in particular focusing on all farming household members, both men and women, as well as extension agents. In recent decades, excellent progress has been achieved by applying a “farmer field school” (FFS) approach. This is a discovery-based learning approach where small groups of farmers meet regularly, facilitated by a specially trained technician, to explore new methods, through simple experimentation and group discussion and analysis, over the course of a growing season. This approach allows farmers to modify and adapt newly introduced methods to local contexts and knowledge, ultimately providing a higher likelihood of appropriate adaptation and adoption of improved technologies. It is only relatively recently that aquaculture has been integrated into an FFS-style curriculum in Guyana and Suriname.[7]

In terms of food security, producers in Asia, especially China, Viet Nam, India, Indonesia and Bangladesh, have benefited from the development of culture of low-trophic-level species, such as carps and barbs, tilapias and *Pangasius* catfish, in easing dependence on high-protein feeds, and thus reduced the vulnerability of their sectors to externalities. Grass carp, the world’s most-produced finfish species from aquaculture, is grown partially with cultivated and wild-collected “pastures”, instead of using formulated feeds only.

The production of 253 000 tonnes of highly carnivorous Mandarin fish (*Siniperca chuatsi*), which feeds on live prey only, was achieved by feeding them with low-trophic-level carp fingerlings grown with low-protein feeds plus pond fertilization.

The approach to validate and disseminate integrated rice–fish farming systems through FFS has been pioneered in Latin America. It is currently being tested in field activities in Mali, with testing also scheduled for Burkina Faso, where considerable potential for the integration of irrigated rice and aquaculture exists.[8] Strong interest has been noted from several other sub-Saharan countries such as the Democratic Republic of the Congo, Senegal, the United Republic of Tanzania, and Zambia.[9]

[1] Halwart, M. and Gupta, M.V., eds. 2004. *Culture of fish in rice fields.* Rome, FAO, and Penang, Malaysia, The WorldFish Center. 83 pp. (also available at www.fao.org/docrep/015/a0823e/a0823e00.htm). (English, French and Spanish language versions)

[2] Bureau of Fisheries. 2011. *2010 China Fishery Statistical Yearbook*. Beijing.

[3] Miao, W.M. 2010. Recent developments in rice–fish culture in China: a holistic approach for livelihood improvement in rural areas. *In* S.S. de Silva and F.B. Davy, eds. *Success stories in Asian aquaculture*, pp. 15–42. London, Springer. (also available at http://web.idrc.ca/en/ev-147117-201-1-DO_TOPIC.html).

[4] Xie, J., Hu, L.L., Tang, J.J., Wu, X., Li, N.N., Yuan, Y.G., Yang, H.S., Zhang, J., Luo, S.M. and Chen, X. 2011. Ecological mechanisms underlying the sustainability of the agricultural heritage rice–fish coculture system. *Proceedings of the National Academy of Sciences of the United States of America*, 108(50): E1381–E1387 [online]. [Cited 19 April 2012]. www.pnas.org/content/108/50/E1381.full

[5] Halwart, M. 1994. *Fish as biocontrol agents in rice: the potential of common carp* Cyprinus carpio *and Nile tilapia* Oreochromis niloticus*.* Weikersheim, Germany, Margraf Verlag. 169 pp.

[6] Lu, J. and Li, X. 2006. Review of rice–fish-farming systems in China – one of the Globally Important Ingenious Agricultural Heritage Systems (GIAHS). *Aquaculture*, 260(1-4): 106–113.

[7] Halwart, M. and Settle, W., eds. 2008. *Participatory training and curriculum development for Farmer Field Schools in Guyana and Suriname. A field guide on Integrated Pest Management and aquaculture in rice*. Rome, FAO. 122 pp. (also available at www.fao.org/docrep/012/al356e/al356e.pdf).

[8] Peterson, J. and Kalende, M. 2006. The potential for integrated irrigation-aquaculture in Mali. *In* M. Halwart and A.A. van Dam, eds. *Integrated irrigation and aquaculture in West Africa: concepts, practices and potential*, pp. 79–94. Rome, FAO. 181 pp. (also available at www.fao.org/docrep/009/a0444e/a0444e00.htm). (English, French and Spanish language versions)

[9] Yamamoto, K., Halwart, M. and Hishamunda, N. 2011. Supporting African rice farmers in their diversification efforts through aquaculture. *FAO Aquaculture Newsletter*, 48: 42–43.

Comparable in quantity with the total production of farmed rainbow trout in Europe (257 200 tonnes), or the combined world production of gilthead seabream and European seabass (265 100 tonnes), Mandarin fish production has been assumed to be dependent on fishmeal and fish oil for feed, and this now needs reconsideration. As discussed above, part of its production could be treated as the non-fed portion of fed species production.

In sub-Saharan Africa, the carnivorous North African catfish (*Clarias gariepinus*) has replaced tilapia as the most-produced fish in aquaculture since 2004. The progressive dominance of catfish species in aquaculture is particularly pronounced in Nigeria and Uganda. Being the largest producer of catfish in Africa, Nigeria even imports catfish feeds from as far away as Northern Europe.

Figure 7

World aquaculture production of non-fed and fed species

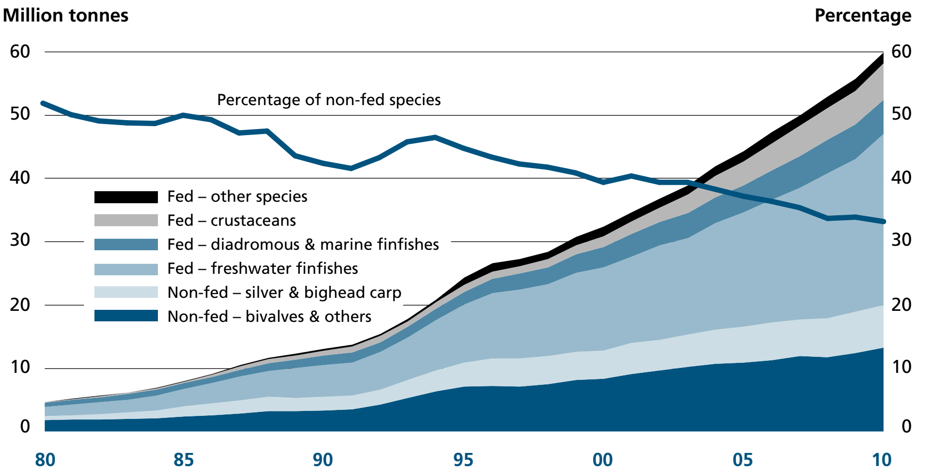
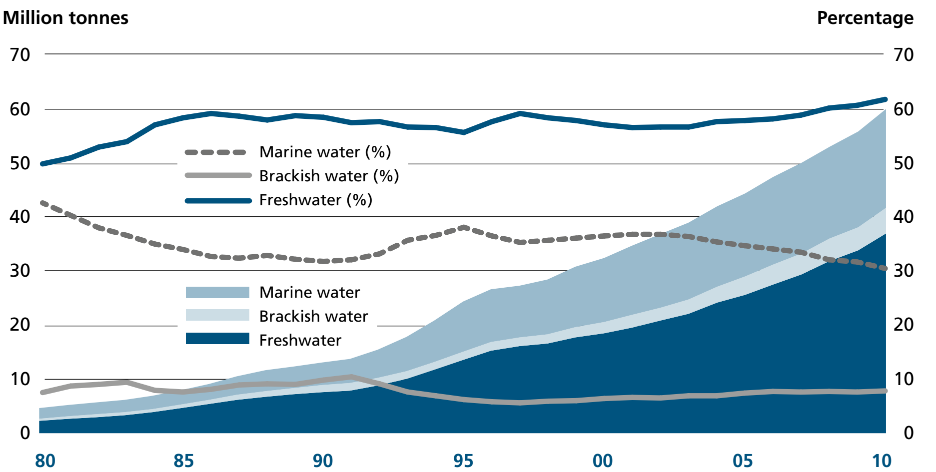


Figure 8

World aquaculture production and relative share by culture environment



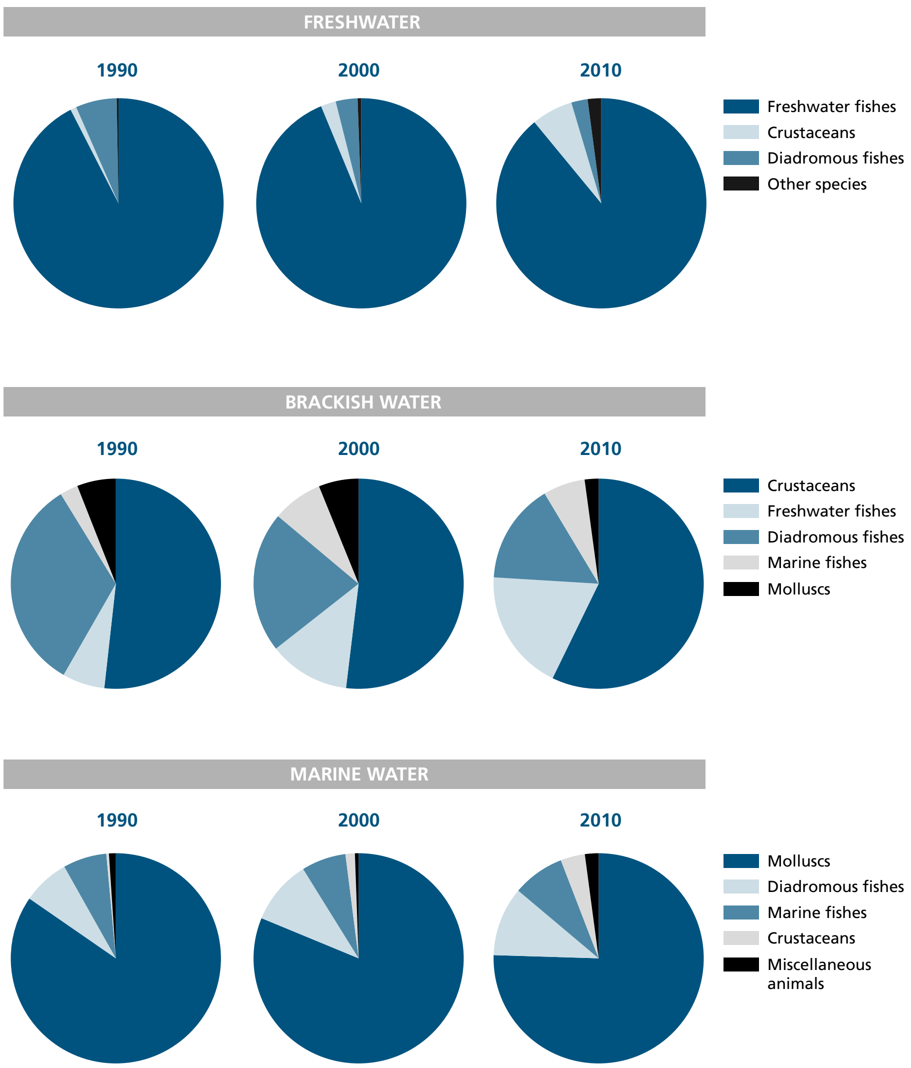
Production by culture environment

Aquaculture production uses freshwater, brackish water and full-strength marine water as culture media. Data available at FAO show that, in terms of quantity, the percentage of production from freshwater rose from less than 50 percent before the 1980s to almost 62 percent in 2010 (Figure 8), with the share of marine aquaculture production declining from more than 40 percent to just above 30 percent. In 2010, freshwater aquaculture was the source of 58.1 percent of global production by value. Brackish-water aquaculture yielded only 7.9 percent of world production in terms of quantity but accounted for 12.8 percent of total value because of the relatively high-valued marine shrimps cultured in brackish-water ponds. Marine water aquaculture accounted for about 29.2 percent of world aquaculture production by value.

The average annual growth rate for freshwater aquaculture production from 2000 to 2010 was 7.2 percent, compared with 4.4 percent for marine aquaculture production. Freshwater fish farming has been a relatively easy entry point for practising aquaculture in developing countries, particularly for small-scale producers.

Figure 9

World aquaculture production composition by culture environment



As such, freshwater aquaculture is expected to contribute further to total aquaculture production in the 2010s.

The share of brackish-water aquaculture production has been stable, ranging between 6 and 8 percent, for most of the time. An exception was in the 1980s and early 1990s when accelerated development of brackish-water culture of marine shrimp species, particularly in coastal regions of Asia and South America, led to brackish-water aquaculture reaching 8–10 percent of total production. However, in the period 1994–2000, world marine shrimp farming was hit by disease outbreaks in Asia and South America, and the share of brackish-water production fell to 6 percent.

At the global level, the composition and types of farmed species differ greatly among the three culture environments, and they have also undergone changes within environments over the years (Figure 9).

Freshwater aquaculture production (36.9 million tonnes) was overwhelmingly dominated by finfishes (91.7 percent, 33.9 million tonnes) in 2010, as in the past. Crustaceans accounted for 6.4 percent, and all other types of species contributed only

1.9 percent. The development of freshwater farming of crustaceans and other species (such as soft-shell turtles and frogs) in the past two decades has slightly eroded the dominance of finfish in production. The share of diadromous fishes, including rainbow trout and other salmonids, eels and sturgeons, shrank from 6.3 percent in 1990 to 2.5 percent in 2010.

Brackish-water aquaculture production (4.7 million tonnes) consisted of crustaceans (57.2 percent, 2.7 million tonnes), freshwater fishes (18.7 percent), diadromous fishes (15.4 percent), marine fishes (6.5 percent) and marine molluscs (2.1 percent) in 2010. More the 99 percent of the crustaceans were marine shrimps. The share of freshwater fishes has increased dramatically in the past two decades, driven largely by rapid development in Nile tilapia and other species in Egypt. Milkfish and barramundi remain important but their combined share has dropped significantly. Salmonids and eels are also cultured in brackish-water in small quantities.

Marine-water aquaculture production (18.3 million tonnes) consists of marine molluscs (75.5 percent, 13.9 million tonnes), finfishes (18.7 percent, 3.4 million tonnes), marine crustaceans (3.8 percent) and other aquatic animals (2.1 percent), e.g. sea cucumbers, and sea urchins. The share of molluscs (mostly bivalves, e.g. oysters, mussels, clams, cockles, arkshells and scallops) declined from 84.6 percent in 1990 to 75.5 percent in 2010, reflecting the rapid growth in finfish culture in marine water, which grew at an average annual rate of 9.3 percent from 1990 to 2010 (seven times faster than the rate for molluscs). Salmonid production, particularly Atlantic salmon, increased dramatically from 299 000 tonnes in 1990 to 1.9 million tonnes in 2010, at an average annual rate exceeding 9.5 percent. Other finfish species also increased rapidly, from 278 000 tonnes in 1990 to 1.5 million tonnes in 2010, at an average annual rate exceeding 8.6 percent. Other finfish species cultured in marine water include amberjacks, seabreams, seabasses, croakers, grouper, drums, mullets, turbot and other flatfishes, snappers, cobia, pompano, cods, puffers and tunas.

Species produced in aquaculture

In 2010, the composition of world aquaculture production was: freshwater fishes (56.4 percent, 33.7 million tonnes), molluscs (23.6 percent, 14.2 million tonnes), crustaceans (9.6 percent, 5.7 million tonnes), diadromous fishes (6.0 percent, 3.6 million tonnes), marine fishes (3.1 percent, 1.8 million tonnes) and other aquatic animals (1.4 percent, 814 300 tonnes). Figure 10 summarizes the production volumes of the major categories. Aquaculture production exceeds capture production for many of the staple species for aquaculture. For example, the wild catch accounts for less than 1 percent of Atlantic salmon production, and farmed marine shrimps contribute 55 percent to the total global production.

Production of freshwater fishes has always been dominated by carps (71.9 percent, 24.2 million tonnes, in 2010). Among carps, 27.7 percent are non-fed filter-feeders and the rest are fed with low-protein feeds. Production of tilapias has a wide distribution, and 72 percent are raised in Asia (particularly in China and Southeast Asia), 19 percent in Africa, and 9 percent in America. Viet Nam dominates production of omnivorous *Pangasius* catfishes although there are other producers, such as Indonesia and Bangladesh. World production of *Pangasius* catfish may be understated because booming production in India has yet to be reflected in statistics. In 2010, Asia accounted for 73.7 percent of the production of other catfish species, America took its share to 13.5 percent (with channel catfish production), leaving 12.3 percent of production in Africa (dominated by North African catfish). Carnivorous species such as perches, basses and snakeheads accounted for only 2.6 percent of all freshwater fish produced in 2010.

Since the beginning of 1990s, more than half of the world production of diadromous fishes has come from salmonids, and the share peaked at 70.4 percent in 2001 before declining slightly in the face of increased milkfish production in Asia. The production of Japanese and European eels, mostly raised in East Asia and to a much lesser extent in Europe, has remained at about 270 000 tonnes in recent years. Limited

by the supply of seeds, the chances of a significant increase in coming years appear remote. Other eel species have been tested with wild-collected seeds with only limited success. Culture of sturgeons, for meat and for caviar, has risen steadily in Asia, Europe and America although production is still small. An increased number of farming systems with sophisticated equipment requiring high investment have been set up to target caviar production in some countries.

World production of marine fishes is more evenly distributed across the cultured species. However, almost half a million tonnes, or one-quarter of global production, are reported without identifying the species, particularly by a few top producers from Asia. There is evidence that production of European seabass and gilthead seabream has been significantly under-reported in some areas in the Mediterranean.

World aquaculture production of crustaceans in 2010 consisted of freshwater species (29.4 percent) and marine species (70.6 percent). The production of marine species is dominated by white leg shrimp (*Penaeus vannamei*), including substantial production in freshwater. In sharp contrast, the giant tiger prawn has lost importance in the last decade. Major freshwater species include red swamp crayfish, Chinese mitten crab, oriental shrimp and giant river prawn.

Regarding molluscs, aquaculture production of clams and cockles has increased much faster than that of other species groups. In 1990, clam and cockle production was half that of oysters, but by 2008 it exceeded oysters and became the most-produced species group of molluscs. Among other aquatic animals, production of sea cucumbers and soft-shell turtles has increased rapidly.

Use of aquatic species in aquaculture production

The number of species recorded in FAO aquaculture production statistics increased to 541 species and species groups in 2010, including 327 finfishes (5 hybrids), 102 molluscs, 62 crustaceans, 6 amphibians and reptiles, 9 aquatic invertebrates and 35 algae. The increase reflects improvements in data collection and reporting at the international and national levels, as well as the farming of new species, including hybrids. In view of the high degree of species aggregation reported by many countries, it is estimated that aquaculture production worldwide uses about 600 aquatic food fish and algae species.

Exotic aquatic species have been widely introduced and used for mass production in aquaculture, and their use is particularly common and important in Asian countries. Successful internationally introduced species for finfishes include tilapias from Africa (especially Nile tilapia), Chinese carps (silver carp, bighead carp and grass carp), Atlantic salmon (*Salmo salar*), *Pangasius* catfishes (*Pangasius* spp.), largemouth black bass (*Micropterus salmoides*), turbot (*Scophthalmus maximus*), piarapatinga (*Piaractus brachypomus*), pacu (*Piaractus mesopotamicus*), and rainbow trout (*Oncorhynchus mykiss*).

Measured by production, white leg shrimp is the most successful internationally introduced marine crustacean species for aquaculture. In 2010, it accounted for 71.8 percent of world production of all farmed marine shrimp species, of which 77.9 percent was produced in Asia (with the rest in its native home in America). Some shrimp-farming countries maintain bans on the farming of this exotic species, and Bangladeshi shrimp growers and seafood exporters have recently requested a lifting of the ban. Red swamp crayfish (*Procambarus clarkii*) from North America and giant river prawn (*Macrobrachium rosenbergii*) from South and Southeast Asia have also become important for freshwater culture in countries foreign to these species.

A significant part of the global production of marine molluscs, particularly in Europe and America, relies on the widely introduced Japanese carpet shell (*Ruditapes philippinarum*, also known as Manila clam) and Pacific cupped oyster (*Crassostrea gigas*). China now produces large quantities of Atlantic bay scallop (*Argopecten irradians*) and Yesso scallop (*Patinopecten yessoensis*).

A considerable number of hybrids, most notably of finfish, are used in aquaculture, especially in countries with a relatively high level of development in aquaculture technologies. Commercially farmed hybrids include: sturgeons (such as beluga *Huso huso* x starlet sturgeon *Acipenser ruthenus* known as "bester") in Asia and Europe;

Figure 10

Production of major species or species group from aquaculture in 2010

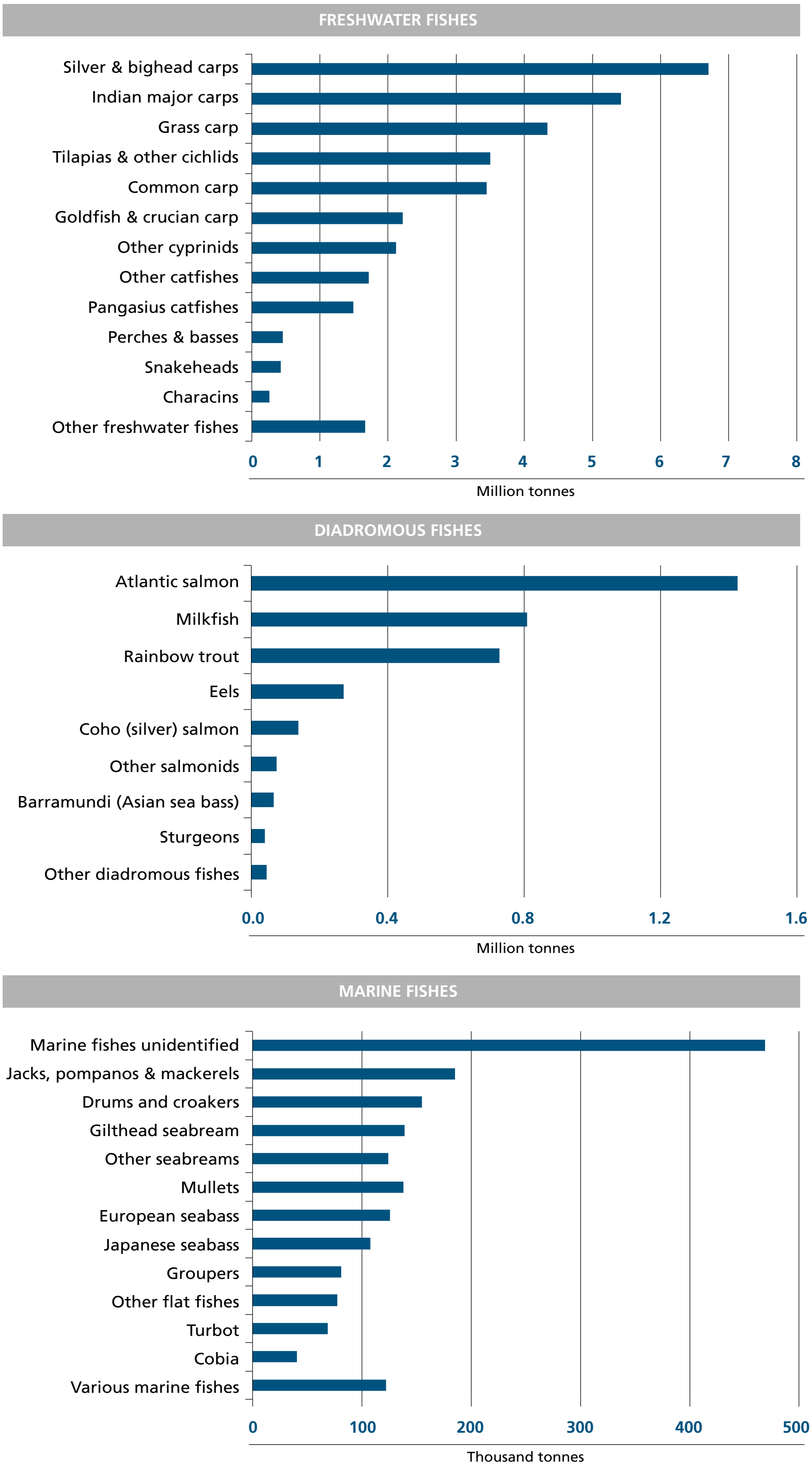
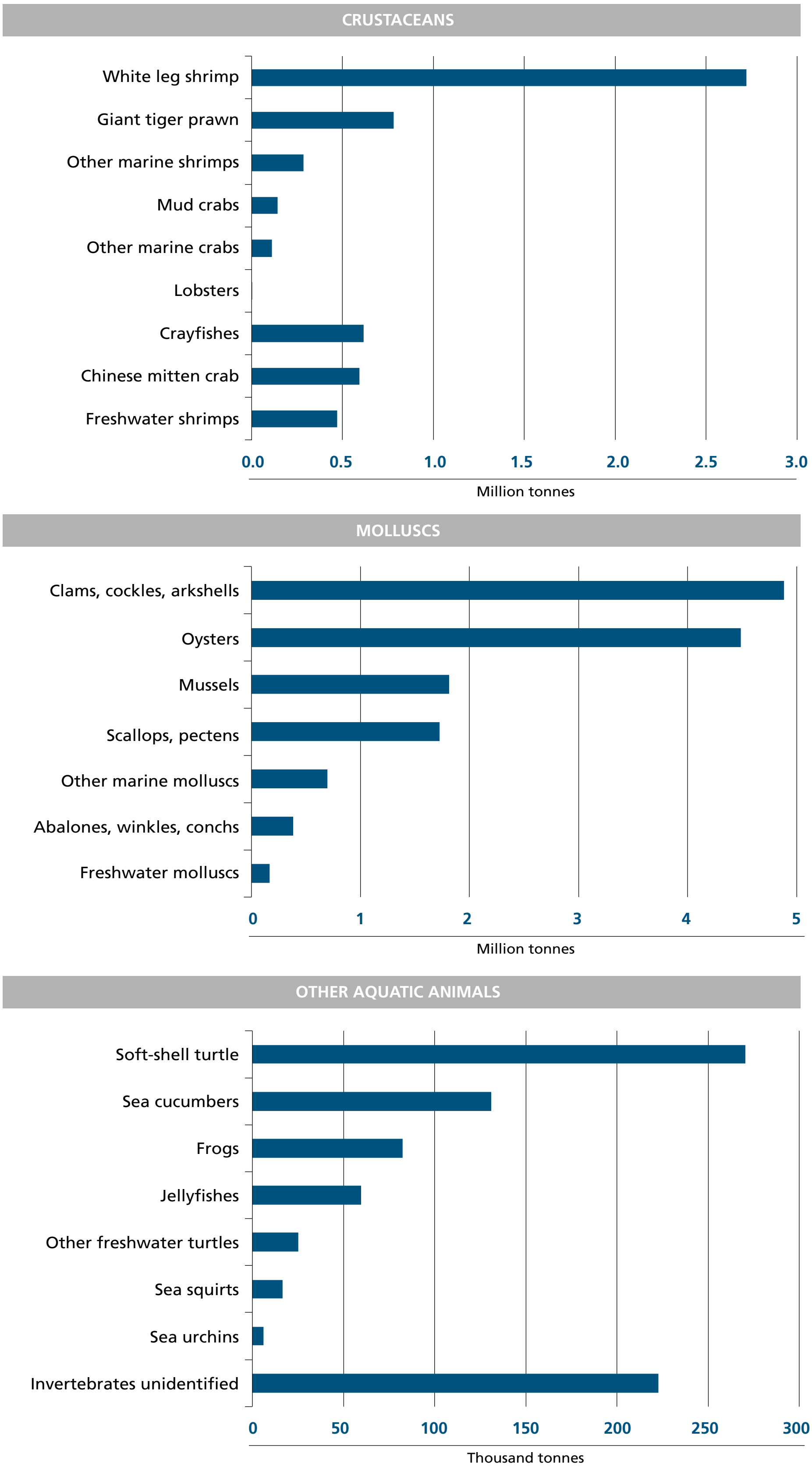


Figure 10 *(cont.)*

Production of major species or species group from aquaculture in 2010



Carassius spp., snakeheads and groupers in China; characins in South America; and freshwater catfishes (*Clarias gariepinus* x *Heterobrachus longifilis*) in Africa and Europe. The culture of hybrid tilapias is particularly common around the world. The hybrid of *Oreochrom aureus* x *O. niloticus* (with a high percentage of male offspring) is farmed in China, and the saline-resistant hybrid of *O. niloticus* x *O. mossambicus* in the Philippines.

Five finfish hybrids have been recorded with national production statistics and FAO estimates, indicating world production levels in 2010 of 333 300 tonnes of blue and Nile tilapia hybrid (*Oreochrom aureus* x *O. niloticus*, in China and in Panama), 116 900 tonnes of *Clarias* catfish hybrid (*Clarias gariepinus* x *C. macrocephalus*, in Thailand), 21 600 tonnes of "tambacu" hybrid (*Piaractus mesopotamicus* x *Colossoma macropomum*, in Brazil), 4 900 tonnes of "tambatinga" hybrid (*Colossoma macropomum* x *Piaractus brachypomus*, in Brazil) and 4 200 tonnes of striped bass hybrid (*Morone chrysops* x *M. saxatilis*, in the United States of America, Italy and Israel).

Aquatic plant (algae) production

To date, only aquatic algae have been recorded globally in farmed aquatic plant production statistics. Global production has been dominated by marine macroalgae, or seaweeds, grown in both marine and brackish waters.

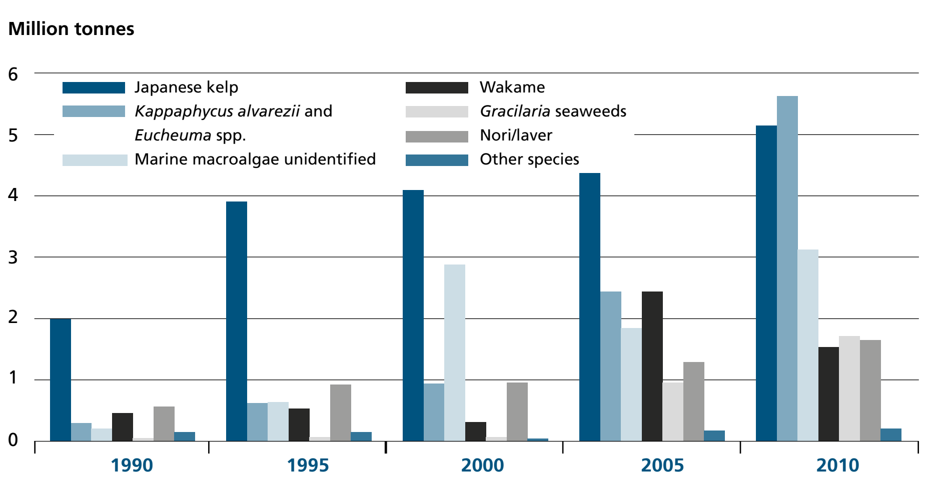
Aquatic algae production by volume increased at average annual rates of 9.5 percent in the 1990s and 7.4 percent in the 2000s – comparable with rates for farmed aquatic animals – with production increasing from 3.8 million tonnes in 1990 to 19 million tonnes in 2010. Cultivation has overshadowed production of algae collected from the wild, which accounted for only 4.5 percent of total algae production in 2010.

Following downward adjustments by FAO of the estimated value of several major species from a few major producers with incomplete reported data, the estimated total value of farmed algae worldwide has been reduced for a number of years in the time series. The total value of farmed aquatic algae in 2010 is estimated at US$5.7 billion, while that for 2008 is now re-estimated at US$4.4 billion.

As shown in Figure 11, a few species dominate algae culture, with 98.9 percent of world production in 2010 coming from Japanese kelp (*Saccharina/Laminaria japonica*) (mainly in the coastal waters of China), *Eucheuma* seaweeds (a mixture of *Kappaphycus alvarezii*, formerly known as *Eucheuma cottonii*, and *Eucheuma* spp.), *Gracilaria* spp., nori/laver (*Porphyra spp.*), wakame (*Undaria pinnatifida*) and unidentified marine macroalgae species (3.1 million tonnes, mostly from China). The remainder consists of

Figure 11

World production of farmed aquatic plant (algae) by major species or species group



marine macroalgae species farmed in small quantities (such as *Fusiform sargassum* and *Caulerpa* spp.) and microalgae cultivated in freshwater (mostly *Spirulina* spp., plus a small fraction of *Haematococcus pluvialis*). The production increase is most obvious in the farming of *Eucheuma* seaweeds. The 2000 production value for unidentified marine macroalgae shown in Figure 11 contains a significant portion of wakame, which was not separately reported by the main producer.

In sharp contrast to fish aquaculture, the cultivation of aquatic algae is practised in far fewer countries. Only 31 countries and territories are recorded with algae farming production in 2010, and 99.6 percent of global cultivated algae production comes from just eight countries: China (58.4 percent, 11.1 million tonnes), Indonesia (20.6 percent, 3.9 million tonnes), the Philippines (9.5 percent, 1.8 million tonnes), the Republic of Korea (4.7 percent, 901 700 tonnes), Democratic People's Republic of Korea (2.3 percent, 444 300 tonnes), Japan (2.3 percent, 432 800 tonnes), Malaysia (1.1 percent, 207 900 tonnes) and the United Republic of Tanzania (0.7 percent, 132 000 tonnes).

FISHERS AND FISH FARMERS

Millions of people around the world find a source of income and livelihood in the fisheries sector. The most recent estimates (Table 7) indicate that in 2010 there were 54.8 million people engaged in the primary sector of capture fisheries and aquaculture. Of these, an estimated 7 million people were occasional fishers and fish farmers (of whom 2.5 million in India, 1.4 million in China, 0.9 million in Myanmar, and 0.4 million each in Bangladesh and Indonesia).

More than 87 percent of all people employed in the fisheries sector in 2010 were in Asia, followed by Africa (more than 7 percent), and Latin America and the Caribbean (3.6 percent). Approximately 16.6 million (about 30 percent of all people employed in the fisheries sector) were engaged in fish farming, and they were even more concentrated in Asia (97 percent), followed by Latin America and the Caribbean (1.5 percent), and Africa (about 1 percent).

In the period 2005–2010, employment in the fisheries sector continued to grow faster (at 2.1 percent per year) than the world's population (at 1.2 percent per year)

Table 7
World fishers and fish farmers by region

	1990	1995	2000	2005	2010
	(Thousands)				
Africa	1 917	2 184	3 899	3 844	3 955
Asia	26 765	31 328	36 752	42 937	47 857
Europe	645	529	752	678	634
Latin America and the Caribbean	1 169	1 201	1 407	1 626	1 974
North America	385	376	343	342	342
Oceania	67	69	74	74	76
World	**30 948**	**35 687**	**43 227**	**49 502**	**54 838**
Of which fish farmers[1]					
Africa	2	61	84	124	150
Asia	3 772	7 050	10 036	12 228	16 078
Europe	32	57	84	83	85
Latin America and the Caribbean	69	90	191	218	248
North America	…	…	…	4	4
Oceania	2	4	5	5	6
World	**3 877**	**7 261**	**10 400**	**12 661**	**16 570**

Note: … = data not available.
[1] Estimates for 1990 and, partly, for 1995 were based on data available for a smaller number of countries and, therefore, may not be fully comparable with those for later years.

and than employment in the traditional agriculture sector (at 0.5 percent per year). The 54.8 million fishers and fish farmers in 2010 represented 4.2 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide, compared with 2.7 percent in 1990.

However, the relative proportion of those engaged in capture fisheries within the sector actually decreased from 87 percent in 1990 to 70 percent in 2010, while the proportion of those engaged in fish farming increased from 13 to 30 percent (Figure 12). In fact, in the last five years for which data are available, the number of people engaged in fish farming has increased at 5.5 percent per year compared with a mere 0.8 percent per year for those engaged in capture fisheries. It is apparent that, in the most important fishing nations, the share of employment in capture fisheries is stagnating or decreasing while aquaculture is providing increased opportunities. Moreover, as many countries still do not report employment data separately for the capture and farming sectors, the relative importance of employment in aquaculture may be underestimated.

The trends in employment vary according to the regions. Europe experienced the largest decrease in the number of people engaged in capture fishing with a 2 percent average annual decline between 2000 and 2010, and almost no increase in people employed in fish farming in the same period. In contrast, Africa showed the highest annual increase (5.9 percent) in the number of people engaged in fish farming in the last decade, followed by Asia (4.8 percent), and Latin America and the Caribbean (2.6 percent).

Table 8 presents the employment statistics for selected countries, including China, where almost 14 million people (26 percent of the world total) are engaged as fishers and fish farmers. In general, employment in fishing has been decreasing in capital-intensive economies, in particular in most European countries, North America, and Japan. For example, in the period 1990–2010, the number of people employed in marine fishing decreased by 53 percent in the United Kingdom of Great Britain and Northern Ireland, by 45 percent in Japan, by 40 percent in Norway, and by 28 percent in Iceland. Several factors may account for this, including the application of policies to reduce overcapacity and less reliance on human power owing to technological developments.

Table 9 compares per capita annual productivity in the capture fisheries and aquaculture primary sector for each region. Overall, average annual production per person is consistently lower in capture fisheries than in aquaculture, with global outputs of 2.3 and 3.6 tonnes per person per year, respectively.

Figure 12

Employment in the fisheries sector for the period 1990–2010

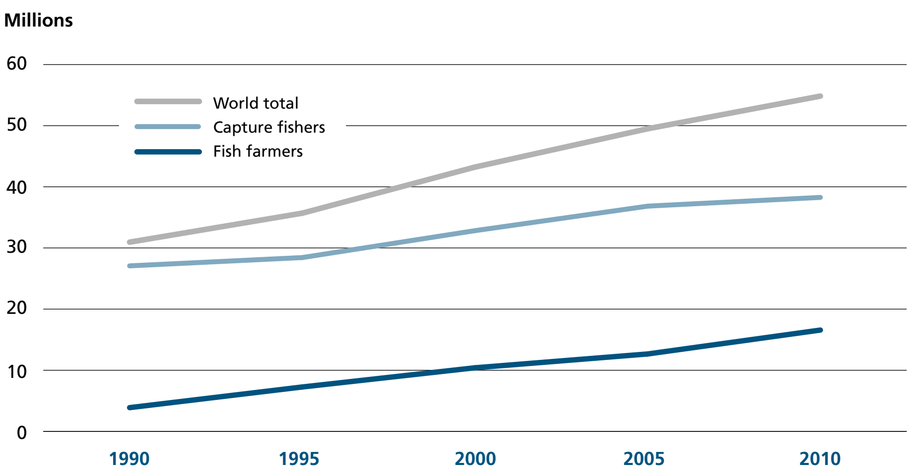


Table 8
Number fishers and fish farmers in selected countries and territories

	Fishery		1990	1995	2000	2005	2010
WORLD	FI + AQ	(number)	**30 948 446**	**35 687 357**	**43 227 132**	**49 502 314**	**54 838 257**
		(index)	***72***	***83***	***100***	***115***	***127***
	FI	(number)	27 071 570	28 426 245	32 826 719	36 841 044	38 268 197
		(index)	*82*	*87*	*100*	*112*	*117*
	AQ	(number)	3 876 876	7 261 112	10 400 413	12 661 270	16 570 060
		(index)	*37*	*70*	*100*	*122*	*159*
China	FI + AQ	(number)	11 173 463	11 428 655	12 935 689	12 902 777	13 992 142
		(index)	*86*	*88*	*100*	*100*	*108*
	FI	(number)	9 432 464	8 759 162	9 213 340	8 389 161	9 013 173
		(index)	*102*	*95*	*100*	*91*	*98*
	AQ	(number)	1 740 999	2 669 493	3 722 349	4 513 616	4 978 969
		(index)	*47*	*72*	*100*	*121*	*134*
Taiwan Province of China	FI + AQ	(number)	325 902	302 161	314 099	351 703	330 181
		(index)	*104*	*96*	*100*	*112*	*105*
	FI	(number)	232 921	204 149	216 501	246 580	246 659
		(index)	*108*	*94*	*100*	*114*	*114*
	AQ	(number)	92 981	98 012	97 598	105 123	83 522
		(index)	*95*	*100*	*100*	*108*	*86*
Iceland	FI	(number)	6 951	7 000	6 100	5 100	5 000
		(index)	*114*	*115*	*100*	*84*	*82*
Indonesia	FI + AQ	(number)	3 617 586	4 568 059	5 247 620	5 096 978	5 971 725
		(index)	*69*	*87*	*100*	*97*	*114*
	FI	(number)	1 995 290	2 463 237	3 104 861	2 590 364	2 620 277
		(index)	*64*	*79*	*100*	*83*	*84*
	AQ	(number)	1 622 296	2 104 822	2 142 759	2 506 614	3 351 448
		(index)	*76*	*98*	*100*	*117*	*156*
Japan	FI	(number)	370 600	301 440	260 200	222 160	202 880
		(index)	*142*	*116*	*100*	*85*	*78*
Mexico	FI + AQ	(number)	242 804	249 541	262 401	279 049	271 608
		(index)	*93*	*95*	*100*	*106*	*104*
	FI	(number)	242 804	249 541	244 131	255 527	240 855
		(index)	*99*	*102*	*100*	*105*	*99*
	AQ	(number)	…	…	18 270	23 522	30 753
		(index)	…	…	*100*	*129*	*168*
Morocco	FI	(number)	56 000	99 885	106 096	105 701	107 296
		(index)	*53*	*94*	*100*	*100*	*101*
Norway	FI + AQ	(number)	24 979	21 776	18 589	18 776	17 667
		(index)	*134*	*117*	*100*	*101*	*95*
	FI	(number)	20 475	160 17	262 14	554 14	280 12
		(index)	*144*	*120*	*100*	*102*	*86*
	AQ	(number)	4 504	4 616	4 327	4 222	5 387
		(index)	*104*	*107*	*100*	*98*	*124*
Peru[1]	FI + AQ	(number)	43 750	62 930	93 789	95 426	99 000
		(index)	*47*	*67*	*100*	*102*	*106*
	FI	(number)	43 750	60 030	87 524	86 755	90 000
		(index)	*50*	*69*	*100*	*99*	*103*
	AQ	(number)	…	2 900	6 265	8 671	9 000
		(index)	…	*46*	*100*	*138*	*144*
United Kingdom	FI	(number)	21 582	19 986	15 649	12 647	10 129
		(index)	*138*	*128*	*100*	*81*	*65*

Note: FI = fishing, AQ = aquaculture; index: 2000 = 100; … = data not available.
[1] Data for 2010 are FAO estimates.

Box 3

Child labour – an important issue also in fisheries and aquaculture

Child labour is a great concern in many parts of the world. In 2008, some 60 percent of the 215 million boys and girls estimated to be child labourers worldwide were engaged in the agriculture sector, including in fisheries, aquaculture, livestock and forestry.[1] In addition to work interfering with schooling and harming personal development in other ways, many of these children work in hazardous occupations or activities that threaten their health and sometimes their lives. They do work that they should not do according to international conventions and/or national legislation, and this situation endangers not only the children themselves but also efforts at poverty alleviation and sustainable development in a larger sense for their families and communities.

However, tackling child labour is no easy task. The occurrence of child labour is entwined in poverty and social injustices and cannot be addressed in isolation. Moreover, some types of work are not harmful but can even be beneficial for children. While it may be relatively easy to identify and agree to eliminate the "worst forms of child labour", the distinction between "acceptable work" and "harmful labour" is not always clear and assessments can be muddled by local and traditional practices and beliefs. There is a need to exercise due care in analysing existing situations, in applying existing conventions, legislation and guidelines, and in raising the awareness and understanding of child labour issues in order to ensure that they are directly addressed as well as integrated into broader policies and programmes. Improvements have proved possible and the overall number of child labourers in the world has declined since 2000.

Information on child labour in fisheries and aquaculture is limited, and data on agriculture child labour are not generally disaggregated by subsector. Nevertheless, case studies and specific surveys indicate that the numbers are important. Child labour is particularly common in the small-scale informal sector, and children work in a large variety of activities, as part of family enterprises, as unpaid family workers or employed by others. They are found, for example, working on board fishing vessels, preparing nets and baits, feeding and harvesting fish in aquaculture ponds, and sorting, processing and selling fish.

A number of factors influence whether a task should be considered acceptable work, child labour or "worst form of child labour". With the support of initiatives such as the global International Partnership for Cooperation on Child Labour in Agriculture, launched by key international agricultural organizations in 2007,[2] the knowledge base and guidance on how to classify and tackle child labour in agriculture have improved in the last decade. However, there is still an urgent need to learn more about child labour also in fisheries and aquaculture and to address the specific situations.

In April 2010, FAO, in cooperation with the International Labour Organization (ILO), organized a workshop[3] to generate inputs and guidance to the contents and process of developing guidance materials on policy and practice in tackling child labour in fisheries and aquaculture. In order to promote awareness on and effective implementation of the relevant UN and ILO conventions on child labour and the rights of the child, the workshop participants:

- reviewed the nature, incidence and causes of child labour in fisheries, fish processing and aquaculture;
- examined the different forms and types of child labour in large-scale, small-scale and artisanal fishing operations, shellfish gathering, aquaculture, seafood processing, and work onboard fishing vessels and fishing platforms;
- examined the health and safety hazards of fishing and aquaculture, including the use of hazardous technologies and relevant alternatives;
- shared examples of good practice in the progressive elimination of child labour drawn from various sectors and regions.

The workshop participants agreed on a series of recommendations relating to legal and enforcement measures, policy interventions and practical actions, including risk assessments, to address child labour issues in fisheries and aquaculture. FAO and ILO were called upon for priority actions to assist governments in withdrawing trafficked children and to effectively prohibit slavery and forced labour. The workshop participants also prioritized awareness raising among all stakeholders and the preparation of guidance materials. In addition, they stressed the need to consider gender issues in all actions and to address adequately issues relating to discrimination and exclusion of fishing communities, castes, tribal and indigenous peoples, and ethnic minorities in fisheries and aquaculture.

FAO and ILO are collaborating in helping to assess and address child labour issues in countries such as Cambodia and Malawi. They have also produced a preliminary version of a good practice guide for addressing child labour in fisheries and aquaculture.[4]

[1] International Labour Organization. 2010. *Facts on child labour 2010* [online]. Geneva, Switzerland. [Cited 31 March 2012]. www.ilo.org/wcmsp5/groups/public/@dgreports/@dcomm/documents/publication/wcms_126685.pdf

[2] In addition to FAO, other current members of the International Partnership for Cooperation on Child Labour in Agriculture are the International Labour Organization (ILO), International Fund for Agricultural Development, International Food Policy Research Institute of the Consultative Group on International Agricultural Research, International Federation of Agricultural Producers (representing farmers/employers and their organizations), and International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations (representing workers and their organizations). Further information is available on the ILO's Web page on the International Programme on the Elimination of Child Labour (IPEC) at www.ilo.org/ipec/lang--en/index.htm#a1.

[3] FAO. 2010. *FAO workshop on child labour in fisheries and aquaculture in cooperation with ILO* [online]. Rome. [Cited 31 March 2012]. www.fao.org/fileadmin/user_upload/newsroom/docs/Final_recommendationsB.pdf

[4] FAO and International Labour Organization. 2011. *FAO–ILO good practice guide for addressing child labour in fisheries and aquaculture: policy and practice* [online]. [Cited 31 March 2012]. ftp://ftp.fao.org/FI/DOCUMENT/child_labour_FAO-ILO/child_labour_FAO-ILO.pdf

Table 9
Fishery production per fisher or fish farmer by region in 2010

Region	Production[1] per person		
	Capture	Aquaculture	Capture + aquaculture
		(Tonnes/year)	
Africa	2.0	8.6	2.3
Asia	1.5	3.3	2.1
Europe	25.1	29.6	25.7
Latin America and the Caribbean	6.8	7.8	6.9
North America	16.3	183.2	18.0
Oceania	17.0	33.3	18.2
World	**2.3**	**3.6**	**2.7**

[1] Production excludes aquatic plants.

Although 87.3 percent of the world's fishers and fish farmers were in Asia, the region accounted for only 68.7 percent of global production with an average of 2.1 tonnes per person per year in 2010, compared with 25.7 tonnes in Europe, 18.0 tonnes in North America, and 6.9 tonnes in Latin America and the Caribbean. The high productivity of Oceania reflects the contributions mainly of New Zealand and Australia and could be caused by the incomplete statistics provided by many other countries in the region. Production per person is considered to reflect a certain degree of industrialization of fishing activities as well as the relative importance of small-scale operators, especially in Africa and Asia.

The contrast is even more evident for aquaculture production. In 2010, fish farmers in Norway had an average annual production of 187 tonnes per person, while in Chile the corresponding figure was 35 tonnes, in China about 7 tonnes, in India about 4 tonnes, and in Indonesia only about 1 tonne.

As a general global trend, while productivity has dropped slightly from 2.8 to 2.3 tonnes per person in capture production, aquaculture has increased its productivity from 3.1 to 3.6 tonnes per person in the last decade.

Although the information available to FAO does not allow detailed analyses by gender, it is estimated that, overall, women accounted for at least 15 percent of all people directly engaged in the fisheries primary sector in 2010. The proportion of women is considered to be somewhat higher, at least 19 percent, in inland water fishing, and far more important, as high as 90 percent, in secondary activities, such as processing.

As in other sectors, child labour is a cause for concern in the fisheries and aquaculture sector. Therefore, together with other organizations, FAO is working to address this issue (Box 3).

The fisheries and aquaculture sector provides numerous jobs in ancillary activities in addition to fishers and fish farmers, such as processing, packaging, marketing and distribution, manufacturing of fish processing equipment, net and gear making, ice production and supply, boat construction and maintenance. Other people are involved in research, development and administration linked with the fisheries sector. Assuming that for each person directly engaged in fisheries production in 2010 about three to four related jobs were generated in secondary activities, and further assuming that, on average, each jobholder provided for three dependants or family members, then fishers, fish farmers and those supplying services and goods to them would have assured the livelihoods of about 660–820 million people, or about 10–12 percent of the world's population.

THE STATUS OF THE FISHING FLEET

Coverage and quality of data

In 2011, FAO obtained data on national fishing fleets from 138 countries, accounting for 67 percent of the countries involved in capture fisheries. When considering the catch amount together with corresponding fleet size, it is estimated that the reported information accounts for 96 percent of the global fishing fleet. While FAO has estimated the fleet size for another 49 countries for the analysis in this section, no estimation has been made for the remaining 18 countries for which data have never been reported or estimated and whose contribution to the global fishing fleet is considered to be negligible.

Depending on countries, national reports on fleet status may be based on national fishing vessel registers and administrative records that reflect the physical existence of vessels and often include vessels not actually engaged in fishing operations in a certain year. Even for the countries whose statistics correspond to active fishing vessels, there is no information about the extent of their engagement in fishing activities, e.g. full-time, part-time, or occasional. This means that the "fleet size" referred to in this section is only a rough estimate and should not be considered as an indicator for either global fishing capacity or global fishing effort, which in principle should be substantially smaller than those indicated here.

At the same time, data quality varies widely by country from well-maintained, long time series of consistent data to very fragmented records. In general, the data available for marine fishing fleets are of better quality and detail than that available for vessels deployed in inland waters. Moreover, small boats are often not well covered as frequently they are not subject to compulsory registration, especially those used in inland waters.

This year, for the first time, an attempt has been made to separate, to the extent possible, the marine fishing fleet from the fleet operating in inland waters.

Estimate of global fleet and its regional distribution

The total number of fishing vessels in the world was estimated to be about 4.36 million vessels in 2010, a value similar to the previous estimates. The fleet in Asia was the largest, consisting of 3.18 million vessels accounting for 73 percent of the global fleet, followed by Africa (11 percent), Latin America and the Caribbean (8 percent), North America (3 percent) and Europe (3 percent).

Among the global fleet, 3.23 million vessels (74 percent) were considered to operate in marine waters, with the remaining 1.13 million vessels operating in inland waters. The separation between inland and marine fishing fleets was made based on: (i) national reported statistics with sufficient details (e.g. China, Indonesia, and Japan); and (ii) allocation of whole fleets of landlocked countries to inland waters (e.g. Burkina Faso, Burundi, Chad, Kazakhstan, Malawi, Mali, Niger, Uganda, Uzbekistan and Zambia).

This preliminary analysis indicated that the inland fleet represents about 26 percent of the global fleet, but the proportion of vessels operating in inland waters varies substantially depending on the regions (Figure 13), the highest being in Africa (42 percent), followed by Asia (26 percent) and Latin America and the Caribbean (21 percent). Although preliminary, this resolves past confusion as to whether the inland-water operating component was included or excluded in the overall fleet analysis. Further work would be needed to disaggregate components operating specifically in the African Great Lakes.

Globally, 60 percent of fishing vessels were engine-powered in 2010. While 69 percent of vessels operating in marine waters were motorized, the corresponding value for those operating in inland waters was only 36 percent. For the fleet operating in marine waters, there were also large variations among regions, with non-motorized vessels accounting for less than 7 percent of the total in Europe and the Near East, but up to 61 percent in Africa (Figure 14). Although North America has

Figure 13

Proportion of fishing vessels in marine and inland waters by region in 2010

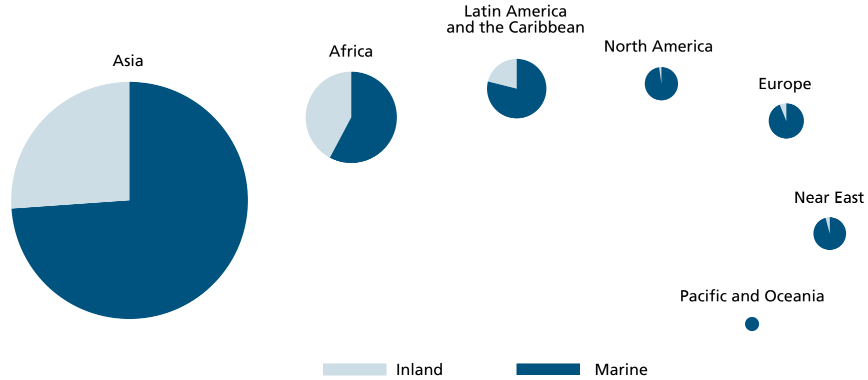


Figure 14

Proportion of marine fishing vessels with and without engine by region in 2010

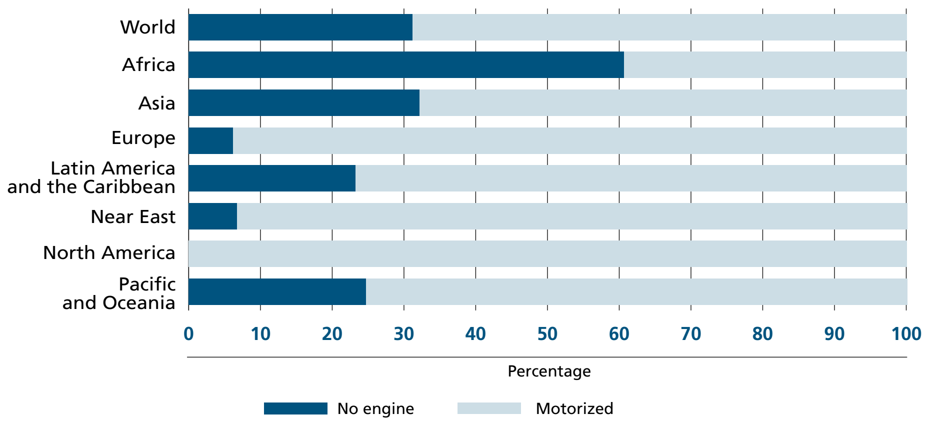
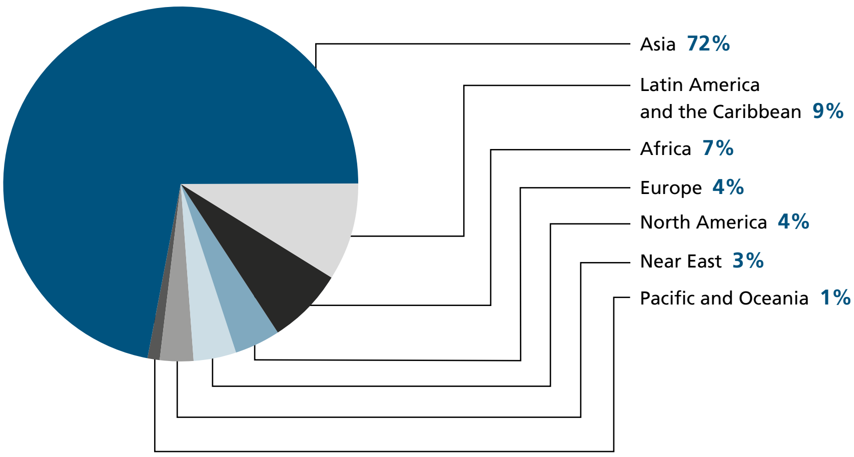


Figure 15

Distribution of motorized fishing vessels by region in 2010



no report of non-motorized vessels, this could be a reflection of the data collection systems in use there.

Globally, the motorized fishing fleet is distributed unevenly among regions. The vast majority of motorized vessels (72 percent) were reported from Asia (Figure 15), with the rest from Latin America and the Caribbean (9 percent), Africa (7 percent), North America (4 percent), and Europe (4 percent).

Size distribution and the importance of small boats

In 2010, more than 85 percent of the motorized fishing vessels in the world were less than 12 m LOA. Such vessels dominated in all regions, particularly the Near East, and Latin America and the Caribbean (Figure 16). About 2 percent of all motorized fishing vessels corresponded to industrialized fishing vessels of 24 m and larger (with a GT of roughly more than 100 GT) and that fraction was larger in the Pacific and Oceania region, Europe, and North America. A segment of the industrialized fishing fleet mentioned above is registered with unique identification numbers provided by the International Maritime Organization (IMO), whose list included more than 22 000 active fishing vessels by the end of 2010.

While the bulk of the global fishing fleet is composed of small-sized vessels (less than 12 m LOA), this is the component for which reliable information is least available. Such is particularly the case in Africa, parts of Asia and the Americas. In many cases, vessels smaller than a certain size are not subject to national registration or are only subject to local registries that might not be reflected in national statistics. In addition, fishing fleets operating in inland waters usually consist mostly of vessels of less than 12 m LOA, which are commonly not subject to either national or local registries and are often omitted from most analyses, particularly in developing countries. Therefore, estimations of the relative importance of the small-scale and industrial components of fisheries for social, economic, and food security purposes are then likely to be skewed owing to inadequate appraisal of the small-scale segment. In Africa, and in Latin America and the Caribbean, small vessels constitute a vast sector of artisanal and subsistence fisheries on which the livelihoods of a great number of fisher households depend.

Table 10 illustrates some examples of the relevance of small motorized vessels for selected countries in different regions. The proportion of vessels of less than 12 m LOA exceeds 90 percent in most cases. In addition, an estimated 98 percent of non-motorized fishing vessels would be less than 12 m LOA.

Figure 16

Size distribution of fishing vessels by region in 2010

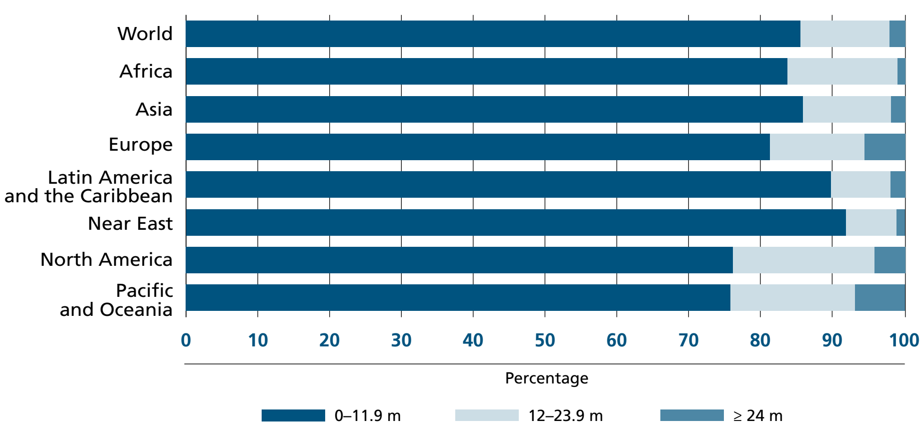


Table 10

Proportion in terms of length of motorized vessels in fishing fleets from selected nations in different regions

Flag	Date of data	Powered vessels	Vessel length category		
			0–11.9 m	12–23.9 m	≥ 24 m
		(Number)		(Percentage)	
Angola[1]	2009	7 767	95.00	4.70	0.30
Cameroon[1]	2009	8 669	82.90	16.50	0.60
Mauritius[1]	2010	1 474	98.20	1.20	0.60
Morocco[1]	2010	19 207	89.70	8.80	1.50
Tunisia[1]	2010	5 705	75.20	20.00	4.80
Subtotal for selected countries in Africa		**42 822**	**87.90**	**9.00**	**3.10**
Bahrain[1]	2010	2 727	90.40	9.60	0.00
Oman[1]	2010	15 349	96.50	3.20	0.30
Syrian Arab Republic[1]	2010	1 663	95.60	4.00	0.40
Subtotal for selected countries in Near East		**19 739**	**95.60**	**4.10**	**0.30**
Bangladesh[1]	2010	21 097	99.20	0.20	0.70
China					
China (marine)[2]	2010	204 456	68.60	20.60	10.80
China (inland)[2]	2010	226 535	88.50	11.10	0.40
Taiwan Province of China[1]	2009	20 654	67.00	24.00	8.90
Myanmar[1]	2010	15 865	88.10	8.40	3.60
Republic of Korea[1]	2010	74 669	90.40	7.60	2.00
Subtotal for selected countries in Asia		**563 276**	**81.10**	**14.10**	**4.80**
EU-27, selected countries in Europe[3]	**2010**	**78 138**	**82.20**	**13.70**	**4.10**
Fiji[1]	2010	2 185	96.90	1.40	1.60
French Polynesia[1]	2010	3 429	98.20	1.70	0.10
New Caledonia[1]	2010	318	93.40	4.70	1.90
New Zealand[1]	2010	1 401	61.20	32.20	6.60
Tonga[1]	2010	951	98.30	1.30	0.40
Subtotal for selected countries in Oceania		**8 284**	**91.50**	**6.80**	**1.70**

[1] Response to FAO questionnaires.
[2] Bureau of Fisheries, Ministry of Agriculture. 2011. *China Fishery Statistical Yearbook 2011*. Beijing.
[3] European Commission. 2012. Fleet Register On the NeT. In: *Europa* [online]. [Cited 13 April 2012]. http://ec.europa.eu/fisheries/fleet/index.cfm?method=Download.menu

Continuous efforts are being made in Africa (in collaboration with regional and subregional fisheries organizations such as the Fishery Committee for the Eastern Central Atlantic [CECAF], Regional Fisheries Committee for the Gulf of Guinea, Fishery Committee for the West Central Gulf of Guinea, and Southwest Indian Ocean Fisheries Commission [SWIOFC]) as well as in Central America (in collaboration with the Organization of Fishing and Aquaculture in Central America) to establish vessel registers as part of fishery resources management plans and policies. Frame surveys and fisheries censuses have already yielded invaluable information, but it may require some time before reflect the results of these efforts are reflected in the official statistics.

Effect of efforts to reduce overcapacity in fishing fleets

In response to the International Plan of Action for the Management of Fishing Capacity, several countries have tried establishing targets for the reduction of national overcapacity of fishing fleets. While the numbers of fishing vessels have been decreasing in some parts of the world in recent years, they have being increasing elsewhere.

Table 11
Motorized fishing fleets in selected countries, 2000–2010[1]

	2000	2005	2007	2008	2009	2010
CHINA						
All fisheries vessels[2]						
number	487 297	513 913	576 996	630 619	672 633	675 170
tonnage GT	6 849 326	7 139 746	7 806 935	8 284 092	8 595 260	8 801 975
power kW[3]	14 257 891	15 861 838	17 648 120	19 507 314	20 567 968	20 742 025
Marine fishing only						
number	–	–	207 353	199 949	206 923	204 456
tonnage GT	–	–	5 527 675	5 776 472	5 838 599	6 010 919
power kW	–	–	12 394 224	12 950 657	13 058 326	13 040 623
Inland fishing only						
number	–	–	172 836	216 571	223 912	226 535
tonnage GT	–	–	835 625	936 774	1 027 500	1 044 890
power kW	–	–	1 940 601	2 908 697	3 382 505	3 473 648
JAPAN						
Marine fishing only						
number	337 600	308 810	296 576	289 456	281 742	–
tonnage GT	1 447 960	1 269 130	1 195 171	1 167 906	1 112 127	–
power kW	11 450 612	12 271 130	12 662 088	12 861 317	12 945 101	–
Inland fishing only						
number	9 542	8 522	8 199	8 422	8 156	–
tonnage GT	9 785	8 623	8 007	8 261	7 978	–
power kW	180 930	209 257	198 098	220 690	219 443	–
EU-15[4]						
number	86 660	77 186	74 597	72 528	72 011	71 295
tonnage GT	2 019 329	1 832 362	1 750 433	1 694 280	1 654 283	1 585 288
power kW	7 632 554	6 812 255	6 557 295	6 343 379	6 243 802	6 093 335
ICELAND						
number	1 993	1 752	1 642	1 529	1 582	1 625
tonnage GT	180 150	181 530	169 279	159 627	158 253	152 401
power kW	522 876	520 242	502 289	471 199	472 052	466 691
NORWAY						
number	13 017	7 722	7 038	6 785	6 510	6 310
tonnage GT	392 316	373 282	354 833	363 169	367 688	366 126
power kW	1 321 624	1 272 965	1 249 173	1 240 450	1 252 813	1 254 129
REPUBLIC OF KOREA						
number	89 294	87 554	82 796	78 280	75 247	74 669
tonnage GT	917 963	697 956	661 519	619 098	592 446	598 367
power kW	10 139 415	9 656 408	10 702 733	9 755 438	9 955 334	9 953 809

[1] Some vessels may not be measured according to the 1969 International Convention on Tonnage Measurement of Ships.
[2] Includes all vessels involved in the fisheries sector, such as capture, aquaculture, support and surveillance, in both inland and marine waters.
[3] All power units standardized to kW.
[4] Combined fleets from Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdom.

Sources:
China: Bureau of Fisheries, Ministry of Agriculture. 2011. *China Fishery Statistical Yearbook 2011*. Beijing.
Japan: Fisheries Agency, Government of Japan. 2009. *Statistical Tables of Fishing Vessels.* General Report No. 62.
EU-15: European Commission. 2012. Fleet Register On the NeT. In: Europa [online]. [Cited 13 April 2012]. http://ec.europa.eu/fisheries/fleet/index.cfm?method=Download.menu; and European Commission. 2012. Main tables. In: *Eurostat* [online]. [Cited 13 April 2012]. http://epp.eurostat.ec.europa.eu/portal/page/portal/fisheries/data/main_tables
Iceland: Response to FAO questionnaires; European Commission. 2012. Main tables. In: *Eurostat* [online]. [Cited 13 April 2012]. http://epp.eurostat.ec.europa.eu/portal/page/portal/fisheries/data/main_tables; and Statistics Iceland. 2012. Fishing vessels. In: *Statistics Iceland* [online]. [Cited 13 April 2012]. www.statice.is/Statistics/Fisheries-and-agriculture/Fishing-vessels
Norway: Response to FAO questionnaires; European Commission. 2012. Main tables. In: *Eurostat* [online]. [Cited 13 April 2012]. http://epp.eurostat.ec.europa.eu/portal/page/portal/fisheries/data/main_tables; and Statistics Norway. 2012. Fisheries. In: *Statistics Norway* [online]. [Cited 13 April 2012]. http://statbank.ssb.no/statistikkbanken/Default_FR.asp?PXSid=0&nvl=true&PLanguage=1&tilside=selecttable/hovedtabellHjem.asp&KortnavnWeb=fiskeri
Republic of Korea: Response to FAO questionnaires, national authorities.

When considering measures to limit fleet capacity, decisions will have to evaluate relative contributions and, therefore, the priority in capacity reduction of the industrial component and the small-scale component. When deciding on such policies, many nations are faced with difficult dilemmas, as not only fishery resources but also social and economic issues are at stake.

Data from some countries indicate a continuous expansion of their fleets. For example, the motorized fishing fleet in Cambodia increased by 19 percent from 38 960 vessels in 2007 to 46 427 in 2009. Indonesia's motorized marine fleet increased by 11 percent from 348 425 fishing vessels in 2007 to 390 770 in 2009. Viet Nam reported a 10 percent increase in offshore fishing vessels (those with engines of more than 90 hp) from a total of 22 729 in 2008 to 25 346 in 2010, and Malaysia reported a 26 percent increase from 24 048 licensed motorized fishing vessels in 2007 to 30 389 in 2009. The case of Sri Lanka illustrates the potential overshoot in efforts to re-establish a fishing fleet partly destroyed by the tsunami that swept the region at the end of 2004. The pre-tsunami fishing fleet numbered 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 23 400 and by 2010 had increased even further to 25 973 motorized fishing vessels; a net increase of 11 percent for the whole period.

Table 11 provides summary details of motorized fleets for several major fishing nations. In 2008–2010, the combined total captures of these countries represented about 33 percent of the world total capture.

China's 2003–2010 marine fishing vessel reduction plan was aimed at achieving a marine fishing fleet of 192 390 vessels with a total combined power of 11.4 million kW. The statistics available indicate that, up to 2008, China did achieve a reduction with 199 949 vessels and 12.95 million kW, still short of the target by about 4 percent for the number of vessels and 13 percent for combined power. However, after 2008, both the number of vessels and total combined power started to increase again.

Japan implemented various schemes in order to reduce its fishing fleet, which resulted in a net reduction of 9 percent in the number of vessels, but a net increase of 5 percent in combined power between 2005 and 2009. In fact, while the number of vessels declined, the mean engine power conversely increased, from 40 kW to 46 kW in the same period.

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 European Union policies. The evolution in the combined number, tonnage, and power of European Union fishing vessels indicates a downward tendency in the last decade. The combined EU-15 motorized fishing fleet achieved a net reduction of 8 percent in number of vessels, and of 11 percent in power between 2005 and 2010. For this same period, mean engine power also decreased slightly from 88 kW to 85 kW.

Other examples of net reduction in fleet for important fishing nations in the period 2005–2010 include Iceland (with a net reduction of 7 percent in the number of vessels and 10 percent in total combined power) and Norway (with a net reduction of 18 percent in the number of vessels but a mere 1.5 percent decrease in total combined power, and increased mean engine power from 165 kW to 199 kW. In a different region, the Republic of Korea achieved a net reduction of 15 percent in the number of vessels but a 3 percent increase in combined power, resulting in the mean engine power increasing from 110 kW to 133 kW for the same period.

THE STATUS OF FISHERY RESOURCES

Marine fisheries

The world's marine fisheries have experienced different stages, increasing from 16.8 million tonnes in 1950 to a peak of 86.4 million tonnes in 1996, and then declining to stabilize at about 80 million tonnes, with interannual fluctuations. Global recorded production was 77.4 million tonnes in 2010. Of the marine areas (Figure 17), the Northwest Pacific had the highest production with 20.9 million tonnes

(27 percent of the global marine catch) in 2010, followed by the Western Central Pacific with 11.7 million tonnes (15 percent), the Northeast Atlantic with 8.7 million tonnes (11 percent), and the Southeast Pacific, with a total catch of 7.8 million tonnes (10 percent).

The proportion of non-fully exploited[7] stocks has decreased gradually since 1974 when the first FAO assessment was completed (Figure 18). In contrast, the percentage of overexploited stocks increased, especially in the late 1970s and 1980s, from 10 percent in 1974 to 26 percent in 1989. After 1990, the number of overexploited stocks continued to increase, albeit at a slower rate. The fraction of fully exploited stocks demonstrates the smallest change over time. Its percentage was stable at about 50 percent from 1974 to 1985, then dropped to 43 percent in 1989 before gradually increasing to 57.4 percent in 2009.

By definition, the fully exploited stocks produce catches that are at or very close to their maximum sustainable production. Therefore, they have no room for further expansion in catch, and may even be at some risk of decline unless properly managed. Among the remaining stocks, 29.9 percent were overexploited, and 12.7 percent non-fully exploited in 2009. Overexploited stocks produce lower yields than their biological and ecological potential. They require strict management plans to rebuild stock abundance and restore full and sustainable productivity. The Johannesburg Plan of Implementation that resulted from the World Summit on Sustainable Development (Johannesburg, 2002) demands that all these stocks be restored to the level that can produce maximum sustainable yield by 2015.[8] The non-fully exploited stocks are under relatively low fishing pressure and have some potential to increase their production. However, these stocks often do not have a high production potential. The potential for increase in catch may be generally limited. Nevertheless, proper management plans should be established before increasing the exploitation rate of these non-fully exploited stocks in order to avoid following the same track of overfishing as many currently overexploited stocks.

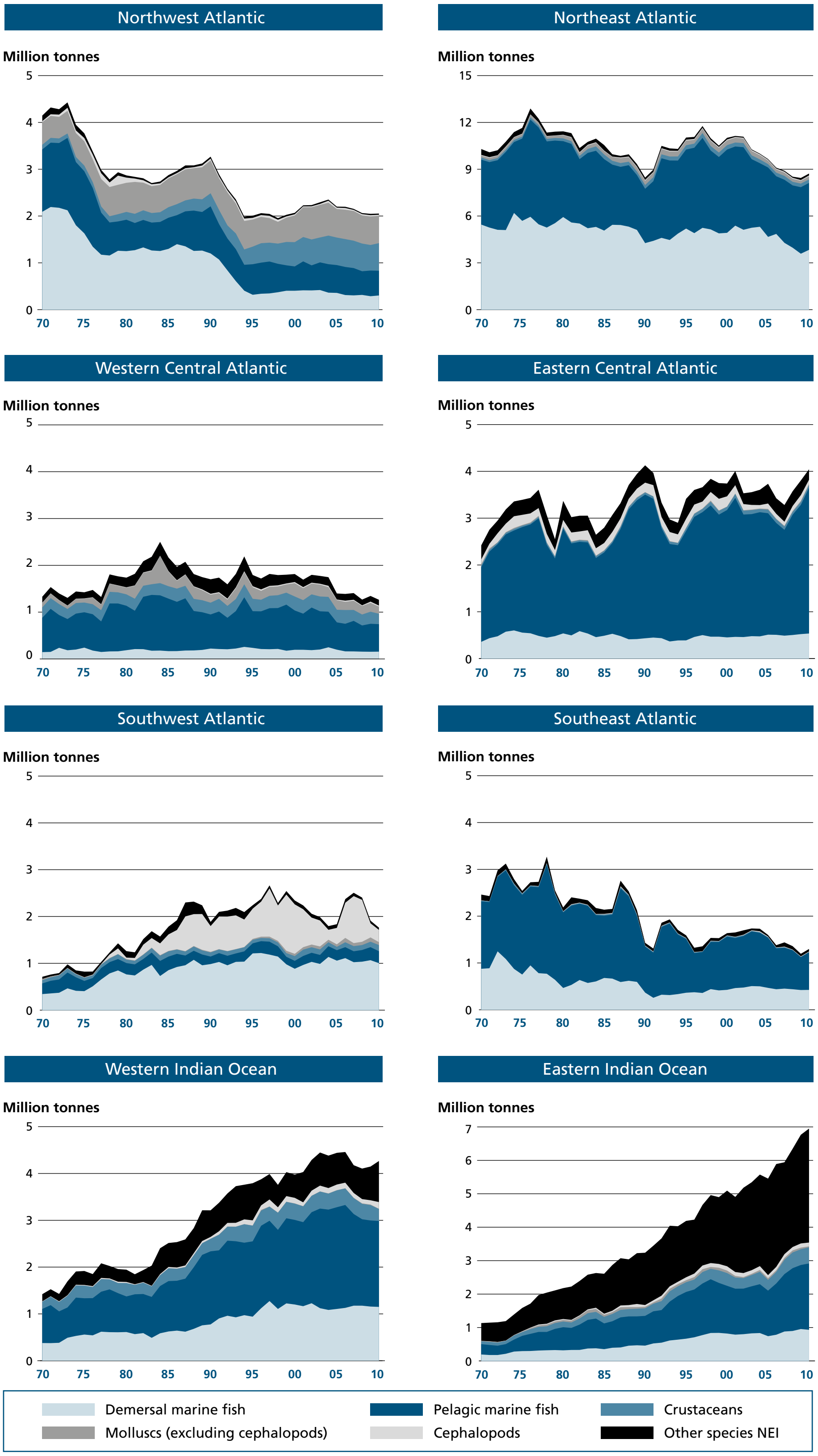
Most of the stocks of the top ten species, which account in total for about 30 percent of the world marine capture fisheries production, are fully exploited and, therefore, have no potential for increases in production, while some stocks are overexploited and increases in their production may be possible if effective rebuilding plans are put in place. The two main stocks of anchoveta in the Southeast Pacific, Alaska pollock (*Theragra chalcogramma*) in the North Pacific and blue whiting (*Micromesistius poutassou*) in the Atlantic are fully exploited. Atlantic herring (*Clupea harengus*) stocks are fully exploited in both the Northeast and Northwest Atlantic. Japanese anchovy (*Engraulis japonicus*) in the Northwest Pacific and Chilean jack mackerel (*Trachurus murphyi*) in the Southeast Pacific are considered to be overexploited. Chub mackerel (*Scomber japonicus*) stocks are fully exploited in the Eastern Pacific and the Northwest Pacific. The largehead hairtail (*Trichiurus lepturus*) was estimated in 2009 to be overexploited in the main fishing area in the Northwest Pacific.

The total catch of tuna and tuna-like species was about 6.6 million tonnes in 2010. The principal market tuna species – albacore, bigeye, bluefin (three species), skipjack and yellowfin – contributed 4.3 million tonnes, maintaining approximately the same level since 2002. About 70 percent of these catches were from the Pacific. The skipjack was the most productive principal market tuna, contributing about 58 percent, and the yellowfin and bigeye were the other two productive species, contributing about 27 and 8 percent, respectively, to the 2010 catch of principal tunas. Bigeye, Atlantic bluefin, Pacific bluefin, southern bluefin and yellowfin tunas have all shown a gradual decline in catch after reaching historical peaks.

Among the seven principal tuna species, one-third were estimated to be overexploited, 37.5 percent were fully exploited, and 29 percent non-fully exploited in 2009. Although skipjack tuna continued its increasing trend up to 2009, further expansion should be closely monitored, as it may negatively affect bigeye and yellowfin tunas (multispecies fisheries). Only for very few stocks of the principal tuna species is their status unknown or very poorly known. In the long term, the status of tuna

Figure 17

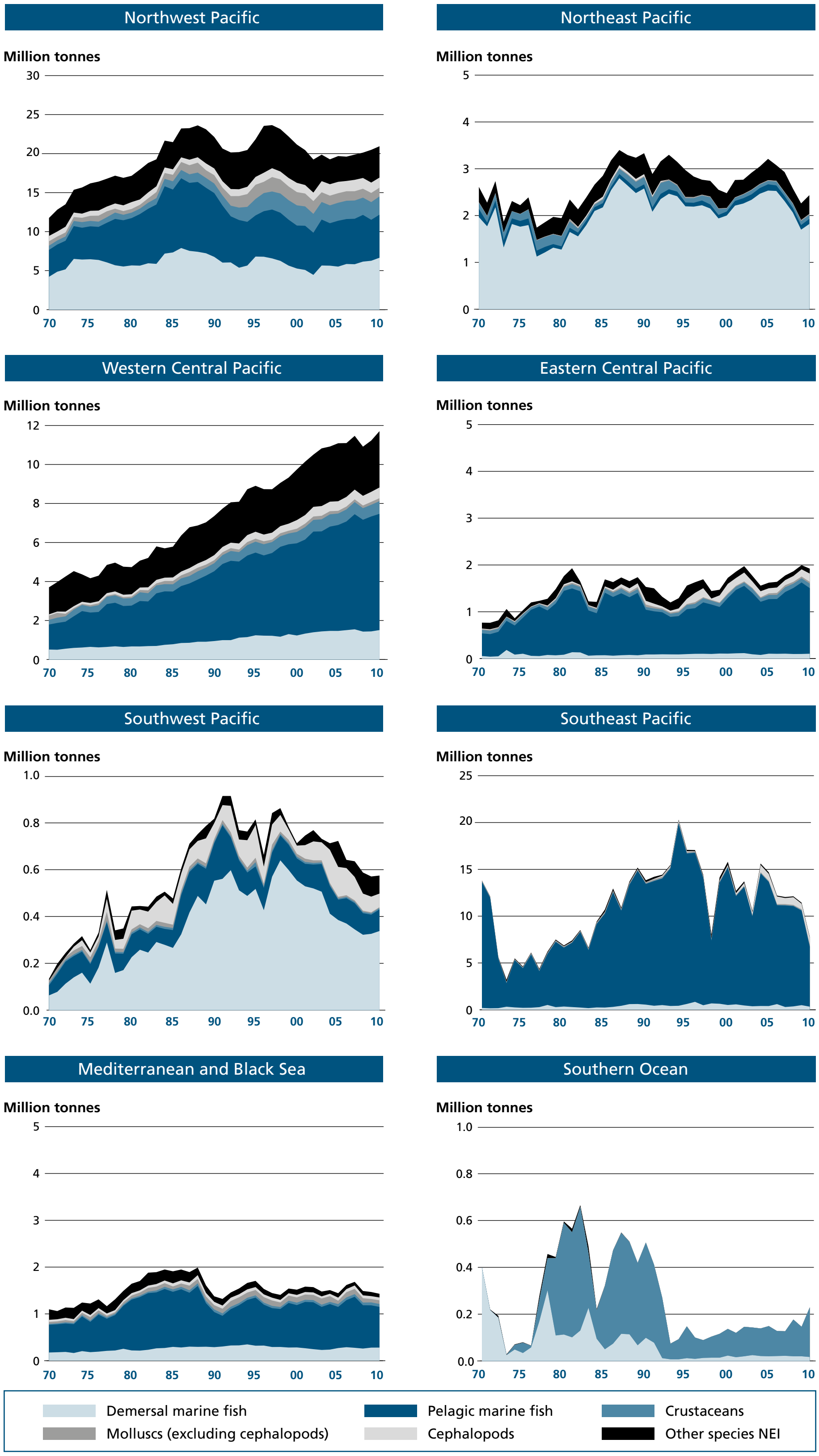
Capture fisheries production in marine areas



(Continued)

Figure 17 *(cont.)*

Capture fisheries production in marine areas



Note: NEI = not elsewhere included.

stocks (and consequently catches) may further deteriorate unless there are significant improvements in their management. This is because of the substantial demand for tuna and the significant overcapacity of tuna fishing fleets.

The concern about the poor status of some bluefin stocks and the inability of some tuna management organizations to manage these stocks effectively led to a proposal by Monaco in 2010 to ban the international trade in Atlantic bluefin tuna under CITES. Although it was hardly disputed 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 management of such an important commercially exploited aquatic species.

World marine fisheries have gone through significant changes since the 1950s. Accordingly, the exploitation level of fish resources and their landings have also varied over time. The temporal pattern of landings differs from area to area depending on the level of urban development and changes that countries surrounding that area have experienced. In general, they can be divided into three groups, i.e. one characterized by oscillations in the catches, another by an overall declining trend following historical peaks, and a third with increasing catch trends.

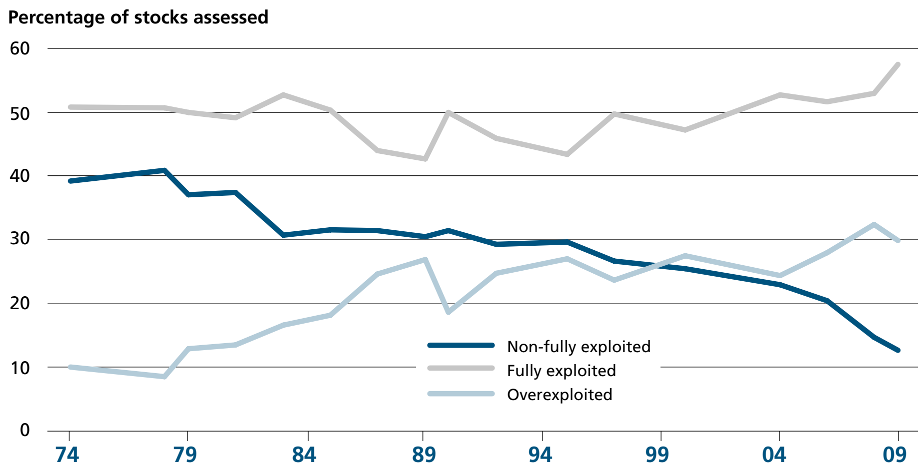
The first group includes those FAO areas that have demonstrated oscillations in total catch (Figure 17), i.e. the Eastern Central Atlantic (Area 34), Northeast Pacific (Area 67), Eastern Central Pacific (Area 77), Southwest Atlantic (Area 41), Southeast Pacific (Area 87), and Northwest Pacific (Area 61). These areas have provided about 52 percent of the world's total marine catch on average in the last five years. Several of these areas include upwelling regions that are characterized by high natural variability.

The second group consists of areas that have demonstrated a decreasing trend in catch since reaching a peak at some time in the past. This group has contributed 20 percent of global marine catch on average in the last five years, and includes the Northeast Atlantic (Area 27), Northwest Atlantic (Area 21), Western Central Atlantic (Area 31), Mediterranean and Black Sea (Area 37), Southwest Pacific (Area 81), and Southeast Atlantic (Area 47). It should be noted that lower catches in some cases reflect fisheries management measures that are precautionary or aim at rebuilding stocks, and this situation should, therefore, not necessarily be interpreted as negative.

The third group comprises the FAO areas that have shown continuously increasing trends in catch since 1950. There are only three areas in this group: Western Central

Figure 18

Global trends in the state of world marine fish stocks since 1974



Pacific (Area 71), Eastern (Area 57) and Western Indian Ocean (Area 51). They have contributed 28 percent of the total marine catch on average over the last five years. However, in some regions, there is still high uncertainty about the actual catches owing to the poor quality of statistical reporting systems in coastal countries.

The Northwest Pacific has the highest production among the FAO statistical areas. Its total catch fluctuated between about 17 and 24 million tonnes in the 1980s and 1990s, and was about 21 million tonnes in 2010. Small pelagics are the most abundant category in this area, with the Japanese anchovy providing 1.9 million tonnes in 2003 but having since declined to about 1.1 million tonnes in 2009 and 2010. 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 1.3 million tonnes in 2010.

The Eastern Central Pacific has shown a typical oscillating pattern in its total catch since 1980 and produced about 2 million tonnes in 2010. The Southeast Pacific has had a large interannual variation with a generally declining trend since 1993. There have been no major changes in the state of exploitation of stocks in these two areas, which are characterized by a large proportion of small pelagic species and great fluctuations in catches. The most abundant species in the Southeast Pacific are the anchoveta, the Chilean jack mackerel and the South American pilchard or sardine (*Sardinops sagax*), accounting for more than 80 percent of the current and historical catches, while in the Eastern Central Pacific the most abundant species are California pilchard and Pacific anchoveta. A moderate El Niño developed in 2009 and continued throughout the equatorial Pacific in the first few 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.

For the Eastern Central Atlantic, total catches, which have fluctuated since the 1970s, were about 4 million tonnes in 2010, about the same as the 2001 peak. The small pelagic species constitute almost 50 percent of the landings, followed by "miscellaneous coastal fishes". The single most important species in terms of landings is sardine (*Sardina pilchardus*) with landings in the range of 600 000–900 000 tonnes in the last ten years. The sardine in Zone C (Cape Bojador and southwards to Senegal) is still considered non-fully exploited; otherwise, most of the pelagic stocks are considered fully exploited or overexploited, such as the sardinella stocks in Northwest Africa and in the Gulf of Guinea. The demersal fish resources are to a large extent fully exploited to overexploited in most of the area, and the white grouper stock (*Epinephelus aenus*) in 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 fully exploited, whereas the other shrimp stocks in the region range between fully exploited and overexploited. The commercially important octopus (*Octopus vulgaris*) and cuttlefish (*Sepia* spp.) stocks remain overexploited. Overall, the Eastern Central Atlantic has 43 percent of its assessed stocks fully exploited, 53 percent overexploited and 4 percent non-fully exploited, a situation warranting attention for improvement in management.

In the Southwest Atlantic, total catches have fluctuated around 2 million tonnes after a period of increasing catches ended in the mid-1980s. Major species such as Argentina hake and Brazilian sardinella are still estimated to be overexploited, although there seem to be some signs of recovery for the latter. The catch of Argentina shortfin squid was only one-fourth of its peak level in 2009 and considered fully exploited to overexploited. In this area, 50 percent of the monitored fish stocks were overexploited, 41 percent fully exploited and the remaining 9 percent considered non-fully exploited.

The Northeast Pacific produced 2.4 million tonnes of fish in 2010, similar to the production level in the early 1970s, although more than 3 million tonnes was seen in the late 1980s. Cods, hakes and haddocks are the largest contributors to its catch.

In this area, only 10 percent of fish stocks were estimated to be overexploited, with 80 percent fully exploited, and another 10 percent non-fully exploited.

In the Northeast Atlantic, total catch appeared to have a decreasing trend after 1975, with a recovery in the 1990s, and was 8.7 million tonnes in 2010. The blue whiting stock decreased rapidly from the peak of 2.4 million tonnes in 2004 to only 0.6 million tonnes in 2009. Fishing mortality has been reduced in cod, sole 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 in the 1960s–1980s. Similarly, the Arctic saithe and haddock stocks have increased to high levels, although stocks elsewhere remain fully exploited or overexploited. The largest sand eel and capelin stocks remain overexploited. Concern remains for redfishes and deep-water species for which data are limited and which are likely to be vulnerable to overfishing. Northern shrimp and Norway lobster are generally in good condition, but there are indications that some stocks are being overexploited. Recently, maximum sustainable yield has been adopted as the standard basis for reference points. Overall, 62 percent of assessed stocks are fully exploited, 31 percent overexploited, and 7 percent non-fully exploited.

Although fishery resources in the Northwest Atlantic continue to be under stress from previous and/or current exploitation, some stocks have recently shown signs of renewal in response to an improved management regime in the last decade (e.g. Greenland halibut, yellowtail flounder, Atlantic halibut, haddock, spiny dogfish). However, some historical fisheries such as cod, witch flounder and redfish still evidence lack of recovery, or limited recovery, which may be the result of unfavourable oceanographic conditions and the high natural morality caused by increasing numbers of seals, mackerel and herring. These factors appear to have affected fish growth, reproduction and survival. Conversely, invertebrates remain at near record levels of abundance. The Northwest Atlantic has 77 percent of stocks fully exploited, 17 percent overexploited and 6 percent non-fully exploited.

The Southeast Atlantic is a typical example of the group of areas that has demonstrated a generally decreasing trend in catches since the early 1970s. This area produced 3.3 million tonnes in the late 1970, but only 1.2 million tonnes were recorded in 2009. The important hake resources remain fully exploited to overexploited although there are signs of some recovery in the deepwater hake stock (*Merluccius paradoxus*) off South Africa and of 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. 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 now fully exploited or overexploited. In contrast, Southern African anchovy has continued to improve and its status was estimated to be fully exploited in 2009. Whitehead's round herring has not been fully exploited. The condition of Cunene horse mackerel has deteriorated, particularly off Namibia and Angola, and it was overexploited in 2009. The condition of the perlemoen abalone stock continues to be worrying, exploited heavily by illegal fishing, and it is currently overexploited and probably depleted.

The Mediterranean has maintained an overall stable catch in a difficult situation in recent years. 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. A newly identified threat is the increasing penetration of exotic Red Sea species, which in some cases seem to be replacing native species, especially in the Eastern Mediterranean. 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 consequence of unfavourable oceanographic conditions, but they are still considered fully exploited to overexploited, an assessment shared with turbot, while most other stocks are probably fully exploited

to overexploited. In general, the Mediterranean and Black Sea had 33 percent of assessed stocks fully exploited, 50 percent overexploited, and the remaining 17 percent non-fully exploited in 2009.

Total production in the Western Central Pacific grew continuously to a maximum of 11.7 million tonnes in 2010. This area contributes about 14 percent of the global marine production. Despite this catch trend, there are reasons for concern as regards the state of the resources, with most stocks being either fully exploited or overexploited, 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.

The Eastern Indian Ocean (Fishing Area 57) is still experiencing a high growth rate in catches, with a 17 percent increase from 2007 to 2010, and now totalling 7 million tonnes. The Bay of Bengal and Andaman Sea regions have seen total catches increase 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 be partly 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 term, 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 4.5 million tonnes in 2006, but have declined slightly since, and 4.3 million tonnes were reported in 2010. A recent assessment has shown that narrow-barred Spanish mackerel (*Scomberomerus commerson*), a migratory species found in the Red Sea, Arabian Sea, Gulf of Oman, Persian Gulf, and off the coast along Pakistan and India, is overexploited. Catch data in this area are often not detailed enough for stock assessment purposes. However, the Southwest Indian Ocean Fisheries Commission conducted stock assessments for 140 species in its mandatory area in 2010 based on best-available data and information. Overall, 65 percent of fish stocks were estimated to be fully exploited, 29 percent overexploited, and 6 percent non-fully exploited in 2009.

The declining global catch over the last few years together with the increased percentage of overexploited fish stocks and the decreased proportion of non-fully exploited species around the world convey a strong message – the state of world marine fisheries is worsening and has had a negative impact on fishery production. Overexploitation not only causes negative ecological consequences, but it also reduces fish production, which further leads to negative social and economic consequences. To increase the contribution of marine fisheries to the food security, economies and well-being of the coastal communities, effective management plans must be put in place to rebuild overexploited 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 that entered into force in 2001 should be used as a legal basis for management measures of the high seas fisheries.

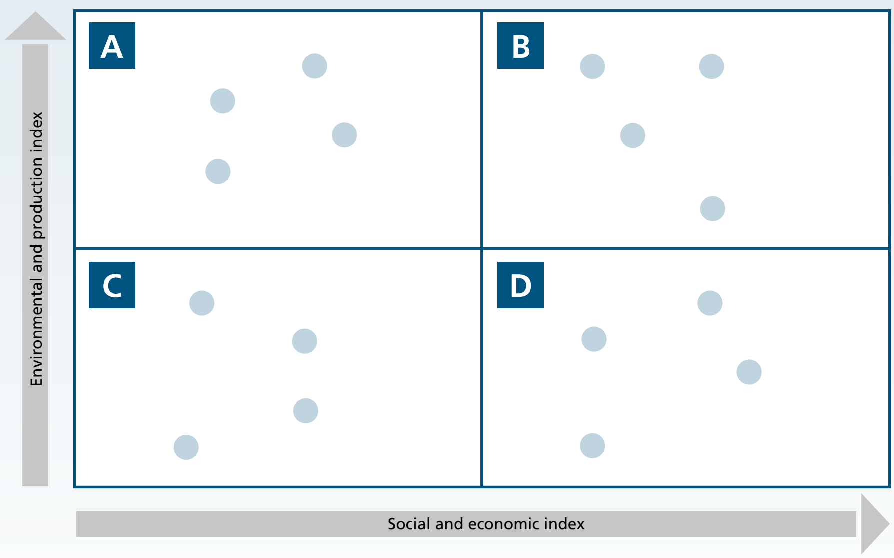
In spite of the worrisome global situation of marine capture fisheries, good progress is being made in reducing exploitation rates and restoring overexploited fish stocks and marine ecosystems through effective management actions in some areas. In the United States of America, the Magnuson–Stevens Act and subsequent amendments have created a mandate to put overfished stocks into restoration; 67 percent of all stocks are now being sustainably harvested, while only 17 percent are still being overexploited. In New Zealand, 69 percent of stocks are above management targets, reflecting mandatory rebuilding plans for all fisheries that are still below target thresholds. Similarly, Australia reports overfishing for only 12 percent of stocks in 2009.[9] Since the 1990s, the Newfoundland–Labrador Shelf, the Northeast United

Box 4

Developing an assessment strategy for inland fishery resources

An accurate assessment of inland fishery resources must take into account the numerous aspects and drivers that influence the health of inland aquatic ecosystems and the status of inland fishery resources. Given the multiple uses of freshwater, it is recognized that an assessment of inland fishery resources should be based on more than just the amount of catch and the effort applied. The assessment should determine whether or not the management goals for the fishery or waterbody are being met. In general, the goals of responsible inland fisheries include an environmental component, e.g. production and protection of biodiversity, and a social and economic component, e.g. poverty reduction, income generation, and cultural heritage. Thus, rather than a single dimensional plot of status of exploitation rate, inland fisheries could be plotted on multidimensional axes that examine environmental and production parameters in the light of social and economic parameters. In the accompanying figure, specific inland capture fisheries (●) are assigned to a given quadrant (A, B, C or D) depending on how they perform according to environmental and production parameters (y-axis) and social and economic parameters (x-axis). Fisheries in quadrant B would be performing well on both environmental/production and social/economic criteria, whereas fisheries in quadrant C would be performing poorly. Individual fisheries could be tracked over time to determine how the state of the fishery was changing and whether changes to management are indicated. For example, a highly productive fishery that provided very little economic value would be placed in quadrant A; a very lucrative recreational fishery that focused on a few high-value species that were stocked from aquaculture facilities would be placed in D.

Conceptual diagram of assessment of the status of inland capture fisheries



For such an assessment, it will be necessary to develop appropriate indicators (i.e. data requirements) in order to create indices that can be expressed in a simple and effective graph. The objective would be to examine the services provided by inland fisheries over time to assess whether or not the fishery was performing as desired. The services provided by inland fisheries are similar to the ecosystem services provided by inland water ecosystems (see accompanying table). Specific services provided by inland capture fisheries could also be seen as management objectives. It is not expected that indices would be developed to encompass the complete range of services provided by inland capture fisheries. Additional work will be needed to prioritize data requirements and develop indicators that are informative, practical and cost-effective.

Ecosystem services provided by inland capture fisheries

Ecosystem service type	Specific service provided by inland capture fisheries
Provisioning	Food provision – extraction of aquatic organisms for human consumption and nutrition Livelihood provision – contribution to employment and income, including recreational and ornamental fisheries Aquaculture seed provision – inputs to aquaculture for grow-out
Cultural and scientific	Cultural heritage and identity – value associated with freshwater fisheries themselves Recreational fisheries – the non-commercial perspective Cognitive values – education and research resulting from the fisheries Catch composition and species as bio-indicators of health of ecosystem
Regulation	Regulation of food web dynamics Nutrient transport and cycling Control of pest organisms
Support	Maintenance of genetic, species and ecosystem biodiversity Resilience and resistance – life support by the freshwater environment and its response to pressures, including maintenance of ecosystem balance

The specific data requirements, indicators and indices for this assessment have not yet been established. However, together with partners and resource managers, FAO will work on refining the model and test its applicability in selected inland fisheries around the world.

States Shelf, the Southern Australian Shelf, and 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.[10] It is critically important to understand the key elements of these and other successes and apply them well to other fisheries.

Inland fisheries

The difficulty in assessing the state of inland capture fisheries has been noted in past editions of The State of World Fisheries and Aquaculture as well as by those working on the active management and development of inland fishery resources.[11] Reasons for the lack of adequate assessments include:

- the diffuse nature of the sector, with numerous landing sites and methods of fishing;
- the large number of people involved and the seasonality of fishing effort;
- the subsistence nature of many small-scale inland fisheries;
- the fact that catch is often consumed or traded locally without entering the formal market chain;
- a lack of capacity and resources to collect adequate data;
- activities not associated with inland fishing can greatly influence the abundance of inland fishery resources, e.g. stocking from aquaculture, water diversion for agriculture and hydroelectric development.

The informative and widely cited data summarizing the state of the major marine fish stocks are virtually impossible to duplicate for the state of the world's inland fisheries. The primary reason for this is that whereas exploitation rate is the main driver affecting the state of the major marine stocks that comprise the figure, other drivers affect the status of inland fishery resources to a much greater extent.[12] Drivers associated with habitat quantity and quality, including aquaculture in the form of stocking and competition for freshwater, influence the state of the majority of inland fishery resources much more than exploitation rates do. Water abstraction and diversion, hydroelectric development, draining wetlands, and siltation and erosion from land-use patterns can negatively affect inland fishery resources regardless of the rate of exploitation. Conversely, stock enhancement from aquaculture facilities, which is widely practised in inland waters, can keep catch rates high in the face of increased fishing and in spite of an ecosystem that is not capable of producing that level of catch through natural processes. Overexploitation can also affect inland fishery resources, but the result is generally a change in species composition and not necessarily a reduced overall catch. Catches are often higher where smaller and shorter-lived species become the main component of the catch; however, the smaller fish may be much less valuable.

Another issue complicating the assessment of inland fishery resources is the definition of a “stock”. The major marine fish stocks are well defined biologically and geographically, and comprise management units. Very few inland fisheries have stocks that are defined as precisely or are defined at the level of species. There are notable exceptions, e.g. Lake Victoria Nile perch and Tonle Sap dai fisheries, but many inland fishery stocks are defined by watershed or river and comprise numerous species.

Nonetheless, it is vitally important that an accurate assessment be made of those inland fishery resources that are of major importance. The Twenty-eighth Session of COFI observed that data and statistics on small-scale fisheries, especially in inland waters, were not always comprehensive, resulting in underestimating their economic, social and nutritional benefits and contribution to livelihoods and food security.[13] FAO convened a workshop in late 2011 to develop a strategy to undertake such an assessment[14] (Box 4). The intention is to utilize the new methodology to provide a more robust and informative summary of the state of the world's inland capture fishery resources for future editions of *The State of World Fisheries and Aquaculture*.

FISH UTILIZATION AND PROCESSING

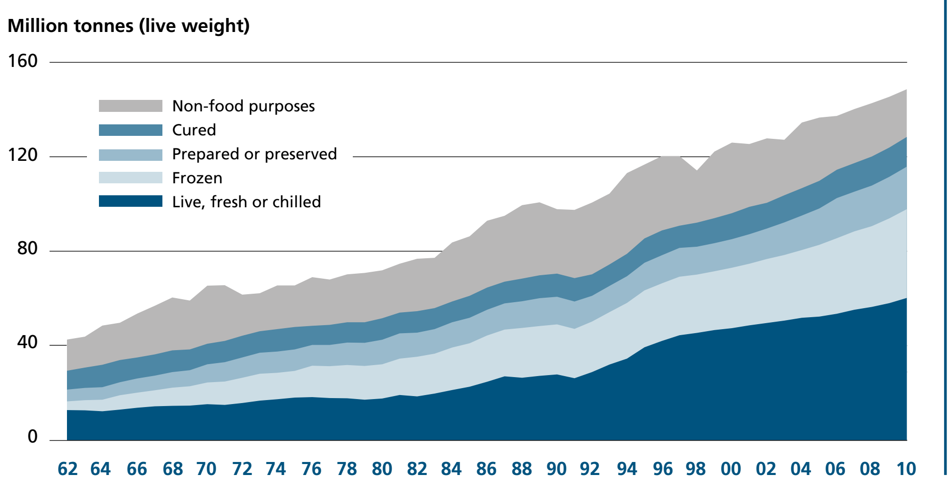
Fishery production is very heterogeneous in terms of its range of species and product forms. Being highly perishable, fish needs timely harvesting and procurement, efficient transportation, and advanced storage, processing and packaging facilities for its marketing. In particular, specific requirements and preservation techniques (Box 5) are needed in order to preserve its nutritional quality, extend its shelf-life, minimize the activity of spoilage bacteria and avoid losses caused by poor handling. Fish is also very versatile as it can be processed into a wide array of products to increase its economic value. 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. Fish can also be preserved by many other methods destined for food or non-edible uses.

In 2010, 40.5 percent (60.2 million tonnes) of world fish production was marketed in live, fresh or chilled forms, 45.9 percent (68.1 million tonnes) was processed in frozen, cured or otherwise prepared forms for direct human consumption, and 13.6 percent destined to non-food uses (Figure 19). Since the early 1990s, there has been an increasing trend in the proportion of fisheries production used for direct human consumption rather than for other purposes. In the 1980s, about 68 percent of the fish produced was destined for human consumption, this share increased to 73 percent in the 1990s, and in 2010 it was more than 86 percent, equalling 128.3 million tonnes. In 2010, 20.2 million tonnes was destined to non-food purposes, of which 75 percent (15 million tonnes) was reduced to fishmeal and fish oil; the remaining 5.1 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 2010, of the fish destined for direct human consumption, the most important product form was live, fresh or chilled fish, with a share of 46.9 percent, followed by frozen fish (29.3 percent), prepared or preserved fish (14.0 percent) and cured fish (9.8 percent). Freezing represents the main method of processing fish for human consumption, and it accounted for 55.2 percent of total processed fish for human consumption and 25.3 percent of total fish production in 2010. These general data mask significant differences. The utilization of fish and, more significantly, the processing methods vary according to the continent, region, country and even within countries. The highest percentage of fishmeal is produced by Latin American countries (44 percent of the total in 2010). In Europe and North America, fish in frozen and

Figure 19

Utilization of world fisheries production (breakdown by quantity), 1962–2010



Box 5

The work of the Codex Alimentarius Commission

The Codex Alimentarius Commission (CAC) develops Standards, Codes of Practice, and Guidelines in the area of food safety and fair practices in trade. The Standards specify the characteristics of food products, while the Codes of Practice identify the procedures that national competent authorities and operators in the food chain need to follow in order to reach those Standards. The Guidelines identify steps that need to be taken to protect consumers' health from certain specific food hazards. Standards, Codes of Practice and Guidelines are continuously updated, and new sections are added as required.

Recent work by the CAC has led to: (i) adoption of Standards for live and raw bivalve molluscs and fish sauce; (ii) updating of the Code of Practice for Fish and Fishery Products with sections on live and raw bivalve molluscs and smoked fish; and (iii) adoption of Guidelines on the Application of General Principles of Food Hygiene to the Control of Pathogenic *Vibrio* Species in Seafood.

canned forms represents more than two-thirds of fish used for human consumption. Africa has a higher proportion of cured fish (14 percent of total production) than the world average. In Africa, but also significantly in Asia, a large amount of production is commercialized 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. Commercialization of live fish has grown 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. Nevertheless, marketing and transportation of live fish can be challenging as they are often subject to stringent health regulations and quality standards. In some parts of Southeast Asia, their commercialization and trade are not formally regulated but based on tradition. However, in markets such as the European Union, live fish have to comply with requirements, *inter alia*, concerning animal welfare during transportation.

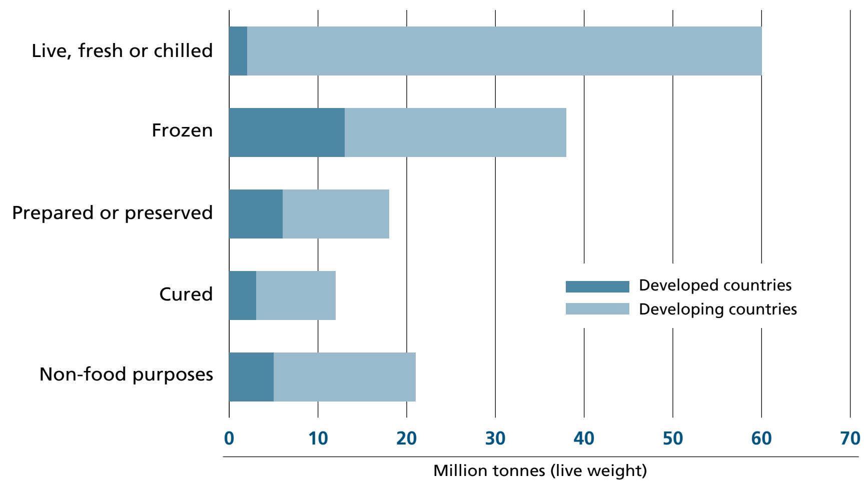
Not only live fish, but, as mentioned above, fish and fishery products must be handled and transported by highly efficient distribution channels that can ensure that the integrity of the produce is maintained. Improvements in packaging help in preserving the quality of products. In the last few decades, major innovations in refrigeration, ice-making and transportation have also allowed the distribution of fish in fresh and other forms. As a result, developing countries have experienced a growth in the share of frozen products (24.1 percent of the total fish for human consumption in 2010, up from 18.9 percent in 2000) and of prepared or preserved forms (11.0 percent in 2010, compared with 7.8 percent in 2000). However, notwithstanding the technical advances and innovations, many countries, especially less-developed economies, still lack adequate infrastructure and services including hygienic landing centres, electric power supply, potable water, roads, ice, ice plants, cold rooms and refrigerated transport. These factors, associated with tropical temperatures, result in a high proportion of post-harvest losses and quality deterioration, with subsequent

risk to the health of consumers. In addition, marketing of fish is also more difficult owing to often limited and congested market infrastructure and facilities. Owing to these deficiencies, together with well-established consumer habits, fish in developing countries is commercialized mainly in live or fresh form (representing 56.0 percent of fish destined for human consumption in 2010) soon after landing or harvesting. Cured forms (dried, smoked or fermented) still remain a traditional method to retail and consume fish in developing countries, even if their share in total fish for human consumption is declining (10.9 percent in 2000 compared with 8.9 percent in 2010). In developed countries, the bulk of production destined to human consumption is commercialized frozen or in prepared or preserved forms. The proportion of frozen fish has been growing in the last four decades: it represented 33.2 percent of total production for human consumption in 1970, increased to 44.8 percent in 1990, to 49.8 percent in 2000, and reached a record high at 52.1 percent in 2010. The share of prepared and preserved forms remained rather stable during the same period and it was 26.9 percent in 2010 (Figure 20).

Fishmeal is the crude flour obtained after milling and drying fish or fish parts, and it is produced from whole fish, fish remains or other fish by-products resulting from processing. Many different species are used for fishmeal and fish-oil production. However, small pelagics, in particular anchoveta, are the main groups of species used for reduction, and the volume of fishmeal and fish oil produced worldwide annually fluctuates according to the fluctuations in 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, going from 12.5 million tonnes in 1994 to 4.2 million tonnes in 2010. Fishmeal production peaked in 1994 at 30.2 million tonnes (live weight equivalent) and has followed a fluctuating trend since then. In 2010, it dropped to 15.0 million tonnes owing to reduced catches of anchoveta, representing a 12.9 percent decrease compared with 2009, of 18.2 percent compared with 2008 and of 42.8 percent with respect to 2000. Another important source of raw material for the production of fishmeal is the processing waste from commercial fish species used for human consumption. Growing value addition in fishery products for human consumption leads to more residues, which in the past very often were simply discarded. Nowadays, more and more waste is used in feed markets, and a growing percentage of fishmeal is being obtained from trimmings and other residues from the preparation of fish fillets. According to recent estimates, about 36 percent of world fishmeal production was obtained from offal in 2010.

Figure 20

Utilization of world fisheries production (breakdown by quantity), 2010



In the past, fishery by-products, including waste, were considered to be of low value, or as a problem to be disposed of in the most convenient way or discarded. In the last two decades, there has been a global trend of growing awareness about the economic, social and environmental aspects of optimal use of fishery by-products, and of the importance of reducing discards and losses in post-harvesting phases (storage, processing and distribution). The utilization of fish by-products has become an important industry in various countries, with a growing focus on handling by-products in a controlled, safe and hygienic way. Improved processing technologies have also helped in their utilization. In addition to the fishmeal industry, fisheries by-products are also utilized for a wide range of other purposes, including the production of cosmetics and pharmaceuticals, other industrial processes, as direct feeding for aquaculture and livestock, incorporation into pet feed or feed for animals kept for fur production, ensiling, fertilizer and landfill. Technologies such as microencapsulation and nanoencapsulation are facilitating incorporation of important nutrients such as fish oils into various other foods. These technologies enable the extension of shelf-life, and provide a taste profile barrier eliminating fish-oil taste and odour while improving the nutritional availability. 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. From crustacean wastes, also the pigments carotenoids and astaxanthins can be extracted for use in the pharmaceutical industry, and collagen can be extracted from fish skin, fins and other processing discards. Fish silage and fish protein hydrolysates obtained from fish viscera are finding applications in the pet-feed and fish-feed industries. Calcium carbonate for industrial use can be obtained from mussel shells. In some countries, oyster shells are used 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. A number of anticancer agents have been discovered following research on marine sponges, bryozoans and cnidarians. However, following their discovery, for reasons of conservation, these agents are not extracted from marine organisms directly but are chemically synthesized. Another approach being researched is aquaculture of some sponge species. Fish skin, in particular of larger fish, is exploited to obtain gelatin as well as leather to be used in clothing, shoes, handbags, wallets, belts and other items. Species commonly used for leather include shark, salmon, ling, cod, hagfish, tilapia, Nile perch, carp and seabass. Shark cartilage is utilized in many pharmaceutical preparations and reduced in powder, creams and capsules, as are other parts of sharks, e.g. ovaries, brain, skin and stomach. 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. Procedures for the industrial preparation of biofuel from fish waste as well as from seaweeds are being developed.

Great technological development in food processing and packaging is in progress, with increases in efficient, effective and lucrative utilization of raw materials, and innovation in product differentiation for human consumption as well as for the production of fishmeal and fish oil. Processors of traditional products have been losing market share as a result of long-term shifts in consumer preferences as well as 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, fuelled by changing consumer tastes and advances in technology, packaging, logistics and transport. In developed countries, innovation in value addition is converging on convenience foods and a wider range of high-value-added products, mainly in fresh, frozen, breaded, smoked or canned forms to be marketed as ready and/or portion-controlled, uniform-quality meals. These require sophisticated production equipment and methods and, hence, access to capital. Supported by cheaper labour, in developing countries, processing is still done through less sophisticated methods of transformation, such as filleting, salting, canning, drying

and fermentation. These traditional labour-intensive, fish-processing methods provide livelihood support to large numbers of people in coastal areas in many developing countries, and they will probably remain important components in rural economies structured to promote rural development and poverty alleviation. However, in the last decade, fish processing has been evolving also in many developing countries, with increased fish 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, by a shift in cultured species, by outsourcing of processing and by the fact that producers in developing countries are increasingly being linked with, and coordinated by, firms located abroad. Supermarket chains and large retailers are also emerging as important players in setting requirements for the products they buy. 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 large retailers controlling the growth of international distribution channels. 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, 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 States. Whole frozen 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. The further outsourcing of production to developing countries might be restricted by sanitary and hygiene requirements that are difficult to meet as well as by growing labour costs.

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 enhance the product mix, obtain better yields and respond to evolving quality and safety requirements in importing countries. Processors that operate without the purchasing or sourcing power of strong brands are also experiencing increasing problems linked to the scarcity of domestic raw material, and they are being forced to import fish for their business.

FISH TRADE AND COMMODITIES

Fish and fishery products are among the most traded food commodities worldwide. Trade plays a major role in the fishery industry as a creator of employment, food supplier, income generator, and contributor to economic growth and development. For many countries and for numerous coastal, riverine, insular and inland regions, fishery exports are essential to the economy. For example, in 2010 they accounted for more than half of the total value of traded commodities in Greenland, Seychelles, Faeroe Islands and Vanuatu. In the same year, fishery trade represented about 10 percent of total agricultural exports (excluding forest products) and 1 percent of world merchandise trade in value terms.

A significant share of total fishery production is exported in the form of various food and feed items. This share increased from 25 percent in 1976 to about 38 percent (57 million tonnes in 2010 (Figure 21), reflecting the sector’s growing degree of openness to, and integration in, international trade. Sustained demand, trade liberalization policies, globalization of food systems and technological innovations have furthered the overall increase in international fish trade. Improvements in processing, packaging and transportation as well as changes in distribution and marketing have significantly changed the way fishery products are prepared, marketed and delivered to consumers. All these factors have facilitated and increased the movement of production in relative terms from local consumption to international markets. The fishery supply chain is complex as goods might cross national boundaries several times before final consumption, also owing to increasing outsourcing of processing to countries where comparatively low wages and production costs provide a competitive advantage, as indicated above in the Fish Utilization and Processing section.

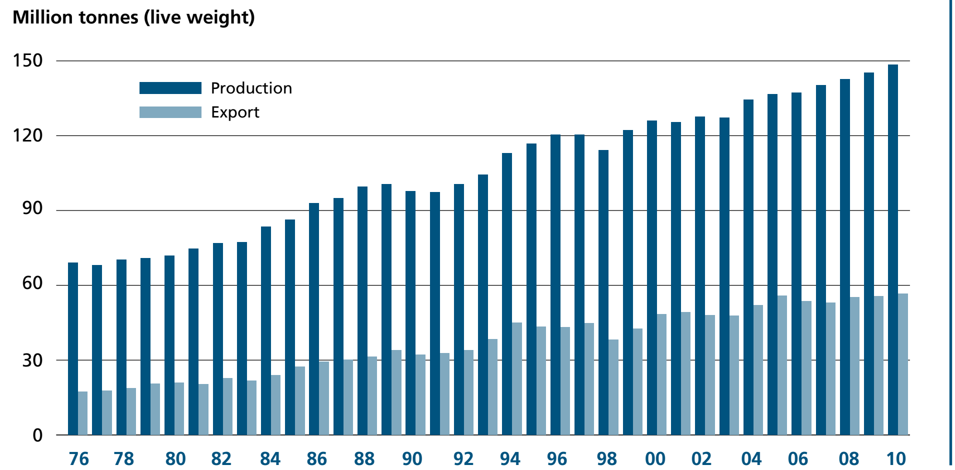
In the period 1976–2008, world trade in fish and fishery products grew significantly also in value terms, rising from US$8 billion to US$102 billion, with annual growth rates of 8.3 percent in nominal terms and of 3.9 percent in real terms. In 2009, as a consequence of the general economic contraction affecting consumer confidence in major markets, trade dropped by 6 percent compared with 2008. The decline was only in value terms as a consequence of falling prices and margins, whereas traded volumes, expressed in live weight equivalent, increased by 1 percent to 55.7 million tonnes. The decrease was not uniform and, in particular, many developing countries experienced rising demand and imports even during a difficult 2009. In 2010, trade rebounded strongly, reaching about US$109 billion, with an increase of 13 percent in value terms and 2 percent in volume compared with 2009. The difference between the growth in value and volume reflects the higher fish prices experienced during 2010 as well as a decrease in the production of and trade in fishmeal.

In 2011, despite the economic instability experienced in many of the world's leading economies, increasing prices and strong demand in developing countries pushed trade volumes and values to the highest level ever reported and, despite some softening in the second half of the year, preliminary estimates indicate that exports exceeded US$125 billion. It is worth noting that currency fluctuations influence not only sales and markets, but also trade statistics; for statistics stated in US dollars, a weakening dollar will inflate both import and export figures.

Fishery trade is closely tied to the overall economic situation. In the last few years, world trade has been hit by a series of economic, financial and food crises. After the 12 percent drop experienced in 2009, world trade recovered strongly in 2010 and, according to the World Trade Organization (WTO), merchandise exports increased by 14.5 percent, sustained by a 3.6 percent growth in global output as measured by gross domestic product.[15] In 2010, economic conditions rebounded in both developed and developing economies, but the resurgence of both trade and output was slower in developed countries. The World Bank estimates that the volume of global trade (merchandise and services) increased by a further 6.6 percent in 2011.[16] However, performance across the year was not uniform. Since late 2011 and early 2012, the world economy has entered a difficult phase characterized by significant downside risks and fragility, with great uncertainty on how markets will evolve in the medium

Figure 21

World fisheries production and quantities destined for export



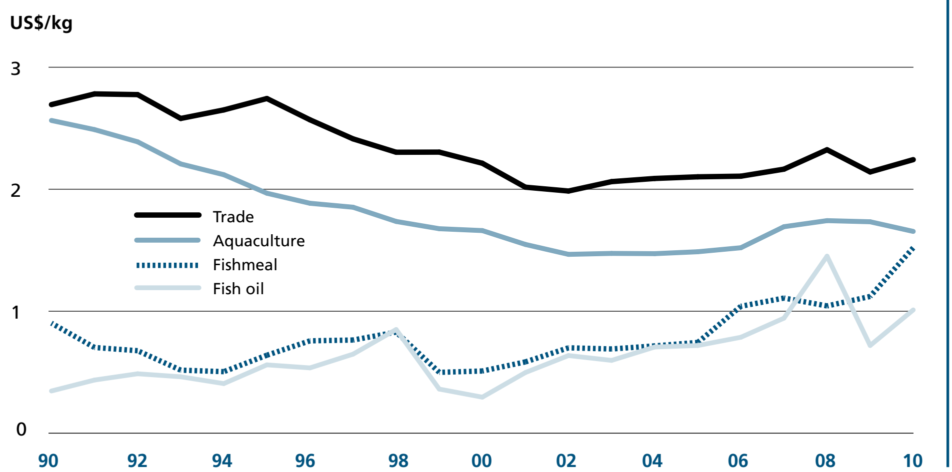
term. The financial turmoil generated by the intensification of the fiscal crisis in Europe has expanded to both developing and high-income countries. As a result, and despite relatively strong activity in the United States of America and Japan, key markets for fisheries trade, global growth and world trade have slowed sharply. In addition, among other risks, there is the possibility that geopolitical and domestic political tensions could disrupt oil supplies, which could have an impact on increasing costs of capture fisheries as well. Therefore, according to the World Bank, the global economy is now expected to expand by 2.5 percent in 2012 and by 3.1 percent in 2013. The growth rate for high-income countries should be 1.4 percent in 2012 and 2.0 percent in 2013, while growth for developing countries is projected at 5.4 percent and 6.0 percent in 2012 and 2013, respectively. Reflecting this slowdown, world trade is expected to expand by 4.7 percent in 2012, before strengthening to 6.8 percent in 2013. Despite the renewed economic instability, fish trade has expanded in key markets in the first few months of 2012, and the long-term trend for fish trade remains positive, with a growing share of fish production entering international markets.

Among the factors that might influence the sustainability and growth of fishery trade are the evolution of production and transportation costs and the prices of fishery products and alternative commodities, including meat and feeds. As is the case for other products, fish prices are influenced by demand and supply factors. At the same time, the very heterogeneous nature of the sector, with hundreds of species and thousands of products entering international trade, makes it challenging to estimate price developments for the sector as a whole. In the last few decades, the growth in aquaculture production has contributed significantly to increased consumption and commercialization of species that were once primarily wild-caught, with a consequent price decrease. This was particularly evident in the 1990s and early 2000 (Figure 22), with average unit values of aquaculture production and trade in real terms regularly declining. Subsequently, owing to increased costs and continuous high demand, prices have started to rise again. In the next decade, with aquaculture accounting for a much larger share of total fish supply, the price swings of aquaculture products could have a significant impact on price formation in the sector overall, possibly leading to more volatility.

Similar to trade, also fish prices contracted in 2009 but have since rebounded. Fish prices rose strongly in the first part of 2011, declining slightly towards the end of the year and into early 2012, but remaining higher than levels of earlier years. Rising energy and feed costs will probably keep fish prices high in 2012, especially

Figure 22

Average fish prices in real terms (2005)



as alternative protein sources such as meat are influenced by the same factors. Since 2009, FAO has been working on the construction and enhancement of a fish price index to illustrate both relative and absolute price movements. The index is being developed in cooperation with the University of Stavanger and with data support from the Norwegian Seafood Council. The FAO Fish Price Index (base year 2002–04 = 100) indicates that average prices in 2009 declined by 7 percent compared with 2008, then increased by 9 percent in 2010 and by more than 12 percent in 2011. The absolute peak in the index was reached in August 2011 at 158.3 (14 percent more than in August 2010). Prices for species from capture fisheries increased by more than those for farmed species because of the larger impact from higher energy prices on fishing vessel operations than on farmed species.

Trade in fish and fishery products is characterized by a wide range of product types and participants. In 2010, 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. Table 12 shows the top ten exporters and importers of fish and fishery products in 2000 and 2010. Since 2002, China has been by far the leading fish exporter, contributing almost 12 percent of 2010 world exports of fish and fishery products, or about US$13.3 billion, and increasing further to US$17.1 billion in 2011. 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. Thailand has established itself as a processing centre of excellence largely dependent on imported raw material, while Viet Nam has a growing domestic resource base and imports only limited, albeit growing, volumes of raw material. Viet Nam has experienced significant growth in its exports of fish and fish products, up from US$1.5 billion in 2000 to US$5.1 billion in 2010, when it became the fourth-largest exporter in the world. In 2011, its exports rose further to US$6.2 billion. Its rising 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 2010, developing countries confirmed their fundamental importance as suppliers to world markets with more than 50 percent of all fishery exports in value terms and of more than 60 percent in quantity (live weight). For many developing nations, fish trade represents a significant source of foreign currency earnings in addition to the sector's important role as a generator of income, source of employment, and provider of food security and nutrition. 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 2010, in value terms, 67 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 raw fish to be used for further processing and re-export. In 2010, in value terms, 39 percent of the imports of fish and fishery products by developing countries originated from developed countries. Developing countries cover an important segment of world exports of non-food fish exports (74 percent in 2010 in terms of quantity). Fishmeal represents a significant share of their exports (35 percent by quantity, but only 5 percent by value in 2010). However, developing countries have also considerably increased their share of the quantity of world fish exports destined for human consumption, from 32 percent in 1980 to 47 percent in 2000 and to 56 percent in 2010. 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 grown significantly in recent decades, rising from US$3.7 billion in 1980 to US$10.2 billion in 1990, to US$18.3 billion in 2000, and reaching US$27.7 billion in 2010. For LIFDCs, net export revenues amounted to US$4.7 billion in 2010, compared with

US$2.0 billion in 1990.[17] In 2010, their fishery exports (US$8.2 billion) accounted for 8 percent of world exports in value terms.

World imports[18] of fish and fish products set a new record at US$111.8 billion in 2010, up 12 percent on the previous year and up 86 percent with respect to 2000. Preliminary data for 2011 point to further growth, with a 15 percent increase. The United States of America and Japan are the major importers of fish and fishery products and are highly dependent on imports for about 60 percent and 54 percent, respectively, of their fishery consumption. With a growing population and a positive long-term trend in seafood consumption, United States imports reached US$15.5 billion in 2010, 12 percent more than in 2009, and further increased in 2011 to US$17.5 billion. After the decline of 11 percent experienced in 2009 as compared with 2008, Japanese imports of fish and fishery products increased by 13 percent in 2010. In 2011, they grew by a further 16 percent, reaching US$17.4 billion, also as a consequence of the tsunami that struck Japan in early 2011, which had an impact on the country's production capacity in the affected area, with damage to the fleet, aquaculture facilities, processing plants and port infrastructure. China, the world's largest fish producer and exporter, has significantly increased its fishery imports, partly a result of outsourcing, as Chinese processors import raw material from all major regions, including South and

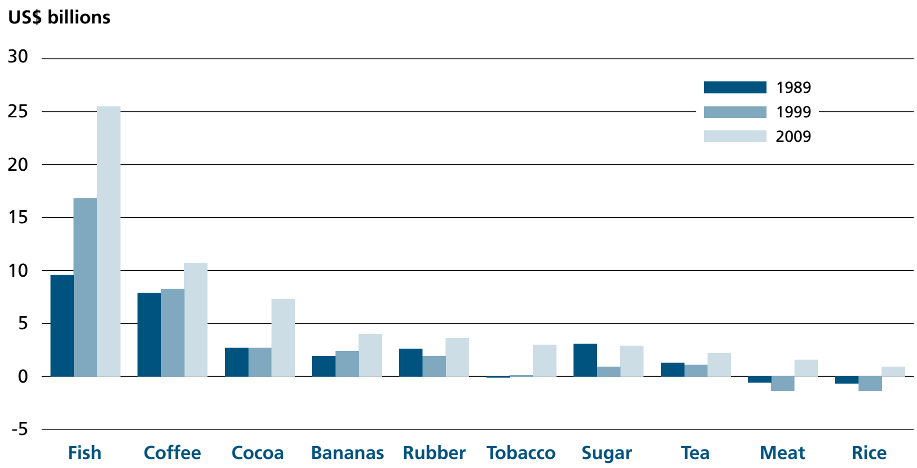
Table 12
Top ten exporters and importers of fish and fishery products

	2000	2010	APR
	(US$ millions)		(Percentage)
EXPORTERS			
China	3 603	13 268	13.9
Norway	3 533	8 817	9.6
Thailand	4 367	7 128	5.0
Viet Nam	1 481	5 109	13.2
United States of America	3 055	4 661	4.3
Denmark	2 756	4 147	4.2
Canada	2 818	3 843	3.1
Netherlands	1 344	3 558	10.2
Spain	1 597	3 396	7.8
Chile	1 794	3 394	6.6
TOP TEN SUBTOTAL	26 349	57 321	8.1
REST OF WORLD TOTAL	29 401	51 242	5.7
WORLD TOTAL	**55 750**	**108 562**	**6.9**
IMPORTERS			
United States of America	10 451	15 496	4.0
Japan	15 513	14 973	–0.4
Spain	3 352	6 637	7.1
China	1 796	6 162	13.1
France	2 984	5 983	7.2
Italy	2 535	5 449	8.0
Germany	2 262	5 037	8.3
United Kingdom	2 184	3 702	5.4
Sweden	709	3 316	16.7
Republic of Korea	1 385	3 193	8.7
TOP TEN SUBTOTAL	26 349	69 949	10.3
REST OF WORLD TOTAL	33 740	41 837	2.2
WORLD TOTAL	**60 089**	**111 786**	**6.4**

Note: APR refers to the average annual percentage growth rate for 2000–2010.

Figure 23

Net exports of selected agricultural commodities by developing countries



North America and Europe for re-processing and export. Imports are also being fuelled by robust domestic demand for species not available from local sources, in particular marine species, as a consequence of economic growth and rising disposable incomes. Its imports increased from US$1.8 billion in 2000 to US$6.2 billion in 2010. Imports further grew by 23 percent in 2011 to US$7.6 billion, when China became the third-largest importer in the world. This increase in imports also reflects the lowered import duties following China's accession to the WTO in late 2001.

The European Union is by far the largest single market for imported fish and fishery products owing to its growing domestic consumption. However, it is extremely heterogeneous, with markedly different conditions from country to country. European Union fishery imports reached US$44.6 billion in 2010, up 10 percent from 2009, and representing 40 percent of total world imports. However, if intraregional trade is excluded, the European Union imported fish and fishery products worth US$23.7 billion from suppliers outside the European Union, an increase of 11 percent from 2009. This makes the European Union the largest market in the world, with about 26 percent of world imports (excluding intra-European Union trade). In 2011, imports rose further to US$50.0 billion including intra-European Union trade (US$26.5 billion if excluded). The dependence of the European Union on imports for its fish consumption is growing. This is a result of the positive underlying trend in consumption, but also evidences the constraints within the European Union on further expansion of supply. In this respect, the current reform of its Common Fisheries Policy aims to rebuild its fish stocks, as well as boosting its aquaculture production. The results of the reform and the effects on supply and trade will only be felt in the medium-to-long term.

In addition to the major importing countries, a number of emerging markets have become of growing importance to the world's exporters. Prominent among these there are Brazil, Mexico, the Russian Federation, Egypt, Asia and the Near East in general. In Asia, Africa and South and Central America, regional trade continues to be of importance even though it is not always adequately reflected in official statistics. Improved domestic distribution systems for fish and fishery products have played a role in increased regional trade, as has growing aquaculture production. Domestic markets, in particular in Asia, but also in Central and South America, remained strong in 2010–11, providing welcome outlets for domestic and regional producers. Africa has also become a growing market for farmed freshwater species from Asia.

In 2010, developed countries were responsible for 76 percent of the total import value of fish and fishery products, a decline compared with the 86 percent of 1990 and 83 percent of 2000. In volume (live weight equivalent), the share of developed countries is significantly less, 58 percent, reflecting the higher unit value of products imported by developed countries. Owing to stagnating domestic fishery production, developed countries have to rely on imports and/or on domestic aquaculture to cover their increasing domestic consumption of fish and fishery products. This may be one reason for 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 increasingly been able to supply fishery products to markets of developed countries without facing prohibitive custom duties. In 2010, 48 percent of the import value of developed countries originated from developing countries.

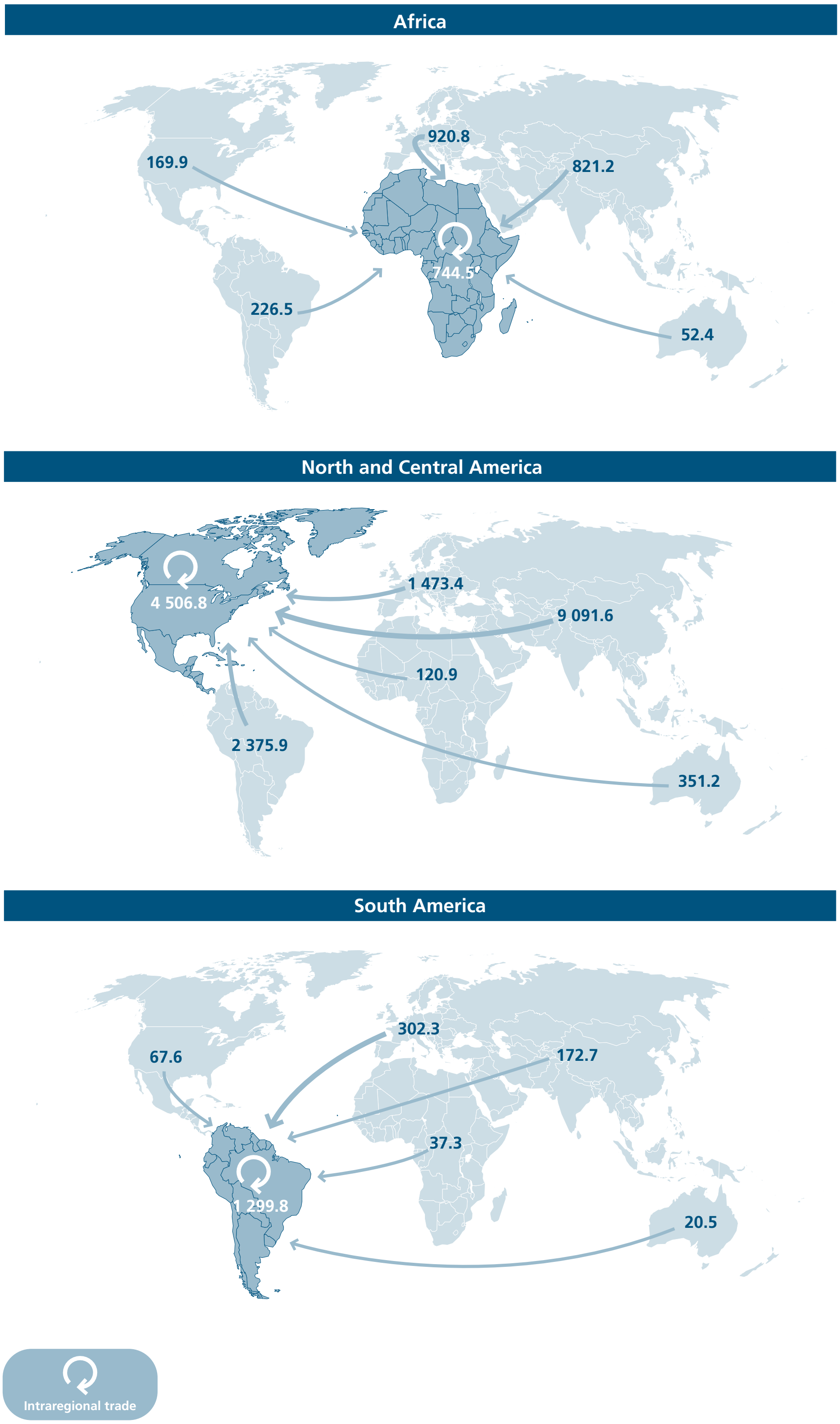
In recent decades, there has been a tendency towards increased fishery trade within regions. Most developed countries trade more with other developed countries. In 2010, in value terms, 79 percent of fishery exports from developed countries were destined to other developed countries, and about 52 percent of fishery imports of developed countries originated from other developed countries. In the same year, fishery trade between developing countries represented only 33 percent of the value of their exports of fish and fishery products. Over time, fishery trade between developing countries will probably increase in the wake of rising disposable incomes in emerging economies, gradual trade liberalization and a reduction in 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. The maps in Figure 24 summarize the average trade flows of fish and fishery products by continent for the period 2008–2010. The overall picture presented by these maps is not exhaustive as trade data are not fully available for all countries, in particular for several African countries. However, the quantity of data at hand is sufficient to establish general trends, with no major changes taking in place compared with the past few years. The Latin America and the Caribbean region continues to maintain a solid positive net fishery exporter role, as is the case for 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 imports (mainly for small pelagics). Europe and North America are characterized by a fishery trade deficit (Figure 25).

Some of the major issues in the past biennium that continue to affect fishery international trade are:

- the volatility of commodity prices in general and their influence on producers as well as on consumers;
- the impact on the domestic fisheries sector of the rising imports of farmed products;
- the role of the small-scale sector in future fish production and trade;
- the relationship between fisheries management design, allocation of rights and the economic sustainability of the sector;
- the introduction of private standards, including for environmental and social purposes, and their endorsement by major retailers;
- the multilateral trade negotiations within the WTO, including the focus on fisheries subsidies;
- climate change, carbon emissions and their impacts on the fisheries sector;
- the growing concern of the general public and the retail sector about overexploitation of certain fish stocks;
- the need to ensure that internationally traded fishery products from capture fisheries have been produced legally;
- the need for competitiveness versus other food products;
- the perceived and real risks and benefits of fish consumption.

Figure 24

Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2008–2010)

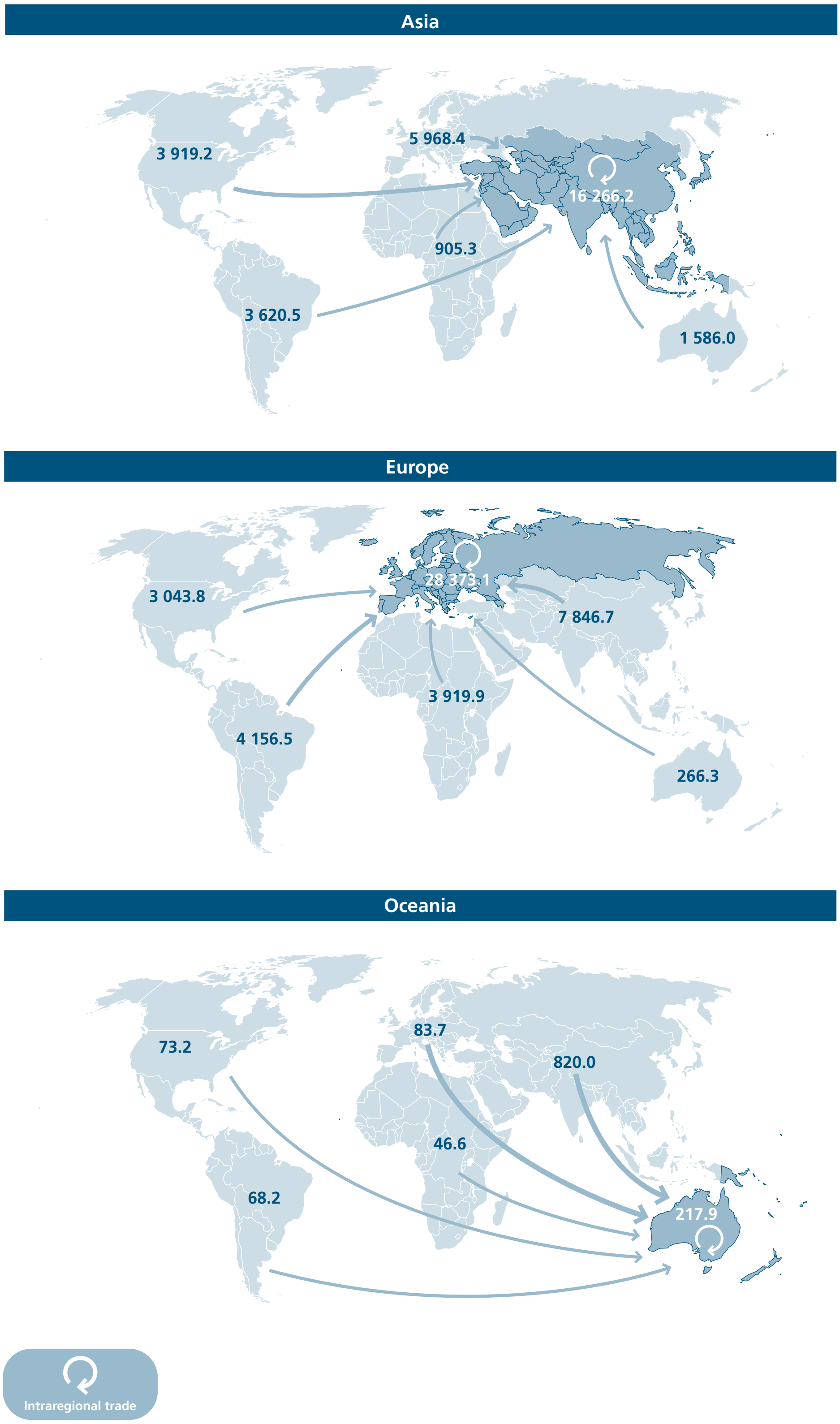


Note: The maps indicate the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

(Continued)

Figure 24 *(cont.)*

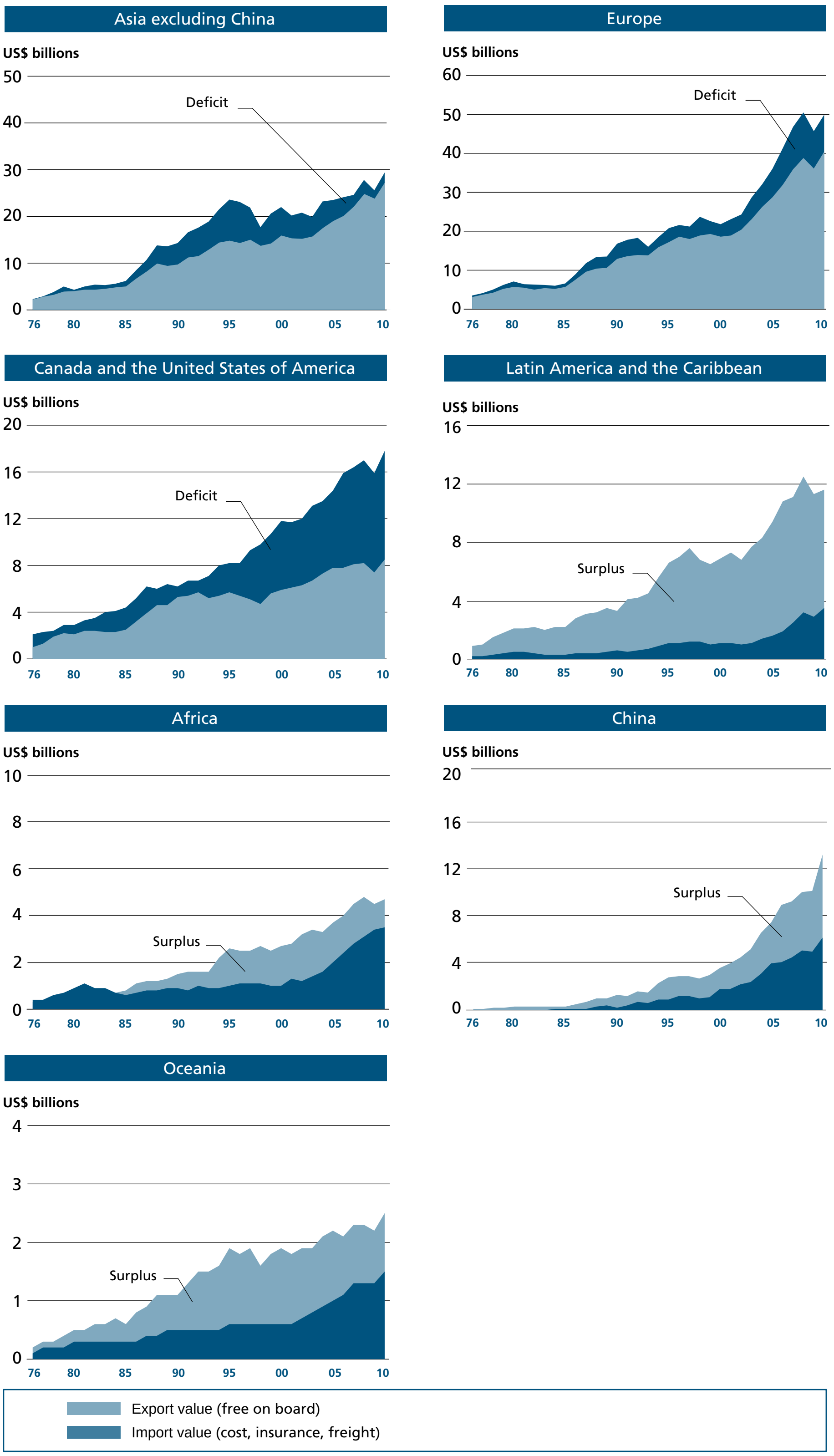
Trade flows by continent (total imports in US$ millions, c.i.f.; averages for 2008–2010)



Note: The maps indicate the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

Figure 25

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



Commodities

The fishery market is very dynamic and it is changing rapidly. It is becoming much more complex and stratified, with greater diversification among species and product forms. High-value species such as shrimp, prawns, salmon, tuna, groundfish, flatfish, seabass and seabream are highly traded, in particular towards more prosperous markets. Low-value species such as small pelagics are also traded in large quantities, mainly being exported to feed low-income consumers in developing countries. In the last two decades, aquaculture has contributed to a growing share of the international trade in fishery commodities, with species such as shrimp, prawns, salmon, molluscs, tilapia, catfish (including *Pangasius*), seabass and seabream. Aquaculture is expanding in all continents in terms of new areas and species, as well as intensifying and diversifying the product range in species and product forms to respond to consumer needs. Many of the species that have registered the highest export growth rates in the last few years are produced by aquaculture. 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.

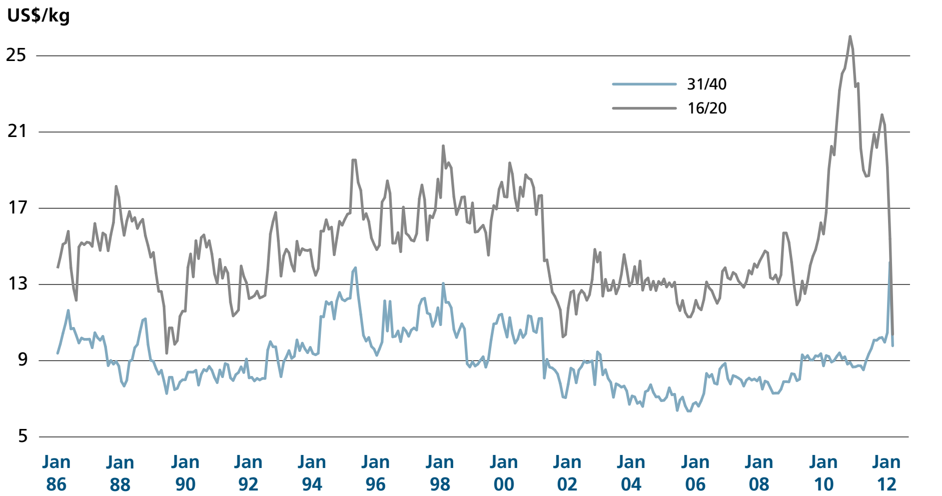
Owing to the high perishability of fish and fishery products, 90 percent of trade in fish and fishery products in quantity terms (live weight equivalent) consists of processed products (i.e. excluding live and fresh whole fish). Fish are increasingly traded as frozen food (39 percent of the total quantity in 2010, compared with 25 percent in 1980). In the last four decades, prepared and preserved fish have nearly doubled their share in total quantity, going from 9 percent in 1980 to 16 percent in 2010. Notwithstanding their perishability, trade in live, fresh and chilled fish represented 10 percent of world fish trade in 2010, up from 7 percent in 1980, 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 2010, 71 percent of the quantity of fish and fishery products exported consisted of products destined for human consumption. The US$109 billion exports of fish and fishery products in 2010 do not include an additional US$1.3 billion for aquatic plants (62 percent), inedible fish waste (31 percent) and sponges and corals (7 percent). In the last two decades, trade in aquatic plants has increased significantly, going from US$0.2 billion in 1990 to US$0.5 billion in 2000 and to US$0.8 billion in 2010, with China as the major exporter and Japan as the leading importer. Trade in inedible fish waste has also grown remarkably in this period, owing to the increasing production of fishmeal and other products deriving from fishery residues from processing (see the Fish Utilization and Processing section above). From just US$61 million in 1990, exports of inedible fish rose to US$0.2 billion in 2000 and reached US$0.4 billion in 2010.

Shrimp

Shrimp continues to be the largest single commodity in value terms, accounting for about 15 percent of the total value of internationally traded fishery products in 2010. In 2010, the shrimp market recovered, after the decline of 2009, characterized by stable volumes, but by substantially decreases of prices. In 2011, notwithstanding a contraction in world production of farmed shrimp, the market performed well. Despite the scepticism and concern over the economic situation, both the United States of America and the European Union imported more shrimp than the year before. The Japanese market moved away from basic raw shrimp to value-added and processed shrimp, thus paying more for imports. Many domestic and regional markets in Asia and Latin America consumed more shrimp, which also kept their prices relatively high and stable throughout 2011 (Figure 26). In 2012, the shrimp market began with positive notes in demand and price trends in various markets. 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.

Figure 26

Shrimp prices in Japan



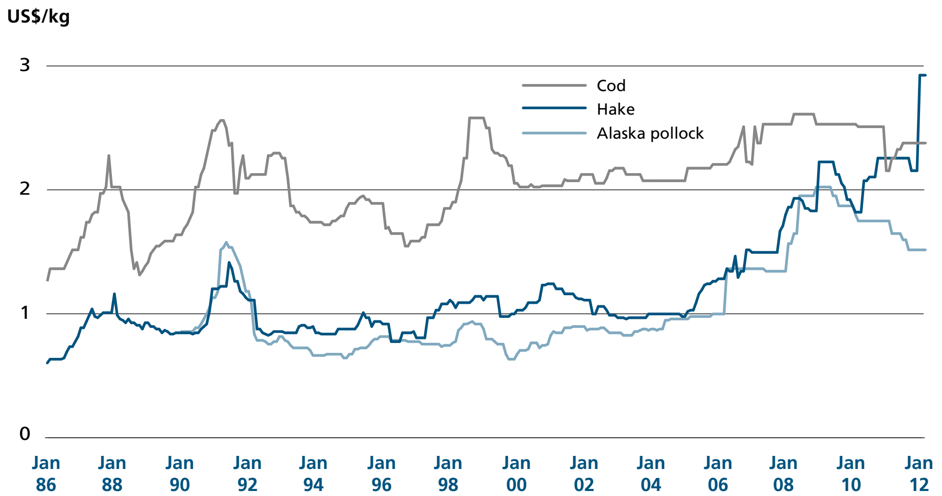
Note: 16/20 = 16–20 pieces per pound; 31/40 = 31–40 pieces per pound.
Data refer to wholesale prices for black tiger, headless, shell-on shrimps. Origin: Indonesia.

Salmon

The share of salmon and trouts in world trade has increased considerably in recent decades, and in 2010 it was more than 14 percent. Overall, demand for farmed salmon has been growing steadily from year to year. However, supply has been more variable, mostly as a result of disease-related problems in the producing countries. In a situation with a positive long-term trend in demand, a temporary shortfall in supply is bound to lead to large price reactions, and this is what happened in 2010 and early 2011, with exceptionally high prices, in particular for farmed Atlantic salmon. Prices started to weaken in the following months also as a result of large additional volumes of farmed salmon reaching world markets. At the beginning of 2012, prices recovered from the low levels reached in late 2011. Demand growth continues to be consistent

Figure 27

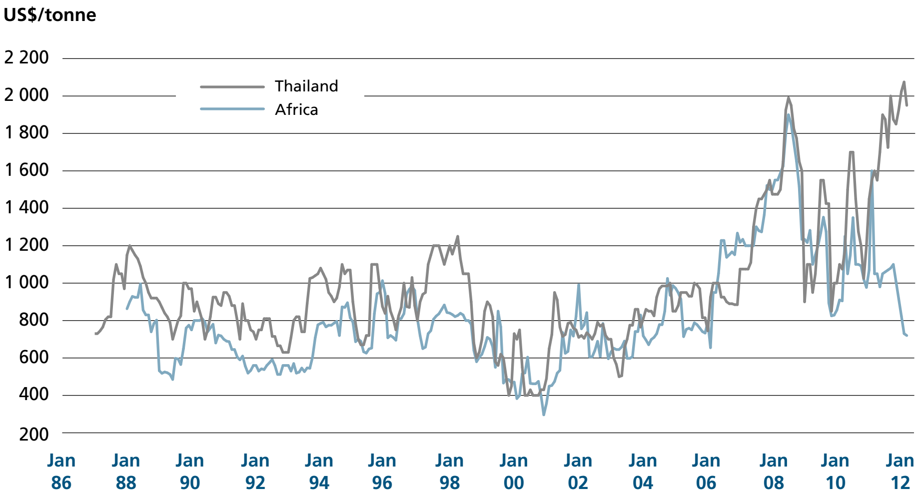
Groundfish prices in the United States of America



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.

in most markets and it is expanding geographically, in particular for farmed Atlantic salmon, also through new varieties of processed products. Norway remains the dominant producer and exporter of Atlantic salmon, but Chile is rapidly ramping up its production towards levels prior to the crisis experienced in 2010. Wild Pacific salmon also plays an important part in world salmon markets with wild salmon representing about 30 percent of the total market for salmonids.

Groundfish

Groundfish species represented about 10 percent of total fish exports by value in 2010. Their prices went down in 2010 and 2011 as a result of good supply from capture fisheries and strong competition from farmed species such as *Pangasius* and tilapia on the market (Figure 27). General demand for groundfish species is increasing, and increased supply will come from good management practices of the wild stocks. Emerging countries will provide new opportunities. For example, Brazil has become a growing destination for Norwegian cod, helping to ease somewhat the concerns of Norwegian exporters that their sales in southern Europe were being affected by the economic crisis, particularly in Portugal, which is the largest single importer of Norwegian cod.

Tuna

The share of tuna in total fish exports in 2010 was about 8 percent. In the last three years, tuna markets have been unstable owing to large fluctuations in catch levels. The major issues affecting the global tuna sector in 2011 were lower catches in major fishing areas, growing restrictions on longline and purse-seine fishing in the pursuit of more sustainable resource management, other moves towards sustainability and the introduction of ecolabels. These factors have had an impact on the tuna market for sashimi and as raw material for canning, with consequent increases in tuna prices (Figure 28). Japan continues to be the main market for sashimi-grade tuna, while the European Union and the United States of America represent the major importers and Thailand the main exporter of canned tuna.

Cephalopods

The share of cephalopods (squid, cuttlefish and octopus) in world fish trade was 4 percent in 2010. Spain, Italy and Japan are the largest consumers and importers of these species. Thailand is the largest exporter of squid and cuttlefish, followed by Spain, China and Argentina, while Morocco and Mauritania are the principal octopus exporters. Recently, Mexico has also emerged as an important supplier to Europe. Supplies of octopus have been a problem, and throughout 2011 this characterized the trade. Import volumes in the main markets, however, were relatively stable, with growing price levels (Figure 29). The diminishing catches of octopus have revived interest in octopus farming. Whether the new technologies being experimented will be able to produce significant amounts of octopus of the right market size in the future remains to be seen, although progress so far is encouraging. Squid supplies were also quite tight throughout 2011. This is reflected in the trade figures. Imports into all major markets, with the exception of Japan, declined. The cuttlefish market has been flat for the last few years. The main importers have seen little variation in imported volumes over the years, although there have been some changes among the suppliers to the various markets.

Pangasius

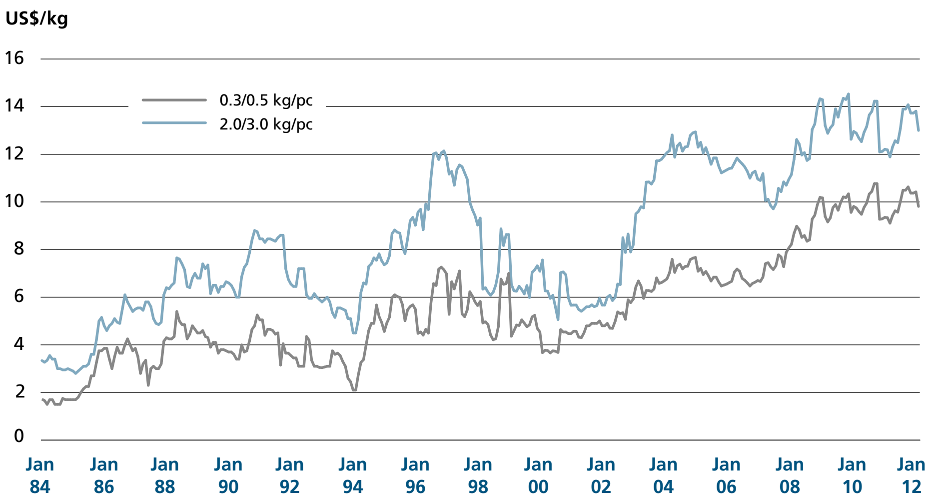
Pangasius is a freshwater fish, and it is a relatively recent arrival in terms of international trade. However, with production of about 1.3 million tonnes, mainly in Viet Nam and all going to the international markets, this species is an important source of low-priced fish. The European Union and the United States of America are the main importers of *Pangasius*. In 2011, imports declined in the European Union, while they increased in the United States market. Supply issues affected the *Pangasius* sector in Viet Nam, and overall output declined in 2011. Although Viet Nam is the largest supplier to the European Union markets, the product is also sourced from China and Thailand. Asian demand remains strong with new markets emerging, including those of India and the Near East, in particular for fillets. Local production facilitated by aggressive promotional activities is also increasing in many countries for domestic consumption.

Fishmeal

Fishmeal production and trade decreased significantly in 2010 owing to reduced catches of anchoveta, while production for 2011 increased by about 40 percent in the

Figure 29

Octopus prices in Japan



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

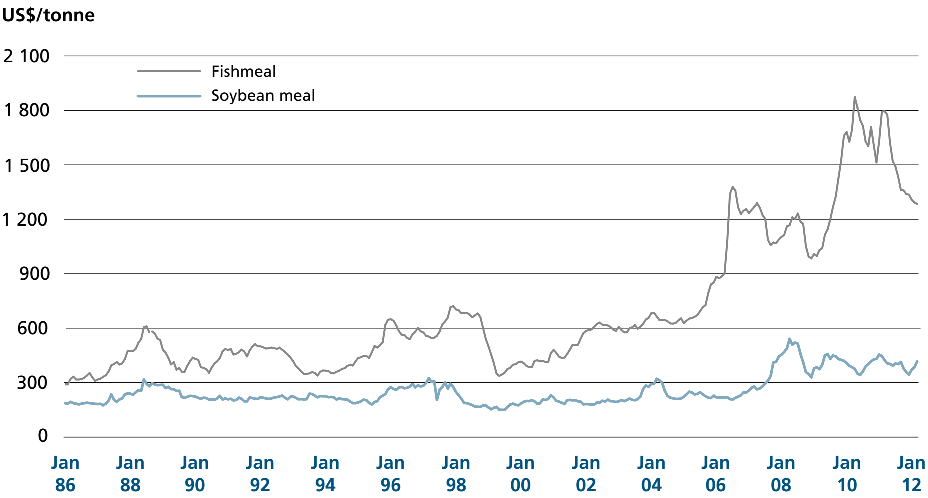
major producing countries. Demand for fishmeal was strong in 2010 and 2011, leading to sharply higher fishmeal prices (Figure 30). Despite some recent softening in late 2011 and early 2012, prices remain at fairly high levels. China remains the main market for fishmeal, importing more than 30 percent of the fishmeal quantity, while Peru and Chile are the major exporters.

Fish oil

Improved landings and access to raw material contributed to a rise in fish-oil production in 2011, after the decline in 2010. Notwithstanding some fluctuations, fish-

Figure 30

Fishmeal and soybean meal prices in Germany and the Netherlands

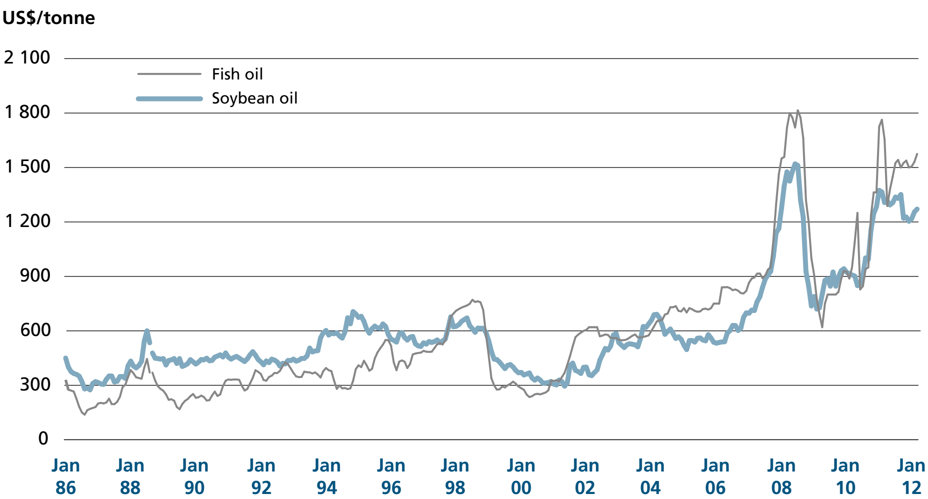


Note: Data refer to c.i.f. prices.
Fishmeal: all origins, 64–65 percent, Hamburg, Germany.
Soybean meal: 44 percent, Rotterdam, Netherlands.

Source: Oil World; FAO GLOBEFISH.

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.

oil prices continued to be at high levels in 2011 and early 2012 (Figure 31). Demand from the aquaculture and health supplement sectors will continue to take most of the volumes offered. The share going to aquaculture is used as an ingredient in fish and shrimp feeds. In 2011, a large increase in salmonoid production in Chile boosted oil demand from Chile and Peru while producers in Europe were able to increase supply, despite high prices of mackerel and herring for direct human consumption.

FISH CONSUMPTION[19]

Fish and fishery products represent a valuable source of nutrients of fundamental importance for diversified and healthy diets. With a few exceptions for selected species, fish is usually low in saturated fats, carbohydrates and cholesterol. Fish provides not only high-value protein, but also a wide range of essential micronutrients, including various vitamins (D, A and B), minerals (including calcium, iodine, zinc, iron and selenium) and polyunsaturated omega-3 fatty acids (docosahexaenoic acid and eicosapentaenoic acid). While average per capita fish consumption may be low, even small quantities of fish can have a significant positive nutritional impact by providing essential amino acids, fats and micronutrients that are scarce in vegetable-based diets. There is evidence of beneficial effects of fish consumption[20] in relation to coronary heart disease,[21] stroke, age-related macular degeneration and mental health.[22] There is also convincing evidence of benefits in terms of growth and development, in particular for women and children during gestation and infancy for optimal brain development of children.[23]

On average, fish provides only about 33 calories per capita per day. However, it can exceed 150 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). The dietary contribution of fish is more significant in terms of animal proteins, as a portion of 150 g of fish provides about 50–60 percent of the daily protein requirements for an adult. Fish proteins can represent a crucial component in some densely populated countries where total protein intake levels may be low. In fact, many populations, more those in developing countries than developed ones, depend on fish as part of their daily diet. For them, fish and fishery products often represent an affordable source of animal protein that may not only be cheaper than other animal protein sources, but preferred and part of local and traditional recipes. For example, fish contributes to, or exceeds, 50 percent of total animal protein intake in some small island developing States, as well as in Bangladesh,

Figure 32

Total protein supply by continent and major food group (average 2007–2009)

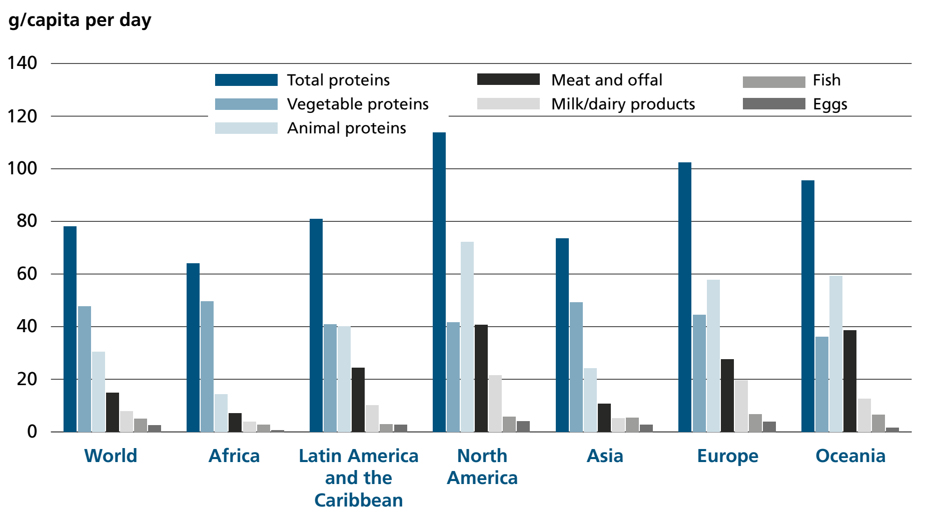
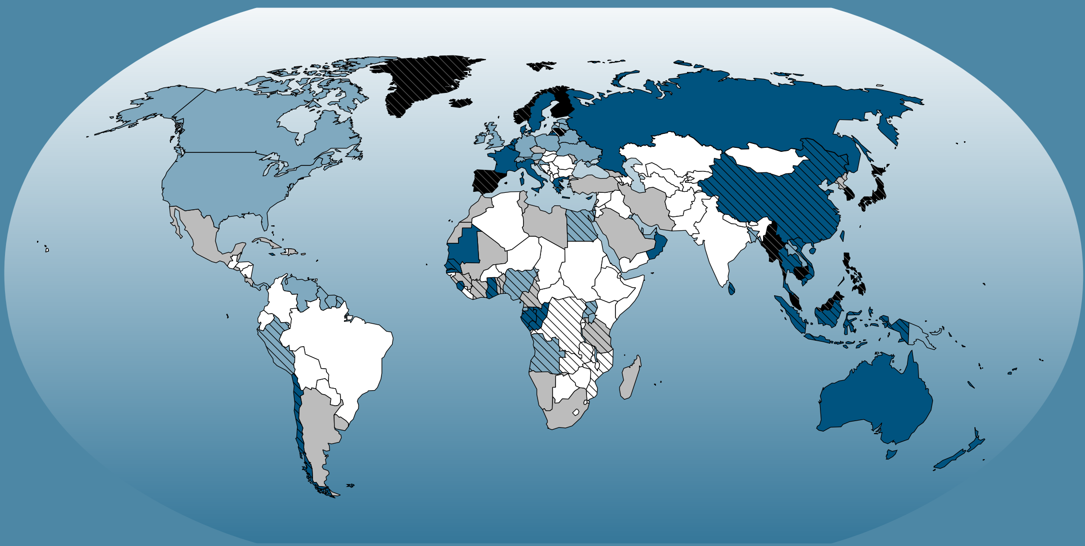


Figure 33

Contribution of fish to animal protein supply (average 2007–2009)



Fish proteins (per capita per day)

< 2 g
2–4 g
4–6 g
6–10 g
> 10 g

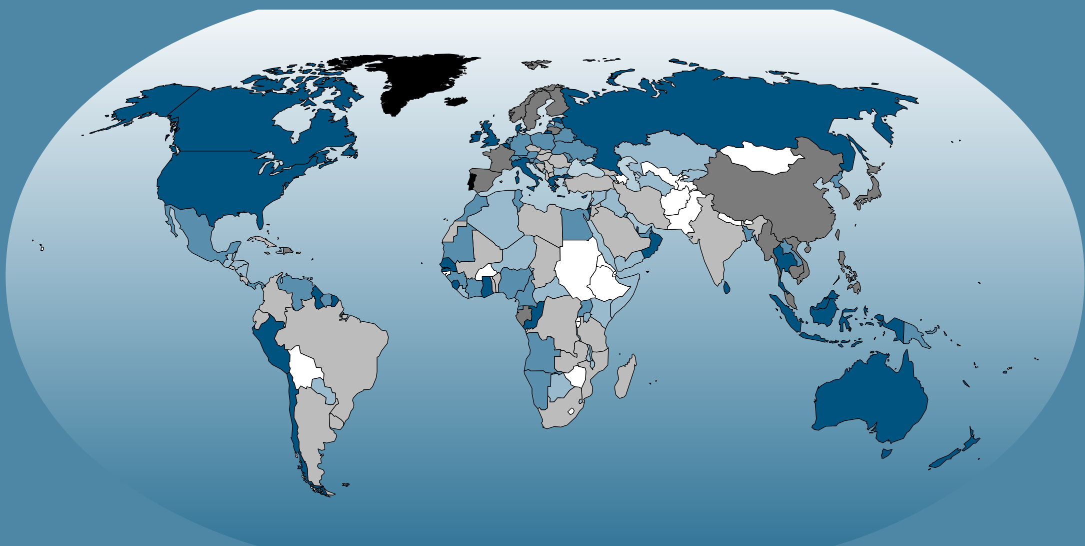
Contribution of fish to animal protein supply

> 20%

Note: The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

Figure 34

Fish as food: per capita supply (average 2007–2009)



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

Note: The map indicates the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

Cambodia, Ghana, the Gambia, Indonesia, Sierra Leone and Sri Lanka. In 2009, fish[24] accounted for 16.6 percent of the global population's intake of animal protein and 6.5 percent of all protein consumed (Figure 32). Globally, fish provides about 3.0 billion people with almost 20 percent of their average per capita intake of animal protein, and 4.3 billion people with about 15 percent of such protein (Figure 33).

Linked to the strong expansion of fish production and of modern distribution channels, world fish food supply grew at an average rate of 3.2 percent per year in the period 1961–2009, outpacing the increase of 1.7 percent per year in the world's population; hence, average per capita availability has risen. World per capita fish consumption increased 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, 17.0 kg in the 2000s and reached 18.4 kg in 2009. Preliminary estimates for 2010 point towards a further increase in per capita fish consumption to 18.6 kg. It should be noted that figures for 2000 are higher than those reported in previous editions of *The State of World Fisheries and Aquaculture*, as FAO has revised downwards the non-food estimates for China's apparent consumption, starting from 2000 data, to reflect improved national information on the sector. As a consequence, per capita fish consumption figures for China as well as for the world have increased in comparison with previous assessments.

Notwithstanding the strong increase in the availability of fish to most consumers, the growth in fish consumption differs considerably among countries and within countries and regions in terms of quantity and variety consumed per head. For example, per capita fish consumption has remained static or decreased in some countries in sub-Saharan Africa (e.g. the Congo, South Africa, Gabon, Malawi and Liberia) and in Japan in the last two decades, while the most substantial increases in annual per capita fish consumption have occurred in East Asia (from 10.6 kg in 1961 to 34.5 kg in 2009), Southeast Asia (from 12.8 kg in 1961 to 32.0 kg in 2009) and North Africa (from 2.8 kg in 1961 to 10.6 kg in 2009). China has been responsible for most of the increase in world per capita fish consumption, owing to the substantial increase in its fish production, in particular from aquaculture. China's share in world fish production grew from 7 percent in 1961 to 34 percent in 2009. Per capita fish consumption in China has also increased dramatically, reaching about 31.9 kg in 2009, with an average annual growth rate of 4.3 percent in the period 1961–2009 and of 6.0 percent in the period 1990–2009. In the last few years, fuelled by growing domestic income and wealth, consumers in China have experienced a diversification of the types

Table 13
Total and per capita food fish supply by continent and economic grouping in 2009[1]

	Total food supply	Per capita food supply
	(million tonnes live weight equivalent)	*(kg/year)*
World	**125.6**	**18.4**
World (excluding China)	83.0	15.1
Africa	9.1	9.1
North America	8.2	24.1
Latin America and the Caribbean	5.7	9.9
Asia	85.4	20.7
Europe	16.2	22.0
Oceania	0.9	24.6
Industrialized countries	27.6	28.7
Other developed countries	5.5	13.5
Least-developed countries	9.0	11.1
Other developing countries	83.5	18.0
LIFDCs[2]	28.3	10.1

[1] Preliminary data.
[2] Low-income food-deficit countries.

of fish available owing to a diversion of some fishery exports towards the domestic market as well as an increase in fishery imports. If China is excluded, annual per capita fish supply to the rest of the world was about 15.4 kg in 2009, higher than the average values of the 1960s (11.5 kg), 1970s (13.5 kg), 1980s (14.1 kg) and 1990s (13.5 kg). It should be noted that during the 1990s, world per capita fish supply, excluding China, was relatively stable at 13.1–13.5 kg and lower than in the 1980s as population grew more rapidly than food fish supply (at annual rates of 1.6 and 0.9 percent, respectively). Since the early 2000s, there has been an inversion of this trend, with food fish supply growth outpacing population growth (at annual rates of 2.6 percent and 1.6 percent, respectively).

Table 13 summarizes per capita fish consumption by continent and major economic group. The total amount of fish consumed and the species composition of the food fish supply vary according to regions and countries, reflecting the different levels of availability of fish and other foods, including the accessibility of fishery resources in adjacent waters as well as the interaction of several socio-economic and cultural factors. These factors include food traditions, tastes, demand, income levels, seasons, prices, health infrastructure and communication facilities. 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 may also be significant within countries, with consumption usually higher in coastal, riverine and inland water areas. Of the 126 million tonnes available for human consumption in 2009, fish consumption was lowest in Africa (9.1 million tonnes, with 9.1 kg per capita), while Asia accounted for two-thirds of total consumption, with 85.4 million tonnes (20.7 kg per capita), of which 42.8 million tonnes was consumed outside China (15.4 kg per capita). The corresponding per capita fish consumption figures for Oceania, North America, Europe, and Latin America and the Caribbean were 24.6 kg, 24.1 kg, 22.0 kg and 9.9 kg, respectively.

Differences in fish consumption exist between the more-developed and the less-developed countries. Although annual per capita consumption of fishery products has grown steadily in developing regions (from 5.2 kg in 1961 to 17.0 kg in 2009) and in LIFDCs (from 4.9 kg in 1961 to 10.1 kg in 2009), it is still considerably lower than that of more developed regions, even though the gap is narrowing. The actual values may be higher than indicated by official statistics in view of the under-recorded contribution of subsistence fisheries and some small-scale fisheries. In 2009, apparent per capita fish consumption in industrialized countries was 28.7 kg, while for all developed countries it was estimated at 24.2 kg. A sizeable share of fish consumed in developed countries consists of imports, and owing to steady demand and declining domestic fishery production (down 10 percent in the period 2000–2010), their dependence on imports, in particular from developing countries, is projected to grow. In developing countries, fish consumption tends to be based on locally and seasonally available products, and the fish chain is driven by supply rather than demand. However, in emerging economies, imports of fishery products not available locally have recently been growing.

Disparities among developed and developing countries exist also with reference to the contribution of fish to animal protein intake. Despite their relatively low levels of fish consumption, this share was significant at about 19.2 percent for developing countries and 24.0 percent for LIFDCs. However, this share has declined slightly in recent years owing to the growing consumption of other animal proteins. In developed countries, the share of fish in animal protein intake, after consistent growth up to 1989, declined from 13.9 percent in 1984 to 12.4 percent in 2009, while consumption of other animal proteins continued to increase.

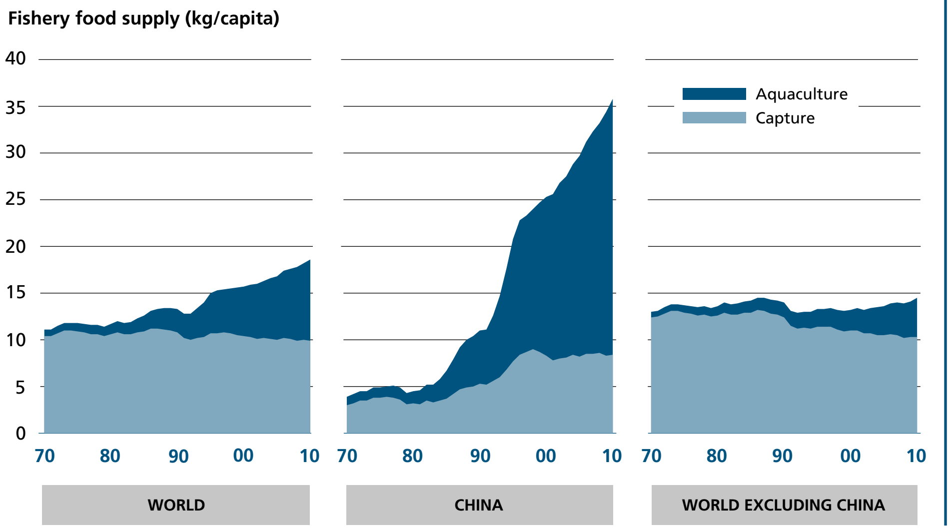
The seafood sector remains very fragmented, in particular for markets of fresh seafood, but it is in a phase of consolidation and globalization. Fish is very heterogeneous and differences may be based on species, production area, method of fishing or farming, handling practice and hygiene. Raw fish can be processed into an even wider range of products to meet consumer demands that differ according to markets, flexibility in supply volumes, physical proximity, suppliers' trustworthiness, ability to adapt to different portion-size specifications, etc. In the last two decades, the consumption of fish and fishery products has also been influenced considerably by globalization in food systems and by innovations and improvements in processing, transportation, distribution, marketing and food science and technology. These factors have led to significant enhancements 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 and consumption of an expanded variety of species and product forms, including live and fresh fish. Consumers can benefit from increased choice, with imports boosting the availability of fish and fishery products in the domestic markets.

Growing interest from local consumers has also underpinned aquaculture development in many regions in Asia and, increasingly, in Africa and in Latin America. Since the mid-1980s, and in particular in the last decade, the contribution of aquaculture to fish consumption has shown dramatic growth, as capture fisheries production has stagnated or even declined in some countries. In 2010, aquaculture contributed about 47 percent of the fishery output for human consumption – impressive growth compared with its 5 percent in 1960, 9 percent in 1980 and 34 percent in 2000 (Figure 35), with an average annual growth rate of 4.7 percent in the period 1990–2010. However, if China is excluded, the average contribution of aquaculture is significantly lower at 17 percent in 2000 and 29 percent in 2010, corresponding to an average annual growth rate of 5.4 percent. 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 for shrimps, salmon, bivalves, tilapia, catfish and *Pangasius*. Aquaculture also plays a role in food security through the significant production of some low-value freshwater species, which are mainly destined for domestic production, also through integrated farming.

The surging contribution of aquaculture can also be noted by observing fish consumption by major groups. 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 in 1961 to 1.7 kg in 2009, and that of molluscs (including cephalopods) rose from 0.8 kg to 2.8 kg in the

Figure 35

Relative contribution of aquaculture and capture fisheries to food fish consumption



same period. 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 6.0 kg in 2009. In the last few years, no major changes have been experienced by the other broader groups. Annual consumption of demersal and pelagic fish species has stabilized at about 3.0 kg and 3.4 kg per capita, respectively. Demersal fish continue to be among the main species favoured by consumers in Northern Europe and in North America (8.6 kg and 7.0 kg per capita per year, respectively, in 2009), whereas cephalopods are mainly preferred by Mediterranean and East Asian countries. Of the 18.4 kg of fish per capita available for consumption in 2009, about 74 percent came from finfish. Shellfish supplied 26 percent (or about 4.5 kg per capita, subdivided into 1.7 kg of crustaceans, 0.5 kg of cephalopods and 2.3 kg of other molluscs).

The global growth in fish consumption mirrors trends in food consumption in general. Per capita food consumption has also been growing in the last few decades. With the exception of the periods of the food and economic crises, the global food market, including the fish market, has experienced unprecedented expansion and a change in global dietary patterns, becoming more homogeneous and globalized. This change has been the result of several factors, including rising living standards, population growth, rapid urbanization and opportunities for trade and transformations in food distribution. A combination of these factors has led to growing demand for proteic food products, in particular meat, fish, milk, eggs as well as vegetables in the diet, with a reduction in the share of staples such as roots and tubers. Protein availability has increased in both the developed and developing world, but this 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. According to FAOSTAT, annual global per capita meat consumption grew from 26.3 kg in 1967 to 32.4 kg in 1987 to reach 40.1 kg in 2007. The growth was particularly marked in the most rapidly emerging economies of developing countries, and annual per capita meat consumption in developing countries more than doubled from 11.2 kg in 1967 to 29.1 kg in 2007. The supply of animal protein continues to remain significantly higher in industrialized and other developed countries than in developing countries. However, having attained a high level of consumption of animal protein, more developed economies have been increasingly reaching saturation levels and are less reactive than low-income countries to income growth and other changes. In developed countries, per capita meat consumption increased from 61.4 kg in 1967 to 80.7 kg in 1987, but then declined to 75.1 kg in 1997 before reaching 82.9 kg in 2007.

Notwithstanding the improvement in per capita availability of food 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. Malnutrition is a major problem worldwide, with one person in seven undernourished and more than one-third of infant mortality attributable to undernutrition. This is especially the case in many developing countries, with the bulk of undernourished people living in rural areas. According to the FAO report *The State of Food Insecurity in the World 2011*,[25] the number of undernourished people was 850 million in 2006–08, of whom 223.6 million were in Africa, 567.8 million in Asia and 47 million in Latin America and the Caribbean. About two-thirds of the undernourished originate in seven countries (Bangladesh, China, the Democratic Republic of the Congo, Ethiopia, India, Indonesia and Pakistan) and more than 40 percent of them live in China and India alone. According to preliminary estimates, the number of undernourished people could have reached about 925 million people in 2010–11. 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 food sector in general is encountering a period of structural adjustment as a result of growing incomes, modifications in the population structure, new lifestyles, globalization, liberalization of trade and the emergence of new markets. A greater focus is also being given to marketing, with producers and retailers becoming more attentive to consumer preferences and attempting to anticipate market expectations in terms of quality, safety standards, variety, value addition, etc. Consumer habits have changed significantly in the past few decades, and food issues such as indulgence, convenience, health, ethics, variety, value for money, and safety are becoming increasingly important, especially in more affluent economies. In these markets, consumers are requesting higher standards in terms of food freshness, diversity, convenience and safety, including quality assurances such as traceability, packing requirements and processing controls. Consumers now demand guarantees that their food has been produced, handled and sold in ways that safeguard their health, respect the environment and address various ethical and social concerns. Health and well-being are increasingly influencing consumption decisions, and fish has a particular prominence in this respect, following mounting evidence confirming the health benefits of eating fish (see above). This is partly related to an ageing society, but food safety issues as well as obesity and allergic reactions have also raised awareness about the relationship between food and health. In more-developed economies, rapid reductions in fertility combined with improvements in survival are leading to an ageing population, wherein an increasing proportion of the population is concentrated among older age groups. In many countries of the more developed regions, more than 20 percent of the population are aged 60 or over. This affects the demand for different types of food.

These ongoing changes in consumer preferences are having an increasing impact on technological innovations and on new procedures for organizing the supply chain. The majority of product innovations deal with incremental modifications, such as variations in taste and packages designed for different forms of consumption. World food markets have become more flexible, with new products entering the markets, including value-added products that are easier for consumers to prepare. Retail chains, transnational companies and 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 in the number of supermarkets, which are increasingly targeting lower- and middle-income consumers as well as the higher-income groups.

Growing urbanization is one of the factors modifying food consumption patterns, with an impact also on the demand for fishery products. People living in urban areas tend to devote a higher proportion of their income to food purchased and, in addition, to eat out of the home more frequently, and to purchase larger quantities of fast and convenience foods. Moreover, increasing urbanization compounds the pressure on adjacent areas to meet the demand of large, concentrated populations. According to the United Nations Population Division,[26] in 2011 52.1 percent (3.6 billion people) of the world's population were living in urban areas. Disparities in the levels of urbanization persist among countries and regions of the world, with more-developed countries having an urban share of up to 78 percent, while others remain mostly rural, in particular, LDCs (with an urban share of about 29 percent) and Africa (40 percent) and Asia (45 percent). However, also in these latter areas, a vast movement of the population towards the cities is taking place. An additional 294 million and 657 million people are expected to become urbanized by 2015 and 2020, respectively, with the bulk of the increase in urban areas expected in Asia and Africa. By 2050, the shares of urban population will be 58 percent in Africa and 64 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.

The outlook for the global food sector remains uncertain. It is facing various challenges related to the economic turndowns in selected countries and demographic issues, including growing urbanization. The long-term forecast for food demand 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 (see p. 188). 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, climate 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. World population growth is expected to slow in the next decade, in all regions and continents, with developing countries continuing to experience the most rapid population increases. The global population is set to increase from about 7 billion in 2011 to 7.3 billion in 2015 and to 7.7 billion in 2020 and 9.3 billion in 2050, with the bulk of the increase occurring in developing countries, according to the medium-variant projections prepared by the United Nations.[27] Much of this increase is projected to come from the high-fertility countries and it is expected to occur in urban areas (see above).

GOVERNANCE AND POLICY

Rio+20

The United Nations Conference on Sustainable Development was held in June 2012 to mark the twentieth anniversary of the 1992 United Nations Conference on Environment and Development, in Rio de Janeiro, and the tenth anniversary of the 2002 World Summit on Sustainable Development in Johannesburg. Known as Rio+20, the objective of the conference – envisioned as a gathering at the highest level possible – aimed to "secure renewed political commitment for sustainable development, assess the progress to date and the remaining gaps in the implementation of the outcomes of the major summits on sustainable development, and address new and emerging challenges".[28] The two themes of the conference were the institutional framework for sustainable development and the support of a green economy in the context of sustainable development and poverty eradication.

While the green economy has no precise definition, it is viewed as a holistic, equitable and far-sighted approach to sustainability that seeks to eliminate the notion that sustainability and growth are mutually exclusive. The hope is that a transition to a green economy will result in resource exploitation that contributes to sustainability, inclusive social development and economic growth.

The conference prioritized seven thematic areas including green jobs and social inclusion, energy, sustainable cities, food security and sustainable agriculture, water, sustainable use of oceans and coasts, and disaster risk reduction and building resilience.

There are several ongoing international initiatives that seek to integrate fisheries and aquaculture into the Rio+20 agenda and framework and continue the processes established by Agenda 21 and the Rio Declaration.

FAO's corporate message to Rio+20 – and beyond – is that hunger eradication is essential for sustainable development, and sustainable consumption and production systems are essential to eradicate hunger and protect ecosystems. Underpinning this message it the need to increase food security – in terms of availability, access, stability and utilization – while using fewer natural resources, through improved management and efficiencies throughout the food value chain. This requires policies that create incentives for producers and consumers to adopt sustainable practices and behaviour. It is also necessary to promote the wide application of ecosystem approaches that encourage producers to participate in managing land, water, fisheries and water resources and help in internalizing environmental costs and benefits and rewarding environmental service provision.

FAO also contributed to specific interagency submissions that address the sustainable management of the world's oceans. The FAO Fisheries and Aquaculture Department co-authored, with the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization, the IMO and the United Nations Development Programme, a submission to Rio+20 titled "A Blueprint for Ocean and Coastal Sustainability",[29] which seeks to engage and focus leaders on oceans while attempting to define the green economy as it relates to marine and coastal resources. It also contributed to the "Monaco Message",[30] i.e. the outcome of a workshop convened by the Principality of Monaco on the sustainable use of oceans in the context of the green economy and poverty eradication. Key components include, *inter alia*: the protection and restoration of ocean biodiversity; a change in fisheries and aquaculture management regimes with an emphasis on non-subsidized and sustainable practices; climate change adaptation (CCA) and disaster risk management (DRM); integrated coastal management; and other cross-sectoral and comanagement approaches.

In addition, the FAO Fisheries and Aquaculture Department contributed to a paper co-ordinated by the United Nations Environment Programme on the "Green Economy in a Blue World",[31] and it prepared with WorldFish Center and others a paper titled "Blending Green and Blue Economics: Sustainability Transitions in the Fisheries and Aquaculture Sector of Small Island Developing States".[32]

The critical role of fisheries and aquaculture in food and nutrition security has been well-recognized at Rio+20. There is urgency to stem overfishing in marine and inland fisheries and curb the degradation of habitats caused by pollution and other forms of unsustainable use of aquatic ecosystems. Fisheries and aquaculture have considerable potential as vectors for the green economy. Their dependence on ecosystem services means that supporting sustainable fishing and fish farming can provide incentives for wider ecosystem stewardship. Therefore, in the context of the green economy, the greening of fisheries and aquaculture requires the overall recognition of their wider societal roles – in particular of small-scale operations for local economic growth, poverty reduction and food security – within a comprehensive governance framework, aiming *inter alia*: to manage externalities from or on the sector; to create alternative livelihood opportunities; and to improve access to social and financial services and education. The greening of marine fisheries and aquaculture also implicitly recognizes the urgency of reducing the carbon footprint of human activities to the goals of sustainable development and management and equitable benefit sharing of marine resources.

The main mechanisms for behavioural change and transition to green growth in fisheries and aquaculture include: (i) adopting an ecosystem approach to fisheries and aquaculture with fair and responsible tenure systems to turn resource users into resource stewards; (ii) integrating fisheries and aquaculture into watershed and coastal area management; (iii) supporting the development of and investment in "green" technology (e.g. low impact and fuel-efficient fishing methods; innovative aquaculture production systems, including greater use of environmentally friendly feeds, reduced energy use, greener refrigeration technologies and improved waste management in fish handling, processing and transportation); and (iv) building industry and consumer awareness to give preference to products from sustainable fisheries and aquaculture.

Furthermore, there is broad recognition of the need to improve ocean governance at all scales, i.e. local, national, regional and global. At the global level, there is the need for stronger coordination across the various UN agencies with mandates in ocean affairs and greater stakeholder participation, including by industry and civil-society organizations. There is also the need to strengthen the management framework for fisheries and other marine resources in areas beyond national jurisdictions. At the regional level, RFMOs need to coordinate more closely with other regional bodies and programmes including the regional seas and large marine ecosystem programmes. Capacity development and strengthening of legal and institutional arrangements are critical at the national and local levels where fisheries and aquaculture stakeholders are often poorly represented and equipped to contribute to intersectoral planning and policy-making.[33]

Small-scale fisheries

The importance of small-scale fisheries to food security, poverty alleviation and poverty prevention in the developing world is becoming increasingly understood and appreciated. However, a lack of institutional capacity and a failure to include the sector into national and regional development policies continue to hamper the potential contributions of small-scale fisheries to economic growth, poverty alleviation and rural development. According to the latest figures, the livelihoods of about 357 million people are directly affected by small-scale fisheries, and they employ more than 90 percent of the world's capture fishers.

Since 2003, COFI has promoted efforts to improve the profile of, and understand the challenges and opportunities facing, small-scale fishing communities in inland and marine waters. Prompted by COFI, in 2008, the FAO Fisheries and Aquaculture Department embarked on a broad-based consultative process that included a global conference[34] and a series of regional workshops for Asia and the Pacific, Africa, and Latin America and Caribbean[35] to examine the need and various options for an international instrument on small-scale fisheries and a global assistance programme for the sector.

Throughout this process, strong support was expressed for the creation of an international instrument as well as for the delivery of an assistance programme. Subsequently, COFI agreed to these suggestions and recommended that this instrument should take the form of international voluntary guidelines and complement the Code as well as other international instruments with similar purposes, in particular those related to human rights, sustainable development and responsible fisheries.

The preparation of the guidelines is expected to contribute to policy development at the national and regional levels. In addition, both the process and the final product are expected to have considerable impact on securing small-scale fisheries and creating benefits, especially in terms of food security and poverty reduction. The process itself has been designed to be highly participatory and collaborative, with the inclusion of cross-sectoral, national and international consultative workshops.[36] The guidelines should be a document that is agreed by governments, regional organizations and civil-society organizations. In addition, the document should be one that small-scale fishers, fishworkers and their communities across the world feel ownership of and can relate to, thus contributing to the process of turning resource users into resource stewards.

A set of basic principles underlie the development process of the guidelines. They promote good governance, including transparency and accountability as well as participation and inclusiveness. Social responsibility and solidarity are supported, as the guidelines take a human rights approach to development (which recognizes that everyone has legally mandated rights and that these rights carry with them responsibilities). These principles include equitable development based on gender equality, non-discrimination, and respect and involvement of all stakeholders, including indigenous people.

The consultative process also aims at identifying good practices, in particular with regard to governance and resource management through the implementation of an ecosystem approach to fisheries (EAF), and by reducing vulnerability and improving livelihoods' resilience through DRM and CCA.

The guidelines promote holistic and integrated approaches that combine natural-resource and ecosystem management with social and economic development. Equal consideration should be given to the environment, social and economic development needs, and community rights.[37] Sustainability is a key concept that is valid for both bioecological aspects and human dimensions. Actions should be guided by the precautionary approach and risk management to guard against undesirable outcomes, including not only overexploitation of fishery resources and negative environmental impacts but also unacceptable social and economic consequences.

The development of the guidelines serves as both process and objective, and intends to:

- provide a comprehensive framework that enhances the understanding of the actions needed to support the governance and sustainable development of small-scale fisheries;
- establish principles and criteria for the elaboration and implementation of national policies and strategies for the enhancement of small-scale fisheries governance and development, and provide practical guidance for implementation of these policies and strategies;
- serve as a reference tool for governments, their development partners and other stakeholders in the area of small-scale fisheries governance and development with a view to assisting in the formulation and implementation of relevant actions and the establishment or improvement of required institutional structures and processes;
- facilitate cooperation in support of small-scale fisheries governance and development;
- promote further research and the advancement of the knowledge on small-scale fisheries governance and development.

Ultimately, it is expected that policies and practices will be developed and adopted, and capacities strengthened for securing sustainable small-scale fisheries at the national and regional levels.

Regional fishery bodies

The RFBs are the primary organizational mechanism through which States work together to ensure the long-term sustainability of shared fishery resources. Throughout the twentieth and twenty-first centuries, the number and diversity of RFBs have expanded so that today the term "RFBs" can apply to fishery bodies with a mandate in a particular region, for a particular species, for marine or inland fisheries and/or for aquaculture bodies. The term RFB also embraces RFMOs, which are those RFBs that have the competence to establish binding conservation and management measures.

The 2010 United Nations Review Conference (the Review Conference) encouraged all States to become parties to RFBs, as these bodies rely upon State cooperation.[38] However, despite this significant endorsement of regional bodies, it is apparent that most RFBs are experiencing difficulties in fulfilling their mandates, and that many of these mandates are outdated as they do not provide appropriate frameworks within which RFBs can address current critical fisheries management issues. The situation is reflected in "alarming statistics" on global fish stocks "highlighting the need to strengthen the regulatory regime for regional fisheries management organizations and arrangements with a view to making them more accountable, transparent and open."[39] The RFBs are intergovernmental organizations and as such they depend on the political will of their member Governments to implement agreed measures or to undertake much needed reform.[40]

New regional fishery bodies

Since publication of *The State of World Fisheries and Aquaculture 2010*, new RFBs have been established, existing RFBs have been modernized, and other RFBs are in the planning or development stage. These new, strengthened and emerging bodies represent an important step forwards in extending the global coverage of RFBs.

The Central Asian and the Caucasus Fisheries and Aquaculture Commission (CACFish) was approved by the Hundred and Thirty-seventh Session of the FAO Council in October 2009.[41] It deals with fisheries management and aquaculture in inland waters within the territorial boundaries of the States of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) and of the Caucasus (Armenia, Azerbaijan, Georgia and Turkey). The agreement to establish CACFish came into effect on 3 December 2010.

The Southern Indian Ocean Fisheries Agreement (SIOFA)[42] aims to ensure the long-term conservation and sustainable use of Southern Indian Ocean fishery resources (other than tuna) outside national jurisdictions in the area (which is defined in Article 3 of the agreement).

In 2008, the Inter-American Tropical Tuna Commission (IATTC) comprehensively updated and replaced its 1950 convention with the new Antigua Convention.[43] The Antigua Convention deals with tuna and tuna-like species within the convention area, which is a broad zone of the Eastern Pacific Ocean delimited by boundaries prescribed in Article 3 of the convention. The Antigua Convention came into force on 27 August 2010. The current members are: Belize, Canada, China, Costa Rica, El Salvador, European Union, France, Guatemala, Japan, Kiribati, Republic of Korea, Mexico, Nicaragua and Panama. In accordance with the terms of the convention, Taiwan Province of China has lodged a written communication of commitment to abide by the terms of the Antigua Convention.

The South Pacific Regional Fisheries Management Organisation (SPRFMO) concluded its convention on 14 November 2009.[44] The convention aims to close the high seas gap that exists in the South Pacific for the conservation and management of non-highly migratory fish stocks, as well as the protection of marine biodiversity. The convention will enter into force 30 days after the date of receipt of the eighth instrument of ratification, accession, acceptance or approval, including three coastal States (one from each side of the Pacific) and three distant-water fishing States that have been or are fishing in the Convention Area. In 2011, there was a burst of activity by signatory States and the number of ratifications increased to five (Belize, Cook Islands, Cuba, Denmark and New Zealand). The SPRFMO anticipates that the convention will come into effect in the course of 2012.

Finally, preparatory discussions aiming to create an RFB for the Red Sea have been initiated with the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden. Countries from this region have been calling for the establishment of such an RFB for many years.

Regional Fishery Body Secretariats Network

The third meeting of the Regional Fishery Body Secretariats Network was held on 7–8 February 2011 in Rome, Italy. Twenty-eight RFB secretariats, with varied responsibilities for inland, coastal and marine capture fisheries and aquaculture, were represented at the meeting. The meeting discussed a range of subjects of particular relevance or importance to RFBs. These subjects included, but were not limited to: combating IUU fishing; managing fishing capacity; ecolabelling and aquaculture certification; supporting small-scale fisheries; adopting an ecosystem approach to capture fisheries and aquaculture; identification of vulnerable marine ecosystems; rebuilding of stocks; low levels of financial and human resources; pollution control; climate change; bycatch; and, where a performance review had taken place, the ongoing need to address its recommendations. The meeting concluded that, to address these issues, RFBs need financial, administrative and scientific support, plus a strong regional (as distinct from a national) focus for achieving sustainable fish stocks.

Performance review of regional fishery bodies

The need for RFBs to modernize their mandates and ensure better compliance with fishery instruments has led to numerous RFBs undergoing independent reviews of their performance. The Review Conference noted that progress had been made in developing best practices for RFMOs and in reviewing their performance against emerging standards. In addition, the Review Conference described the modernizing of RFMOs as a priority. The criteria used to assess RFMO performance have been refined through the Kobe Process (itself developed through meetings by the five joint tuna RFMOs that commenced in Kobe, Japan, in 2007).

Seven RFMOs had undergone performance reviews by the end of 2009. They included: the North Atlantic Salmon Conservation Organization (NASCO, in 2004–05 (where performance was evaluated by stakeholders and non-governmental organizations [NGOs]);[45] the North East Atlantic Fisheries Commission (NEAFC, in 2006);[46] the Commission for the Conservation of Southern Bluefin Tuna (CCSBT, in 2006); the Indian Ocean Tuna Commission (IOTC, in 2007);[47] the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR, in 2008);[48] the International Commission for the Conservation of Atlantic Tunas (ICCAT, in 2009); and the South East Atlantic Fisheries Organisation (SEAFO, in 2009).[49]

Since 2009, another three RFBs have completed a performance review: the North Pacific Anadromous Fish Commission (NPAFC, in 2010); the General Fisheries Commission for the Mediterranean (GFCM)[50] and the Northwest Atlantic Fisheries Organization (NAFO).[51] Reports for these last two reviews were presented in 2011. The Western and Central Pacific Fisheries Commission (WCPFC) is currently undergoing a performance review.

To update its earlier stakeholder review, NASCO is planning a second performance review for 2012 using the Kobe Process. This is a significant initiative as the performance review exercise should not be seen as a singular event, and the United Nations General Assembly (UNGA) has noted the need for reviews to be regular.[52]

When a performance review is conducted, the primary subject of evaluation is the management process. This is relevant to all RFMOs because they have a prescribed management mandate. However, the performance review process is also relevant for other RFBs, including those that mainly serve as advisory bodies. The critical issue for each body, whether an advisory RFB or an RFMO, is the nature of its mandate and how effectively it is addressing its mandate. The Review Conference has encouraged all RFMOs that have not yet done so to undertake a performance review.[53] It observed that performance reviews were generally recognized as being useful, particularly when they led to the adoption of new management measures.[54] In 2011, two FAO Article VI advisory RFBs (without a prescribed regulatory mandate) also underwent the process of independent review: the Fishery Committee for the Eastern Central Atlantic (CECAF) and the Southwest Indian Ocean Fisheries Commission (SWIOFC). The Committee for Inland Fisheries and Aquaculture of Africa (CIFAA), another FAO Article VI body, is also investigating the possibility of conducting an independent review.

Regional fishery bodies can provide an example of strength through unity, with developed and developing States working cooperatively to produce sustainable fish stocks. This is more than a vision; it is a necessity for global food security.

Illegal, unreported and unregulated fishing

Illegal, unreported and unregulated (IUU) fishing and related activities threaten national, regional and international efforts to secure long-term sustainable fisheries and promote healthier and more robust ecosystems. Consequently, the international community continues to express its grave concern at the extent and effects of IUU fishing, referring to it as a "global scourge",[55] and calling for it to be addressed at all levels and on all fronts. Often, IUU fishing is encouraged through corrupt practices.

Some 90 percent of the world's fish harvest is estimated to be taken within the EEZs of coastal States. Given the limited technical capacity of developing coastal States to detect and eradicate IUU fishing and related activities, a very significant proportion of IUU fishing also occurs within their EEZs. Developing countries bear the brunt of this IUU fishing, which undermines their efforts to manage fisheries. It denies them revenue from the fish that is poached and stolen, and adversely affects their attempts to promote food security, eradicate poverty and achieve sustainable livelihoods.

There are indications that IUU fishing is moderating in some areas of the world (e.g. the northeast Atlantic Ocean) as successful policies and measures take hold. However, IUU fishing remains widespread both in the EEZs of coastal States and on the high seas, in contravention of conservation and management measures put in place by RFMOs that have mandates to take fisheries management decisions that are binding on their members. In many areas of the world, IUU fishing is of such magnitude and importance that it is considered routinely not only at RFB sessions but also at global meetings (e.g. at FAO and by the UNGA).

The issue of IUU fishing was covered in the 2010 Secretary General's report to the UNGA.[56] In UNGA Resolution 65/38,[57] IUU fishing was dealt with at length in Section IV. The emphasis given to IUU fishing in the resolution underscored the threat that this practice poses to fisheries and their ecosystem, and the need to intensify fisheries monitoring, control and surveillance, and to implement international instruments and catch documentation schemes (CDSs) and traceability schemes. In addition, the resolution encouraged international cooperation on IUU fishing among States, including through RFBs.

Shortly after the UNGA, the Twenty-ninth Session of the FAO Committee on Fisheries (COFI) addressed IUU fishing.[58] Discussion focused principally on FAO's work and activities to promote and enhance international action against IUU fishing. Subsequently, the 2011 meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea[59] also drew attention to IUU fishing, largely in the context of discussions relating to the implementation of global instruments and problems associated with unregulated fishing activities in EEZs.

The international community is deeply frustrated by the failure of many flag States to meet their primary responsibilities under international law, which are to exercise effective control over their fishing vessels and, at the same time, ensure compliance with conservation and management measures. Of particular concern are those vessels that fly flags of "non-compliance". These are flags belonging to States that sell them to raise revenue. Such States are either unable or unwilling to exercise effective control over their vessels. Many of the vessels carrying these flags engage in IUU fishing in areas beyond the national jurisdiction of the flag State (i.e. on the high seas or in areas under the sovereignty or jurisdiction of other States). As a result, the burden of controlling these rogue vessels is gradually falling on coastal States, port States, RFBs and others. Thus, these States and RFBs need to train staff, and to obtain and develop compliance tools and mechanisms required to combat IUU fishing. This shift in burden, which is costly, has important ramifications for developing countries.

The international community's irritation with IUU fishing by vessels carrying flags of "non-compliance" led FAO Members to request that a Technical Consultation on Flag State Performance be convened. Following extensive preparatory work, the first session of the Technical Consultation was held in May 2011 and a resumed session in March 2012. It is anticipated that the outcome of the Technical Consultation will be a set of voluntary criteria for assessing the performance of flag States. In addition, a list of possible actions to be taken against vessels flying the flags of States not meeting such criteria is likely to be developed.[60] An agreed procedure for assessing compliance would be an important part of the criteria.

The RFBs are grappling with IUU fishing and its effects on the resources they are attempting to manage. Many of them have difficulty in estimating the volume and value of IUU catches. Their achievements in terms of limiting IUU fishing vary widely, depending on factors that are either internal or external to their respective organizations and fisheries. Nonetheless, in one way or another, RFBs promote and implement measures to combat IUU fishing. Depending on the particular circumstances, the measures range from more passive activities such as awareness building and dissemination of information (mainly RFBs without fisheries management functions) to aggressive port, air and surface programmes (RFMOs).

Some recent examples of RFBs' activities in relation to their work on IUU fishing are:

- In 2010, the SEAFO underscored the importance of regional training. Measures to develop capacity were noted as critical tools to speed up the implementation of measures to combat IUU fishing.[61]
- In 2010, the CCAMLR expressed concern as estimates of IUU catches in the convention area had risen since 2009 and concluded that, despite progress in the control of nationals and the implementation of CDSs, IUU fishing did not appear to be declining significantly. Importantly, several Members expressed the view that the CCAMLR appeared to be unable to improve its control of IUU fishing and was,

therefore, neither fulfilling the objectives of Article II of its convention nor, as a consequence, the Antarctic Treaty.[62]

- In 2010, the NEAFC informed the Conference of the Parties of the Convention on Biological Diversity of the importance of its two main tools in addressing IUU fishing: blacklisting of vessels flying the flags of non-contracting parties, and a port State control system that controls all landings of frozen fish into the ports of NEAFC contracting parties.[63] These tools have reduced considerably the level of IUU-caught product entering the European market.

The European Commission (EC) is moving forwards with the implementation of its CDS that took effect on 1 January 2010.[64] Its purpose is to stem the flow of IUU-caught fish into the European market. Cooperation between the EC and relevant RFBs has been established to assist them to develop schemes to ensure conformity with the European Union regulation. On the whole, CDSs should provide an effective tool to strengthen existing efforts to combat IUU fishing while also providing a mechanism for improved economic returns and social development for developing countries that trade fish internationally.

Beyond national boundaries, there is increasing need for international cooperation among fishing and seafood-importing countries to improve global fisheries

Box 6

An update on the 2009 Port State Measures Agreement

On 22 November 2009, the FAO Conference approved the FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (the Agreement). It remained open for one year for signature. During that period, 23 FAO Members signed the Agreement. In addition, at the 2011 session of the FAO Committee on Fisheries (COFI), 13 Members indicated that they had domestic processes in train to ratify, accept or approve the Agreement. It will enter into force 30 days after the date of deposit with the Director-General of FAO of the twenty-fifth instrument of ratification, acceptance, approval or accession. As at 30 September 2011, four FAO Members (including the European Union) had become Parties to the Agreement.

In 2011, COFI reiterated that port State measures are a potent and cost-effective tool to combat illegal, unreported and unregulated (IUU) fishing.[1] It recognized the need to assist developing countries to combat IUU fishing by building their capacity to undertake port State measures.[2] Consequently, in April 2012, a global series of capacity-development workshops to support the implementation of the Agreement was launched. The initial workshop was convened in Thailand to cater for countries from Southeast Asia. To date, Australia, Canada, Norway, the Republic of Korea and the Indian Ocean Tuna Commission have contributed to the programme, which is planned to last three years.

[1] FAO. 2011. *Report of the twenty-ninth session of the Committee on Fisheries. Rome, 31 January – 4 February 2011*. Fisheries and Aquaculture Report No. 973. Rome. 59 pp.
[2] In this respect, Article 21 of the Agreement, which addresses the special requirement of developing States, is central.

management of shared marine resources and to preserve the associated employment and other economic benefits of sustainable fisheries. In September 2011, recognizing this and in line with their commitment to the fight against IUU fishing, the European Union and the United States of America undertook to cooperate bilaterally to combat IUU fishing effectively. As leaders in global fish trade, the United States of America and European Union Members recognize their obligation to keep illegal fish out of the world market. The agreement commits the two signatories to work together to adopt effective tools to combat IUU fishing.[65]

Strengthening fisheries management capacity is fundamental in developing countries in order to facilitate sustainable fisheries and to reduce and mitigate the impacts of IUU fishing. Capacity development is especially important to support the full and effective implementation of existing and new global instruments (e.g. the 2009 Port State Measures Agreement [Box 6]) and other fisheries initiatives as tools to combat IUU fishing.

Aquaculture governance

With the recent dramatic growth in aquaculture, governance of this sector has become increasingly important and has made remarkable progress. Many governments worldwide utilize the the Code, in particular its Article 9. They also use FAO published guidelines for reducing administrative burdens and for improving planning and policy development in aquaculture. In addition, several countries have adequate national aquaculture development policies, strategies, plans and laws, and use “best management practices” and manuals on farming techniques that have been promoted by industry organizations and development agencies. The FAO Technical Guidelines on Aquaculture Certification, which were approved by the Twenty-ninth Session of COFI held in Rome from 31 January to 4 February 2011, constitute an additional important tool for good governance of the sector. By setting minimum substantive criteria for developing aquaculture certification standards, including animal health and welfare, food safety, environmental integrity and socio-economic aspects, these guidelines provide direction for the development, organization and implementation of credible aquaculture certification schemes. The ultimate aim is to ensure orderly and sustainable development of the sector.

Many governments have now recognized sustainability as the principal goal of aquaculture governance because it enables aquaculture to prosper for a long period. Long-term prosperity is predicated on fulfilling the four prerequisites for sustainable aquaculture development: technological soundness, economic viability, environmental integrity and social licence. Meeting these prerequisites also ensures that ecological well-being is compatible with human well-being.

An important component of human well-being is employment. In the last three decades, employment in the primary fisheries and aquaculture sector has grown faster than the world’s population and employment in traditional agriculture (see Employment section in Part 1, p. 41). Including employment in the primary aquaculture producing sector and in the secondary services and support sector together with household dependants, more than 100 million people depend on the aquaculture sector for a living; the industry has provided, and continues to create, a good number of jobs, particularly non-seasonal jobs.

In many places, these employment opportunities have enabled young people to stay in their communities and have strengthened the economic viability of isolated areas. By generating incomes for female workers, especially in fish processing and marketing, employment in aquaculture has enhanced the economic and social status of women in many places in developing countries, where more than 80 percent of aquaculture output occurs. Through incomes from these jobs and various multipliers, employment in aquaculture has also improved the accessibility to food for many households and has increased aquaculture’s contribution to the Millennium Development Goals. For these reasons, aquaculture has been heavily promoted in several countries with fiscal and monetary incentives.

However, these benefits induced by employment in aquaculture are often overlooked. The sector has developed at a time of growing scrutiny from the public, improved communications and vociferous opposition groups. Although opposition groups can act as environmental and social watchdogs and as lobby groups, putting pressure on aquaculture businesses to increase transparency and improve working conditions, it is also important to consider the benefits accruing from the sector, including employment.[66]

However, there are well-documented cases of unfair employment practices in aquaculture. For example, there are some research findings according to which aquaculture enterprises, especially large corporations, exploit local labour. One study argue that local labour is employed in lower-paid jobs, paid low salaries, and subjected to discriminatory practices such as willingly creating gender imbalances or paying female workers less than male workers doing the same jobs.[67] Child labour employment, for example, in factories, processing units, peeling sheds, and in the collection of shrimp seeds, is also sometimes highlighted.[68]

Such claims can undermine trust in the sector, threaten the credibility of policy-makers and jeopardize markets for farmed seafood. Hence, there is a need for more research into this issue, as there are sufficient indications to suggest that these practices might occur on a large scale, especially in developing countries for economic reasons.

Most countries have labour legislation to protect workers. However, compliance with such legislation can result in high indirect costs and deter firms, especially when goods are intended for export. Where these costs are high for firms and differ amply across borders, they can give enterprises operating in countries with lower labour and social standards a competitive advantage compared with those in jurisdictions with higher standards.

A possible result is that governments will be under pressure from companies to reduce labour and social standards in order to ease the burden of high indirect labour costs, thereby enhancing their competitive edge. Otherwise, the companies, especially large transnationals, may threaten to make new investments, or even to relocate existing establishments, in jurisdictions where lower labour standards exist with more amenable regulations. The threat can be exacerbated when there are negative shocks, such as fish disease outbreaks, or price or currency fluctuations, that expose companies to the risk of further erosion of their competitive position.

This pattern of behaviour becomes possible because large companies farming some species (such as shrimp, salmon, tilapia, abalone and others that become global commodities) are generally located in isolated rural communities, which gives them power over the labour force as the sole or dominant employer. To remain attractive to these companies and safeguard employment in rural communities, governments may be prepared to sacrifice good working conditions or even accept the employment of minors. Workers in these communities may also accept reduced wages and salaries, work longer hours without compensation or forgo some benefits.

A thorough understanding of these and other aspects of governance of employment in aquaculture is necessary. It will assist policy-makers in implementing corrective measures where these claims are proved well founded or in taking preventive action otherwise.

For the purpose of improving human well-being, employment in aquaculture, as in any other sector of the economy, must be equitable and non-exploitative. Principled values should guide aquaculture activities so that farmers with strong corporate social responsibility induce beyond-compliance behaviour. This would obviate the need for restrictive regulations; the best regulation is self-regulation. With an ethos of corporate social responsibility, aquaculture companies would assist local communities, employ fair labour practices and demonstrate transparency. Increasingly, with rising consumer awareness of employment practices in general, it makes good business sense for aquaculture enterprises to demonstrate (through certification, or otherwise) that they conform to the best standards. For these reasons, legislation should protect labour, particularly in developing countries, reflecting concepts of social justice and human rights. In reality, however, labour legislation will strike a balance between concern for social justice and control measures that discourage investment. Overly cumbersome regulations can make an otherwise viable business economically unprofitable.

At a minimum, research on the governance of aquaculture employment should lead to information on:

- existing labour legislation (monitoring, enforcement and compliance);
- types of labour contracts; employment characteristics such as the nature of employment (full time or part time);
- workers' educational background, age and gender;
- remuneration schemes including possible wage discrimination, salary levels and competitiveness and minimum wages;
- working conditions such as hours of work, occupational safety and job security;
- miscellaneous benefits including bonuses, training opportunities, maternity leave, health benefits (employer-provided insurance) and education grants.

Improved governance of aquaculture based on such improved knowledge will benefit the development of aquaculture in the long term.

NOTES

1 Figures for 2000 are higher than those reported in previous editions of *The State of World Fisheries and Aquaculture* as FAO has revised downwards the non-food use estimates for China from 2000 onwards to reflect improved national information on the sector. As a consequence, per capita fish consumption for China, as well as for the world, has increased in comparison with previous assessments.

2 Fish import figures differ from export figures because the former are usually reported in c.i.f. (cost, insurance and freight), whereas exports are reported at f.o.b. (free on board) values.

3 Garibaldi, L. 2012. The FAO global capture production database: a six-decade effort to catch the trend. *Marine Policy*, 36(3): 760–768.

4 Gulland, J.A. 1982. Why do fish numbers vary? *Journal of Theoretical Biology*, 97(1): 69–75.
Hilborn, R. 1997. The frequency and severity of fish stock declines and increases. *In* D.A. Hancock, D.C. Smith, A. Grant and J.P. Beumer, eds. *Developing and sustaining world fisheries resources. Proceedings of the 2nd World Fisheries Congress*, pp. 36–38. Collingwood, Australia, CSIRO Publishing.
Soutar, A. and Isaacs, J.D. 1974. Abundance of pelagic fish during the 19th and 20th centuries as recorded in anaerobic sediment off the Californias. *Fishery Bulletin*, 72(2): 257–275.

5 Coates, D. 2002. *Inland capture fishery statistics of Southeast Asia: current status and information needs*. RAP Publication No. 2002/11. Bangkok, FAO Regional Office for Asia and the Pacific, Asia-Pacific Fishery Commission. 114 pp.
De Graaf, G.J. and Ofori-Danson, P.K. 1997. *Catch and fish stock assessment in Stratum VII of Lake Volta. Integrated Development of Artisanal Fisheries (IDAF) (GHA/93/008)*. IDAF/Technical Report/97/I. Rome, FAO. 96 pp.
Kolding, J. and van Zwieten, P.A.M. 2006. *Improving productivity in tropical lakes and reservoirs*. Challenge Program on Water and Food – Aquatic Ecosystems and Fisheries Review Series 1, Theme 3 of CPWF. Cairo, WorldFish Center. 139 pp.

6 Allan, J.D., Abell, R.A., Hogan, Z., Revenga, C., Taylor, B.W., Welcomme, R.L. and Winemiller, K. 2005. Overfishing of inland waters. *BioScience*, 55(12): 1041–1051.

7 FAO now uses three categories of stock status as opposed to the six used in previous assessments. The three categories are not new but are simply the result of aggregating overexploited, recovering and depleted into the one category overexploited, and the categories of moderately exploited and underexploited into the single group non-fully exploited. Details of the classification are provided in: FAO. 2011. *Review of the state of world marine fishery resources*. FAO Fisheries and Aquaculture Technical Paper No. 569. Rome. 334 pp.

8 Paragraph 31a in: United Nations. 2004. Johannesburg Plan of Implementation. IV. Protecting and managing the natural resource base of economic and social development. In: *UN Department of Economic and Social Affairs, Division for Sustainable Development* [online]. [Cited 16 April 2012]. www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIChapter4.htm

9 Wilson, D.T., Curtotti, R. and Begg, G.A., eds. 2010. *Fishery status reports 2009: status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences. 535 pp.

10 Worm, B., Hilborn, R., Baum, J.K., Branch, T.A., Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E.A., Hutchings, J.A., Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A.A., Watson, R. and Zeller, D. 2009. Rebuilding global fisheries. *Science*, 325(5940): 578–585.

11 World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries*. Washington, DC, World Bank.

12 FAO. (forthcoming). *Report of the Workshop to Develop an FAO Strategy for Assessing the State of Inland Capture Fishery Resources, Rome, Italy, 7–9 December 2011*. FAO Fisheries and Aquaculture Report. Rome.

13 FAO. 2009. *Securing sustainable small-scale fisheries: bringing together responsible fisheries and social development* [online]. Committee on Fisheries. Twenty-eighth Session, Rome, Italy, 2–6 March 2009. COFI/2009/7. [Cited 16 April 2012]. ftp://ftp.fao.org/docrep/fao/meeting/015/k3984e.pdf

14 Op. cit., see note 12.

15 World Trade Organization. 2011. *World Trade Report 2011. The WTO and preferential trade agreements: from co-existence to coherence*. Geneva, Switzerland. 251 pp. (also available at www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report11_e.pdf).

16 The International Bank for Reconstruction and Development / The World Bank. 2012. *Global Economic Prospects: Uncertainties and Vulnerabilities*. Volume 4, January 2012. Washington, DC. 160 pp. (also available at http://siteresources.worldbank.org/INTPROSPECTS/Resources/334934-1322593305595/8287139-1326374900917/GEP_January_2012a_FullReport_FINAL.pdf).

17 Compared with previous editions of *The State of World Fisheries and Aquaculture*, the share quoted for low-income food-deficit countries (LIFDCs) differs significantly as a consequence of the change in the composition of LIFDCs. The new list of the LIFDCs stands at 70 countries, seven fewer than in the 2009 LIFDC list. The seven countries no longer on the list are: Angola, Armenia, Azerbaijan, China, Equatorial Guinea, Morocco and Swaziland. All seven have graduated from the list having completed the “transitional phase”, exceeding the World Bank income threshold for three consecutive years.

18 See note 2.

19 Statistics reported in this section are based on data from the Food Balance Sheets published in *FAO yearbook. Fishery and Aquaculture Statistics. 2010* (FAO, 2012). Consumption data for 2009 should be considered as preliminary. Some discrepancies may occur with other sections that quote data made available to FAO more recently. Food Balance Sheet data calculated by FAO refer to “average food available for consumption”, which, for a number of reasons (for example, waste at the household level), is not equal to average food intake or average food consumption. It should be noted that the production from subsistence fisheries as well as border trade between some developing countries could be incompletely recorded and might therefore lead to an underestimation of consumption.

20 FAO/WHO. 2011. *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption, Rome, 25–29 January 2010*. FAO Fisheries and Aquaculture Report No. 978. Rome, FAO. 50 pp.

21 Mozaffarian, D. and Rimm, E.B. 2006. Fish intake, contaminants, and human health: evaluating the risks and the benefits. *JAMA*, 296(15): 1885–1899.

22 Peet, M. and Stokes, C. 2005. Omega-3 fatty acids in the treatment of psychiatric disorders. *Drugs*, 65(8): 1051–1059.
Young, G. and Conquer, J. 2005. Omega-3 fatty acids and neuropsychiatric disorders. *Reproduction Nutrition Development*, 45(1): 1–28.

23 Op. cit., see note 20.

24 In this section, the term “fish” indicates fish, crustaceans, molluscs and other aquatic invertebrates, but excludes aquatic mammals and aquatic plants.

25 FAO. 2011. *The State of Food Insecurity in the World 2011*. Rome. 62 pp.

26 United Nations, Department of Economic and Social Affairs, Population Division. 2012. *World Urbanization Prospects: The 2011 Revision*. CD–ROM edition – data in digital form.

27 United Nations, Department of Economic and Social Affairs, Population Division. 2011. *World Population Prospects: The 2010 Revision, Highlights and Advanced Tables* [online]. New York, USA. [15 May 2012]. http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2010_Highlights.pdf

28 The Web site for Rio+20 is www.uncsd2012.org/rio20/
29 IOC/UNESCO, IMO, FAO, UNDP. 2011. *A blueprint for ocean and coastal sustainability* [online]. Paris, IOC/UNESCO. [Cited 10 May 2012]. www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/interagency_blue_paper_ocean_rioPlus20.pdf
30 Stakeholder Forum. 2011. *Monaco message* [online]. [Cited 10 May 2012]. www.stakeholderforum.org/fileadmin/files/Monaco%20Message.pdf
31 UNEP, FAO, IMO, UNDP, IUCN, World Fish Center and GRIDArendal. 2012. *Green economy in a blue world* [online]. [Cited 10 May 2012]. www.unep.org/pdf/green_economy_blue.pdf
32 Allison, E.H., Bell, J.D., Franz, N., Fuentevilla, C., McConney, P., Robinson, J., Westlund, L. and Willmann, R. 2012. Blending green and blue economics: sustainability transitions in the fisheries and aquaculture sector of small island developing States.
33 FAO. 2011. *Global sustainable fisheries management and biodiversity conservation in the areas beyond national jurisdiction (ABNJ)* [online]. [Cited 30 May 2012]. ftp://ftp.fao.org/FI/brochure/GEF-ABNJ/GEF-ABNJ.pdf
34 FAO. 2009. *Report of the Global Conference on Small-scale Fisheries – Securing Sustainable Small-scale Fisheries: Bringing Together Responsible Fisheries and Social Development, Bangkok, Thailand, 13–17 October 2008*. FAO Fisheries and Aquaculture Report No. 911. Rome. 189 pp.
35 FAO. 2010. *Report of the APFIC/FAO Regional Consultative Workshop – Securing Sustainable Small-Scale Fisheries: Bringing Together Responsible Fisheries and Social Development, Windsor Suites Hotel, Bangkok, Thailand, 6–8 October 2010*. RAP Publication 2010/19. Bangkok. 56 pp.
FAO. 2011. *Report of the African Regional Consultative Workshop on Securing Sustainable Small-Scale Fisheries: Bringing Together Responsible Fisheries and Social Development, Maputo. Mozambique, 12–14 October 2010*. FAO Fisheries and Aquaculture Report No. 963. Rome. 68 pp.
FAO. 2011. *Report of the Latin America and Caribbean Regional Consultative Workshop on Securing Sustainable Small-Scale Fisheries: Bringing Together Responsible Fisheries and Social Development, San José, Costa Rica, 20–22 October 2010*. FAO Fisheries and Aquaculture Report No. 964. Rome. 77 pp.
36 FAO. 2011. Discussion document: towards voluntary guidelines on securing sustainable small-scale fisheries. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 24 November 2011]. www.fao.org/fishery/topic/18241/en
37 Kurien, J. and Willmann, R. 2009. Special considerations for small-scale fisheries management in developing countries. In Cochrane, K. and Garcia, S., eds. *A fishery manager's guidebook*, pp. 404–424. Second edition. Chichester, UK, FAO and Wiley-Blackwell. 536 pp.
38 Refer to paragraph 32 of: United Nations General Assembly. 2010. *Report of the resumed Review Conference on the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* [online]. [Cited 28 November 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N10/465/87/PDF/N1046587.pdf?OpenElement
39 Paragraph 38 in: United Nations General Assembly. 2011. *Report on the work of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea at its twelfth meeting* [online]. [Cited 28 November 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N11/431/39/PDF/N1143139.pdf?OpenElement
40 Op. cit., see note 38, paragraph 75.
41 FAO. 2011. Central Asian and Caucasus Regional Fisheries and Aquaculture Commission (CACFish). In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 28 November 2011]. www.fao.org/fishery/rfb/cacfish/en
42 FAO. 2011. Southern Indian Ocean Fisheries Agreement. In: *FAO Legal Office* [online]. Rome. [Cited 28 November 2011]. www.fao.org/Legal/treaties/035s-e.htm

43 Inter-American Tropical Tuna Commission. 2011. *Antigua Convention* [online]. [Cited 28 November 2011]. www.iattc.org/IATTCdocumentationENG.htm
44 South Pacific Regional Fisheries Management Organisation. 2011. *South Pacific Regional Fisheries Management Organisation* [online]. [Cited 28 November 2011]. www.southpacificrfmo.org/
45 North Atlantic Salmon Conservation Organization. 2011. *Report of the 'Next Steps' for NASCO Review Group* [online]. [Cited 28 November 2011]. www.nasco.int/pdf/2011%20papers/CNL(11)12.pdf
46 North East Atlantic Fisheries Commission. 2011. NEAFC Performance Review. In: *North East Atlantic Fisheries Commission* [online]. [Cited 28 November 2011]. www.neafc.org/news/579
47 Indian Ocean Tuna Commission. 2009. *Report of the IOTC Performance Review Panel: January 2009* [online]. [Cited 28 November 2011]. www.iotc.org/files/misc/performance%20review/IOTC-2009-PRP-R[E].pdf
48 Commission for the Conservation of Antarctic Marine Living Resources. 2008. Report of the CCAMLR Performance Review Panel. In: *CCAMLR* [online]. [Cited 28 November 2011]. www.ccamlr.org/pu/E/revpanrep.htm
49 South East Atlantic Fisheries Organisation. 2010. Report of the Performance Review Panel. In: *South East Atlantic Fisheries Organisation* [online]. [Cited 28 November 2011]. www.seafo.org/PerformanceReview.html
50 General Fisheries Commission for the Mediterranean. 2011. *Performance Review of the General Fisheries Commission for the Mediterranean and Black Sea* [online]. [Cited 28 November 2011]. http://151.1.154.86/GfcmWebSite/GFCM/35/CAF_II_2011_Inf.5_COC_V_Inf.4_GFCM_XXXV_2011_Inf.8.pdf
51 Northwest Atlantic Fisheries Organization. 2011. About NAFO. In: *Northwest Atlantic Fisheries Organization* [online]. [Cited 28 November 2011]. www.nafo.int/about/frames/about.html
52 Op. cit., see note 39, paragraph 38.
53 Op. cit., see note 38, paragraph 77.
54 Op. cit., see note 38, paragraph 76.
55 Damanaki, M. 2011. U.S. and Europe join forces to stop pirate fishing. In: *Europa* [online]. Brussels. [Cited 28 November 2011]. http://ec.europa.eu/commission_2010-2014/damanaki/headlines/press-releases/2011/09/20110907_2_en.htm
56 United Nations General Assembly. 2011. *Oceans and the law of the sea. Report of the Secretary-General. Addendum* [online]. A/66/70/Add.1. New York, USA. [Cited 29 November 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N11/296/00/PDF/N1129600.pdf?OpenElement
57 United Nations General Assembly. 2011. *Resolution adopted by the General Assembly. Sustainable fisheries, including through the 1995 Agreement for the Implementation of the provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments* [online]. A/RES/65/38. New York, USA. [Cited 29 November 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N10/514/82/PDF/N1051482.pdf?OpenElement
58 FAO. 2011. *Report of the twenty-ninth session of the Committee on Fisheries.* Fisheries and Aquaculture Report No. 973. FAO. Rome. 59 pp. IUU fishing is a standing COFI agenda item.
59 United Nations General Assembly. 2011. *Report on the work of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea at its twelfth meeting* [online]. A/66/186. New York, USA. [Cited 29 November 2011]. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N11/431/39/PDF/N1143139.pdf?OpenElement
60 Op. cit., see note 59.
61 South East Atlantic Fisheries Organisation. 2010. *Report of the Seventh Annual Meeting of the Commission, 2010 Report.* [online]. [Cited 29 November 2011]. www.seafo.org/TheCommission/Reports/2010%20Commission%20Report%20finale.pdf

62 Commission for the Conservation and Management of Antarctic Marine Living Resources. 2011. *Report of the twenty-ninth meeting of the Commission, Hobart, Australia, 25 October – 5 November 2010,* Item 9, paras: 9.3–9.4. [online]. Hobart, Australia. [Cited 29 November 2011]. www.ccamlr.org/pu/E/e_pubs/cr/10/all.pdf

63 North East Atlantic Fisheries Commission. 2010. Information on experience gained on combating IUU fishing in the NEAFC Area. A report prepared by the NEAFC Secretariat for the CBD COP 10, Nagoya, October 2010. In: *North East Atlantic Fisheries Commission* [online]. London. [Cited 29 November 2011]. www.neafc.org/international/3539

64 European Commission. 2008. Council Regulation (EC) No 1005/2008 of 29 September 2008 establishing a Community system to prevent, deter and eliminate illegal fishing, amending Regulations (EEC) No 2847/93, (EC) No 1936/2001 and (EC) No 601/2004 and repealing Regulations (EC) No 1447/1999. In: *EUR-Lex* [online]. Brussels. [Cited 29 November 2011]. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32008R1005:EN:NOT

65 European Commission. 2011. *Joint statement between the European Commission and the United States Government on efforts to combat illegal, unreported and unregulated (IUU) fishing* [online]. [Cited 29 November 2011]. Washington, DC. http://ec.europa.eu/commission_2010-2014/damanaki/headlines/press-releases/2011/09/20110907_jointstatement_eu-us_iuu_en.pdf

66 World Wildlife Fund. 2012. Aquaculture: shrimp. In: *WWF* [online]. Washington, DC. [Cited 13 April 2012]. www.worldwildlife.org/what/globalmarkets/aquaculture/dialogues-shrimp.html

SeafoodSource. 2010. NGO takes aim at farmed salmon critics. In: *SeafoodSource.com* [online]. [Cited 13 April 2012]. www.seafoodsource.com/newsarticledetail.aspx?id=4294990320

67 Arengo, E., Ridler, N. and Hersoug, B. 2010. *State of information on social impacts of salmon farming. A report by the Technical Working Group of the Salmon Aquaculture Dialogue* [online]. [Cited 13 April 2012]. www.worldwildlife.org/what/globalmarkets/aquaculture/WWFBinaryitem16115.pdf

68 FAO. 2010. *Report of the FAO Workshop on Child Labour in Fisheries and Aquaculture in cooperation with ILO, Rome, 14–16 April 2010*. FAO Fisheries and Aquaculture Report No. 944. Rome. 24 pp.

Halim, U. 2010. *Child labour in fishery and aquaculture: need for a perspective* [online]. Paper presented at the Expert Consultation on Child Labour in Fisheries organized by FAO and ILO. [Cited 13 April 2012]. www.fao-ilo.org/fileadmin/user_upload/fao_ilo/pdf/WorkshopFisheries2010/WFPapers/UjjainiHalimWFFChildLabourFishery_Aquaculture.pdf

Halim, U. 2003. *Political ecology of shrimp aquaculture in India: a case study in Orissa*. Saarbruecken, Germany, Verlag fuer Entwicklungspolitik. 286 pp.

PART 2

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

Mainstreaming gender in fisheries and aquaculture: from recognition to reality

THE ISSUE

> "Gender mainstreaming is not only a question of social justice but is necessary for ensuring equitable and sustainable human development. The long-term outcome of gender mainstreaming will be the achievement of greater and more sustainable human development for all."[1]

In 1997, the United Nations Economic and Social Council (ECOSOC) adopted gender mainstreaming as the methodology by which the entire UN system would work towards the advancement of women and gender equality goals, noting that: "Mainstreaming a gender perspective is the process of assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas and at all levels. It is a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal of mainstreaming is to achieve gender equality".[2]

In 2000, all 193 UN Member States and more than 23 international organizations agreed to the Millennium Development Goals (MDGs), and the issue of promoting gender equality and empowering women (MDG 3) was again highlighted on the international agenda. The objective was one of ensuring that, in whatever sector they may be working, men and women should have equal rights to participate in the development process, and their interests and needs should be protected.

Despite this, women tend to be marginalized in a variety of ways – and this is very much true for women in the fisheries and aquaculture sector. Thus, more than 30 years after the 1979 Convention on the Elimination of All Forms of Discrimination Against Women, some 15 years after the ECOSOC decision and more than a decade after the Millennium Declaration, and with only 3 years to go before the goal of achieving the MDGs by 2015, the issue at hand is how to ensure genuine and active mainstreaming of gender and the many facets of gender considerations in the fisheries and aquaculture sector.

Indeed, until recently, gender analysis in fishing communities focused mainly on the different occupational roles of men and women, i.e. that men usually do the actual fishing and women are to a large extent involved in post-harvest and marketing activities. While the role of women in the management and utilization of natural resources is generally acknowledged, their role does not carry the same weight as that of men. Given that production goals have tended to be the focus of research and policy, the predominantly male catching sector has remained the centre of attention.[3]

However, with the shift to a multidimensional and more holistic definition of poverty and the increased focus on reducing vulnerability, gender has become more central to fisheries policy and development practice. Fisheries resource management is increasingly being linked to all levels of the so-called "deck to dish" fish value chain in which both men and women have important roles to play. With almost 45 million people worldwide directly engaged, full time or part time, in the fishery primary sector in 2008[4] and an additional estimated 135 million people employed in the secondary sector, including post-harvest activities, this is no simple task. Many involved in these sectors are recognizing that it is vital to look beyond the simplified picture of men as fishers and women as processors and to examine the more complex picture of multifaceted relationships between men and women as boat owners, processors, sellers, family members, community members and co-workers (Box 7).

Information provided to FAO from 86 countries indicates that, in 2008, 5.4 million women worked as fishers and fish farmers in the primary sector and represented 12 percent of the total. In two major producing countries, China and India, women represented 21 percent and 24 percent, respectively, of all fishers and fish farmers. Women make up at least 50 percent of the workforce in inland fisheries, while as much as 60 percent of seafood is marketed by women in Asia and West Africa. Moreover, although comprehensive data are not available on a sex-disaggregated basis, case studies suggest that women may comprise up to 30 percent of all those employed in fisheries, including primary and secondary activities.

Revealing hidden contributions

While reliable estimates are not available, a recent expert panel review paper[5] reported that women are probably more involved in aquaculture (Box 8) than in fisheries[6] but that studies of women and gender issues are more numerous for the fisheries sector than for the aquaculture sector. As the review paper points out, this relative lack of attention to gender in aquaculture may reflect the more recent history of aquaculture

Box 7

A gender baseline in the fisheries and aquaculture sector

Men and women engage in distinct and often complementary activities that are strongly influenced by the social, cultural and economic contexts in which they live. Male–female relations in the fisheries sector vary greatly and are based on economic status, power relations and access to resources.

In most regions, women have rarely participated in commercial offshore and long-distance capture fishing. Ocean-going boats for offshore deep-sea fishing have male crews – not only because of the vigorous work involved, but also because of women's domestic responsibilities and/or social norms.

More commonly, in coastal artisanal fishing communities, women manage the smaller boats and canoes that go out fishing. Women are also involved in gathering shells, sea cucumbers and aquatic plants in the intertidal zone. They also contribute as entrepreneurs and provide labour before, during and after the catch in both artisanal and commercial fisheries. In addition, they are often responsible for skilled and time-consuming onshore tasks, such as net making and mending, processing and marketing catches, and providing auxiliary services to the boats.

However, gender issues in the fisheries and aquaculture sector have seldom been examined, and the important role women that play has often been overlooked and, thus, not taken into account in decision-making processes and outcomes, thereby hindering development.

and academic interest in the complex sociology and anthropology of fishing communities and practices.

However, it is known that there are vital differences in the power positions of men and women (Box 9); as a result, women generally have less control over the value chain, their activities are less profitable, and they have access to fish of poorer quality. Women

Box 8

The contribution of women in the aquaculture sector

FAO's National Aquaculture Sector Overview[1] provides insights into the roles and contributions of women in the aquaculture sector in countries around the globe:

- In Bangladesh, women's non-governmental organizations and other entrepreneurs have encouraged women to participate in aquaculture activities.
- In Belize, most workers involved in processing are women from rural communities where unemployment levels are high and poverty is greatest.
- In Cuba, female workers constitute 27 percent of the aquaculture workforce (19 percent are intermediate and higher education technicians; 11 percent have attended higher education institutions).
- In Estonia, the gender ratio of the aquaculture workforce is 1:1.
- In Israel, the workforce is a skilled one because of the highly technical nature of aquaculture in the country. In a sector where women make up about 95 percent of the workforce, most workers have a high school diploma while a high percentage have a degree (Bachelor of Science or Master of Science).
- In Jamaica, about 8–11 percent of fish farmers are women who own and operate fish farms; and in processing plants, women dominate the workforce.
- In Malaysia, women account for about 10 percent of the total aquaculture workforce, and they are mostly involved in freshwater aquaculture and hatchery operations for marine fish, shrimp and freshwater fish.
- In Panama, 80 percent of the workforce in processing plants are women, but in the production sector only 7 percent of workers are women.
- In Sri Lanka, women constitute 5 percent of the workforce in shrimp aquaculture and 30 percent of those engaged in the production and breeding of ornamental fish.

Information such as this provides a starting point for learning about the differences between men and women in these situations and about whether there are similar opportunities, wages and benefits – or whether there are policy, governance and operational gaps that need to be addressed in order to really mainstream gender in the sector.

[1] FAO. 2012. National Aquaculture Sector Overview. NASO Fact Sheets. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 20 March 2012]. www.fao.org/fishery/naso/search/en

Box 9

Differences in power lead to different opportunities

Artisanal fisherwomen's relatively insecure access to fish resources and, hence, to fish leads to different opportunities for women and men. When fish business activities are being upscaled in response to increasing globalization, local women risk being forced out of the business and, therefore, not benefiting from development and market opportunities in the sector in which they were previously extensively involved. Examples are:

- In India in the early 1980s, shrimp marketing was initially largely in the hands of women. However, when shrimp became a higher-priced commodity, male traders arrived on bicycles and later in motorized transport, eventually forcing the fisherwomen out of this trade (Bay of Bengal Programme).
- In Cotonou, Benin, urban-based male and female traders entered the fish trade, forcing women from the fishing villages out of business and making their access to fish more difficult (Programme for the Integrated Development of Artisanal Fisheries in West Africa).
- In Senegal, as fishermen change gear and the focus of their effort in response to changing profit opportunities in their fishery (e.g. shifting from harvesting pelagic fish to cephalopods) and switch from selling into local to export markets, the local post-harvest sector can suffer (Network on Fishery Policies in West Africa).

tend to be excluded from the most profitable markets and enterprises, and from highly paid posts in fish-processing factories even though they make up the majority of workers in the post-harvest sector. Compared with men, they are often greater losers from increasing market globalization, and they are more vulnerable to poor services and catch declines.

The most significant role played by women in both artisanal and industrial fisheries is at the processing and marketing stages. Active in all regions of the world, in some countries, women have become significant entrepreneurs in fish processing. In fact, most fish processing is performed by women, either in their own household-level industries or as wage labourers in the large-scale processing industry. For example, in West Africa, women play a major role – they usually own capital and are directly and vigorously involved in the coordination of the fisheries chain, from production to the sale of fish.

Some of the factors that weaken women's capabilities in terms of participation in decision-making are:

- lower literacy and education levels;
- time burdens and constraints;
- mobility burdens and constraints;
- participation in less-formal organizations that are, as a result, weaker organizations;
- fewer or reduced organizational skills in the sense that women frequently associate in less-formal organizations and, where part of formal organizations, frequently do not hold leadership roles such as president and secretary because of poor literacy skills.

Very importantly, the absence of women from most post-harvest statistics means that it is extremely difficult to quantify the number of women and the extent of the value addition and contribution their work makes to economies. Nonetheless, inequalities are beginning to be quantified and publicized.

POSSIBLE SOLUTIONS

Women's participation as equal and productive partners in the fisheries and aquaculture sector has significant impacts on households' nutrition and living standards. If fisheries and aquaculture projects generate the data for and, potentially, include analyses of, all gender aspects (livelihood factors, relationships, actions and results), they can contribute to gender equality and promote women's participation as active agents for change in the sector (Box 10).

Data solutions

Comprehensive and accurate sex-disaggregated statistics are lacking, and this gap must be filled as one of the first steps in gender mainstreaming at the policy level. Quantitative and qualitative gender-sensitive indicators can be formulated with fishing communities to see how well policies and associated development projects satisfy the practical and strategic needs of men and women, and to help reduce existing gender gaps.

At the more macro level, statistical censuses should focus more attention on areas in which women are relatively more active. They should collect sex-disaggregated data on ownership of, access to and control over productive resources such as land, water, equipment, inputs, information and credit.

Macro-level policy solutions

As in other sectors, women's empowerment in fisheries requires examination of the means of production, gender relationships, and how to create equalities. New institutional arrangements are being created in response to climate change, resource depletion, aquaculture development and global trade. All these factors are increasingly affecting the sector, and it is vital that gender considerations are built into the new

Box 10

Quantifying inequalities

A study conducted for the United States Agency for International Development on the Bangladesh shrimp value chain[1] revealed differences in earnings between women and men (see table), a finding that created a starting point for addressing gender-related discrepancies.

Relative earnings of women compared with those of male counterparts

Activity	Percentage
Catching, sorting fry	64
Repairing ponds, undertaking casual agricultural labour	82
Processing plants – packing section	72
Processing plants – cooking/breading section	60

[1] Development & Training Services, Inc. 2006. *A pro-poor analysis of the shrimp sector in Bangladesh* [online]. USAID. [Cited 21 May 2012]. www.usaid.gov/our_work/cross-cutting_programs/wid/pubs/Bangladesh_Shrimp_Value_Chain_Feb_2006.pdf

arrangements. Increasingly, practical manuals for gender mainstreaming and gender analysis are being produced to facilitate just such changes.[7]

Responsible governance of tenure and tenure security, especially of access to natural resources, are issues where mainstreaming gender can have a marked effect. Providing policies that create the opportunities for ensuring equitable resource access rights, access to markets, benefits from aquaculture and codes of conduct for the industry – especially for the most marginalized and poorest categories of men and women – can empower people to become more equal stakeholders. However, where governance and policies are developed without a strategic assessment of the relative roles of the men and women involved, the effect can be to disempower stakeholders.

Resource control and access

In addition to the responsible governance of tenure, the broader issue of women's access to and control over resources is an important gender consideration. For women to have a real impact on their economic situation and their position in society, it is essential that they have access to and control over aquatic resources as well as appropriate information that enables them to use such resources wisely.[8]

Development arena solutions

Gendered value-chain approaches can be used to recognize and value women's roles and contributions to agriculture and fisheries. To mainstream gender equality in development cooperation programmes and related activities, a number of steps are essential:[9]

- Require that programmes and related activities generate or obtain sex-disaggregated statistics (not only at the level of project and/or programme beneficiary, but also at both middle and macro levels of policy and governance) and qualitative information on the situation of women and men for the population in question. This information is required.
- Conduct a gender analysis with regard to: the gendered division of labour; access to and control over material and non-material resources; the legal basis for gender equality/inequality; political commitments with respect to gender equality; and the culture, attitudes and stereotypes that affect all preceding issues. Gender analyses should be conducted at the micro, meso and macro levels.
- Conduct a gender analysis of a programme or project concept to reveal whether gender equality objectives are articulated in the initial idea, whether or not the planned activity will contribute to or challenge existing inequalities, and whether there are any gender issues that have not been addressed.
- During the identification and formulation phases, ensure that the gender analysis contributes to the identification of entry points for actions that will be needed in order to meet gender equality objectives.
- Strengthen the participatory and organizational capacity of stakeholders at various levels so that they are better able to translate gender concerns into actions. This includes strengthening female umbrella organizations that can participate in debates and in project and programme processes.
- Put in place a gender-sensitive monitoring and evaluation system from the design phase onwards, including the establishment of indicators to measure the extent to which gender equality objectives are met and changes in gender relations are achieved.

On the ground – closing the gap in social capital

Building women's social capital can be an effective way to improve information exchange and resource distribution, to pool risks and to ensure that women's voices are heard in decision-making at all levels. This includes strengthening women's organizational abilities and roles and developing the capacity of women to take on leadership positions and engage with decision-makers and other stakeholders.

Functioning as production cooperatives, savings associations and marketing groups, women's groups can promote production and help women maintain control over the additional income they earn, as has been demonstrated by a project based around polyculture fish production in Bangladesh. As the project proved successful in providing additional incomes, the position of women within the household and community was also strengthened.[10] Indeed, in communities with a high level of gender segregation, single-sex groups may lead to more desirable outcomes for women.[11]

However, excluding men can sometimes generate unnecessary obstacles. A project to introducing the new livelihood strategy of mud-crab production to supply hotels on Unguja Island, United Republic of Tanzania, excluded men. The resultant anger among the men added transaction and input costs as women had to rely on a small number of male fishers for seedstock and feedstuffs.[12]

The clear message here is that interventions within the local sociocultural dynamics should base their interventions on the specific context – including the gender segregation within a community – and the underlying problem.

RECENT ACTIONS

The issues of women, gender and fisheries have been highlighted in a series of international and now global symposiums and other related initiatives:[13]

- The Global Conference on Aquaculture 2010 delivered the Phuket Consensus and responded to the recommendations of Expert Panel VI.3 (Sustainable Aquaculture by Developing Human Capacity and Enhancing Opportunities for Women Development) by including a recommended action to: "Support gender sensitive policies and implement programmes in line with globally accepted principles of gender equality and women's empowerment."
- The 2011 Special Workshop on Future Directions for Gender in Aquaculture and Fisheries Action, Research and Development (Shanghai, China)[14] prepared a working draft of a working vision statement for mainstreaming gender in the aquaculture and fisheries sectors: "To promote and achieve gender equity in the aquaculture and fisheries sector in support of responsible and sustainable use of resources and services for food and nutrition security, quality of life of all stakeholders, primarily women, children, vulnerable and marginalized groups/communities."

Other ongoing initiatives that have contributed to increasing attention on gender issues in fisheries and aquaculture include:

- the triennial symposia on women and gender in fisheries and aquaculture organized by the Asian Fisheries Society;
- the Women in Fisheries publications of the Secretariat of the Pacific Community, and *Yemaya* (published by the International Collective in Support of Fishworkers);
- the Asia–Europe Meeting Aquaculture Platform (AqASEM09) project work on Empowering Vulnerable Stakeholder Groups.

OUTLOOK

No single blueprint exists for closing the gender gap as yet, but some basic principles are universal,[15] and its seems plausible that governments, the international community and civil society will work together to:

- eliminate discrimination under the law, improving women's endowments, opportunities and agency to help shape more positive outcomes for the next generation;
- promote equal access to resources and opportunities, reducing barriers to more efficient allocation of women's skills and talents and helping to generate large (and growing) productivity gains;
- ensure that policies and programmes are gender-aware, increasing women's individual and collective agency to produce better outcomes, institutions and policy choices;
- make women's voices heard as equal partners for sustainable development.[16]

In addition to helping to achieve the MDG of promoting gender equality and empowering women, mainstreaming gender is an essential component of alleviating poverty, achieving greater food and nutrition security, and enabling sustainable development of fisheries and aquaculture resources.

Gender considerations should be firmly placed on all fisheries and aquaculture policy agendas at all geographical and institutional scales. Attention to gender is needed in order to help improve women's productivity and enhance human justice. Increasing awareness on gender and being gender-sensitive are no longer sufficient. A coalition of gender champions, informed researchers, expert networks and policy advocates will be necessary.[17]

An opportunity to alleviate poverty and ensure greater food and nutrition security

Women who are offered and provided with the best circumstances to enhance their socio-economic empowerment will also be able to contribute meaningfully to food security, poverty alleviation and improved well-being for themselves, their families and their communities. In short, they will help to create a world in which responsible and sustainable use of fisheries and aquaculture resources can make an appreciable contribution to human well-being, food security and poverty alleviation.

An opportunity for economic empowerment

Economic empowerment should be the end goal of a road map on gender in fisheries and aquaculture. Economic empowerment is not narrowly focused on the financial component but rather on having the ability to recognize and exploit opportunities to make wealth and to make the right decisions, which means having the capacity for analytical thinking – and this boils down to having a good education (formal or informal) and appropriate human capacity development.

An opportunity to contribute fully

By mainstreaming gender in the fisheries and aquaculture sector, women will be given a chance to recognize and appropriately exploit opportunities to generate wealth and to make the right decisions in terms of more responsible fisheries and aquaculture practices and sustainable development.

Improved preparedness for and effective response to disasters in fisheries and aquaculture

THE ISSUE

Fishers, fish farmers and their communities around the world tend to be particularly vulnerable to disasters. This is because of their location, the characteristics of their livelihood activities, and their overall high levels of exposure to natural hazards, livelihood shocks and climate change impacts. Exposure and vulnerability to these hazards is increasing. For example, in the past century, there has been an increasing trend in the number of natural disasters reported around the world (Figure 36).

The social, economic and environmental impact of these disasters is significant, with disproportionate effects in developing countries and on vulnerable groups. Between 2000 and 2004, of the 262 million people affected annually by disasters related to weather and climate, more than 98 percent lived in developing countries and the vast majority were dependent mainly on agriculture and fisheries for their livelihoods.[18] Loss of life from such events is more prevalent in developing countries – from 1970 to 2008, more than 95 percent of deaths from natural disasters were in developing countries.[19] In 2010 alone, a total of 385 natural disasters killed more than 297 000 people worldwide, affected more than 217 million others and caused almost US$124 billion of economic damages.[20] It is acknowledged that the poor will be most affected by such hazards in the future and that this is likely to undermine progress toward poverty reduction.[21] While total economic damage from disasters tends to be higher in developed countries, as a percentage of gross domestic product it is higher in developing countries.[22]

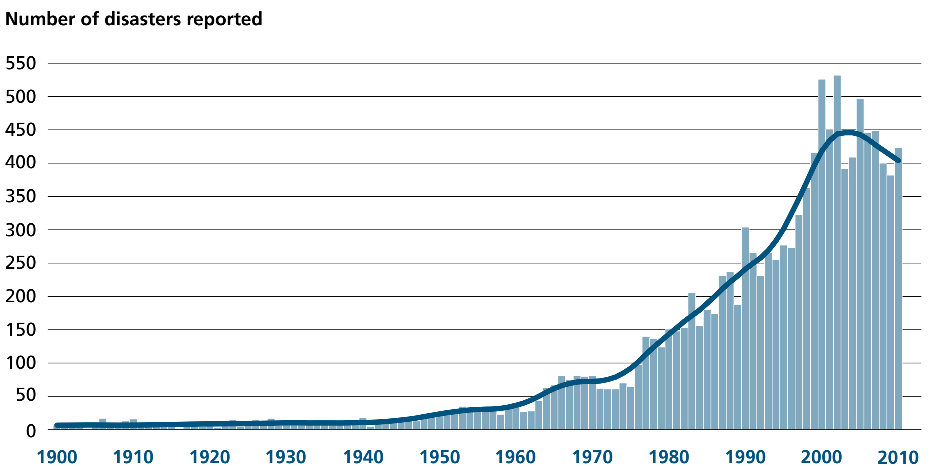
The types of disasters that affect the fisheries and aquaculture sector include natural disasters such as storms, cyclones/hurricanes with associated flooding and tidal surges, tsunamis, earthquakes, droughts, floods and landslides. Disasters of human origin affecting the sector have included oil and chemical spills and nuclear/radiological material. Food and nutrition security, post-conflict and protracted crises, HIV/AIDS and sector-specific hazards (e.g. transboundary aquatic animal diseases and pest outbreaks) can also have significant impacts on aquaculture production and fisheries. In addition to the tragic loss of life, the effects of disasters on the sector can include the loss of livelihood assets such as boats, gear, cages, aquaculture ponds and broodstock, post-harvest and processing facilities, and landing sites. In the longer term, the impact of the effects of disasters can be considerably mitigated by the effectiveness of response activities. However, damage caused by disasters can have social and economic impacts throughout and well beyond the sector (such as in terms of reduced employment and food availability). Other longer-term disasters such as fish disease outbreaks can build up over time and significantly affect production.

The vulnerability of countries and communities to these hazards is determined, on the one hand, by their exposure to such hazards and, on the other, by their ability to withstand (sensitivity), respond to and recover from (adaptive capacity) the effects of such hazards. Thus, susceptibility is directly affected by underlying issues such as food and nutrition insecurity, weak institutions, conflict and poor access to markets. However, the way each of these issues affects people varies considerably. Men and women, the old and the young, the rich and the poor, and small-scale and large-scale undertakings are all affected differently and have different ways of responding to hazards that affect them. Different people can also have quite distinctly different needs in the face of an emergency, face different threats and have different skills and aspirations.[23]

For coastal fishers, fish farmers and their communities, the relationship between them and the ecosystems that they depend on is complex.[24] This complexity is changing as the interface between fishers and fish farmers and the ecosystem is being affected by both slow- and rapid-onset hazards. The exposed nature of the livelihoods of fishers

Figure 36

Natural disasters reported worldwide, 1900–2010



Source: EM-DAT. 2012. *EM-DAT: The OFDA/CRED International Disaster Database* [online]. Université Catholique de Louvain, Brussels. [Cited 22 March 2012]. www.emdat.be and fish farmers, and the location of their communities, means that hazards often become disasters.

The extent of the impact of such disasters is also affected by people's social and economic conditions, which often include poverty and marginalization, especially in developing countries. Given the important role of the fisheries and aquaculture sector in food and nutrition security at both the local and national levels, disasters that affect these communities will also have multiplier effects on the wider economy. Fishers, fish farmers and their communities have been particularly affected by recent major events such as the Asian tsunami of 2004, Cyclone Nargis (which affected Myanmar in 2008), the recent floods in Bangladesh, Pakistan and Viet Nam, and the 2011 tsunami in Japan.

The effect of these hazards on fishing communities is increasing for a number of reasons. Extreme weather events are becoming more frequent, often associated with increasing climate variability and change. The impacts of disasters on coastal communities are particularly pronounced in the case of subsea events resulting in tsunamis (geological), storm surges and coastal flooding (hydrological), and coastal and lakeshore storms (meteorological). Droughts and floods can also affect river flows, wetland areas, and lacustrine and riparian communities. More indirectly, droughts and other catastrophic events can cause mass migration of people into areas normally occupied by fishing and fish-farming communities, so increasing competition for resources such as water.

Fishers, fish farmers and their communities are also often exposed to more prolonged hazards such as the spread of fish disease, the increase in invasive undesirable alien species, pollution from land and aquatic sources, and aquatic ecosystem degradation from farming, mining, industry and urbanization. Moreover, fishers, fish farmers and their communities often live in locations where tenure over land and other resources is contested, leading to disputes and more complex emergencies.

The land–water interface is being particularly affected by inward migration and the unsustainable use of resources. The result can be a depletion of the ecosystem services that these resources provide, particularly protection from coastal hazards such as storms and cyclones, and a reduction in support for productive livelihoods. Deforestation is leading to increased sedimentation and land erosion in coastal, lakeshore and delta regions, and this can adversely affect marine habitats (especially reefs). In addition, the effects of population increases in fishing and fish-farming communities are compounded by the lack of alternative livelihood options and weak market linkages.

The susceptibility of fishers, fish farmers and their communities to rapid-onset disasters is also being affected by climate change.[25] Seasonal weather patterns are likely to change, with some areas experiencing greater periods of drought and others more floods. Extreme weather events, such as storms, are likely to increase in frequency and affect fishing operations, and coastal and wetland flooding is likely to become more frequent. Increased precipitation in some areas will lead to the erosion of riparian lands and to greater sedimentation in coastal areas, affecting seagrass and reef production. Sea-level rise is likely to increase coastal flooding, and the incursion of saltwater into coastal areas will affect agricultural production and fish farming. Species distributions are also being changed, and increased temperatures are likely to affect coral reefs adversely, with higher incidences of coral bleaching occurring. Temperature changes will also affect fish physiology, with implications for both capture fisheries and fish farming. Increased ambient air temperatures could have very significant effects on the types of fish that can be cultured.

Changes in weather patterns will affect traditional fish processing methods, especially where fish is sun-dried. In some locations, this may be of benefit for processors. However, in other locations, poor weather in glut fish landing seasons will affect drying rates, with the potential for substantial losses. There are also likely to be changes in terms of road access to markets where unusual flooding or heavy rains occur.

Badly managed fisheries and aquaculture farms may cause increased stress in fish, reduce water quality, and make fisheries and aquaculture more exposed to climate change threats such as changes in water temperature and salinity.

Changing weather patterns will also affect non-fisheries livelihood strategies and will increase pressure on people to join a fishery where other opportunities have decreased. Efforts to redirect fishing to alternative livelihoods are also being affected by climate change effects on livelihood options and opportunities in the wider economy.

POSSIBLE SOLUTIONS

Reducing the effects of disasters on the fisheries and aquaculture sectors can be achieved through measures for prevention, mitigation,[26] and preparedness (disaster risk reduction [DRR]; Box 11). In the fisheries and aquaculture sector, this includes preparedness to respond rapidly and effectively if disasters occur, and early warning to provide information before potentially disastrous events occur. Managing the effects of hazards and disasters (disaster risk management [DRM]) goes beyond DRR to incorporate emergency response, recovery and rehabilitation within a management framework. Thus, as shown in Figure 37, DRM involves three distinct phases: (i) reducing vulnerability; (ii) responding to emergencies when they arise; and (iii) rehabilitating communities after the emergency has passed.

Box 11

Disaster management and climate change adaptation: key definitions

Disaster risk reduction (DRR) is the concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.[1]

Disaster risk management (DRM) goes beyond preparedness, prevention and mitigation, which form the core of DRR, to incorporate emergency response, recovery and rehabilitation within a management framework.[2]

Climate change adaptation (CCA) refers to adjustments in ecological, social or economic systems in response to actual or expected climate stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities, regions and activities to climate change and variability. Adaptation is important in the climate change issue in two ways: one relating to the assessment of impacts and vulnerabilities; and the other to the development and evaluation of response options.[3]

[1] United Nations International Strategy for Disaster Reduction. 2009. Terminology. In: *UNISDR* [online]. [Cited 20 April 2012].
[2] Baas, S., Ramasamy, S., Dey DePryck, J. and Battista, F. 2008. *Disaster risk management systems analysis: a guide book* [online]. Rome, FAO. [Cited 19 March 2012]. ftp://ftp.fao.org/docrep/fao/010/ai504e/ai504e00.pdf
[3] Intergovernmental Panel on Climate Change. 2001. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK, Cambridge University Press. 1042 pp.

Key actions in the DRM cycle may include:

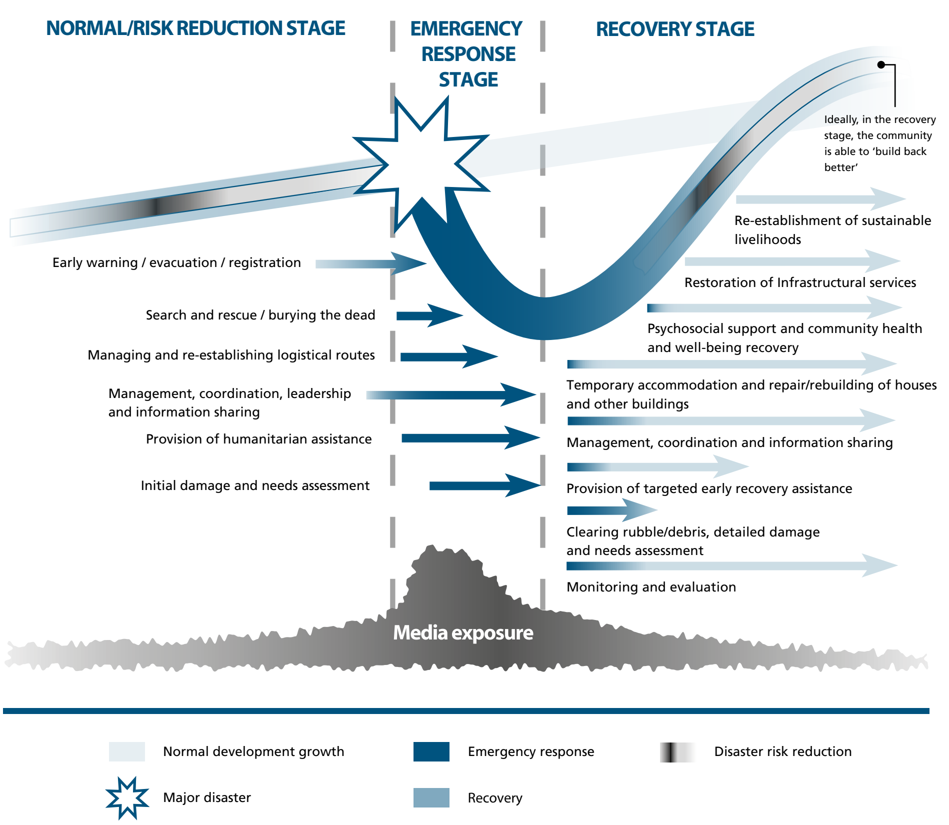
- assessment of damage and need (with respect to fisheries and aquaculture);
- rehabilitation of livelihoods (to reduce dependence on food aid);
- longer-term development and planning and preparedness;
- relief or emergency response to address immediate humanitarian needs and to protect livelihoods following a disaster;
- rehabilitation to initialize the restoration and rebuilding of livelihoods;
- reconstruction for replacing destroyed infrastructure;
- sustainable recovery for longer-term re-establishment and enhancement of livelihoods and livelihood support structures.

During emergency response, advocacy is required in order to ensure that recovery efforts comply with international instruments (including the Code of Conduct for Responsible Fisheries [the Code] and the MDGs) and are guided by international best practice, national policies and agreed recovery plans. This can include the promotion of:

- sustainable rehabilitation of fishing and fish farming;
- fish preservation and processing practices compatible with the state of fishery resources;
- rehabilitation and conservation of the environment and fisheries resources;
- strengthened governance and community-based planning;
- strengthening and diversification of sustainable livelihoods of traditional fishing and fish-farming communities.

Figure 37

The disaster risk management cycle[1]



[1] This mainly applies to a relatively quick-onset disaster (e.g. cyclone, flood, earthquake, tsunami, bushfire), rather than a slow-onset one such as famine (due to drought/war).

Source: Adapted from: Piper, C./TorqAid. 2011. *DRMC version XVI* [online]. [Cited 22 March 2012]. www.torqaid.com/images/stories/latestDRMC.pdf

Resilience to the effects of disasters can be achieved by working with communities and multilevel stakeholders to reduce their sensitivity to disasters (through preventive actions or by reducing levels of dependence) and/or by strengthening coping and adaptive strategies that respond to those hazards. In so doing, the differences between different stakeholder groups within a given community need to be carefully considered.

As the effects of climate change will be to alter the magnitude and frequency of extreme events, it is important to recognize that existing coping and response mechanisms to disasters – based on past vulnerabilities – may no longer be appropriate for what is to come. Indeed, in many countries, existing mechanisms are already insufficient for the current level of vulnerability.[27]

Climate change and more rapid-onset hazards such as cyclones, floods and earthquakes are related in a number of ways:

- They both directly affect the livelihoods of fishers and fish farmers and invariably reduce the quality of those livelihoods.
- They interact to compound the adverse effects of both – most noticeable will be the increased frequency and impact of extreme events as a result of climate change.
- Climate change will interact with extreme events to change their location and, thus, the communities affected.
- Adaptation to both forms of hazard at the community level tends to have many aspects in common.

Effective DRM needs to consider changing climate risk patterns, and, given that an increase in extreme climate events is one of the major threats posed by climate change, DRM is a natural entry point for adaptation.[28] When considering adaptation to climate change risks, it should be recognized that adaptive capacity has developed as a response to existing vulnerability to extreme events. Improving the adaptive capacity of communities, civil society and governments to deal with current hazards is also likely to improve their capacity to adapt to climate change.[29]

The extent of climate change effects on fishing and fish-farming communities has been extensively investigated.[30] The exposure and vulnerability of fishing communities to hazards is increasingly being seen as a convergence of climate change and more acute hazards. This compounds situations where natural resources are already overexploited or under other forms of pressure from human activities. The Intergovernmental Panel on Climate Change has recently drawn attention to the need to integrate expertise in climate science, DRM and adaptation in order to reduce and manage more effectively the risks of extreme events and disasters in a changing climate.[31] However, climate change adaptation (CCA) is not simply an extension of DRM. Adaptation to climate change not only means addressing changes in the intensity and frequency of extreme events, but also more subtle changes in climate conditions as well as emerging risks that have not been experienced in a region before.[32] Some effects of climate change, such as global changes in sea levels, are new within recent human history, and little experience is available to tackle such impacts.[33]

This growing interconnectedness of climate change and more acute events suggests a need for a convergence of DRM and CCA preparedness and response approaches, particularly at the land–water interface where the effects are felt most strongly and particularly by fishers, fish farmers and their communities. This would suggest that DRM and CCA need to be fully incorporated into fisheries and fish-farming policies and plans, and that fisheries and fish farming should be fully considered in CCA and DRM approaches. In addition, the increasing vulnerability of the poor to both climate change and hazards would suggest that CCA and DRM need to link to livelihoods (taking account of the different assets and production, coping and adaptive strategies of different groups, such as the old and the young, men and women, and people from different cultures and religions) in a holistic and integrated way. Moreover, the implications of both extreme events and climate change for wider national and regional food security suggest that these elements also need to be integrated with each other.

RECENT ACTIONS

A World Conference on Disaster Reduction was convened by the United Nations General Assembly (UNGA) in Hyogo, Japan, in 2005 just a few weeks after the Indian Ocean tsunami. The conference, which was attended by representatives of 168 States, agreed on a strategic and systematic approach to reducing vulnerabilities and risks to hazards. The need for building resilience of nations and communities was stressed, and the conference adopted five priorities for action:

- Ensure that DRR is a national and a local priority with a strong institutional basis for implementation.
- Identify, assess and monitor disaster risks and enhance early warning.
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthen disaster preparedness for effective response at all levels.

The Hyogo Framework for Action (HFA) 2005–2015: Building the Resilience of Nations and Communities to Disasters was endorsed by the UNGA in Resolution 60/195. The ten-year plan of the HFA reflects the intention to take a holistic approach in identifying and putting into action complex multidisciplinary DRR measures. The HFA supports a stronger recognition of climate change concerns in DRR strategies and seeks to establish a multidisciplinary, forward-looking approach. It also calls on the United Nations International Strategy for Disaster Reduction to facilitate the coordination of effective and integrated action among the organizations of the UN System and among other relevant international and regional entities, in accordance with their respective mandates, to support the implementation of the HFA.

In line with the HFA, FAO has developed a Framework Programme on Disaster Risk Reduction/Management. The Framework Programme strives to assist Members in implementing the HFA five priorities for action in the agriculture sector. The direction and content of the Framework Programme respond to recent recommendations by FAO governing bodies, including priority areas as identified by FAO Regional Conferences. These "pillars" are: (i) institutional strengthening and good governance for DRR in the agriculture sector; (ii) information and early warning systems on food and nutrition security and transboundary threats; (iii) preparedness for effective response and recovery in agriculture, livestock, fisheries and forestry; and (iv) good practices, processes and technologies for mitigation and prevention in farming, fisheries and forestry. Interventions under the Framework Programme are tailored to the specific strengths and needs of a country or region and delivered in a demand- and modular-responsive manner.

The fisheries and aquaculture sector must be considered in a different way to other sectors (such as agriculture) in emergencies in view of the many unique challenges related to management and the complex range of activities undertaken by fishers and fish farmers. Specifically, within the fisheries and fish-farming sector, FAO has initiated a programme of consultation with partners at the global level, where the synergies between managing climate change and DRR were explored.[34] At the regional level, in Bangkok, Maputo and San José, consultations with partners addressed regional issues,[35] where the integration of fisheries and aquaculture with DRM–CCA was discussed in detail and options for taking this integration forward were outlined. The need for this integration was further endorsed at the 29th Session of the FAO Committee on Fisheries (COFI) in 2011. The different initiatives at the regional and international level constitute important opportunities for ensuring that concerted efforts are made to tackle the issues relevant to DRM and CCA. However, challenges remain with regard to integrating CCA and DRM sufficiently in fisheries and aquaculture governance and development planning and implementation and, vice versa, integrating fisheries and aquaculture into CCA and DRM, and taking the characteristics and special needs of fishers, fish farmers and their communities into account in DRM and CCA policies and actions. To this extent, FAO is actively involved in identifying climate-related vulnerabilities and adaptation strategies, including DRR/DRM, specific to fisheries and aquaculture in order to inform more fully fisheries and climate-change decision-makers. The work of the FAO Fisheries and Aquaculture Department is aligned to priorities expressed in international, regional and national policies and agreements, such as national adaptation programmes of action for least-developed countries and regional strategies/agreements for disaster reduction and related programme of action. It is also aligned with the FAO Framework Programme on Climate Change Adaptation (known as FAO-Adapt).

Furthermore, the FAO Fisheries and Aquaculture Department continues to provide support to FAO Members and partners in responding to emergencies affecting the fisheries and aquaculture sector. Since 2005, it has supported emergency responses through 135 projects in 25 countries. The overall objective of this support has been to strengthen food and nutrition security through the sustainable rehabilitation and long-term recovery of the fisheries and aquaculture sector and the livelihoods that depend on it. In particular, efforts have focused on targeting women and other marginalized groups. The technical advice provided aims to ensure that these efforts are aligned to national policies, regional strategies and international best practice and guidance for the sector, in particular the Code.

OUTLOOK

In view of the in-depth and ongoing consultation with partners and stakeholders from the DRM, CCA and fisheries and fish-farming sectors, it seems likely that that the key areas for action in the coming years will include:

- strengthening policy coherence and institutional structures to ensure explicit and adequate consideration of fisheries and aquaculture activities in disaster preparedness and CCA strategies;
- integrating an understanding of the increasing vulnerability of fishers, fish farmers and their communities both to extreme events and to climate change, and developing and incorporating comprehensive preparedness and response strategies into fisheries and fish-farming sector plans and wider development frameworks;
- building an increased understanding of the vulnerability of fishers, fish farmers and their communities into wider social, economic and environmental development plans;
- working with communities, governments and civil society to help build their productive, coping and adaptive capacity and to ensure that the adaptive, coping and livelihood strategies of fishers, fish farmers and their communities are incorporated into wider disaster preparedness and response strategies;
- developing shared tools, guidance and approaches that combine DRM and CCA at a practical level and that link into fisheries and fish-farming development strategies to increase the resilience of communities and that of aquatic systems on which they depend;
- building partnerships at the global, regional, national and subnational levels among international agencies, national agencies, local government, civil society and communities to learn lessons about, prepare for and respond to slow- and rapid-onset hazards in an integrated and informed way.

Managing recreational fisheries and their development

THE ISSUE

Recreational fishing is well established in most developed countries and expanding fast elsewhere. It involves a large number of individuals, and there is growing awareness that recreational fishing is a considerable industry in terms of numbers of practitioners, catch and social and economic relevance. However, in many recreational fisheries, this awareness has not been accompanied by enhanced management practices, and concerns are spreading about the influence of recreational fishing on the livelihood opportunities of full-time fishers, on the environment and on aquatic biodiversity.

Recreational fishing is fishing of aquatic animals that do not constitute the individual's primary resource to meet nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets.[36] While angling is how most people perceive recreational fishing, the activity also includes gathering, trapping, spearing, bow fishing and netting aquatic organisms. Recreational fishing currently constitutes the dominant use of wild fish stocks in freshwater environments of industrialized countries. The increased affordability of high-efficiency fishing equipment (including navigational devices, fish finders and improved boats) and ongoing urbanization in coastal zones have resulted in a continuing expansion of recreational fisheries in coastal and marine environments.

Although estimates are difficult, the total annual catch by recreational fishers was estimated at 47 billion fish in 2004, or at about 12 percent of the total world catch.[37] Tentative estimates indicate that about 10 percent of the population in developed countries practise recreational fishing, and recreational fishers probably number more than 140 million worldwide.[38] One study,[39] summarizing ecosystem-based marine recreation valuation results, estimated the total number of marine recreational fishers for 2003 at 58 million. Several million jobs depend on recreational fisheries as associated spending may add up to billions of dollars annually. In the United States of America and in Europe, where angling is the best-documented form of recreational fishing, it has been estimated in recent years that there are at least 60 million and 25 million recreational anglers, respectively;[40] and it has been estimated that there are 8–10 million recreational saltwater fishers in Europe.[41] Similarly, it was estimated in 2009 that some 10 percent of the population in Central Asia were involved in recreational fisheries in inland waters of that region.[42]

The contribution that recreational fishing can make to local economies is considerable, including in less-developed countries. In some areas, the income and employment generated by the spending of recreational fishers is higher than that generated by commercial fisheries or aquaculture. Improved valuation of natural habitats and clean waters have been additional benefits of recreational fishing.[43]

Recreational fishing has shown itself able to provide value as an educational activity, promoting the concept of responsibility for fish stocks and the environment they inhabit and upon which all people depend. Recreational fishers often have a strong sense of responsibility for the environment in which they fish, as is, for example, recognized by the Bern Convention of the Council for Europe in the European Charter on Recreational Fishing and Biodiversity (2010).[44]

In some cases, aquaculture escapees have come under the control of sports fishers. In southern Chile, recreational fisheries that used to be based only on rainbow trout and brown trout now include escaped Atlantic salmon (*Salmo salar*) and chinook salmon (*Oncorhynchus tshawytscha*). In Chile and Argentina, where chinook salmon have migrated successfully in the ocean, self-sustained populations of chinook salmon have generated much enthusiasm among recreational fishers and concerns among conservationists.[45]

However, at times, recreational fishers also interact negatively with professional small-scale and artisanal fishers in open-access areas and at common fishing grounds. There are records of controversial and anecdotal observations of the detrimental effects of recreational fisheries, such as spear fishing on individual species of groupers along the coasts of the Mediterranean and Australia[46] and in the eastern Red Sea.[47] Moreover, recreational diving for species such as Caribbean spiny lobster[48] in combination with commercial fisheries and other pressures (e.g. pollution) has caused significant declines in certain stocks.

Nevertheless, recreational fishers have the potential to enhance fish conservation and maintain or rehabilitate important habitat.[49] As stakeholders, they can be instrumental in successful fisheries conservation through participation in management and conservation endeavours.

Increasingly, recreational fishers are capable of reaching offshore fishing grounds and use technologies – including fish-locating devices – that can make them equivalent to commercial fishers in term of fishing capacity and capability. Recreational fisheries have developed for species historically only exploited by the commercial fishery, in some cases causing conflict between the sectors.[50] Fishing similar locations and using the same types of fishing gear and facilities, such as moorings, can also put recreational fishers in competition with coastal small-scale commercial fishers. Other specialized recreational fisheries target highly iconic species such as salmon, marlins, sailfish and swordfish, often in particular areas and seasons, contributing significantly to the total catch. However, it should be noted that most game fishing associations actively promote catch-and-release practices and that the fish caught in game fishing tournaments are generally released unless the fish caught is a record fish.

Many recreational fisheries tend to be highly selective. Often, recreational fisheries target larger individuals in the population. However, removal of larger individuals of long-lived species may have important effects on the reproductive potential of the population.[51] Larger females are more fecund, spawn over prolonged periods (thus providing more resilience to changing environmental conditions), and can produce larvae with higher survival rates. Sequential hermaphroditic species may have large individuals of the same sex and their sustained removal can affect spawning success. Age- or size-truncated populations may suffer from changes in density or from behaviourally mediated indirect interactions, and cause significant effects in food webs, also altering the ecosystem structure and productivity.[52] All this would assume even more relevance in the case of those stocks concurrently exploited by both commercial and recreational fisheries.

POSSIBLE SOLUTIONS

Development

Sustainable development of the recreational fisheries sector will depend on the acceptance of its multidisciplinary nature and whether recreational fishery stakeholders will be allowed to facilitate successful conservation and management. There is an urgent need to integrate biological and social sciences in order to provide insights into the dynamics of the entire social and ecological system of the recreational fishing industry.[53]

The sustainability of recreational fisheries – including the conservation of aquatic animal biodiversity in areas fished – in combination with commercial fisheries requires recognition by those responsible for this sector. Policy-makers and managers responsible for recreational fisheries need to obtain information about the sector, as well as knowledge of possible factors that affect the sector negatively (including coastal development, fish habitat modification, pollution and extreme climate events). In addition, recreational fishing has a significant social component, and the benefits of the activity need to be weighed against investment in resource protection.[54]

Appraisal of the performance of recreational fisheries and of their potentialities needs to be a multidimensional and multidisciplinary exercise in order to capture the societal, economic, environmental and educational components of the sector, and importantly, to ensure effective participation of stakeholders.[55] One recent study[56] has made an effort in this respect by recommending "methodologies assessing socio-economic benefits of European inland recreational fisheries", which may be of use not only in Europe but also elsewhere.

Management

Management of recreational fisheries needs to reconcile conflicting demands for access to the wild fish while ensuring both sustained exploitation of the marine fauna and conservation of the marine ecosystem of which the fauna are a part.

To do this, management of recreational fisheries needs to follow a process that is similar to that used by most fisheries managers; it involves: (i) defining the resource to be managed, the state of the system and constraints; (ii) setting goals and objectives; (iii) evaluating management options; (iv) choosing appropriate actions to achieve management objectives; (v) implementing such actions and monitoring outcomes; and (vi) evaluating the success of management, and adjusting management in the light of learning.[57] The choice of tools is wide in freshwater recreational fisheries. Management tools include: stocking, biomanipulation, prey enhancement, suppression of detrimental fishes, selective removal, renovation, and management of aquatic plants.

However, at the same time, fisheries managers need to recognize that freshwater recreational fisheries differ from commercial fisheries and aquaculture and that, therefore, they need to be dealt with in a way that reflects this difference. The main differences relate to species introduction, stocking of waterbodies, catch-and-release practices, the potential for selective overexploitation, and the role of recreational fishers in habitat and biodiversity conservation.

Managers also need to be aware that for many fisheries there exists a perception that the catch of the individual recreational fisher will have only a minimal and localized impact on resources, and that recreational fishing has had little influence on reported stock declines worldwide. However, this perspective often changes dramatically when the size and activity of the recreational fisher population is considered.

There is an open-access scenario characterizing many recreational fisheries, particularly marine ones, that has consequences for the sustainability of the resources and the fisheries. In contrast, many inland and coastal recreational fishing areas, especially in Europe, North America and Oceania, do not apply open-access regimes and sometimes have extremely restrictive access requirements instead.

However, traditional management objectives such as maximizing yield may not be the most appropriate goal for a recreational fishery – enjoyment of the fishing experience is the primary objective of recreational fishing, and this requires different management strategies and tools.[58]

An integrated monitoring system in support of the management of recreational fisheries should entail all the relevant components of the recreational fishery. It could include, *inter alia*, representatives of: recreational fishers and their associations, equipment suppliers, commercial fishers and their organizations, public authorities, civil society, universities, research institutes, and the tourism industry.

The limited reliable data and scientific information available call for precautionary management. As in any other fishery, management of recreational fisheries requires clear identification of goals and measurable operational objectives. Simple and easy-to-obtain multidisciplinary indicators, and their reference points, should be used to measure the state of recreational fishery systems in terms of pressure exerted on the resources and generation of added value. Such indicators can be used to compare recreational fisheries with commercial fisheries.[59] Adequate funding and support should be available to manage recreational fishing within the wider context of fisheries and environmental management strategies. The recreational fishers may be requested to contribute to the cost of managing recreational fishing; "user-pay, user-benefit" systems could be used in some cases. The need to estimate total harvest, effort and impact has to be addressed in order to be able to manage a resource responsibly. Recreational fisheries registration and licensing can play a major role in this respect; registration being a means to quantify and identify participation, and licensing being a means to do the same and generate income. Issues to consider when establishing licensing schemes are the costs of their establishment and operation, and how to ensure that the licence revenues collected flow back into the sector.

Management that focuses on preserving larger specimens of a population may involve the creation of appropriate conservation areas (refugia, marine protected areas or areas closed to fishing) or guidance and/or regulations on catch and release.

Some recreational fisheries target individuals belonging to stocks of transboundary or migratory fish species that are exploited by recreational and commercial fisheries of more than one country. Moreover, some target species of marine recreational fisheries (e.g. tuna and marlin) migrate between high seas areas and areas under national jurisdiction. This confers an additional international facet to the national management system. Regional fisheries management organizations (RFMOs) and regional fisheries advisory bodies can provide the regional frameworks required to include recreational fisheries into the regional dialogue and mechanisms for the conservation and management of recreational fisheries of common interest.

RECENT ACTIONS

The Code of Practice (COP) for Recreational Fisheries developed (2007–08) under the auspices of the then European Inland Fishery Advisory Commission (EIFAC, now the European Inland Fisheries and Aquaculture Advisory Commission [EIFAAC]) constituted a major step towards elaborating a suite of tools for the management and conservation of recreational inland fisheries.[60] The COP includes standards for responsible, environmentally friendly recreational fishing in consideration of changing societal values and conservation concerns. Its aim is to foster best practices in recreational fisheries that would promote their long-term viability in the face of expanding threats, such as habitat manipulation and destruction, resource overexploitation, and loss of biodiversity.

The relevance of the development and management of recreational fisheries beyond national jurisdictions is becoming evident in the agenda of regional fishery bodies (RFBs), particularly where recreational fishing occurs in international waterbodies or semi-closed seas.[61] Regional bodies could develop long-term common monitoring frameworks and promote regional cooperation in order to: establish standard guidelines to describe the fishery and determine the impact upon the resources; and characterize the social and economical dimension of recreational fisheries that occur in the region of their competence.

At the global scale, the World Recreational Fishing Conference series is a major scientific forum for discussing progress and issues in the development and management of recreational fisheries. The conferences aim to increase dialogue and knowledge about the diversity, dynamics and future prospects of recreational fisheries.

FAO is developing technical guidelines on responsible recreational fisheries. In August 2011, an Expert Consultation met to develop the FAO Technical Guidelines for Responsible Fisheries: Recreational Fisheries. The technical guidelines cover all types of recreational fisheries (harvest-oriented angling, catch-and-release fishing, trapping, spearfishing, etc.) in all environments (marine, coastal and inland). They are global in scope, and will be congruent with the the Code.

OUTLOOK

Recreational fishing is developing and expanding in many countries, as are its impacts on fish stocks through exploitation or related practices such as stocking and introduction of non-native fishes. The social and economic importance to local and regional economies is also being recognized.[62] The dimension of global fisheries is greater than previously assumed when recreational fisheries are considered, and local economies are a major beneficiary of good recreational fisheries management. The economic, educational, health and other social benefits of recreational fishing should be recognized and promoted. Ideally, both commercial and recreational fishing industries should share a common interest in ensuring the maintenance of fish stocks and their habitats.

It seems plausible that, over time, the development and management of recreational fisheries will build increasingly on the application of the precautionary and ecosystem approaches. This will include using a holistic approach to recreational fisheries management based on the concomitant consideration of fish biology, fishing activity, catches, and the economic and social values of recreational fishing.

Given the growing importance of recreational fisheries, national fisheries management will probably recognize and incorporate them in the overall fisheries management discourse, including in fisheries sector reviews, management plans and conservation strategies. Future fisheries management will probably aim for balanced development of recreational and commercial fishing, including allocation of resource shares in order to optimize local community benefits and ecosystem health.

The potential role of recreational fisheries for livelihoods of rural communities will be assessed and promoted, given that, in many parts of the world, recreational fisheries and associated tourism activities could provide alternative livelihoods for small-scale fishers.

Barriers to achieving low-impact fuel-efficient fishing

THE ISSUE

Most fishing techniques in use today have their origin in an era when fisheries resources were abundant, energy costs were much lower than current levels, and less attention was paid to the negative impacts of fishing on aquatic and atmospheric ecosystems. Current high energy prices and greater awareness of ecosystem impacts are

Box 12

Fishing vessels and fuel consumption

With regard to consumption of fuel, recent overall estimates have shown that about 620 litres of fuel (530 kg) is used per tonne of landed fish.[1] The global fishing fleet is estimated to consume approximately 41 million tonnes of fuel per annum.[2] This amount of fuel generates about 130 million tonnes of CO_2. However, fuel consumption varies widely according to gear type, fishing practice, operational technique and the distance between the fishing ground and port. Moreover, there are substantial differences in fuel consumption between fisheries targeting groundfish or shellfish and those targeting pelagic fish or industrial fisheries.

Notwithstanding the above, studies of fuel consumption patterns by gear type indicate that passive fishing gear (e.g. pots, traps, longlines and gillnets) generally require lower amounts of fuel than active fishing gear (e.g. bottom trawls). Encircling gear types that are dragged a limited distance at slow speed, including gear such as bottom seines, rank between passive and towed gears in fuel consumption.

Active pelagic gear types like midwater trawls and purse seines target fish that form dense schools, and the catch can be hundreds of tonnes of fish in one short tow or haul; therefore, the fuel consumption is generally low in relation to the quantity of catch. In particular, purse seining is one of the most fuel-efficient techniques for catching fish although vessels using this gear often spend significantly more time and fuel searching for schools than actually catching fish. Fishing with the help of powerful artificial lights is common in purse seining, squid jigging and stick-held dip netting, particularly in Asia. While these fishing operations in themselves are fuel efficient, the use of the lights adds to the energy requirement.

[1] Tyedmers, P.H., Watson, R. and Pauly, D. 2005. Fueling global fishing fleets. *Ambio*, 34(8): 635–638.

[2] World Bank and FAO. 2009. *The sunken billions. The economic justification for fisheries reform*. Washington, DC, Agriculture and Rural Development Department, The World Bank. 100 pp.

now realities and present major challenges to the viability of fisheries, particularly in developing countries where access to and promotion of energy-efficient technologies have been limited. However, as illustrated in this article, which is largely based on a paper by Suuronen *et al.*,[63] each type of fishing gear and practice has advantages and disadvantages, and the suitability of each gear type depends considerably on the operational conditions and on the species to be targeted.

The impacts of fishing gear on ecosystems vary widely. Overall, these impacts largely depend on: the physical characteristics of the gear; the mechanics of its operation; where, when and how the gear is used; and the extent of its use. Moreover, gear types that rank high for one kind of impact may rank low for another. Physical damage to the environment may also result from the inappropriate use of an otherwise acceptable gear. Only a small number of fishing methods are recognized as inherently destructive no matter how they are used, prime examples being explosives and toxins. It should also be kept in mind that in spite of the fact that many fisheries are highly selective, fishers are often not capable of catching only the desired target species. When poorly selective fishing occurs, it leads to the incidental catch of fish and invertebrates, part of which may consist of juveniles of ecologically important and/or economically valuable species. In addition, fishing can also result in the incidental mortality of non-target species of seabirds, sea turtles and marine mammals, as well as causing damage to vulnerable ecosystems, such as coldwater corals, which can take many decades to recover.

With regard to greenhouse gas (GHG) emissions, insufficient attention has been paid to the fisheries sector as a whole and to fishing operations in particular. Consequently, it is difficult to rank fishing gear and practices in terms of GHG emissions. However, using the consumption of fuel as a proxy for total GHG emissions can provide a good estimate (Box 12). It is also a fact that, notwithstanding the provisions of existing international conventions, the quality of available fuel is not constant worldwide with regard to sulphur content.

It is noteworthy that life cycle assessments show that significant energy consumption and GHG emissions occur after the catch is taken on board and more so after landing, owing to fish processing, cooling, packaging and transport. Thus, minimizing the impacts and energy consumption throughout the whole product chain would be important to reducing the overall environmental costs of fishing.

POSSIBLE SOLUTIONS

The fishing sector should strive to further lower its fuel consumption and decrease ecosystem impacts. Despite a growing number of initiatives and experimentation with energy-reducing technologies, there is currently no viable alternative to fossil fuels for mechanically powered fishing vessels. However, it is well demonstrated that, through technological improvements, gear modifications and behavioural change, the fishing sector can substantially decrease the damage to aquatic ecosystems, reduce GHG emissions (which is a legal obligation for governments under existing international conventions) and lower operational costs for fuel without excessive negative impacts on fishing efficiency.

Solutions by fishing operation

Demersal trawling

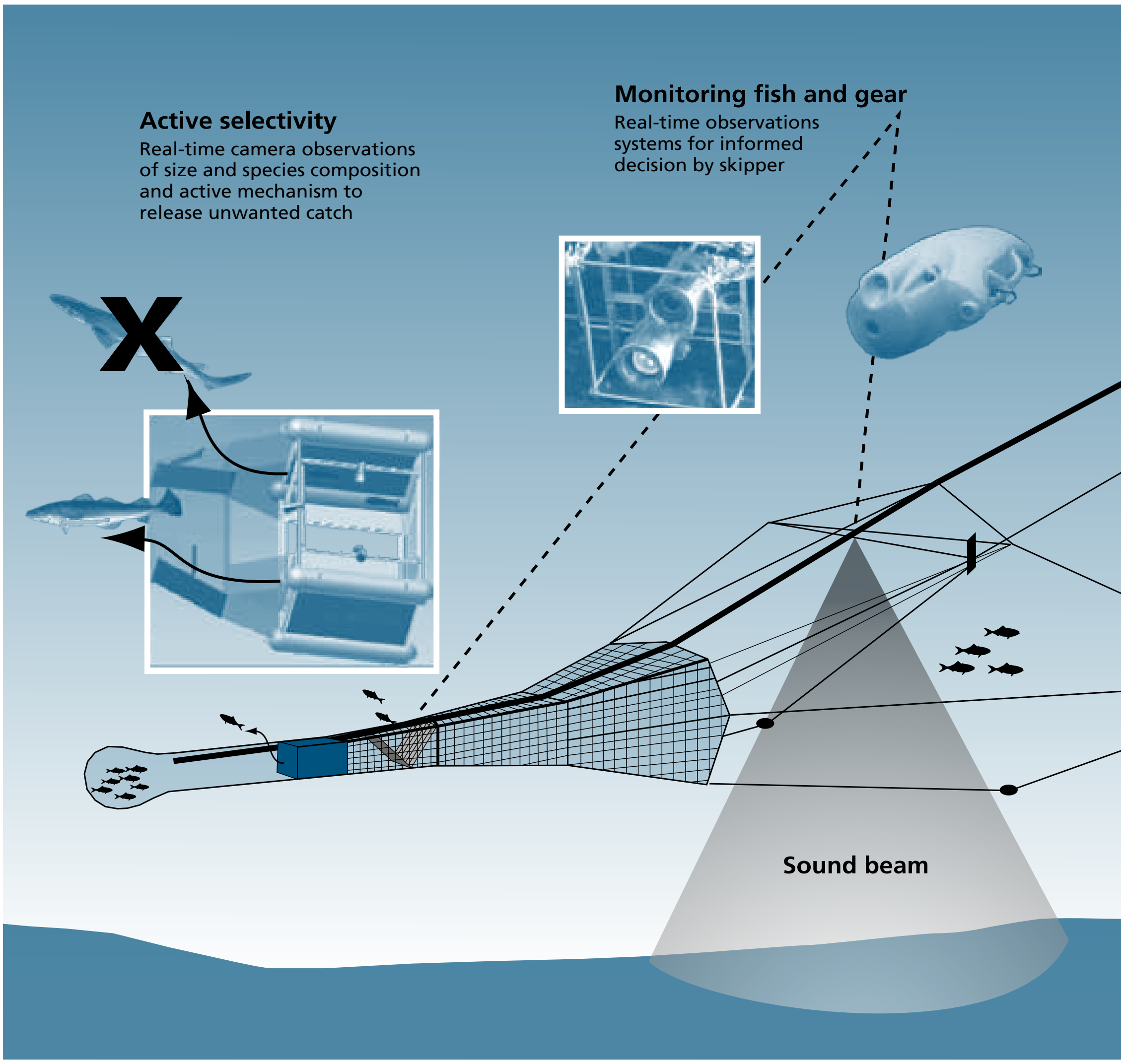
Trawls are flexible gear and can be used on many types of areas and grounds, in shallow and deep waters, and by small and large vessels for a wide range of target species. These characteristics have made trawling the preferred method for many fishers, and it may be the only short-term economic solution for capturing, for example, certain shrimp species. However, bottom trawling has been identified as one of the most difficult to manage in terms of bycatch and habitat impacts.

There are many techniques and operational adaptations available to reduce the drag and weight of the bottom trawl gear and, thereby, to reduce significantly fuel consumption and sea-bed impacts without marked decrease in the catch of the target species.[64] Fuel savings of 25–45 percent and gear-drag reductions of 20–35 percent have been reported.

However, in general, further work is needed to improve the construction of different components of trawl gear in order to minimize friction on the bottom and to reduce overall gear drag. In this regard, there is further potential to develop technologies in which the force of trawl doors and ground gear on the sea bed is automatically measured and adjusted by instrumentation (Figures 38 and 39). In the case of beam trawls, progress has been made in recent years by developing alternative

Figure 38

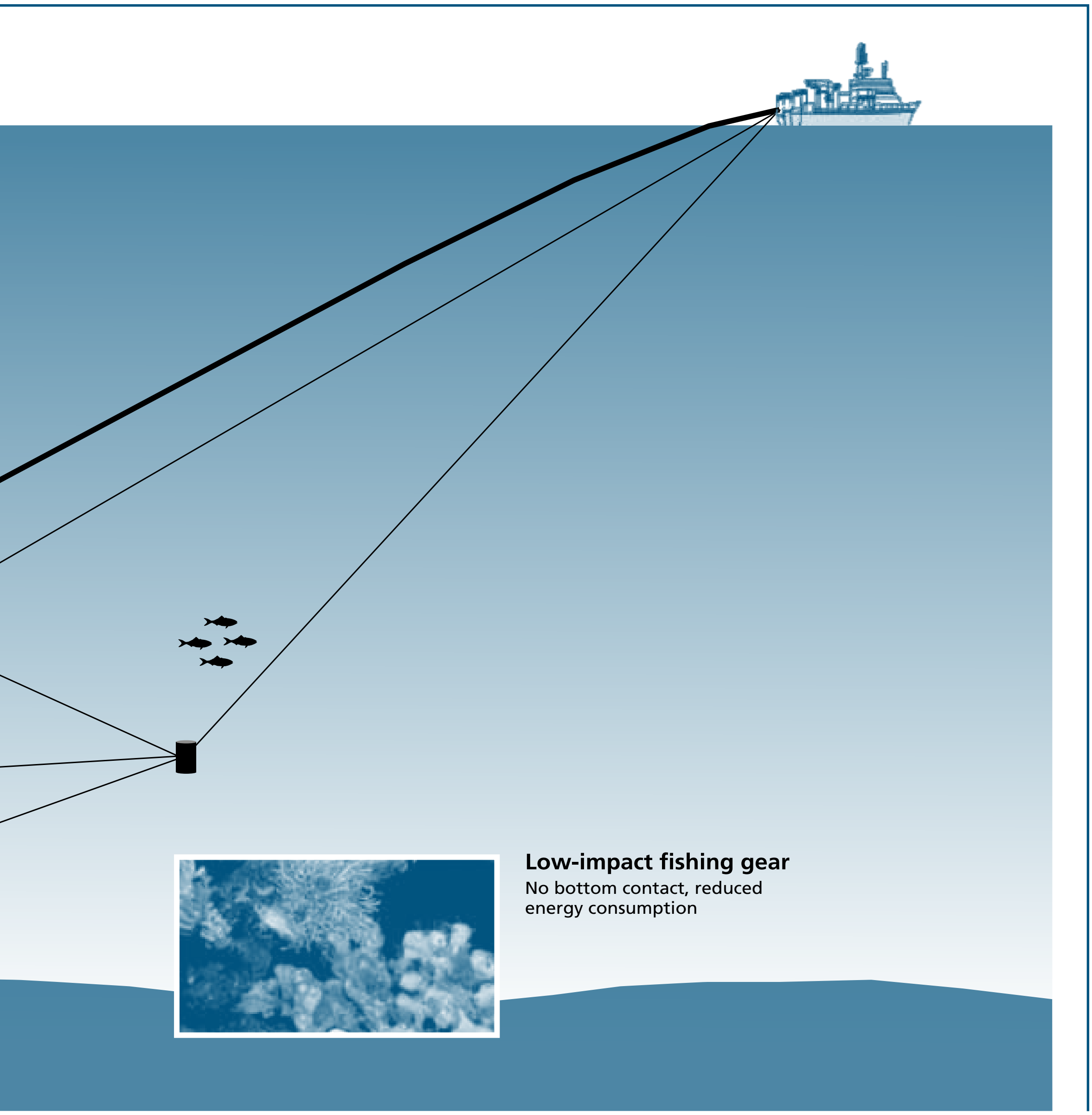
A new semi-pelagic low-impact and selective trawl gear (CRIPS-trawl) that is under development in Norway



Notes: The new trawl design (CRIPS-trawl) has a reduced bottom contact and less drag compared with a conventional bottom trawl. The trawl doors and the footrope of the trawl are lifted off the bottom. The front panels of the trawl are replaced by herding ropes, and the aft parts are made of square-mesh netting. This will reduce the drag of the trawl while still maintaining the stimulation for herding the fish into the codend. The extension piece and the codend are made of four panels and include a net camera and various selection devices to release unwanted fish from the trawl. The four-panel design improves the stability of the trawl and the selection devices. The net camera gives real-time information of the fish species and sizes entering the codend, and allows the skipper to make informed decisions regarding how to continue the fishing process. The trawl may also be fitted with an active mechanism to release unwanted catch (based on image analysis). The trawl concept also includes a cable connection from the vessel to the trawl headline. The cable will carry the video signal from the net camera and acoustic sensors, and it will also increase the vertical opening of the trawl. The concept will later also include an independent system to adjust the distance of the doors from the sea bed.

gear designs. In essence, the objectives are to reduce the amount of tickler chains, avoid excess weight in the beams, and use other stimuli (e.g. electric pulses) as an alternative to chains to scare the target fish off the bottom and into the net. The use of acoustics, light or any other additional stimuli to enhance encounters by target species within the catching zone of trawl nets is worth exploring.

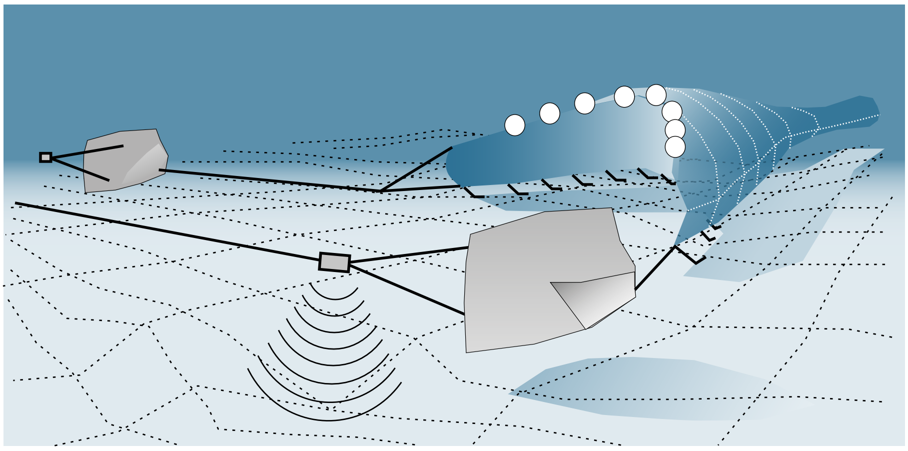
The use of improved location and targeting of fish with the help of electronic sea-bed mapping tools and integrated global navigation satellite systems has resulted in avoidance of sensitive bottom habitats and helped to minimize fishing effort and fuel



Source: Valdemarsen, J.W., Øvredal, J.T. and Åsen, A., 2011. *Ny semipelagisk trålkonstruksjon (CRIPS-trålen). Innledende forsøk i august-september 2011 om bord i M/S "Fangst".* Rapport fra Havforskningen nr. 18. Bergen, Norway, Institute of Marine Research. 17 pp.

Figure 39

Smart trawling: reduced seabed damage of bottom trawling



Note: In "smart trawling technology", the distance of trawl doors and ground gear from the sea bed is constantly and automatically measured and adjusted by special instrumentation. The use of ballast elements or dropper chains suspended from the footrope to hold the trawl near to, but not in contact with, the bottom offers potential in some fisheries to reduce sea bed contact while maintaining catching efficiency.

Source: Modified from Valdermarsen, J.W. and Suuronen, P. 2003. Modifying fishing gear to achieve ecosystem objectives. *In* M. Sinclair and G. Valdimarsson, eds. *Responsible fisheries in the marine ecosystem,* pp. 321–341. Rome, Italy, and Wallingford, UK, FAO and CABI International Publishing.

consumption. Multibeam acoustic technology, widely used in sea-bed exploration, has been successfully applied, for example, to mapping scallop beds off the east coast of Canada, thereby substantially reducing the time required to locate the grounds and the actual fishing time.

Bottom seining

Bottom seining (Danish, Scottish and pair seining) is generally considered to be a more environmentally friendly and fuel-efficient fishing method than bottom otter trawling. The gear is lighter in construction and the area swept is smaller than in bottom trawling. Moreover, because there are no trawl doors or heavy ground gear, there is less force on the sea bed. The light gear and low hauling speed mean that fuel usage can be significantly lower than for a comparable trawling operation. Bottom seine nets are generally also regarded as having low impact on benthic invertebrates. However, the high bycatch of both undersized individuals of the target species and individuals of non-target species can be a problem in some seine fisheries.

Trap-net

Trap-nets are passive fishing gear that are usually set on traditional sites in the path of migrating fish in relatively shallow coastal waters. Leader-netting herds and guides fish into a holding chamber or pound where they are entrapped. The pontoon trap is a more recent innovation and offers various advantages compared with traditional trap-nets such as being easy to transport, handle and haul, adjustable in terms of size, target species and capture depth, as well as being predator-safe. Future developments may include large-scale, ocean-based fish traps together with the technology to attract fish. Modern trap-net fisheries can be energy efficient, flexible, selective and habitat-friendly, providing catches of high quality as the catch is usually alive when brought aboard the vessel. Live capture provides the operator with a greater number of options to add value to the catch. However, designs and practices need to be developed to prevent the entangling of non-fish species in netting and mooring ropes of the trap.

Pots

A pot is a small transportable cage or basket with one or more entrances designed to allow the entry of fish, crustaceans or cephalopods, and prevent or retard their escape. Pots are usually set on the bottom, with or without bait. While pot fishing vessels in general have low fuel use, some pot fisheries have high fuel use owing to the need to tend fleets of many pots and lifting them more than once a day, necessitating travelling at high speed over long distances.

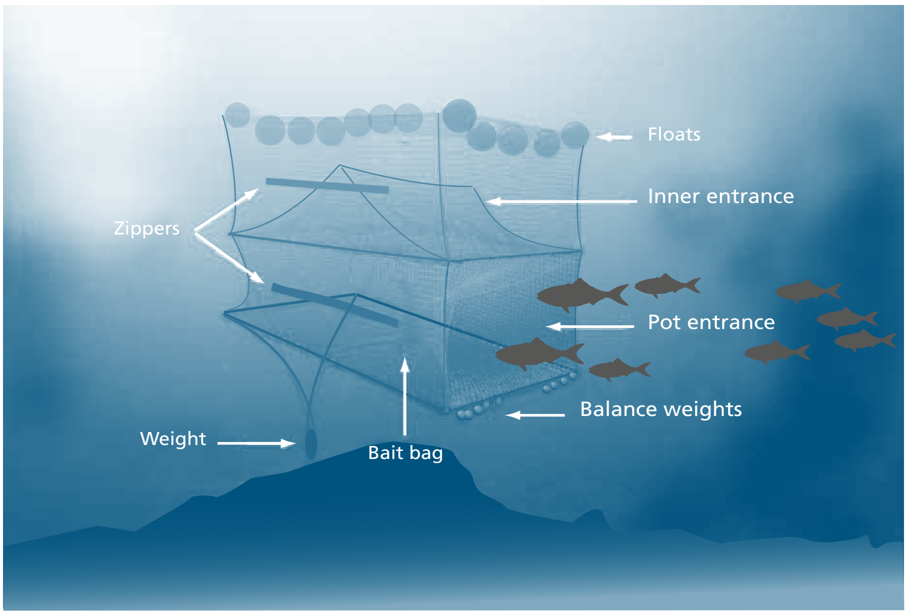
Pots are extensively used in the capture of crustaceans such as lobster and crab. Although the use of pots for capturing finfish has a long tradition in many parts of the world, it has progressively declined. Nevertheless, pots are still an efficient and economically viable fishing method for finfish. They are also successfully used in fisheries targeting coral-reef species inhabiting areas where the use of active gear is banned or not practical.

Recent tests with collapsible pots have shown promising results for Atlantic cod in Canada and for pink cusk-eel (*Genypterus blacodes*) in Argentina. A floating pot developed in Scandinavia provides another example of an innovative pot design that has shown significant potential (Figure 40).[65] Floating the pot off the bottom allows the pot to turn with the current so the entrance always faces down current, resulting in a higher catch rate of cod. It also avoids non-target catch of crabs and may also reduce the seabed impacts compared with a pot sitting on the bottom. The same type of floating pot has successfully been tested in the Baltic Sea as an alternative to the gillnet fishery for cod, where there are serious problems with depredation by seals.

Compared with many other types of fishing gear, pots, like trap-nets, possess several appealing characteristics such as low energy use, minimal habitat impact, high quality and live delivery. On the negative side, lost or abandoned pots may continue catching target and non-target species (ghost fishing) and contribute to marine debris with associated effects. Design features such as biodegradable materials may reduce ghost fishing, while delayed surface marker buoys and location aids may promote the recovery of lost gear. Understanding fish behaviour in relation to pots is essential in

Figure 40

A floating pot



Source: Adapted from Königson, S. 2011. *Seals and fisheries: a study of the conflict and some possible solutions.* Department of Marine Ecology, University of Gothenburg. (PhD thesis) order to increase efficiency for those species that are currently not captured by pots in commercially viable quantities.[66]

Hook and line

Hook and line refers to gear to which fish, squid or other species are attracted by natural or artificial bait or lures placed on a hook, on which they are caught. Wide variations in hook and line configuration and their mode of operation have made them an effective gear type for a wide variety of species. It is a versatile fishing method, employed by a wide range of vessels from artisanal boats to large mechanized longliners. Hook and line fishing is generally considered an environmentally friendly but labour-intensive fishing method that catches fish of high quality. Fuel consumption in these fisheries is comparatively low although it can increase significantly depending on the distances vessels have to travel to and from the fishing ground (e.g. coastal hook and line fisheries versus high seas tuna longlining). Longline fishing may cause the incidental mortality of seabirds, sea turtles and sharks, many of which are either protected or endangered. The lines can be set with a streamer[67] in order to deter seabirds from seizing the baited hooks – this system is reported to have led not only to a reduced mortality level of sea birds but also to higher catch rates of the target species. There are several other mitigation measures capable of reducing the likelihood of incidental bycatch of seabirds[68] and sea turtles,[69] such as the new "circle hook" and "weak hook". While bottom-set longlines may snag and damage benthic epifauna and irregular objects on the bottom, longline fisheries do offer the potential to conduct fishing without severe habitat damage and to do so in a relatively energy-conscious manner.

Gillnetting

Bottom-set gillnets, entangling nets and trammelnets are widely used, and improved materials and techniques have allowed the expansion of such gear to rougher grounds (including wrecks and reefs) and deeper waters. Gillnetting is a very versatile and flexible fishing method but can also be labour-intensive. Except with trammelnets, the size selectivity for finfish is generally good, but species selectivity can be poor. In addition, fish are often injured and die during capture; accordingly, catch quality is typically not as good as with pots, traps and longlines, although gillnets may also give catch of good quality when the time the net is left in the water to fish is short.

Gillnet fishing operations in general can damage benthic epifauna during retrieval of the gear, at which time the nets and leadlines are more likely to snag bottom structures. Although the capture of seabirds, sea turtles and marine mammals by gillnets has received increased attention in recent years, more development work is required to develop mitigation measures further.

The impacts of ghost fishing by abandoned, lost or otherwise discarded gillnets are of concern as such nets may continue to fish for long periods depending on their construction, the depth, and prevailing environmental conditions. This problem can be addressed by increasing efforts to avoid losing gillnets and by facilitating the quick recovery of lost nets. Abandoned gillnets have been identified as a particular problem in deeper waters and where long lengths of gear are deployed.[70]

Barriers to change

There are many barriers to the transition to low-impact and less fuel-intensive practices and gear.[71] In summary, the most important seem to be:

- lack of familiarity with cost-effective and practical alternatives;
- limited availability of suitable technologies, especially in developing countries;
- incompatibility of vessels with alternative gear;
- risk of losing marketable catch;
- additional work at sea;
- concerns with safety at sea related to using unfamiliar gear or strategies;
- high investment costs;

- lack of capital or restricted access to capital;
- ineffective technology infrastructure support;
- inflexible fisheries management systems that include too rigid regulatory regimes.

With regard to inflexible management systems, regulatory regimes that are too rigid can create a new set of problems to be solved and deny fishers the flexibility required to innovate and adopt new technologies. In this regard, stakeholders should be an integral part of the management process, particularly as and when amendments to legislation are under consideration. Changes from high-energy high-impact fishing methods or practices to ones with lower energy consumption and lower ecosystem impacts offer opportunities for conserving fuel, preserving ecosystems and improving food security. However, the transition from one gear type to another is seldom easy or practical. First, the size and design of existing fishing vessels and their machinery and equipment often limit the possibilities of changing the fishing method. Second, fishing gear, fishing vessels, operations and practices have evolved around specific fishing grounds and the behaviour of target fish species over a considerable period. Accordingly, the evolved fishing gear and practices are "tailor-made" to catch specific target species or species groups in a manner that is often perceived to be optimized to the best technical and economic scenarios that will be encountered during fishing. Moreover, where fishing practices are rooted in tradition there is a strong resistance to change.

Nevertheless, fuel consumption and ecosystem impacts can often be reduced through simple modifications in operational techniques and gear design without drastic changes in the gear and operational practices. This approach has shown promising results in many cases and is often preferred by the fishing industry over transitioning to a completely new gear type and fishing practice, which is an alternative that has many more uncertainties and higher economic risks.

RECENT ACTIONS

Environment

International conventions include timetables for compliance regarding emissions of nitrogen oxides from diesel engines of over 130 kW and new fishing vessels are required to comply. Morevoer, as a consequence of research and development (R&D) on energy-saving technologies carried out by designers of machinery and fishing vessels and gear, there are signs that the fishing industry has begun to improve its fuel efficiency. Nevertheless, fuel continues to be the major cost of operation in capture fisheries and further refinements to fuel quality, such as lowering the content of sulphur oxides and particulate matter, could well lead to even higher fuel and lubricating-oil costs. This may have an even greater impact on the fishing industry in developing countries where mechanization continues to increase, although it will also strengthen the drive for fuel efficiency.

Bycatch and discards

The seriousness of the impacts related to bycatch and discards has been recognized by the international community and in particular through the endorsement of the International Guidelines on Bycatch Management and Reduction of Discards at the Twenty-ninth Session of the FAO Committee on Fisheries in 2011. There is a range of tools to manage bycatch and reduce discards, including technological measures to improve the selectivity of fishing gear. The declines in the bycatches and discards in many fisheries have mainly been the result of introducing effective gear modifications and bycatch reduction devices.[72] However, there remains concern about the impacts of unaccounted fishing mortalities such as ghost fishing by abandoned, lost or otherwise discarded fishing gear and the fact that such gear may also cause environmental damage.

Furthermore, at the sixty-second session of the Marine Environment Protection Committee of the International Maritime Organization (IMO) in July 2011, Annex V of the International Convention for the Prevention of Pollution from Ships 1973/78 (MARPOL) was amended to provide a regulation for the loss of fishing gear that may be a substantial threat to the environment or the safety of navigation to be reported to the flag State, and, where the loss occurs in waters under the jurisdiction of another coastal State, to that State. This regulation is supported within guidelines for the application of Annex V currently under revision.

OUTLOOK

With continued exposure to rising fuel prices and little or no significant price increases at the point of first sale for catches, capture fisheries will probably continue to suffer declining profitability. Moreover, if resource abundance remains static, some bottom trawl and dredge fisheries may become uneconomic (although passive gear and seine net fisheries may be less affected). As demersal trawl fishing accounts for a significant part of the total catch destined for direct human use, there could be an adverse affect on global fish supply and food security, at least in the short term.

With medium-term forecasts indicating a high likelihood of further and steady increases in fuel prices, as indicated by the International Energy Agency, the future of the fishing industry is challenging. An increase in sulphur-oxide-emission control areas (the most recent being adopted by the IMO in 2011) would add to the cost of fuel for vessels operating in such zones.

The fishing sector will no doubt strive to lower its fuel consumption, reduce its carbon footprint, and decrease ecosystem impacts. Although the continuation or expansion of fuel subsidies would reduce immediate costs, this is less acceptable. To help the fisheries sector achieve significant and permanent reductions, governments will most probably strengthen their fisheries sector energy policy and create an enabling environment in which fishing industries can rapidly and comprehensively adopt low-impact fuel-efficient (LIFE) fishing technologies and practices. The development and adoption of such fishing techniques offer scope for maintaining the long-term profitability and sustainability of capture fisheries worldwide.

With fossil fuels remaining the dominant energy source, pursuing energy efficiency in capture fisheries may generate benefits by reducing operating costs, controlling GHG emissions and minimizing environmental impacts within the aquatic environment. However, the success of this transition will depend heavily on the response of governments to the implementation of international conventions together with a positive reaction from the engine manufacturing sector, fuel-oil and lubricating-oil producers and the fishing industry (including the manufacturers of fishing gear). This could lead to the development and application of suitable and acceptable measures to conventional fisheries and create an appropriate catalyst for change in the behaviour of fishers. Of equal importance are initiatives such as pursuing the modification of existing gear types and the development of low-resistance towed fishing gear with minimal impact within the aquatic environment. In some cases, it may be necessary to switch to completely new gear types or practices in order to enable LIFE fishing.

However, to be effective, this would require global R&D priorities to be established and work undertaken in support of the development and uptake of LIFE fishing.[73] These include:

- promoting and funding studies of cost-effective gear designs and fishing operations, including the establishment of technology incubators and other public–private sector initiatives to commercialize economically viable, practical and safe alternatives to conventional fishing methods;
- analysis and review of best practice operations across fisheries;
- improvement of technical ability among fishers;
- establishment of appropriate incentives;
- industry compliance with international conventions;
- execution of robust but flexible fishery policies that support the transition to alternative technologies.

Finally, close cooperation between the fishing industry, scientists, fisheries managers and other stakeholders will be fundamental to the development, introduction and acceptance of LIFE fishing technologies.

Putting into practice the ecosystem approach to fisheries and aquaculture

THE ISSUE

The ecosystem approach to fisheries (EAF) represents a move away from management systems that focus only on the sustainable harvest of target species to a system that also considers the major components in an ecosystem, and the social and economic benefits that can be derived from their utilization.

An ecosystem approach to aquaculture (EAA) follows similar considerations and it has been defined as: "a strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems."[74]

While the term "ecosystem approach" often evokes the idea that the approach is mainly a natural-science undertaking, the approach adopted by FAO[75] explicitly states the importance of taking into account all the essential components of sustainability (ecological, social and economic), i.e. taking a genuinely systemic approach by considering fisheries and aquaculture as systems whose sustainability depends on all their parts.

In addition to sector-based approaches, the need for developing adequate institutional frameworks to address multisectoral management is also recognized (e.g. ecosystem-based management), and EAF/EAA will then be nested within these broader frameworks.

Despite general acceptance of the principles of EAF and EAA, a widespread perception has existed of their being too complex and impossible to implement in practice because they require human and financial resources that are usually not available, particularly in developing countries.

POSSIBLE SOLUTIONS

Despite the perceived complexity of implementing an ecosystem approach, there is good evidence that progress is being made at various levels, from formally adoption of the framework by regional and national institutions, to actually starting with implementation.

There are examples of concrete steps being taken towards an ecosystem approach, both in sectoral fisheries management (e.g. EAF and EAA) and at the multisectoral level (such as ecosystem-based management), the latter being necessary where more than one sector affects a given area or region. Management approaches that integrate across sectors become particularly relevant in inland waters (Box 13), where major impacts on fishery resources and ecosystems are often not caused by fishing activities but by water use and habitat modification. Moreover, as the once-separate sectors of "fisheries" and "aquaculture" increasingly overlap and integrate an ecosystem approach may well facilitate sustainable resource management (Box 14).

Practical implementation of EAF/EAA entails examining existing or developing fisheries or aquaculture activities so as to identify key priority issues to be dealt with by management in order to achieve sustainable outcomes within a risk-based management framework. An example of a framework for planning and implementation is presented in Figure 41. The framework facilitates the developing of the EAF/EAA management/development plans, which are the backbone of any ecosystem approach strategy.

The key features of the strategy proposed for implementing an ecosystem approach to fisheries and to aquaculture can be summarized as:

Box 13

The need for an ecosystem approach in inland waters

Inland waters are characterized by strong competition for freshwater resources from sectors outside the fisheries and aquaculture sector. Demands on freshwater are expected to double by 2050 as the world population reaches 9 billion people. Of the available 3 800 km^3 of freshwater in the world, agriculture currently uses 70 percent, industry extracts another 20 percent, and 10 percent is for domestic use.[1] These sectors are extremely important in national economies, but they rarely consider fishery resources, although freshwater fisheries are a non-consumptive user of water. Implementing an ecosystem approach to managing freshwater resources for fisheries and aquaculture will necessitate involving these competing sectors and appreciating the value of multiple uses of freshwater resources.

In 2008, capture fishery production from inland waters was 10.2 million tonnes and was worth about US$5.5 billion, while the corresponding figures for inland aquaculture were 33.8 million tonnes and US$61.1 billion, respectively. However, these figures are much lower than the value derived from other uses of freshwater. On a global scale, the value of industrial and agricultural products produced with freshwater as a necessary factor of production is several magnitudes larger. However, at the regional or local level, there may be little industrial use for freshwater, and fish can be an essential contributor of animal protein and micronutrients in local diets. In such locations, using an ecosystem approach to the development and management of natural resource should ensure a place also for freshwater fisheries.

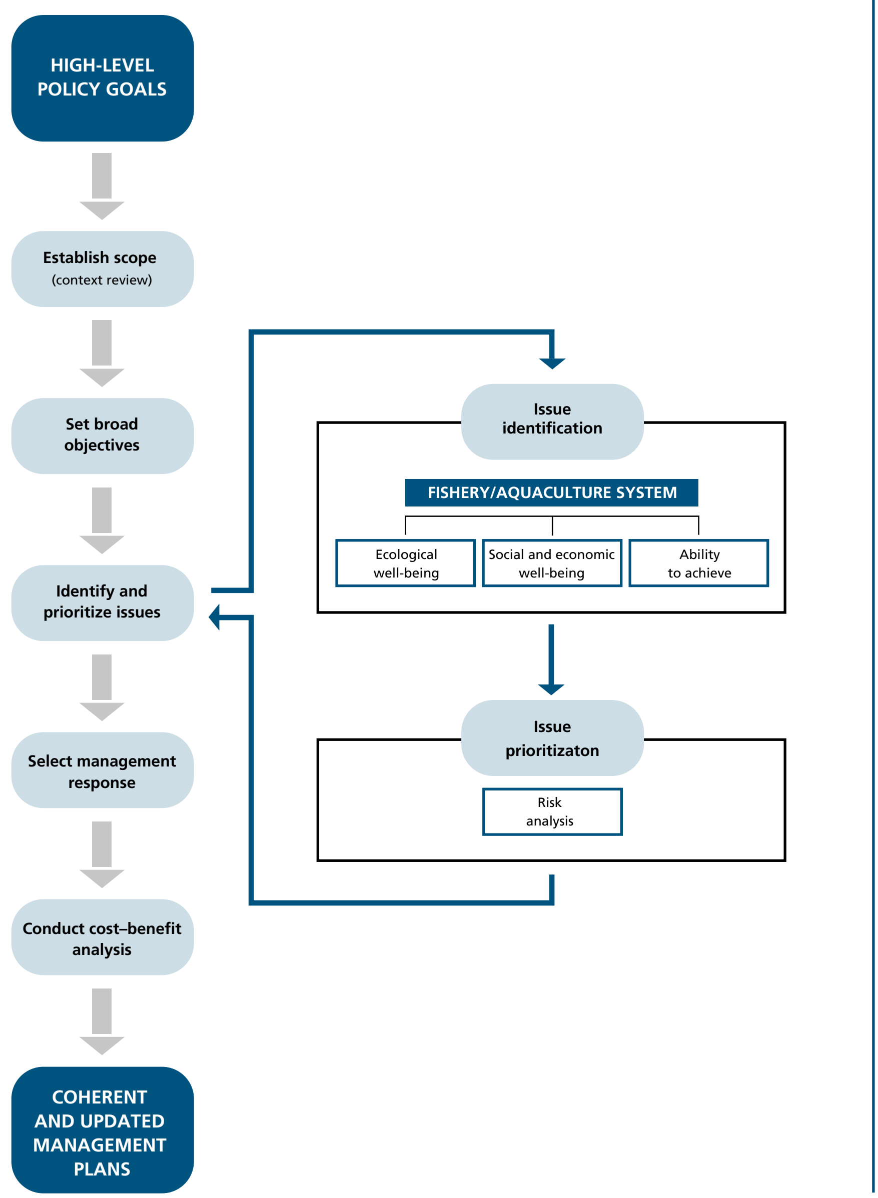
The continued use of freshwater as a locale for fish production, as industries and agriculture grow, can be promoted through technological change. There are encouraging signs of this, such as the development of improved fish passes that allow riverine fish to migrate past hydroelectric facilities and improvements in irrigation systems that increase their efficiency.[2] However, many countries still lack the institutional capacity to deal effectively with multisectoral issues.

[1] Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for food, water for life: a comprehensive assessment of water management in agriculture*. Summary. London, Earthscan, and Colombo, International Water Management Institute. 40 pp.
[2] FAO. 2003. *Unlocking the water potential of agriculture*. Rome. 70 pp. (also available at www.fao.org/DOCREP/006/Y4525E/Y4525E00.HTM).

- adopting participatory approaches at all levels of the planning and implementation steps;
- ensuring that all the key components of the fishery/aquaculture system are considered, including those related to the ecological, social, economic and governance dimensions, while also taking into account external drivers (e.g. changes in the supply of and demand for inputs and outputs; climate change; and environmental disturbances);
- encouraging the use of the "best available knowledge" in decision-making, including both scientific and traditional knowledge, while promoting risk assessment and management and the notion that decision-making should take place also in cases where detailed scientific knowledge is lacking;

Figure 41

The EAF/EAA planning framework



Source: Modified from: FAO. 2003. *Fisheries management 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome. 112 pp.; and FAO. 2005. *Putting into practice the ecosystem approach to fisheries.* Rome. 76 pp.

- promoting the adoption of adaptive management systems, including monitoring performance and creating feedback mechanisms linked to performance, at different time scales, to permit the adjusting of the tactical and strategic aspects of the management/development plans;
- building on existing institutions and practices.

The methodology proposed has aspects that are common to any other sector utilizing renewable natural resources. The methodology is recommended by the ISO 14000 that deals specifically with the management of renewable resources.[76]

The methodology builds on the accumulated experience of the management of fisheries and aquaculture but also embraces recent insights about what makes socio-ecological systems sustainable. These insights lead to an approach that:

Box 14

Interactions between fisheries and aquaculture

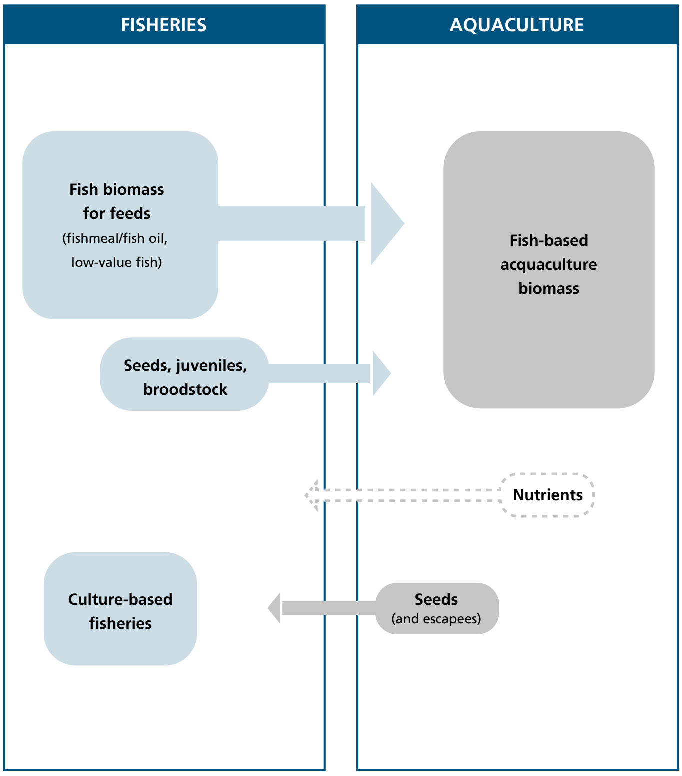
Increasingly – by design or by accident – fisheries and aquaculture occur in the same ecosystem. Aquaculture-based fisheries (stock enhancement programmes) and capture-based aquaculture are becoming more common and resulting in a growing interdependence of fisheries and aquaculture. Fish that escape from fish farms may affect not only local fisheries but have a wider interaction in the marine environment. Fisheries and aquaculture interact with increasing intensity as fishers shift from fishing to aquaculture and by competing in the same markets with similar products. The need to integrate planning and management of the two sectors seems vital to their future development and sustainability.

The implementation of the ecosystem approach to aquaculture and the ecosystem approach to fisheries should help to overcome the sectoral and intergovernmental fragmentation of resource management efforts and to develop institutional mechanisms and private-sector arrangements for effective coordination among the various sectors and subsectors active in ecosystems in which aquaculture and fisheries operate and between the various levels of government. Ecosystem-based management involves a transition from traditional sectoral planning and decision-making to the application of a more holistic approach to integrated natural resource management in an adaptive manner.

In the long run, all significant commercial seafood supplies and non-food fish will come from one of three sources: (i) fish farms/aquaculture; (ii) aquaculture-enhanced fisheries; and (iii) fisheries that adopt efficient management systems. The first two pose a challenge to aquaculture and require an emphasizing of the synergies and complementarities between fisheries and aquaculture including institutional, social, economic, environmental and biotechnological aspects. Acknowledgement of these interactions offers opportunities for sectoral development, for increasing food security, reducing poverty and improving rural livelihoods. The two subsectors need to form partnerships as both are strongly linked (see accompanying figure), both depend on healthy aquatic environments, and both are affected by other development activities. For example, in the coming decades, culture-based fisheries will probably play a much greater role in sustaining and increasing capture fisheries yields for an ultimate public good including conservation objectives. Therefore, it is important to analyse the present status of culture-based fisheries culture-based fisheries and stock enhancement, to assess comprehensively the impacts of the activities, and to identify constraints and ways to improve the ecological, economic and socio-economic benefits by implementing an ecosystem approach to overall fish production. It is also necessary to improve understanding on the potential and actual environmental impacts of stocking and escapees worldwide.

- is context-specific – it describes a process whose result depends on cultural context and needs;
- emphasizes stakeholder participation – the approach advocates participation of stakeholders in the planning and implementation processes, and encourages various forms of comanagement that will in turn be shaped by context and type of fisheries;
- is systemic – by taking a “systemic” approach, it tries to ensure that all “system” components move towards the same and agreed direction;

Biophysical linkages between capture fisheries and aquaculture



Source: Soto, D., White, P., Dempster, T., De Silva, S., Flores, A., Karakassis, Y., Knapp, G., Martinez, J., Miao, W., Sadovy, Y., Thorstad, E. and Wiefels, R. 2012. Addressing aquaculture-fisheries interactions through the implementation of the ecosystem approach to aquaculture (EAA). *In* R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan and P. Sorgeloos, eds. *Farming the Waters for People and Food. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand, 22–25 September 2010*, pp. 385–436. Rome, FAO, and, Bangkok, NACA. 896 pp.

- is risk-based – being risk-based, it allows a more proactive approach to addressing information-poor situations, considered one of the main obstacles to the ecosystem approach in fisheries and aquaculture.

In summary, success in implementing the ecosystem approach to fisheries and aquaculture requires that management and development of the sectors are well-functioning components in a public-sector, multisectoral coordination effort supported by adequate governance. Consistent with the commitments reflected in the United Nations Convention on Biological Diversity (CBD), each economic sector (including, mining, tourism, coastal development, fisheries and aquaculture) relying on the use of natural resources within a given region/ecosystem should adopt an ecosystem approach.

RECENT ACTIONS

The ecosystem approach was first defined by the CBD in 1993 as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.

Since 1993, countries have taken several steps to promote the use of the ecosystem approach, including specifically in fisheries. The Code of Conduct for Responsible Fisheries (the Code) was adopted in 1995 by FAO Members. The Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (adopted in 2001) encouraged countries and fishing entities to achieve sustainable fisheries in the marine ecosystem. Guidelines for an EAF were produced by FAO in 2003. Aquaculture has also developed a framework for the adoption of the ecosystem approach.[77] At present, FAO is developing voluntary guidelines on securing small-scale fisheries. These guidelines will recognize the ecosystem approach as an important guiding principle.

Approaches are being developed to coordinate multiple uses of natural resources, such as marine spatial planning[78] and integrated watershed management. These are methodologies that complement the sectoral-based approaches to management that remain the basic pillars of sustainable development and its governance.

In some ways, the ecosystem approach has been practised in traditional management regimes for a long time. An example is the tenure system in marine fisheries as practised in Pacific island States.

More recently, many countries have made important strides towards the application of several of the principles contained in the EAF/EAA. Some are partly implementing the approach without necessarily recognizing this.[79] In some cases, progress has also been made in the development of multisectoral management.

In Australia, following the outcomes of the 1992 United Nations Convention on Environment and Development, a national strategy for ecologically sustainable development was endorsed in the same year.[80] Since then, significant progress has been made in implementing an ecosystem approach within the management of most individual fisheries and, and there has also been more recent progress in adopting more coordinated regional level management for this sector.[81]

In the European Union, substantial efforts are being made to integrate the objectives of its Marine Strategy Framework Directive within the new European Union Common Fisheries Policy, as part of an ecosystem-based management approach. As a result of the project Making the European Fisheries Ecosystem Plan Operational (funded by the European Union), fisheries ecosystem plans have been developed for three major European marine regions (North Sea, North Western Waters and South Western Waters).[82] Efforts are also being made at the national level. For example, in Norway, an integrated management plan for the Barents Sea–Lofoten area has been developed to resolve conflicts between petroleum activities, fisheries activities and to address conservation concerns.[83] Implementation of the plan is ensured through multisectoral coordinating groups headed by a steering group that is in turn coordinated by the Ministry of Environment. Representatives from the Norwegian Petroleum Directorate and the Directorate of Fisheries have worked together to revise laws and regulations covering seismic activities in order to reduce conflicts. A central concept of the plan is that it is based on science and takes a precautionary approach. A similar plan has also been developed for the Norwegian Sea, and the idea is to cover all the Norwegian Exclusive Economic Zone (EEZ).[84]

Ongoing efforts in the adoption of ecosystem-based approaches at both the sectoral and multisectoral level are being pursued in various large marine ecosystems including in the Caribbean,[85] the Canary Current,[86] the Benguela Current[87] and the Bay of Bengal.[88] However, in most of these large marine ecosystems, efforts are concentrated on planning for an ecosystem-based approach – its full-scale implementation remains to be realized.

In addition, FAO has specifically addressed EAF by developing guidance[89] for its implementation and by providing extrabudgetary funding for regional and/or national case studies, dedicated workshops and training courses.

Collaborations with universities in Africa, i.e. University of Ghana (Ghana), Rhodes University (South Africa) and Ibn Zohr University (Morocco), have allowed a large number of fisheries professionals to be trained in the ecosystem approach, and it is hoped that the approach will be absorbed by universities in developing countries as part of existing curricula in fisheries science and management. These efforts have resulted in increased understanding of the approach and its "demystification".

OUTLOOK

A dramatic shift in attitudes as regards the relevance and applicability of the ecosystem approach has taken place, including an increasing appreciation of how this approach can help in addressing the challenges linked to sustaining socio-ecological systems such as fisheries, both within the sector and across sectors affecting a given ecosystem. Pragmatic ways are being adopted to improve conventional fisheries and aquaculture management by incorporating ecosystem considerations and by dealing with the social dimension more properly.

However, important challenges still exist beyond the technical aspects of practical day-to-day implementation. The challenges are not only those related to controlling the direct drivers of marine ecosystem change such as fisheries and aquaculture. Probably the greatest challenges come from indirect drivers such as changes in human population coupled with a widespread aspiration for improved standards of living. At the national level, economic policies and social and economic conditions are often in conflict with sustainability objectives. Climate change will most probably emerge as a major driver of change in aquatic ecosystems and will in turn affect coastal communities. In this situation, modifying governance towards more holistic approaches (such as the ecosystem approach), both horizontally (across sectors and institutions) and vertically (from local to global), may take on increased urgency.

NOTES

1 Arenas, M.C. and Lentisco, A. 2011. *Mainstreaming gender into project cycle management in the fisheries sector.* Bangkok, FAO. 92 pp. (also available at www.rflp.org/mainstreaming_gender/Mainstreaming_gender_handbook.pdf).

2 United Nations. 1997. *The Report of the Economic and Social Council for 1997* [online]. A/52/3. [Cited 20 March 2012]. www.un.org/documents/ga/docs/52/plenary/a52-3.htm

3 Bennett, E., Valette, H.R., Mäiga, K.Y. and Medard, M., eds. 2004. *Room to manoeuvre: gender and coping strategies in the fisheries sector*. Portsmouth, UK, IDDRA. 154 pp.

4 The FAO Fisheries and Aquaculture Department regularly collects employment statistics in fisheries and aquaculture related to the primary sector only. Therefore, the data exclude post-harvest activities.

5 Williams, M.J., Agbayani, R., Bhujel, R., Bondad-Reantaso, M.G., Brugère, C., Choo, P.S., Dhont, J., Galmiche-Tejeda, A., Ghulam, K., Kusakabe, K., Little, D., Nandeesha, M.C., Sorgeloos, P., Weeratunge, N., Williams, S. and Xu, P. 2012. Sustaining aquaculture by developing human capacity and enhancing opportunities for women. *In* R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mohan and P. Sorgeloos, eds. *Farming the Waters for People and Food. Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand, 22–25 September 2010*, pp. 785–822. Rome, FAO, and, Bangkok, NACA. 896 pp.

6 Weeratunge, N. and Snyder, K. 2009. Gleaner, fisher, trader, processor: understanding gendered employment in the fisheries and aquaculture sector. Paper presented at the FAO–IFAD–ILO Workshop on gaps, trends and current research in gender dimensions of agricultural and rural employment: differentiated pathways out of poverty, Rome, 31 March – 2 April 2009. 32 pp.

7 Two examples directly related to the fisheries and aquaculture sectors are: Ministry of Agriculture, Forestry and Fisheries, Fisheries Administration. 2010. *Training manual on gender awareness and gender mainstreaming in fisheries sector.* Phnom Penh. 44 pp. (also available at www.rflp.org/sites/default/files/Training%20manual%20on%20gender%20awareness%20for%20Fisherieis.pdf), and Op. cit., see note 1.

More generally, toolkits such as the FAO Agri-Gender Statistics Toolkit (www.fao.org/gender/agrigender/en/) and Web sites such as FAO's Sharing our resources – participation (www.fao.org/Participation/) are also becoming available.

8 The work of Chen with low-income women in Bangladesh and India enabled the identification of four pathways by which women experience change; and having access to and control of aquatic resources can also facilitate changes in the above pathways. The pathways include: (i) material change in access to and control over material resources, in level of income and in satisfaction of basic needs; (ii) cognitive change, change in level of knowledge, skills and awareness of wider environment; (iii) perceptual change, change in individual perceptions of own individuality, interested and value; and (iv) relational change, change in contractual agreements, in bargaining power and in ability to resist exploitation. *Source:* Chen, M.A. 1997. *A guide for assessing the impact of microenterprise services at the individual level*. AIMS Project Report, USAID/G/EG/MD. Washington, DC, Management Systems International.

9 Op. cit., see note 1, p. 12.

10 Naved, R.T. 2000. *Intrahousehold impact of the transfer of modern agricultural technology: a gender perspective* [online]. FCND Discussion Paper No. 85. IFPRI. [Cited 19 March 2012]. http://impact.cgiar.org/pdf/278.pdf

11 Pandolfelli, L., Meinzen-Dick, R. and Dohrn, S. 2008. Gender and collective action: motivations, effectiveness and impact. *Journal of International Development*, 20: 1–11.

12 Coles, C. and Mitchell, J. 2010. *Gender and agricultural value chains – a review of current knowledge and practice and their policy implications* [online]. ESA Working Paper No. 11-05. FAO. [Cited 19 March 2012]. www.fao.org/docrep/013/am310e/am310e00.pdf

13 Initiated by the Asian Fisheries Society and its partners, these have included the 1998 International Symposium on Women in Asian Fisheries held in Chiang Mai, Thailand; the 2001 Global Symposium on Women in Fisheries held in Kaohsiung, Taiwan Province of China; the 2004 First Global Symposium on Gender and Fisheries (GAF) held in Penang, Malaysia; GAF2 2007 held in Kochi, India; and GAF3 2011 held in Shanghai, China.

14 FAO. (forthcoming). *Report of FAO Workshop on Future Directions for Gender in Aquaculture and Fisheries Action, Research and Development, Shanghai, China, 23–24 April 2011.* FAO Fisheries and Aquaculture Report No. 998. Rome, FAO.

15 FAO. 2011. *The State of Food and Agriculture 2010-11. Women in agriculture: closing the gender gap for development.* Rome. 160 pp. (also available at www.fao.org/docrep/013/i2050e/i2050e.pdf).

16 World Bank. 2011. *World Development Report 2012: Gender Equality and Development.* Washington, DC. 47 pp. (also available at http://siteresources.worldbank.org/INTWDR2012/Resources/7778105-1299699968583/7786210-1315936222006/Complete-Report.pdf).

17 Op. cit., see note 5.

18 FAO. 2008. *Options for decision makers* [online]. Expert Meeting on Climate Change and Disaster Risk Management, FAO Headquarters, Rome, 28-29 February 2008. [Cited 19 March 2012]. www.fao.org/fileadmin/user_upload/foodclimate/presentations/disaster/OptionsEM4.pdf

19 Intergovernmental Panel on Climate Change. 2011. *IPCC special report on managing the risks of extreme events and disasters to advance climate change adaptation: fact sheet* [online]. [Cited 19 March 2012]. www.ipcc.ch/news_and_events/docs/srex/SREX_fact_sheet.pdf

20 Guha-Sapir, D., Vos, F., Below, R. with Ponserre, S. 2011. *Annual Disaster Statistical Review 2010: the numbers and trends.* Brussels, Centre for Research on the Epidemiology of Disasters (CRED). 42 pp.

21 Organisation for Economic Co-operation and Development. 2002. *Poverty and climate change: reducing the vulnerability of the poor through adaptation.* Paris. 14 pp.

22 Op. cit., see note 19.

23 Inter-Agency Standing Committee. 2006. *Gender handbook in humanitarian action: women, girls, boys and men different needs – equal opportunities* [online]. [Cited 19 March 2012]. www.humanitarianinfo.org/iasc/documents/subsidi/tf_gender/IASC%20Gender%20Handbook%20(Feb%202007).pdf

24 IMM, CFDO and CBNRM LI. 2005. *Understanding the factors that support or inhibit livelihood diversification in coastal Cambodia.* An output from DFID-funded research in Cambodia. Exeter, UK, IMM Ltd.

25 Cochrane, K., De Young, C., Soto, D. and Bahri, T., eds. 2009. *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge.* FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp.

26 The United Nations International Strategy for Disaster Reduction defines mitigation as: the lessening or limitation of the adverse impacts of hazards and related disasters.

27 Sperling, F. and Szekely, F. 2005. *Disaster risk management in a changing climate* [online]. Discussion Paper prepared for the World Conference on Disaster Reduction on behalf of the Vulnerability and Adaptation Resource Group (VARG). Reprint with Addendum on Conference outcomes. Washington, DC. [Cited 19 March 2012]. www.preventionweb.net/files/7788_DRMinachangingclimate1.pdf

28 FAO. 2008. *Climate change and disaster risk management* [online]. Technical background document from the expert consultation held on 28 to 29 February 2008. Climate change, energy and food: high-level conference on food security: the challenges of climate change and bioenergy. Rome. [Cited 19 March 2012]. ftp://ftp.fao.org/docrep/fao/meeting/013/ai786e.pdf
29 Op. cit., see note 27.
30 Op. cit., see note 25.
31 Op. cit., see note 19.
32 European Union. 2006. *Linking climate change adaptation and disaster risk management for sustainable poverty reduction* [online]. Synthesis Report, Framework Contract AMS/451 Lot No 6 November 2006. Brussels. [Cited 19 March 2012]. http://ec.europa.eu/development/icenter/repository/env_cc_varg_adaptation_en.pdf
33 Op. cit., see note 27.
34 FAO. 2010. Reduced vulnerability of fishing and fish farming communities to natural disasters. *In* FAO. *Report of the Inception Workshop of the FAO Extrabudgetary Programme on Fisheries and Aquaculture for Poverty Alleviation and Food Security, Rome, 27–30 October 2009*, pp. 57–65. FAO Fisheries and Aquaculture Report No. 930. Rome. 68 pp.
35 FAO. 2010. *Securing sustainable small-scale fisheries: bringing together responsible fisheries and social development, Windsor Suites Hotel, Bangkok, Thailand, 6–8 October 2010*. RAP Publication 2010/19. Bangkok, FAO Regional Office for Asia and the Pacific. 56 pp.
FAO. 2011. *Report of the Africa Regional Consultative Meeting on Securing Sustainable Small-scale Fisheries: Bringing together Responsible Fisheries and Social Development, Maputo, Mozambique, 12–14 October 2010. Rapport de l'atelier consultatif régional africain sur les pêches artisanales pour une pêche artisanale durable: associer la pêche responsable au développement social, Maputo, Mozambique, 12-14 octobre 2010*. FAO Fisheries and Aquaculture Report/FAO, Rapport sur les pêches et l'aquaculture No. 963. Rome. 68 pp.
FAO. 2011. *Informe de la reunión consultiva regional de América Latina y el Caribe sobre Proteger la pesca sostenible en pequeña escala: unificación de la pesca responsable y el desarrollo social, San José, Costa Rica, 20-22 de octubre de 2010. Report of the Latin America and Caribbean Regional Consultative Meeting on Securing Sustainable Small-scale Fisheries: Bringing Together Responsible Fisheries and Social Development. San José, Costa Rica, 20–22 October 2010*. FAO Fisheries and Aquaculture Report/FAO Informe de pesca y acuicultura No. 964. Rome. 77 pp.
36 FAO European Inland Fisheries Advisory Commission. 2008. *EIFAC Code of Practice for Recreational Fisheries.* EIFAC Occasional Paper No. 42. Rome, FAO. 45 pp.
37 Cooke, S.J. and Cowx, I.G. 2004. The role of recreational fishing in global fish crises. *BioScience*, 54(9): 857–859.
38 Arlinghaus, R. and Cooke, S.J. 2009. Recreational fishing: socio-economic importance, conservation and management. *In* W.M. Adams, B. Dickson and J.M. Hutton, eds. *Recreational hunting, conservation and rural livelihoods: science and practice*, pp. 39–58. Oxford, UK, Blackwell Publishing.
39 Cisneros-Montemayor, A.M. and Sumaila, U.R. 2010. A global estimate of benefits from ecosystem-based marine recreation: potential impacts and implications for management. *Journal of Bioeconomics*, 12(3): 245–268.
40 European Anglers Alliance. 2003. Number of anglers in Europe. In: *EAA* [online]. [Cited 29 November 2011]. www.eaa-europe.org/index.php?id=14
41 Council of Europe. 2011. *European Charter on Recreational Fishing and Biodiversity* [online]. Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee, 30th meeting, Strasbourg, 6–9 December 2010. [Cited 1 December 2011]. https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=1979230&SecMode=1&DocId=1617470&Usage=2

42 Van Anrooy, R., Hickely, P., Sipponen, M. and Mikkola, H., eds. 2010. *Report of the Regional Workshop on Recreational Fisheries in Central Asia, Issyk Kul, Kyrgyzstan, 14–16 September 2009.* FAO Fisheries and Aquaculture Report No. 926. Ankara, FAO. 113 pp.

43 Arismendi, I. and Nahuelhual, L. 2007. Non-native salmon and trout recreational fishing in Lake Llanquihue, southern Chile: economic benefits and management implications. *Reviews in Fisheries Science*, 15(4): 311–325.

44 Op. cit., see note 41.

45 Soto, D., Arismendi, I., Di Prinzio, C. and Jara, F. 2007. Recent establishment of Chinook salmon (*Oncorhynchus tshawytscha*) in Pacific catchments of southern South America and its potential ecosystem implications. *Revista Chilena de Historia Natural*, 80: 81–98.

46 Pollard, D. and Scott, T.D. 1966. River and reef. *In* A.J. Marshall, ed. *The Great Extermination*, pp. 95–115. London, Heinemann.

47 Oakley, S.G. 1984. The effects of spearfishing pressure on grouper (Serranidae) populations in the eastern Red Sea. *In* M.A.H. Saad, ed. *Proceedings of the Symposium on the Coral Reef Environment of the Red Sea*, pp. 341–359. Jeddah, Saudi Arabia, King Abdulaziz University.

48 Eggleston, D.B., Johnson, E.G., Kellison, G.T. and Nadeau, D.A. 2003. Intense removal and non-saturating functional responses by recreational divers on spiny lobster *Panulirus argu. Marine Ecology Series*, 257: 197–207.

49 Arlinghaus, R. 2006. Overcoming human obstacles to conservation of recreational fishery resources, with emphasis on central Europe. *Environmental Conservation*, 33: 46–59.
Soto, D., Arismendi, I., González, J., Guzman, E., Sanzana, J., Jara, F., Jara, C. and Lara, A. 2006. Southern Chile, trout and salmon country: invasion patterns and threats for native species. *Revista Chilena de Historia Natural*, 79: 97–117.

50 Griffiths, S.P., Pollock, K.H., Lyle, P., Julian G., Tonks, M. and Sawynok, W. 2010. Following the chain to elusive anglers. *Fish and Fisheries*, 11: 220–228.

51 Birkeland, C. and Dayton, P. 2005. The importance in fishery management of leaving the big ones. *Trends in Ecology and Evolution*, 20(7): 356–358.

52 Berkeley, S.A., Hixon, M.A., Larson, R.J. and Love, M.S. 2004. Fisheries sustainability via protection of age structure and spatial distribution of fish populations. *Fisheries*, 29(8): 23–32.

53 Op. cit., see note 38.

54 Morales-Nin, B., Moranta, J., García, C., Tugores, M.P., Grau, A.M., Riera, F. and Cerdà, M. 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. *ICES Journal of Marine Science*, 62: 727–739.

55 Arlinghaus, R., Cooke, S.J. and Cowx, I.G. 2010. Providing context for the global code of practice for recreational fisheries. *Fisheries Management and Ecology*, 17: 146–156.

56 Parkkila, K., Arlinghaus, R., Artell, J., Gentner, B., Haider, W., Aas, Ø., Barton, D., Roth, E. and Sipponen, M. 2010. *Methodologies for assessing socio-economic benefits of European inland recreational fisheries.* EIFAC Occasional Paper No. 46. Ankara, FAO. 112 pp.

57 FAO. 2011. *Report of the Expert Consultation to Develop the FAO Technical Guidelines for Responsible Fisheries: Recreational Fisheries, Berlin, Germany, 5–6 August 2011.* FAO Fisheries and Aquaculture Report No. 979, Ankara. 136 pp.

58 FAO will provide further guidance on responsible recreational fisheries management and practices in line with the FAO Code of Conduct for Responsible Fisheries in its *Technical Guidelines for Responsible Fisheries No. 13: Recreational Fisheries* (to be published in 2012).

59 Op. cit., see note 56.

60 Op. cit., see note 55.

61 Gaudin, C. and De Young, C. 2007. *Recreational fisheries in the Mediterranean countries: a review of existing legal frameworks.* Studies and Reviews. General Fisheries Commission for the Mediterranean No. 81. Rome, FAO. 85 pp.
General Fisheries Commission for the Mediterranean. 2011. *Report of the Transversal Workshop on the monitoring of recreational fisheries in the GFCM area, Palma de Mallorca, Spain, 20–22 October 2010* [online]. General Fisheries Commission for the Mediterranean, Scientific Advisory Committee (SAC), Thirteenth Session Marseilles, France, 7–11 February 2011. [Cited 30 November 2011]. http://151.1.154.86/GfcmWebSite/SAC/2010/Recreational_Fisheries/Report.pdf
Op. cit., see note 42.

62 Cooke, S.J. and Cowx, I.G. 2006. Contrasting recreational and commercial fishing: searching for common issues to promote unified conservation of fisheries resources and aquatic environments. *Biological Conservation*, 128: 93–108.

63 Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D. and Rihan, D. 2012. Low impact and fuel efficient fishing—looking beyond the horizon. *Fisheries Research*, 119–120: 135–146.

64 Løkkeborg, S. 2005. *Impacts of trawling and scallop dredging on benthic habitats and communities.* FAO Fisheries Technical Paper No. 472. Rome, FAO. 67 pp.
Valdemarsen, J.W., Jørgensen, T. and Engås, A., 2007. *Options to mitigate bottom habitat impact of dragged gears.* FAO Fisheries Technical Paper No. 506. Rome, FAO. 29 pp.
Valdemarsen, J.W., Øvredal, J.T. and Åsen, A., 2011. *Ny semipelagisk trålkonstruksjon (CRIPS-trålen). Innledende forsøk i august-september 2011 om bord i M/S "Fangst".* Rapport fra Havforskningen nr. 18. Bergen, Norway, Institute of Marine Research. 17 pp.

65 Furevik, D.M., Humborstad, O.-B., Jørgensen, T. and Løkkeborg, S. 2008. Floated fish pot eliminates bycatch of red king crab and maintains target catch of cod. *Fisheries Research*, 92(1): 23–27.

66 Thomsen, B., Humborstad, O.-B. and Furevik, D.M. 2010. Fish pots: fish behavior, capture processes and conservation issues. *In* P. He, ed. *Behavior of marine fishes: capture processes and conservation challenges*, pp. 143–158. Blackwell Publishing.

67 Streamers are plastic flagging tied to lines attached to the fishing vessel near where the vessel places its fishing line in the water and help frighten birds away from the baited hooks.

68 Løkkeborg, S. 2011. Best practices to mitigate seabird bycatch in longline, trawl and gillnet fisheries – efficiency and practical applicability. *Marine Ecology Progress Series*, 435: 285–303.

69 FAO. 2010. *Guidelines to reduce sea turtle mortality in fishing operations.* Rome. 128 pp.

70 Macfadyen, G., Huntington, T. and Cappell, R. 2009. *Abandoned, lost or otherwise discarded fishing gear.* UNEP Regional Seas Reports and Studies No. 185 and FAO Fisheries and Aquaculture Technical Paper No. 523. Rome, FAO and UNEP. 115 pp.

71 Op. cit., see note 63.
Gascoigne, J. and Willsteed, E. 2009. *Moving towards low impact fisheries in Europe: policy hurdles & actions.* Brussels, Seas At Risk. 103 pp.

72 Op. cit., see note 63.

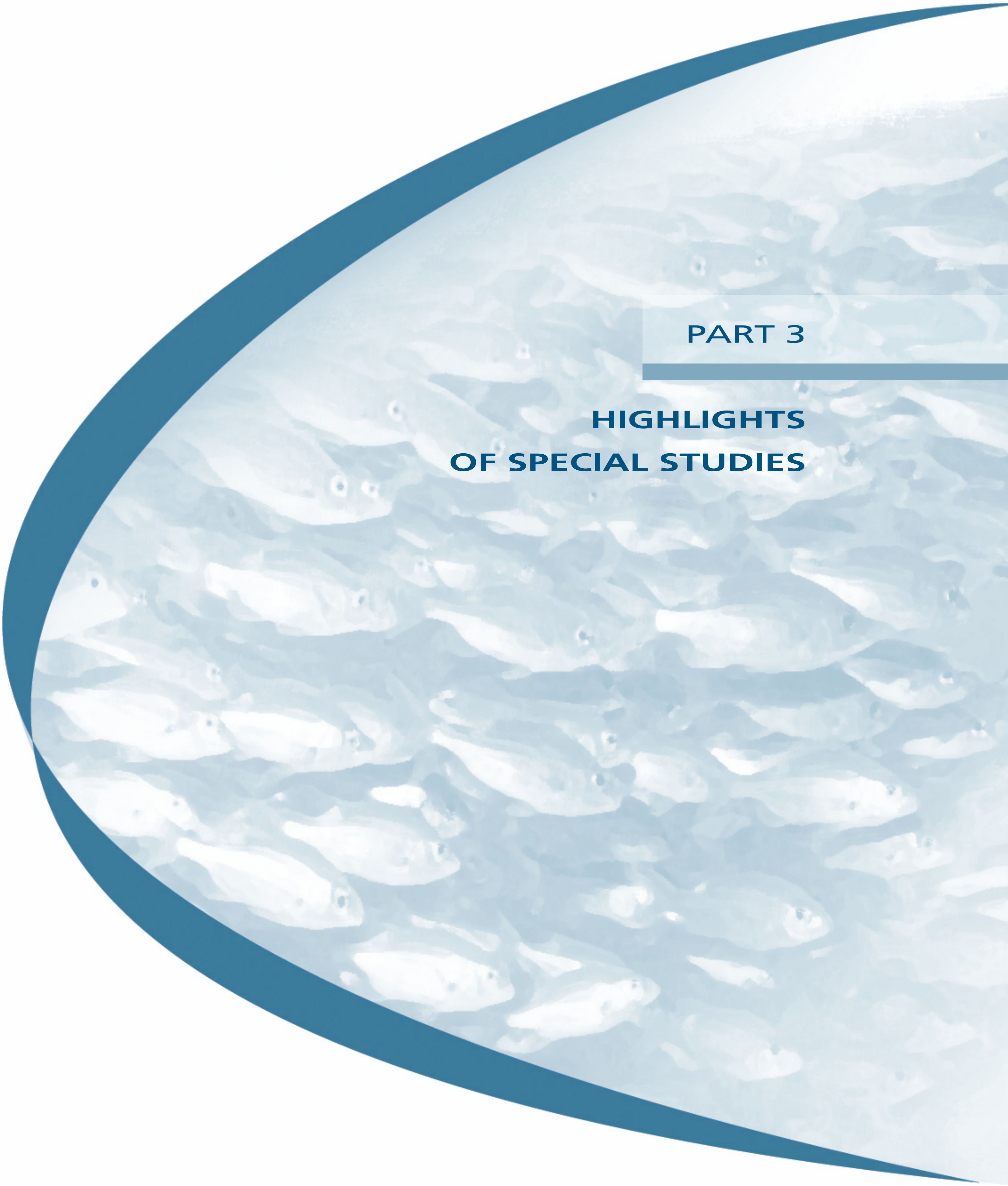
73 Op. cit., see note 63.

74 FAO. 2010. *Aquaculture development. 4. Ecosystem approach to aquaculture.* FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. Rome. 53 pp.

75 FAO. 2003. *Fisheries management 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome. 112 pp.
FAO. 2012. EAF-Net. About the EAF Toolbox. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 26 March 2012]. www.fao.org/fishery/eaf-net/topic/166272/en

76 The Web page for ISO 14000 is www.iso.org/iso/iso_14000_essentials

77 Op. cit., see note 74.
78 Ehler, C. and Douvere, F. 2009. *Marine spatial planning: a step-by-step approach toward ecosystem-based management.* Intergovernmental Oceanographic Commission and Man and the Biosphere Programme. IOC Manual and Guides No. 53, ICAM Dossier No. 6. Paris, UNESCO.
79 There is an urgent need to document the progress that is taking place in both developing and developed countries. Apart from the expected positive and encouraging effect on fisheries managers, documenting progress will also offer an opportunity for active sharing of experiences in good fisheries and aquaculture management.
80 Council of Australian Governments. 1992. *National Strategy for Ecologically Sustainable Development.* Canberra, AGPS.
81 Fletcher, W.J. 2008. Implementing an ecosystem approach to fisheries management: lessons learned from applying a practical EAFM framework in Australia and the Pacific. *In* G. Bianchi and H.R. Skoldal, eds. *The ecosystem approach to fisheries*, pp. 112–124. Rome, FAO and CABI.
Fletcher, W.J., Shaw, J., Metcalf, S.J. and Gaughan, D.J. 2010. An ecosystem based fisheries management framework: the efficient, regional-level planning tool for management agencies. *Marine Policy*, 34: 1226–1238.
82 The Web homepage of this project is hosted on the Web site of the University of Liverpool at www.liv.ac.uk/mefepo/
83 This plan is detailed in a press release from the Office of the Prime Minister, available at www.regjeringen.no/mobil/en/dep/smk/press-center/Press-releases/2011/updated-version-of-the-integrated-manage.html?id=635620
84 A description of the integrated management plans are available on a Web page of Norway's official site for information about seafood safety, fisheries and aquaculture management at www.fisheries.no/resource_management/Area_management/Integrated_management_plans/
85 The Web page for the Caribbean Large Marine Ecosystem Project is hosted at www.cavehill.uwi.edu/cermes/clme.html
86 The Web site for the Canary Current Large Marine Ecosystem is at www.canarycurrent.org/
87 The Web site for the Benguela Current Commission is at www.benguelacc.org/
88 The Web site for the Bay of Bengal Large Marine Ecosystem Project is at www.boblme.org/
89 Op. cit., see note 75.
Carocci, F., Bianchi, G., Eastwood, P. and Meaden, G. *Geographic information systems to support the ecosystem approach to fisheries: status opportunities and challenges.* FAO Fisheries and AquacultureTechnical Paper No. 532. Rome, FAO. 101 pp.
FAO. 2005. *Putting into practice the ecosystem approach to fisheries.* Rome. 76 pp.
FAO. 2008. *Fisheries management. 2. The ecosystem approach to fisheries. 2.1 Best practices in ecosystem modelling for informing an ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2, Add. 1. Rome. 78 pp.



PART 3

HIGHLIGHTS OF SPECIAL STUDIES

HIGHLIGHTS OF SPECIAL STUDIES

Effects of fisheries management policies on fishing safety

Commercial fishing has always been a dangerous occupation. Although it is inherently dangerous, many would argue that the degree of danger is a function of fishers' choices about the risks they take, such as the weather they fish in, the boats they use, the rest they obtain, and the safety gear they carry. Multiple studies suggest that although fisheries management policies are not meant to regulate safety at sea, they do sometimes contribute to safety problems.[1] For example, following interviews with 22 experienced boat owners, captains and crew in the fishing community of New Bedford, the United States of America, about their attitudes on safety at sea and fisheries management, one study reported: "Approximately two-thirds rated fisheries management regulations as an important factor that affected safety at sea. In fact, for over half of the fishermen, fisheries management was believed to be among the most important issues that impact safety at sea. Fishermen reported several problems in which increased dangers at sea were attributed to management regulations designed to protect various fisheries."[2]

Despite a variety of evidence that fisheries management affects safety, there has been relatively little systematic analysis of how management policies affect safety or the extent to which changes in management can affect safety.

In order to understand more fully the relationship between fisheries management policies and fishing safety, FAO and the United States National Institute for Occupational Safety and Health developed a study with the purpose to document globally the relationship between safety at sea and fisheries management policies and to provide practical guidelines for fisheries managers and safety professionals on how they can work together to make commercial fishing safer.[3]

METHODS

FAO contracted researchers to prepare country-specific case studies on fisheries management and safety in 16 countries and regions. Each case study was reviewed to identify evidence supporting, or refuting, one or more of four hypotheses regarding potential effects of fisheries management policies on fishing safety.

Hypothesis 1: Fisheries management policies have wide-ranging indirect effects on fishing safety. Although fisheries management policies are enacted primarily to achieve resource management and social and economic goals, they may affect fishing safety indirectly by affecting fishers' options (how, when and where they may fish), creating incentives for fishers to make risky choices.

Hypothesis 2: Quota-based fishery management systems are safer than competitive fishery management systems. In competitive fishery management systems, fishers compete with one another for the available fish. In quota-based fishery management systems, managers limit how much individual fishers may catch. Under the latter, fishers may have less incentive to take risks such as fishing without adequate rest or fishing in bad weather. Quota-based fishery management may also result in the use of newer, safer vessels and gear, and more professional and better-trained crew.

Hypothesis 3: Fisheries management policies that are unsuccessful in protecting resources or limiting the numbers of fishers competing for limited resources may affect safety. If the resources are not managed well, fishers are faced with trade-offs between safety and the income they can earn from fishing. Fishers may venture farther offshore and take greater risks. Similarly, if total catches are limited, more fishers participating in a fishery will result in less opportunity for each fisher to earn income. If the number of fishers competing for resources is not limited, then fishers' average incomes may decline, causing them to take greater risks.

Hypothesis 4: Fisheries management can contribute to safer fisheries directly by integrating safety policies with fishery management policies. Fisheries management agencies may require safety equipment, safety training, and/or inspections as a condition for participating in a given fishery. Fisheries developed in remote locations or identified as being particularly hazardous could have additional requirements placed on participants.

Where evidence was found for a hypothesis, the strength of evidence was then evaluated:

Table 14
Study hypotheses

Country/ region	Hypothesis 1 *Indirect effects of fishery management on safety*	Hypothesis 2 *Effects of quota-based management on safety*	Hypothesis 3 *Effects of unsuccessful management on safety*	Hypothesis 4 *Integration of safety policies with management*
Argentina		Empirical and anecdotal		
Chile		Empirical		
European Union	Hypothesized			
France		Empirical		
Ghana			Hypothesized and anecdotal	Hypothesized
Iceland	Hypothesized	Anecdotal		Empirical and hypothesized
Japan	Implicit			
Malawi	Hypothesized and anecdotal		Hypothesized effects	Hypothesized effects
New Zealand	Empirical and anecdotal			
Pacific Islands			Hypothesized and anecdotal	Hypothesized and anecdotal
Peru				Hypothesized and anecdotal
Philippines	Hypothesized and anecdotal			Hypothesized and anecdotal
Spain	Hypothesized and anecdotal			Hypothesized and anecdotal
Sri Lanka	Empirical and hypothesized			Hypothesized
Sweden	Implicit			
Thailand	Anecdotal		Anecdotal	

Notes: Shaded cells indicate that the hypothesized potential effect is not relevant for the fishery. Blank cells indicate that insufficient information was provided in the study to draw any inferences about potential effects.

- Empirical evidence was obtained by an analysis of quantitative data.
- Anecdotal evidence was based on observations by fishers or managers.
- Hypothesized evidence was based on reasoning by the study authors about potential effects.
- Implicit evidence was deducted from information presented by study authors that suggests potential effects that were not specifically identified or discussed in the studies.

RESULTS

Between May and August 2008, researchers from 15 countries prepared 16 case studies. Each case study offered some level of evidence for one or more of the four hypotheses (Table 14).

CASE STUDY
Godelman, E. Argentine safety at sea and fisheries management. August 2008.
Carrasco, J.I. The Artisanal Regime of Extraction and its impact on the safety at sea. The case of a Chilean coastal pelagic fishery as an artisanal fishery under transition. 2008.
Renault, C., Douliazel, F. & Pinon, H. Incidence of gross tonnage limitations under the European Common Fisheries Policy. June 2008.
Le Berre, N., Le Roy, Y. & Pinon, H. Safety incidence of the management of scallop fisheries in Brittany and Normandy (France). June 2008.
Bortey, A., Hutchful, G., Nunoo, F.K.E. & Bannerman, P.O. Safety and management practices in marine fisheries industry of Ghana. June 2008.
Petursdottir, G. & Hjorvar, T. Fisheries Management and Safety at Sea (Iceland). September 2008.
Matsuda, A. & Takahashi, H. Present status of the study of safety and management of fishery in Japan. November 2008.
Njaya, F. & Banda, M. Fishing safety and health and fisheries management practices: case of southern Lake Malawi fisheries. June 2008.
Wells, R. & Mace, J. Case study on the relationship between fisheries management and safety at sea. The New Zealand albacore fishery. September 2008.
Gillett, R. Sea safety in the Pacific Islands: The relationship between tuna fishery management and sea safety. June 2008.
Cardenas, C.A. Project artisanal fisheries and survival at sea in Peru. July 2008.
CBNRM Learning Center. Sea safety and fisheries management: tuna fishing industry in General Santos City, Philippines. August 2008.
Seco, B.R. Study of the relationship between safety at sea and fisheries management in the competence of autonomous regions and their influence on the safety of fishermen and fishing vessels and fisheries management in Spain. July 2008.
Hettiarachchi, A. The multi-day fisheries of Sri Lanka: management and safety at sea. June 2008.
Roupe, U. Fisheries management and lobster fishery: a case study on risk and safety from Sweden. August 2008.
Chokesanguan, B., Rajruchithong, S., Taladon, P. & Loogon, A. Safety at sea of trawler and purse seiner in Thailand. August 2008.

Hypothesis 1

Ten case studies provided evidence supporting Hypothesis 1. One of the most compelling studies was a report discussing the hypothesized effects of fisheries management on safety in Iceland, including the special line of dispensation and days of effort. The special line of dispensation allows small vessels to fish with baited hooks and lines rather than nets to catch 16 percent more than their allocated individual transferable quota (ITQ) limit without incurring any penalty. However, the vessel is required to return to the same port from which it sailed within 24 hours. This restriction may result in the vessel not being able to go to the nearest port to avoid dangerous weather. Days of effort resulted in a potential safety problem because, when a vessel sailed from port, one whole day was deducted from the total allotment. This resulted in an incentive to stay out at sea if problems were encountered or in deteriorating weather. However, in 2003–04, this rule was changed and the hazard was eliminated by measuring effort by hours started.

Another report from the European Union discussed the safety effects of restrictions on the gross tonnage of fleets. Member States are obligated to reduce fishing capacity as measured by gross tonnage and engine power. The authors argue that gross tonnage restrictions have important negative impacts on safety owing to the ageing fleet and restrictions on new vessel construction. The physical characteristics of older vessels may make it almost impossible to install technological advances that protect workers, and constraints placed on new vessel construction do not allow modern construction methods to be used. Similarly, the Spanish authors suggest that the vessel-size limits imposed by the European Union result in vessels carrying equipment that makes them unstable in bad weather. The Spain case study also expresses concern over multiple and overlapping jurisdiction resulting in an overly complicated system.

In addition to the above examples, the case report from New Zealand discussed risks that fishers take in preparation for implementation of a quota-based fishery management system. When implementing a quota-based management system, shares are sometimes based on fishers' catches during a specified period (the "catch history years"). The financial benefits of catching fish during this period are greatly multiplied by the right they may confer to catch more fish in the future. The phenomenon of "fishing for history" is widespread in fisheries where there is a perception that managers may impose quota management. The authors from New Zealand expressed concern over risks that fishers take while "fishing for history".

Hypothesis 2

Four case studies provided insights about whether quota-based fishery management systems are safer than competitive fishery management systems. The case study from France supported this hypothesis. The study compared three scallop fisheries where the local fisheries committees have adopted different management regimes for controlling fishing effort. Safety in scallop fisheries is of particular concern – scallop fisheries account for less than 6 percent of full-time equivalent fishers in France but account for more than 15 percent of fishing fatalities. In the Bay of St. Brieuc, management regulations result in a 45-minute race to fish. In contrast, in and off the Bay of Seine, a

Table 15
Comparison of accident rates in French scallop fisheries

Fishery	Type of management	Total accidents 2000–05	Yearly average accidents	Yearly exposure time	Frequency rate
		(No.)	*(No.)*	*(Hours)*	*(F)**
Bay of St. Brieuc	Competitive	80	13.3	108 900	122
Bay of Seine	Quota-based	227	37.8	638 600	59
Off Bay of Seine	Quota-based	313	52.2	2 860 000	18

* F = (yearly average accidents/yearly exposure time) × 1 000 000.

daily quota system without time limits is enforced. The study reviewed the respective scallop fishing fleets including the vessel type, gear and fisheries management regulations. They also estimated the population at risk, reviewed accident data, and calculated accident rates. The results show strong empirical evidence that daily catch quotas resulted in fewer occupational accidents than the competitive fishery because they provided fishers with the option to fish more safely.

Much higher accident rates were found in the competitive scallop fishery than in the two quota-based management fisheries (Table 15). The authors concluded that the major contributing factor to these differences was the management regime.

The study from Chile contrasted different strategies for using fishing quotas. During the first period (2001–03), global quotas were established for both industrial and artisanal fleets, and industrial fishing was banned from the Artisanal Fishing Reserved Area. Increased resources in the artisanal sector led to substantial growth in the artisanal fleet during these years, which encouraged a race for fish. During the second period (2004–07), the "Artisanal Regime of Extraction" was implemented; shares of the global artisanal quota were allocated to ad-hoc organizations of fishers based on groups' past participation and landings in the fishery. Compliance with the global quota improved, which contributed to a lessening of the race for fish and vessel overloading. The rates of fatalities, injuries and search and rescue (SAR) incidents show that safety problems increased during the first period but decreased during the second period.

Although the case report from Iceland did not evaluate the ITQ programme specifically, the authors did note that the ITQ system in Iceland "opened an opportunity for consolidation and modernization of older, less efficient and safe vessels" and that it contributed to a significant decline in the numbers of vessels and fishers. Under the quota system, there has been a significant decline in total SAR and medical evacuation missions and fatalities.

Hypothesis 3

Four case studies (those for Ghana, Malawi, Pacific Islands, and Thailand) discussed situations in which fisheries management agencies lacked the capacity to limit effectively catches and/or the number of fishers participating and provided evidence for Hypothesis 3. In all of these reports, economic pressures on coastal populations, for whom fishing is an important traditional activity and employer of last resort, led to increasing catches, which led to depletion of near-shore resources. This problem was sometimes aggravated by uncontrolled catches by larger industrial vessels, both domestic and foreign, operating (often illegally) in the same waters. As near-shore resources were overfished and declined, fishers fished increasingly farther offshore, where they faced greater risks.

Hypothesis 4

Several case studies discussed Hypothesis 4 and listed the potential benefits for safety if managers placed safety requirements on fishery participants. A study that reviewed the accident and fatality data from fishers between 1991 and 2007 made the strongest argument for this. The authors discussed three features of the Icelandic management system. Most importantly, in Iceland, a fishing licence is only issued when minimum safety equipment and crew training are achieved. The authors concluded that mandatory requirements for safety training, equipment and awareness have increased safety. From 1991 to 2007, SAR missions decreased by 50 percent. The Icelandic authors state that: "the system contributed to the increased safety through placing requirements on equipment and training, resulting in a lower accident rate."

DISCUSSION

The case studies provide evidence of how fisheries management policies can affect safety. Many case studies provided persuasive arguments for change. They add to a body of existing literature that demonstrates that fisheries management policies have wide-ranging effects on fishing safety. The FAO Code of Conduct for Responsible Fisheries (the Code) provides a necessary framework to ensure sustainable and safe fishing.[4] In FAO Fisheries Circular No. 966,[5] the authors argue that: "safety at sea should be integrated into the general management of the fisheries in each country." They further state that regulations should ensure "the safety and well-being of the fishermen, as well as sustainable utilization of the fishstocks."

Although fisheries management policies may be enacted primarily to conserve resources and achieve economic and social goals, fisheries managers need to be aware of how management affects safety. They need to consider whether management policies that negatively affect safety are necessary, or whether conservation, economic and social goals can be achieved through regulations that allow and encourage fishers to fish more safely. Safety in the fishing industry cannot be separated from fisheries management. To improve fishing safety, fisheries management personnel and fishing safety professionals should work together to identify solutions to meet all goals. Policies that result in fishers being forced to choose between risk-avoidant situations and maximizing profits should be examined. Most case studies (63 percent) provided some evidence of how fisheries policies affect safety (Hypothesis 1). Management regulations that negatively affect safety need to be modified to protect fishers.

Four case studies reviewed how quota-based fisheries managed policies affect safety (Hypothesis 2). They reported mixed results. One of the underlying goals of quota-based management systems is to improve safety. In theory, quota-based systems may reduce fishers' incentives to take risks such as fishing without adequate rest or fishing in bad weather. Thus, replacing a competitive derby fishery with an individual fishing quota may remove some incentives to take risk.

However, this does not in itself guarantee that such risks will not be taken. It is overly simplistic to argue that quota-based fishery management systems are always or necessarily safer than competitive fishery management systems. Therefore, it is not quota-based management in itself that makes a fishery safer or less safe. Rather, it is how quota-based management affects those who participate in the fishery, how they participate, and the conditions and incentives under which they participate. These effects may vary widely across quota-based programmes depending on how the programmes are structured and on other factors affecting the fishery, ranging from the marine environment to the market.

It is clear that under certain conditions quota systems can reduce the risks in a given fishery. A report on the comparative analysis of regulatory regimes[6] states: "Some fisheries have experienced significant improvements in health and safety following the implementation of IQ programs, including the Nova Scotia offshore fishery ..., the Alaskan halibut and sablefish fisheries ... and the British Columbia geoduck fishery ...; others have maintained relatively high accident and fatality rates under the IQ system, such as the surf clam and ocean quahog fisheries of New England ... and the national fisheries of Iceland ... and New Zealand".

Case studies reviewing Hypothesis 3 found evidence that if fishery resources are depleted, or competition for limited resources becomes more intense, fishers will take greater risks, such as fishing farther offshore, to seek a living. The challenge faced by managers in addressing safety problems extends to balancing resource protection, economic development and social goals such as access to economic opportunities in an occupation that, in many places, is one of last resort. It is clear from these case studies that fishery managers in developing countries face very serious challenges, and that fishers in these countries may face much greater risks than those in most developed countries. These risks are less likely to derive from constraints imposed by fishery managers than from the inability of fishery managers to constrain harvests and access to fishing by coastal residents willing to take risks in pursuit of their livelihoods.

Half of the case studies provided examples and ideas about how fisheries management can contribute to safer fisheries directly by integrating safety policies with fishery management policies (Hypothesis 4). Where practical, fisheries management policies should incorporate strategies to reduce hazards and make fishing safer. A Canadian study[7] concluded that: "If properly facilitated, many aspects of safety can be enhanced through the fisheries management definition without compromising other management objectives. Connecting licenses with competency, safety certificates and vessel seaworthiness may provide a good system of checks and balances for a long-standing problem. Incorporating safety oriented measures into other management procedures such as permitting variations on partnering and quota allocations, could introduce valuable safety practices that makes fishing in small vessels more practical. Before proceeding with these kind of measures however, there would have to be a serious buy in by other players, including fishing industry representatives."

Managers find themselves in a position where they have to attempt to balance multiple objectives under significant uncertainty, with limited resources. Managers should take practical steps and acknowledge that: "Safety at sea must be integrated into the general management of fisheries in all coastal states if safer working conditions for fishermen are to become a reality."[8]

CONCLUSIONS AND FOLLOW-UP

All of the case studies provided some level of evidence for one or more of the four hypotheses. Although most case studies did not empirically measure safety effects, the anecdotal and persuasive arguments regarding the effects of policies on safety cannot be dismissed. Fisheries managers, safety professionals and fishers need to work together in order to develop and coordinate strategies to improve safety and integrate safety into management policies that not only protect the fish but protect the fishers as well.

While the risks associated with commercial fishing cannot be completely eliminated through policy changes, there should not be a conflict between following policies and choosing to be safe. Fishing safety is a complex problem. The significance and persistence of safety problems in fisheries around the world suggests that there are no easy or obvious solutions. Fisheries management is not the only or most important factor affecting fishing safety. However, the case studies reviewed add to the wide range of evidence that fisheries management can affect fishing safety in a variety of ways. It is important to understand what these effects are, and to consider the ways in which fisheries management policies, while continuing to meet fishery management goals, may also be used to make fishing safer.

Future research should continue to: examine relationships between fisheries management policies and safety to identify policies that create incentives for fishers to take risks; identify modifiable factors; and develop policy alternatives. This type of research will help support changes in policy to incorporate safety assessments into fisheries management decisions. This synthesis provides evidence for the significant potential for policies to contribute to improved safety in many fisheries. There is evidence of potential policy changes in the United States of America. In 2011, the United States National Oceanic and Atmospheric Administration (NOAA) initiated an Advanced Notice of Proposed Rulemaking to request public comment on potential revisions to its National Standard 10 guidelines, which state: "Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea."[9] In any country and commercial fishery, continued monitoring of the change in risks is warranted. Improved data collection and coding are necessary to track adverse events by type of fishery for future evaluation.

Food safety remains a critical component for food and nutrition security

INTRODUCTION

Today, food safety remains a major concern facing the seafood industry and it is a critical component in ensuring food and nutrition security worldwide. The production and consumption of safe food are central to any society and they have a wide range of economic, social and, in many cases, environmental consequences. The issue of food safety is even more important in view of the growth in international fish trade, which has undergone tremendous expansion during the last three decades, increasing from US$8 billion in 1976 to a record export value of US$102.5 billion in 2010. Developing countries play a major role in international fish trade. In 2010, their exports represented 49 percent (US$42.5 billion) of world fish exports in value and 59 percent (31.6 million tonnes live weight equivalent) in volume.

In 1994, FAO published *Assurance of Seafood Quality*[10] in response to the growing need for guidance on the subject from Members. A decade later, in 2004, FAO published an expanded and revised technical paper *Assessment and Management of Seafood Safety and Quality*[11] that addressed new developments, especially with regard to food safety and the adoption, internationally, of the Hazard Analysis and Critical Control Point (HACCP) system and risk analysis concepts.

In response to the increasing importance of seafood trade and to the significant changes in the regulatory environment in the last decade, a new and revised FAO technical paper[12] has re-examined the whole area of seafood safety and quality. The study focuses on:

- developments in food safety and quality management systems;
- characterization of the food safety hazards in seafoods and seafood quality;
- implementation of management systems to ensure safe and high-quality seafoods.

The study also analyses:

- the regulatory framework that all food business operators (producers, processors, distribution and retailers) must now operate within – at the international, regional and national levels;
- the probable impact of climate change on food safety, focusing on the most important hazards – microbial pathogens and natural toxins from algal blooms;
- the challenges facing developing countries.

DEVELOPMENT OF FOOD SAFETY AND QUALITY SYSTEMS

In the 1980s, food trade expanded dramatically with more food products crossing national and continental borders. Exports from developing countries increased. At the same time, several food scares, caused by bacterial (e.g. *Salmonella* and *Listeria*) and chemical (e.g. mycotoxins) contamination meant that food safety was an issue of major public concern. This concern was exacerbated during the 1990s by “mad cow disease” and the “dioxin crisis”, and these food safety problems forced regulators to rethink food safety strategies, integrating the various components of the value chain and introducing traceability requirements. In the new millennium, food production and distribution have become even more complex and market choices for consumers even wider. The media and consumers have developed a much greater interest in food safety issues following a number of food scares, such as:

- In Germany, a new strain of *E. coli* linked to bean sprouts infected more than 3 500 people and killed 53.
- In the United States of America, a *Listeria* outbreak resulted in 100 cases and 18 deaths, leading to recalls of about 5 000 freshly cut cantaloupes, while a *Salmonella* outbreak linked to peanut butter resulted in more than 500 cases in 43 states and led to recalls worth US$1 billion.
- In China, official figures indicate that 6 babies died and 294 000 were made sick from intentional addition of melamine to various foodstuffs, mainly milk and infant formulas.

Expansion of the food industry and food distribution systems across borders and continents required the development of quality assurance systems to support business-to-business contractual agreements and verification of conformity of food supplies with the specifications. At the same time, the development of bilateral, regional and

multilateral trade agreements brought about changes in national and supranational food control systems to harmonize requirements and procedures.

The efforts of the industry and food control authorities were not harnessed in a synergistic way until the advent of regulatory HACCP food control systems. Much still needs to be done to promote complementary systems that will enable the control and prevention of food safety hazards at the source along the supply chain and decrease the reliance on end-product sampling and testing.

RISK ANALYSIS

Food-borne illnesses continue to be a major public health problem worldwide. It is estimated that up to 30 percent of the population in industrialized countries are affected annually,[13] and the situation in developing countries could be worse, although less-developed data systems means quantification is difficult.

The public health significance of seafood-borne illnesses depends on the probability of illness (number of cases) and the severity of illness. The concept of "risk analysis" has become the method for establishing tolerable levels of hazards in foods in international trade and, equally, within national jurisdictions. Risk analysis consists of three separate but integrated parts:

- risk assessment,
- risk management,
- risk communication.

The management and control of food-borne diseases is carried out by several groups of people. First, it involves technical experts assessing the risk, i.e. examining epidemiological, microbiological and technological data about the hazard and the food. Risk managers at the government level decide what level of risk society will tolerate, while balancing other considerations, e.g. the cost of risk management measures and their effect on the affordability and utility of foods. Risk managers in both industry and government are then required to implement procedures to minimize the risk. In the current international food safety management environment, the tolerable level of hazard at the point of consumption is expressed as "food safety objectives". At the industry level, these objectives are met using prerequisite programmes and HACCP procedures.

Risk communication is an integral part of risk analysis and provides timely, relevant and accurate information about the risk of eating food to industry, consumers and public bodies alike. Perception of risk has both technical and emotional dimensions, and risk communication should address both these aspects. Often, non-technical information provided by media, consumer groups or industry captures the attention of the general public exposed to the risk. Risk communication should address the concerns of the public and not dismiss these as irrational.

EXAMPLE OF RISK ANALYSIS LEADING TO DEVELOPMENT OF SEAFOOD SAFETY STANDARDS

At the international level, the Codex Alimentarius Commission (CAC) has the mandate for developing food safety standards. The risk assessment that is required by the CAC for taking risk management decisions are provided by FAO and the World Health Organization (WHO) through joint expert committees such as the Joint FAO/WHO Meetings on Microbiological Risk Assessment and Joint FAO/WHO Expert Committee on Food Additives. In the last decade, there have been examples of FAO/WHO risk assessments leading to the development of Codex Standards. When *Listeria monocytogenes* was recognized as a food-borne pathogen (smoked fish was one of the incriminated commodities), risk managers in some countries adopted a "zero tolerance" approach, while risk managers in others chose a microbiological criterion in terms of colony-forming units per gram of product (this provides a maximum level of bacterial presence) of 100 cfu/g. An FAO/WHO risk assessment showed that predicted illness depends on how many non-compliant products reach the market. Owing to the environmental presence of this organism, achieving zero in all products is technologically difficult, and the risk assessment showed that a criterion would be needed for public health protection in ready-to-eat products, e.g. smoked fish, and that the risk depended on the ability of the product to support growth of the organism. As a result of discussions by the experts, the CAC set a standard of 100 cfu/g in products that do not support the growth of this organism and a "zero tolerance" for products that can support growth.

SEAFOOD QUALITY

While the concepts of risk analysis are clearly developed to ensure food safety, the same approach and thinking can be applied to cover, for example, sensory quality, composition and labelling. National regulations, commercial specifications or international Codex Standards set the specifications for quality.

Similar to the risk assessment process, biological, chemical and physical agents capable of causing quality loss that may affect a particular seafood need to be identified. In addition, a qualitative and/or quantitative evaluation of quality loss needs to be characterized.

SAFETY MANAGEMENT SYSTEMS

As indicated above, there are many pathogens and spoilage agents that can contaminate fish and seafood during handling, processing or distribution, either from

Box 15

The Hazard Analysis and Critical Control Point system and prerequisite programmes

Hazard Analysis and Critical Control Point (HACCP) is a system that identifies, evaluates and controls physical, chemical and biological hazards that are significant for food safety.[1] It is a science-based and systematic tool that assesses hazards and establishes control systems that focus on prevention rather than rely mainly on end-product testing. It not only has the advantage of enhancing the safety of the product but, because of the means of documentation and control, it provides a way of demonstrating competence to customers and compliance with legislative requirements to the food control authorities.

Prerequisite programmes are defined as:

- Procedures, including good manufacturing practices that address operational conditions providing the foundation for the HACCP system (National Advisory Committee on Microbiological Criteria for Foods, 1998).
- Practice and conditions needed prior to and during the implementation of HACCP and which are essential for food safety (World Health Organization, 1999).
- A programme that is required prior to the application of the HACCP system to ensure that a fish and shellfish processing facility is operating according to the Codex Principles of Food Hygiene, the appropriate Code of Practice and appropriate food safety legislation (Codex Alimentarius Commission, 2003).

[1] Codex Alimentarius Commission. 2003. *Recommended International Code of Practice: General Principles of Food Hygiene. CAC/RCP 1-1969, Rev. 4-2003*. Rome, FAO/WHO. 31 pp.

handlers, equipment, surrounding environment or other sources, such as cleaning water or ice.

The advent of the HACCP-based system (Box 15) in recent decades has provided a single system that has now been adopted by international bodies and trading countries and regions to control food safety. However, there are important foundations to be put in place before implementing the HACCP system. International organizations have defined the importance of so-called prerequisite programmes, and this clearly differentiates the prerequisite programmes from the HACCP system – something that is always not fully appreciated by processors in many countries.

Moreover, various bodies have defined what is required in these "pre-HACCP" operations and, while there is overlap, they do differ. This lack of a universally agreed set of operations prior to implementing HACCP has possibly given rise to the lack of consistency in documentation of these procedures when compared with the very structured approach offered by the 12 steps of the HACCP system.

More recently, the International Organization for Standardization (ISO) has developed the ISO 22000 family of standards (ISO 22000 – "Food safety management systems – requirements for any organization in the food chain"). It takes the approach of ISO 9001 as a management system, and incorporates the hygiene measures of prerequisite programmes and the HACCP principles and criteria. In 2008, PAS 220:2008 was developed to cover what were seen to be shortcomings in the prerequisite element of ISO 22000 at the time.

THE REGULATORY FRAMEWORK

The frameworks for ensuring food safety in the international context are provided by: (i) the World Trade Organization (WTO) under two binding agreements (the Agreement on the Application of Sanitary and Phytosanitary Measures [SPS Agreement], and the Agreement on Technical Barriers to Trade [TBT Agreement]); (ii) the Codex Alimentarius Commission (CAC) through various instruments, for example, the Code of Practice for Fish and Fishery Products and the basic texts on Food Hygiene; and (iii) the FAO Code of Conduct for Responsible Fisheries (the Code), especially under Article 6 (General principles, provisions 6.7 and 6.14) and Article 11 (Post-harvest practices and trade), both of which are of particular relevance to fish trade, safety and quality.

For international fish trade, countries have enacted national and regional regulations to control seafood entering or exiting their territories. As more than 70 percent of seafood trade is destined for three main markets (the European Union, the United States of America, and Japan), these markets are important regulatory reference points.

The United States of America has a decentralized system for food safety and quality regulation. There are no fewer than 17 federal government agencies involved in food regulation. The two most important agencies are the Food and Drug Administration of the Department of Health and Human Services, which regulates all food except meat and poultry, and the Food Safety Inspection Service of the Department of Agriculture, which is primarily responsible for meat and poultry. The Environmental Protection Agency regulates the safety of water, while the Agricultural Marketing Service offers product quality and grading services for a fee to all food commodity groups except seafood. Seafood quality and safety services for a fee are provided by the Seafood Inspection Program of NOAA Fisheries within the Department of Commerce. The Department of Homeland Security is involved in ensuring that intentional product adulteration does not occur. The recent Food Safety Modernization Act (2011) is now the guiding legislation for improved food safety in the United States of America.

In the European Union, as the result of a white paper on food safety in 2000, the approach taken in the legislation is to separate aspects of food hygiene from animal health and to harmonize food control across the European Union member countries. A key aspect of the legislation is that all food and feed business operators, from farmers and processors to retailers and caterers, have principal responsibility for ensuring that food placed on the European Union market meets the required food safety standards. The Regulations[14] apply at every stage in the food chain, including primary production (i.e. farming, fishing and aquaculture) in line with the "farm to fork" approach to food safety in the European Union. The Regulations also include provisions for guides to good practice to be developed by industry with support from other stakeholders.

In Japan, distrust of regulatory food safety has been rising among the public. People's growing concern has been triggered by various problems, including the occurrence of bovine spongiform encephalopathy, commonly known as mad cow disease, in 2001. Against this background, Japan has enacted the Food Safety Basic Law, a comprehensive law to ensure food safety to protect the health of the public. In the wake of the development of the basic law and other related laws, Japan has introduced a risk analysis approach (described above) to the national food safety control programme work. The Food Safety Basic Law assigns responsibility for risk assessment, and the Food Sanitation Law and other related laws identify who are responsible for risk management. The risk assessment is in practice conducted by the Food Safety Commission established under the Food Safety Basic Law.

CLIMATE CHANGE AND FOOD SAFETY

The earth's climate is changing, and this may influence the safety of food harvested from marine and freshwater environments. There are two main areas that have the potential for change: microbial pathogens, and harmful algal blooms.

Microbial pathogens

Climate change is expected to accelerate the water cycle with increased precipitation in the tropics and at high altitudes, drier conditions in subtropics and increased frequencies of extreme droughts and floods. Events such as floods are likely to disrupt sanitary infrastructure around fish harvesting and aquaculture sites, affecting fish safety. The presence of *Salmonella* in rivers and the marine environment has been related to torrential rains and storm-generated flows, and the pathogen could thus reach aquaculture sites or contaminate fish in coastal waters. Outbreaks of illness caused by *Vibrio parahaemolyticus* in shellfish in Chile have been related to the arrival of warm equatorial water during El Niño events.

Harmful algal blooms

Harmful algal blooms are a completely natural phenomenon that have occurred throughout recorded history in all parts of the globe. Whereas wild fish stocks are free to swim away from problem areas, caged fish and shellfish are trapped and, thus, can suffer mortalities and/or become toxic. Of greatest concern to human society are algal species that produce potent neurotoxins that can find their way through shellfish and fish to consumers, where they cause a variety of gastrointestinal and neurological illnesses. Worldwide, almost 2 000 cases of food poisoning from consumption of contaminated fish or shellfish are reported each year. Some 15 percent of these cases prove fatal. In the past three decades, harmful algal blooms seem to have become more frequent, more intense and more widespread, in part ascribed to climate changes. The seafood industry (capture and farmed) must monitor for an increasing number of harmful algal species in the water column and for an increasing number of algal toxins in seafood products. Global climate change is adding a new level of uncertainty to many seafood safety monitoring programmes.

IMPACT ON DEVELOPING COUNTRIES

While efforts in the major markets are focusing on a regulatory framework to ensure the safety of their consumers, several development agencies and donors have been exploring ways and means, both financial and technical, to assist developing exporting countries build the necessary national and regional capacity to meet these international safety and quality standards. Proper assessment of the extent of assistance needed is key in decision-making. Therefore, costing the impact of substandard products, from

both a quality and safety perspective, is of interest not only to producers, processors, quality control authorities and consumers, but also to governments, donors, public health authorities and development agencies. In addition to the economic losses incurred because of fish spoilage, product rejections, detention and recalls, and the resulting adverse publicity to an industry and even to a country, fish-borne illnesses cost vast amounts to the community because of adverse health effects, loss of productivity and medical expenses.

Fish and seafood are crucial income earners for many developing countries. Trade liberalization has reduced tariff barriers, which should have a positive impact on developing countries' access to developed country markets. However, it is increasingly clear that the main barrier to increased exports is no longer import tariffs but the difficulties developing countries have in meeting import market quality-related and safety-related requirements.

Developing countries have pointed to the challenge presented by national and regional safety and quality control regimes that vary from one jurisdiction to the next. This multitude of approaches imposes significant costs on exporters in countries where there is limited capacity to develop comprehensive safety and quality management systems and infrastructures, let alone several different systems to meet diverse import market requirements. Although progress has been made in terms of harmonization, in particular via the WTO and the CAC, it has been slow and more work is required.

The concerns expressed by developing countries in relation to public regulation in importing countries are mirrored in their concerns related to private standards for food safety. The costs of compliance (including the duplication of effort required to complete various levels of documentation), the need to respond to a multiplicity of different standards, the increasing specificity of those standards, and the lack of harmonization among them are major concerns for developing countries. Much effort has gone into meeting European Union and other importer requirements in many

Box 16

An Indian success story

Small farmers with holdings of less than 2 ha account for 90 percent of shrimp aquaculture in India. The outbreak of white spot disease seriously affected the shrimp aquaculture industry in India in the mid-1990s and the related losses in 1995–96 were estimated at about US$120 million. Subsequently, the problem of antibiotic residues affected market access for shrimp in India. To address this, better management practices (BMPs) using a cluster-based approach were started in one state. In 2001, this approach was demonstrated in 10 ponds covering 7 ha and producing 4 tonnes of shrimp. The BMPs contributed to improved production and reduced diseases without the use of antibiotics. This initiative slowly expanded to 108 ponds covering 58 ha in 2003, and, by 2007–08, it had expanded to 5 states in India covering an area of 6 826 ha. The BMPs included documentation of inputs, which facilitated implementation of traceability in this sector of small farmers. The goal is to organize 75 000 farmers into 1 500 societies by the end of 2012.

Source: Umesh, N.R., Mohan, A.B.C., Ravibabu, G., Padiyar, P.A., Phillips, M.J., Mohan, C.V. and Vishnu Bhat, B. 2010. Shrimp farmers in India: empowering small-scale farmers through a cluster-based approach. *In* S.S. De Silva and F.B. Davy, eds. *Success stories in Asian aquaculture*, pp. 44–66. Dordrecht, Netherlands, Springer Science+Business Media B.V.

developing countries. Consequently, more than 100 countries, most of them developing countries, are approved exporters of fish products to the European Union because they have food safety management systems equivalent to those of the European Union. However, for other developing countries, poor public infrastructure challenges their abilities to meet either public or private overseas standards.

Furthermore, many developing countries have been unable to access the growing market for higher value-added products. Instead, their processing activities have been limited to less sophisticated types of processing (filleting and canning). Private-sector companies appear unwilling to invest in more sophisticated production equipment in developing countries if their activities are not supported by the public infrastructure. Companies can and do relocate processing to developing countries – including to take advantage of lower labour costs – where they have confidence in the local administrative systems (including safety and quality management regimes). Integrated supply chains mean closer collaboration with import markets. This could also mean opportunities for transfers of technology and expertise to developing countries.

Some countries have introduced state-mediated certification procedures to certify their safety and environmental credentials, in particular in their aquaculture industries. This can be seen as a proactive strategy to respond to safety and quality demands from import markets by promoting themselves as suppliers of safe and high quality fish and seafood, e.g. Thai Quality Shrimp.

Organizing fishers and fish farmers in developing countries, for example, by encouraging farmers/fishers associations or clusters (Box 16), enables them to respond collectively to the requirements of both public and private standards, and ensures that they are able to take advantage of available technical assistance.

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. Compliance with mandatory requirements is a prerequisite to any private-sector certification, but the reverse is not true. For example, certification to a private standard scheme will not allow access to the European Union market if the exporting country itself (and its competent authority) has not been given the green light to export to the European Union.

Hence, there is a need for continued technical assistance and dissemination of relevant information to developing nations to help them meet the ever-increasing and more complex challenges posed by international markets.

Marine protected areas: a tool for the ecosystem approach to fisheries

INTRODUCTION

As people have become more aware of their impact on the environment and the possible consequences thereof not only on their current well-being but also for future generations, the recognition of the need for protection balanced with sustainable use of the world's natural resources has increased dramatically. There have been calls for integrated and holistic natural-resource management approaches, focusing on ecosystems rather than only on specific species or ecosystem components. In response, various international fora have advocated adoption of more holistic approaches such as the ecosystem approach, and the use of tools such as marine protected areas (MPAs) and MPA networks. One of the primary fora that first brought MPAs to the forefront of discussions on global marine conservation was the Johannesburg Summit of 2002 – the World Summit on Sustainable Development. Its Plan of Implementation requests that nations promote the conservation and management of important and vulnerable marine and coastal areas.

In fact, spatial management measures, including MPAs, or fishing closures as a management tool have a long history in fisheries (see Box 17). With the current move

Box 17

Marine protected areas, fisheries and the Code

In fisheries management, spatial management tools, including marine protected areas, are not new – they have been used for centuries. Protection of specified areas through bans on types of gear and fishing activities has long been part of the fisheries management toolbox and practised by communities employing traditional management arrangements around the world. The FAO Code of Conduct for Responsible Fisheries (the Code) mentions the use of spatial management measures, for example, in Article 6.8, which emphasizes the importance of protection and rehabilitation for all critical habitats, and particularly protection against human impacts such as pollution and degradation.[1] In an effort to promote its goal – sustainable fisheries – the Code addresses protected area measures in Article 7.6.9:

"States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species. Where appropriate, such measures may include technical measures related to fish size, mesh size or gear, discards, closed seasons and areas and zones reserved for selected fisheries, particularly artisanal fisheries."

[1] FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome. 41 pp.

in fisheries management towards the ecosystem approach to fisheries (EAF) and similar methods, their use may become even more prevalent.

Hence, a convergence of interests has come about as fisheries managers emphasize healthy ecosystems as a requirement for sustainable fisheries. Conservation groups have also become increasingly aware of the necessity to include human needs and interests in designing and implementing MPAs. However, there remains confusion regarding the establishment of MPAs with varying objectives, as well as the general role of MPAs meeting multiple objectives within fisheries management systems. Views on how and when to use MPAs and what they can achieve differ significantly among diverse political, social and professional groups, and also among individuals.

Considering this confusion and the attention given to MPAs, the FAO Fisheries and Aquaculture Department has developed guidelines on MPAs and fisheries[15] (hereafter, the Guidelines) with a view to clarifying the bioecological and socio economic constraints and effects of MPAs in the context of fisheries. The Guidelines address the interface between fisheries management and biodiversity conservation, and they provide guidance on implementing MPAs with multiple objectives where one of the primary objectives is related to fisheries management. They draw on experiences from around the world and make use of a number of national case studies conducted in order to gather information on governance regimes of spatial management measures.

BACKGROUND

The diversity of marine protected areas

A stumbling block in many discussions on MPAs is the terminology; what is an MPA? The MPA concept is applied diversely around the world and with different names for similar policies. The many terms used for protected areas include, to name a few, fully protected marine areas, no-take zones, marine sanctuaries, ocean sanctuaries, marine parks, fishery closed areas, fisheries refugia and locally managed marine areas (while other protected areas in aquatic environments also include freshwater protected areas [Box 18]). Moreover, the same term may have different meanings in different countries or locations, e.g. a "reserve" in one country may prohibit fishing, while a "reserve" in another country may allow certain forms of non-destructive fishing. Box 19 gives some examples of national-level definitions extracted from the FAO MPA case studies.[16]

The Guidelines do not propose a single definition for MPAs but adopt a broad characterization in order to facilitate discussion of the various aspects considered important; hence, any marine geographical area that is afforded greater protection than the surrounding waters for biodiversity conservation or fisheries management purposes is considered an MPA. It is recognized that this characterization includes very large areas, such as exclusive economic zones (EEZs) at the extreme, but the term MPA is usually understood to apply to areas specifically designated to protect a particular ecosystem, ecosystem component or some other attribute (e.g. historical site).

An MPA network refers to two or more MPAs that complement one another. Ecological networks are formed when the natural connections among and within sites enhance ecological functions. However, besides ecological networks, social and institutional networks are also possible and can contribute to enhancing the administration and management of MPAs through communication, sharing of results and coordination among institutions.

Effects of MPAs: lessons learned

The effects of MPAs and MPA networks on fishery resources, ecosystems and people depend on a variety of factors, including their location, size, number, the nature of the protection afforded and the movement of the fish species (at all life stages) across MPA boundaries. It is also important to consider activities occurring outside the MPA itself.

Box 18

Freshwater protected areas

Freshwater protected areas (FPAs) have been a common fishery management practice in many areas to address the threats facing freshwater species and habitats. Following habitat rehabilitation and stock enhancement, the use of FPAs is the third-most common intervention to protect freshwater fish populations.[1] Closed fishing seasons and areas, prevention of fishing on spawning grounds, wild and scenic river designations, and native fish conservation areas can all be considered FPAs to one extent or another. However, the usual impression of an FPA involves a designated geographic area that is permanently protected, i.e. closed to fishing and other anthropogenic impacts. While less well known than marine protected areas, FPAs are subject to the same issues relating to diversity of terminology and meaning.

[1] Cowx, I.G. 2002. Analysis of threats to freshwater fish conservation: past and present challenges. *In* M.J. Collares-Pereira, I.G. Cowx and M.M. Coelho, eds. *Conservation of freshwater fish: options for the future*, pp. 201–220. Oxford, UK, Blackwell Science.

Experience shows that, when designed and managed appropriately, MPAs will probably provide benefits for fishery resources inside the enclosure in terms of abundance (in number and biomass) and average individual size of populations. There may also be some benefits to the fishery in the areas close to the MPA as a result of spillover, but fewer studies are available on this effect. In general, conservation benefits are likely to be greater for more sedentary species, and fisheries benefits should be greater for species with intermediate mobility. Marine protected areas can also play an important role in the protection of habitats and critical life stages, and in reducing bycatch.

Box 19

Different national definitions of marine protected area

In Brazil, there are two main categories of protected areas: areas under total protection (no-take zones); and areas for sustainable use. The main difference between them relates to permission to extract natural resources and to live inside their boundaries – forbidden in the former and allowed in the latter. Within these two categories, there are different types of no-take and sustainable-use protected areas, each of them with specific objectives.

In the Philippines, a wide range of terms is used for marine protected areas (MPAs). Their use may vary depending on the legislation, designating authority and type and quality of the resources and the intent. However, in practice, a standardized terminology is emerging among policy-makers with MPAs being defined as "any specific marine area which has been reserved by law or other effective means and is governed by specific rules or guidelines to manage activities and protect part or the entire enclosed coastal and marine environment".

In Senegal, the concept of MPAs continues to be the subject of numerous discussions with regard to their objectives, origin, legal status, relevant institutions, and design and implementation approaches. In the legal framework, the role of MPAs has been defined as "protection, on a scientific basis, for current and future generations, of important natural and cultural resources and ecosystems representative of the marine environment". In practice, MPAs in Senegal have two main characteristics. First, the purpose of MPAs is to contribute to the conservation of marine and coastal biodiversity. Second, an area of particular interest can be designated according to bioecological, territorial or socio-economic considerations and given special management measures for improving conservation, while taking the livelihoods of the resource users into account.

Palau characterizes MPAs through two distinct categories: management and use. The first type follows the six levels of the management guidelines of the International Union for Conservation of Nature, while the second includes traditional, local and national uses of protected areas. Many MPAs in Palau encompass a range of levels or types of management.

Sources: Sanders, J.S., Gréboval, D. and Hjort, A., comps. 2011. *Marine protected areas: country case studies on policy, governance and institutional issues.* FAO Fisheries and Aquaculture Technical Paper No. 556/1. Rome, FAO. 118 pp.
Sanders, J.S., Gréboval, D. and Hjort, A., comps. (forthcoming). *Marine protected areas: country case studies on policy, governance and institutional issues.* FAO Fisheries and Aquaculture Technical Paper No. 556/2. Rome, FAO.

However, the use of an MPA or MPA network as the only management tool to control or reduce fish mortality or to sustain fish populations is likely to result in overall lower fisheries yield potential and higher costs of fishing. The MPA should be combined with other management measures that control fishing effort outside the protected area, or fishing effort will probably be displaced with potentially negative consequences. Hence, MPAs must be an integral part of overall fisheries management plans and should not be viewed as a stand-alone fisheries management tool unless they are the only viable option, such as in situations where the capacity to implement other forms of management is lacking.

Because MPAs decrease the fishing area, they are likely to mean – at least in the short term – lower yields for fishers who cannot fish efficiently elsewhere. Benefits from changes in the fishery resource thanks to MPAs may be realized only in the longer term. Coastal communities adjacent to MPAs, especially those with a high economic dependence on the fishery, could thus face a disproportionate impact as a result of aggregate reduction in fishing revenue.

Appropriately designed and managed MPA networks can have several benefits compared with single MPAs. A network may be more flexible with regard to the distribution of social and economic costs and benefits among various stakeholders (fishers), while still achieving fisheries management and biodiversity conservation objectives. A network is also more likely to provide higher resilience to catastrophic events and other changes in the environment, such as climate change.

One tool in the fisheries management toolbox

When wishing to use an MPA or MPA network as a tool within fisheries management or the conservation of marine biodiversity, it is important to keep in mind the full set of management tools available. Indeed, MPAs and MPA networks are only one tool among many other fisheries management and biodiversity conservation measures. As such, they have strengths and weaknesses and should not be considered a "magic bullet". They are effective for management when planned and implemented under the right circumstances and through appropriate processes in combination with other tools. Both the opportunities and the limitations they represent should be respected and their suitability assessed in relation to what is to be achieved in a specific situation. Therefore, defining the overall fishery management and biodiversity conservation objectives is a fundamental element of the planning process, and the MPA or MPA network, if found to be suitable for these objectives, must be embedded within broader policy and spatial management frameworks. Considering that MPAs will have multisectoral effects (whether they have been designed with multiple objectives or not), they should be designed within a framework such as the EAF or integrated coastal zone management, with appropriate cross-sectoral coordination and collaboration established at all levels (national, regional and local) to ensure that externalities are capitalized on or mitigated.

PLANNING AND IMPLEMENTATION: LESSONS LEARNED

When an MPA has been appropriately designed, its success will depend on how well it is managed and whether it is implemented effectively. Issues related to governance span two main dimensions: the existence of an enabling environment through legal, institutional and policy frameworks; and the management structure and institutional requirements at the level of the individual MPA or MPA network (including with regard to the process by which it is planned and designated).

Decisions on design and on the governance regime should be made in accordance with the objectives of the MPA. The setting of objectives is a critical first step that goes beyond the MPA concept itself. Only when the fisheries management objectives, including biodiversity conservation, have been defined can it be decided whether an MPA or an MPA network is the best tool for achieving them. If this is found to be the case, the goals and objectives of the individual MPA or MPA network can be decided. Most MPAs have biological, socio-economic and governance goals and objectives.

Governance perspectives

Whether designated primarily for biodiversity conservation or for fisheries management – or with multiple objectives – MPAs require supporting legal, institutional and policy frameworks, as well as long-term political commitment, in order to be successful. They are tools for achieving defined objectives and are most effective when embedded within broader management frameworks such as an EAF or a spatial management framework that requires intersectoral coordination. Moreover, good governance, including stakeholder participation, is key to successful and equitable management outcomes.

The institutional arrangements for spatial management measures vary considerably among countries. They include both the broad framework of rules and processes that guide societal and economic activities and the entities that operate within this framework (government agencies, institutions, committees, councils, organizations, etc.). The legal framework of laws and regulations defines the rights, responsibilities, options and restrictions applicable to all affected stakeholders, and provides the basis for protection and enforcement of rights and responsibilities. Box 20 provides examples of national institutional structures for MPAs.

Box 20

Examples of national institutional MPA arrangements

In Senegal, marine protected areas (MPAs) have been covered by forestry legislation and have fallen under the responsibility of the National Parks Department of the Ministry of Environment. However, MPAs created more recently have instead been designated by presidential decree or by provincial governor approval. In 2009, a new Department for Community Areas was created within the Ministry of Maritime Affairs. This department will have responsibility for community-managed MPAs. There have also been attempts to establish procedures to facilitate coordination of MPA designation between the two ministries. Moreover, in 2010, a marine interministerial committee was created to, among other things, facilitate the development of an ecosystem approach to marine management.

In the Philippines, the authority to establish and manage MPAs is held by three jurisdictions: the Department of Environment and Natural Resources; the Bureau of Fisheries and Aquatic Resources of the Department of Agriculture, and the local government unit. Both of the national government agencies have responsibilities for protecting marine environments, although their mandates may sometimes overlap. The Local Government Code of 1991 contains several important measures that enhance the administrative abilities of local government units, including political autonomy and the ability to generate and mobilize economic resources through taxes and fees. Local government units possess broad powers to control fishing activities in coastal waters and are able to set conditions for marine resource use by local ordinance, including the establishment of MPAs. Local government units do not require the approval of the national government agencies to establish MPAs.

Sources: Sanders, J.S., Gréboval, D. and Hjort, A., comps. 2011. *Marine protected areas: country case studies on policy, governance and institutional issues.* FAO Fisheries and Aquaculture Technical Paper No. 556/1. Rome, FAO. 118 pp.
Eisma-Osorio, R.L., Amolo, R.C., Maypa, A.P., White, A.T. and Christie, P. 2009. Scaling-up local government initiatives towards ecosystem-based fisheries management in Southeast Cebu Island, the Philippines. *Coastal Management,* 37(3–4): 291–307.

The international workshop "Exploring the Role of MPAs in Reconciling Fisheries Management with Conservation" (29–31 March 2011, Bergen, Norway) focused on the need for and role of MPAs with multiple objectives. It also discussed the need for institutional arrangements, noting that a coordinating interministerial or intersectoral institution may be needed at the national level to reconcile objectives (fisheries management and biodiversity conservation, as well as those related to the interests of, for example, local communities and the tourism sector). Such a body would need to make strategic trade-offs between sectors and balance different power structures. Moreover, vertical links in the decision-making processes from the local level to the national policy level are required, with appropriate representation of different interests at each level.

The types of management arrangement and governance regime under which an MPA can be planned and implemented depend on the conditions provided by the overall legal, institutional and policy framework. While centralized, state-controlled, command-and-control systems are still common, there has been a trend towards increasingly decentralized fisheries management in recent decades. Various forms of comanagement governance systems are applied in many parts of the world, based on partnerships between governments and resource users with shared responsibility and authority for fisheries management. These governance systems are often combined with rights-based approaches to fisheries management.

Stakeholder involvement in planning and implementation is crucial for the success, in particular, of coastal MPAs. The socio-economic impacts of an MPA can be positive and negative, direct and indirect, affecting sectors and stakeholders adjacent to and beyond the MPA site. Marine protected areas have distributional effects, often very significant ones, and different stakeholder groups are affected in different ways. People, individually and as a group, should be made to feel that they have been part of the decision-making process and have been able to participate in and influence it. Without their involvement, it will be difficult to obtain support and compliance.

Setting objectives

Within the context of the defined overall fisheries management and/or biodiversity conservation objectives, specific goals and objectives should be set for the individual MPA or MPA network. There should be both longer-term visionary goals and operational objectives. The goals and objectives should be easy to understand and widely communicated. Because MPAs will have multisectoral effects, multiple goals should be considered even where the original initiative to designate an MPA has emerged from one particular concern. For example, when setting up an MPA for biodiversity conservation, its harmonization with relevant fisheries policies and legislation, and its potential contribution to sustainable fisheries should also be explored. If the effects on fisheries are internalized in the planning and design process, instead of being dealt with as an externality, the outcomes are likely to be more useful. Setting clear goals and objectives helps ensure more-effective management and facilitates the monitoring of progress. When the specific MPA objectives are set, decisions on the site, scale and other design aspects of the MPA should follow. These decisions should be goal- and objective-driven.

The Bergen MPA workshop also emphasized the need to establish clearly defined goals and objectives. The need for baseline assessments that will allow for monitoring was also raised. The design and management of an MPA should be flexible and adaptive, allowing for adjustment of management if monitoring shows that the objectives are not being reached.

As in all management planning processes, early involvement of stakeholders in the MPA planning process is important. This means that stakeholders should be involved in identifying the issues that the MPA is expected to address and resolve and in the setting of MPA goals and objectives. The diversity and type of information brought to bear on decisions depends on who has the right to participate in decision-making processes. Consequently, participatory planning arrangements generally increase the amount of information integrated into MPA planning and implementation. When taking a holistic and integrated approach to MPA planning, the process of identifying and agreeing on pertinent issues is likely to be complex. With a broad range of stakeholders and views on what aspects are important, prioritization becomes a critical element of the process. Several methods and approaches can help both in the identification of issues as well as when defining goals and objectives (Box 21).

THE WAY FORWARD

The current trend towards greater emphasis on MPAs as a fisheries management and biodiversity conservation tool will continue both within the framework of the EAF and in the context of the international commitments made on conservation and sustainable development. In attempting to maximize the contribution of this spatial management measure to achieving healthy marine ecosystems and sustainable fisheries, and meeting broader societal objectives – including poverty reduction and food security – there are both opportunities and challenges.

The Bergen MPA workshop recognized the increasing reconciliation between the fisheries management and biodiversity goals. However, it also found that further institutional arrangements, such as legal frameworks, stakeholder/community participation and coordination among high-level agencies, have to be secured in order to enhance reconciliation and realize both perspectives.

Current trends in the devolution of power to local levels of government and communities, for example, through fisheries and ecosystem comanagement arrangements, support stakeholder involvement in MPA planning and implementation. This is an important development that MPAs can both benefit from and contribute to –

Box 21

Tools for analysis and prioritization

Various analytical frameworks can assist in the decision-making and prioritization process when selecting what issues a marine protected area should address and what the goals and objectives should be:

- A hierarchical or problem tree is often used as part of participatory planning and helps define root causes by clustering identified problems and issues.
- Analysis is used to determine the economic efficiency of various options from among which decision-makers must choose. Put simply, future costs and benefits are estimated for each option and compared.
- Assessments are essentially used to determine whether the probability of a particular hazard or threat, combined with the magnitude of its possible impact or cost, is considered acceptable or not when compared with some standard or benchmark.
- Impact reviews examine who will benefit or suffer, the total costs and benefits (as in cost–benefit analysis), and the temporal and spatial distribution thereof.

Source: De Young, C., Charles, A. and Hjort, A. 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.

experiences from MPA management can inform policy on decentralization and shared responsibilities.

Marine protected areas, which need to be integrated into wider fisheries and biodiversity management frameworks, imply a long-term management undertaking, and both political commitment and sustainable resourcing are required. Adequate support in terms of human and other resources must be planned from the outset and could include multiple funding sources. Considerable time, effort and perseverance will be required to make MPAs and MPA networks fulfil their potential.

Demand and supply of aquafeed and feed ingredients for farmed fish and crustaceans: trends and future prospects

INTRODUCTION

The global population is increasing and, in order to maintain at least the current level of per-capita consumption of aquatic foods, the world will require an additional 23 million tonnes thereof by 2020. This additional supply will have to come from aquaculture. Meeting the future demand for food from aquaculture will largely depend on the availability of quality feeds in the requisite quantities. Although the discussion on the availability and use of aquafeed ingredients often focuses on fishmeal and fish-oil resources (including low-value fish[17]), considering the past trends and current predictions, the sustainability of the aquaculture sector will probably be closely linked with the sustained supply of terrestrial animal and plant proteins, oils and carbohydrates for aquafeeds. Apart from ensuring the sustained availability of feed ingredients to meet the growing demand of aquaculture, several other important areas and issues also require attention. FAO Fisheries and Aquaculture Technical Paper No. 564[18] analyses the demand and supply of feed ingredients in aquaculture, raises several issues and questions, and provides recommendations on how to meet the challenge of increasing aquaculture production. These aspects are reviewed below.

AQUACULTURE GROWTH AND AQUAFEED

In 2008, global aquaculture production totalled 68.8 million tonnes, made up of 52.9 million tonnes of aquatic animals and 15.9 million tonnes of aquatic plants.[19] The volume of farm-produced aquatic animals represented 46.7 percent of the global food fish supply in that year. Considering the increasing global population and recognizing that no additional supply from marine capture fisheries will only be obtained if overexploited stocks are brought back to their full potential, it has been estimated that, to maintain the current level of per-capita consumption, by 2030 the world will require at least another 23 million tonnes of aquatic animal food – which aquaculture will have to provide.

Although aquatic plants and molluscs are produced under natural conditions without any additional feed, other aquatic animals requires some form of feed. Filter-feeding finfishes (e.g. silver carp and bighead carp) receive their food, primarily in the form of phytoplankton and zooplankton, in the pond or other waterbody through natural productivity and/or through fertilization. These fishes do not require any other forms of feeding, thus aquafeeds are not used for their production.

Aquafeeds (Box 22) are generally used for feeding omnivorous fishes (e.g. tilapia, catfish, common carp, and milkfish), carnivorous fishes (e.g. salmon, trout, eel, seabass, seabream and tuna) and crustacean species (marine and brackish-water shrimps, freshwater prawns, crabs and lobsters).

According to FAO estimates, in 2008, about 31.7 million tonnes (46.1 percent of total global aquaculture production including aquatic plants) of fish and crustaceans were feed-dependent, either as farm-made aquafeeds[20] or as industrially manufactured compound aquafeeds.[21] In 2008, fed aquaculture contributed to 81.2 percent of global farmed fish and crustacean production of 38.8 million tonnes and 60.0 percent of global farmed aquatic animal production.

While more than 200 species of fish and crustaceans are currently believed to be fed on externally supplied feeds, just 8 species or species groups account for 62.2 percent of the total feed used. These are: grass carp, common carp, Nile tilapia, Indian major carps (catla and rohu), whiteleg shrimp, crucian carp, Atlantic salmon, and pangasiid catfishes. More than 67.7 percent of farmed fed fish production is contributed by freshwater fishes, including carps and other cyprinids, tilapias, catfishes and miscellaneous freshwater fishes.

AQUAFEED PRODUCTION AND USE

Some fed-aquaculture farming systems use low-cost earthen ponds in semi-intensive production systems for the mass production of freshwater omnivorous fishes destined for local domestic consumption. However, they also range up to the use of more-intensive pond-, cage- or tank-based systems for the production of freshwater, diadromous and marine carnivorous fishes and crustaceans for export or high-end domestic markets.

The choice of feeding method depends upon a variety of factors (which may vary from country to country and from farmer to farmer) and objectives (local/home consumption or cash crop/export). Important factors include the market value of the cultured species, the financial resources of the farmer and the local availability of appropriate fertilizers and feeds.

The FAO technical paper highlighted here deals mainly with fish and crustaceans fed through exogenous feed, particularly industrially produced aquafeed (as comprehensive information on other feed types is generally lacking). Compound aquafeeds are used for the production of both lower-value (in marketing terms) food-fish species, such as non-filter-feeding carps, tilapias, catfishes and milkfish, as well as higher-value species, such as marine finfishes, salmonids, marine shrimps, freshwater eels, snakeheads and crustaceans.

Globally, 708 million tonnes of industrial compound animal feeds were produced in 2008, of which 29.2 million tonnes were aquafeeds (4.1 percent of all animal feeds). As animal production has increased, so has global industrial compound animal feed production – almost fourfold from 7.6 million tonnes in 1995 to 29.2 million tonnes

Box 22

Fed fish and non-fed fish

Fish fed with aquafeeds during culture practice are referred to as "fed fish", while fish that do not receive any feed are generally referred to as "non-fed fish". Aquaculture practices that produce fed fish are called "fed aquaculture",[1] as opposed to "non-fed aquaculture".

As the same species of fish may be cultured as fed fish or non-fed fish in different production systems, it is difficult to obtain precise production data and information on the use of feed for several aquaculture species, especially some omnivorous species (e.g. common carp, and Indian major carps) and herbivorous species (e.g. grass carp). For example, in many aquaculture production systems, grass carp are fed exclusively on plant materials and/or grasses, while in other systems this species is produced through externally supplied farm-made or commercial aquafeed. This situation makes it difficult to produce accurate estimates of feed use for many such species.

[1] Fed aquaculture is aquaculture production that utilizes, or has the potential to utilize, aquafeeds of any type; in contrast to the farming of filter-feeding invertebrates and aquatic plants, which relies exclusively on natural productivity.

in 2008, at an average rate of 11 percent per year. Production is expected to grow to 51.0 million tonnes by 2015 and to 71.0 million tonnes by 2020.

By volume, industrial compound aquafeeds used by major species and species groups are estimated to have been as follows in 2008: fed carps (9.1 million tonnes, 31.3 percent of the total), marine shrimps (17.3 percent), tilapias (13.5 percent), catfishes (10.1 percent), marine fishes (8.3 percent), salmons (7.0 percent), freshwater crustaceans (4.5 percent), trouts (3.0 percent), milkfish (2.0 percent), eels (1.4 percent), and miscellaneous freshwater fishes (1.6 percent).

While there is no comprehensive information available on the global production of farm-made aquafeeds,[22] the estimate is that it was between 18.7 million and 30.7 million tonnes in 2006. Farm-made aquafeeds play an important role in the production of low-value freshwater fish species. More than 97 percent of carp feeds used by Indian farmers are farm-made aquafeeds (7.5 million tonnes in 2006/07), and they are the mainstay of feed inputs for low-value freshwater fishes in many other Asian and sub-Saharan countries.

Although, again, accurate information is lacking, it has been estimated that the total use of low-value fish (i.e. as raw ingredients not reduced into fishmeal) in aquaculture was between 5.6 million and 8.8 million tonnes in 2006 and that, in 2008, Chinese aquaculture alone used 6–8 million tonnes of low-value fish, including marine fish, freshwater fish, and live food fish.

FEED INGREDIENT PRODUCTION AND AVAILABILITY

Feed ingredients used for the production of aquafeeds are broadly categorized into three types depending upon their origin: animal nutrient sources (including both aquatic and terrestrial animals); plant nutrient sources; and microbial nutrient sources.

Aquatic animal protein meals and lipids

The major aquatic animal protein meals and lipids used in aquafeeds include: fish/shellfish meals and oils; fish/shellfish by-product meals and oils; and zooplankton meals and oils.

Fishmeal and fish oil derived from wild-harvested whole fish and shellfish including bycatch currently constitute the major aquatic protein and lipid sources available for animal feed. World reduction fisheries (marine capture fishery products converted to fishmeal) were 18.2 million tonnes in 1976. This total rose progressively to 30.2 million tonnes in 1994 but then declined steadily to 17.9 million tonnes in 2009.[23] As a result, fishmeal and fish-oil production exhibited similar trends. Global fishmeal production increased from 5.00 million tonnes in 1976 to 7.48 million tonnes in 1994 and then decreased steadily thereafter to 5.74 million tonnes in 2009. Similarly, global fish-oil production rose gradually from 1.02 million tonnes in 1976 to 1.50 million tonnes in 1994 (with the exception of production peaks of 1.67 million and 1.64 million tonnes recorded in 1986 and 1989, respectively) but then fell back steadily to 1.07 million tonnes in 2009. Hence, analysis of the data for the last 15 years (1994–2009) indicates that global fishmeal and fish-oil production from marine capture fisheries have been decreasing at annual average rates of 1.7 and 2.6 percent, respectively.

The amount of captured fish destined for non-food uses increased from 20.6 million tonnes in 1976 to 34.2 million tonnes in 1994 (a proportionate increase from 31.5 to 37.1 percent of total catch). Since 1995, this amount has been decreasing both in absolute terms and as a proportion of total catch. In 1995, 31.3 million tonnes of global fish and shellfish landings were destined for non-food uses (33.9 percent of total catch), and, out of this total, 27.2 million tonnes (29.5 percent of total catch) were reduced into fishmeal and fish oil. In 2009, the corresponding figure was 22.8 million tonnes (25.7 percent of total). Out of this total, 17.9 million tonnes (20.2 percent of total catch) were reduced into fishmeal and fish oil. The amount of captured fish destined for non-food uses will probably decrease further in the near future.

In recent years, increasing volumes of fishmeal and fish oil have originated from fisheries by-products (capture fisheries and aquaculture). An estimated 6 million tonnes of trimmings and rejects from food fish are currently used for fishmeal and fish-oil production. The International Fishmeal and Fish Oil Organisation estimates that about 25 percent of fishmeal production (1.23 million tonnes in 2008) comes from fisheries by-products. This amount will grow as its processing becomes increasingly viable. Accurate information on the proportion of by-product fishmeal and fish oil produced from aquaculture processing waste is not available, but it is probable that a significant volume of farmed fish wastes is contributed.

Although some marine zooplanktons have potential for use as feed ingredients for aquaculture, commercial operations only exist for Antarctic krill (*Euphausia superba*), with total landings of 118 124 tonnes in 2007. Although krill meal and krill oil are available, information concerning their total global production and market availability is currently unavailable. While there are large biomasses of other zooplankton species in the oceans, it is probably unlikely that zooplankton meals will become a major protein ingredient in feed for farmed fish in the on-growing phase. It is more reasonable to expect that relatively minor amounts of zooplankton meal may be used as a bioactive ingredient, or attractant, in aquafeed or in feed for fish larvae.

Terrestrial animal protein meals and fats

The major terrestrial animal protein meals and lipids commonly used in aquafeeds are: (i) meat by-product meals and fats; (ii) poultry by-product meal, hydrolysed feather meal and poultry oil; and (iii) blood meals. Although accurate information is not available, it has been estimated that the global combined production levels of rendered animal protein meals and fats in 2008 were about 13.0 million and 10.2 million tonnes, respectively.

Plant nutrient sources

The major plant dietary nutrient sources used in aquafeeds include: cereals, including by-product meals and oils; oilseed meals and oils; and pulses and protein concentrate meals.

Total global cereal production was 2 489 million tonnes in 2009, growing at an annual average rate of 2.2 percent since 1995, with maize totalling 817.1 million tonnes (32.8 percent of the total), followed by wheat, rice paddy, and barley.

In 2009, oilseed production was 415 million tonnes, with soybean being the largest and fastest-growing oilseed crop and accounting for slightly more than 50 percent (210.9 million tonnes) of this total. About 151.6 million tonnes of soybean meal were produced in 2008/09, and other major oilseed protein meals were: rapeseed (30.8 million tonnes), cottonseed (14.4 million tonnes), sunflower seed (12.6 million tonnes), palm kernel (6.2 million tonnes), groundnut/peanut (6.0 million tonnes), and copra/coconut (1.9 million tonnes).

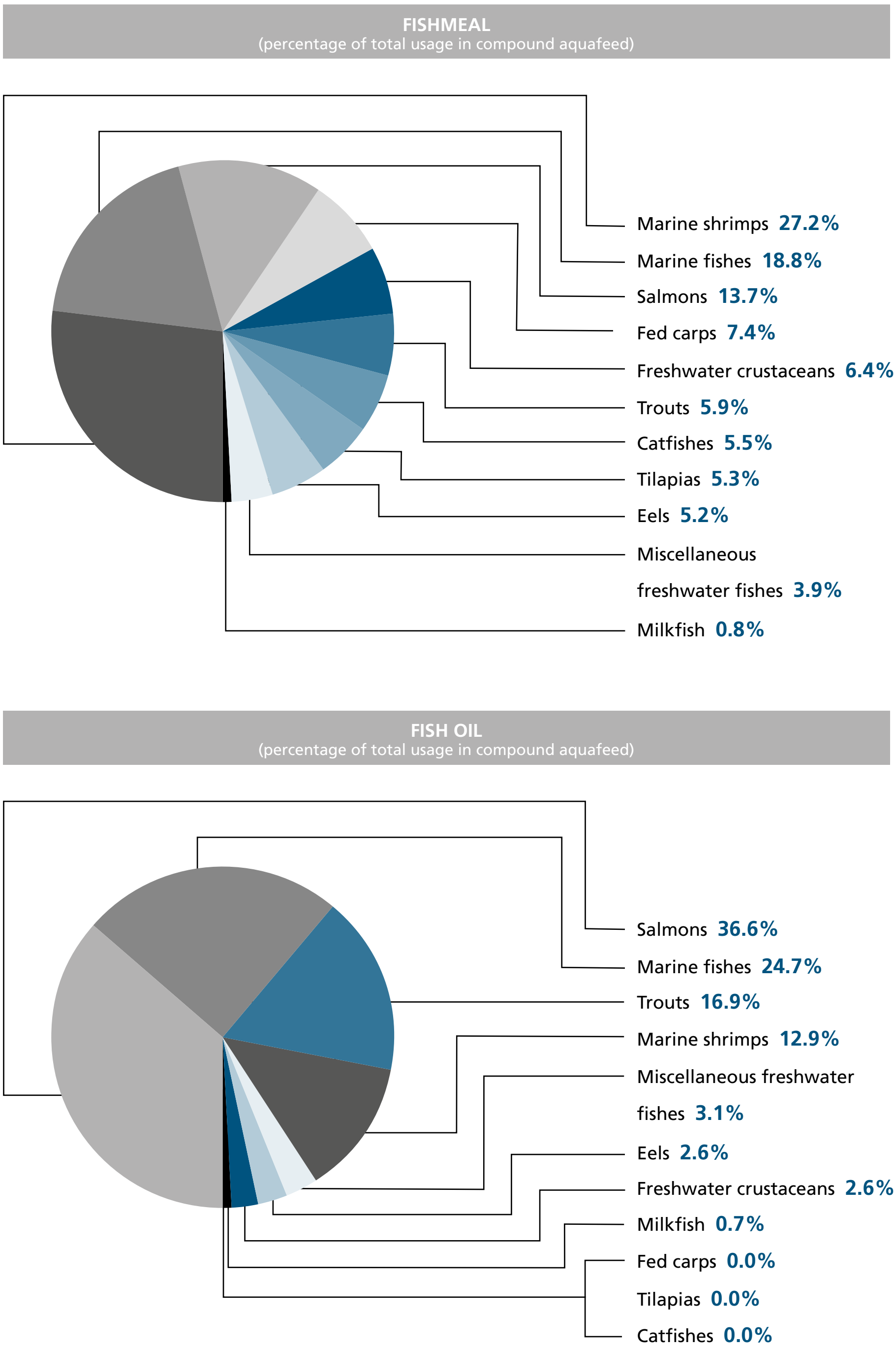
Among the pulses, protein concentrate meals from peas and lupins are commercially available for use within compounded animal feeds, including aquaculture feeds. The total global production figures for dry peas and lupins were 10.5 million and 0.93 million tonnes, respectively, in 2009.

Microbial ingredient sources

Microbial-derived feed ingredient sources for aquafeed include algae, yeasts, fungi, bacteria and/or mixed bacterial/microbial single-cell protein sources. The only such sources available in commercial quantities globally are yeast-derived products, including brewer's yeast and extracted fermented yeast products, but with limited information concerning their total global production and availability. Given the relatively low cost of some of these single-cell proteins, they are probably most relevant as a major protein ingredient in fish feed or may at least partially replace fishmeal in feeds for some fish species. Although microbial and algal species are considered innovative protein sources for aquafeeds, production costs will be an issue with some of them.

Figure 42

Global consumption of fishmeal and fish oil by major aquaculture species groups in 2008



Source: Adapted from Tacon, A.G.J., Hasan, M.R. and Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects.* FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO. 87 pp.

CURRENT FEED INGREDIENT USAGE AND CONSTRAINTS

Fishmeals and fish oils

Within the animal husbandry subsectors, aquaculture is the largest user of fishmeal and fish oil. Their use in aquafeeds is more prevalent for higher-trophic-level finfishes and crustaceans (with fishmeal inclusion levels of 17–65 percent and those for fish

oil of 3–25 percent). However, low-trophic-level finfish species/species groups (carps, tilapias, catfishes, milkfish, etc.) are also fed fishmeal and fish oil in varying amounts in their diets. The fishmeal use for these diets varies between 2 and 10 percent, with the exception of those for tilapias and catfishes in a few countries where up to 25 percent fishmeal use has been reported.

There is a wide variation in fishmeal and fish-oil usage between major species and species groups, with shrimps, marine fishes and salmons being the largest combined users thereof (Figure 42).

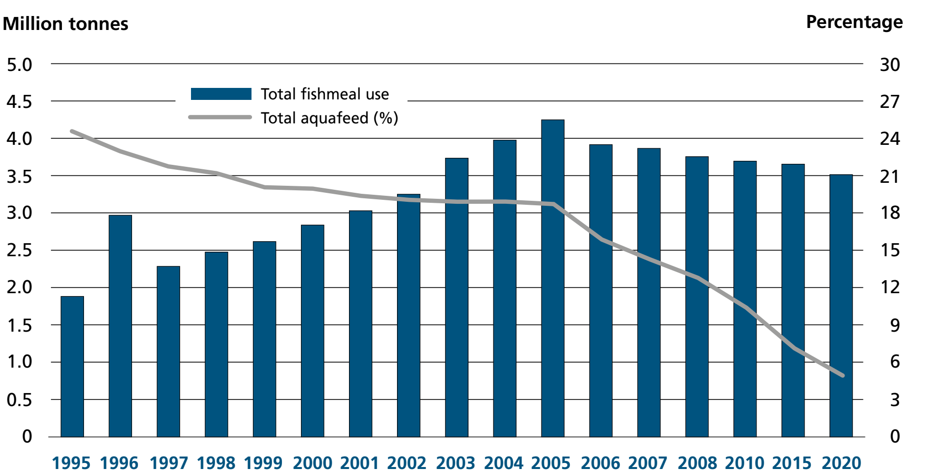
Although global fishmeal and fish-oil supplies have fluctuated between 4.57 million and 7.48 million tonnes for the last 33 years and have now stabilized at about 5.0–6.0 million tonnes per year, the amounts of fishmeal and fish oil used in aquafeeds have grown – rising between 1995 and 2008 from 1.87 million tonnes to 3.73 million tonnes and from 0.46 million tonnes to 0.78 million tonnes, respectively. This has been possible at the expense of the land-animal sector, particularly the pig and poultry sector, which is continuously reducing its use of fishmeal. In 1988, 80 percent of world fishmeal production was used in feed for pigs and poultry while only 10 percent went to aquaculture feed. In 2008, aquaculture used 60.8 percent of world fishmeal production and 73.8 percent of fish-oil production.

As mentioned above, low-value fish are also increasingly used as aquafeeds for carnivorous species, particularly in Asia. Increased use of fishmeal, fish oil and low-value fish in aquaculture in the last 10–12 years has primarily been attributed to the worldwide increase in the production of carnivorous species, particularly marine crustaceans, marine finfish, salmonids and other diadromous fishes.[24]

Although the aquaculture sector remains the largest user of fishmeal in the world, fishmeal use in aquafeeds has gradually fallen since 2006. Aquaculture consumed about 4.23 million tonnes (18.7 percent of total aquafeeds by weight) of fishmeal in 2005, but this figure was down to 3.72 million tonnes in 2008 (12.8 percent). It has been predicted that, even with increasing aquaculture production globally, the use of fishmeal for aquafeeds will decrease further to 3.63 million tonnes by 2015 (7.1 percent of total aquafeeds for that year) and to 3.49 million tonnes by 2020 (4.9 percent) (Figure 43). Among the reasons for this reduction are: decreased supplies of industrially

Figure 43

Actual and predicted reduction in fishmeal use relative to the global production of compound aquafeed



Source: Adapted from Tacon, A.G.J., Hasan, M.R. and Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects.* FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO. 87 pp.

caught fish as a result of tighter quotas; additional controls on unregulated fishing; and increased use of more cost-effective dietary fishmeal replacers.

In recent decades, because of an increased awareness of the likelihood of a scarcity of fishmeal, research institutions and the aquaculture feed industry have conducted numerous studies to try to reduce dependence on fishmeal. These studies have provided more detailed knowledge on the digestive processes and nutritional requirements of many farmed species and on how to process raw materials to make them more suitable for use in feed. Since 1995, this increased knowledge has led to an impressive reduction in the average inclusion of fishmeal in compound feeds for major groups of farmed species as well as improved feed conversion ratios (FCRs), reducing the amount of waste from the industry.

In the last 13 years for which data are available (1995–2008), fishmeal inclusion in major fish diets declined considerably (Table 16). The FAO technical paper projects that, in the next 10–12 years, fishmeal inclusion in the diets of carnivorous fish and crustacean species will be further reduced by 10–22 percent, and by 2–5 percent for omnivorous fishes.

Moreover, with improved feed efficiency and management, the FCRs for many aquaculture species dependent on industrially manufactured compound aquafeeds are projected to decline. For example, the FCR for fed carps is expected to fall from 1.8 in 2008 to 1.6 in 2020, that for catfishes to decline from 1.5 to 1.3, and that for milkfish to drop from 2.0 to 1.6. If these materialize, coupled with lower fishmeal inclusion in the diets for the above species and species groups, the amount of fishmeal used will decrease by about 6 percent in spite of the projected increases of 143 and 168 percent in estimated total aquafeed and fed aquaculture production, respectively.

Although it is projected that fish-oil inclusion in the diets for different carnivorous fish and crustacean species will also be reduced by 0.5–7.0 percent over the next ten years, the use of fish oil by the aquaculture sector will probably increase in the long run, albeit slowly. The total amount used will increase by more than 16 percent, from 782 000 tonnes (2.7 percent of total aquafeeds by weight) in 2008 to 845 000 tonnes by 2015 (1.7 percent) and to 908 000 tonnes by 2020 (1.3 percent). The reasons for this increase are the rapidly growing marine finfish and crustacean aquaculture sector and the absence of cost-effective alternative sources of dietary lipids rich in long-chain highly unsaturated fatty acids (HUFAs), including eicosapentaenoic acid (20:5n-3) and

Table 16
Reduction in fishmeal inclusion in compound aquafeed of different fish species and species groups

Species/species group	Fishmeal inclusion in compound aquafeed		
	1995	2008	2020*
	(Percentage)		
Fed carp	10	3	1
Tilapias	10	5	1
Catfishes	5	7	2
Milkfish	15	5	2
Miscellaneous freshwater fishes	55	30	8
Salmons	45	25	12
Trouts	40	25	12
Eels	65	48	30
Marine fishes	50	29	12
Marine shrimps	28	20	8
Freshwater crustaceans	25	18	8

* Projected.
Source: Adapted from Tacon, A.G.J., Hasan, M.R. and Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects.* FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO. 87 pp.

docosahexaenoic acid (22:6n-3). There is also a growing demand for fish oil for direct use as human supplements and pharmaceutical medicines.

Alternatives to fish oil are being used in greater amounts. Key alternative lipids include vegetable oils (e.g. linseed, soybean, canola and palm) – those with a high omega-3 content are preferred – and poultry oil. The use of oil from farmed fish offal is also a potential source of omega-3 for farmed fish.

Although a reduction in the dietary inclusion level of fish oil in aquafeed would not have any deleterious effect on the health of the farmed target species, there may be reduced health benefits from the final fish products because of lower HUFAs, including eicosapentaenoic and docosahexaenoic acid levels. Therefore, intensive research is required in order to find alternatives to fish oil. Research is aiming to produce long-chain omega-3 fatty acids from hydrocarbons by yeast fermentation, through extraction from algal sources and/or through genetic modification of plants.

In order to keep pace with fed aquaculture production, global aquafeed production will continue to grow, and it is expected to reach 71.0 million tonnes by 2020. The FAO technical paper highlighted here also indicates that, although the availability of fishmeal and probably fish oil over the next ten years may not be a major constraining factor, other feed ingredient and input supplies will need to expand at a similar rate if this growth is to be sustained, and these inputs will have to come from other sources (e.g. soybean, corn, and rendered animal by-products).

Terrestrial animal meals and oils

In non-European countries, the use of terrestrial animal protein meals and oils within compound aquafeeds is increasing for both high- and low-trophic-level species and species groups (e.g. salmons, trouts, marine finfishes, marine shrimps, catfishes, tilapias, carps and mullets), although the type and level vary depending upon species and species group. The inclusion level is generally: 2–30 percent for poultry by-product meal; 5–20 percent for hydrolysed feather meal; 1–10 percent for blood meal; 2–30 percent for meat meal; 5–30 percent for meat and bone meal; and 1–15 percent

Table 17
Feed ingredient usage for major aquaculture species and species groups

Feed ingredients	Inclusion level in compound aquafeed (Percentage)
Plant protein meal	
Soybean meal	3–60
Wheat gluten meal	2–13
Corn gluten meal	2–40
Rapeseed/canola meal	2–40
Cottonseed meal	1–25
Groundnut/peanut meal	≈ 30
Mustard oil cake	≈ 10
Lupin kernel meal	5–30
Sunflower seed meal	5–9
Canola protein concentrate	10–15
Broad bean meal	5–8
Field pea meal	3–10
Plant oil	
Rapeseed/canola oil	5–15
Soybean oil	1–10

Source: Adapted from Tacon, A.G.J., Hasan, M.R. and Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects.* FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO. 87 pp.

for poultry oil. Despite the apparent increasing trend, it is estimated that the total usage of terrestrial animal by-product meals and oils within compound aquafeeds ranges between 0.15 million and 0.30 million tonnes, or less than 1 percent of total global compound aquafeed feed production. Thus, there is considerable room for expansion.

Plant protein meals and oils

Plant protein meals commonly used in aquafeed include soybean meal, wheat gluten meal, corn gluten meal, rapeseed/canola meal, cottonseed meal, sunflower seed meal, groundnut/peanut meal, mustard oil cake, lupin kernel meal, and broad bean meal; and plant oils include rapeseed/canola oil, soybean oil, and palm oil. Plant proteins represent the major dietary protein source used within feeds for lower-trophic-level fish species and the second major source of dietary protein and lipids (after fishmeal and fish oil) for marine shrimps and European high-trophic-level fish species (e.g. salmons, trouts, marine fishes, and eels). Other species and species groups that use substantial amounts of plant protein meals and oils include milkfish, mullets, freshwater prawns, cachama and freshwater crayfishes. The inclusion levels of plant protein meals and oils vary widely depending upon species and species group (Table 17).

Soybean meal is the most common source of plant protein used in compound aquafeeds and the most prominent protein ingredient substitute for fishmeal in aquaculture feeds, with feeds for herbivorous and omnivorous fish species and crustaceans usually containing 15–45 percent soybean meal, with a mean of 25 percent in 2008. In global terms, and based on a total compound aquafeed production of 29.3 million tonnes in 2008, it is estimated that the aquaculture feed sector consumes about 6.8 million tonnes of soybean meal (23.2 percent of total compound aquafeeds by weight). Other plant proteins that are being increasingly used include corn products (e.g. corn gluten meal), pulses (e.g. lupins and peas), oilseed meals (rapeseed meal, cottonseed and sunflower), and protein from other cereal products (e.g. wheat, rice and barley).

Currently, plant protein and/or oil choice and selection are based upon a combination of local market availability and cost, as well as their nutritional profile (including antinutrient content and level). With the continued rise in the fishmeal price, plant protein concentrates (soybean protein concentrate, canola protein concentrate, pea protein concentrate and corn/wheat gluten meals) will gain increasing prominence over regular plant protein meals within aquafeeds for high-trophic-level cultured species and crustaceans. For example, the demand for soybean protein concentrates within aquafeeds is projected to exceed 2.8 million tonnes by 2020.

CONCLUSION

The discussion on the availability and use of aquafeed ingredients often focuses on fishmeal and fish-oil resources (including low-value fish). However, considering past trends and current predictions, the sustainability of the aquaculture sector is more likely to be closely linked to the sustained supply of terrestrial animal and plant proteins, oils and carbohydrate sources for aquafeeds. Therefore, the aquaculture sector should strive to ensure sustainable supplies of terrestrial and plant feed ingredients.

Apart from ensuring the sustained availability of feed ingredients (including fishmeal and fish oil) to meet the growing demand of aquaculture, the other important areas that need to be explored are:

- developing coping strategies and farmers' resilience to increases and fluctuations in raw material prices;
- addressing the supply of feed and feed ingredients to poor producers, particularly in sub-Saharan countries where farmers and small-scale feed manufacturers need assured access to feed and feed ingredients;
- ensuring national quality standards for feed raw materials, feed additives and feeds;
- facilitating the safe and appropriate use, and reliable quality, of aquafeeds produced by small-scale feed manufacturers;
- improving on-farm feeding and feed management practices and the transfer of associated technology at farmer level;

- improving feed formulation and production (e.g. farm-made feed, and semi-commercial feed) at the local level;
- improving the capacity, production technology and associated support services of small-scale feed manufacturers in Asia and sub-Saharan Africa.

ISSUES TO BE ADDRESSED

Continued emphasis on alternatives to fishmeal and fish oil

Aquaculturists should continue to search for alternative sources of affordable and high-quality plant- and animal-based feed ingredients to replace fishmeal in aquafeeds. Much research has already been carried out on plant feed ingredients to enhance their nutritional quality, with significant successes. Therefore, it is imperative that equal priority be given to improving the quality of terrestrial products and/or by-products, considering that the total volume of terrestrial animal by-product meals and oils used within compound aquafeeds is less than 1 percent of the total volume of global compound aquafeed feed production.

Continued research on fish-oil substitutes will be a priority. The objective should be to maintain the quality of farmed target species in respect of HUFAs in the final products, as it is projected that the overall total usage of fish oil in aquaculture will increase although the fish-oil inclusion level in various carnivorous fish and crustacean species is expected to decrease.

Reducing country dependence upon imported feed ingredient sources

Feed manufactures in developing countries should be encouraged to reduce their use of imported feed ingredients and fertilizers by fostering, through outreach and training opportunities, the use of locally available feed ingredients.

Special focus on small-scale farmers and aquafeed producers

There is an urgent need to assist and train those resource-poor farmers who use farm-made and semi-commercial aquafeeds, not only to minimize the use of unnecessary feed additives and chemicals (including antibiotics) but also to improve feed management techniques. Farm-made feeds need to be improved through research and development (R&D) programmes focusing on factors such as ingredient quality, seasonal variability, marketing and storage, and improvements in processing technology. These R&D efforts need to be supported by improved extension services. There is also a need for support services that can help improve and build the production processes and capacity of small-scale aquafeed producers.

Minimizing the environmental impact of feeds and feeding regimes

An effort to minimize the environmental impact of feeds and feeding regimes may include: (i) the use of highly digestible feed ingredients; (ii) the selection of a mix of species so that one or more species can benefit from the nutrient waste streams produced by other species inhabiting the same aquatic milieu; and (iii) culture of fish under closed biofloc-based zero-water exchange culture conditions.[25]

Diversification of feed and fertilizer resources

There should be a greater effort to promote the diversified utilization of feed and fertilizer resources through research, extension and information on the nutritional requirements of farmed species and the nutrient content of the available feed materials.

Global guidelines on ecolabelling and certification in capture fisheries and aquaculture

INTRODUCTION

Ecolabelling and certification schemes are increasingly being used in the global trade and marketing of fish and fish products. The visible signs of these schemes are labels that those adhering to the schemes may place on the products they offer for sale. The label guarantees that the product originates in capture fisheries and/or aquaculture enterprises that are sustainably managed and/or that adhere to criteria reflecting social and cultural values deemed important by the scheme's originators. In this manner, consumers can promote sustainable resource use through the purchase of labelled products; or, as this is sometimes expressed, ecolabels and certification schemes use market forces to incentivize more responsible use of physical and human resources.

Large-scale retailers and food services now drive the demand for certification of both aquaculture and capture fishery products in relation to food safety and quality, sustainability and social criteria.[26] The presence of an ecolabel, for example, helps retailers and brand owners meet the growing consumer demand for products originating from sustainably managed fisheries. In some markets, retailers look for niche products that are certified as organic fish, or for a degree of social responsibility in the production systems and practices.

In addition, ecolabels and certification help retailers by ensuring that the products delivered by a range of certified international suppliers, at times operating in different continents, are standardized in terms of sustainability, food safety, quality and traceability depending on the specific ecolabel or certification.

FAO Members first discussed ecolabels in 1996 at a meeting of the FAO Committee on Fisheries (COFI). Several Members expressed concerns at the emergence of ecolabelling schemes and especially that they could become non-tariff barriers to trade. In 1996, there was no consensus that FAO should become substantively involved.

However, in keeping with its mandate to monitor developments in world fisheries and aquaculture, FAO continued to assemble information on ecolabelling and certification schemes. In particular, information was assembled regarding:

- environmental sustainability;
- food safety and quality;
- human well-being;
- animal welfare.

Drawing on this information, FAO organized a first Technical Consultation in 1998 to investigate the possibility of developing guidelines on the ecolabelling of fish and fish products. The Technical Consultation[27] did not reach agreement on FAO's role in developing such guidelines, except to concur that any future guidelines should be consistent with the FAO Code of Conduct for Responsible Fisheries (the Code), and that FAO should not be directly involved in the actual implementation of any ecolabelling scheme. However, in the absence of global initiatives to standardize the development of the use of ecolabelling and certification schemes in fisheries and aquaculture, and with a growing number of such schemes, COFI agreed in 2003 that FAO should develop guidelines on ecolabelling.[28]

Since then, FAO has developed the following guidelines:

- Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries (Marine Guidelines), 2005/2009;[29]
- Guidelines for the Ecolabelling of Fish and Fishery Products from Inland Capture Fisheries (Inland Guidelines), 2011;[30]
- Guidelines on Aquaculture Certification (Aquaculture Guidelines), 2011.[31]

The FAO COFI Sub-Committee on Fish Trade has recently discussed a draft "Framework for assessment of ecolabelling schemes in inland and marine capture fisheries" (February 2012).

THE MARINE GUIDELINES

The Marine Guidelines were adopted in 2005. Focusing on issues related to the sustainable use of fisheries resources, they are of a voluntary nature and applicable to ecolabelling schemes designed to certify and promote labels for products from well-managed marine capture fisheries. They contain principles, general considerations, terms and definitions, minimum substantive requirements and criteria, and procedural and institutional aspects.

The principles require that any ecolabelling scheme should be consistent with relevant international law and agreements, including the 1982 United Nations Convention on the Law of the Sea, the Code, and WTO rules and mechanisms. They also require that ecolabelling schemes should be market-driven, transparent and non-discriminatory, including by recognizing the special conditions applying to developing countries.

The Marine Guidelines were revised in 2009 to take into account a request by COFI that FAO should review and provide more guidance on the general criteria in relation to "stock under consideration" and to serious impacts of the fishery on the ecosystem. The revised guidelines call for the minimum substantive requirements and criteria of ecolabelling schemes to include the following elements:

- The fishery is conducted under a management system that is based on good practice, including the collection of adequate data on the current state and trends of the stocks and based on the best scientific evidence.
- The stock under consideration is not overfished.
- The adverse impacts of the fishery on the ecosystem are properly assessed and effectively addressed.

Furthermore, the procedural and institutional aspects of ecolabelling schemes should encompass:

- the setting of certification standards;
- the accreditation of independent certifying bodies;
- the certification that a fishery and the chain of custody of its products are in conformity with the required standards and procedures.

In the light of improved capacity to farm marine fish and the need for increased food from aquatic ecosystems, stock enhancement and the use of introduced species may become more common management interventions also in the marine environment. The Marine Stewardship Council has recently addressed species introductions and enhancements in its ecolabelling scheme[32] and developed policy on when such fisheries would be within the scope thereof. Currently, without revising the Marine Guidelines, it would not be possible to assess whether the scheme operated by the Marine Stewardship Council would comply with the Marine Guidelines when assessing enhanced marine fisheries or those marine fisheries based on introduced species. Because FAO is developing benchmarks to assess whether private schemes comply with these guidelines, consideration may need to be given to revising the Marine Guidelines in order to address explicitly the issues of stock enhancement and species introductions.

THE INLAND GUIDELINES

When adopting the Marine Guidelines in 2005, the Twenty-sixth Session of COFI requested that FAO also prepare guidelines on the ecolabelling of fish and fishery products from inland capture fisheries (Inland Guidelines). The Inland Guidelines are similar to the Marine Guidelines in all aspects except for some differences in scope.

During development of the Inland Guidelines, it became clear that the use of enhancement is common in inland fisheries. However, there are several different forms of enhancement, and some may be more appropriately considered forms of aquaculture than forms of capture fisheries. It became evident that not all enhanced fisheries could be subject to the Inland Guidelines.

Enhanced fisheries are those "that are supported by activities aimed at supplementing or sustaining the recruitment of one or more aquatic organisms and raising the total production, or the production of selected elements of a fishery, beyond a level which is sustainable by natural processes. Enhancement may entail stocking with material originating from aquaculture installations, translocations from the wild and habitat modification."[33]

Enhancement practices range from minor interventions either in the flow of water and/or in a flora or fauna, to highly controlled aquaculture systems that release animals into semi-natural environments. Thus, there is a need to define carefully the scope of fisheries eligible for an ecolabel in regard to, *inter alia*, the relationship between the type of enhancement activities or production system and the intent of management with respect to the "stock under consideration".

FAO declared that the characteristics and management of the "stock under consideration" would decide whether or not the enhanced fisheries would fall within the scope of the Inland Guidelines. It also declared that to be within the scope of the Inland Guidelines, enhanced fisheries must meet the following criteria:

- The species are native to the fishery's geographic area or were introduced far back in time and have subsequently become established as part of the "natural" ecosystem.
- There are natural reproductive components of the "stock under consideration".
- The growth during the post-release phase is based upon food supply from the natural environment, and the production system operates without supplemental feeding.

Enhanced fisheries may comprise naturally reproductive components and components maintained by stocking. The overall enhanced fishery should be managed in such a way that the naturally reproductive components are managed in accordance with the provisions of Article 7 of the Code. The management system of enhanced fisheries should permit a verification that proves that stocking material originating from aquaculture facilities meets the provisions of Article 9 of the Code.

FAO concluded that culture-based fisheries, specifically, those supported solely by stocking (i.e. with no associated management intent to sustain the natural reproduction components and capacity of the "stock under consideration"), would not fall within the scope of the Inland Guidelines.

In 2010, an FAO Expert Consultation[34] recommended that guidelines on culture-based fisheries could be developed either by using the aquaculture certification guidelines or by establishing a separate set of certification guidelines for this category of enhanced fisheries.

Another difference between the Marine Guidelines and Inland Guidelines regarding scope is the approach to ecolabelling fisheries based on introduced species. There are circumstances where countries with depauperate inland fauna or modified aquatic ecosystems may wish to introduce new species to increase production and value from these systems. Although international guidelines and risk assessment exist to help make responsible introductions, FAO felt that the application of guidelines, risk assessment and subsequent monitoring and enforcement were not sufficiently established to ensure adequate protection of inland aquatic ecosystems. Therefore, inland fisheries based on new species introductions would fall outside the scope of the Inland Guidelines and only inland fisheries on species introduced "historically" would be eligible for ecolabelling.

THE AQUACULTURE GUIDELINES

In 2011, the Twenty-ninth Session of COFI approved the FAO Technical Guidelines on Aquaculture Certification (Aquaculture Guidelines). While endorsing the guidelines, COFI recognized the existing standards and guidelines set by international organizations such as the World Organisation for Animal Health for aquatic animal health and welfare, the Codex Alimentarius Commission for food safety, and the International Labour Organization for socio-economic aspects. However, in the absence of a precise international reference framework for the implementation of some of the specific minimum criteria contained in the Aquaculture Guidelines, COFI recognized the importance of developing appropriate standards in order to ensure that aquaculture certification systems do not become unnecessary barriers to trade. It noted the necessity for the certification systems to remain consistent with and to comply with the provisions contained in the SPS Agreement and the TBT Agreement of the WTO. In addition, COFI also recommended that FAO develop an evaluation framework to assess the conformity of public and private certification schemes with the Aquaculture Guidelines.

The Aquaculture Guidelines provide guidance for the development, organization and implementation of credible aquaculture certification schemes. Minimum substantive criteria for developing aquaculture certification standards are provided for: (i) animal health and welfare; (ii) food safety; (iii) environmental integrity; and (iv) socio-economic aspects. The extent to which a certification scheme seeks to address the issues depends on its objectives. Therefore, the scheme should explicitly and transparently state its objectives. The Aquaculture Guidelines, which apply to voluntary certification schemes, are to be interpreted and applied in a manner consistent with their objectives, with national laws and regulations, and, where they exist, with international agreements.

The Aquaculture Guidelines make it clear that credible aquaculture certification schemes have three main components: standards, accreditation and certification. Therefore, the Aquaculture Guidelines cover: (i) standard-setting processes, which are needed to develop and review certification standards; (ii) accreditation systems, which are needed to provide formal recognition to a qualified body to carry out certification; and (iii) certification bodies, which are needed to verify compliance with certification standards.

The Aquaculture Guidelines recognize the fact that responsible development of aquaculture depends on social, economic and environmental sustainability, all of which have to be addressed. They also recognize that there is an extensive national and international legal framework in place for various aspects of aquaculture and its value chain, covering issues such as aquatic animal disease control, food safety and conservation of biodiversity.

The Aquaculture Guidelines recommend that developers of certification schemes should recognize that it is of vital importance that those who implement them are able both to measure the performance of aquaculture systems and practices and to assess conformity with certification standards.

EVALUATION FRAMEWORK

In 2009, COFI asked FAO to develop an evaluation framework to assess whether private or public ecolabelling schemes were in conformity with the Marine Guidelines. This followed earlier discussions in both COFI and the COFI Sub-Committee on Fish Trade regarding whether FAO could, or should, verify the correctness of claims being made by ecolabelling schemes that they complied with the Marine Guidelines. The advice from COFI to FAO was not to monitor the compliance actively, but instead to develop an evaluation framework for assessing whether private or public ecolabelling schemes for marine fisheries were in conformity with the Marine Guidelines. Such a framework would provide a transparent tool that could allow national ecolabelling schemes to be assessed against the Marine Guidelines. Schemes found to be consistent with the Marine Guidelines could then be considered equivalent to any other scheme that conforms to the Marine Guidelines.

In 2010, FAO convened an Expert Consultation that produced an evaluation framework. The evaluation framework identified indicators to permit an assessment of conformity with the Marine Guidelines and the Inland Guidelines. A total of 115 indicators were identified, 6 of which only apply to inland fisheries. At present, the assessment process enables the evaluator to determine whether a scheme conforms with the indicators identified in the evaluation framework, but only on a pass or fail basis. Complete conformity is possible only where all indicators have been included in the scheme being assessed. The evaluation framework was submitted to the COFI Sub-Committee on Fish Trade in February 2012 for discussion and subsequent forwarding to the Thirtieth Session of COFI (scheduled for July 2012).

Programmes to develop ecolabelling schemes have recently been initiated by a number of States, e.g. Iceland Responsible Fisheries (Iceland), and the California Sustainable Seafood Initiative and Alaska FAO-based Responsible Fisheries Management Certification (both in the United States of America). These initiatives have been partially driven by concerns about the costs associated with private ecolabelling schemes. However, public schemes may be perceived as self-serving. National administrations could be seen as certifying themselves, running the risk of being accused of a conflict of interest. Nonetheless, those national ecolabelling schemes assessed as being in compliance in the evaluation framework would significantly increase their legitimacy and the likelihood of receiving national and international recognition.

REMAINING ISSUES

Ecolabels and certification schemes arose in response to concerns for environmental sustainability and a perceived decline in the abundance of many of the world's major fish stocks. Owing to heightened consumer awareness and interest in environmental issues, it became clear that ecolabels and certification schemes could improve access to certain markets and provide a price premium for fish or fish products. It appears that ecolabelling and certification schemes have resulted in increased market share and price for some fisheries and suppliers. However, such a result is not guaranteed. For example, one study has shown that some certified coffee growers have become poorer in relation to conventional growers.[35] More studies are needed to know when a fishery should attempt to obtain an ecolabel or certification in order to increase profitability.

The efficacy of ecolabelling or certification as tools for improving the status of fisheries, i.e. changing poorly managed fisheries into well-managed ones, has not been well established. It is not clear how many of the concerned fisheries were poorly managed prior to the introduction of ecolabelling. Moreover, the question is still unanswered as to whether market forces in practice help to conserve aquatic resources. However, the onus is increasingly on suppliers to verify that their products meet certain standards, and certification provides this "burden of proof" (for further discussion of this issue, readers are referred to the publication on which this article is based[36]).

The OECD–FAO Agricultural Outlook: chapter on fish[37]

THE MODEL

Outlook models are very valuable for obtaining a good understanding on perspectives of developments in the sector they analyse. They are an important tool for providing organizations such as FAO and the Organisation for Economic Co-operation and Development (OECD), their Members and the international community with relevant information for developing strategic responses to emerging challenges. Internally, outlook studies can also help to highlight work priorities and to develop an overview of major challenges facing the organization.

Notwithstanding the importance of the fishery sector and its essential role in the livelihoods of millions of people around the world as a source of food, creator of employment, and contributor to economic growth and development, until 2010 FAO did not have a specific outlook model for fish on a short-term, medium-term or long-term perspective. Therefore, FAO decided to develop such a model to analyse the outlook of the fisheries and aquaculture sector in terms of future production potential, projected demand for fisheries products, consumption, prices and key factors that might influence future supply and demand.

It was considered important not to develop an isolated fish model but instead one integrated in the overall structure of an already existing and valid agricultural model, the OECD–FAO AGLINK–COSIMO Projection System, in view of the links and interactions of the fisheries and agriculture sectors. Fisheries, and in particular aquaculture, interact in several ways with agriculture. One evident example is in integrated farming, but more important is their impact on ecosystems, markets, products and prices, as well as on innovations and technology. Competition between the fishery sector and agriculture and livestock may arise over water and land resources, especially for irrigated agriculture, as well as in relation to the availability and relative efficiency of the use of feeds between livestock and farmed fish. Capture fisheries play an important role also in terms of the production of fishmeal and fish oil, which are used as feed in aquaculture and in the diets of pigs, poultry, ruminants and companion animals. With the expansion of aquaculture, supplies of fishmeal have been largely directed to this sector. The growth of the aquaculture sector has also led to increasing demand for additional or substitutive sources of feed. Raw materials from agriculture and livestock, used traditionally to feed livestock, are being increasingly employed in the aquaculture sector. Continued growth in demand for livestock and fish has raised alarm over the sustainability of feed supplies, in particular for fishmeal, and the impacts of such growth on the environment.

The OECD–FAO AGLINK–COSIMO Projection System is one of the most comprehensive partial equilibrium models for the analysis of international agriculture and food markets. The model is used to generate medium-term projections on annual supply, demand and prices for selected agricultural commodities. Non-agricultural markets, including fish, are not modelled and are treated exogenously within the projection system. The overall design of the model focuses in particular on the potential influence of agriculture and trade policies on agricultural markets in the medium term. The model is one of the tools used in the generation of the baseline projections underlying the *OECD–FAO Agricultural Outlook* publication presenting projections and related market analysis for some 15 agricultural products over a ten-year horizon. The modelling framework was started by the OECD in the early 1990s through the development of its AGLINK model, an economic model of world agriculture with very detailed agriculture sector representation of OECD countries as well as of Argentina, Brazil, China and the Russian Federation. Since 2004, this modelling system has been greatly enhanced through the development by FAO of a similar agricultural model – COSIMO – representing the agriculture sectors of a large number of developing countries. For many countries, agriculture policies are specifically modelled within AGLINK–COSIMO. This makes the model a powerful tool for forward-looking analysis of domestic and trade policies through the comparison of scenarios of alternative policy settings against the benchmark of the baseline projections.[38]

In view of the importance and validity of the AGLINK–COSIMO modelling system, FAO, with the collaboration and agreement of the OECD and FAO Secretariats for AGLINK–COSIMO, decided to construct a satellite model on fish and fishery products, which has links to, but is not integrated into, the AGLINK–COSIMO model used for the agriculture projections. Being a satellite, it has been built following the same general principles used to build the AGLINK–COSIMO modelling system in order to facilitate its eventual integration. Since their creation, the AGLINK and then the COSIMO models have increased their size and coverage. The inclusion of the fishery component might represent an opportunity for the model to expand the coverage of food consumption, including an alternative and competitive source of food and protein, as well to expand the coverage of the oil and feed markets in order to have a better picture of the food and feed sectors.

The fish model is a dynamic, policy-specific, partial-equilibrium one. It contains 1 100 equations and covers the same 56 countries and regions as AGLINK–COSIMO with 42 of these countries endogenous as well as 5 continents and a world total. There are two types of supply functions: capture and aquaculture. Supply of capture fisheries can be exogenous or endogenous, but only affected by El Niño events, or endogenous but responding to price. For aquaculture, 99 percent of the total world is endogenous and responding to the price of output and the price of feed. Supply of fishmeal and fish oil consists of two components: from crushed whole fish (reduction) and from fish residues. Demand is for aggregate fisheries, but it is split according to three end uses: food, processed into fishmeal and fish oil, and other uses (kept exogenous). There are three links between the fishery and the agriculture markets: on the demand side through the substitution between fish and other animal products, through the amount of feed demanded by aquaculture, and through the interaction between fishmeal and fish oil and their respective oilseed substitutes.

In 2011, for the first time the OECD–FAO Agricultural Outlook publication (*OECD–FAO Agricultural Outlook 2011–2020*) included a separate chapter on fish, illustrating the main results of the fish model. The fish chapter was also incorporated in the 2012 edition, which covers projections for the period 2012–2021. Both chapters give a brief overview of the present situation of the fishery sector on production, trade and consumption. They then analyse the main results of the fish model, giving a plausible scenario in a ten-year horizon of what can be expected to happen under a certain set of assumptions, such as the macroeconomic environment, international trade rules and tariffs, frequency and effects of El Niño phenomena, absence of abnormal fish-related disease outbreaks, fishery quotas, longer-term productivity trends and the non-appearance of market shocks. These assumptions portray a specific macroeconomic and demographic environment that shapes the evolution of demand and supply for agricultural and fish products. Should any of these assumptions change, the resulting fish projections would be affected. Therefore, the chapters also illustrate the main issues and uncertainties that might affect the fishery sector and, as a consequence, the projections.

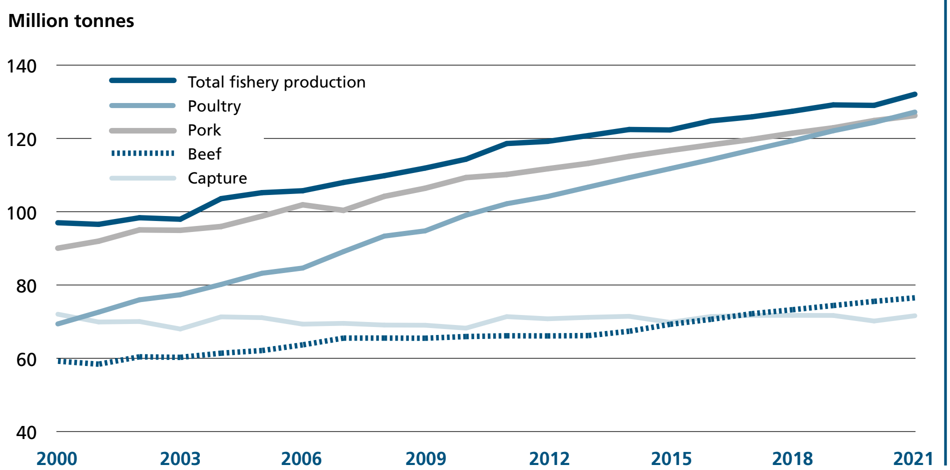
The main outcomes of the latest projections[39] included in the *OECD–FAO Agricultural Outlook 2012–2021* (publication date: June 2012) are summarized below.

PROJECTIONS 2012–2021

Stimulated by higher demand for fish, world fisheries and aquaculture production is projected to reach about 172 million tonnes in 2021, a growth of 15 percent above the average level for 2009–11. The increase should be mainly driven by aquaculture, which is projected to reach about 79 million tonnes, rising by 33 percent over the period 2012–2021 compared with the 3 percent growth of capture fisheries. However, a slowing in aquaculture growth is anticipated, from an average annual rate of 5.8 percent in the last decade to 2.4 percent during the period under review. This decline will be mainly caused by water constraints, limited availability of optimal production locations and the rising costs of fishmeal, fish oil and other feeds. Notwithstanding the slower growth rate, aquaculture will remain one of the fastest-growing animal food-producing sectors. Thanks to its contribution, total fisheries production (capture and aquaculture) will exceed that of beef, pork or poultry

Figure 44

Meat and fishery production, dressed weight or eviscerated basis



Notes: Total fishery production = capture + aquaculture. Beef and pork on a dressed-weight basis; poultry and fish on an eviscerated basis.
Sources: OECD and FAO Secretariats.

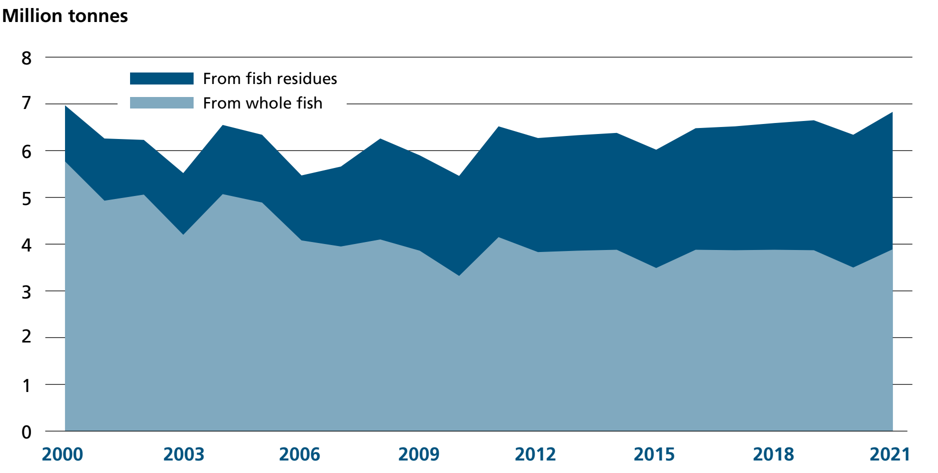
(Figure 44). Products derived from aquaculture will contribute to an increasing share of global fishery production, growing from 40 percent on average in 2009–2011 to 46 percent in 2021. Aquaculture production is expected to continue to expand on all continents, with variations across countries and regions in terms of the product range of species and product forms. Asian countries will continue to dominate world aquaculture production, with a share of 89 percent in 2021, with China alone representing 61 percent of total production.

The portion of capture fisheries used to produce fishmeal will be about 17 percent by 2021,[40] declining by 6 percent compared with the 2009–2011 average owing to the growing demand for fish for human consumption. In 2021, fishmeal production should be 15 percent higher compared with the 2009–2011 average,[41] but almost 87 percent of the increase will derive from improved use of fish waste, cuttings and trimmings. Growing income and urbanization will entail an increasing consumption of fish in fillets or prepared and preserved forms, thus creating more residual production to be used in fishmeal manufacturing. Fishmeal produced from fish waste should represent 43 percent of world fishmeal production in 2021 (Figure 45).

The fish sector is expected to enter into a decade of higher prices, but also higher production costs (Figure 46). The main drivers will be the underlying positive trend in demand, income and population growth, increasing meat prices, a generally weak US dollar and limited growth of capture fisheries production, as well as rising costs for some of the most important input factors such as energy, including crude oil and feed. In particular, as a consequence of slightly declining capture fisheries for reduction and a preference for fishmeal and fish oil in the production of certain animals, prices for fishmeal and fish oil are expected to grow by about 59 percent and 55 percent, respectively, in nominal terms during the projection period. Against the backdrop of stagnant supplies, increasing demand is expected to lead to an increase in the price ratio of fish to oilseed meal and oil, especially in assumed years of El Niño events. The impact of the coarse grain price on the price of aquaculture products will continue to be relatively modest, although it is expected to increase somewhat over the period 2012–2021. The price ratio of aquaculture compared with fishmeal will gradually stabilize over the period under review. Owing to the rising prices of fishmeal, fish oil and other feeds, the average price of farmed species should increase by slightly more

Figure 45

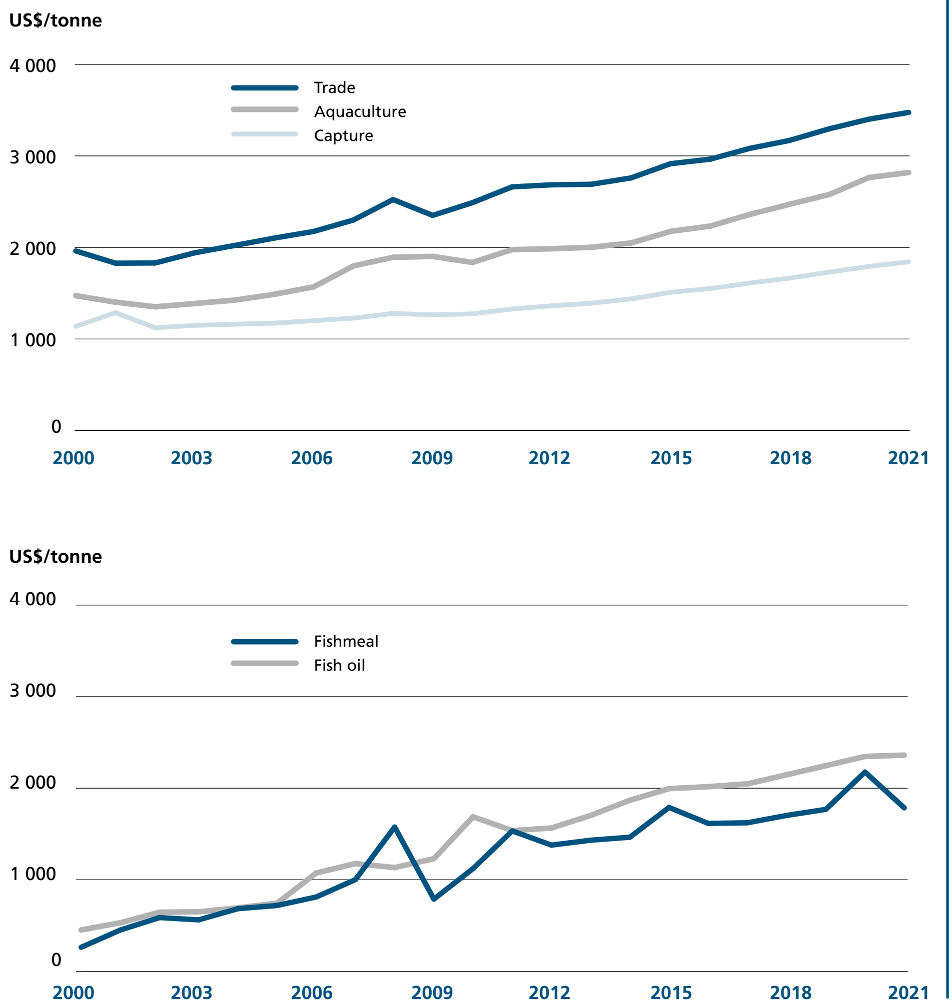
Fishmeal production in product weight



Sources: OECD and FAO Secretariats.

Figure 46

General growth in fish prices for high feed costs and strong demand, nominal terms



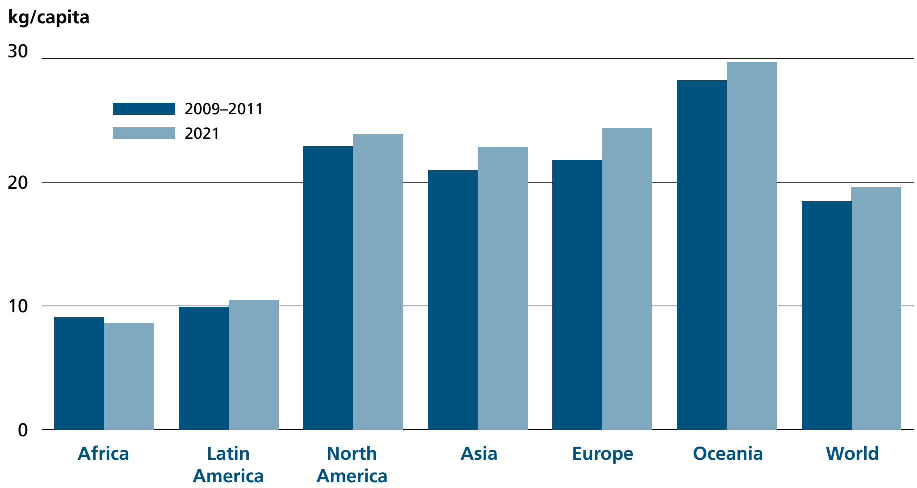
Sources: OECD and FAO Secretariats.

than that for capture fisheries (excluding fish for reduction), by 48 percent compared with 43 percent, in the next decade. Higher prices for substitutes, meat in particular, will stimulate demand for fish and fishery products for human consumption. This in turn, will increase fish prices, which will encourage more aquaculture production, in particular in developing countries, for export as well as for local and regional consumption.

World per-capita apparent fish consumption is expected to reach 19.6 kg in 2021, 16 percent higher than the average level for 2009–2011. The average annual growth rate will be lower in the second half of the projection period, when fish will start to become more expensive than red meats. Owing to high fish prices, fish consumption growth is projected to slow to 0.3 percent per year over the projection period, compared with 1.7 percent per year in the previous decade. Per capita fish consumption will increase in all continents (Figure 47), except in Africa (owing to population growing faster than supply), with Oceania showing the highest growth rate. Products derived from aquaculture will contribute to an increasing share of global fishery supply

Figure 47

Per capita fish consumption



Sources: OECD and FAO Secretariats.

for human consumption. By 2018, farmed fish is expected to exceed captured fish for human consumption for the first time, and its share is projected at 52 percent in 2021 (Figure 48).

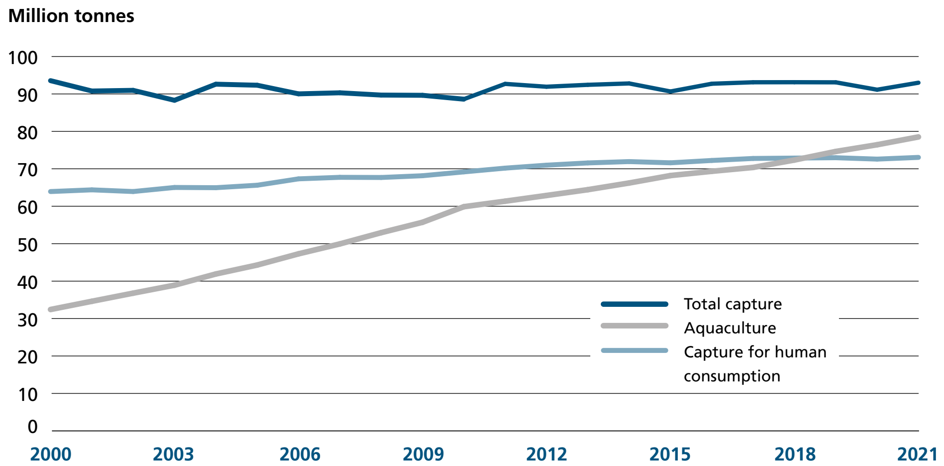
Fisheries supply chains will continue to be globalized, with a significant share of total fishery production being exported (39 percent, including intra-European Union trade). In quantity terms, world trade of fish for human consumption is expected to expand by 25 percent in the period 2012–2021. However, the annual growth rate of exports will decline from the 3.6 percent of the past decade to 1.9 percent over the next ten years. The share of developed countries in world fish imports for human consumption will fall from 59 percent to 56 percent in next decade. This will mainly be because of the growing imports by developing countries for domestic consumption as well as of unprocessed fish as raw material for their processing industries. Developing countries will continue to account for about 67 percent of world exports. Exports will be driven by Asian countries, which remain very competitive and are expected to benefit from growing investment in the aquaculture sector. In 2021, 55 percent of world fish exports for human consumption will originate from Asia, with China as the world's leading exporter.

The main issues and uncertainties that might affect the fishery sector and, as a consequence, the projections are summarized below.

The next decade is likely to see major changes in the macroeconomic environment, international trade rules and tariffs, market characteristics, resources and social conduct. Their effects may influence fish markets in the medium term. Climate change impacts may also bring increasing uncertainty in many food sectors and might represent a compounding threat to the sustainability of capture fisheries and aquaculture development. These possible events take place in the context of other global social and economic pressures on natural resources and ecosystems, including environmental degradation and increasing land and water scarcity. New climate adaptation approaches will probably have to be integrated into the processes of improving fisheries governance. Action may also be required to secure conservation of aquatic ecosystems and safeguard stocks and productivity through technological innovation, investment in research and development (R&D), and a more closely controlled approach to fisheries management. Moreover, increased risks of species

Figure 48

Fishery production in live weight equivalent



Source: OECD and FAO Secretariats.

invasions and the spread of diseases raise additional concerns. Fish diseases could have major impacts on supply, demand and trade in domestic and international markets, as resulting trade restrictions might alter markets for extended periods.

Considerable benefits can accrue from rebuilding fisheries, an urgent task that is high on the international policy agenda. The OECD Committee for Fisheries decided to contribute to efforts by its Member States to rebuild their fisheries, where needed, by providing an analysis of the main policy issues. The focus was on rebuilding fisheries, which is a broader approach than rebuilding fish stocks, and took into consideration the social, economic and environmental dimensions. The outcome of this project, the study *The Economics of Rebuilding Fisheries*, is a set of principles and guidelines that help policy-makers in their rebuilding efforts, taking into account the economic and institutional aspects.[42] These practical and evidence-based principles and guidelines aim to ensure that rebuilding plans are examples of good governance, which implies inclusiveness, empowerment, transparency, flexibility and predictable sets of rules and processes. Rebuilding of fisheries may imply a change in fisheries management settings and reform towards the use of market-based instruments. The principles and guidelines have been adopted as an OECD Council Recommendation.

As production from capture fisheries has remained virtually constant, further aquaculture growth will be needed to meet the rising global demand for seafood. However, many constraints might affect the production prospects for this sector. They include the growing scarcity of water and limited opportunities for sites for new operations given the multiple users of coastal and riparian areas, the carrying capacity of the environment for nutrient and pollution loading and a less permissive regulatory environment. Unless guided and monitored adequately, aquaculture expansion may contribute to environmental problems, including degradation of land and marine habitats, chemical pollution, endangering biodiversity through escapees, and reduction of fish resistance to diseases. Inadequate biosecurity measures and disease outbreaks could also cause large economic losses to the sector. Meeting the future demand for food from aquaculture will also depend on the availability of inputs, including fish seeds[43] as well as of feeds in the requisite quality and quantities. Continued progress in developing terrestrially sourced substitutes for fishmeal and oils will help support continued growth in aquaculture.

Consumer concerns related to issues such as animal welfare, food quality, production and processing methods may cause further uncertainties in the fish sector. Especially in the more affluent markets, consumers are increasingly requiring high standards of quality assurance and demanding guarantees that the fish they purchase are produced sustainably. The stringent quality- and safety-related import standards, together with requirements for products meeting international animal health and environmental standards and social responsibility requirements, might act as barriers to small-scale fish producers and operators attempting to penetrate international markets and distribution channels. Future prices might be influenced not only by higher feed prices but also by the introduction of more rigorous regulations on the environment, food safety, traceability and animal welfare.

NOTES

1 Windle, M.J.S., Neis, B., Bornstein, S. and Navarro, P. 2006. *Fishing occupational health and safety: a comparative analysis of regulatory regimes* [online]. St. John's, Canada, SafetyNet, Memorial University of Newfoundland. [Cited 6 December 2011]. www.safetynet.mun.ca/pdfs/CARR.pdf
Wiseman, M. and Burge, H. 2000. *Fishing vessel safety review (less than 65 feet).* St. John's, Canada, Maritime Search and Rescue Newfoundland Region.
Petursdottir, G., Hannibalsson, O. and Turner, J. 2001. *Safety at sea as an integral part of fisheries management*. FAO Fisheries Circular No. 966. Rome, FAO. 39 pp. (also available at www.fao.org/docrep/003/x9656e/x9656e00.htm).
Jensen, O. 1997. Health hazards while fishing in heavy weather. *Occupational and Environmental Medicine*, 54(2): 141.

2 Kaplan, I.M. and Kite-Powell, H.L. 2000. Safety at sea and fisheries management: fishermen's attitudes and the need for co-management. *Marine Policy*, 24(6): 493–497.

3 Lincoln, J. and Knapp, G. (forthcoming). *Synthesis of case studies: effects of fisheries management policies on fishing safety.* FAO Fisheries Circular No. 1073. Rome, FAO.

4 FAO. 1995. *Code of Conduct for Responsible Fisheries.* Rome. 41 pp. (also available at www.fao.org/docrep/005/v9878e/v9878e00.HTM).

5 Op. cit. see note 1, Petursdottir, Hannibalsson and Turner (2001).

6 Op. cit. see note 1, Windle *et al*. (2006, p. 14).

7 Op. cit. see note 1, Wiseman and Burge (2000, p B5).

8 Op. cit. see note 1, Petursdottir, Hannibalsson and Turner (2001, p. 25).

9 National Oceanic and Atmospheric Administration. 2011. National Standard 10 Guidelines: a proposed rule by the National Oceanic and Atmospheric Administration on 04/21/2011. In: *Federal Register* [online]. [Cited 6 December 2011]. www.federalregister.gov/articles/2011/04/21/2011-9718/national-standard-10-guidelines

10 Huss, H.H. 1994. *Assurance of seafood quality*. FAO Fisheries Technical Paper No. 334. Rome, FAO. 169 pp.

11 Huss, H.H., Ababouch, L. and Gram, L. 2004. *Assessment and management of seafood safety and quality*. FAO Fisheries Technical Paper No. 444. Rome, FAO. 230 pp.

12 Ababouch, L. and Karunasagar, I. (forthcoming). *Seafood safety and quality: current practices and emerging issues.* FAO Fisheries and Aquaculture Technical Paper No. 574. Rome, FAO.

13 World Health Organization. 2007. Food safety and foodborne illness. In: *World Health Organization* [online]. [Cited 30 November]. www.who.int/mediacentre/factsheets/fs237/en/index.html

14 The Food Hygiene Regulations include Regulation EC/852/2004, which lays down the general hygiene requirements for all food business operators, and Regulation EC/853/2004, which lays down additional specific requirements for food businesses dealing with foods of animal origin, including live bivalve molluscs and fishery products. Regulation EC/854/2004 lays down the official controls for foods of animal origin. The basis for the Regulations is set down by the General Food Law Regulation EC/178/2002, which provides a framework to ensure a coherent approach in the development of food legislation.

15 FAO. 2011. *Fisheries management. 4. Marine protected areas and fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 4. Rome. 198 pp.

16 Sanders, J.S., Gréboval, D. and Hjort, A., comps. 2011. *Marine protected areas: country case studies on policy, governance and institutional issues*. FAO Fisheries and Aquaculture Technical Paper No. 556/1. Rome, FAO. 118 pp.

17 The term "low-value fish" is preferred to "trash fish".

18 Tacon, A.G.J., Hasan, M.R. and Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects*. FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO. 87 pp.

19 FAO. 2011. FishStat Plus – universal software for fishery statistical time series. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. [Cited 20 December 2011]. www.fao.org/fishery/statistics/software/fishstat/en

20 Typically, a farm-made aquafeed is a feed produced by farmers or small-scale feed manufacturers using some form of processing on-farm or in a small processing plant, resulting in a moist dough or a simple moist or dry pellet.

21 An industrially manufactured compound aquafeed consists of a number of ingredients mixed in various proportions to complement one another to form a nutritionally complete compound diet.

22 De Silva, S.S. and Hasan, M.R. 2007. Feeds and fertilizers: the key to long-term sustainability of Asian aquaculture. *In* M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon, eds. *Study and analysis of feeds and fertilizers for sustainable aquaculture development*, pp. 19–47. FAO Fisheries Technical Paper No. 497. Rome, FAO. 510 pp.

23 Op. cit., see note 19.

24 Rana, K.J., Siriwardena, S. and Hasan, M.R. 2009. *Impact of rising feed prices on aquafeeds and aquaculture production*. FAO Fisheries and Aquaculture Technical Paper No. 541. Rome, FAO. 63 pp.

25 Avnimelech, Y. 2009. *Biofloc technology – a practical guide book.* Baton Rouge, USA, World Aquaculture Society. 181 pp.

26 Washington, S. and Ababouch, L. 2011. *Private standards and certification in fisheries and aquaculture: current practice and emerging issues*. FAO Fisheries and Aquaculture Technical Paper No. 553. Rome, FAO. 181 pp.

27 FAO. 1998. *Report of the Technical Consultation on the Feasibility of Developing Non-Discriminatory Technical Guidelines for Eco-Labelling of Products from Marine Capture Fisheries. Rome, Italy, 21–23 October 1998.* FAO Fisheries Report No. 594. Rome. 29 pp.

28 FAO has concentrated on ISO Type I environmental labels, which are voluntary and based on third-party assessment of the environmental impact of the production system. ISO Type II and Type III ecolabels are self-declared statements of compliance with previously established indices, i.e. no independent confirmation of product claims. Although ISO Type II and Type III are not the subject of FAO guidelines, they are often high-profile types of labels and are becoming increasingly widespread.

29 FAO. 2009. *Guidelines for the Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries. Revision 1. Directives pour l'étiquetage écologique du poisson et des produits des pêches de capture marines. Révision 1. Directrices para el ecoetiquetado de pescado y productos pesqueros de la pesca de captura marina. Revisión 1*. Rome/Roma. 97 pp.

30 FAO. 2011. *Guidelines for the Ecolabelling of Fish and Fishery Products from Inland Capture Fisheries. Directives pour l'étiquetage écologique du poisson et des produits des pêches de capture continentales. Directrices para el ecoetiquetado de pescado y productos pesqueros de la pesca de captura continental*. Rome/Roma. 106 pp.

31 FAO. 2011. *Technical Guidelines on Aquaculture Certification. Directives techniques relatives à la certification en aquaculture. Directrices técnicas para la certificación en la acuicultura*. Rome/Roma. 122 pp.

32 For introductions, see www.msc.org/documents/scheme-documents/msc-scheme-requirements/msc-certification-requirement-v1.1/view [cited 6 February 2012] and for enhancements, see www.msc.org/documents/scheme-documents/msc-scheme-requirements/directives/TAB_D_001_Enhanced_Fisheries.pdf/view [cited 6 February 2012].

33 Op. cit., note 29.

34 FAO. 2010. *Report of the Expert Consultation on the Development of Guidelines for the Ecolabelling of Fish and Fishery Products from Inland Capture Fisheries. Rome, 25–27 May 2010*. FAO Fisheries and Aquaculture Report No. 943. Rome. 37 pp.

35 Beuchelt, T.D. and Zeller, M. 2011. Profits and poverty: certification's troubled link for Nicaragua's organic and fairtrade coffee producers. *Ecological Economics*, 70(7): 1316–1324.

36 Op. cit., note 26.

37 This highlight article is based on the chapter on fish in the most recent edition of the *OECD–FAO Agricultural Outlook: OECD/FAO. 2012*. OECD–FAO Agricultural Outlook 2012. Paris, OECD Publishing. DOI : 10.1787/agr_outlook-2012-en

38 More information on the OECD–FAO AGLINK–COSIMO Projection System is available at www.agri-outlook.org/

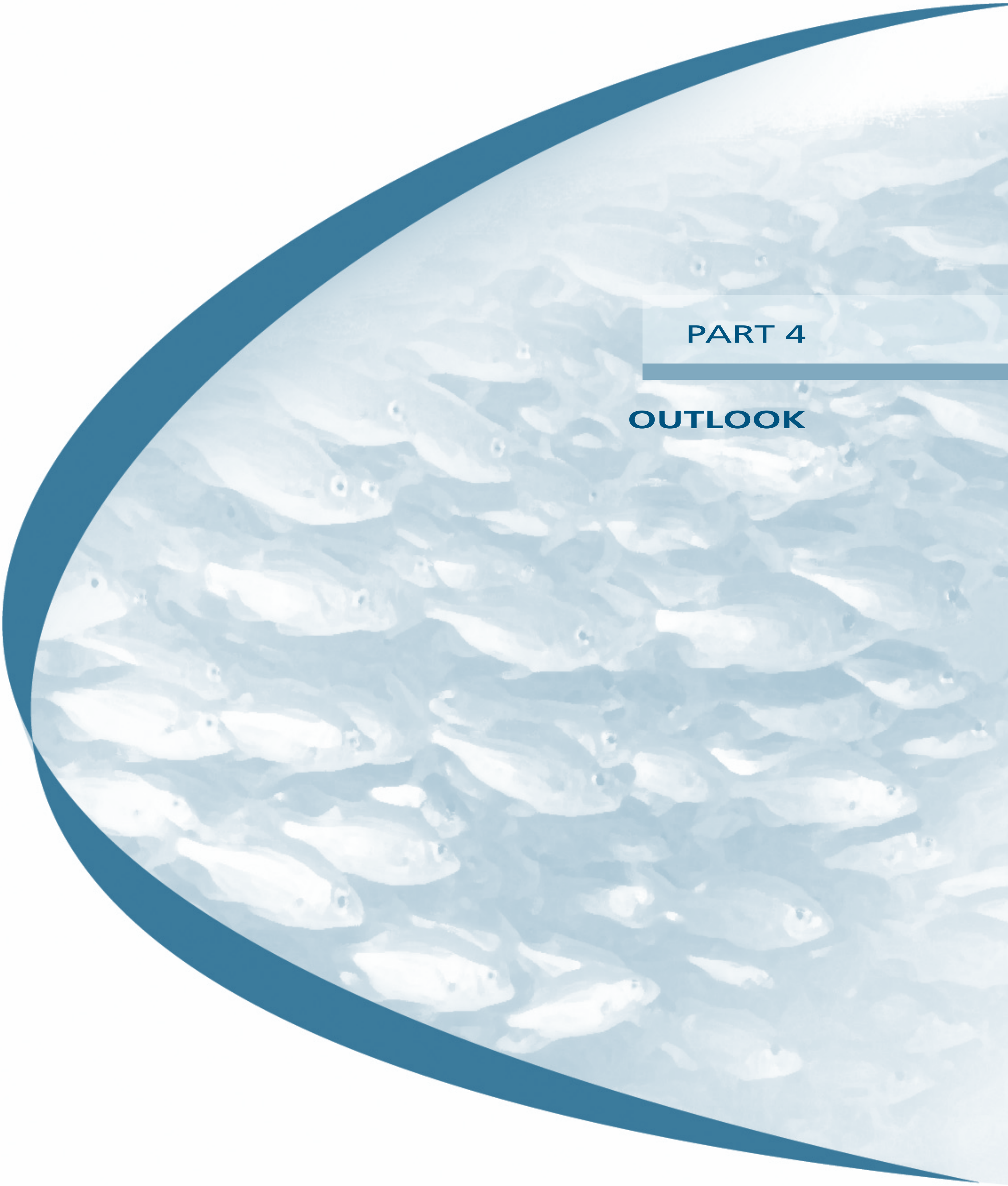
39 The baseline is deterministic and assumes normal weather and production conditions, with the exception of the impact of the El Niño phenomenon set in the model for selected Latin American countries in 2015 and 2020.

40 That share will be lower in years of El Niño events (set in the model in 2015 and 2020) owing to reduced catches of anchoveta.

41 The reference point is low because of the El Niño event in 2010.

42 Organisation for Economic Co-operation and Development. 2010. *The Economics of Rebuilding Fisheries: Workshop Proceedings*. Paris. 268 pp.

43 The term fish seeds indicates eggs, spawn, offspring, progeny or brood of the aquatic organism (including aquatic plants) being cultured. At this infantile stage, seed may also be referred to or known as fry, larvae, postlarvae, spat and fingerlings. They may originate from two principal sources: from captive breeding programmes, or caught from the wild.



PART 4

OUTLOOK

OUTLOOK

The role of capture fisheries in a global sustainable food production system: opportunities and challenges

In recent editions of *The State of World Fisheries and Aquaculture*, the Outlook section has focused on aquaculture (in 2008) and inland fisheries (in 2010). In this Outlook, while not ignoring their importance (aquaculture is highlighted in Part 3 on p. 172), the emphasis is on how developments in capture fisheries in particular can contribute to ensuring a global sustainable food production system.

CONTEXT

A recent major study of the world's food production systems[1] found that they are unsustainable and that, in attempting to improve the present ones, policy-makers face five major challenges:

- balancing future demand and supply sustainably – to ensure that food supplies are affordable;
- ensuring that there is adequate stability in food supplies – and protecting the most vulnerable from the volatility that does occur;
- achieving global access to food and ending hunger;
- managing the contribution of the food system to the mitigation of climate change;
- maintaining biodiversity and ecosystem services while feeding the world.

The study also concluded that policies affecting agriculture should be developed on the basis of assessments of the whole food chain and that these assessments should include judgements of the extent to which food chains contribute to meeting the above five challenges. The study states that actions are required now to ensure that:

- more food is produced sustainably;
- demand for the most resource-intense types of food is contained;
- waste in all areas of the food system is minimized;
- the political and economic governance of the food system is improved to increase the productivity and sustainability of food systems.

Therefore, as a part of the whole, those responsible for capture fisheries (and aquaculture) will be expected to play their part in meeting these challenges, initially by implementing the above actions. The following sections examine how they may address the task and contribute to achieving the goal of a global sustainable food production system.

THE PROSPECTS FOR SUSTAINABLE INCREASED PRODUCTION

The latter half of the twentieth century witnessed widespread expansion of capture fisheries supply, and correspondingly positive social and economic impacts associated with the global availability of high-quality aquatic foods.[2] However, recent decades have been marked by an increasingly uneasy relationship between, on the one hand, the concerns for stock levels and fishing effort, and, on the other, the attempts by commercial fleets and smaller-scale fishers to maintain and improve income and livelihoods. These have interacted with national policy aims of controlling resource access, supporting income and food supply, and meeting local interests in commercial and artisanal fishing, and the related vessel and gear, fishing supplies and post-harvest sectors.[3] Through a combination of inadequate regulatory and monitoring capacity, misguided or misapplied policy aims and interventions, overcapitalization, and short-term profit-seeking by fishing fleets, the global imbalance between stock levels and fishing capacity and effort has grown steadily, and the pressures on key stocks have become increasingly unsupportable.[4] Based on FAO statistics for 1950–2006, the first overview of marine fisheries resources by country confirmed that, globally, the maximum average level of bottom fish and small pelagic fish production had been reached within the final decade. While data were not available to explore fully the relationship between stock status and global landings, data covering some 75 percent of recent landings (1998–2002) showed that 14.1 percent of world production (about 11 million tonnes) came from underexploited or moderately exploited stocks, 57.3 percent (about 41 million tones) from fully exploited stocks, 13.7 percent (about 18.4 million tonnes) from overexploited stocks and 7.6 percent (about 10.2 million tonnes) from depleted or recovering stocks.[5]

These analyses are troubling from a resource exploitation perspective and suggest a global system that is overstressed, reducing in biodiversity and in imminent danger of collapse.[6] However, total capture fisheries output data over this period suggest that under the management regimes in place to date, or in spite of them, the resource system has been surprisingly resilient in terms of output and food value, although harvesting has been increasingly inefficient in terms of catch per unit of effort (CPUE). There is also a strong societal argument for maximizing beneficial use of natural resources, and the clear need for food, which would justify the fullest possible level of harvesting consistent with the ability for these harvests to be sustained. However, there have been specific instances of serious stock collapse, evidence of historically low biomasses of key stocks, increasing awareness of ecosystem interactions and changing balances towards harvesting lower in the food chain. Together with mounting concern for the possible impacts of climate change on ecosystems and dependent communities,[7] these have all combined to build the case for more explicit and increasingly urgent strategies to improve the capture fisheries system and to put in place securely sustainable fisheries.

The biological and ecosystem arguments for change have been widely expressed, and they have also been reflected in growing consumer awareness and concern for purchasing decisions related to sustainable fisheries.[8] An increasingly compelling claim for policy action also arises from the explicit and continuing economic losses associated with the current fishing system. On a 2004 baseline, a joint World Bank and FAO review[9] estimated global losses of net economic benefit of the order of US$50 billion, compared with first sale values of US$80 billion, resulting from a combination of excess capacity and effort, linked with capital and operating-cost subsidies. For 2003, "harmful" subsidies, acting primarily to perpetuate overfishing, were estimated at US$16.2 billion out of a total of US$27 billion a year globally.[10] A simulation of subsidy impacts in North Sea fisheries[11] showed that, while removing subsidies might reduce total catch and revenue, overall profitability would increase, as would the total biomass of commercially important species. A strategy for fisheries reform would be to reduce the capitalization of fleets, reduce vessel numbers, restore depleted stocks, change key practices and improve efficiency by increasing the CPUE, and by devising resource-access and management approaches to bring this about effectively.[12]

The reasons for change and the prescriptions for action exist, and significant moves can be expected in the next two decades to bring more of the world's fisheries into a more recognizably sustainable state. This is also reflected in the growing number of commitments for change,[13] linked also with concerns for effective climate change response.[14] However, as noted by the World Bank/FAO review,[15] fisheries reform would "require broad-based political will founded on a social consensus" with "a common vision that endures changes of governments", which would take time to build. To further define the potential for change and the future share of landings from sustainable fisheries, distinctions can be made between those parts of the global capture fishing system that are:

- unmanaged – including those outside national jurisdictions and/or fished by fleets not under specific flag state control, characterized by illegal unregulated and unreported (IUU) fishing, and with significant potential for catching and discard of non-target species;
- poorly managed, either because of limited capacity or political will, and may be overfished, have high levels of IUU fishing and have negative ecosystem impacts;
- managed relatively well, with definable processes for regulating fishing activity and monitoring outcomes.

The building of political commitment, even in wealthy economies with adequate financial and human resources for effective management, can take time, and in regionally shared waters, as currently evidenced in the European Union process of fisheries reform, interactions can be complex and conflictual. Nonetheless, a number of processes are under way to bring more unmanaged areas under effective international agreement, to improve the effectiveness of poorly managed systems, to increase the numbers of well-managed fisheries, and to strengthen and make more resilient their potential for remaining so.

The FAO Code of Conduct for Responsible Fisheries (the Code) and its associated international plans of action and technical guidelines[16] have an important role in this process, providing a means for establishing political commitment, a structure within which various contributing actions can be implemented, and a basis for support for strengthening management capacity. Although the challenges of implementation can be considerable, a number of initiatives have, together with market incentives, helped to create the prospects of a “virtuous circle” of systems and actions that can significantly improve the prospects of sustainable fisheries. These initiatives include the Global Record of Fishing Vessels, port State measures to define landing locations and recording of catches, global and national initiatives on control of IUU fishing, and strategies for introducing various forms of rights-based approaches to address constraints of managing open-access fisheries.

While there is scope for reducing fishing capacity across the sector, there are particular challenges in small-scale fisheries, which involve large numbers of people, often in very difficult circumstances of poverty and vulnerability.[17] Low costs of entry and operation allow access to income and food for many, and individual fishing impacts are usually relatively modest. However, cumulative effects are potentially very significant, with numerous examples of excess fishing pressure, yet with few other livelihood options[18] to provide alternatives. Approaches based on fishing rights could potentially rationalize effort and improve returns in small-scale fisheries, and increase resource rent at the national level. However, unless the benefits were broadly shared within fishing communities, these could increase vulnerability in the absence of access to alternative livelihoods or other forms of social support.[19] Although various community-based management approaches have been developed and applied, the effectiveness of reconciling sustainable fishing with human needs varies widely with the resource, social and economic context.[20] This aspect of reconciling potentially competing needs is also important in relation to inland fisheries (Box 23).

More positively, across a range of capture fisheries, opportunities may be seen for creating tipping points, which, if well defined and with widely understood ecosystem and social impacts, could bring about an accelerating process of change towards sustainability. Thus, where the costs or other constraints to non-compliance become too great (including sanctions on vessels and fleets and markets, and possible trade or indirect penalties), vessels, fleets and fishing nations may respond more rapidly and definitively. Similarly, where rising fuel costs combine with excess fishing effort, and subsidies are less politically acceptable, incentives will increase for more rational management. The impacts of such change would extend not just to target and bycatch fish stocks but also to secondary impacts such as increased protection for endangered fish, mammalian and avian species. A number of leverage opportunities can be identified – the example already exists for pressures on supermarkets to improve

Box 23

Reconciling sustainable inland fisheries with the needs of other sectors

Although important in many parts of the world, inland fisheries tend to have been overlooked in many development policy perspectives and feature far less in the sustainable fisheries debate. They face significant issues relating not just to fishing pressure but also the impacts of infrastructure development, drainage and land reclamation, continuous or periodic water withdrawals, and water-quality impacts from urban, industrial and agricultural use.[1] Here, the governance of fishing and the associated social impacts are important, and they are now starting to receive more policy attention. However, the achieving of sustainable inland fisheries will also depend on policies and actions in many other sectors, and will require a level of strategic interaction, value trade-offs across specific resource benefits, and a policy response that has yet to be developed. Where there is a convergence of impacts of climate change on hydrological balances, potential increases in related extraction demands for agriculture and other sectors, and greater calls for renewable energy, the case for defending inland fisheries resources and the livelihoods of many millions of dependent people becomes more challenging.

[1] Welcomme, R.L., Cowx, I.G., Coates, D., Béné, C., Funge-Smith, S., Halls, A. and Lorenszen, K. 2010. Inland capture fisheries. *Philosophical Transactions of the Royal Society B*, 365(1554): 2881–2896.

buying practices, and for campaigners to target specific policy issues. Further leverage could also be applied at fleet level, pushing for compliance at the total level of activity (not just in specific fisheries or vessels), and at the national level, whereby all forms of fishing engagement could be made subject to good conduct criteria.

Possible changes by 2030

The current decade and the next are likely to see major changes in economies, markets, resources and social conduct. Climate change impacts will bring about increasing uncertainty in many food sectors, including capture fisheries, and climate adaptation approaches will need to be well integrated with the processes of improving fisheries governance. The size of the shift in balance towards sustainable fisheries will also depend in part on how it will be defined; whether, for example, by conduct (the fishing sector agreeing to specific actions or signing commitments of varying force) or by outcome (where significant measures or indicators are put in place to confirm the consequences of good practice). It will also depend on whether sustainable fisheries are species-based or ecosystem-based, and whether the affirmation of sustainability action or outcome is determined by private-sector monitoring and accreditation or through more broadly defined standards.

Within the policy framework set out by the Code and related instruments, the role of private-sector certification systems, such as those of the Marine Stewardship Council and others, have already been significant in incentivizing better fishing practice and in requiring certification of fleet operations and their management regimes, chain of custody controls and guarantees to customers. However, although their scope has expanded markedly in the last five years, many fisheries are still relatively unconnected with the market or political drivers necessary to create the incentives. There is also substantial scope for misrepresenting the provenance of fish, and, given the cost of certification and the related benefits of market access, the rewards for doing so can be significant. This might only be countered effectively by the widespread availability of rapid diagnostic tools for species or stock identification and by appropriate levels of monitoring. There are notable challenges in moving outside higher-value global markets, where certification has a role in supply chain competition, towards other markets where there may be far less incentive to adopt certification, much less the resources to do so.

With a view to improving estimates of the potential for sustainable capture fisheries, prospects for enhanced fishing regimes can be divided into broad categories. First, there are well-managed national and regional fisheries with management regimes that have undergone considerable improvement in recent years, support sustainable fisheries and have strong prospects for continuing to do so. A second category comprises national and regional fisheries systems undergoing steady improvement as management measures take effect and bring about greater levels of compliance. A further category includes national and regional fisheries with low management capacity and widespread IUU fishing, commonly with complex fisheries and difficult management contexts. A fourth group contains international high seas fisheries, also including deep-sea fisheries, with varying levels of fleet or national management agreement and compliance. In some cases, responsible fishing practice can be incentivized through market pressures, but compliance is at best partial, actions of non-compliant fleets are difficult to sanction, and, in many instances, effective protocols under international law are as yet developing. A final category is that of new fisheries undergoing possible expansion, for which management systems are only emerging. A more detailed assessment of management change potential is yet to be carried out, but based on the earlier estimates of catch status,[21] more than 20 percent of output is related to overexploited, depleted or recovering stocks. A moratorium on fishing for all of these is unlikely, but a concerted approach for change might reasonably be expected to reduce this category to 10 percent (some 14 million tonnes). Similarly, a more significant part of the 41 million tonnes from fully exploited stocks could be subject to more secure regimes, and the 11 million tonnes from underexploited or moderately exploited stocks might be expanded, but this would need to done within a sound management environment.

Policies conducive to an increased share for sustainable fisheries

A number of policy areas can be distinguished, and their potential evolution considered. These can broadly be described as: (i) direct, which specifically affect the way the capture fishing system operates; and (ii) indirect, which change the wider environment in which people, businesses and communities interact, and which can create positive or negative incentives for improving function and behaviour.

Direct policies would include those on resource management and their allocation to specific groups, licensing and regulatory features, capacity development in key agencies, those associated with fuel and energy pricing, capital costs and possible subsidization, and those addressing market management and trade issues (including market access and the use of market sanctions against unsustainable fishing). Where possible, these would be aligned to provide positive incentives for good practice, removal of perverse influences, and adequate deterrence for non-compliance. Although more immediately effective within national jurisdictions, a strong policy environment at the national level can have an important impact on wider application.

A range of indirect policy areas can be noted. Apart from the generic fiscal environment and its effects on investment and earnings, and policies affecting infrastructure investment and maintenance, a number of social policy areas may be relevant. Those addressing broader development issues, including gender and rights, child labour, health, education and social welfare, may help to ease pressures in small-scale fisheries, while various local empowerment policies can provide more positive environments in which community-based management initiatives may be developed.

The clarity and coherence of policies in related sectors will also affect the potential for sustainable fisheries, as noted above in the case of inland fisheries. Climate change response policies with effective resilience building measures are also likely to have an important effect on the stress on capture fisheries systems. Across these policy areas, the role of knowledge and capacity building will be critical, and effective policies for these, including resources for fisheries data and scientific management,[22] will be important.

While policy areas and approaches to support sustainable fisheries can be readily identified, their effective implementation is a particular challenge. There have been too many examples of policy formulation that has been unconnected with action and outcome, or in some cases has resulted in perverse consequences. Where existing practices have to be substantially changed, social and political interests challenged, and previously unconnected issues brought together, considerable thought and effort may be required, building support for action across a range of agents.

CAPTURE FISHERIES AS TARGETS OF EFFORTS TO REDUCE RESOURCE USE AND GREENHOUSE GAS EMISSIONS

Bottom trawling and dredging are likely to become double targets, not just because of their potential damage to seafloor habitats,[23] but because of their relatively high fuel use (and hence greenhouse gas [GHG] output) per quantity of fish landed (see also p. 126). Rising energy costs may possibly limit some of the more extreme cases of high fuel use (e.g. with inefficient gear or low-CPUE characteristics). However, if fuel subsidies are maintained or increased to permit their continuation, this is likely to attract more adverse response from the public and non-governmental organizations (NGOs). More generally, the possibility of structuring fisheries reform so that it eliminates "the race for fish" or reduces overfishing more widely has the potential to deliver "triple win" outcomes – better returns to fishing vessels, healthier stocks, and reduced energy use and GHG output per unit of output. For smaller-scale, less-energy-intensive fisheries, the choices may not be so extreme, but rising energy costs may well limit longer trips for low catches and create longer-term disincentives for overcapacity.

There may be more complex interactions if climate change impacts on stock distribution result in fleets having to travel greater distances and fish wider areas, hence increasing energy use per unit of output, even if stocks are relatively healthy. In such cases, a longer-term monitoring approach would be justified, and the balance of preferred types of fishing gear might change.

A further issue may relate to the whole life-cycle assessment of the fishery in question, as investment in new vessels and gear, and the associated carbon emissions and energy use, will have to be considered. However, if accompanied by greater fuel efficiency, e.g. through improved hull, propeller and gear design, this investment could quickly be recouped.

Policy trade-offs

In many renewable-resource contexts, there is a presumption that secure access rights together with fully costed operating conditions can bring about long-lasting outcomes that are efficient and able to meet wider social objectives. Appropriate valuing of externalities and a transparent process of internalizing these costs will allow producers to select the most effective means of delivering output commensurate with the returns available from marketed products. Such a system can also be used to incorporate compensatory values associated with mitigation, for example through carbon sequestration in aquatic systems. However, there may be wider social and environmental trade-offs; for example, regarding the need for more fish supply, a balance between fuel subsidy and additional output food value. Another example would concern the need to retain communities and rural economies, where it would be necessary to strike a balance between fuel subsidy, local food security, supply into wider markets, and opportunity costs associated with avoiding social breakdown.

Public pressure

The public pressure exerted by NGOs on approaches in fisheries that are more resource and energy efficient will be an important element in change. However, experience across other policy fields has suggested that independent evidence is also essential in targeting the debate towards realistic, broadly supported and effective policy. Therefore, it will be necessary to build support and intent across a range of stakeholders, particularly for more difficult areas of change.

MINIMIZING WASTE

The current discussions about mandatory landing of catch, particularly in the lead-up to the reform of the European Union Common Fisheries Policy, have helped to highlight the dilemmas of quota management in multispecies fishing, the conflicting views of the range of stakeholders,[24] and the increasing role of issue-targeted public campaigns in fisheries policy formulation.[25] It is clear also that, under closer public scrutiny, with valuable local markets much more directly influenced by perceptions of fishing conduct, and with increasing technical means to engage in real-time decision-making on stock conditions and fishing activity, much more flexible, responsive and ecosystem-sensitive fishing could start to become more feasible. The processes of discussion themselves are also important examples of greater openness of debate on such issues, and ideally will lead to more mature, fully reasoned and widely sanctioned management strategies and industry responses. Given the wide diversity of capture fishery systems and management regimes, it is unlikely that mandatory landing of catch will rapidly become the norm. However, the arguments are likely to gain traction, and together with a growing appreciation of the practical aspects of ecosystem approaches to fisheries management,[26] catch landing practice in more fisheries may be expected to follow suit. In many fisheries, particularly multispecies fishing in tropical waters, substantial quantities of bycatch are already being landed and used.

Policies to promote low-impact fuel-efficient fishing strategies

The development of low-impact fuel-efficient (LIFE) fishing is increasingly seen as a practical response to rising fuel costs and concern for ecosystem impacts, potentially delivering gains in fuel use and GHG outputs, improving selectivity and catch value, reducing habitat damage and improving returns (see also p. 134). Regardless of other factors, a primary element in fuel efficiency is that of fish stock status, and improved stock levels and better effort allocation should lead to substantial reductions in fuel use in many fisheries. In the absence of further subsidies, and their possible phasing out, fuel costs alone may start to shift practice in this direction, although a more strategic approach could permit more effective adjustment, and ensure that the interests of more socially dependent groups were adequately addressed. Ideally, these would involve incentives and transfer mechanisms to enable these groups to access and benefit from LIFE strategies with appropriate investment in improving vessels and gear, and in promoting market and other incentives to change. Energy use and GHG mitigation linkages would also be important, and options could be further explored for raising awareness of the significance of the fisheries sector, and for accessing mitigation funding. Were payments to be made for ecosystem services, more stringent monitoring might be required, linked with the development of benchmarks and best practice concepts. Policy approaches would also need to be expanded to demonstrate the wider impacts of LIFE fishing, their linkages into the larger fishery sector supply and value chain,[27] and the means by which LIFE fishing become embedded into normal practice.

IMPROVING GOVERNANCE

In addition to the array of mechanisms for transition to a green economy considered at Rio+20 (see Part 1 sections on Governance and Rio+20), the focus here is on aspects relating to sanctions and small-scale fisheries.

Sanctions

Sanctions for IUU fishing will probably become tougher, to the extent that consensus building for strong and resolute policy action is effective among fishing nations, particularly those engaged in international waters or operating with access agreements or licences. Pressure from international lobbying groups is unlikely to relent, and market sanctions have been shown to have direct effects on a number of fisheries. While IUU fishing remains a serious global challenge, there is increasing evidence that some IUU control measures are starting to "bite", and there is more potential for better regulated fisheries to become the norm.[28] However, sanctions for stock depletions per se may be more difficult to put in place, as the attribution and responsibility issues may be more complex. Nonetheless, as evidenced by the current international concern for management of tuna, particularly for Eastern Atlantic stocks,[29] a range of pressures may be brought to bear on the management agencies and individual countries concerned.

As the capture fisheries sector is not commonly a major part of national economies, and may not receive immediate priority for action, the threat of applying wider trade or other sanctions, e.g. in other sectors or for specific interest groups, can also potentially be effective in addressing non-compliance issues at the national level. However, groups within individual nations wishing to resist compliance, by political or other means, may still attempt to hold back wider and more effective management in more complex resource and exploitation systems. Here, careful and sensitive assessments of the political economy of fishing and its beneficiaries may need to be made, and appropriate mixes of incentives and sanctions through a number of routes may need to be considered, in order to bring about change.

Small-scale fisheries and access to public services

There is widespread evidence that many communities engaged in small-scale fisheries exhibit multiple deprivations with respect to income opportunities, market power, access to land-based resources, political access, and inclusion in public services such as health and education.[30] This poverty and vulnerability nexus leaves little scope for people to give up the immediate possibilities of fishing income, and little opportunity to move away from fishing, either in the shorter term through livelihood diversification or over the longer term through education and skill building. Improving public services and social support will be an important factor in reducing this negative dynamic, and some specific poverty alleviation interventions, such as improved maternal and child health care, or school feeding programmes, can have very positive effects relatively quickly.[31] However, for lasting changes and more stable human–resource relationships, this has to be done as part of an integrated approach, one that also includes a fuller understanding of the role of fishing as a "last resort", the causes and dynamics of people leaving and entering fishing, evolving links between rural and urban populations, markets and economies, and the political weight related to these. Much is now being done within the fisheries sector to raise awareness of the economic and social importance of small-scale fisheries and the need to address wider development issues;[32] the challenge will be to move these more centrally into national economic development agendas and investment strategies.

NOTES

1 Foresight. 2011. *The future of food and farming: challenges and choices for global sustainability*. Final project report. London, The Government Office for Science. 208 pp.

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

3 Hilborn, R. 2007. Defining success in fisheries and conflicts in objectives. *Marine Policy*, 31(2): 153–158.

4 Garcia, S.M. and Grainger, R.J.R. 2005. Gloom and doom? The future of marine capture fisheries. *Philosophical Transactions of the Royal Society B*, 360(1453): 21–46.

5 Garcia, S.M. and Rosenberg, A.A. 2010. Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives. *Philosophical Transactions of the Royal Society B*, 365(1554): 2869–2880.

6 Pauly, D., Watson, R. and Alder, J. 2005. Global trends in world fisheries: impacts on marine ecosystems and food security. *Philosophical Transactions of the Royal Society B*, 360(1453): 5–12.

Worm, B., Barbier, E.B., Beaumont, N., Duffy, J.E., Folke, C., Halpern, B.S., Jackson, J.B.C., Lotze, H.K., Micheli, F, Palumbi, S.R., Sala, E., Selkoe, K.A., Stachowicz, J.J. and Watson, R. 2006. Impacts of biodiversity loss on ocean ecosystem services. *Science*, 314: 787–790.

7 Brander, K.M. 2007. Global fish production and climate change. *Proceedings of the National Academy of Sciences of the United States of America,* 104(50): 19709–19714.

Ficke, A.D., Myrick, C.A. and Hansen, L.J. 2007. Potential impacts of global climate change on freshwater fisheries. *Reviews in Fish Biology and Fisheries*, 17 (4): 581–613.

Cochrane, K., De Young, C., Soto, D. and Bahri, T., eds. 2009. *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge*. Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO. 212 pp.

Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, W.N., Brown, K., Conway, D., Halls, A.S., Pilling, G.M., Reynolds, J.D., Andrew, N. L. and Dulvy, N.K. 2009. Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, 10(2), 173–196.

8 Parkes, G., Young, J.A., Walmsley, S.F., Abel, R., Harman, J., Horvat, P, Lem, A., MacFarlane, A., Mens, M. and Nolan, C. 2010. Behind the signs – a global review of fish sustainability information schemes. *Reviews in Fisheries Science*, 18(4): 344–356.

9 World Bank and FAO. 2009. *The sunken billions: the economic justification for fisheries reform*. Washington, DC, The World Bank, and Rome, FAO. 100 pp.

10 Sumaila, U.R., Khan, A.J., Dyck, A., Watson, R., Munro, G., Tyedmerset, P. and Pauly, D. 2010. A bottom-up re-estimation of global fisheries subsidies. *Journal of Bioeconomics*, 12(3): 201–225.

11 Heymans, J.J., Mackinson, S., Sumaila, U.R., Dyck, A., Little, A. 2011. The impact of subsidies on the ecological sustainability and future profits from North Sea fisheries. *PLoS ONE*, 6(5): e20239 [online]. [Cited 31 March 2012]. www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0020239

12 Leal, D.R., ed. 2010. *The political economy of natural resource use: lessons for fisheries reform*. Washington, DC, World Bank.

13 UN. 2011. *Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments*. Resolution 65/38. New York, USA. 26 pp.

Stakeholder Forum. 2011. *Monaco message* [online]. [Cited 31 March 2012]. www.stakeholderforum.org/fileadmin/files/Monaco%20Message.pdf

14 Hall, S.J. 2011. Climate change and other external drivers in small-scale fisheries: practical steps for responding. *In* R. Pomeroy and N.L. Andrew, eds. S*mall-scale fisheries management: frameworks and approaches for the developing world*, pp. 132–159. Wallingford, UK, CABI Publishing. 247 pp.

15 Op. cit., see note 9.

16 FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome, FAO. 41 pp.

17 Andrew, N.L., Béné, C., Hall, S.J., Allison, E.H., Heck, S. and Ratner, B.D. 2007. Diagnosis and management of small-scale fisheries in developing countries. *Fish and Fisheries*, 8(3): 227–240.

FAO. 2009. *Report of the Global Conference on Small-Scale Fisheries – Securing sustainable small-scale Fisheries: Bringing together responsible fisheries and social development. Bangkok, Thailand, 13–17 Octobre 2008. Rapport de la Conférence mondiale sur les pêches artisanales – Pour une pêche artisanale durable: Associer la pêche responsable au développement social. Bangkok, Thaïlande, 13-17 octobre 2008. Informe de la Conferencia Mundial sobre la Pesca en Pequeña Escala – Garantizar la pesca en pequeña escala: Pesca responsable y desarrollo social unidos. Bangkok, Tailandia, 13-17 de octubre de 2008*. FAO Fisheries and Aquaculture Report/FAO Rapport sur les pêches et l'aquaculture/FAO Informe de Pesca y Acuicultura No. 911. Rome/Roma. 189 pp.

18 World Bank, FAO and WorldFish Center. 2010. *The hidden harvests: the global contribution of capture fisheries.* Conference edition. Washington, DC, World Bank. 99 pp.

Mills, D.J., Westlund, L., de Graaf, G., Kura, Y., Willman, R. and Kelleher, K. 2011. Under-reported and undervalued: Small-scale fisheries in the developing world. *In* R. Pomeroy and N.L. Andrew, eds. S*mall-scale fisheries management: frameworks and approaches for the developing world*, pp. 1–15. Wallingford, UK, CABI Publishing. 247 pp.

19 Béné, C., Hersoug, B. and Allison, E.H. 2010. Not by rent alone: analysing the pro-poor functions of small-scale fisheries in developing countries. *Development Policy Review*, 28(3): 325–358.

20 Béné, C., Belal, E., Baba, M.O., Ovie, S., Raji, A., Malasha, I., Njaya, F., Na Andi, M., Russell, A. and Neiland, A. 2009. Power struggle, dispute and alliance over local resources: analyzing 'democratic' decentralization of natural resources through the lenses of Africa inland fisheries. *World Development*, 37(12): 1935–1950.

21 Op. cit., see note 5.

22 Mora, C., Myers, R.A., Coll, M., Libralato, S., Pitcher, T.J., Sumaila, R.U., Zeller, D., Watson R., Gaston K.J. and Worm, B. 2009. Management effectiveness of the world's marine fisheries. *PLoS Biology*, 7(6): e1000131 [online]. [Cited 31 March 2012]. www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.1000131

23 Hiddink, J.G., Johnson, A.F., Kingham, R. and Hinz, H. 2011. Could our fisheries be more productive? Indirect negative effects of bottom trawl fisheries on fish condition *Journal of Applied Ecology*, 48(6): 1441–1449.

24 National Federation of Fishermen's Organisations. 2011. *The mixed blessings of celebrity – the fight for fish* [online]. [Cited 31 March 2012]. www.nffo.org.uk/news/mixed_blessing.html

25 Young, I.A. 2011. *Change and continuity in Common Fisheries Policy: a case study of the proposed discards ban*. School of Government and Public Policy, University of Strathclyde. (MSc dissertation)

Suárez de Vivero, J.L., Rodríguez Mateos, J.C. and Florido del Corral, D. 2008. The paradox of public participation in fisheries governance. The rising number of actors and the devolution process. *Marine Policy*, 32(3): 319–325.

26 FAO. 2003. *Fisheries management. 2. The ecosystem approach to fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 4 Suppl. 2. Rome. 112 pp.

27 Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D. and Rihan, D. 2012. Low impact and fuel efficient fishing—looking beyond the horizon. *Fisheries Research*, 119–120: 135–146.

28 Agnew, D.J., Pearce, J., Pramod, G., Peatman, T., Watson, R., Beddington, J.R. and Pitcher, T.J. 2009. Estimating the worldwide extent of illegal fishing *PLoS ONE*, 4(2): e4570 [online]. [Cited 31 March 2012]. www.plosone.org/article/info:doi/10.1371/journal.pone.0004570

29 Convention on International Trade in Endangered Species of Wild Fauna and Flora. 2010. *Fifteenth meeting of the Conference of the Parties Doha (Qatar), 13–25 March, Summary record of the eighth session of Committee I* [online]. [Cited 31 March 2012]. www.cites.org/eng/cop/15/sum/E15-Com-I-Rec08.pdf

30 Béné, C. 2003. When fishery rhymes with poverty: a first step beyond the old paradigm on poverty in small-scale fisheries. *World Development*, 31(6): 949–975.
Op. cit., see note 17, FAO.

31 FAO. 2006. *Microfinance helps poverty reduction and fisheries management – policies to support microfinance.* New Directions in Fisheries – a series of Policy Briefs on Development Issues No. 4. Rome. 8 pp.
Shepherd, A. 2011. *Tackling chronic poverty: the policy implications of research on chronic poverty and poverty dynamics* [online]. Chronic Poverty Research Centre. [Cited 31 March 2012]. www.chronicpoverty.org/uploads/publication_files/Tackling%20chronic%20poverty%20webcopy.pdf

32 Op. cit., see note 17, FAO.
Béné, C., Macfadyen, G. and Allison, E.H. 2007. *Increasing the contribution of small-scale fisheries to poverty alleviation and food security.* FAO Fisheries Technical Paper No. 481. Rome, FAO. 125 pp.

THE STATE OF WORLD FISHERIES AND AQUACULTURE

2012

In addition to striving to meet the United Nations Millennium Development Goals, the global community is also grappling with other pressing and complex challenges such as the widespread economic crisis and the effects of climate change. It is in this context that this edition of *The State of World Fisheries and Aquaculture* highlights the vital role of fisheries and aquaculture in both food and nutrition security as well as economic expansion. The sector remains a major supplier of high-quality animal protein and supports the livelihoods and well-being of more than ten percent of the world's population. International trade in fish has reached new peaks as overall production has continued to rise. Yet, as the document underlines, an array of problems – ranging from the need for more effective governance to that of ensuring environmental sustainability – threatens to undermine the sector's valuable contribution to alleviating hunger and reducing poverty.

Using the latest available statistics on fisheries and aquaculture, this edition presents a global analysis of the sector's status and trends. It also examines broader related issues such as gender, emergency preparedness and the ecosystem approach to fisheries and aquaculture. Selected highlights, from ecolabelling and certification to the effects of fisheries management policies on fishing safety, provide insights on specific topics. Finally, the document looks at the opportunities and difficulties for capture fisheries in the coming decades.

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