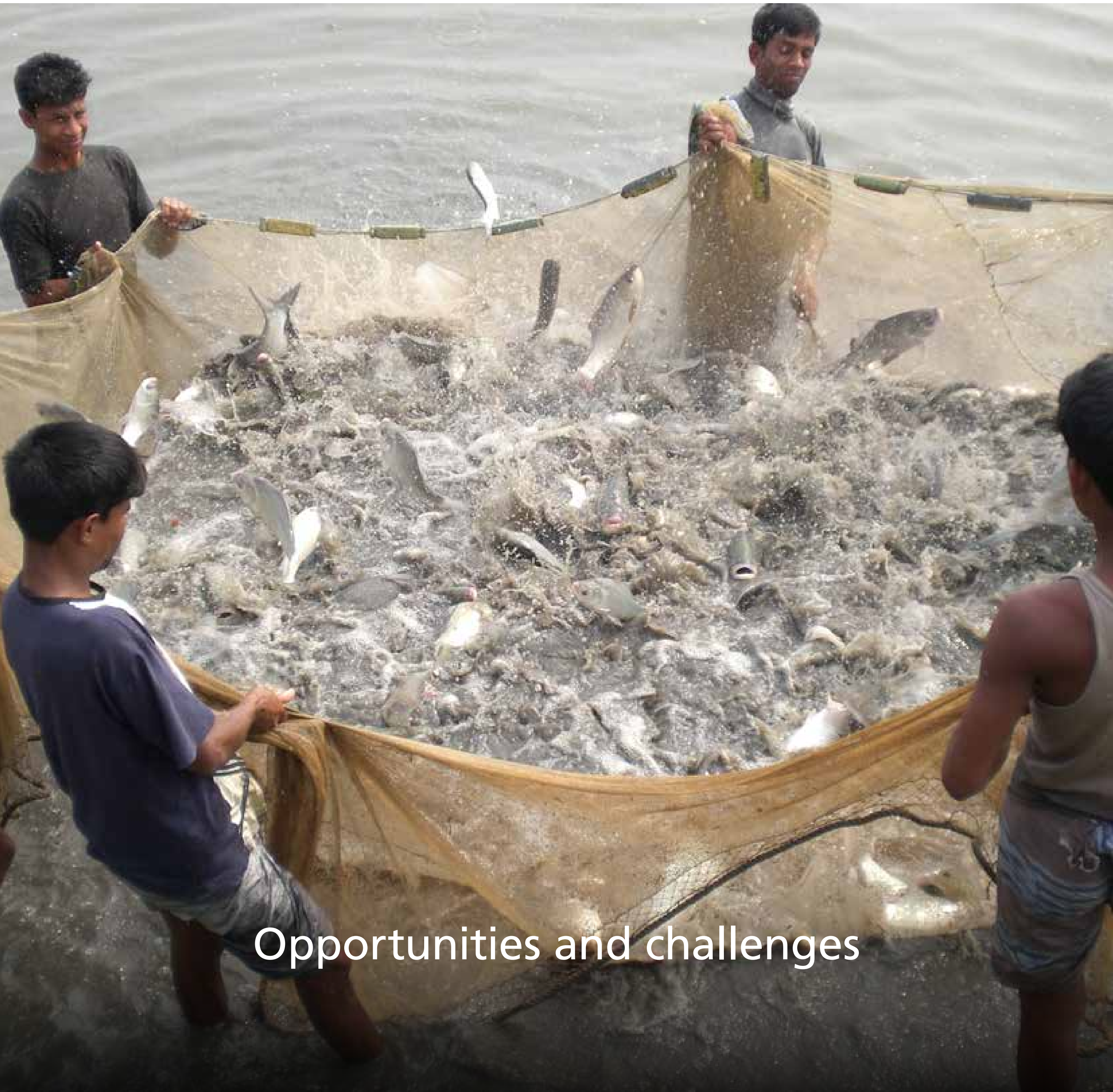
Food and Agriculture Organization of the United Nations

2014

ISSN 1020-5489

The State of World Fisheries and Aquaculture



Opportunities and challenges

Cover and sidebar photograph: Harvest of Indian major and exotic (silver, grass and common) carps from a semi-intensive polyculture pond, Rajshahi, Bangladesh (FAO/M.R. Hasan).

2014

The State of World Fisheries and Aquaculture

Opportunities and challenges

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2014

ISBN 978-92-5-108275-1 (print)
E-ISBN 978-92-5-108276-8 (PDF)

FOREWORD

In a world where more than 800 million continue to suffer from chronic malnourishment and where the global population is expected to grow by another 2 billion to reach 9.6 billion people by 2050 – with a concentration in coastal urban areas – we must meet the huge challenge of feeding our planet while safeguarding its natural resources for future generations.

This new edition of *The State of World Fisheries and Aquaculture* highlights the significant role that fisheries and aquaculture plays in eliminating hunger, promoting health and reducing poverty. Never before have people consumed so much fish or depended so greatly on the sector for their well-being. Fish is extremely nutritious – a vital source of protein and essential nutrients, especially for many poorer members of our global community.

Fisheries and aquaculture is a source not just of health but also of wealth. Employment in the sector has grown faster than the world's population. The sector provides jobs to tens of millions and supports the livelihoods of hundreds of millions. Fish continues to be one of the most-traded food commodities worldwide. It is especially important for developing countries, sometimes worth half the total value of their traded commodities.

However, we need to look beyond the economics and ensure that environmental well-being is compatible with human well-being in order to make long-term sustainable prosperity a reality for all. To this end, promoting responsible and sustainable fisheries and aquaculture is central to our work and purpose. We recognize that the health of our planet as well as our own health and future food security all hinge on how we treat the blue world. To provide wider ecosystem stewardship and improved governance of the sector, FAO is advancing Blue Growth as a coherent framework for the sustainable and socio-economic management of our aquatic resources. Anchored in the principles set out in the benchmark Code of Conduct for Responsible Fisheries back in 1995, Blue Growth focuses on capture fisheries, aquaculture, ecosystem services, trade and social protection. In line with FAO's Reviewed Strategic Framework, the initiative focuses on promoting the sustainable use and conservation of aquatic renewable resources in an economically, socially and environmentally responsible manner. It aims at reconciling and balancing priorities between growth and conservation, and between industrial and artisanal fisheries and aquaculture, ensuring equitable benefits for communities. To reach these goals, the Blue Growth initiative taps into technical expertise throughout the Organization.

FAO recognizes the important contribution that small-scale fisheries make to global poverty alleviation and food security. To strengthen their often vulnerable and marginalized communities, FAO has been actively supporting the development of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries and working with Governments and non-state actors to assist countries in the implementation of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests. These efforts are also very much aligned with the 2014 International Year of Family Farming, during which we will continue to highlight the importance of aquaculture – especially small-scale fish farming – and support its development.

Global fish production continues to outpace world population growth, and aquaculture remains one of the fastest-growing food producing sectors. In 2012, aquaculture set another all-time production high and now provides almost half of all fish for human food. This share is projected to rise to 62 percent by 2030 as catches from wild capture fisheries level off and demand from an emerging global middle class substantially increases. If responsibly developed and practised, aquaculture can generate lasting benefits for global food security and economic growth.

The fisheries and aquaculture sector is facing major challenges. These range from the scourge of illegal, unreported and unregulated (IUU) fishing to harmful fishing practices to wastage to poor governance. They can all be overcome with greater political will, strategic partnerships and fuller engagement with civil society and the private sector. We need to foster good governance by ensuring the uptake and application of international instruments such as the Port State Measures Agreement, and we need to spur innovative solutions with business and industry. We all have a role to play in order to enable fisheries and aquaculture to thrive responsibly and sustainably for present and future generations.

In this regard, it is my sincere hope that you will find this issue of *The State of World Fisheries and Aquaculture* a valuable reference tool and that it will enhance your understanding of the vital role that fisheries and aquaculture can play in reaching the food-secure and sustainable future we aim for.

José Graziano da Silva
FAO DIRECTOR-GENERAL

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ACKNOWLEDGEMENTS

The State of World Fisheries and Aquaculture 2014 was prepared by staff of the FAO Fisheries and Aquaculture Department. General direction was provided by the Department's Information Management and Communications Committee in close consultation with senior management and under the overall supervision of L. Ababouch, Director Fisheries and Aquaculture Policy and Economics Division.

Part 1, World review of fisheries and aquaculture, includes contributions from G. Bianchi, M. Camilleri, F. Chopin, T. Farmer, N. Franz, C. Fuentevilla, L. Garibaldi, R. Grainger (retired), N. Hishamunda, F. Jara (retired), I. Karunasagar (retired), G. Laurenti, A. Lem, G. Lugten, J. Turner, S. Vannuccini, R. Willmann (retired), Y. Ye and X. Zhou. S. Montanaro and contributors of selected sections prepared most of the figures and tables.

Main contributors to Part 2, Selected issues in fisheries and aquaculture, were: N. Franz, C. Fuentevilla, D. Kalikoski, R. Willmann, S. Siar and H. Josupeit (collective action and organizations in small-scale fisheries); J. Toppe and R. Subasinghe (role of aquaculture in nutrition); Y. Diei-Ouadi (post-harvest losses in small-scale fisheries); C. Capper, N. Leonard, G. Marmulla and D. Bartley (management of inland waters for fish); J. Fischer (shark conservation and management); A. Mosteiro, M. Camilleri and S. Tsuji (IUU fishing); and G. Bianchi, F. Chopin, S. Garcia, R. Grainger, P. Suuronen and Y. Ye (balanced harvest).

For Part 3, Highlights of special studies, contributors included: S. Funge-Smith and S. Needham (Asia-Pacific consumption surveys); N. Franz and R. Metzner (voluntary guidelines on tenure); M. Hasan (transition to compound feed in cage farming in Asia); I. Karunasagar and J. Toppe (fisheries by-products); G. Lugten (RFB update); and C. De Young, D. Brown, D. Soto and T. Bahri (climate change).

Part 4, Outlook, was prepared by D. Bartley, G. Bianchi, D. Soto and S. Vannuccini.

The FAO Fisheries and Aquaculture Department, under the guidance of a team led by T. Farmer and assisted by R. Grainger and J. Plummer, managed the editing, design and production of *The State of World Fisheries and Aquaculture 2014*.

ABBREVIATIONS AND ACRONYMS

ABNJ
areas beyond national jurisdiction

ALDFG
abandoned, lost or otherwise discarded fishing gear

BMP
better management practice

CCAMLR
Commission for the Conservation of Antarctic Marine Living Resources

CFS
Committee on World Food Security

CHD
coronary heart disease

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

CMS
Convention on Migratory Species

CODE
Code of Conduct for Responsible Fisheries

COFI
FAO Committee on Fisheries

CSO
civil society organization

DHA
docosahexaenoic acid

EAA
ecosystem approach to aquaculture

EAF
ecosystem approach to fisheries

EEZ
exclusive economic zone

EPA
eicosapentaenoic acid

FDA
Food and Drug Administration (United States of America)

FFA
Pacific Islands Forum Fisheries Agency

GDP
gross domestic product

GEF
Global Environment Facility

GFCM
General Fisheries Commission for the Mediterranean

GLOBAL RECORD
Comprehensive Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels

HS
Harmonized System

HUFA
highly unsaturated fatty acid

IFPRI
International Food Policy Research Institute

IMO
International Maritime Organization

IPOA
international plan of action

IPOA–IUU
International Plan of Action to Prevent, Deter and Eliminate IUU Fishing

IPOA–SHARKS
International Plan of Action for the Conservation and Management of Sharks

ITLOS
International Tribunal for the Law of the Sea

IUCN
International Union for Conservation of Nature

IUU
illegal, unreported and unregulated (fishing)

LIFDC
low-income food-deficit country

LOA
length overall

MCS
monitoring, control and surveillance

MOU
memorandum of understanding

MPA
marine protected area

MSY
maximum sustainable yield

NEAFC
North East Atlantic Fisheries Commission

NFFP
NEPAD-FAO Fisheries Programme

NGO
non-governmental organization

NPAFC
North Pacific Anadromous Fish Commission

OIE
World Organisation for Animal Health

PSMA
FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing

RFB
regional fishery body

RFMO/A
regional fisheries management organization/arrangement

RPHLA
regional post-harvest loss assessment

RSN
Regional Fishery Bodies Secretariats Network

SRFC
Sub-Regional Fisheries Commission

SSF
small-scale fishery

SSF GUIDELINES
Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication

TAC
total allowable catch

UNGA
United Nations General Assembly

UNEP
United Nations Environment Programme

UVI
unique vessel identifier

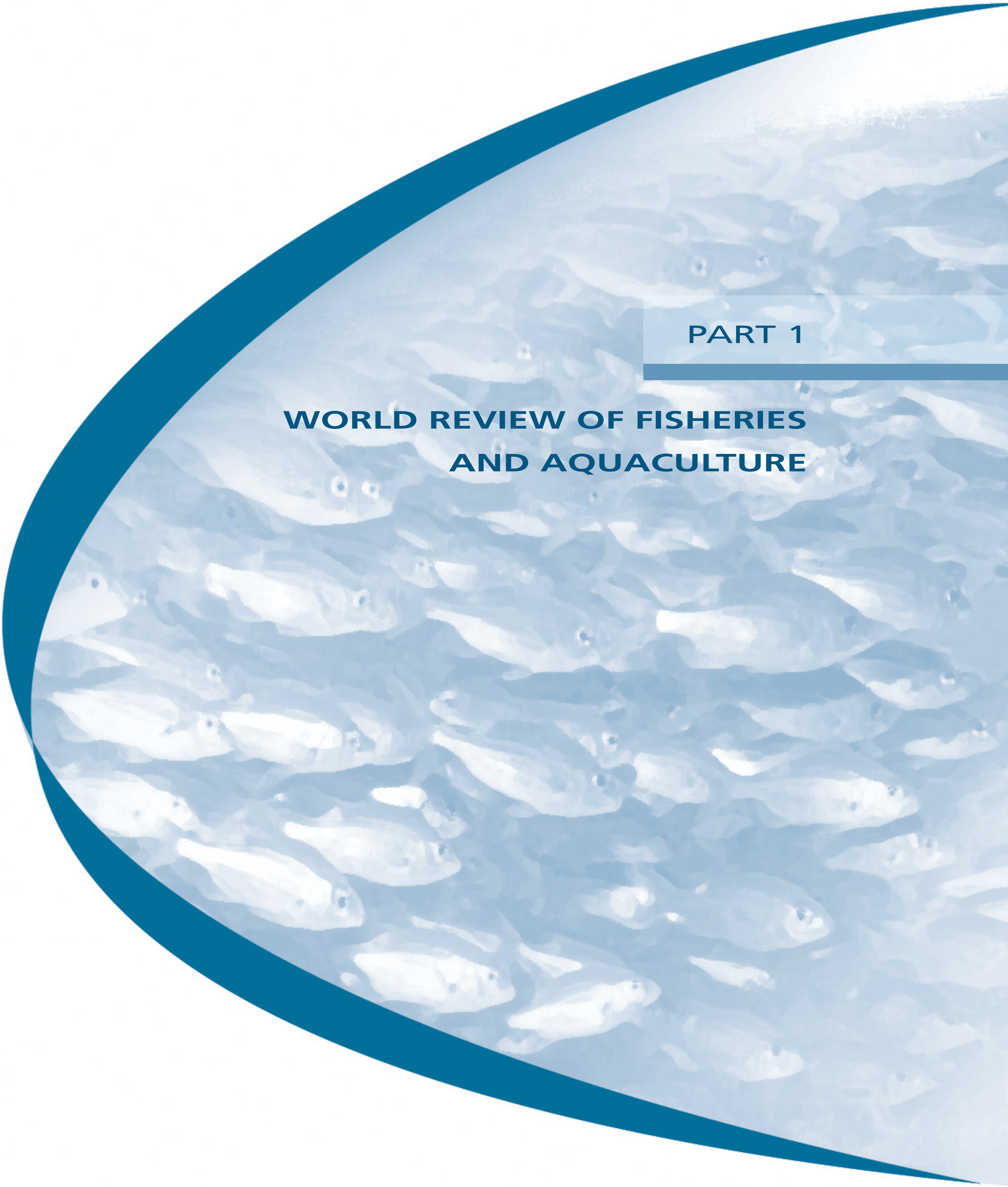
VG TENURE
Voluntary Guidelines for the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security

VMS
vessel monitoring system

WCO
World Customs Organization

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

Global fish production has grown steadily in the last five decades (Figure 1), with food fish supply increasing at an average annual rate of 3.2 percent, outpacing world population growth at 1.6 percent. World per capita apparent fish consumption increased from an average of 9.9 kg in the 1960s to 19.2 kg in 2012 (preliminary estimate) (Table 1 and Figure 2, all data presented are subject to rounding). This impressive development has been driven by a combination of population growth, rising incomes and urbanization, and facilitated by the strong expansion of fish production and more efficient distribution channels.

China has been responsible for most of the growth in fish availability, owing to the dramatic expansion in its fish production, particularly from aquaculture. Its per capita apparent fish consumption also increased an average annual rate of 6.0 percent in the period 1990–2010 to about 35.1 kg in 2010. Annual per capita fish supply in the rest of the world was about 15.4 kg in 2010 (11.4 kg in the 1960s and 13.5 kg in the 1990s).

Despite the surge in annual per capita apparent fish consumption in developing regions (from 5.2 kg in 1961 to 17.8 kg in 2010) and low-income food-deficit countries (LIFDCs) (from 4.9 to 10.9 kg), developed regions still have higher levels of consumption, although the gap is narrowing. A sizeable and growing share of fish consumed in developed countries consists of imports, owing to steady demand and declining domestic fishery production. In developing countries, fish consumption tends to be based on locally and seasonally available products, with supply driving the fish chain. However, fuelled by rising domestic income and wealth, consumers in emerging economies are experiencing a diversification of the types of fish available owing to an increase in fishery imports.

Figure 1

World capture fisheries and aquaculture production

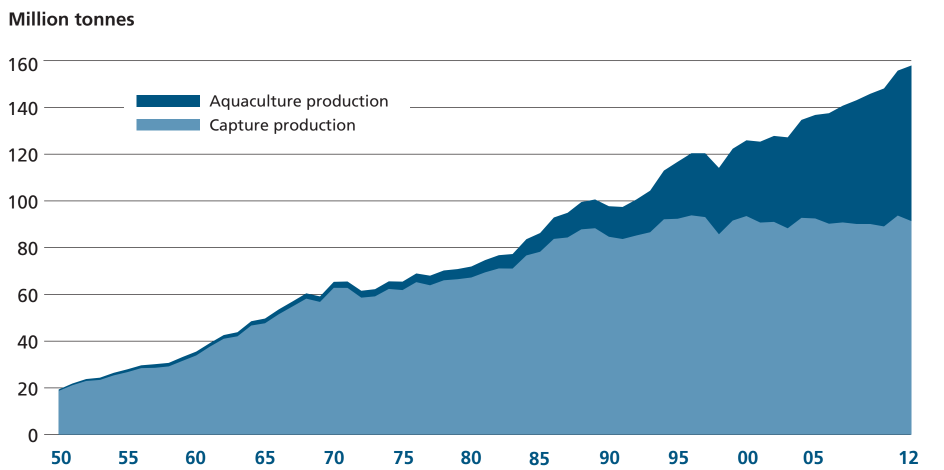


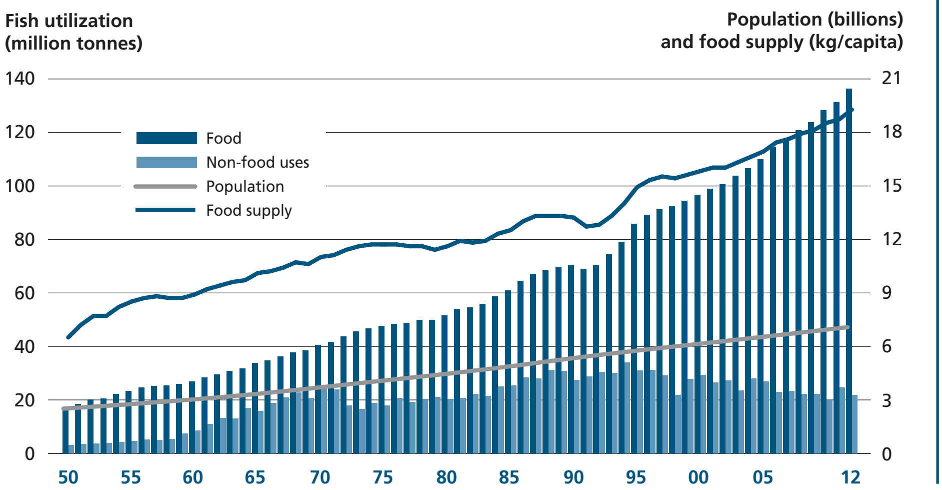
Table 1
World fisheries and aquaculture production and utilization

	2007	2008	2009	2010	2011	2012
	(Million tonnes)					
PRODUCTION						
Capture						
Inland	10.1	10.3	10.5	11.3	11.1	11.6
Marine	80.7	79.9	79.6	77.8	82.6	79.7
Total capture	**90.8**	**90.1**	**90.1**	**89.1**	**93.7**	**91.3**
Aquaculture						
Inland	29.9	32.4	34.3	36.8	38.7	41.9
Marine	20.0	20.5	21.4	22.3	23.3	24.7
Total aquaculture	**49.9**	**52.9**	**55.7**	**59.0**	**62.0**	**66.6**
TOTAL WORLD FISHERIES	**140.7**	**143.1**	**145.8**	**148.1**	**155.7**	**158.0**
UTILIZATION[1]						
Human consumption	117.3	120.9	123.7	128.2	131.2	136.2
Non-food uses	23.4	22.2	22.1	19.9	24.5	21.7
Population (*billions*)	6.7	6.8	6.8	6.9	7.0	7.1
Per capita food fish supply (*kg*)	17.6	17.9	18.1	18.5	18.7	19.2

Note: Excluding aquatic plants. Totals may not match due to rounding.
[1] Data in this section for 2012 are provisional estimates.

Figure 2

World fish utilization and supply



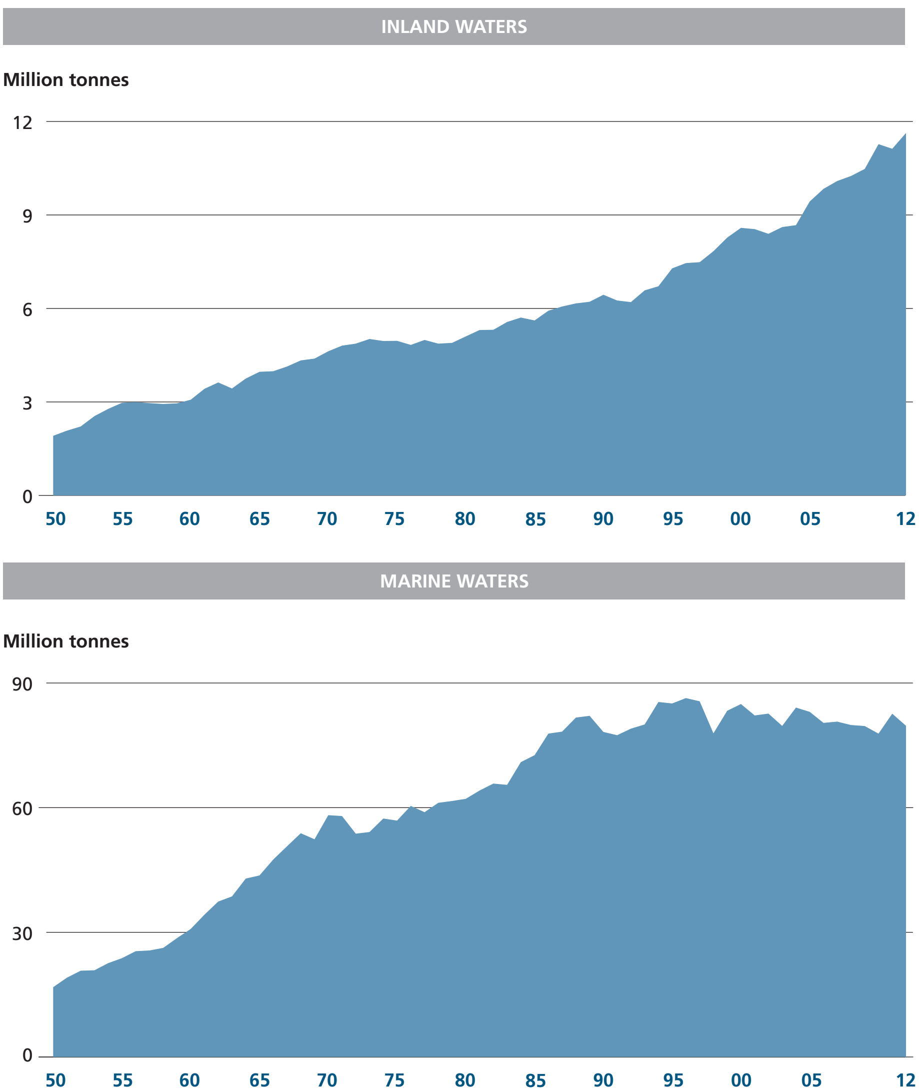
A portion of 150 g of fish can provide about 50–60 percent of an adult's daily protein requirements. In 2010, fish accounted for 16.7 percent of the global population's intake of animal protein and 6.5 percent of all protein consumed. Moreover, fish provided more than 2.9 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein. Fish proteins can represent a crucial nutritional component in some densely populated countries where total protein intake levels may be low.

Global capture fishery production of 93.7 million tonnes in 2011 was the second-highest ever (93.8 million tonnes in 1996). Moreover, excluding anchoveta catches, 2012 showed a new maximum production (86.6 million tonnes). Nevertheless, such figures represent a continuation of the generally stable situation reported previously.

Global fishery production in marine waters was 82.6 million tonnes in 2011 and 79.7 million tonnes in 2012 (Figure 3). In these years, 18 countries (11 in Asia) caught more than an average of one million tonnes per year, accounting for more than 76 percent of global marine catches. The Northwest and Western Central Pacific are the areas with highest and still-growing catches. Production in the Southeast Pacific is always strongly influenced by climatic variations. In the Northeast Pacific, the total catch in 2012 was the same as in 2003. The long-standing growth in catch in the Indian Ocean continued in 2012. After three years (2007–09) when piracy negatively affected fishing in the Western Indian Ocean, tuna catches have recovered. The Northern Atlantic areas and the Mediterranean and Black Sea again showed shrinking catches for 2011 and 2012. Catches in the Southwest and Southeast Atlantic have recently been recovering.

Figure 3

World capture fisheries production



Catches of tuna and tuna-like species set a new record of more than 7 million tonnes in 2012. The annual global catch of the sharks, rays and chimaeras species group has been about 760 000 tonnes since 2005. In 2012, capture production of shrimp species registered a new maximum at 3.4 million tonnes, and the total catch of cephalopods exceeded 4 million tonnes.

Global inland waters capture production reached 11.6 million tonnes in 2012, but its share in total global capture production still does not exceed 13 percent.

Global aquaculture production attained another all-time high of 90.4 million tonnes (live weight equivalent) in 2012 (US$144.4 billion), including 66.6 million tonnes of food fish and 23.8 million tonnes of aquatic algae, with estimates for 2013 of 70.5 million and 26.1 million tonnes, respectively. China alone produced 43.5 million tonnes of food fish and 13.5 million tonnes of aquatic algae that year. Some developed countries, e.g. the United States of America, have reduced their aquaculture output in recent years, mainly owing to competition from countries with lower production costs.

World food fish aquaculture production expanded at an average annual rate of 6.2 percent in the period 2000–2012 (9.5 percent in 1990–2000) from 32.4 million to 66.6 million tonnes. In the same period, growth was relatively faster in Africa (11.7 percent) and Latin America and the Caribbean (10 percent). Excluding China, production in the rest of Asia grew by 8.2 percent per year (4.8 percent in 1990–2000). The annual growth rate in China, the largest aquaculture producer, averaged 5.5 percent in 2000–2012 (12.7 percent in 1990–2000). In 2012, production in North America was lower than in 2000.

The fifteen main producer countries accounted for 92.7 percent of all farmed food fish production in 2012. Among them, Chile and Egypt became million-tonne producers in 2012. Brazil has improved its global ranking significantly in recent years. However, Thailand's production fell to 1.2 million tonnes in 2011 and 2012 owing to flood damage and shrimp disease. Following the 2011 tsunami, Japanese aquaculture recovered slightly in 2012.

Some 58.3 million people were engaged in the primary sector of capture fisheries and aquaculture in 2012. Of these, 37 percent were engaged full time. In 2012, 84 percent of all people employed in the fisheries and aquaculture sector were in Asia, followed by Africa (more than 10 percent). About 18.9 million were engaged in fish farming (more than 96 percent in Asia). In the period 2010–2012, at least 21 million people were capture fishers operating in inland waters (more than 84 percent in Asia).

Employment in the sector has grown faster than the world's population. In 2012, it represented 4.4 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide (2.7 percent in 1990). Overall, women accounted for more than 15 percent of all people directly engaged in the fisheries primary sector in 2012. The proportion of women exceeded 20 percent in inland water fishing and up to 90 percent in secondary activities (e.g. processing). FAO estimates that, overall, fisheries and aquaculture assure the livelihoods of 10–12 percent of the world's population.

The total number of fishing vessels was estimated at 4.72 million in 2012. The fleet in Asia accounted for 68 percent of the global fleet, followed by Africa (16 percent). Some 3.2 million vessels were considered to operate in marine waters. Globally, 57 percent of fishing vessels were engine-powered in 2012, but the motorization ratio was much higher (70 percent) in marine-operating vessels than in the inland fleet (31 percent). The marine fleet shows large regional variations, with non-motorized vessels accounting for 64 percent in Africa.

In 2012, about 79 percent of the world's motorized fishing vessels were less than 12 m length overall (LOA). The number of industrialized fishing vessels of 24 m and larger operating in marine waters was about 64 000.

Several countries have established targets to tackle national overcapacity of fishing fleets and implemented restrictions on larger vessels or gear types. Although China may have reduced its vessel numbers, its fleet's total combined power has increased, and its mean engine power rose from 64 to 68 kW between 2010 and 2012. Reduced by the 2011 tsunami, Japan's marine fishing fleet showed a net increase from 2011 to

2012, with the incorporation of new and more powerful units. In the European Union (Member Organization), the downward trend in terms of numbers, tonnage and power has continued.

The proportion of assessed marine fish stocks fished within biologically sustainable levels declined from 90 percent in 1974 to 71.2 percent in 2011, when 28.8 percent of fish stocks were estimated as fished at a biologically unsustainable level and, therefore, overfished. Of the stocks assessed in 2011, fully fished stocks accounted for 61.3 percent and underfished stocks 9.9 percent.

Stocks fished at biologically unsustainable levels have an abundance lower than the level that can produce the maximum sustainable yield (MSY) and are therefore overfished. They require strict management plans to rebuild them to full and biologically sustainable productivity. Stocks fished within biologically sustainable levels have abundance at or above the level associated with MSY. Stocks fished at the MSY level produce catches that are at or very close to their maximum sustainable production. Therefore, they have no room for further expansion in catch, and require effective management to sustain their MSY. Stocks with a biomass considerably above the MSY level (underfished stocks) may have some potential to increase their production.

The ten most productive species accounted for about 24 percent of world marine capture fisheries production in 2011. Most of their stocks are fully fished and some are overfished.

Rebuilding overfished stocks could increase production by 16.5 million tonnes and annual rent by US$32 billion. With the ever-strengthening declarations of international political will and increasing acceptance of the need to rebuild overfished stocks, the world's marine fisheries can make good progress towards long-term sustainability.

The proportion of fisheries production used for direct human consumption increased from about 71 percent in the 1980s to more than 86 percent (136 million tonnes) in 2012, with the remainder (21.7 million tonnes) destined to non-food uses (e.g. fishmeal and fish oil).

In 2012, of the fish marketed for edible purposes, 46 percent (63 million tonnes) was in live, fresh or chilled forms. For developing countries as a whole, these forms represented 54 percent of fish destined for human consumption in 2012. Developing countries have experienced a growth in the share of fish production utilized as frozen products (24 percent in 2012). In developed countries, this proportion increased to a record high of 55 percent in 2012.

A significant, but declining, proportion of world fisheries production is processed into fishmeal (mainly for high-protein feed) and fish oil (as a feed additive in aquaculture and also for human consumption for health reasons). They can be produced from whole fish, fish remains or other fish by-products. About 35 percent of world fishmeal production was obtained from fish residues in 2012.

About 25 million tonnes of seaweeds and other algae are harvested annually for use as food, in cosmetics and fertilizers, and are processed to extract thickening agents or used as an additive to animal feed.

Fish remains among the most traded food commodities worldwide. In 2012, about 200 countries reported exports of fish and fishery products. The fishery trade is especially important for developing nations, in some cases accounting for more than half of the total value of traded commodities. In 2012, it represented 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 different product forms for human consumption or non-edible purposes grew from 25 percent in 1976 to 37 percent (58 million tonnes, live-weight equivalent) in 2012. Fishery exports reached a peak of US$129.8 billion in 2011, up 17 percent on 2010, but declined slightly to US$129.2 billion in 2012 following downward pressure on international prices of selected fish and fishery products. Demand was particularly uncertain in many developed countries, thus encouraging exporters to develop new markets in emerging economies. Preliminary estimates for 2013 point to an increase in fishery trade.

Fish prices are influenced by demand and supply factors, including the costs of production and transportation, but also of alternative commodities (e.g. meat and feeds). The aggregate FAO Fish Price Index increased markedly from early 2002 and, after some fluctuations, reached a record high in October 2013.

China is, by far, the largest exporter of fish and fishery products. However, since 2011, it has become the world's third-largest importing country, after the United States of America and Japan. The European Union (Member Organization) is the largest market for imported fish and fishery products, and its dependence on imports is growing.

An important change in trade patterns is the increased share of developing countries in fishery trade. Developing economies saw their share rise to 54 percent of total fishery exports by value in 2012, and more than 60 percent by quantity (live weight). Although developed countries continue to dominate world imports of fish and fishery products, their share has decreased. Exports from developing countries have increased significantly in recent decades also thanks to the lowering of tariffs. This trend follows the expanding membership of the World Trade Organization (WTO), the entry into force of bilateral and multilateral trade agreements, and rising disposable incomes in emerging economies. However, several factors continue to constrain developing countries in accessing international markets.

Almost two decades since its adoption, the Code of Conduct for Responsible Fisheries (the Code) remains key to achieving sustainable fisheries and aquaculture. The Code provides the framework, and its implementation is steered by 4 international plans of action (IPOAs), 2 strategies and 28 technical guidelines, which have evolved to embrace the ecosystem approach. Most countries have fisheries policy and legislation that are consistent with the Code, while other countries have plans to align them. Globally, the priority for implementation is the establishment of responsible fisheries with due consideration of relevant biological, technical, economic, social, environmental and commercial aspects. Members have reported progress on various aspects of the Code including establishment of systems to control fisheries operations, developing food safety and quality assurance systems, establishment of mitigation measures for post-harvest losses, and development and implementation of national plans to combat illegal, unreported and unregulated (IUU) fishing and curtail fishing capacity. Several regional fishery bodies (RFBs) have implemented management measures to ensure sustainable fisheries and protect endangered species. The 2012 independent evaluation of FAO's support to the implementation of the Code was positive but called for more strategic and prioritized development and support, improved outreach, closer articulation between normative and operational work, and more attention to the human dimensions.

FAO is promoting "Blue Growth" as a coherent approach for the sustainable, integrated and socio-economically sensitive management of oceans and wetlands, focusing on capture fisheries, aquaculture, ecosystem services, trade and social protection of coastal communities. The Blue Growth framework promotes responsible and sustainable fisheries and aquaculture by way of an integrated approach involving all stakeholders. Through capacity development, it will strengthen the policy environment, institutional arrangements and the collaborative processes that empower fishing and fish-farming communities, civil society organizations and public entities.

The contributions of small-scale fisheries (SSFs) to poverty alleviation and food and nutrition security are being increasingly recognized, most notably in the Rio+20 outcome document (*The Future We Want*), in the Voluntary Guidelines for the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VG Tenure), and in the development of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). These initiatives aim to ensure that fishers and their communities have tenure security and market access while safeguarding their human rights.

Traceability in the food supply chain is increasingly becoming a requirement in major fish importing countries. It can safeguard public health and demonstrate that fish has been caught legally from a sustainably managed fishery or produced in an approved aquaculture facility. FAO technical guidelines describe best practices for certification of products and processes and for ensuring that labels on fish products are accurate and verifiable.

The RFBs are the primary organizational mechanism through which States work together to ensure the long-term sustainability of shared fishery resources. Progress has been made in extending the global coverage of RFBs, which ideally will eventually result in all marine and transboundary inland aquatic regions being covered by some form of RFB or arrangement. The RFBs recognize the need for their mandates to be sound and for their practices, procedures and advice to be best practice. Most have prioritized plans for implementing review recommendations and are effectively monitoring their progress.

Illegal, unreported and unregulated (IUU) fishing remains a major threat to marine ecosystems. Therefore, many States are striving to implement the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA–IUU), while RFBs have engaged in vigorous campaigns to combat IUU fishing. The binding 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) has not yet come into force but it has the potential to be a cost-effective and efficient means of combating IUU fishing. In June 2014, the FAO Committee on Fisheries (COFI) will consider the "Voluntary Guidelines for Flag State Performance". These should prove a valuable tool for strengthening compliance by flag States regarding fishing vessels.

Bycatch and discards remain a major concern. FAO has developed international guidelines on bycatch management and discard reduction and has been urged to provide support in capacity building for their implementation within the ecosystem approach. FAO and its partners are therefore developing a series of global and regional bycatch initiatives.

A recent FAO survey indicates a good overall status of governance in aquaculture. The ecosystem approach to aquaculture (EAA) and spatial planning are becoming important in supporting implementation of the Code, particularly with respect to social licence and environmental integrity. Interest in the certification of aquaculture production systems, practices, processes and products is also increasing. However, the plethora of international and national certification schemes and accreditation bodies has led to some confusion and unnecessary costs. In this regard, FAO has developed technical guidelines on aquaculture certification and an evaluation framework for assessing such schemes. Overall, the major challenge for aquaculture governance is to ensure that the right measures are in place to guarantee environmental sustainability without destroying entrepreneurial initiative and social harmony.

Areas beyond national jurisdiction (ABNJ) comprise the high seas and the sea bed beyond the exclusive economic zones (EEZs). They include ecosystems that are subject to impacts from shipping, pollution, deep-sea mining, fishing, etc. FAO is coordinating the "Global sustainable fisheries management and biodiversity conservation in the Areas Beyond National Jurisdiction Program" to promote efficient and sustainable management of fisheries and biodiversity conservation.

CAPTURE FISHERIES PRODUCTION

Total capture fisheries production

According to final data, total global capture production of 93.7 million tonnes in 2011 was the second-highest ever, slightly below the 93.8 million tonnes of 1996. Moreover, 2012 showed a new maximum production (86.6 million tonnes) when the highly variable anchoveta (*Engraulis ringens*) catches are excluded.

However, these recent results should not raise expectations of significant catch increases. Rather, they represent a continuation of the generally stable situation reported previously.[1] Variations in production by country, fishing area and species are buffered at the global level through compensatory developments in different fisheries. In 1998, extremely low anchoveta catches reduced the total catch to 85.7 million tonnes. Thereafter, the widest deviations from the annual average of 91.1 million tonnes in the best and worst years (2011 and 2003 at 93.7 and 88.3 million tonnes, respectively) have been only about 3 percent.

World marine capture production

Global fishery production in marine waters was 82.6 million tonnes in 2011 and 79.7 million tonnes in 2012 (74.3 and 75.0 million tonnes excluding anchoveta). In these two years, 18 countries caught more than an average of one million tonnes per year, accounting for more than 76 percent of global marine catches (Table 2). Eleven of these countries are in Asia (including also the Russian Federation, which fishes much more in the Pacific than in the Atlantic).

Most of these Asian countries have shown considerable increases in marine catches in the last 10 years, with the exception of Japan and Thailand, which have registered decreases, and the Philippines and the Republic of Korea, whose catches have grown slightly. However, while some countries (i.e. the Russian Federation, India and Malaysia) have reported decreases in some years, marine catches submitted to FAO by Myanmar,

Table 2
Marine capture fisheries: major producer countries

2012 Ranking	Country	Continent	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
				(Tonnes)		*(Percentage)*	
1	China	Asia	12 212 188	13 536 409	13 869 604	13.6	2.4
2	Indonesia	Asia	4 275 115	5 332 862	5 420 247	27.0	1.7
3	United States of America	Americas	4 912 627	5 131 087	5 107 559	4.0	–0.5
4	Peru	Americas	6 053 120	8 211 716	4 807 923	–20.6	–41.5
5	Russian Federation	Asia/Europe	3 090 798	4 005 737	4 068 850	31.6	1.6
6	Japan	Asia	4 626 904	3 741 222	3 611 384	–21.9	–3.5
7	India	Asia	2 954 796	3 250 099	3 402 405	15.1	4.7
8	Chile	Americas	3 612 048	3 063 467	2 572 881	–28.8	–16.0
9	Viet Nam	Asia	1 647 133	2 308 200	2 418 700	46.8	4.8
10	Myanmar	Asia	1 053 720	2 169 820	2 332 790	121.4	7.5
11	Norway	Europe	2 548 353	2 281 856	2 149 802	–15.6	–5.8
12	Philippines	Asia	2 033 325	2 171 327	2 127 046	4.6	–2.0
13	Republic of Korea	Asia	1 649 061	1 737 870	1 660 165	0.7	–4.5
14	Thailand	Asia	2 651 223	1 610 418	1 612 073	–39.2	0.1
15	Malaysia	Asia	1 283 256	1 373 105	1 472 239	14.7	7.2
16	Mexico	Americas	1 257 699	1 452 970	1 467 790	16.7	1.0
17	Iceland	Europe	1 986 314	1 138 274	1 449 452	–27.0	27.3
18	Morocco	Africa	916 988	949 881	1 158 474	26.3	22.0
Total 18 major countries			**58 764 668**	**63 466 320**	**60 709 384**	**3.3**	**–4.3**
World total			**79 674 875**	**82 609 926**	**79 705 910**	**0.0**	**–3.5**
Share 18 major countries (percentage)			**73.8**	**76.8**	**76.2**		

Viet Nam, Indonesia and China have shown continuous growth, in some cases resulting in an astonishing decadal increase (e.g. Myanmar up 121 percent, and Viet Nam up 47 percent).

The drop in capture production for Japan and Thailand (–22 and –39 percent, respectively) has been due to different reasons. Japan has been progressively reducing its fishing fleet since the early 1980s. In March 2011, its northeast coast was hit by a tsunami caused by the fifth-most powerful earthquake in the world since modern record-keeping began in 1900. Following the destruction of fishing vessels and infrastructure, Japan's total catch was forecast to fall by about one-third. However, the actual decrease in comparison to 2010 was about 7 percent, with a further decrease of 3.5 percent in 2012. Thailand's catches have fallen markedly owing to depletion of some marine resources by overfishing and environmental degradation in the Gulf of Thailand, and cessation of fishing operations by Thai vessels in Indonesian waters since 2008.

Reflecting the extensive fishing by Asian countries, the Northwest and Western Central Pacific are the areas with highest and still-growing catches (Table 3). Production in the Southeast Pacific is always strongly influenced by climatic variations. In the Northeast Pacific, despite annual strong fluctuations for major species (i.e. Alaska pollock and salmons), the total catch in 2012 was the same as in 2003.

The growth in total catch seems unending in the Indian Ocean, as in 2012 two new record highs were recorded for the Western (4.5 million tonnes) and Eastern (7.4 million tonnes) fishing areas. After three years (2007–09) in which total tuna catches in the Western Indian Ocean decreased by 30 percent as piracy deterred fishing operations, tuna catches have recovered since 2010.

The decline in catches in the Northern Atlantic areas and in the Mediterranean and Black Sea seemed to have ended at the beginning of the 2010s, but data for 2011

Table 3
Marine capture: major fishing areas

Fishing area code	Fishing area name	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
		(Tonnes)			(Percentage)	
21	Atlantic, Northwest	2 293 460	2 002 323	1 977 710	–13.8	–1.2
27	Atlantic, Northeast	10 271 103	8 048 436	8 103 189	–21.1	0.7
31	Atlantic, Western Central	1 770 746	1 472 538	1 463 347	–17.4	–0.6
34	Atlantic, Eastern Central	3 549 945	4 303 664	4 056 529	14.3	–5.7
37	Mediterranean and Black Sea	1 478 694	1 436 743	1 282 090	–13.3	–10.8
41	Atlantic, Southwest	1 987 296	1 763 319	1 878 166	–5.5	6.5
47	Atlantic, Southeast	1 736 867	1 263 140	1 562 943	–10.0	23.7
51	Indian Ocean, Western	4 433 699	4 206 888	4 518 075	1.9	7.4
57	Indian Ocean, Eastern	5 333 553	7 128 047	7 395 588	38.7	3.8
61	Pacific, Northwest	19 875 552	21 429 083	21 461 956	8.0	0.2
67	Pacific, Northeast	2 915 275	2 950 858	2 915 594	0.0	–1.2
71	Pacific, Western Central	10 831 454	11 614 143	12 078 487	11.5	4.0
77	Pacific, Eastern Central	1 769 177	1 923 433	1 940 202	9.7	0.9
81	Pacific, Southwest	731 027	581 760	601 393	–17.7	3.4
87	Pacific, Southeast	10 554 479	12 287 713	8 291 844	–21.4	–32.5
18, 48, 58, 88	Arctic and Antarctic areas	142 548	197 838	178 797	25.4	–9.6
World total		**79 674 875**	**82 609 926**	**79 705 910**		

Box 1

The value of African fisheries

The contribution of fishery activities to national economies is multifaceted. In addition to supplying food, capture and aquaculture production contributes to gross domestic product (GDP), provides livelihoods for fishers and processors, is a source of hard currency (from exports of fishery products), and boosts government revenues through fisheries agreements and taxes.

The study "The value of African fisheries"[1] was carried out in the framework of the NEPAD-FAO Fisheries Programme funded by the Swedish International Development Cooperation Agency (Sida). The aim was to estimate the contribution to national and agriculture GDPs and the employment generated by the whole fisheries sector, defined as including fishing, processing, licensing of local fleets, and aquaculture.

Information was provided by 42 experts from the 23 countries (more than 40 percent of all African States) collaborating in the study. To obtain figures for the entire continent, data from the sampled countries were analysed and calibrated to extrapolate values for the non-sampled countries, which were classified into separate groups for marine fisheries, inland fisheries and aquaculture according to their geographical location or productivity.

The value added by the fisheries sector as a whole in 2011 was estimated at more than US$24 billion, 1.26 percent of the GDP of all African countries (see table). Detailed figures by subsector highlight the relevance of marine artisanal fisheries and related processing, and also of inland fisheries, which contribute one-third of the total catches in African countries. Aquaculture is still developing in Africa and is mostly concentrated in a few countries but already produces an estimated value of almost US$3 billion per year.

To calculate the contribution of the fisheries sector to agriculture GDPs, it is necessary to exclude the value generated by fish processing. This is because agriculture GDPs published by the United Nations Statistics Division cover "agriculture, livestock, hunting, forestry, and fishing" but exclude processing, which comes under "manufacture of food products". On this basis, fishing and aquaculture contribute 6 percent of the agriculture GDPs in Africa.

and 2012 again showed shrinking catches. Trends in the Southwest and Southeast Atlantic have been variable in the last decade but in recent years both areas have been recovering from the catch decreases of the late 2000s.

About one-third of total capture production in the Western Central Atlantic comes from United States' catches of Gulf menhaden (*Brevoortia patronus*), a clupeoid species that is processed into fishmeal and fish oil. In 2010, the menhaden fishery experienced unprecedented closures of long-established fishing grounds owing to the Deepwater Horizon oil spill. High catches in 2011 contributed to a recovery in the overall total for the Western Central Atlantic to about 1.5 million tonnes, a level not achieved since 2004. In-depth analysis of catch trend in this area is hampered by the low quality of data or non-submission of fishery statistics by several Caribbean and coastal States.

Similarly, for a real picture of the trend in the Eastern Central Atlantic, where the maximum was reached in 2010 at 4.4 million tonnes, catch data are needed for all distant-water fleets fishing in the EEZs of West African countries (Box 1 provides an estimate of the value of fisheries agreements with foreign nations fishing in these EEZs). Some coastal countries (e.g. Guinea-Bissau and Mauritania) provide information on such catches to FAO. This information is cross-checked with data submitted by the flag States, and the catches that had not been reported to FAO are added to the

Contribution to gross domestic product (GDP), by subsector

	Value (US$ millions)	Contribution to GDP (Percentage)
Total GDP all African countries	**1 909 514**	
Total fisheries and aquaculture value added	**24 030**	**1.26**
Total fishing and aquaculture value added[1]	*17 369*	*6.02*[2]
Total marine industrial fisheries	**6 849**	**0.36**
Marine industrial fishing	4 670	0.24
Processing	1 878	0.10
Licences	302	0.02
Total marine artisanal fisheries	**8 130**	**0.43**
Marine artisanal fishing	5 246	0.27
Processing	2 870	0.15
Licences	13	0.00
Total inland fisheries	**6 275**	**0.33**
Inland fishing	4 676	0.24
Processing	1 590	0.08
Licences	8	0.00
Total aquaculture	**2 776**	**0.15**

[1] Excluding processing.
[2] This value indicates the contribution to agriculture GDP rather than overall GDP.
Note: Totals may not match due to rounding.

(Continued)

FAO database. However, some foreign vessels operate in joint ventures with local companies, which makes correct attribution of catch nationality more complex and avoiding catch recording easier.

Table 4 ranks the 23 species and genera for which catches exceeded an average of half a million tonnes in 2011 and 2012. The FAO global capture database now includes statistics for almost 1 600 harvested marine species, but these 23 major species alone represent about 40 percent of the total marine catch. Almost two-thirds of these species are small pelagics that present large fluctuations owing to environmental regimes. In several cases, they are widely used as raw material in reduction to meal and oil, and are of low commercial value.

Besides the above-mentioned drop in anchoveta catches, 2012 also saw significant decreases in catches of California pilchard and Chilean jack mackerel. Final catch data for the latter will also be at a low level in 2013 as the South Pacific Regional Fisheries Management Organisation has adopted conservation and management measures to arrest its depletion, including a reduced overall catch quota.

In 2011 and 2012, the Gadiformes group confirmed its recovery from the catch of less than 7 million tonnes recorded in 2009. The two most important species in this group (Alaska pollock and Atlantic cod) have shown continuously increasing catches

Box 1 *(cont.)*

The value of African fisheries

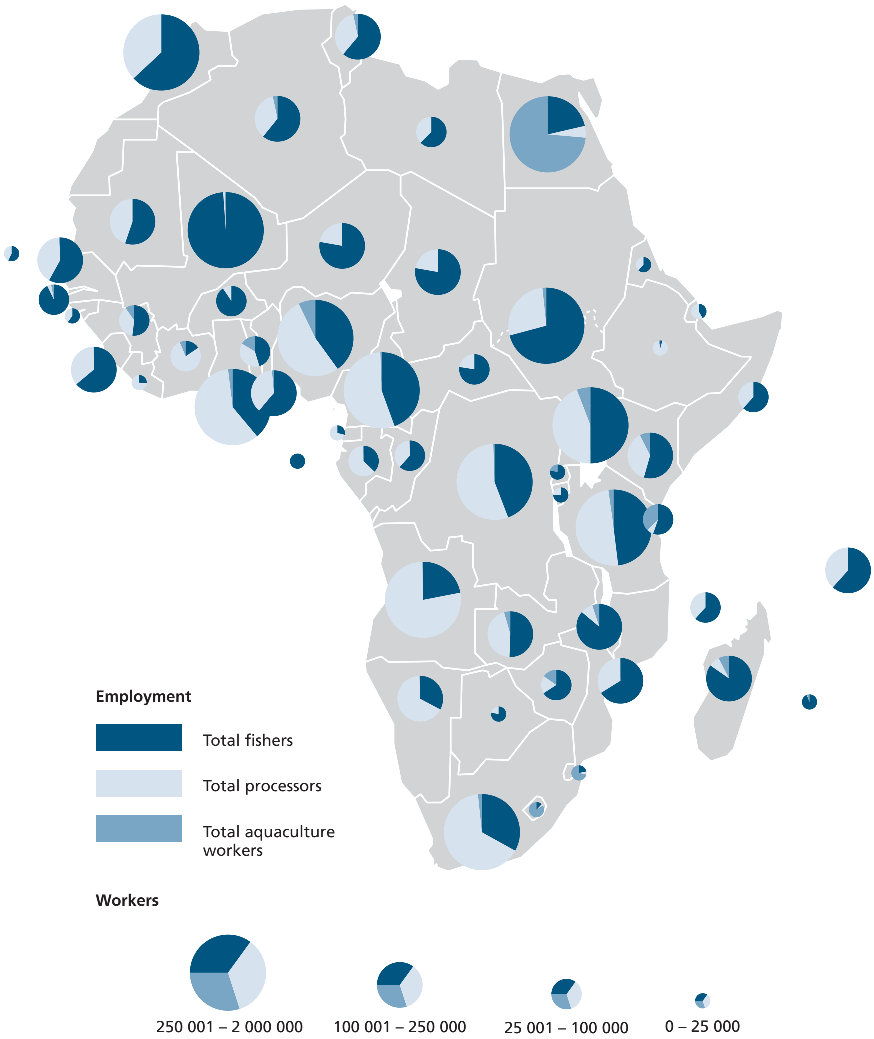
According to the new estimates produced by the study, the fisheries sector as a whole employs 12.3 million people as full-time fishers or full-time and part-time processors, representing 2.1 percent of Africa's population of between 15 and 64 years old. Fishers represent half of all people engaged in the sector, 42.4 percent are processors and 7.5 percent work in aquaculture. About 27.3 percent of the people engaged in fisheries and aquaculture are women, with marked differences in their share among fishers (3.6 percent), processors (58 percent), and aquaculture workers (4 percent). There are clear geographical patterns with high percentages of processors in western and southern Africa, and consequently large female employment, whereas in eastern Africa the number of fishers often exceeds that of processors (see figure). Expanding on what the figure indicates, at the country level, Nigeria ranks first with almost 2 million people engaged in the fisheries and aquaculture sector, followed by Morocco (almost 1.4 million) and Uganda (almost 1 million). Breaking this down, in terms of number of fishers, Morocco (870 000) tops Nigeria (790 000), Uganda (470 000) and Mali (350 000). In terms of processors, Nigeria (more than 1 million) has almost double the number of Morocco (slightly more than 500 000), followed by Uganda (420 000) and Ghana (385 000). For aquaculture, the picture is very different with Egypt (580 000) having more people employed in the sector than all the other countries of Africa combined, followed by Nigeria (135 000) and Uganda (53 000). In addition to this direct employment, substantial numbers of people are engaged in support services to the sector such as boat building and repair, provisioning vessels, fish marketing, administration and research.

In addition to the estimated value added of US$24 billion, in 2011 African countries also received US$0.4 billion under fisheries agreements with foreign nations fishing in their exclusive economic zones, according to a conservative estimate by FAO. This figure was calculated using publicly available information on the agreements with countries in the European Union (Member Organization) and extrapolated values for other countries. Considering that 25 percent of all marine catches around Africa are still by non-African countries, the value added to national economies could be much higher than US$0.4 billion if African fleets also accounted for this portion of catches.

[1] De Graaf, G. & Garibaldi, L. (forthcoming). *The value of African fisheries*. FAO Fisheries and Aquaculture Circular No. 1093. Rome, FAO.

in the last 3–4 years, and the levels attained in 2012 had not been reached since 1998. Blue whiting (*Micromesistius poutassou*), which was the third most-caught of all species in 2004, ranked about thirtieth in 2012. From the late 1990s, this species had eight strong consecutive year classes until 2005 when recruitment collapsed to former levels. Various hypotheses have been proposed for these variations but firm conclusions have yet to be drawn.[2] However, in 2012, catches resumed growing after an extremely

Employment in African fisheries, by subsector



Note: Final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

low level in 2010 and, on the basis of a spawning stock biomass that almost doubled from 2010 to 2013, the International Council for the Exploration of the Sea advised an increase in the total allowable catch by 64 and 48 percent for 2013 and 2014, respectively.

Catches of flatfish, coastal and other demersal species groups have been stable in recent years.

Table 4

Marine capture: major species and genera

2012 Ranking	Scientific name	FAO English name	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
			(Tonnes)			(Percentage)	
1	*Engraulis ringens*	Anchoveta (= Peruvian anchovy)	6 203 751	8 319 597	4 692 855	–24.4	–43.6
2	*Theragra chalcogramma*	Alaska pollock (= walleye pollock)	2 887 962	3 207 063	3 271 426	13.3	2.0
3	*Katsuwonus pelamis*	Skipjack tuna	2 184 592	2 644 767	2 795 339	28.0	5.7
4	*Sardinella* spp.[1]	Sardinellas nei	2 052 581	2 344 675	2 345 038	14.2	0.0
5	*Clupea harengus*	Atlantic herring	1 958 929	1 780 268	1 849 969	–5.6	3.9
6	*Scomber japonicus*	Chub mackerel	1 825 130	1 715 536	1 581 314	–13.4	–7.8
7	*Decapterus* spp.[1]	Scads nei	1 438 905	1 384 105	1 441 759	0.2	4.2
8	*Thunnus albacares*	Yellowfin tuna	1 498 652	1 239 232	1 352 204	–9.8	9.1
9	*Engraulis japonicus*	Japanese anchovy	1 899 570	1 325 758	1 296 383	–31.8	–2.2
10	*Trichiurus lepturus*	Largehead hairtail	1 249 408	1 258 389	1 235 373	–1.1	–1.8
11	*Gadus morhua*	Atlantic cod	849 015	1 051 545	1 114 382	31.3	6.0
12	*Sardina pilchardus*	European pilchard (= sardine)	1 052 003	1 037 161	1 019 392	–3.1	–1.7
13	*Mallotus villosus*	Capelin	1 143 971	853 449	1 006 533	–12.0	17.9
14	*Dosidicus gigas*	Jumbo flying squid	402 045	906 310	950 630	136.4	4.9
15	*Scomberomorus* spp.[1]	Seerfishes nei	702 010	918 495	914 591	30.3	–0.4
16	*Scomber scombrus*	Atlantic mackerel	689 606	945 452	910 697	32.1	–3.7
17	*Strangomera bentincki*	Araucanian herring	304 048	887 272	848 466	179.1	–4.4
18	*Acetes japonicus*	Akiami paste shrimp	542 974	550 297	588 761	8.4	7.0
19	*Brevoortia patronus*	Gulf menhaden	522 195	623 369	578 693	10.8	–7.2
20	*Nemipterus* spp.[1]	Threadfin breams nei	636 644	551 239	576 487	–9.4	4.6
21	*Engraulis encrasicolus*	European anchovy	620 200	607 118	489 297	–21.1	–19.4
22	*Trachurus murphyi*	Chilean jack mackerel	1 797 415	634 126	447 060	–75.1	–29.5
23	*Sardinops caeruleus*	California pilchard	633 554	639 235	364 386	–42.5	–43.0
Total 23 major species and genera			**33 095 160**	**35 424 458**	**31 671 035**	**–4.5**	**–10.7**
World total			**79 674 875**	**82 609 926**	**79 705 910**		
Share 23 major species and genera (percentage)			**41.5**	**42.9**	**39.7**		

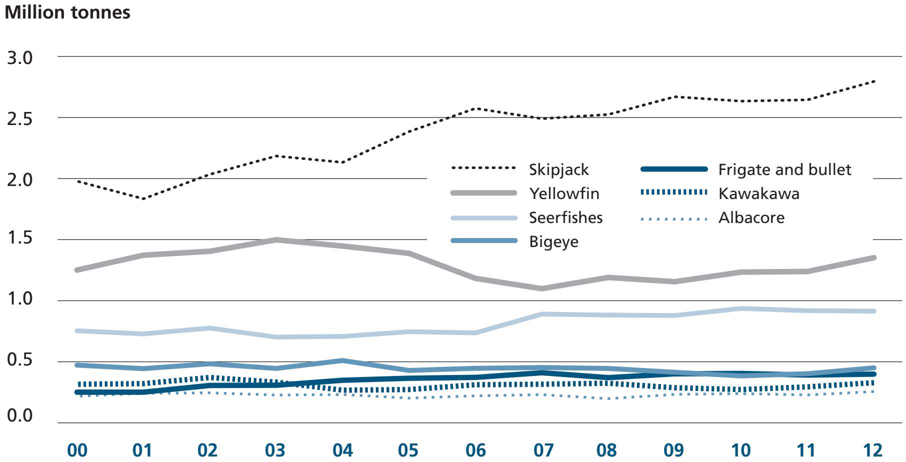
Note: nei = not elsewhere included.

[1] Catches for single species have been added to those reported for the genus.

Catches of tuna and tuna-like species resumed growing and set a new record of more than 7 million tonnes in 2012. Seven species and genera have consistently accounted for about 90 percent of the total tuna catch since 2000. Catches of small tunas (such as skipjack, frigate and bullet tunas), seerfishes (*Scomberomorus* spp.) and albacore have grown significantly (Figure 4). In 2012, catches of yellowfin exceeded their 2000 level after fluctuating, while bigeye had the only decreasing trend with catches down by 5 percent.

Figure 4

Trends in major tuna species and genera



The global catch of the sharks, rays and chimaeras species group has been stable since 2005 around an annual average of 760 000 tonnes. About 37 percent of recent catches are for shark species items, 30 percent for rays, 1 percent for chimaeras, and 32 percent are unidentified "Elasmobranchii". However, as the great majority of catches grouped under "Elasmobranchii" belong to proper sharks, total recent shark catches can be estimated at about 520 000 tonnes. Previous issues of *The State of World Fisheries and Aquaculture* mentioned that the apparent increase in shark catches in the 1990s up to the record high of 2003 may have been influenced by the enhanced species breakdown in the catch statistics reported (see also section Continuing challenges for the conservation and management of sharks on pp. 121–130). As improvement in the quality of the shark catch data collected by national offices and regional fishery bodies seems to be approaching a plateau, the indication from recent data of a stable trend is now considered more reliable.

In 2012, capture production of shrimp species registered a new maximum at 3.4 million tonnes. More than half of the global shrimp catch comes from the Northwest and Western Central Pacific, with other important fisheries in the Indian Ocean and Western Atlantic (respectively, almost 20 and 17 percent of the total). After peaking in 2007 at 4.3 million tonnes, the total catch of cephalopods slowed for some years, but in 2012 it again exceeded 4 million tonnes. The jumbo flying squid (*Dosidicus gigas*) from the Eastern Pacific, Japanese flying squid (*Todarodes pacificus*) from the Northwest Pacific, and the Argentine shortfin squid (*Illex argentines*) from the Southwest Atlantic are the most-caught species, also by distant-water fleets. Catches of octopuses, which at the global level are more stable than those of squids, come mainly from the Northwest Pacific and Eastern Central Atlantic.

World inland waters capture production

Global inland waters capture production reached 11.6 million tonnes in 2012. Although its upward trend seems continuous, its share in total global capture production does not exceed 13 percent.

"Inland waters" remains the most difficult subsector for which to obtain reliable capture production statistics. Several countries in Asia, the continent that accounts for two-thirds of the global total, are believed to either under- or over-estimate their inland water catches. The total catch reported by India is very variable and that from Myanmar has increased 4.3 times in a decade (see Table 5, which shows data for countries whose catches exceeded 200 000 tonnes in 2012). However, consumption surveys in Cambodia, the Lao People's Democratic Republic, Thailand and Viet Nam reveal that capture production in the lower Mekong Basin is probably significantly greater than officially reported.[3]

Table 5
Inland waters capture: major producer countries

2012 Ranking	Country	Continent	2003	2011	2012	Variation 2003–2012	Variation 2011–2012
			(Tonnes)			Percentage	
1	China	Asia	2 135 086	2 232 221	2 297 839	7.6	2.9
2	India	Asia	757 353	1 061 033	1 460 456	92.8	37.6
3	Myanmar	Asia	290 140	1 163 159	1 246 460	329.6	7.2
4	Bangladesh	Asia	709 333	1 054 585	957 095	34.9	–9.2
5	Cambodia	Asia	308 750	445 000	449 000	45.4	0.9
6	Uganda	Africa	241 810	437 415	407 638	68.6	–6.8
7	Indonesia	Asia	308 656	368 578	393 553	27.5	6.8
8	United Republic of Tanzania	Africa	301 855	290 963	314 945	4.3	8.2
9	Nigeria	Africa	174 968	301 281	312 009	78.3	3.6
10	Brazil	Americas	227 551	248 805	266 042	16.9	6.9
11	Russian Federation	Europe/Asia	190 712	249 140	262 548	37.7	5.4
12	Egypt	Africa	313 742	253 051	240 039	–23.5	–5.1
13	Thailand	Asia	198 447	224 708	222 500	12.1	–1.0
14	Democratic Republic of the Congo	Africa	230 365	217 000	214 000	–7.1	–1.4
15	Viet Nam	Asia	208 872	206 100	203 500	–2.6	–1.3
Total 15 major countries			**6 597 640**	**8 753 039**	**9 247 624**	**40.2**	**5.7**
World total			**8 611 840**	**11 124 401**	**11 630 320**	**35.1**	**4.5**
Share 15 major countries (percentage)			**76.6**	**78.7**	**79.5**		

Inland fisheries are also important in Africa, where one-third (2.7 million tonnes) of total capture fisheries production comes from inland waters. The numerous populations living near the Great Lakes (Victoria, Tanganyika and Malawi) and major rivers (Nile, Niger, Congo, etc.) depend primarily on fish for their protein intake. The "Value of African Fisheries" study (see Box 1) highlights the importance of inland fisheries in terms of value and employment.

The total inland waters catch in the other continents is stable at about 0.58 million and 0.38 million tonnes for the Americas and Europe (including the Russian Federation), respectively, and 18 000 tonnes in Oceania.

AQUACULTURE

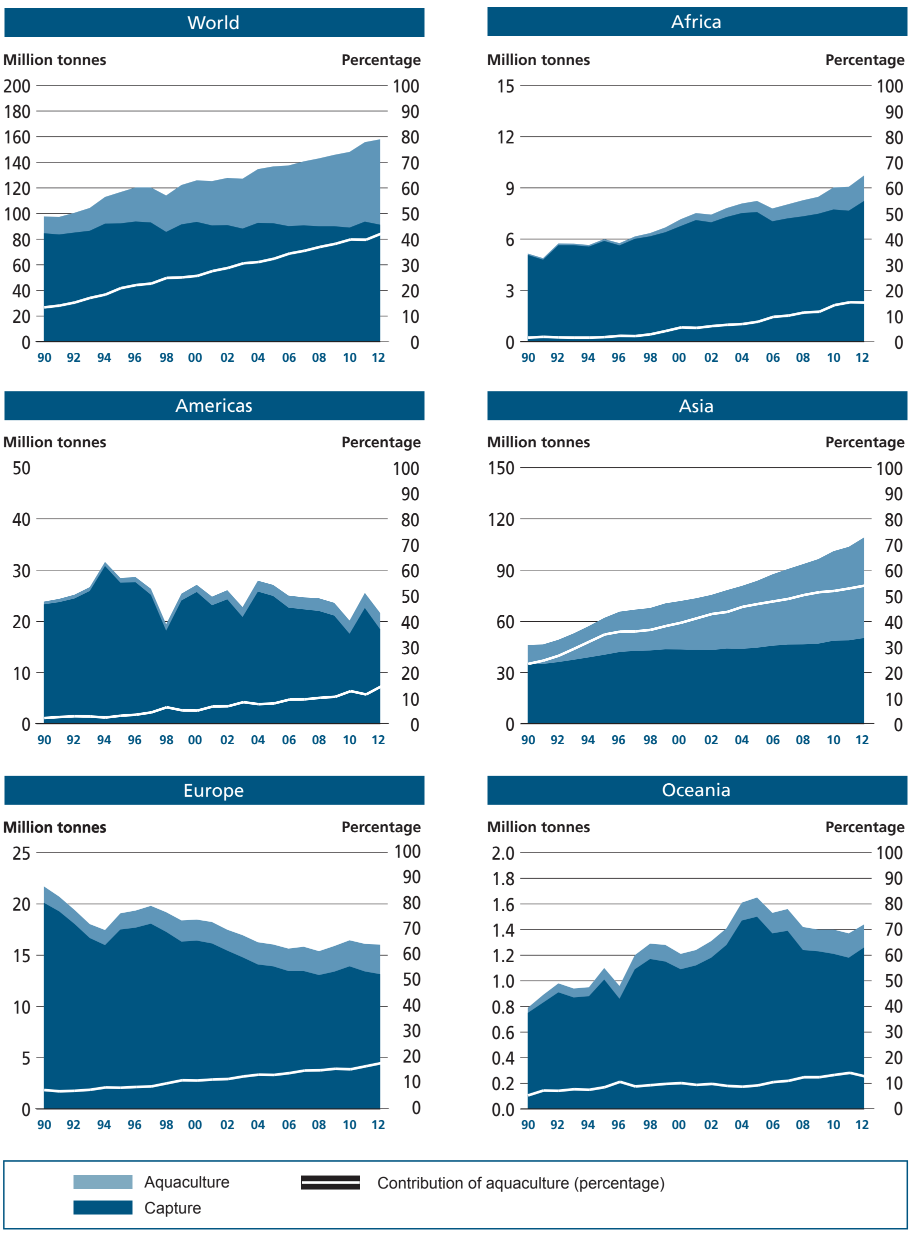
World aquaculture production continues to grow, albeit at a slowing rate. According to the latest available statistics collected globally by FAO, world aquaculture production attained another all-time high of 90.4 million tonnes (live weight equivalent) in 2012 (US$144.4 billion), including 66.6 million tonnes of food fish (US$137.7 billion) and 23.8 million tonnes of aquatic algae (mostly seaweeds, US$6.4 billion). In addition, some countries also reported collectively the production of 22 400 tonnes of non-food products (US$222.4 million), such as pearls and seashells for ornamental and decorative uses. For this analysis, the term "food fish" includes finfishes, crustaceans, molluscs, amphibians, freshwater turtles and other aquatic animals (such as sea cucumbers, sea urchins, sea squirts and edible jellyfish) produced for the intended use as food for human consumption. At the time of writing, some countries (including major producers such as China and the Philippines) had released their provisional or final official aquaculture statistics for 2013. According to the latest information, FAO estimates that world food fish aquaculture production rose by 5.8 percent to 70.5 million tonnes in 2013, with production of farmed aquatic plants (including mostly seaweeds) being estimated at 26.1 million tonnes. In 2013, China alone produced 43.5 million tonnes of food fish and 13.5 million tonnes of aquatic algae.

The total farmgate value of global aquaculture has probably been overstated owing to factors such as some countries reporting retail, product or export prices instead of prices at first sale. Nonetheless, when used at aggregated levels, the value data are useful in showing the development trend and for comparison of the relative importance of economic benefit among different types of aquaculture and different groups of farmed aquatic species.

The global trend of aquaculture development gaining importance in total fish supply has remained uninterrupted. Farmed food fish contributed a record 42.2 percent of the total 158 million tonnes of fish produced by capture fisheries (including for non-food uses) and aquaculture in 2012 (Figure 5). This compares with just 13.4 percent in 1990 and 25.7 percent in 2000. Asia as a whole has been producing more farmed fish than wild catch since 2008, and its aquaculture share in total production reached 54 percent in 2012, with Europe at 18 percent and other continents at less than 15 percent.

Figure 5

Share of aquaculture in total fish production



The overall growth in aquaculture production remains relatively strong owing to the increasing demand for food fish among most producing countries. However, aquaculture output by some industrialized regional major producers, most notably the United States of America, Spain, France, Italy, Japan and the Republic of Korea, has fallen in recent years. A decline in finfish production is common to all these countries, while mollusc production has also decreased in some of them. The availability of fish imported from other countries where production costs are relatively low is seen as a major reason for such production falls. The resulting fish supply gap in the aforementioned countries has been one of the drivers encouraging production expansion in other countries with a strong focus on export-oriented species.

World food fish aquaculture production expanded at an average annual rate of 6.2 percent in the period 2000–2012, more slowly than in the periods 1980–1990 (10.8 percent) and 1990–2000 (9.5 percent). Between 1980 and 2012, world aquaculture production volume increased at an average rate of 8.6 percent per year. World food fish aquaculture production more than doubled from 32.4 million tonnes in 2000 to 66.6 million tonnes in 2012.

Table 6
Aquaculture production by region: quantity and percentage of world total production

Selected groups and countries		1990	1995	2000	2005	2010	2012
Africa	**(tonnes)**	**81 015**	**110 292**	**399 688**	**646 182**	**1 286 591**	**1 485 367**
	(percentage)	***0.62***	***0.45***	***1.23***	***1.46***	***2.18***	***2.23***
North Africa	(tonnes)	63 831	75 316	343 986	545 217	928 530	1 030 675
	(percentage)	*0.49*	*0.31*	*1.06*	*1.23*	*1.57*	*1.55*
Sub-Saharan Africa	(tonnes)	17 184	34 976	55 702	100 965	358 062	454 691
	(percentage)	*0.13*	*0.14*	*0.17*	*0.23*	*0.61*	*0.68*
Americas	**(tonnes)**	**548 479**	**919 571**	**1 423 433**	**2 176 740**	**2 581 089**	**3 187 319**
	(percentage)	***4.19***	***3.77***	***4.39***	***4.91***	***4.37***	***4.78***
Caribbean	(tonnes)	12 169	28 260	39 704	29 790	37 301	28 736
	(percentage)	*0.09*	*0.12*	*0.12*	*0.07*	*0.06*	*0.04*
Latin America	(tonnes)	179 367	412 650	799 234	1 478 443	1 885 965	2 565 107
	(percentage)	*1.37*	*1.69*	*2.47*	*3.34*	*3.19*	*3.85*
North America	(tonnes)	356 943	478 661	584 495	668 507	657 823	593 476
	(percentage)	*2.73*	*1.96*	*1.80*	*1.51*	*1.11*	*0.89*
Asia	**(tonnes)**	**10 801 531**	**21 677 062**	**28 420 611**	**39 185 417**	**52 436 025**	**58 895 736**
	(percentage)	***82.61***	***88.90***	***87.67***	***88.46***	***88.82***	***88.39***
China	(tonnes)	6 482 402	15 855 653	21 522 095	28 120 690	36 734 215	41 108 306
	(percentage)	*49.58*	*65.03*	*66.39*	*63.48*	*62.22*	*61.69*
Central and Western Asia	(tonnes)	72 164	65 602	122 828	190 654	259 781	311 133
	(percentage)	*0.55*	*0.27*	*0.38*	*0.43*	*0.44*	*0.47*
Southern and Eastern Asia (excluding China)	(tonnes)	4 246 965	5 755 807	6 775 688	10 874 073	15 442 028	17 476 296
	(percentage)	*32.48*	*23.61*	*20.90*	*24.55*	*26.16*	*26.23*
Europe	**(tonnes)**	**1 601 649**	**1 581 359**	**2 052 567**	**2 137 340**	**2 548 094**	**2 880 641**
	(percentage)	***12.25***	***6.49***	***6.33***	***4.83***	***4.32***	***4.32***
European Union (Member Organization) (28)	(tonnes)	1 033 857	1 182 098	1 400 667	1 269 958	1 280 236	1 259 971
	(percentage)	*7.91*	*4.85*	*4.32*	*2.87*	*2.17*	*1.89*
Other European countries	(tonnes)	567 792	399 261	651 900	867 382	1 267 858	1 620 670
	(percentage)	*4.34*	*1.64*	*2.01*	*1.96*	*2.15*	*2.43*
Oceania	**(tonnes)**	**42 005**	**94 238**	**121 482**	**151 466**	**185 617**	**184 191**
	(percentage)	***0.32***	***0.39***	***0.37***	***0.34***	***0.31***	***0.28***
World	**(tonnes)**	**13 074 679**	**24 382 522**	**32 417 781**	**44 297 145**	**59 037 416**	**66 633 253**

Notes: Data exclude aquatic plants and non-food products. Data for 2012 for some countries are provisional and subject to revisions. For the purpose of this table, Cyprus, classified as part of Asia by FAO, is included under Europe as one of the 28 members of European Union (Member Organization). Details about countries and territories included under georegions for statistics purposes by FAO are available at: http://unstats.un.org/unsd/methods/m49/m49regin.htm

By continent, annual aquaculture production growth was fastest in Africa (11.7 percent) and Latin America and the Caribbean (10 percent) in the first twelve years of the new millennium. When China is excluded, the expansion in farmed food fish production in the rest of Asia recorded an annual growth rate of 8.2 percent from 2000 to 2012, which is significantly higher than in the periods 1980–1990 (6.8 percent) and 1990–2000 (4.8 percent). The annual growth rate in China, the single largest aquaculture producer, fell to an average of 5.5 percent in the period 2000–2012, less than half that of 1980–1990 (17.3 percent) and 1990–2000 (12.7 percent). Europe and Oceania had the lowest average annual growth rates in the period 2000–2012 at 2.9 and 3.5 percent, respectively. In sharp contrast to other regions, production in North America started to shrink gradually from 2005 and, by 2012, was lower than in 2000, owing to the production fall in the United States of America.

FAO has recorded statistics from 187 countries and territories worldwide with aquaculture production in 2012 and from 9 countries and territories with no production in 2012 but with production recorded previously. Of the 196 countries and territories with production statistics registered, 71 of them (36 percent) did not respond to FAO's aquaculture statistics questionnaire for the year 2012. The non-reporting countries include one of the world's major producers in Asia and five major producers in Europe. The data from the reporting countries vary greatly in terms of completeness of coverage, quality and timeliness of reporting. It remains a challenge to obtain good-quality national data for a better and more detailed analysis of the status and trends in aquaculture worldwide. For example, in recent years, the number of countries from the European Union (Member Organization) intentionally blurring some statistical details in their national data reporting has increased owing to the confidentiality of the data in question.

Production distribution

Aquaculture development is imbalanced and its production distribution is uneven (Table 6), with Asia accounting for about 88 percent of world aquaculture production by volume.

Worldwide, 15 countries produced 92.7 percent of all farmed food fish in 2012 (Table 7). Among them, Chile and Egypt became million-tonne producers in 2012. Brazil's global ranking has improved significantly in recent years. In contrast, Thailand, after its record-high production of 1.4 million tonnes in 2009, saw its production fall to 1.3 million tonnes in 2010 and 1.2 million tonnes in 2011 and 2012, mainly owing to widespread flood damage in 2011 and the dive in shrimp yield as a consequence of early mortality syndrome (see Box 11 on p. 213). Cut to just over half a million tonnes by the 2011 tsunami, Japan's aquaculture production recovered slightly to more then 0.6 million tonnes in 2012. Production peaked at more than 0.6 million tonnes in both the United States of America and the Republic of Korea in 2004 and 2007, respectively. In 2012, their respective production levels were slightly more than 0.4 million tonnes and just less than 0.5 million tonnes. Farmed food fish production has been rising steadily among the other leading producers, except in Chile, where disease outbreaks in marine cage culture of Atlantic salmon hit production in 2009–2010 before recovery and further expansion in production in 2011–12.

Among the leading producers, the major groups of species farmed and the farming systems vary greatly. India, Bangladesh, Egypt, Myanmar and Brazil rely very heavily on inland aquaculture of finfish while their potential for mariculture production of finfish remains largely untapped. Norwegian aquaculture, however, rests almost exclusively on finfish mariculture, particularly marine cage culture of Atlantic salmon, an increasingly popular species in the world market. Chilean aquaculture is similar to that of Norway but it also has a significant production of molluscs (mostly mussels) and finfish farmed in freshwater, and all farmed species are targeted at export markets. In Japan and the Republic of Korea, well over half of their respective food fish production is marine molluscs, and their farmed finfish production depends more on marine cage culture. Half of Thailand's production is crustaceans, consisting mostly of internationally traded marine shrimp species. Indonesia has a relatively large proportion of finfish production

Table 7
Farmed food fish production by top 15 producers and main groups of farmed species in 2012

Producer	Finfish: Inland aquaculture	Finfish: Mariculture	Crustaceans	Molluscs	Other species	National total	Share in world total
	(Tonnes)			(Tonnes)			(Percentage)
China	23 341 134	1 028 399	3 592 588	12 343 169	803 016	41 108 306	61.7
India	3 812 420	84 164	299 926	12 905	…	4 209 415	6.3
Viet Nam	2 091 200	51 000	513 100	400 000	30 200	3 085 500	4.6
Indonesia	2 097 407	582 077	387 698	…	477	3 067 660	4.6
Bangladesh	1 525 672	63 220	137 174	…	…	1 726 066	2.6
Norway	85	1 319 033	…	2 001	…	1 321 119	2.0
Thailand	380 986	19 994	623 660	205 192	4 045	1 233 877	1.9
Chile	59 527	758 587	…	253 307	…	1 071 421	1.6
Egypt	1 016 629	…	1 109	…	…	1 017 738	1.5
Myanmar	822 589	1 868	58 981	…	1 731	885 169	1.3
Philippines	310 042	361 722	72 822	46 308	…	790 894	1.2
Brazil	611 343	…	74 415	20 699	1 005	707 461	1.1
Japan	33 957	250 472	1 596	345 914	1 108	633 047	1.0
Republic of Korea	14 099	76 307	2 838	373 488	17 672	484 404	0.7
United States of America	185 598	21 169	44 928	168 329	…	420 024	0.6
Top 15 subtotal	**36 302 688**	**4 618 012**	**5 810 835**	**14 171 312**	**859 254**	**61 762 101**	**92.7**
Rest of world	2 296 562	933 893	635 983	999 426	5 288	4 871 152	7.3
World	**38 599 250**	**5 551 905**	**6 446 818**	**15 170 738**	**864 542**	**66 633 253**	**100**

Note: The symbol "…" means the production data are not available or the production volume is regarded as negligibly low.

from mariculture, which depends primarily on coastal brackish-water ponds. It also has the world's fourth-largest marine shrimp farming subsector. In the Philippines, finfish production overshadows that of crustaceans and molluscs. The country produces more finfish from mariculture than freshwater aquaculture, and about one-fourth of the mariculture-produced finfish, mostly milkfish, are harvested from cages in marine and brackish water. In Viet Nam, more than half of the finfish from inland aquaculture are *Pangasius* catfish, which are traded overseas. In addition, its crustacean culture subsector, including marine shrimps and giant freshwater prawn, is smaller only than that of China and Thailand. China is very diversified in terms of aquaculture species and farming systems, and its finfish culture in freshwater forms the staple supply of food fish for its domestic market. Its finfish mariculture subsector, especially marine cage culture, is comparatively weak, with only about 38 percent (395 000 tonnes) being produced in marine cages.

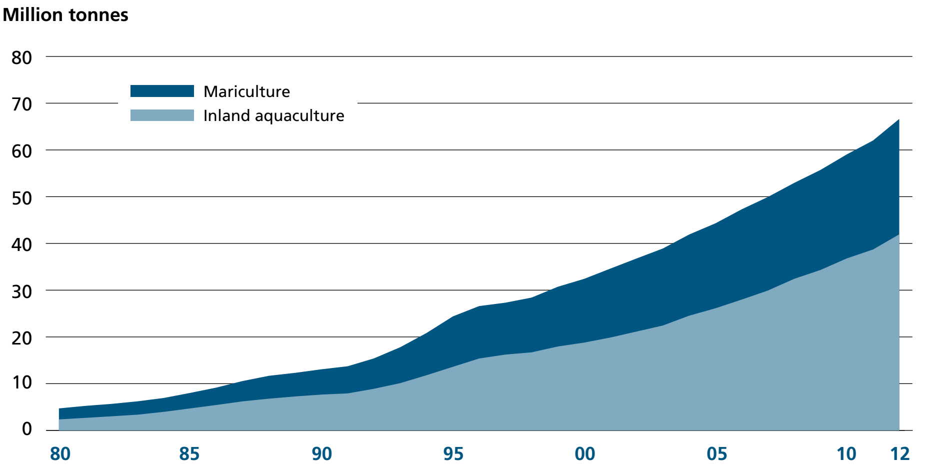
Inland aquaculture, mariculture and species groups farmed

World aquaculture production can be categorized into inland aquaculture and mariculture. Inland aquaculture generally use freshwater, but some production operations use saline water in inland areas (such as in Egypt) and inland saline-alkali water (such as in China). Mariculture includes production operations in the sea and intertidal zones as well as those operated with land-based (onshore) production facilities and structures.

Global food fish productions from inland aquaculture and from mariculture were at the same level of 2.35 million tonnes in 1980 (Figure 6). However, inland aquaculture growth has since outpaced mariculture growth, with average annual growth rates of 9.2 and 7.6 percent, respectively. As a result, inland aquaculture steadily increased its contribution to total farmed food fish production from 50 percent in 1980 to 63 percent in 2012.

Figure 6

World inland aquaculture and mariculture production, 1980–2012



Of the 66.6 million tonnes of farmed food fish produced in 2012, two-thirds (44.2 million tonnes) were finfish species grown from inland aquaculture (38.6 million tonnes) and mariculture (5.6 million tonnes) (Table 8). Although finfish species grown from mariculture represent only 12.6 percent of the total farmed finfish production by volume, their value (US$23.5 billion) represents 26.9 percent of the total value of all farmed finfish species. This is because finfish grown from mariculture include a large proportion of carnivorous species, such as Atlantic salmon, trouts and groupers, that are higher in unit value than most freshwater-farmed finfish.

In 2012, farmed crustaceans accounted for 9.7 percent (6.4 million tonnes) of food fish aquaculture production by volume but 22.4 percent (US$30.9 billion) by value. Mollusc production (15.2 million tonnes) was more than double that of crustaceans, but its value was only half that of crustaceans. In fact, many of the molluscs produced in freshwater were by-products of freshwater pearl culture in Asia. Other aquatic species are still marginal in terms of production volume (0.9 million tonnes), and are farmed mainly in a few countries in Eastern Asia and for markets within the region. However, some species, such as Japanese sea cucumber, are of high value.

The rapid growth in inland aquaculture of finfish reflects the fact that it is a relatively easy-to-achieve type of aquaculture in developing countries when compared with mariculture. It now accounts for 57.9 percent of farmed food fish production globally. Freshwater fish farming makes the greatest direct contribution to the supply

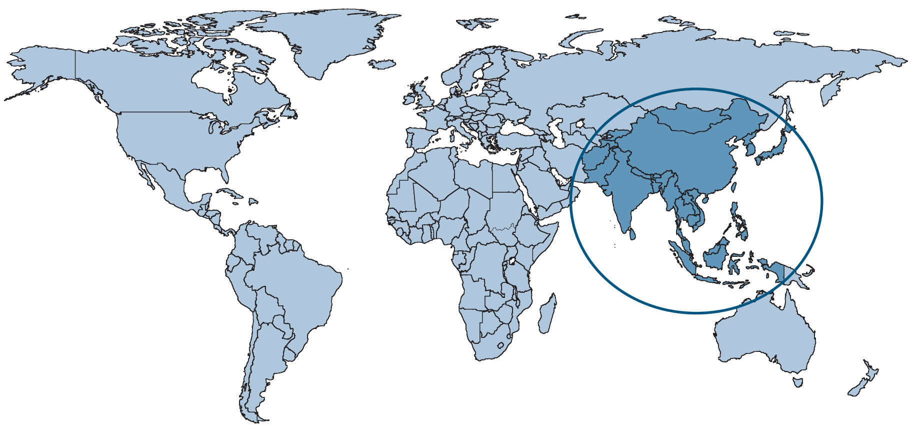
Table 8

World production of farmed species groups from inland aquaculture and mariculture in 2012

	Inland aquaculture	Mariculture	Quantity subtotal		Value subtotal	
	(Million tonnes)	*(Million tonnes)*	*(Million tonnes)*	*(Percentage by volume)*	*(US$ million)*	*(Percentage by value)*
Finfish	38.599	5.552	44.151	66.3	87 499	63.5
Crustaceans	2.530	3.917	6.447	9.7	30 864	22.4
Molluscs	0.287	14.884	15.171	22.8	15 857	11.5
Other species	0.530	0.335	0.865	1.3	3 512	2.5
Total	**41.946**	**24.687**	**66.633**	**100**	**137 732**	**100**

Figure 7

Map highlighting most populous countries in Asia



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.

of affordable protein food, particularly for people still in poverty in developing countries in Asia, Africa and Latin America. This subsector is also expected, through continued promotion and sustainable development, to be the lead player in achieving long-term food and nutrition security and in meeting the increased demand for food fish by the growing population in many developing countries in the coming decades.

In 2012, 3.9 billion people, 55 percent of all humanity, lived inside the circle shown on the map in Figure 7. The development of aquaculture has made a great contribution to the supply of food fish for consumption in most of the countries there, including several of the world's most populous countries such as China, India, Indonesia, Pakistan, Bangladesh and Japan. In 2012, the countries inside the circle produced 58.3 million tonnes of food fish from aquaculture – 87.5 percent of the world's farmed food fish production. When these countries are counted together, the contribution of aquaculture to total fish production rose from 23.9 percent in 1990, to 40.2 percent in 2000, and 54.6 percent in 2012.

Species produced in aquaculture

As at 2012, the number of species registered in FAO statistics was 567, including finfishes (354 species, with 5 hybrids), molluscs (102), crustaceans (59), amphibians and reptiles (6), aquatic invertebrates (9), and marine and freshwater algae (37). It is estimated that more than 600 aquatic species are cultured 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. For most farmed aquatic species, hatchery and nursery technology have been developed and established. For a few species, such as eels (*Anguilla* spp.), farming still relies entirely on wild seed.

In 2012, global production of non-fed species from aquaculture was 20.5 million tonnes, including 7.1 million tonnes of filter-feeding carps and 13.4 million tonnes of bivalves and other species. Continuing its established trend, the share of non-fed species in total farmed food fish production declined further from 33.5 percent in 2010 to 30.8 percent in 2012, reflecting a relatively stronger growth in the farming of fed species. The potential for non-fed aquaculture development, particularly of marine bivalves, has yet to be fully explored in Africa and in Latin America and the Caribbean. However, limited capacity in mollusc seed production is regarded as a constraint in some countries in the latter region. The feasibility of establishing regional mollusc hatcheries to serve these countries is being explored.

Many indigenous aquatic species are used in aquaculture without being registered individually in national statistics. In China alone, more than 200 species are farmed commercially according to government reports, but its total production is registered under fewer than 90 species and species groups in national statistics. Similarly, in India and Viet Nam, the number of cultured species far exceeds the number included in statistics. Analysis of aquaculture production with further details about farmed species remains an approximation.

The farming of tilapias, including Nile tilapia and some other cichlids species, is the most widespread type of aquaculture in the world. FAO has recorded farmed tilapia production statistics for 135 countries and territories on all continents. The true number of producer countries is higher because commercially farmed tilapias are yet to be reflected separately in national statistics in Canada and some European countries.

As there have been no major changes in the last two years, the 2012 edition of this report[4] should be consulted for further information on the major species and species groups produced from aquaculture and the proportional relationships among them.

Production of farmed aquatic plants

Concerning the production of aquatic plants, FAO statistics include both macroalgae (seaweeds) grown in marine or brackish waters and microalgae grown in seawater, brackish water or freshwater. Some freshwater aquatic macrophytes farmed as food, such as water caltrop, water chestnut and edible lotus, are excluded. Farmed aquatic plants are usually discussed separately from food fish because much of overall aquatic plant production is used for non-food purposes. Although the microalgae of *Spirulina* spp. have a high protein content (more than 60 percent in dry weight), its production volume is still marginal compared with other farmed species. The culture of microalgae, including *Spirulina* spp. for human consumption and feed use, *Haematococcus pluvialis* for pharmaceutical, nutraceutical and feed use, and microalgal biofuel production are poorly reported in terms of production statistics.

According to the available data, in 2012, 33 countries and territories worldwide harvested 23.8 million tonnes (wet weight) of aquatic plants from aquaculture, while capture production was 1.1 million tonnes. A few Asian countries dominate farmed algae production (Table 9), with China and Indonesia accounting for 81.4 percent of the total.

World production of farmed seaweeds more than doubled from 2000 to 2012. Expansion has been particularly impressive in Indonesia. Further rapid development there is expected as the national policy is to embrace "blue growth", and the country has vast areas of sunlit shallow sea as suitable culture sites and possesses the relatively simple techniques required for reproduction and culture of *Kappaphycus alvarezii* and *Eucheuma* spp.

In China, farmed seaweed production almost doubled between 2000 and 2012, with the development of high-yield strains of major species playing an important role. The culture of Japanese kelp, the most-farmed coldwater seaweed species, has become well established in the relatively warmer coastal provinces in the south of the country thanks to the development of a warmwater-tolerant strain of this species. More kelp is now produced in the south than the north. Seaweed farming has long been promoted in China in areas of marine cage culture for bioextraction of nutrients in the seawater.

Among Asia's major producers, seaweed farming production has declined only in Japan. However, this fall in domestic production has been offset by imports from neighbouring countries.

Beyond Asia, Zanzibar (the United Republic of Tanzania) in East Africa and Solomon Islands in the Pacific have experienced strong growth in seaweed farming (mostly *Kappaphycus alvarezii*) for export markets. In some countries, including India, Timor-Leste, the United Republic of Tanzania, Madagascar, Fiji, Kiribati and Mozambique, seaweed farming has been recognized as offering potential for significant production volumes. Currently, these countries each produce from a few hundred to a few thousand tonnes annually, except Mozambique, where seaweed farming has ceased owing to non-technical reasons (including marketing).

Table 9
Aquaculture production of farmed aquatic plants in the world and selected major producers

		1990	1995	2000	2005	2010	2012
China	Volume (tonnes)	1 470 230	4 162 620	6 938 095	9 494 591	11 092 270	12 832 060
	Share in world total (percentage)	39.05	60.78	74.55	70.23	58.35	53.97
Indonesia	Volume (tonnes)	100 000	102 000	205 227	910 636	3 915 017	6 514 854
	Share in world total (percentage)	2.66	1.49	2.21	6.74	20.59	27.40
Philippines	Volume (tonnes)	291 176	579 035	707 039	1 338 597	1 801 272	1 751 071
	Share in world total (percentage)	7.73	8.45	7.60	9.90	9.48	7.36
Republic of Korea	Volume (tonnes)	411 882	649 099	374 463	621 154	901 672	1 022 326
	Share in world total (percentage)	10.94	9.48	4.02	4.59	4.74	4.30
Japan	Volume (tonnes)	565 387	569 489	528 881	507 742	432 796	440 754
	Share in world total (percentage)	15.02	8.31	5.68	3.76	2.28	1.85
Malaysia	Volume (tonnes)	…	…	16 125	40 000	207 892	331 490
	Share in world total (percentage)			0.17	0.30	1.09	1.39
Zanzibar (United Republic of Tanzania)	Volume (tonnes)	8 080	39 170	49 910	73 620	125 157	150 876
	Share in world total (percentage)	0.21	0.57	0.54	0.54	0.66	0.63
Solomon Islands	Volume (tonnes)	…	…	…	3 260	8 000	13 000
	Share in world total (percentage)				0.02	0.04	0.05
Subtotal	Volume (tonnes)	2 846 755	6 101 413	8 819 740	12 989 600	18 484 076	23 056 431
	Share in world total (percentage)	75.60	89.08	94.77	96.08	97.24	96.97
Rest of world	Volume (tonnes)	918 570	747 802	486 302	529 346	525 591	720 018
	Share in world total (percentage)	24.40	10.92	5.23	3.92	2.76	3.03
WORLD	**Volume (tonnes)**	**3 765 325**	**6 849 215**	**9 306 042**	**13 518 946**	**19 009 667**	**23 776 449**

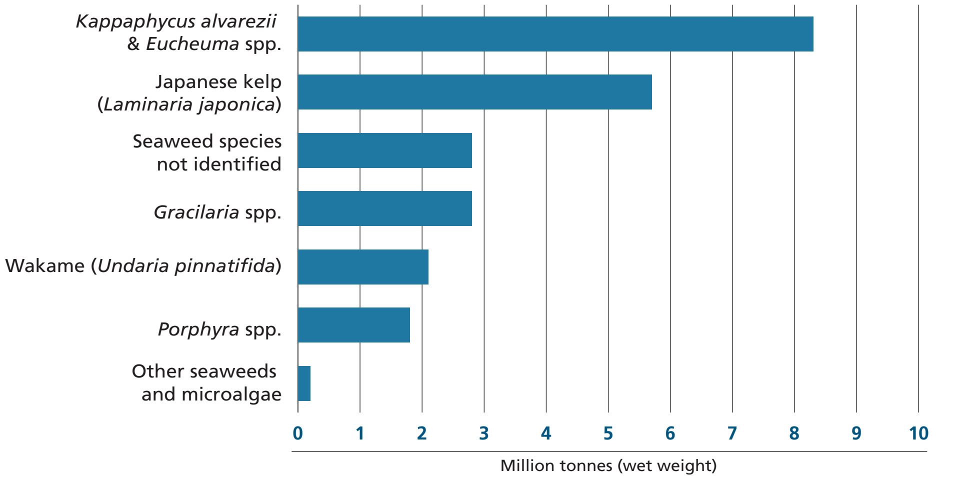
Notes: The Democratic People's Republic of Korea and Viet Nam are among the major producers of farmed seaweeds. They are not listed separately in this table due to the unavailability of reliable statistics data. Instead, they are included in "Rest of world".
... = data not available.

FAO aquaculture statistics record all farmed aquatic algae under 37 separate species or species groups. Farmed algae can be categorized into seven groups according to their nature and intended uses (Figure 8). Driven by the aforementioned expansion in Indonesia and elsewhere, the most obvious change in the species composition of world farmed aquatic algae production is the rapid increase in the dominance of *Eucheuma* seaweeds (*Kappaphycus alvarezii* and *Eucheuma* spp.) farmed in tropical and subtropical seawater and used for carageenan extraction. Their production level surpassed that of Japanese kelp in 2010.

Seaweed species not identified and *Gracilaria* seaweeds are mostly produced in China, and a large proportion of their production is used as feed for abalone and sea cucumber culture. Farmed wakame and *Porphyra* seaweeds are almost entirely destined for direct human consumption. A small portion (less than 20 percent) of Japanese kelp produced in China is used for iodine and algin extraction. It is estimated that, in 2012, about 9 million tonnes of farmed seaweeds were used for direct human consumption, mostly in East Asia, in product forms recognizable as seaweeds by consumers. In

Figure 8

World aquaculture production of farmed aquatic algae grouped by nature and intended use, 2012



addition, agar and carrageenan extracted from other seaweed species are also destined for human consumption in forms not easily recognized, such as thickening agents in some beverages.

FISHERS AND FISH FARMERS

Many millions of people around the world find a source of income and livelihood in the fisheries and aquaculture sector. The most recent estimates (Table 10) indicate that 58.3 million people were engaged in the primary sector of capture fisheries and aquaculture in 2012. Of these, 37 percent were engaged full time, 23 percent part time, and the remainder were either occasional fishers or of unspecified status.

In 2012, 84 percent of all people employed in the fisheries and aquaculture sector were in Asia, followed by Africa (more than 10 percent), and Latin America and the Caribbean (3.9 percent). About 18.9 million (more than 32 percent of all people employed in the sector) were engaged in fish farming, concentrated primarily in Asia (more than 96 percent), followed by Africa (1.6 percent), and Latin America and the Caribbean (1.4 percent).

In the period 2010–2012, at least 21 million people (about 36 percent of all those engaged in the overall sector) were capture fishers operating in inland waters, concentrated primarily in Asia (more than 84 percent), followed by Africa (about 13 percent). The above figures do not include people engaged in fish farming in inland waters as the employment statistics collected by FAO do not separate marine from freshwater aquaculture.

Historically (1990–2012), employment in the fisheries sector has grown faster than the world's population and than employment in the traditional agriculture sector (Table 11). The 58.3 million fishers and fish farmers in 2012 represented 4.4 percent of the 1.3 billion people economically active in the broad agriculture sector worldwide, compared with 2.7 and 3.8 percent in 1990 and 2000, respectively.

However, the relative proportion of those engaged in capture fisheries within the fisheries and aquaculture sector decreased overall from 83 percent in 1990 to 68 percent in 2012, while that of those engaged in fish farming correspondingly increased from 17 to 32 percent. At the global level, the number of people engaged in fish farming has, since 1990, increased at higher annual rates than that of those engaged in capture fisheries.

In the last two decades, the trends in the number of people engaged in the fisheries primary sector have varied by region. As Table 11 shows, in percentage terms, Europe

Table 10
World fishers and fish farmers by region

	1995	2000	2005	2010	2011	2012
	(Thousands)					
Africa	2 392	4 175	4 430	5 027	5 250	5 885
Asia	31 296	39 646	43 926	49 345	48 926	49 040
Europe	530	779	705	662	656	647
Latin America and the Caribbean	1 503	1 774	1 907	2 185	2 231	2 251
North America	382	346	329	324	324	323
Oceania	121	126	122	124	128	127
World	**36 223**	**46 845**	**51 418**	**57 667**	**57 514**	**58 272**
Of which, fish farmers						
Africa	65	91	140	231	257	298
Asia	7 762	12 211	14 630	17 915	18 373	18 175
Europe	56	103	91	102	103	103
Latin America and the Caribbean	155	214	239	248	265	269
North America	6	6	10	9	9	9
Oceania	4	5	5	5	6	6
World	**8 049**	**12 632**	**15 115**	**18 512**	**19 015**	**18 861**

Notes: Several time series have been recently revised, completed and updated with data from national and alternative sources, such as yearbooks, historical accounts, and project reports. Where figures in this issue differ from those previously published, the current data represent the most recent version. The above-mentioned changes are more notable for Asia, Africa and the Americas. Some statistics provided to FAO by national offices, in particular those for 2011–2012, are provisional and may be amended in future editions, and in other FAO publications.
Estimates for 1995 were partly based on data available for a smaller number of countries and, therefore, may not be fully comparable with those for later years.

and North America, with very low population growth and decreasing economically active populations in the agriculture sector, have experienced the largest decrease in the number of people engaged in capture fishing, and little increase or even a decrease in those engaged in fish farming. These trends relate to the trends in production from capture fishing and aquaculture. In contrast, Africa and Asia, with higher population growth and growing economically active populations in the agriculture sector, have shown sustained increases in the number of people engaged in capture fishing and even higher rates of increase in those engaged in fish farming. These trends in employment are also related to sustained increases in production from capture fisheries and even more so from aquaculture.

The Latin America and Caribbean region stands somewhere in between the tendencies already described, with a decreasing population growth, a decreasing economically active population in the agriculture sector in the last decade, moderately growing employment in the fisheries sector, decreasing capture production and rather high sustained aquaculture production. However, its vigorously growing aquaculture production may not result in an equally vigorously growing number of employed fish farmers as several of the important organisms cultivated in the region are aimed at satisfying foreign markets. Hence, efficiency, quality and lower costs rely more on technological developments than human labour.

Table 12 presents the employment statistics for selected countries, including China, where more than 14 million people (25 percent of the world total) are engaged as fishers (16 percent of the world total) and fish farmers (9 percent of the world total). In general, employment in fishing continues to decrease in capital-intensive economies, in particular in most European countries, North America and Japan. For example, in the period 1995–2012, the number of people employed in marine fishing decreased by 30 percent in Iceland, by 42 percent in Japan, and by 49 percent in Norway. Factors that may account for this include: the application of policies to reduce overcapacity in the fleets; and less dependence on human power owing to technological developments and associated increased efficiencies.

Table 11
Comparative average annual percentage growth rate by region and period

Region		1990–1995	1995–2000	2000–2005	2005–2010
		(Percentage)			
World	**Total population**	**1.5**	**1.3**	**1.2**	**1.2**
	Economically active population in agriculture	0.8	0.6	0.6	0.5
	Fishers and fish farmers[1]	2.7	5.3	1.9	2.3
	Capture fishers	1.4	4.0	1.2	1.5
	Fish farmers	8.6	9.4	3.7	4.1
	Capture production[2]	1.8	0.2	–0.2	–0.8
	Aquaculture production	13.3	5.9	6.4	5.9
Africa	Total population	2.6	2.4	2.4	2.5
	Economically active population in agriculture	2.2	2.1	2.1	2.1
	Capture fishers	4.0	11.9	1.0	2.3
	Fish farmers	6.3	7.0	9.0	10.5
	Capture production	3.1	2.8	2.3	0.4
	Aquaculture production	6.4	29.4	10.1	14.8
Asia	Total population	2.0	1.3	1.2	1.1
	Economically active population in agriculture	1.0	0.5	0.5	0.4
	Capture fishers	1.1	3.1	1.3	1.4
	Fish farmers	8.3	9.5	3.7	4.1
	Capture production	2.7	1.5	0.5	1.8
	Aquaculture production	14.9	5.6	6.6	6.0
Europe	Total population	–1.6	0.0	0.1	0.2
	Economically active population in agriculture	–7.7	–3.5	–3.0	–2.9
	Capture fishers	5.1	7.3	–1.9	–1.9
	Fish farmers	12.3	13.0	–2.6	2.4
	Capture production	–2.6	–1.2	–3.1	0.0
	Aquaculture production	–0.3	5.3	0.8	3.6
Latin America and the Caribbean	Total population	1.8	1.6	1.3	1.2
	Economically active population in agriculture	0.3	0.1	–0.2	–0.7
	Capture fishers	1.2	3.0	1.4	3.0
	Fish farmers	7.5	6.6	2.2	0.7
	Capture production	6.0	–1.5	–1.2	–8.5
	Aquaculture production	18.1	13.7	12.4	5.0
North America	Total population	1.1	1.2	0.9	0.9
	Economically active population in agriculture	–2.2	–1.5	–2.1	–1.9
	Capture fishers	–0.5	–2.0	–1.3	–0.3
	Fish farmers	…	0.0	0.9	–0.8
	Capture production	–3.4	–1.1	1.2	–2.2
	Aquaculture production	6.0	4.1	2.7	–0.3
Oceania	Total population	1.5	1.5	1.5	1.7
	Economically active population in agriculture	1.2	1.3	1.4	1.6
	Capture fishers	0.6	0.7	–0.6	0.2
	Fish farmers	…	4.0	–0.5	1.4
	Capture production	6.5	1.4	6.7	–4.2
	Aquaculture production	17.5	5.2	4.5	4.2

Note: … = data not available.
[1] The generally much higher rates of change observed for fishers and fish farmers for the periods 1990–1995 and 1995–2000 are partially due to the fact that estimates for 1990 and, partly, for 1995 were based on data available for a smaller number of countries than those for following years.
[2] Production (capture and aquaculture) excludes aquatic plants.

Table 12
Number of fishers and fish farmers in selected countries and territories

	Fishery		1995	2000	2005	2010	2012
WORLD	FI + AQ	(thousands)	**36 223**	**46 845**	**51 418**	**57 667**	**58 272**
		(index)	***70***	***91***	***100***	***112***	***113***
	FI	(thousands)	28 174	34 213	36 304	39 155	39 412
		(index)	*78*	*94*	*100*	*108*	*109*
	AQ	(thousands)	8 049	12 632	15 115	18 512	18 861
		(index)	*53*	*84*	*100*	*122*	*125*
China	FI + AQ	(thousands)	11 429	12 936	12 903	13 992	14 441
		(index)	*89*	*100*	*100*	*108*	*112*
	FI	(thousands)	8 759	9 213	8 389	9 013	9 226
		(index)	*104*	*110*	*100*	*107*	*110*
	AQ	(thousands)	2 669	3 722	4 514	4 979	5 214
		(index)	*59*	*82*	*100*	*110*	*116*
Taiwan Province of China	FI + AQ	(thousands)	302	314	352	330	329
		(index)	*86*	*89*	*100*	*94*	*93*
	FI	(thousands)	204	217	247	247	238
		(index)	*83*	*88*	*100*	*100*	*97*
	AQ	(thousands)	98	98	105	84	90
		(index)	*93*	*93*	*100*	*79*	*86*
Iceland	FI	(thousands)	7.0	6.1	5.1	5.3	4.9
		(index)	*137*	*120*	*100*	*104*	*96*
Indonesia	FI + AQ	(thousands)	4 568	5 248	5 097	5 972	6 093
		(index)	*90*	*103*	*100*	*117*	*120*
	FI	(thousands)	2 463	3 105	2 590	2 620	2 749
		(index)	*95*	*120*	*100*	*101*	*106*
	AQ	(thousands)	2 105	2 143	2 507	3 351	3 344
		(index)	*84*	*85*	*100*	*134*	*133*
Japan	FI	(thousands)	301	260	222	203	174
		(index)	*136*	*117*	*100*	*91*	*78*
Mexico	FI + AQ	(thousands)	…	262	279	272	266
		(index)	…	*94*	*100*	*97*	*95*
	FI	(thousands)	250	244	256	241	210
		(index)	*98*	*96*	*100*	*94*	*82*
	AQ	(thousands)	…	18	24	31	56
		(index)	…	*78*	*100*	*131*	*239*
Morocco	FI	(thousands)	100	106	106	107	114
		(index)	*94*	*100*	*100*	*102*	*108*
Norway	FI + AQ	(thousands)	28	24	19	19	18
		(index)	*151*	*130*	*100*	*99*	*96*
	FI	(thousands)	24	20	15	13	12
		(index)	*163*	*138*	*100*	*89*	*83*
	AQ	(thousands)	4.6	4.3	4.2	5.5	5.9
		(index)	*109*	*102*	*100*	*131*	*139*

Note: FI = fishing, AQ = aquaculture; index: 2005 = 100; … = data not available.

Table 13 compares per capita annual productivity in the capture fisheries and aquaculture primary sector at the global level and for each region. Average annual production per person in aquaculture tends to be consistently higher (more than 1.5 times in 2012) than in capture fisheries, partly owing to the large-scale industrial fisheries for pelagic species. As a general global trend, while annual productivity dropped slightly from 2.7 to 2.3 tonnes per person in capture fisheries in the period 2000–2012, aquaculture improved its productivity from 2.6 to 3.5 tonnes per person.

Table 13
Fishery production per fisher or fish farmer by region

	Production[1] per person				
	2000	2005	2010	2011	2012
	(Tonnes/year)				
Capture + aquaculture					
Africa	1.7	1.9	1.8	1.7	1.7
Asia	1.8	1.9	2.0	2.1	2.2
Europe	23.4	22.7	24.8	24.5	24.7
Latin America and the Caribbean	11.7	10.6	6.4	8.4	6.6
North America	18.7	21.0	19.2	21.0	20.8
Oceania	9.6	13.5	11.3	10.7	11.4
World	**2.7**	**2.7**	**2.6**	**2.7**	**2.7**
Capture					
Africa	1.7	1.8	1.6	1.5	1.5
Asia	1.6	1.5	1.5	1.6	1.6
Europe	24.0	22.5	24.8	24.2	24.2
Latin America and the Caribbean	12.7	11.2	6.2	8.3	6.2
North America	17.3	19.6	17.7	19.8	19.7
Oceania	9.0	12.8	10.2	9.7	10.4
World	**2.7**	**2.5**	**2.3**	**2.4**	**2.3**
Aquaculture					
Africa	4.4	4.6	5.6	5.4	5.1
Asia	2.3	2.7	2.9	3.0	3.2
Europe	19.8	23.5	24.9	26.0	27.8
Latin America and the Caribbean	3.9	6.3	7.8	9.0	9.7
North America	91.5	68.2	70.0	59.5	59.3
Oceania	23.1	29.5	33.8	30.4	32.7
World	**2.6**	**2.9**	**3.2**	**3.3**	**3.5**

[1] Production excludes aquatic plants.

In addition to differences in per capita average outputs between aquaculture and capture fisheries, there are also regional differences. The most populated regions, Africa and Asia, that together also account for the largest proportion (94 percent or more) of fishers and fish farmers, show the lowest outputs with annual averages of about 1.8 and 2.0 tonnes per person per year, respectively. Those figures contrast with annual average outputs of 24.0 and 20.1 tonnes per person in Europe and North America, respectively. Latin America and the Caribbean, with annual average outputs of 6.4–11.7 tonnes per person, lies somewhere between the aforementioned low- and high-output regions. To an extent, production per person reflects the higher degree of industrialization of fishing activities (e.g. in Europe and North America) as well as the relative importance of small-scale operators, especially in Africa and Asia.

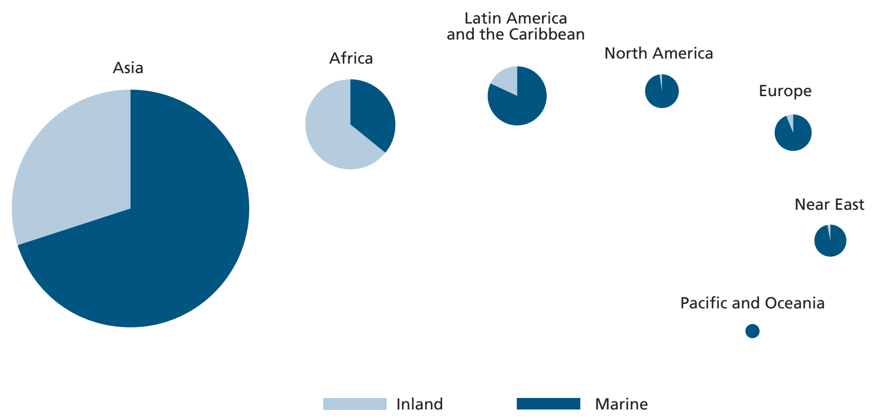
This contrast is more evident for aquaculture production. In 2011, the annual average production of fish farmers in Norway was 195 tonnes per person, compared with 55 tonnes in Chile, 25 tonnes in Turkey, 10 tonnes in Malaysia, about 7 tonnes in China, about 4 tonnes in Thailand, and only about 1 tonne in India and Indonesia.

The information provided to FAO still lacks sufficient detail to allow full analyses by gender. However, based on the data available, it is estimated that, overall, women accounted for more than 15 percent of all people directly engaged in the fisheries primary sector in 2012. The proportion of women exceeded 20 percent in inland water fishing and is considered far more important, as high as 90 percent, in secondary activities, such as processing.

As stated in *The State of World Fisheries and Aquaculture 2012* (p. 46),[5] fisheries and aquaculture provide numerous jobs in the secondary sector (e.g. fish processing, trade and marketing) as well as in many ancillary services. FAO estimates that, overall,

Figure 9

Proportion of fishing vessels in marine and inland waters by region in 2012



fisheries and aquaculture assure the livelihoods of 10–12 percent of the world's population.

THE STATUS OF THE FISHING FLEET

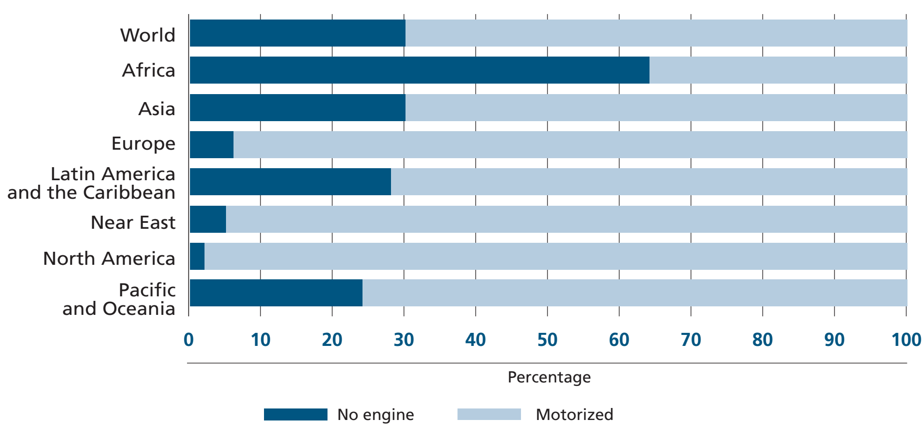
Estimate of global fleet and its regional distribution

The total number of fishing vessels in the world was estimated to be about 4.72 million in 2012. The fleet in Asia was the largest, consisting of 3.23 million vessels accounting for 68 percent of the global fleet, followed by Africa (16 percent), Latin America and the Caribbean (8 percent), North America (2.5 percent) and Europe (2.3 percent).

Among the global fleet, 3.2 million vessels (68 percent) were considered to operate in marine waters, with the remaining 1.5 million vessels operating in inland waters. The distinction between inland and marine fishing fleets was made based on: (i) national reported statistics with sufficient details (e.g. China, Indonesia and Japan); (ii) integration of fishing fleet data reported for vessels operating on large inland waterbodies (e.g. lakes such as Tanganyika, Victoria, Volta, and Titicaca; rivers such as the Mekong, Amazon and Nile); and (iii) allocation of whole fleets of landlocked

Figure 10

Proportion of marine fishing vessels with and without engine by region in 2012



countries to inland waters (e.g. Burkina Faso, Burundi, Chad, Kazakhstan, Malawi, Mali, Niger, Uganda, Uzbekistan, Zambia).

Compared with 2010 global fishing fleet estimates, the slight apparent increase in the global fleet reflects improved data for vessels operating in inland waters (especially in Africa), which had been misrepresented in the database until recent years.

Although the inland fleet represented 32 percent of the global fleet in 2012, the proportion of vessels operating in inland waters varied substantially by region (Figure 9), the highest being in Africa (64 percent), followed by Asia (30 percent) and Latin America and the Caribbean (18 percent).

Globally, 57 percent of fishing vessels were engine-powered in 2012, but the motorization ratio was much higher (70 percent) in marine-operating vessels than in the inland fleet (31 percent). For the marine fleet, there were also large variations among regions, with non-motorized vessels accounting for about 5 and 6 percent respectively in the Near East and Europe, but up to 64 percent in Africa (Figure 10). The low percentage of non-motorized vessels in North America could be a reflection of the data collection systems in use there, and the low reporting rate from that region.

Globally, the motorized fishing fleet is distributed unevenly among regions. The vast majority of motorized vessels (72 percent) were reported from Asia (Figure 11).

Size distribution of vessels and the importance of small boats

In 2012, about 79 percent of the motorized fishing vessels in the world were less than 12 m LOA. Such vessels dominated in all regions, particularly Latin America and the Caribbean, Africa, and the Near East (Figure 12). About 2 percent of all motorized fishing vessels corresponded to industrialized vessels of 24 m and larger (roughly more than 100 GT) and that fraction was larger in the Pacific and Oceania region, Europe, and North America. The estimated number of industrialized fishing vessels of 24 m and larger operating in marine waters was about 64 000. This figure is about three times higher than the number of fishing vessels registered with a unique identification number provided by the International Maritime Organization.

The dominance of small vessels (less than 12 m LOA) is even higher in inland waters fisheries, where they represent more than 91 percent of all motorized vessels operating in inland waters. Estimations of the relative importance of the small-scale and industrial components of fisheries for social, economic, and food security purposes are likely to be skewed owing to an inadequate appraisal of the small-scale segment. The reasons for this are that often small vessels may not be subject to registration, but even where they are, those figures might not be reflected in national statistics. The lack of information

Figure 11

Distribution of motorized fishing vessels by region in 2012

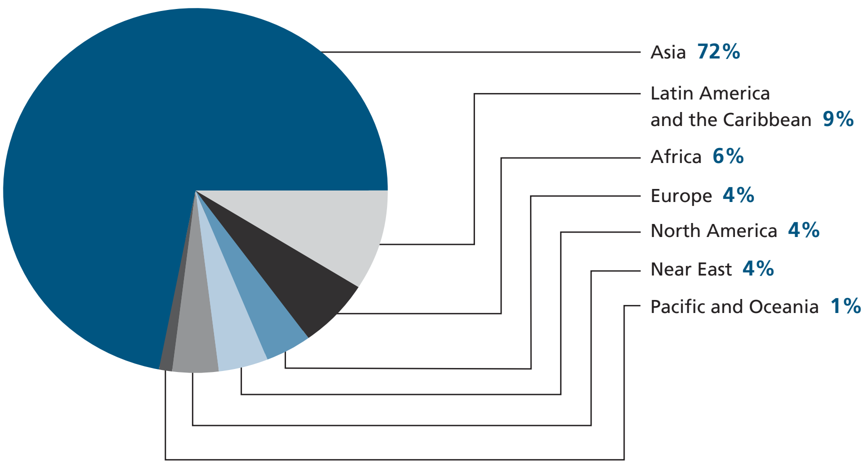
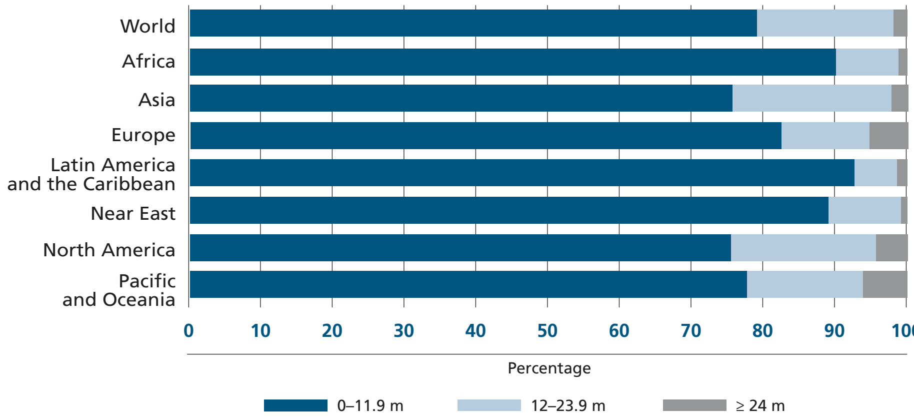


Figure 12

Size distribution of motorized fishing vessels by region in 2012



regarding small vessels is more acute for inland fleets, which are commonly not subject to national or local registries.

Table 14 illustrates some examples of the relevance of small-sized motorized fishing vessels for selected countries. The proportion of vessels of less than 12 m LOA exceeds 90 percent in most cases. In addition, an estimated 99 percent of non-motorized fishing vessels globally are less than 12 m LOA.

Efforts to reduce overcapacity in fishing fleets

In response to the International Plan of Action for the Management of Fishing Capacity, several countries have established targets to tackle national overcapacity of fishing fleets. In addition, several countries have implemented restrictions in inshore waters on larger vessels or those using certain gear types (e.g. trawls). However, while the numbers of fishing vessels have been decreasing in some parts of the world, they have being increasing elsewhere.

Table 15 provides summary details on the motorized fleets of several major fishing nations. It seems that the goals set by China's 2003–2010 marine fishing vessel reduction plan (of a marine fishing fleet of 192 390 vessels with a total combined power of 11.4 million kW) could finally have resulted in a reduction approaching their target by 2012, at least in terms of number of vessels. However, the fleet's total combined power has increased continuously away from the set target, and its mean engine power increased from 64 to 68 kW between 2010 and 2012.

Beyond the various schemes Japan has implemented to reduce overcapacity, Japan's marine fishing fleet was further reduced as a consequence of the tsunami of 11 March 2011. However, actions aimed at replacing vessels lost to the tsunami resulted in a net increase in the fleet from 2011 to 2012, with the incorporation of new and more powerful units. In fact, its mean engine power increased from 47 to 52 kW between 2010 and 2012.

In the European Union (Member Organization), the downward trend in the combined number, tonnage and power of fishing vessels has continued. The combined EU-15 motorized fishing fleet achieved a net reduction of 4 percent in both number of vessels and engine power, between 2010 and 2012, while its mean engine power remained unchanged at 85 kW.

After a period of decline (2005–2010), Iceland's fishing fleet experienced a net increase of 4 percent in number of vessels and 6 percent in total combined power from 2010 to 2012, with its mean engine power increasing from 287 to 293 kW. Between 2010 and 2012, Norway's fishing fleet maintained its downward trend, in terms of

Table 14
Numbers and proportion in terms of length of motorized vessels in fishing fleets from selected countries and territories

Flag	Date of data[1]	Powered vessels	Vessel length category		
			0–11.9 m	12–23.9 m	≥ 24 m
		(Number)	(Percentage)		
Kenya	2012	2 506	89.9	9.7	0.3
Malawi	2012	1 226	98.7	0.7	0.6
Mauritius	2011	1 887	98.9	0.7	0.4
Mozambique	2012	1 398	76.1	17.1	6.8
Tunisia	2012	5 631	77.1	18.7	4.2
Uganda	2011	6 795	97.0	2.9	0.0
United Republic of Tanzania	2012	10 799	97.2	2.4	0.3
Subtotal for selected countries in Africa		**30 242**	**92.0**	**6.7**	**1.3**
Bahrain	2012	2 521	86.4	13.5	0.1
Iran (Islamic Republic of)	2012	12 275	71.4	28.3	0.4
Oman	2012	16 595	96.1	3.7	0.2
Subtotal for selected countries in Near East		**31 391**	**85.7**	**14.1**	**0.3**
Bangladesh	2012	27 965	99.3	0.1	0.6
Myanmar	2012	14 886	83.9	11.7	4.5
Republic of Korea	2012	72 922	89.6	8.3	2.1
Sri Lanka	2012	31 300	95.4	4.5	0.1
Subtotal for selected countries in Asia		**147 073**	**92.1**	**6.3**	**1.6**
EU-27, selected countries in Europe[2]	**2012**	**75 302**	**83.0**	**13.1**	**3.9**
Bahamas	2012	1 296	82.0	16.4	1.6
Chile	2012	11 871	92.5	5.4	2.1
Honduras	2012	10 901	98.0	1.6	0.4
Mexico	2012	71 654	95.8	3.6	0.6
Nicaragua	2012	4 337	97.1	2.0	0.8
Saint Kitts and Nevis	2012	362	98.6	1.4	0.0
Saint Lucia	2012	700	99.0	1.0	0.0
Uruguay	2012	713	90.5	3.8	5.8
Venezuela (Bolivarian Republic of)	2012	20 473	85.2	14.2	0.6
Subtotal for selected countries in Latin America and the Caribbean		**122 691**	**93.8**	**5.4**	**0.8**
Fiji	2011	2 608	97.8	0.8	1.4
French Polynesia	2012	3 991	98.4	1.5	0.1
New Caledonia	2012	247	91.9	5.7	2.4
New Zealand	2012	1 417	61.7	32.5	5.9
Tonga	2012	837	95.8	2.7	1.4
Subtotal for selected countries in Oceania		**9 100**	**92.1**	**6.4**	**1.5**

[1] Data sourced from response to FAO questionnaires, except for EU-27 data.
[2] European Commission. 2013. Fleet Register On the NeT. In: *Europa* [online]. [Cited 19 June 2013]. http://ec.europa.eu/fisheries/fleet/index.cfm?method=Download.menu

both number of vessels and total combined power, with reductions of 2 and 1 percent, respectively. However, its mean engine power increased from 199 to 201 kW in the same period. Another important fishing country, the Republic of Korea achieved a net reduction of 2 percent in the number of vessels but a 5 percent increase in combined power, resulting in mean engine power increasing from 133 to 143 kW between 2010 and 2012.

Table 15
Motorized fishing fleets in selected countries, 2000–2012[1]

	2000	2005	2010	2011	2012
CHINA					
All fisheries vessels[2]					
number	487 297	513 913	675 170	696 186	695 555
tonnage GT	6 849 326	7 139 746	8 801 975	9 022 317	9 542 349
power kW[3]	14 257 891	15 861 838	20 742 025	21 412 243	21 735 732
Marine fishing only					
number	–	–	204 456	201 694	193 327
tonnage GT	–	–	6 010 919	6 182 268	6 560 469
power kW	–	–	13 040 623	13 255 855	13 223 354
Inland fishing only					
number	–	–	226 535	250 855	257 002
tonnage GT	–	–	1 044 890	1 123 686	1 189 572
power kW	–	–	3 473 648	3 867 809	4 042 183
JAPAN					
Marine fishing only					
number	337 600	308 810	276 074	252 665	254 052
tonnage GT	1 447 960	1 269 130	1 086 506	1 018 705	1 017 275
power kW	11 450 612	12 271 130	13 106 509	12 866 187	13 327 310
Inland fishing only					
number	9 542	8 522	7 851	7 780	7 425
tonnage GT	9 785	8 623	7 448	7 320	6 972
power kW	180 930	209 257	208 124	206 529	201 659
EU-15[4]					
number	86 660	77 186	71 295	69 780	68 187
tonnage GT	2 019 329	1 832 362	1 585 288	1 537 745	1 496 886
power kW	7 632 554	6 812 255	6 093 335	5 942 211	5 823 944
ICELAND					
number	1 993	1 752	1 625	1 655	1 690
tonnage GT	180 150	181 530	152 401	159 902	166 086
power kW	522 876	520 242	466 691	476 487	495 996
NORWAY					
number	13 017	7 722	6 310	6 250	6 212
tonnage GT	392 316	373 282	366 126	313 385	306 996
power kW	1 321 624	1 272 965	1 254 129	1 256 611	1 246 228
REPUBLIC OF KOREA					
number	89 294	87 554	74 669	73 427	72 922
tonnage GT	917 963	697 956	598 367	604 415	607 887
power kW	10 139 415	9 656 408	9 953 809	9 787 652	10 404 506

[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, France, Finland, Germany, Greece, Ireland, Italy, Netherlands, Spain, Portugal, Sweden and United Kingdom.

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THE STATUS OF FISHERY RESOURCES

Marine fisheries

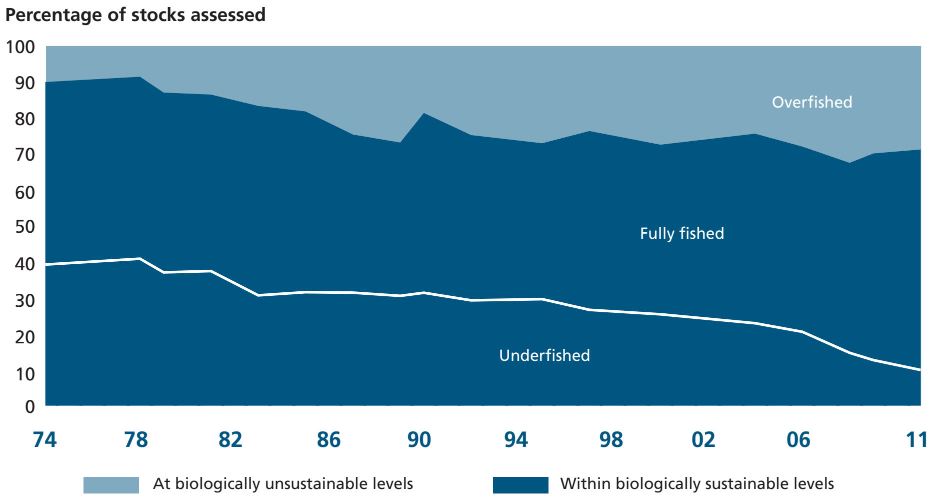
The world's marine fisheries expanded continuously to a production peak of 86.4 million tonnes in 1996 but have since exhibited a general declining trend. Global recorded production was 82.6 million tonnes in 2011 and 79.7 million tonnes in 2012. Of the FAO statistical areas, the Northwest Pacific had the highest production with 21.4 million tonnes (26 percent of the global marine catch) in 2011, followed by the Southeast Pacific with 12.3 million tonnes (15 percent), the Western Central Pacific with 11.5 million tonnes (14 percent), and the Northeast Atlantic with 8.0 million tonnes (9 percent).

The fraction of assessed stocks fished within biologically sustainable levels[6] has exhibited a decreasing trend, declining from 90 percent in 1974 to 71.2 percent in 2011 (Figure 13). Thus, in 2011, 28.8 percent of fish stocks were estimated as fished at a biologically unsustainable level[7] and therefore overfished. Of the total number of stocks assessed in 2011, fully fished stocks accounted for 61.3 percent and underfished stocks 9.9 percent (separated by the line in Figure 13). The underfished stocks decreased continuously from 1974 to 2011, but the fully fished stocks decreased from 1974 to 1989, and then increased to 61.3 percent in 2011. Correspondingly, the percentage of stocks fished at biologically unsustainable levels increased, especially in the late 1970s and 1980s, from 10 percent in 1974 to 26 percent in 1989. After 1990, the number of stocks fished at unsustainable levels continued to increase, albeit more slowly, and peaked at 32.5 percent in 2008 before declining slightly to 28.8 percent in 2011.

By definition, stocks fished at biologically unsustainable levels have an abundance lower than the level that can produce the MSY and are therefore being overfished. These stocks require strict management plans to rebuild stock abundance to full and biologically sustainable productivity. The stocks fished within biologically sustainable levels have abundance at or above the level associated with MSY. Stocks fished at the MSY level produce catches that are at or very close to their maximum sustainable production. Therefore, they have no room for further expansion in catch, and effective management must be in place to sustain their MSY. The stocks with a biomass considerably above the MSY level (underfished stocks) have been exposed to relatively low fishing pressure and may have some potential to increase their production. In accordance with the Code, effective and cautious management plans should be established before increasing the fishing rate of these underfished stocks in order to prevent overfishing affecting them as it has other stocks.

Figure 13

Global trends in the state of world marine fish stocks, 1974–2011



Notes: Dark shading = within biologically sustainable levels; light shading = at biologically unsustainable levels. The light line divides the stocks within biologically sustainable levels into two subcategories: fully fished (above the line) and underfished (below the line).

In total, the ten most productive species accounted for about 24 percent of world marine capture fisheries production in 2011. Most of their stocks are fully fished and, therefore, have no potential for increases in production, while some stocks are overfished and increases in their production may be possible only 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 Atlantic herring (*Clupea harengus*) stocks in both the Northeast and Northwest Atlantic are fully fished. Atlantic cod (*Gadus morhua*) is considered to be overfished in the Northwest Atlantic, but fully fished in the Northeast Atlantic. Chub mackerel (*Scomber japonicus*) stocks are fully fished in both the Eastern Pacific and the Northwest Pacific. Skipjack tuna (*Katsuwonus pelamis*) stocks are considered either fully fished or underfished.

The total catch of tuna and tuna-like species was about 6.8 million tonnes in 2011. The principal market tuna species – albacore, bigeye, bluefin (three species), skipjack and yellowfin – contributed 4.5 million tonnes, maintaining approximately the same level since 2003. About 68 percent of these catches were from the Pacific. Skipjack was the most productive principal market tuna, contributing about 58 percent to the 2011 catch of principal tunas, followed by yellowfin and bigeye (about 27 and 8 percent, respectively).

Among the seven principal tuna species, one-third of the stocks were estimated as fished at biologically unsustainable levels, while 66.7 percent were fished within biologically sustainable levels (fully fished or underfished) in 2011. The landings of skipjack tuna plateaued at 2.6 million tonnes in 2010–11, after peaking at 2.7 million tonnes in 2009. Only for very few stocks of the principal tuna species is their status unknown or very poorly known. Market demand for tuna is still high and the significant overcapacity of tuna fishing fleets remains. Effective management plans need to be implemented to prevent deterioration of tuna stocks.

World marine fisheries have undergone significant changes since the 1950s. Accordingly, their fishing levels and landings have also varied over time. The temporal pattern of landings differs from area to area depending on the level of urban and economic development and changes that countries in the surrounding area have experienced. In general, they can be divided into three groups: (i) oscillating catches around a globally stable value; (ii) overall declining trend following historical peaks; and (iii) continuously increasing catch trends since 1950.

The first group includes those FAO areas that have demonstrated oscillations in total catch, i.e. the Eastern Central Atlantic, Northeast Pacific, Eastern Central Pacific, Southwest Atlantic, Southeast Pacific, and Northwest Pacific. These areas provided about 54 percent of the world's total marine catch in 2011. Several of them include upwelling regions characterized by high natural variability.

The second group contributed 18 percent of the global marine catch in 2011, and includes the Northeast Atlantic, Northwest Atlantic, Western Central Atlantic, Mediterranean and Black Sea, Southwest Pacific, and Southeast Atlantic. In some cases, lower catches 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 only three areas: Western Central Pacific, Eastern Indian Ocean and Western Indian Ocean. They contributed 28 percent of the total marine catch in 2011. However, in some regions, there is still uncertainty about the actual catches owing to the poor quality of statistical reporting systems.

The Northwest Pacific has the highest production among the FAO areas. Its total catch fluctuated between about 17 million and 24 million tonnes in the 1980s and 1990s, and was about 21.4 million tonnes in 2011. Small pelagic fish are the most abundant category in this area, with Japanese anchovy providing 1.9 million tonnes in 2003 but then declining to about 1.3 million tonnes in 2011. Other important contributors to the total catch in the area are large-head hairtail, considered overfished, and Alaska pollock and chub mackerel, both considered fully fished.

The Eastern Central Pacific has shown a typical oscillating pattern in its total catch since 1980 and produced about 2 million tonnes in 2011. The Southeast Pacific has had large interannual variations with a generally declining trend since 1993. There have been no major changes in the state of fishing of stocks in these two areas, which are characterized by a large proportion of small pelagic species and considerable fluctuations in catches. The most abundant species in the Southeast Pacific is anchoveta, whose catch increased by about 4 million tonnes in 2011, followed by araucanian herring (*Strangomera bentincki*) and jumbo flying squid (*Dosidicus gigas*). In the Eastern Central Pacific, the most abundant species are California pilchard and yellowfin tuna.

For the Eastern Central Atlantic, total catches, which have fluctuated since the 1970s, were about 4.2 million tonnes in 2011, similar to the 2001 peak. 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*) at 600 000–900 000 tonnes in the last ten years. The sardine stock in the area of Cape Bojador and southward to Senegal is considered underfished; otherwise, most of the pelagic stocks are considered either fully fished or overfished. The demersal fish resources are to a large extent fully fished to overfished in most of the area, and the white grouper (*Epinephelus aenus*) stock 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 fished, whereas the other shrimp stocks in the region range between fully fished and overfished. The commercially important stocks of octopus (*Octopus vulgaris*) and cuttlefish (*Sepia* spp.) remain overfished. Overall, the Eastern Central Atlantic has 48 percent of its assessed stocks fished at biologically unsustainable levels, and 52 percent within sustainable levels.

In the Southwest Atlantic, total catches have fluctuated between 1.7 million and 2.6 million tonnes after a period of increase that ended in the mid-1980s. Major species such as Argentina hake and Brazilian sardinella are considered overfished. The catch of Argentina shortfin squid was only one-fourth of its peak level in 2009 and considered fully fished to overfished. In this area, 55 percent of the monitored fish stocks were fished at biologically unsustainable levels, and 45 percent within biologically sustainable limits.

The Northeast Pacific produced 3 million tonnes of fish in 2011, an average level since the early 1970s. Cods, hakes and haddocks are the largest contributors to its catch. In this area, only 12 percent of fish stocks were estimated to be fished at biologically unsustainable levels and 88 percent fully or underfished.

In the Northeast Atlantic, total catch showed a decreasing trend after 1975, with a recovery in the 1990s, and was 8 million tonnes in 2011. The blue whiting stock decreased rapidly from the peak of 2.4 million tonnes in 2004 to only 103 000 tonnes in 2011. 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 are fully fished. The largest sand eel stock remains overfished, while capelin stocks have recovered to a fully fished state. 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 stocks are generally in good condition. Recently, MSY has been adopted as the standard basis for reference points.

Although fishery resources in the Northwest Atlantic remain under stress from previous and/or current fishing, some stocks have shown signs of recovery 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. However, invertebrates remain at near-record levels of abundance.

The Southeast Atlantic is a typical example of an area with a generally decreasing trend in catches since the early 1970s. It produced 3.3 million tonnes in the late 1970s, but only 1.2 million tonnes in 2011. The important hake resources remain fully fished to overfished although there are signs of 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 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 fished in 2004, but which now, under unfavourable environmental conditions, has declined considerably in abundance and is now fully fished or overfished. In contrast, Southern African anchovy has continued to improve and its status was estimated to be fully fished in 2011. Whitehead's round herring has not been fully fished. The condition of Cunene horse mackerel has deteriorated, particularly off Namibia and Angola, and it was considered overfished in 2011. The condition of the perlemoen abalone stock, exploited heavily by illegal fishing, remains worrying, and it is currently overfished.

The Mediterranean has maintained an overall stable catch in recent years. All hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*) stocks are considered overfished, as are probably also the main stocks of sole and most sea breams. The main stocks of small pelagic fish (sardine and anchovy) are assessed as fully fished. 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. However, they are still considered overfished, an assessment shared with turbot, while most other stocks are probably fully fished to overfished. In general, the Mediterranean and Black Sea had 52 percent of assessed stocks fished at unsustainable levels, and 48 percent fully or underfished in 2011.

Total production in the Western Central Pacific grew continuously to a maximum of 11.7 million tonnes in 2010, and was 11.5 million tonnes in 2011. This area contributes about 14 percent of global marine production. However, there are reasons for concern as regards the state of the resources, with most stocks being either fully fished or overfished, particularly in the western part of the South China Sea. The high reported 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 is still showing a high growth rate in catches, with a 17 percent increase from 2007 to 2011, and now totals 7.2 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, about 42 percent of the catches in this area are attributed to the category "marine fishes not identified", which is a cause for 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 exclusive economic zone can be partly explained by a reduction in effort and catches following structural adjustment to reduce overcapacity 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, and higher profits can also be expected for individual fishers in the short term as fewer vessels are operating.

In the Western Indian Ocean, total landings reached a peak of 4.5 million tonnes in 2006, but then declined slightly, with 4.2 million tonnes reported in 2011. A recent assessment has shown that narrow-barred Spanish mackerel (*Scomberomorus 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 fully fished to overfished. 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, 75 percent of fish stocks were estimated to be fully fished or underfished, and 25 percent fished at unsustainable levels.

The declining trend in global marine catch has been seen since 1996, although with large fluctuations. Overall, the number of stocks fished at unsustainable levels was estimated at 29 percent in 2011, slightly improved from the peak of 33 percent in 2008. These results are based on single-species assessments and it is ecologically impossible to harvest all species at the MSY level simultaneously. Therefore, some stocks may need to have their abundance maintained above the MSY level to avoid ecosystem overfishing.

Overfishing not only causes negative ecological consequences, it also reduces fish production, which further leads to negative social and economic consequences. It is estimated that rebuilding overfished stocks could increase fishery production by 16.5 million tonnes and annual rent by US$32 billion,[8] which would certainly increase the contribution of marine fisheries to the food security, economies and well-being of the coastal communities. The situation seems more critical for some highly migratory, straddling and other fishery resources that are fished solely or partially in the high seas. The United Nations Fish Stocks Agreement that entered into force in 2001 should be used as the 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 fishing rates and restoring overfished 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. By 2012, 79 percent of United States fish stocks were at or above a level able to provide MSY. In New Zealand, the percentage of fish stocks having abundance above the overfishing threshold declined from 25 percent in 2009 to 18 percent in 2013. Similarly, Australia reports only 11 percent of its assessed stocks overfished in 2011. In the European Union (Member Organization), up to 70 percent of assessed stocks had either decreasing fishing rates or increasing stock abundance.[9] Similar examples of success also exist in many other fisheries around the world. For example, Namibia has rebuilt its hake fishery and Mexico has succeeded in restoring its abalone stock. With the ever-strengthening declarations of political will in the international arena and increasing acceptance of the need for restoration of overfished stocks to ensure resource sustainability, food security and human well-being, the world's marine fisheries can make good progress towards long-term sustainability.

Inland fisheries

The State of World Fisheries and Aquaculture 2012 described the particular difficulties associated with assessing the status of inland fishery resources. It also proposed a new assessment strategy that would rate the status of inland fishery resources on the extent to which management goals for the fishery or waterbody were being met by considering environmental as well as social and economic components. This approach is entirely consistent with the ecosystem approach to fisheries (EAF). FAO and its partners are working on refining and testing the methodology with the aim of enabling more systematic and comparable assessments in the future.

FISH UTILIZATION AND PROCESSING

Fishery production can be processed into a wide array of products in many forms. Great technological development in food processing and packaging is ongoing in many countries, with increases in efficient, effective and lucrative utilization of raw materials, and innovation in product differentiation for human consumption as well as for production of fishmeal and fish oil. The expansion in demand for fish products in recent decades has been accompanied by growing interest in food quality and safety, nutritional aspects, and wastage reduction. In the interests of food safety and consumer protection, increasingly stringent hygiene measures have been adopted at national and international trade levels. Fish is highly perishable and, unless correctly treated after harvesting, can soon become unfit to eat and possibly dangerous to health through microbial growth, chemical change and breakdown by endogenous enzymes. Proper handling, processing, preservation, packaging and storage measures are essential to improve its shelf-life, ensure its safety, maintain its quality and nutritional attributes and avoid waste and losses.

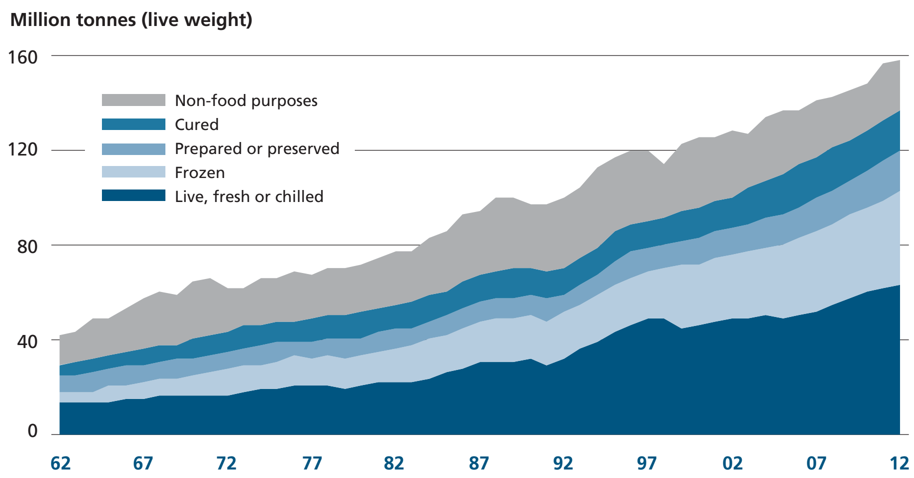
Fish production can be utilized for food and other non-food uses. Since the early 1990s, the proportion of fisheries production used for direct human consumption has been increasing. In the 1980s, about 71 percent of the fish produced was destined for human consumption, this share grew to 73 percent in the 1990s, and to 81 percent in the 2000s. In 2012, more than 86 percent (136 million tonnes) of world fish production was utilized for direct human consumption (Figure 14). The remaining 14 percent (21.7 million tonnes) was destined to non-food uses, of which 75 percent (16.3 million tonnes) was reduced to fishmeal and fish oil. The residual 5.4 million tonnes was largely utilized as fish for ornamental purposes, for culture (fingerlings, fry, etc.), bait, pharmaceutical uses and as raw material for direct feeding in aquaculture, for livestock and for fur animals.

In 2012, of the fish marketed for edible purposes, 46 percent (63 million tonnes) was in live, fresh or chilled forms, which in some markets are often the most preferred and highly priced product forms. In addition, 12 percent (16 million tonnes) was utilized in dried, salted, smoked or other cured forms, 13 percent (17 million tonnes) in prepared and preserved forms, and 29 percent (40 million tonnes) in frozen form. Freezing is the main processing method for fish for human consumption, accounting for 54 percent of total processed fish for human consumption and 25 percent of total fish production in 2012.

Utilization and processing methods show marked continental, regional and national differences. In Africa, and more notably Asia, the share of fish marketed in live or fresh forms is particularly relevant. For developing countries as a whole, live, fresh or chilled fish represented 54 percent of fish destined for human consumption in 2012. Live fish is especially appreciated in Southeast Asia and the Far East and in niche markets in other countries, mainly among immigrant Asian communities. However, from available statistics, it is not possible to determine the exact amount of fish marketed in live form. Handling of live fish for trade and use has been practised in China and other countries for more than 3 000 years. Thanks to technological improvements, keeping fish alive

Figure 14

Utilization of world fisheries production (breakdown by quantity), 1962–2012



for later consumption is a common fish-handling practice worldwide. The means of transportation of live fish range from simple artisanal systems of transporting fish in plastic bags with an atmosphere supersaturated with oxygen, to specially designed or modified tanks and containers, and on to very sophisticated systems installed on trucks and other vehicles that regulate temperature, filter and recycle water, and add oxygen. Nevertheless, marketing and transportation of live fish can be challenging as they are often subject to stringent health regulations and quality standards. In parts of Southeast Asia, their commercialization and trade are not formally regulated but based on tradition. However, in markets such as the European Union (Member Organization), live fish have to comply with requirements, inter alia, concerning animal welfare during transportation.

In recent decades, major innovations in refrigeration, ice-making, packaging and transportation to ensure product integrity have also allowed an expansion of fish distributed in fresh, chilled and frozen forms. Developing countries have experienced a growth in the share of fish production utilized as frozen products (24 percent of fish for human consumption in 2012, up from 20 percent in 2002 and 13 percent in 1992). However, many countries, especially less-developed economies, still lack adequate infrastructure and services including hygienic landing centres, electricity, potable water, roads, ice, ice plants, cold rooms and refrigerated transport. These factors, associated with tropical temperatures, result in high post-harvest losses and quality deterioration, with subsequent risks for consumers' health. In addition, fish marketing is also more difficult owing to often limited and congested market infrastructure and facilities. Due to these deficiencies, together with well-established consumer habits, fish in developing countries is commercialized mainly live or fresh soon after landing or harvesting, or it is processed using traditional preservation methods, e.g. salting, drying and smoking. These methods remain prevalent in many countries, in particular in Africa and Asia, which show higher proportions of cured fish compared with other continents.

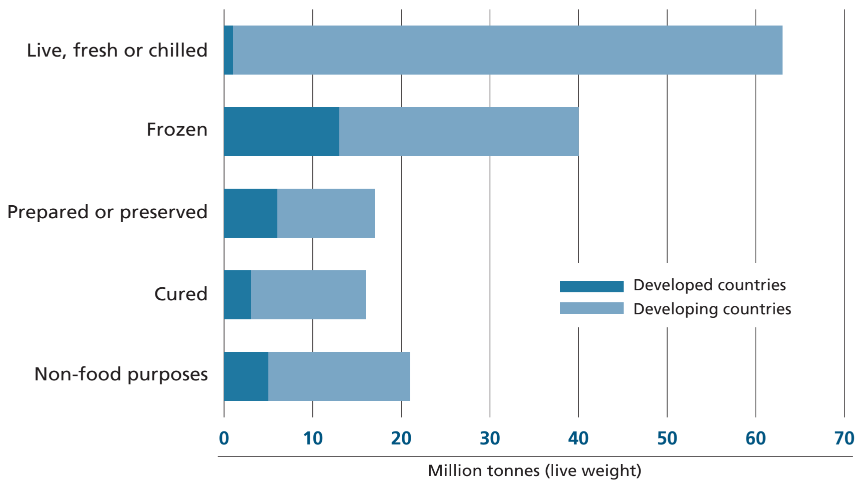
In many developing countries, processing uses less-sophisticated methods of transformation, such as filleting, salting, canning, drying and fermentation. These traditional labour-intensive methods provide livelihood support to large numbers of people in coastal areas in many developing countries, and 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 evolved also in many developing countries. 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 shifts in cultured species, by outsourcing of processing and by producers in developing countries being increasingly linked with, and coordinated by, firms located abroad. In 2012, the proportion of their fish production being processed into prepared or preserved forms represented 10 percent of total fish for human consumption.

In developed countries, the bulk of fish production is processed (Figure 15). The proportion of frozen fish has increased in the last four decades, up from 38 percent of their total production for human consumption in 1972 to a record high of 55 percent in 2012. The share of prepared and preserved forms has remained rather stable, and it was 27 percent in 2012. In developed countries, innovation in value addition is converging on convenience foods and a wider range of high-value-added products. These are mainly in fresh, frozen, breaded, smoked or canned forms and marketed as ready and/or portion-controlled, uniform-quality meals. In addition, 14 percent of their fish production used for human consumption is in dried, salted, smoked or other cured forms.

A significant, but declining, proportion of world fisheries production is still processed into fishmeal and fish oil. Fishmeal is mainly used for high-protein feed. Fish oil is used in the aquaculture industry, but increasingly for human consumption mainly to replace mineral oil or to treat diabetes, hypertension and other conditions and diseases. Technologies such as microencapsulation and nanoencapsulation are

Figure 15

Utilization of world fisheries production (breakdown by quantity), 2012



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 nutritional availability. In the period 2008–2012, fish for reduction represented about 9–12 percent of total fisheries production and 16–20 percent of total capture fisheries production. Fishmeal and fish oil can be produced from whole fish, fish remains or other fish by-products such as heads, tails, bones and other offals. Although many different species are used for fishmeal and fish-oil production, oily fish such as small pelagics, in particular anchoveta, are the main groups of species utilized. In recent decades, catches of anchoveta have experienced a series of peaks and drastic falls as a direct consequence of the El Niño phenomenon. In addition, stricter management measures have reduced catches of anchoveta and other species usually used for reduction. Hence, the volumes of fishmeal and fish oil produced have fluctuated with variations in the catches of these species. Fishmeal production peaked in 1994 at 30.2 million tonnes (live weight equivalent). In 2010, it dropped to 14.8 million tonnes owing to reduced catches of anchoveta, increased in 2011 to 19.4 million tonnes and then declined to 16.3 million tonnes in 2012. Owing to the growing demand for fishmeal and fish oil and rising prices, more fishmeal is being produced from fish by-products, which previously were often discarded. This can affect the composition and quality of the fishmeal with, in general, more ash (minerals), an increased level of small amino acids (such as glycine, proline, hydroxyproline) and less protein, which may affect its share in feeds used in aquaculture and livestock farming. According to recent estimates, about 35 percent of world fishmeal production was obtained from fish residues in 2012.

Given the above, efforts to replace fishmeal and fish oil are ongoing and further improvements are expected. In recent years, the percentage of fishmeal and fish oil in compound feeds for aquaculture has shown a clear downward trend while their international prices have increased. At present, and in the near future, fishmeal and fish oil are and will be widely used as strategic ingredients at lower levels and for specific stages of production, e.g. fry. However, depending on the alternatives used, their substitution by other ingredients may affect the health properties of farmed fish. Almost completely absent in the higher plants, highly unsaturated fatty acids (HUFAs) determine the dietary value of fish in human nutrition. However, there are differences in the ability of different aquatic animals to synthesize HUFAs, such as eicosapentaenoic acid and docosahexaenoic acid – which fishmeal and fish oil are particularly rich in. Such differences appear to depend on species and life stage. Alternative sources of

HUFAs are being explored, including large marine zooplankton stocks, such as Antarctic krill (*Euphausia superba*) and the copepod *Calanus finmarchicus*. To offset their rising prices, as feed tonnages increase, feed companies will continue to stretch available quantities of fishmeal and fish oil further by substituting them with other ingredients.

Growing value addition in fishery products for human consumption is leading to more residual by-products. These by-products are usually not put on the market owing to low acceptance by consumers or because sanitary regulations restrict their use for reasons of food safety and quality. Such regulations might also govern the collection, transport, storage, handling, processing and use or disposal of these by-products. In the past, fish by-products, including waste, were considered to be of low value, or as something 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 resources, and of the importance of reducing discards and losses in post-harvest phases (storage, processing and distribution). Utilization of fish by-products is gaining attention also because they can represent a significant source of minerals, proteins and fat for use in a variety of products (for more detail, see Challenges and opportunities in the utilization of fisheries by-products on pp. 169–173). Their utilization 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 are also enabling their more efficient utilization. In addition to the fishmeal industry, fisheries by-products are also utilized for a wide range of other purposes. Heads, frames, and fillet cut-offs can be turned into products for human consumption such as fish sausages, cakes, gelatin and sauces. Small fish bones, with a minimum amount of meat, are also consumed as snacks in some Asian countries. Other by-products are used in the production of feed, biodiesel/biogas, dietetic products (chitosan), pharmaceuticals (including oils), natural pigments (after extraction), cosmetics (collagen), other industrial processes, as direct feeding for aquaculture and livestock, incorporation into pet feed or feed for animals kept for fur production, silage, fertilizer and landfill.

Some fishery by-products, in particular the viscera, are highly perishable and should therefore be processed while still fresh. Fish viscera and frames are used as a potential source of protein hydrolysate, which is receiving growing interest because it is a potential source of bioactive peptides. Fish protein hydrolysates and fish silage[10] obtained from fish viscera are finding applications in the pet-feed and fish-feed industries. Shark cartilage is utilized in many pharmaceutical preparations and reduced to powder, creams and capsules, as are other parts of sharks, e.g. ovaries, brain, skin and stomach. Fish collagens are of interest for cosmetics, but also to the food processing industry as gelatin is extracted from the collagen. Chitosan, produced from shrimp and crab shell, has shown a wide range of applications such as in water treatments, cosmetics and toiletries, food and beverages, agrochemicals and pharmaceuticals. From crustacean wastes, pigments (carotenoids and astaxanthin) can be extracted for use in the pharmaceutical industry, and collagen can be extracted from fish skin, fins and other processing by-products. Mussel shells can provide calcium carbonate for industrial use. In some countries, oyster shells are a raw material in building construction and the production of quicklime (calcium oxide). Research on marine sponges, bryozoans and cnidarians has discovered a number of anticancer agents. However, following their discovery, for conservation reasons, these agents are not extracted from marine organisms directly but chemically synthesized. Another approach being researched is the culture of some sponge species to be used for this purpose. Fishbone is used to manufacture bonemeal, mainly for feed additives. Fish internal organs yield protease, a digestive enzyme that can be widely used in the manufacture of cleaners to remove plaques and dirt, and in food processing and biological research. Fish skin, in particular of larger fish, provides 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. In addition, shark teeth are utilized in handicrafts; similarly, scallop and mussel shells can be used in handicrafts and jewellery, and for making buttons. Shells can also be processed into pearl powder and shell powder. Pearl powder is employed for medicine and cosmetics manufacturing, and shell powder (a rich source of calcium) is used as a diet supplement in feeding livestock and poultry. Fish scale is used for processing fish silver, a raw material in medicines, biochemical drugs and paint manufacturing. Procedures for the industrial preparation of biofuel from fish waste and seaweeds are being developed.

About 25 million tonnes of seaweeds and other algae are harvested annually for further processing. They are used as food (traditionally in Japan, the Republic of Korea and China), but also in cosmetics and fertilizers. They are industrially processed to extract thickening agents such as alginate, agar and carrageenan or used, generally in dried powder form, as an additive to animal feed.

In recent decades, the complex patterns of globalization have transformed the fish processing sector, making it more heterogeneous and dynamic. The fish food sector is becoming increasingly globalized, with supermarket chains and large retailers emerging as important players in setting requirements for the products they buy and influencing the growth of international distribution channels. Processing is becoming more intensive, geographically concentrated, vertically integrated and linked with global supply chains. Processors are becoming more integrated with producers to enhance the product mix, obtain better yields and respond to evolving quality and safety requirements in importing countries. The outsourcing of processing activities at the regional and world levels is significant, with a growing number of countries participating, although its extent depends on species, product form, costs of labour and transportation. For example, in Europe, smoked and marinated products, for which shelf-life and transportation time are important, are 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 (to China in particular, but also other countries such as India, Indonesia and Viet Nam) for filleting and packaging, and then re-imported. Further outsourcing of production to developing countries might be constrained by sanitary and hygiene requirements that are difficult to meet and also by growing labour costs in some countries, in particular in Asia. Outsourcing to some countries might be also affected by rising oil prices and, hence, transportation costs. All these factors might lead to changes in distribution and processing facilities and increases in fish prices.

FISH TRADE AND COMMODITIES

Fish is among the most traded food commodities worldwide. Fishery trade has expanded considerably in recent decades, as the fisheries sector operates in an increasingly globalized environment. The way fishery products are prepared, marketed and delivered to consumers has changed significantly, and commodities may well cross national boundaries several times before final consumption. Fish can be produced in one country, processed in a second and consumed in a third. Among the driving forces behind this globalized fisheries and aquaculture value chain are: dramatic decreases in transport and communication costs; outsourcing of processing to countries where comparatively low wages and production costs provide a competitive advantage; increasing consumption of fishery commodities; favourable trade liberalization policies; more efficient distribution and marketing; and continuing technological innovations, including improvements in processing, packaging and transportation. Geopolitics has also played a decisive role in advancing and reinforcing these structural trends. The intermingling of these drivers of change has been multidirectional and complex, and the pace of transformation rapid. All these factors have facilitated and increased the movement of production from local consumption to international markets. This change is manifested most clearly in wider geographical participation in trade. In 2012, about 200 countries reported exports of fish and fishery products.

The role of fishery trade varies among countries and is important for many economies, especially for developing nations. For many countries and for numerous insular, coastal, riverine and inland regions, fishery exports are essential to the economy. For example, in 2012, they accounted for more than half of the total value of traded commodities in Faroe Islands, Greenland, Seychelles 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.

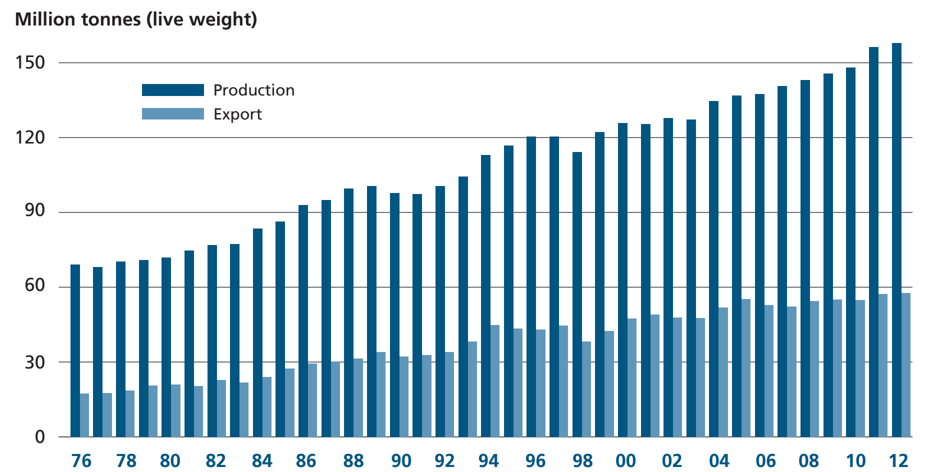
A significant share of total fishery production is exported in the form of different product forms for human consumption or non-edible purposes. This share grew from 25 percent in 1976 to 37 percent (58 million tonnes, live-weight equivalent) in 2012 (Figure 16), reflecting the sector's degree of openness to, and integration in, international trade. In the period 1976–2012, world trade of fish and fishery products increased by about 8.3 percent per year in nominal terms and by 4.1 percent in real terms. Fishery exports reached a peak of US$129.8 billion in 2011, up 17 percent on 2010. In 2012, they declined slightly to US$129.2 billion. This sluggishness was mainly the result of the downward pressure experienced by international prices of selected fish and fishery products for human consumption, in particular of farmed species. In addition, there was also reduced demand in many key markets as a consequence of the economic contraction still affecting consumer confidence. Demand was particularly uncertain in many developed countries, the main importers of fish for human consumption. Therefore, exporters were encouraged to develop new markets in a number of emerging economies still presenting healthy demand.

Fishery trade is closely tied to the overall economic situation. Since 2009, 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 term. World trade has been hit by a series of economic, financial and food crises. At present, the global economy appears to be transitioning towards more stable but slower growth. Economic conditions are rebounding in both developed and developing economies, but the resurgence in both trade and output remains slower in developed countries. According to the World Bank,[11] five years after the global financial crisis, the world economy is showing signs of bouncing back in 2014, pulled along by a recovery in high-income economies. Developing-country growth is also firming, thanks in part to the recovery in high-income economies as well as moderating, but still strong, growth in China.

Also thanks to these overall signs of growth, preliminary estimates for 2013 point to a new increase in trade of fish and fishery products. Exports reached a new record of more than US$136 billion, up more than 5 percent on the previous year. For major developed countries, still suffering from economic slowdown or only slowly recovering,

Figure 16

World fisheries production and quantities destined for export



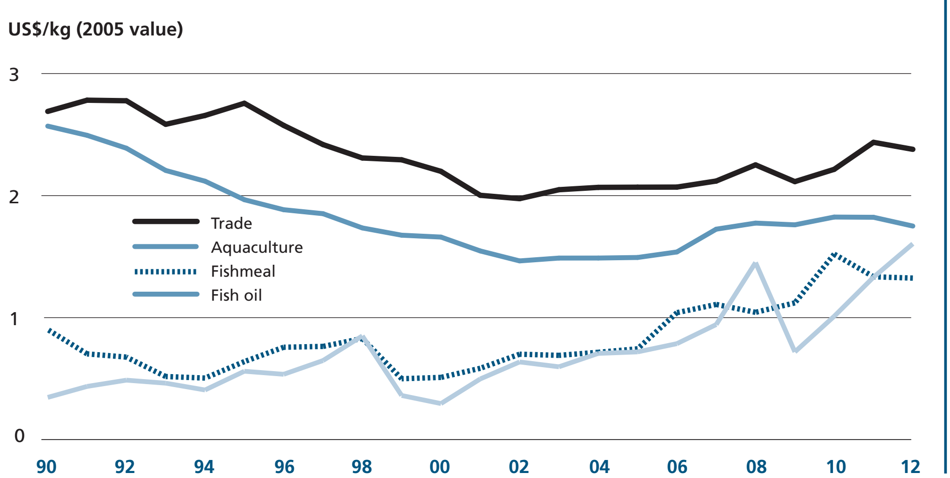
this increase in trade value is mainly a reflection of inadequate supply pushing prices upwards. Despite the instability experienced in 2012 and part of 2013, the long-term trend for fish trade remains positive. Thanks to their slow but continuing economic recovery, major developed economies are expected to revitalize consumer interest in seafood. Demand is also increasing steadily in emerging economies for high-value species such as salmon, tuna, bivalves and shrimp. However, with capture production stable and various factors restricting aquaculture supply of shrimp and salmon – two of the world's major traded species – the upward pressure exerted on prices by continued global demand growth may be significant.

Fish prices are influenced by demand and supply factors, including the costs of production and transportation, but also of alternative commodities, including meat and feeds. At the same time, the heterogeneous nature of the fishery 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. Since 2009, FAO has been working on the construction and enhancement of the FAO Fish Price Index[12] 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. With a base of the 2002–04 average set to 100, the aggregate FAO Fish Price Index increased markedly from 90 in early 2002 to peak at 157 in March 2011, although with strong within-year oscillations. The index then declined slightly, but overall remained high at above 140 in 2012–13. In the rest of 2013, the upward trend in prices started to become evident in the FAO Fish Price Index, which climbed steeply to a record high of 160 in October. A rise in prices for farmed species, particularly shrimp, is the major component of this rapid increase, although positive developments in prices for some wild species such as cod and certain pelagic species is another important driver.

In addition to the aggregate index, FAO has developed separate indices for the most important commodities, and for wild and farmed categories of species. One interesting aspect highlighted by the FAO Fish Price Index is the divergence in price trends for capture and aquaculture products. The main causes for this appear to be on the supply side and in the respective cost structures – higher energy prices on fishing vessel operations than on farmed ones, and supply lower than demand for certain species. Aquaculture has benefited to a greater degree from cost reductions through productivity gains and economies of scale, but it has recently been experiencing higher costs, in particular for feeds, which has affected production of carnivorous species in particular. Aquaculture production also responds to price changes with a

Figure 17

Average fish prices in real terms (2005)



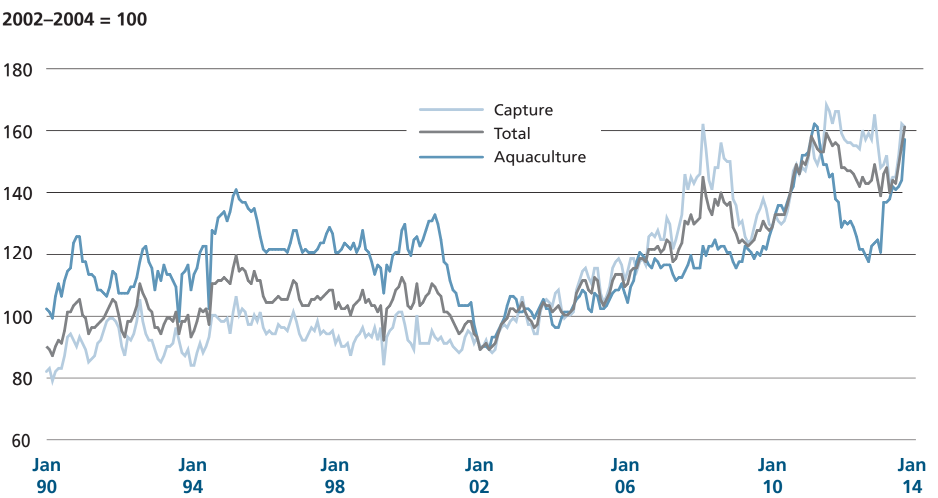
time lag, given the stocking and production cycle for most species. In recent decades, the growth in aquaculture production has contributed significantly to increased consumption and commercialization of species that were once primarily wild caught, with a consequent price decrease. This was particularly evident in the 1990s and early 2000s (Figure 17), with average unit values of aquaculture production and trade in real terms (2005 value) 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. Until late 2012, the FAO Fish Price Index for species from capture fisheries increased more than those for farmed species, reaching 164 versus 123 in December 2012 (Figure 18), because of the larger impact from higher energy prices on fishing vessel operations than on farmed species. However, in 2013, the gap narrowed to 160 versus 156 in October 2013.

Trade in fish and fishery products is characterized by a wide range of product types and participants. Table 16 shows the top ten exporters and importers in 2002 and 2012. Since 2002, China has been, by far, the largest exporter, but its imports are also growing. Since 2011, it has become the world's third-largest importing country, after the United States of America and Japan. The increase in its imports is partly a result of outsourcing. China's processors import raw material from all major regions, including South and North America and Europe, for re-processing and re-export. However, this growth also reflects China's surging domestic consumption of species not available from local sources. In 2013, China's trade of fish and fishery products reached a new record, with exports valued at US$19.6 billion and imports at US$8.0 billion.

Norway, the second major exporter, has a diverse product mix, ranging from farmed salmonids to small pelagic species and traditional whitefish products. The recovery in Arctic cod has also allowed the country to expand its markets for fresh cod products. In 2013, Norway further increased its fishery exports to US$10.4 billion, up 16.4 percent on 2012. Thailand and Viet Nam are the third- and fourth-largest exporters. In 2013, Thailand experienced a decline in its exports (to US$7.0 billion, down more than 13 percent on 2012), as disease problems reduced farmed shrimp production. In both countries, the processing industry contributes significantly to the domestic economy through job creation and trade. Thailand is a processing centre of excellence largely dependent on imported raw material. In contrast, Viet Nam has a growing domestic

Figure 18

FAO Fish Price Index



Data source: Norwegian Seafood Council.

Table 16
Top ten exporters and importers of fish and fishery products

	2002	2012	APR
	(US$ millions)		(Percentage)
EXPORTERS			
China	4 485	18 228	15.1
Norway	3 569	8 912	9.6
Thailand	3 698	8 079	8.1
Viet Nam	2 037	6 278	11.9
United States of America	3 260	5 753	5.8
Chile	1 867	4 386	8.9
Canada	3 044	4 213	3.3
Denmark	2 872	4 139	3.7
Spain	1 889	3 927	7.6
Netherlands	1 803	3 874	7.9
TOP TEN SUBTOTAL	28 525	67 788	9.0
REST OF WORLD TOTAL	29 776	61 319	7.5
WORLD TOTAL	**58 301**	**129 107**	**8.3**
IMPORTERS			
Japan	13 646	17 991	2.8
United States of America	10 634	17 561	5.1
China	2 198	7 441	13.0
Spain	3 853	6 428	5.3
France	3 207	6 064	6.6
Italy	2 906	5 562	6.7
Germany	2 420	5 305	8.2
United Kingdom	2 328	4 244	6.2
Republic of Korea	1 874	3 739	7.2
China, Hong Kong SAR	1 766	3 664	7.6
TOP TEN SUBTOTAL	44 830	77 998	5.7
REST OF WORLD TOTAL	17 323	51 390	11.5
WORLD TOTAL	**62 153**	**129 388**	**7.6**

Note: APR refers to the average annual percentage growth rate for 2002–2012.

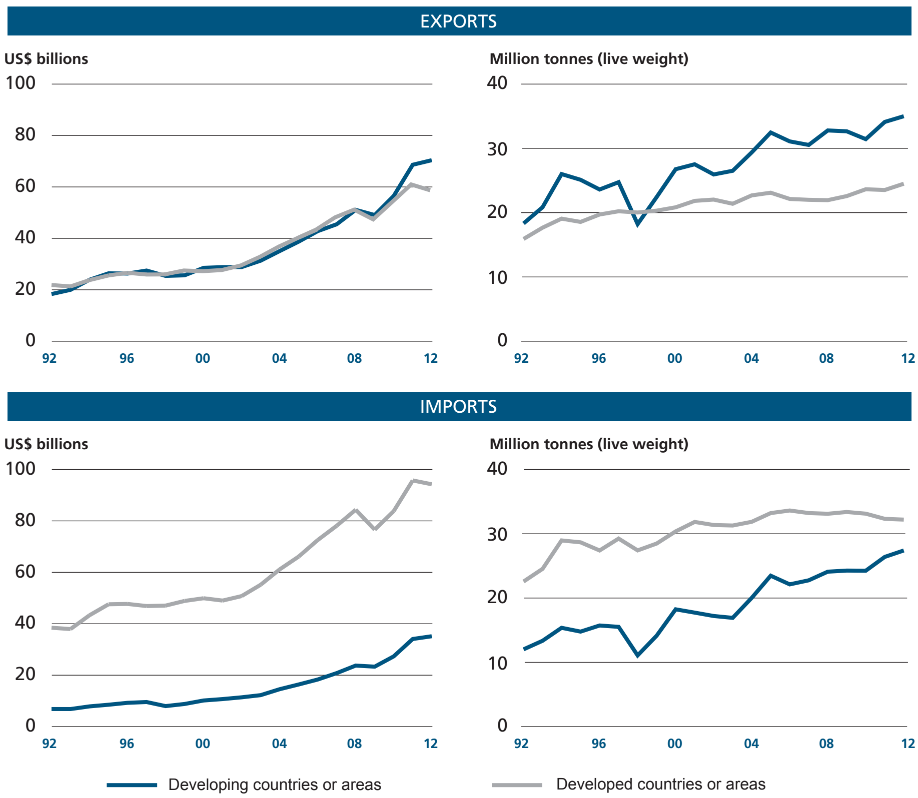
resource base and imports only limited, albeit growing, volumes of raw material. Its rising exports are linked to its flourishing aquaculture industry, in particular to the production of *Pangasius* and of both marine and freshwater shrimps and prawns.

The European Union (Member Organization) is, by far, the largest single market for imported fish and fishery products. In 2012, its imports were valued at US$47.0 billion, down 6 percent on 2011, and representing 36 percent of total world imports. However, official statistics also include trade among its partners. If intraregional trade is excluded, its fishery imports were worth US$24.9 billion in 2012 – still making it the largest market, with about 23 percent of world imports. Preliminary data for 2013 show its imports growing 8 percent relative to 2012, to more than US$50 billion (US$26 billion excluding trade within the region). Its dependence on imports for fish consumption is growing. This is a result of the positive underlying trend in consumption, but also evidence of internal constraints on further expansion of supply.

The United States of America and Japan are the largest single importers of fish and fishery products and also highly dependent on imports for fish consumption (at about 60 and 54 percent, respectively, of their total fish supply). Japan, traditionally the largest single importer of fish, was overtaken by the United States of America in 2011, but again became the main importer in 2012 at US$18.0 billion. In 2013, its imports

Figure 19

Trade of fish and fishery products



declined by about 15 percent, to US$15.3 billion, as the combined dampening effect of high prices and a weak yen compounded a long-term decline in underlying demand. In 2013, the fishery imports of the United States of America reached US$19.0 billion, up 8 percent on 2012.

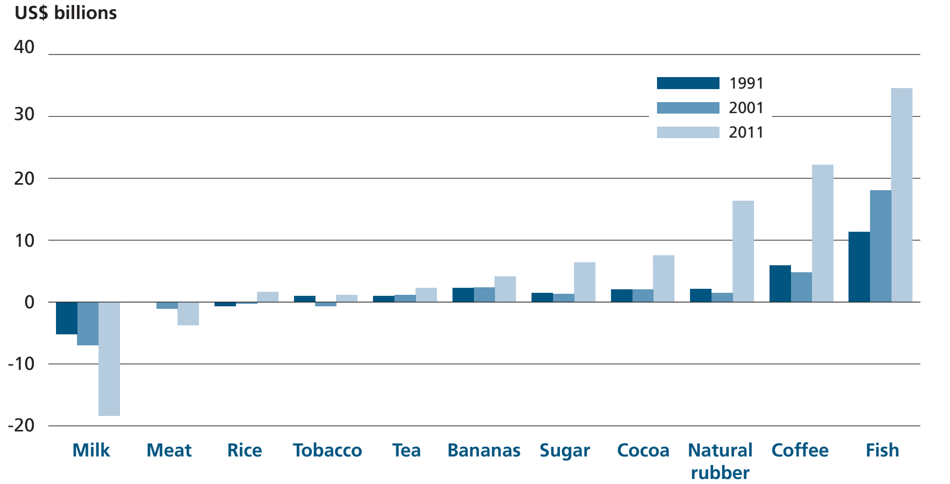
A number of emerging countries have become of growing importance to the world's exporters. Prominent among these markets are Brazil, Mexico, the Russian Federation, and Egypt.

Next to the faster rate of trade growth, perhaps the most important change in trade patterns in recent years has been the increased share of developing countries in fisheries trade, and the corresponding decline in the share of developed economies (Figure 19). Developing economies, whose exports represented just 34 percent of world trade in 1982, saw their share rise to 54 percent of total fishery export value by 2012. In the same year, their exports represented more than 60 percent of the quantity (live weight) of total fishery exports. For many developing nations, fish trade represents a significant source of foreign currency earnings, in addition to the sector's important role in income generation, employment, food security and nutrition. Their fishery net-export revenues (exports minus imports) reached US$35.3 billion in 2012, higher than other major agricultural commodities (Figure 20). In 2012, LIFDCs accounted for 9 percent of world fishery exports in value terms, with their net exports reaching US$6.2 billion.

Developed countries continue to dominate world imports of fish and fishery products, although their share has decreased in recent years. Their share of world imports was 85 percent in 1992 and 73 percent in 2012. In quantity (live weight), their share is significantly less at 55 percent, reflecting the higher unit value of the products they import. Owing to stagnating domestic fishery production, developed countries

Figure 20

Net exports of selected agricultural commodities by developing countries



have to rely on imports and/or on domestic aquaculture to cover their increasing consumption of fish and fishery products. This may be one of the reasons for low import tariffs on fish in developed countries, albeit with a few exceptions (i.e. some value-added products). As a consequence, in recent decades, developing countries have increasingly been able to supply fishery products to markets in developed countries without facing prohibitive customs duties. In 2012, 49 percent of the import value of developed countries originated from developing countries. In addition, in recent few years, developing countries have increased fishery imports to supply their processing sectors and to meet rising domestic consumption.

In the past ten years, international trade patterns have been changing in favour of trade between developed and developing countries. Developed countries still trade mainly among themselves and, in 2012, in value terms, 80 percent of fishery exports from developed countries were destined to other developed countries. However, in the last three decades, the share of their exports going to developing countries has increased, also owing to their outsourcing the processing of their fisheries production. At the same time, while developed countries remain their main export markets, developing countries have increased trade among themselves, even if fishery trade between developing countries represented only 33 percent of the value of their exports of fish and fishery products in 2012. In Asia, Africa and South and Central America, regional flows remain important, although this trade is often not adequately reflected in official statistics. Improved domestic distribution systems for fish and fishery products as well as growing aquaculture production have played a role in increasing regional trade. Domestic markets, in particular in Asia, but also in Central and South America, remained strong in the 2011–13 period, providing welcome outlets for domestic and regional producers. Eastern and Central Europe have also seen growing imports in response to increasing purchasing power among consumers. The maps in Figure 21 summarize trade flows of fish and fishery products for the period 2010–12. The overall picture presented is not exhaustive as trade data are not fully available for all countries, in particular for several African countries. However, the quantity of data available is sufficient to establish general trends, with no major changes taking in place compared with recent 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 was a net exporter for the period 1985–2010, but a net importer since 2011. However, Africa has long been 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 22).

Exports from developing countries have increased significantly in recent decades also thanks to the lowering of tariffs, in particular for non-value added products. This trend follows the expanding membership of the WTO, the entry into force of a number of bilateral and multilateral trade agreements, and rising disposable incomes in emerging economies. However, several factors continue to affect the performance of developing countries in accessing international markets.

These issues include problems linked to the internal structures in some countries. Despite technical advances and innovations, many countries, especially those with less-developed economies, still lack adequate infrastructure and services, which can affect the quality of fishery products, contributing to their loss or difficulty in marketing. Some developing countries might have inadequate regulatory frameworks and institutional capacity for sustainable governance of the fishery sector.

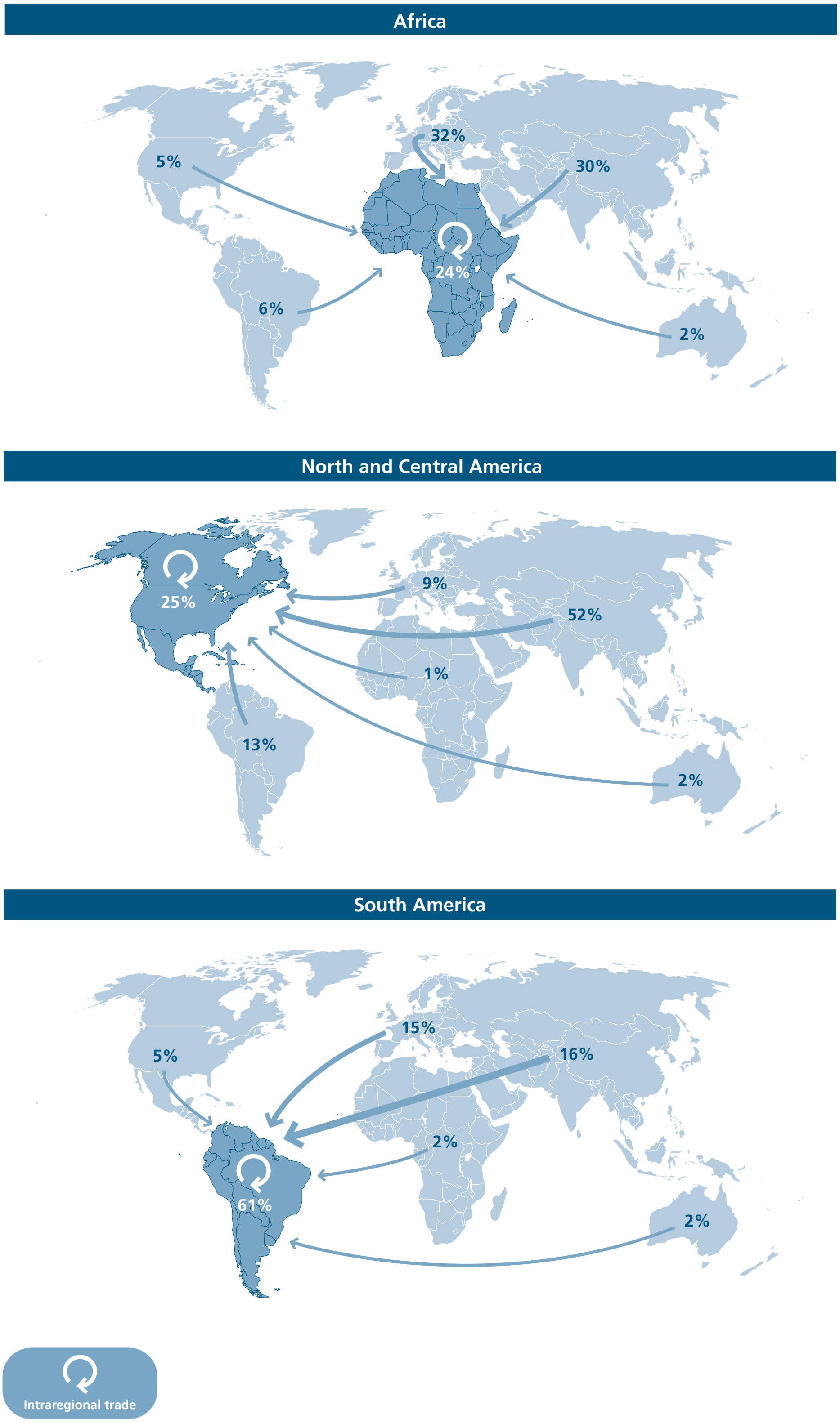
In exporting, developing countries can face more tariff and non-tariff barriers to trade than do developed countries. The impact of non-tariff barriers on trade and economic welfare is difficult to evaluate. They may affect trade through the application of required product standards, control on sanitary and phytosanitary measures, procedures for import licensing and rules of origin, conformity assessments and others. Trade in developing countries can also be influenced by the specific ways in which customs classifications, valuation and clearance procedures are handled, including lengthy or duplicative certification procedures. High customs fees may also negatively affect trade. Other impacts on trade in developing countries might be linked to technical barriers to trade, which refer to technical regulations and standards that set out specific characteristics of a product. The WTO Agreement on Technical Barriers to Trade contains rules expressly aimed at preventing these measures from becoming unnecessary barriers, but they still exist and create difficulties for traders.

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

- the volatility of commodity prices in general and its influence on producers and consumers;
- the distribution of margins and benefits throughout the fisheries value chain;
- the globalization of supply chains, with growing outsourcing of production;
- climate change, carbon emissions and their impacts on the fisheries sector;
- the role of the small-scale sector in fish production and trade;
- the growing concern of the general public and the retail sector about overfishing of certain fish stocks;
- the relationship between fisheries management requirements, allocation of fishing rights and the economic sustainability of the sector;
- the need to ensure that internationally traded fishery products from capture fisheries have been produced legally;
- the increase in farmed products in international trade and the impact on the domestic fisheries sector from a surge in imports of farmed products;
- the economic crises and the risk of increased import barriers and tariffs;
- the multilateral trade negotiations within the WTO, including the focus on fisheries subsidies;
- the need for competitiveness of fish and fishery products versus other food products;
- the introduction of private standards, including for environmental and social purposes, their endorsement by major retailers, and their possible effect on market access for developing countries;
- the more stringent rules for quality and safety of food products, including for imported products, in several countries;
- the perceived and real risks and benefits of fish consumption.

Figure 21

Trade flows by continent (share of total imports in value; averages for 2010–2012)



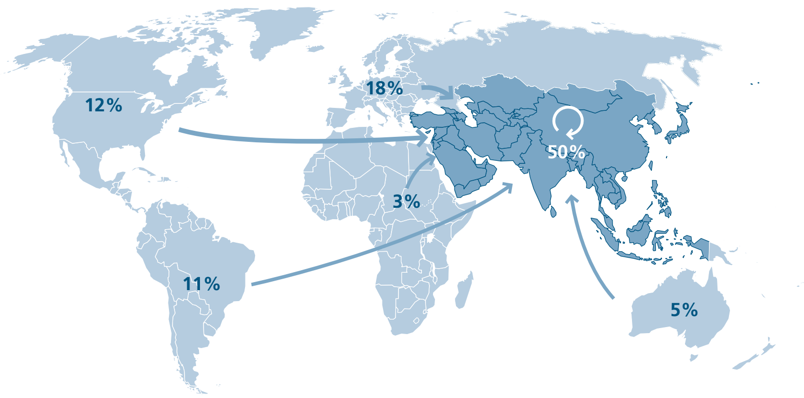
Note: The maps indicate the borders of the Republic of the Sudan for the period specified. The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined.

(Continued)

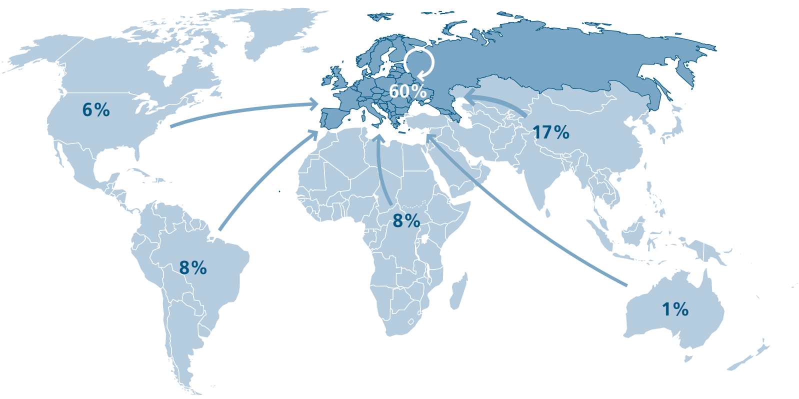
Figure 21 *(cont.)*

Trade flows by continent (share of total imports in value; averages for 2010–2012)

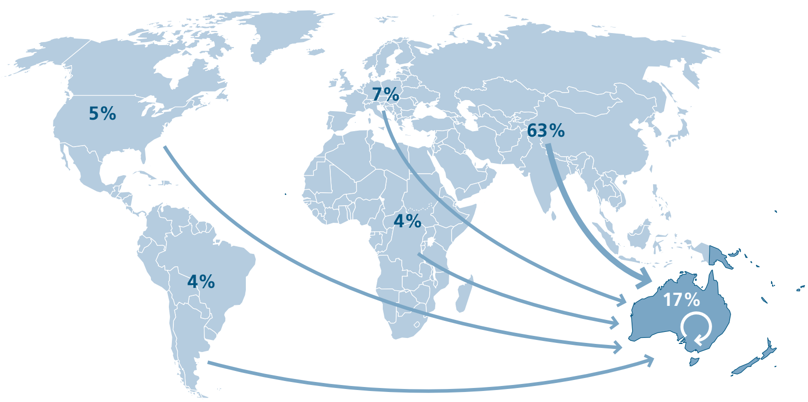
Asia



Europe



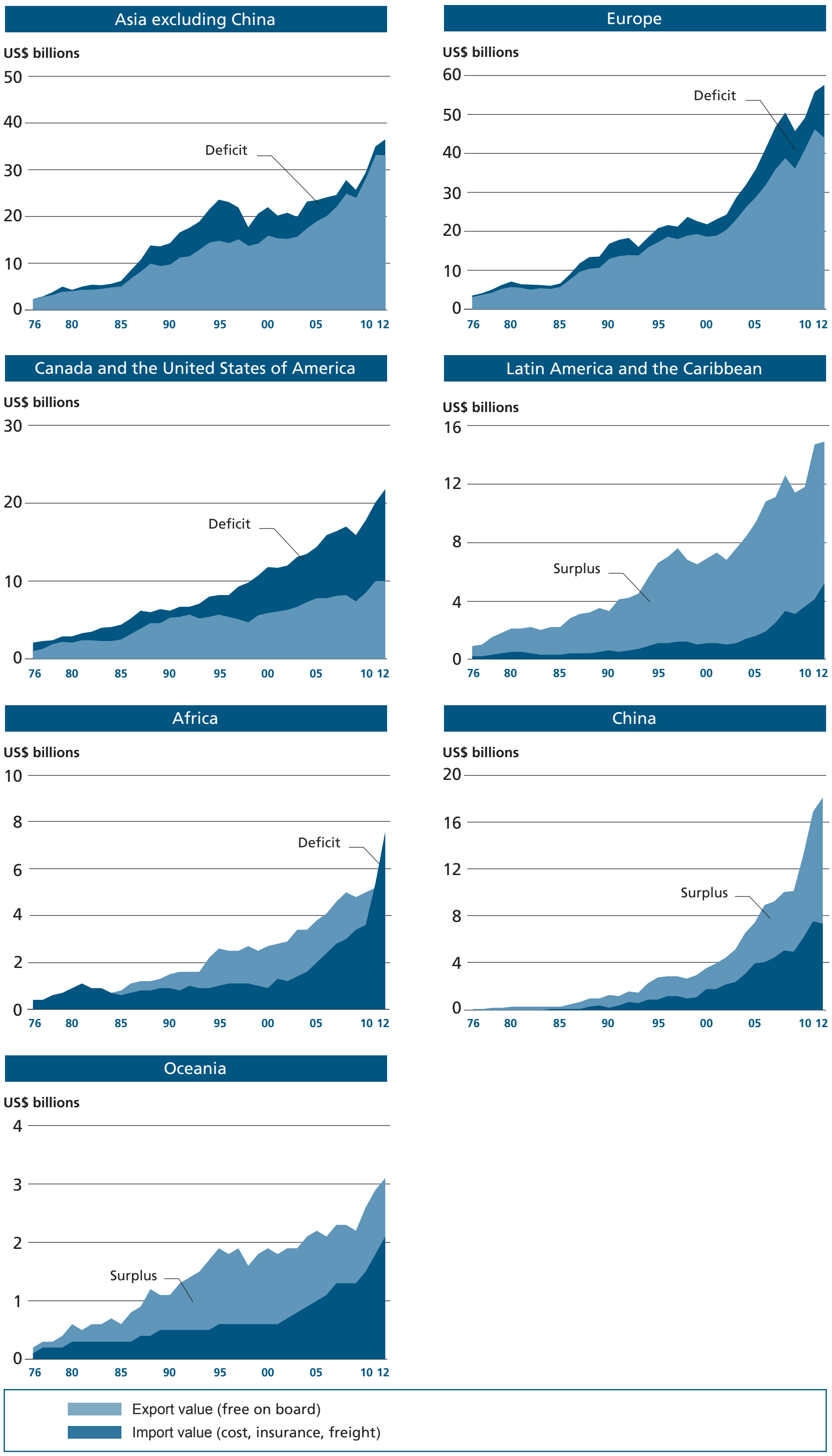
Oceania



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 22

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



Commodities

The fishery market is very dynamic and 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 low-income consumers in developing countries. However, in recent years, emerging economies in developing countries have increasingly been importing species of higher value for their domestic consumption.

In the last two decades, in line with the impressive growth in aquaculture production, there has been a substantial increase in trade in many aquaculture products based on both low- and high-value species, with new markets opening up in developed, transition and developing countries. Aquaculture is contributing to a growing share of international trade in fishery commodities, with high-value species such as salmon, seabass, seabream, shrimp and prawns, bivalves and other molluscs, but also relatively low-value species such as tilapia, catfish (including *Pangasius*) and carps. These low-value species are also traded in large quantities, not only nationally and within major producing regions (such as Asia and South America) but also at the interregional level. 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 species registering the highest export growth rates in recent 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.

Consumers' tastes and preferences for fish and fishery products vary, with markets catering to demand for items ranging from live aquatic animals to a variety of processed products. In 2012, 76 percent of the quantity of fish and fishery products exported was destined for human consumption. Notwithstanding their perishability, trade in live, fresh and chilled fish represented 10 percent of world fish trade in 2012, up from 5 percent in 1976, reflecting improved logistics and increased demand for unprocessed fish. Trade in live fish also includes ornamental fish and fish for culture, which are high in value terms but almost negligible in terms of quantity traded. In 2012, 90 percent of trade in fish and fishery products in quantity terms (live weight equivalent) consisted of processed products (i.e. excluding live and fresh whole fish). Fish are increasingly traded as frozen food (46 percent of the total quantity in 2012, compared with 23 percent in 1976). In the last four decades, prepared and preserved fish have nearly doubled their share in total quantity, up from 9 percent in 1976 to 17 percent in 2012.

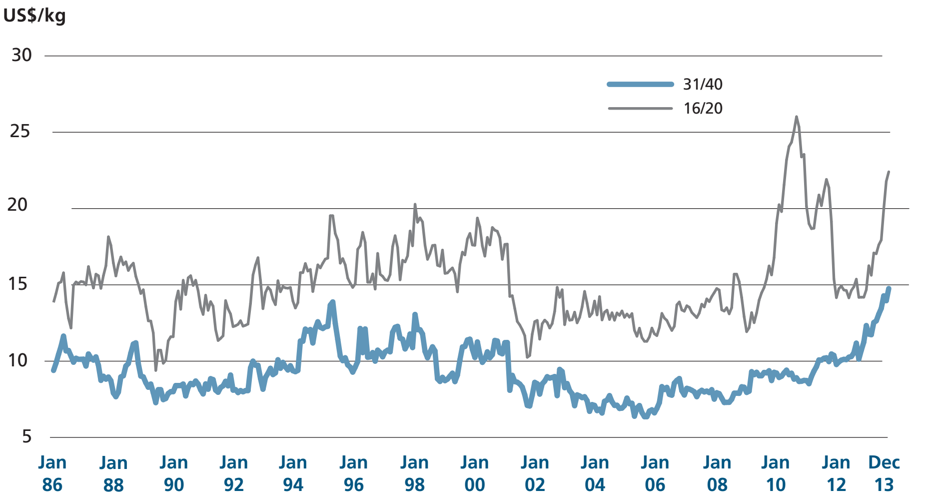
The US$129 billion of exports of fish and fishery products in 2012 do not include an additional US$1.6 billion represented by aquatic plants (64 percent), inedible fish by-products (24 percent) and sponges and corals (12 percent). Trade in aquatic plants has increased from US$0.1 billion in 1982 to US$0.5 billion in 2002 and to US$1.0 billion in 2012, with China as the major exporter and Japan the leading importer. Owing to the increasing production of fishmeal and other products deriving from fishery residues from processing (see the section Fish Utilization and Processing above), trade in inedible fish by-products has also surged, up from just US$35 million in 1982 to US$0.2 billion in 2002 and US$0.4 billion in 2012.

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 2012. It is mainly produced in developing countries, and much of this production finds its way into international trade. However, as economic conditions improve in these countries,

Figure 23

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.

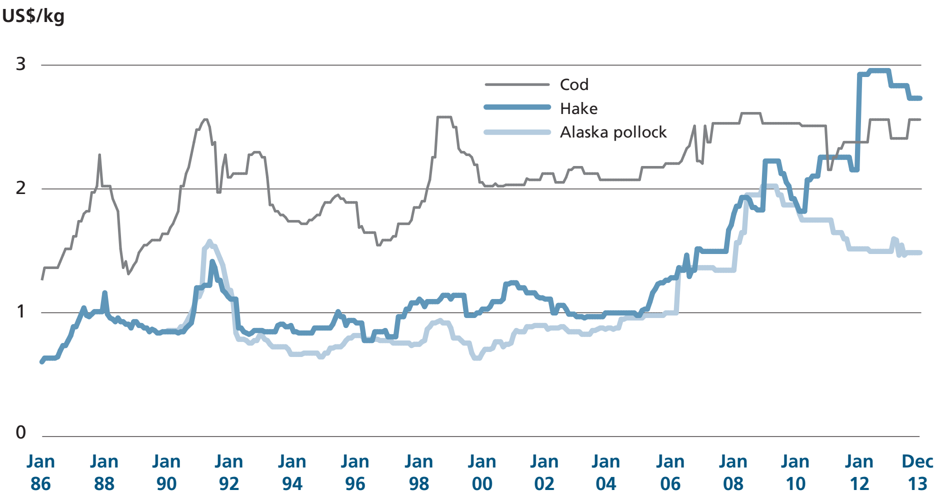
growing demand is leading to increased domestic consumption and hence lower exports. World farmed shrimp production volumes decreased in 2012 and particularly in 2013, mainly as a result of disease-related problems, such as early mortality syndrome (see Box 11 on p. 213), in some countries in Asia and Latin America. This reduced supply boosted shrimp prices worldwide and affected consumption in the traditional developed markets such as the European Union (Member Organization), the United States of America and Japan (Figure 23). The Japanese market, wholly dependent on imported supplies, also suffered because of a weaker yen and increased landing costs. Export processing industries in East and Southeast Asian met the raw material shortfalls through imports, particularly from Ecuador and India, with frozen shrimp imports noted at record high levels in Viet Nam. China's imports for domestic consumption also increased.

Salmon

Salmon's share in world fishery trade has increased strongly in recent decades to 14 percent thanks to expansion of salmon and trout aquaculture production in northern Europe and in North and South America. Overall, demand has grown steadily in most markets and it is expanding geographically, in particular for farmed Atlantic salmon, also through new varieties of processed products. However, in recent years, supply has been more variable, mostly as a result of disease-related problems in Chile. Wild Pacific salmon also plays an important part in world markets, representing about 30 percent of the total market for salmonids. Prices of farmed salmon fell drastically in the second half of 2011 and took several months to stabilize. The recovery began in late 2012, and the salmon market witnessed a positive price trajectory, lifting export revenues to record levels, particularly for Norwegian producers supplying markets in the European Union (Member Organization). In the third quarter of 2013, this price trend was reversed as a result of some evidence of weakening demand, as higher costs of raw material filtered down the value chain. However, it appears that the market balance should be sufficiently tight to halt the decline in 2014. Norway remains the dominant producer and exporter of Atlantic salmon. In Chile, the second major producer and exporter, the industry is undergoing an important transformation process in response to the current financial crisis and in order to address higher production costs resulting from stricter production regulations. Chilean farms continue to suffer

Figure 24

Groundfish prices in the United States of America



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

from disease problems and high feed costs that compound an overall production efficiency disadvantage.

Groundfish

Groundfish species, such as cod, hake, saithe and pollock, represented about 10 percent of total fish exports by value in 2012. The market for groundfish products seems widely diversified and in recent years has been behaving quite differently from the norms of the past. Overall supply was higher in 2012 and the first half of 2013 thanks to both recovery in a number of stocks and good management practices. However, there were differences according to species, with, for example, abundant supply of Arctic cod and a shortage of saithe and haddock. In general, prices firmed in 2011–13, also owing to strong competition from farmed species such as *Pangasius* and tilapia on the market. Cod remained the most expensive groundfish species, experiencing increasing prices (Figure 24) even in a situation of good supply, but with lower prices for the more traditional products, such as frozen fillets and blocks, and klipfish and stockfish.

In the past, traditional species dominated world whitefish markets, but with the advent of aquaculture this has changed remarkably. Farmed whitefish species, in particular less expensive alternatives such as tilapia and *Pangasius*, have made inroads into traditional groundfish markets and are permitting the sector to expand substantially and reach new consumer groups. *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 international markets, this species is an important source of low-priced traded fish. The European Union (Member Organization) and the United States of America are the main importers of *Pangasius*, but other growing markets are Japan, the Russian Federation, and Egypt; and at the regional level, the Near East, South America and Africa. New markets are emerging in Asia and Eastern Europe. However, *Pangasius* supply in 2013 was lower than 2012 because of reduced output in Viet Nam. Steady demand from across the globe is expected to drive production development of *Pangasius* in other producing countries, particularly in Asia, for exports, but also for domestic consumption.

Despite the overall decline in per capita apparent fish consumption in the United States of America, tilapia remains popular, with its main suppliers being Asian and Central American countries (of fish in frozen form and fresh, respectively). According to the National Fisheries Institute,[13] consumption of whitefish (cod, pollock, tilapia and *Pangasius*) in the United States of America surpassed that of shrimp and rose by 6.2 percent in 2012. Together with *Pangasius*, tilapia has the main driving force behind the growth in whitefish consumption in the country in recent years. In contrast, demand in Europe for this species remains limited. Tilapia production is expanding in Asia, South America and Africa, with new supply targeting domestic and regional consumers rather than international markets. African producers are also now seeing tilapia's potential for domestic consumption as well as for export.

Tuna

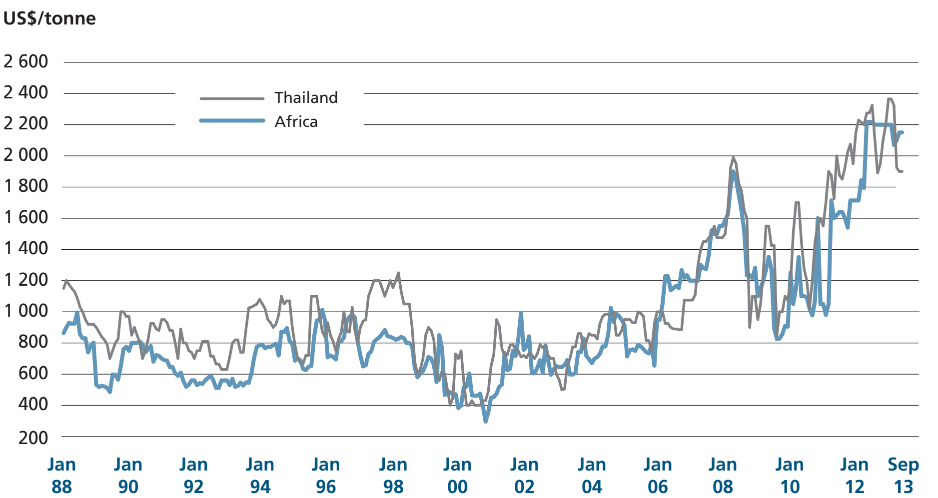
The share of tuna in total fish export value in 2012 was about 8 percent. In the last three years, tuna markets have been unstable owing to large fluctuations in catch level, growing restrictions on longline and purse-seine fishing in the pursuit of more sustainable resource management, other moves towards 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 fluctuations in prices (Figure 25). Japan remains the largest market for sashimi-grade tuna. It was less active, with lower imports, in the first three quarters of 2013, but recovered in late 2013 and early 2014. Demand for fresh/chilled sashimi remained high in the United States of America, which is now the second-largest market for non-canned tuna products. The United States of America's market for canned tuna remained stagnant in 2013, while across Europe, the market posted positive growth reflected by increasing imports. Canned tuna demand has also improved in non-conventional markets, especially in Asia.

Cephalopods

The share of cephalopods (squid, cuttlefish and octopus) in world fish trade was about 3 percent by value in 2012. 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. Viet Nam is expanding its markets for cephalopods, including squid, in Southeast Asia. Other Asian countries such as China, the Republic of Korea, India, and Thailand are other important suppliers. In South America, there

Figure 25

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.

has been growing interest in jumbo flying squid (*Dosidicus gigas*), with exports from Peru to more than 50 countries and increased efforts going into developing new products. In 2013, main markets, in particular Japan and the European Union (Member Organization), remained strong, in spite of difficult economic situations and the high prices of these species. Octopus, which showed signs of improved supplies, has been experiencing increasing demand in many markets. Its prices were stable in 2013, at least on the European market. Squid supplies were a bit tighter in some areas, but demand remained good. Squid prices, which had been on a relatively steady upward trend from early 2010, fell sharply in the second half of 2012, but started climbing again in 2013. For cuttlefish, the market was quieter and international trade diminished.

Fishmeal

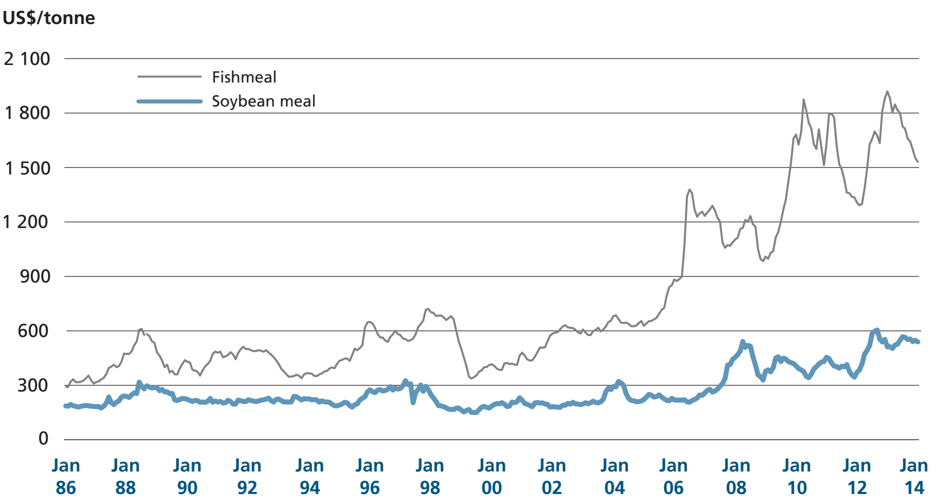
Notwithstanding annual fluctuations owing to anchoveta catches, overall, the production of fishmeal from whole fish has declined gradually since 2005. This decrease has been only partly offset by a growing share of fishmeal production obtained from fishery by-products. In contrast, overall demand continued to grow, pushing prices to historic highs until January 2013, with an increase of 206 percent between January 2005 and January 2013 to US$1 919/tonne (Figure 26). Between January 2013 and January 2014, prices declined by 20 percent. As soybean meal prices remained relatively stable during the same period, the growing price differential provided incentives for terrestrial farmers to substitute fishmeal with less expensive feed alternatives. China remains the main market, importing more than 30 percent of fishmeal in terms of quantity, while Peru and Chile are the major exporters.

Fish oil

Fish oil production is also declining, mainly as a result of lower production in Latin America, and more stringent quotas on raw materials, contributing to price pressure and increased volatility. Fish oil prices rose steadily (Figure 27) to new highs in April 2013 before dropping significantly (down 31 percent from April 2013 to January 2014). As fish oil is an important ingredient in feeds for selected carnivorous fish species, growing demand for fed-aquaculture products is increasing the demand for fish oil and, hence, its price. Demand for fish oil as a human nutritional supplement also continues to grow.

Figure 26

Fishmeal and soybean meal prices in Germany and the Netherlands

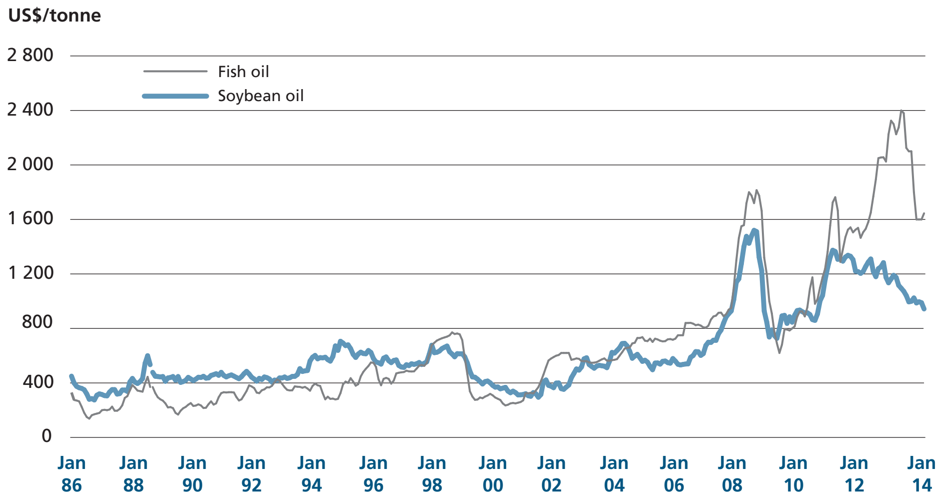


Note: Data refer to c.i.f. prices.
Fishmeal: all origins, 64–65 percent, Hamburg, Germany.
Soybean meal: 44 percent, Rotterdam, Netherlands.

Source: Oil World; FAO GLOBEFISH.

Figure 27

Fish oil and soybean oil prices in the Netherlands



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

Source: Oil World; FAO GLOBEFISH.

FISH CONSUMPTION[14]

Fish and fishery products play a critical role in global food security and nutritional needs of people in developing and developed countries. Global food fish[15] supply has grown steadily in the last five decades, at an average annual rate of 3.2 percent, outpacing world population growth (1.6 percent). Hence, average per capita availability has risen. World per capita apparent fish consumption increased from an average of 9.9 kg in the 1960s to 17.0 kg in the 2000s and 18.9 kg in 2010, with preliminary estimates for 2012 pointing towards further growth to 19.2 kg. The driving force behind this impressive surge has been a combination of population growth, rising incomes, and urbanization interlinked to the strong expansion of fish production and modern distribution channels.

Despite the overall increase in the availability of fish to most consumers, growth patterns of per capita apparent fish consumption have been uneven. For example, it has remained static or decreased in some countries in sub-Saharan Africa (e.g. the Congo, Gabon, Liberia, Malawi and South Africa) and, albeit from a high level, in Japan in the last two decades, while growing most substantially in East Asia (from 10.7 kg in 1961 to 35.4 kg in 2010), Southeast Asia (from 12.8 to 33.4 kg) and North Africa (from 2.8 to 12.2 kg). China has been responsible for most of the growth in world per capita fish availability, owing to the dramatic expansion in its fish production, in particular from aquaculture. Per capita apparent fish consumption in China has also increased steadily, reaching about 35.1 kg in 2010, with an average annual growth rate of 4.5 percent in the period 1961–2010 and of 6.0 percent in the period 1990–2010. If China is excluded, annual per capita fish supply in the rest of the world was about 15.4 kg in 2010, higher than the average values of the 1960s (11.4 kg), 1970s (13.4 kg), 1980s (14.1 kg) and 1990s (13.5 kg). In the 1990s, world per capita fish supply, excluding China, was relatively stable at 13.1–13.6 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). However, since the early 2000s, food fish supply growth has outpaced population growth (at annual rates of 2.5 and 1.4 percent, respectively).

Table 17 summarizes per capita fish supply by continent and major economic group. Of the 130.1 million tonnes available for human consumption in 2010, fish supply was lowest in Africa, while Asia accounted for two-thirds of the total, with

Table 17
Total and per capita food fish supply by continent and economic grouping in 2010[1]

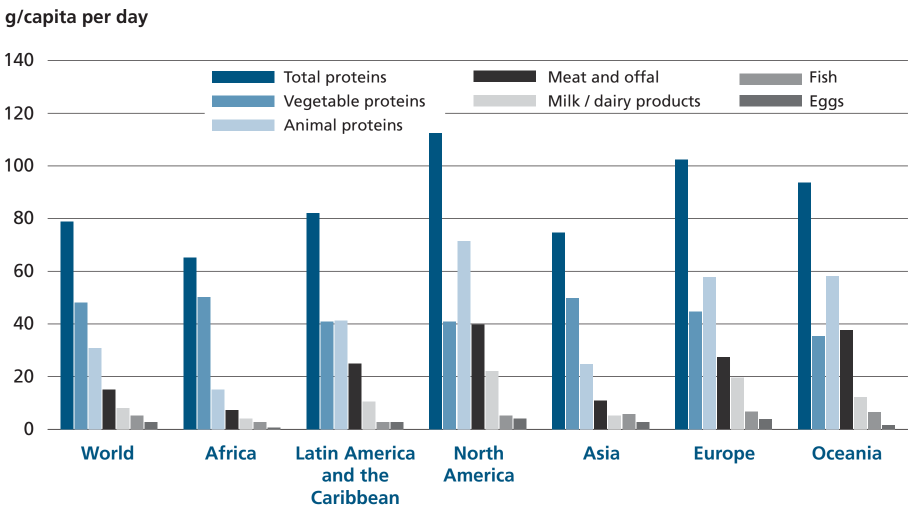
	Total food supply	Per capita food supply
	(million tonnes live weight equivalent)	*(kg/year)*
World	**130.1**	**18.9**
World (excluding China)	85.7	15.4
Africa	9.9	9.7
North America	7.5	21.8
Latin America and the Caribbean	5.7	9.7
Asia	89.8	21.6
Europe	16.2	22.0
Oceania	0.9	25.4
Industrialized countries	26.5	27.4
Other developed countries	5.5	13.5
Least-developed countries	9.6	11.5
Other developing countries	88.5	18.9
LIFDCs[2]	30.9	10.9

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

89.8 million tonnes (21.6 kg per capita), of which 45.4 million tonnes outside China (16.1 kg per capita). Marked differences exist between and within countries and regions in terms of quantity and variety consumed per capita and the subsequent contribution to the nutritional intake (Figures 28–30). These dissimilarities in consumption depend on the availability and cost of fish and other alternative foods, disposable income and 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 30). Within countries, consumption is usually higher in coastal, riverine and inland water areas.

Figure 28

Total protein supply by continent and major food group (average 2008–2010)



Disparities in fish consumption also exist between the more developed and the less developed countries. Despite an impressive surge in annual per capita apparent fish consumption in developing regions (from 5.2 kg in 1961 to 17.8 kg in 2010) and in LIFDCs (from 4.9 to 10.9 kg), developed regions still have higher levels of consumption, although the gap is narrowing. However, effective consumption in developing countries may be higher in view of the under-recorded contribution of subsistence fisheries and some small-scale fisheries in official statistics. In 2010, per capita apparent fish consumption in industrialized countries was 27.4 kg, while for all developed countries it was estimated at 23.3 kg. A sizeable and growing share of fish consumed in developed countries consists of imports, owing to steady demand and declining domestic fishery production (down 22 percent in the period 1992–2012). 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, fuelled by rising domestic income and wealth, consumers in emerging economies are experiencing a diversification of the types of fish available owing to an increase in fishery imports.

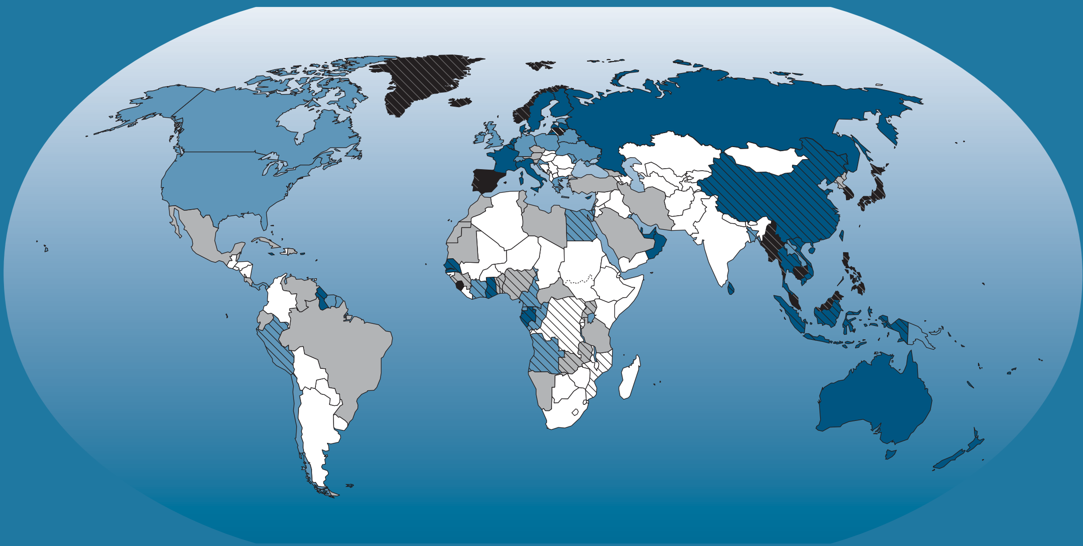
Fish as a commodity is very heterogeneous, and differences may be originated by species, production areas, methods of fishing or farming, handling practices and hygiene. Innovations and improvements in processing, transportation, distribution, marketing and food science and technology have facilitated the trade and consumption of an expanded variety of species and product forms. Changes in species consumed are also due to the dramatic growth in aquaculture production, which is also linked to increased demand for fish and fishery products. 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. In 2012, aquaculture contributed about 49 percent of the fishery output for human consumption – impressive growth compared with its 5 percent in 1962 and 37 percent in 2002 (Figure 31), with an average annual growth rate of 6.2 percent in the period 1992–2012. The surging contribution of aquaculture can also be noted by observing fish consumption by major groups. Owing to the rising 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 2010, and that of molluscs (including cephalopods) rose from 0.8 to 2.9 kg in the 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 6.5 kg in 2010. In recent years, no major changes have been experienced by the other broader groups, with many species originating from capture fisheries production. Annual per capita consumption of demersal and pelagic fish species has stabilized at about 2.9 and 3.4 kg, respectively. Demersal fish continue to be among the main species favoured by consumers in Northern Europe and in North America (annual per capita consumption of 8.1 and 5.1 kg, respectively, in 2010), whereas cephalopods are mainly preferred by Mediterranean and East Asian countries. Of the 18.9 kg of fish per capita available for consumption in 2010, about 74 percent came from finfish. Shellfish supplied 24 percent (or about 4.6 kg per capita, subdivided into 1.7 kg of crustaceans, 0.5 kg of cephalopods and 2.4 kg of other molluscs).

In addition, aquaculture provides about 95 percent of all seaweed and aquatic plant production, of which an important portion is directed to human consumption. At present, these species are not included in the food balance sheets for fish and fishery products calculated by FAO owing to the lack of separated data by destination in trade data. However, thanks to the collaboration between FAO and the World Customs Organization (WCO), the 2012 version of the Harmonized Commodity Description and Coding System, commonly referred to as HS, contains two separate codes for

Figure 29

Contribution of fish to animal protein supply (average 2008–2010)



Fish proteins (per capita per day)

< 2 g	4–6 g	> 10 g
2–4 g	6–10 g	

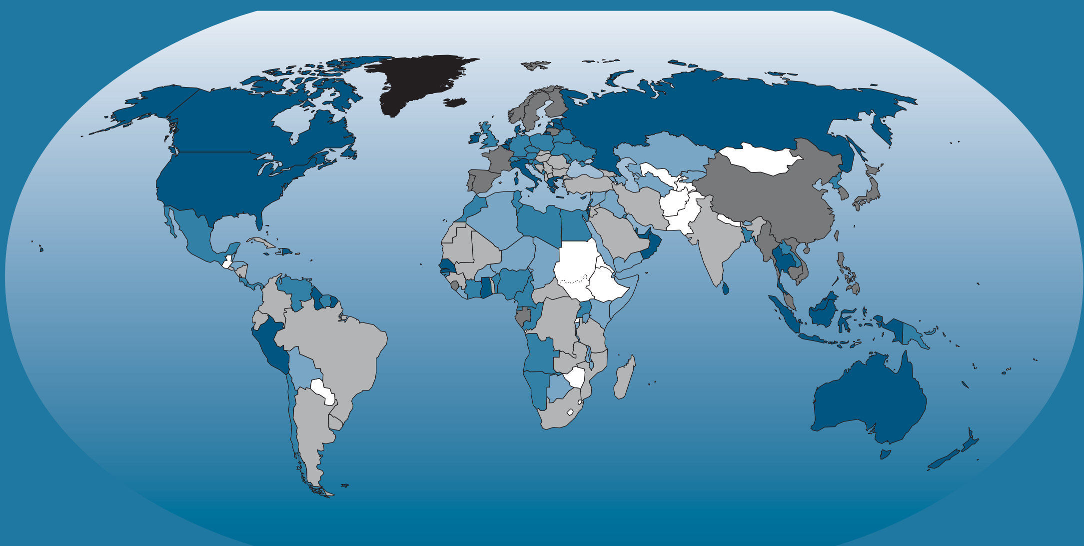
Contribution of fish to animal protein supply

> 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 30

Fish as food: per capita supply (average 2008–2010)



Average per capita fish supply (in live weight equivalent)

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

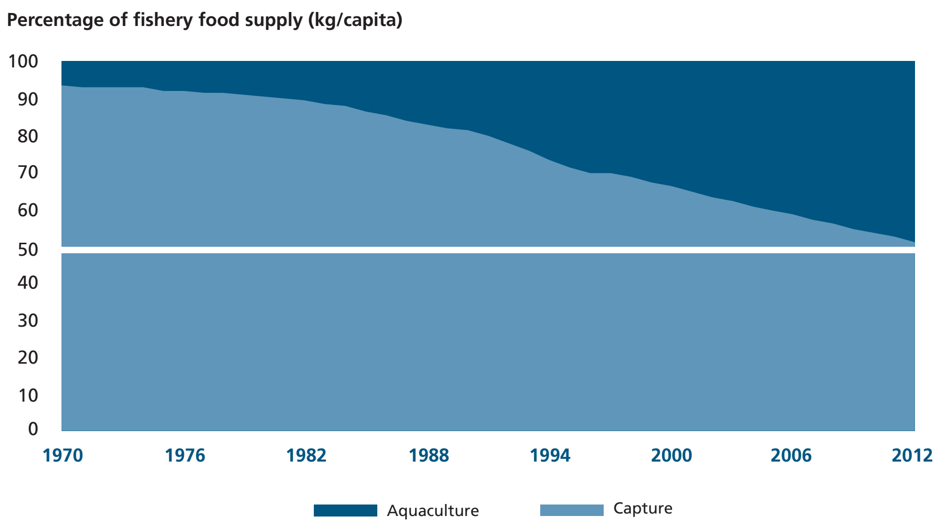
seaweeds for edible purposes and other uses. This separation might soon allow the contribution of seaweeds in human consumption to be monitored. The HS is used as a basis for the collection of customs duties and international trade statistics by more than 200 countries. The HS 2012 version reflects the FAO joint proposal to the WCO, and for fish and fishery products the modifications have attempted to improve the quality of fish trade coverage through an improved specification for species and product forms. A better coverage of fishery trade is essential for improved monitoring of the sector and to evaluate the contribution of fish in diets more correctly.

On average, the daily dietary contribution of fish is rather low in terms of calories, at about 33 calories per capita. However, it can exceed 150 calories per capita 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). Fish and fishery products represent a valuable source of animal protein, as a portion of 150 g of fish provides about 50–60 percent of the daily protein requirements for an adult. In 2010, fish accounted for 16.7 percent of the global population's intake of animal protein and 6.5 percent of all protein consumed (Figure 28). Moreover, fish provided more than 2.9 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 29). Fish proteins can represent a crucial nutritional component in some densely populated countries where total protein intake levels may be low. In fact, many populations depend on fish as part of their daily diet, and this dependence is usually higher in developing countries than developed ones. The dietary pattern in many of these countries can reveal heavy dependence on staple food, with fish consumption becoming particularly important in helping to correct an imbalanced calorie/protein ratio. In addition, for these populations, fish often represents 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, or exceeds, 50 percent of total animal protein intake in some small island developing States, as well as in Bangladesh, Cambodia, the Gambia, Ghana, Indonesia, Sierra Leone and Sri Lanka.

Disparities among developed and developing countries also exist in terms of the contribution of fish to animal protein intake. Despite their relatively lower levels of fish consumption, developing countries and LIFDCs have a higher share compared with developed countries and the overall world average. In 2010, fish accounted for

Figure 31

Relative contribution of aquaculture and capture fisheries to food fish consumption



about 19.6 percent of animal protein intake in developing countries and 24.7 percent in LIFDCs. However, this contribution 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, weakened from 13.9 percent in 1989 to 11.8 percent in 2010, while consumption of other animal proteins continued to increase. In recent decades, average per capita apparent food consumption has also been growing, and global dietary patterns have become more homogeneous and globalized. Such changes have been the result of several factors, including rising living standards, population growth, rapid urbanization and opportunities for trade and transformations in food distribution. These patterns of change have fuelled growing demand for proteic food products, in particular meat, fish (Figure 32), milk, eggs as well as vegetables, with a reduction in the share of staples such as roots and tubers in the diet. Protein availability has risen overall, but this increase has not been equally distributed. 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. Taking meat as an example, according to FAOSTAT, in developed countries, per capita meat consumption increased from 62.8 kg in 1969 to 81.4 kg in 1989, but then declined to 77.6 kg in 1999 before reaching 81.8 kg in 2009. On the other hand, average annual per capita meat consumption in developing countries almost tripled from 11.0 kg in 1969 to 30.7 kg in 2009. Overall, annual global per capita meat consumption grew from 26.3 kg in 1969 to 32.6 kg in 1989 and 40.9 kg in 2009 (Figure 33).

In the last two decades, food supplies in developing countries have grown faster than population, leading to rising food availability per person. Dietary energy supplies have also risen faster than average dietary energy requirements, resulting in higher levels of energy adequacy in most developing regions. Despite the improvement in per

Figure 32

World meat and fish food supply

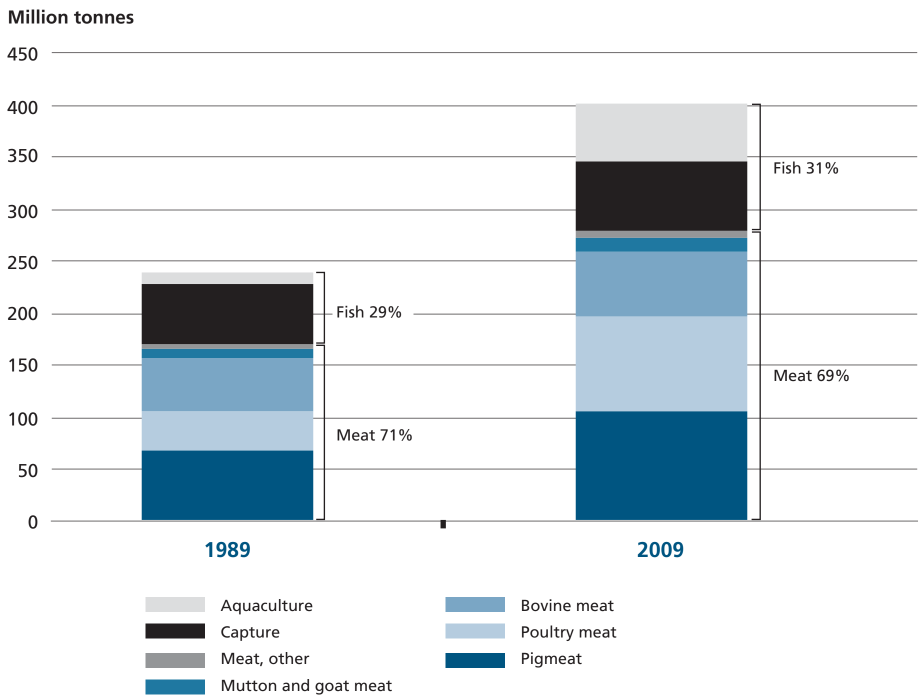
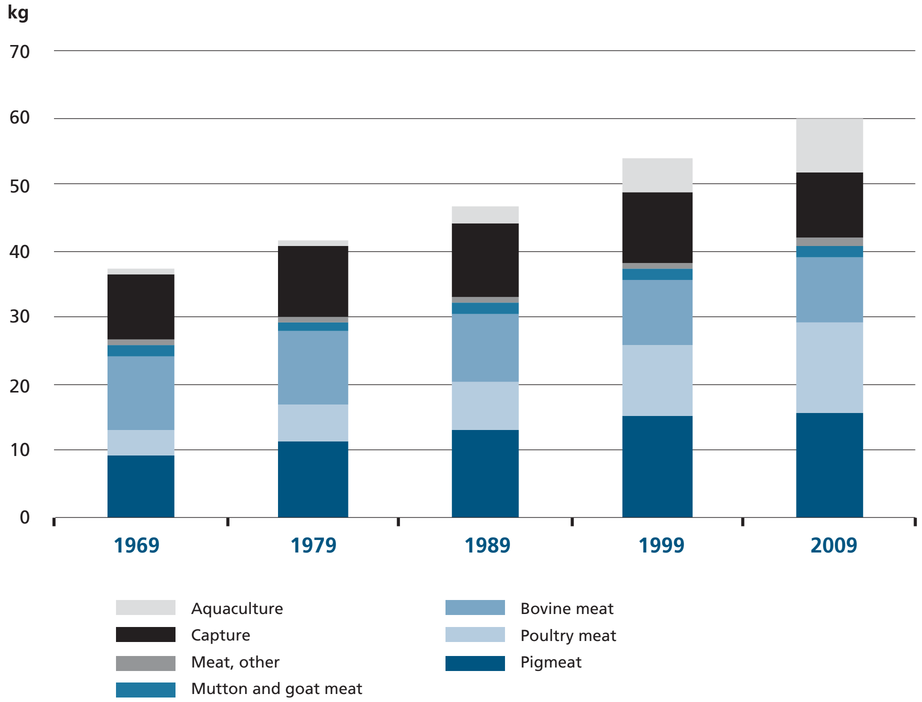


Figure 33

World per capita meat and fish food supply



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 in seven people 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 a recent report,[16] in 2011–13, 842 million people, or about one in eight people in the world, were estimated to be suffering from chronic hunger, regularly not consuming enough food to conduct an active life. This figure is lower than the 868 million reported with reference to 2010–12. The total number of undernourished has fallen by 17 percent since 1990–92. While the estimated number of undernourished people has continued to decrease, the rate of progress appears insufficient to reach international goals for hunger reduction in developing regions – the 1996 World Food Summit target of halving the number of hungry people by 2015, and the 2001 Millennium Development Goal of halving the proportion of hungry people in the total population by 2015. While at the global level, the number of undernourished declined between 1990–1992 and 2011–2013, different rates of progress across regions have led to changes in the distribution of undernourished people in the world. Most of the world's undernourished people are still to be found in Southern Asia, closely followed by sub-Saharan Africa and Eastern Asia. 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.

According to a United Nations report,[17] the current world population of about 7.3 billion is projected to reach 8.1 billion in 2025 and 9.6 billion in 2050, with most of the population growth occurring in developing regions. Ensuring adequate food and nutrition security to this growing population is a daunting challenge. Food security exists when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life."[18] The fisheries and aquaculture sector plays, and can continue to play, a prominent role in world food security, making a valuable and nutritious contribution to diversified and healthy diets. With a few exceptions for selected species, fish is usually low in saturated fats, carbohydrates and cholesterol. While average per capita apparent fish consumption may be low, even small quantities of fish can have a significant positive nutritional impact, it being a concentrated source of protein and of a range of other essential fatty acids and micronutrients (see The role of aquaculture in improving nutrition on pp. 104–109).

Consumer habits have changed significantly in recent decades, and food issues such as indulgence, convenience, health, ethics, variety, value for money, and safety are becoming more important. Health and well-being are increasingly influencing consumption decisions, and fish has a particular prominence in this respect, as mounting evidence confirms the health benefits of eating fish.

The food sector in general is facing structural changes as a result of growing incomes, new lifestyles, globalization, trade liberalization and the emergence of new markets. 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 increasingly driving consumption patterns, 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.

In addition, growing urbanization is a major driving force influencing food consumption patterns, with an impact also on the demand for fishery products. City dwellers tend to devote a higher proportion of their income to food purchased than do rural populations on lower incomes. In addition, they generally eat out of the home more frequently, and purchase larger quantities of fast and convenience foods. Moreover, increasing urbanization stimulates improvements in infrastructure, including cold chains, which permit trade in perishable goods. According to the United Nations,[19] in 2011, 52.1 percent (3.6 billion people) of the world's population lived in urban areas. Disparities in urbanization levels 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, least-developed countries (about 29 percent urban) and Africa (40 percent) and Asia (45 percent). However, also in these latter areas, a vast movement of people towards 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 in most other continents. The rural population is expected to decline in every major area except in Africa.

GOVERNANCE AND POLICY

Implementation of the Code of Conduct for Responsible Fisheries

Today, almost two decades since its adoption,[20] the Code remains key to achieving sustainable fisheries. It continues to be a reference framework for national and international efforts, including in the formulation of policies and other legal and institutional frameworks and instruments, to ensure sustainable fishing and production of aquatic living resources in harmony with the environment. COFI has consistently recognized the importance of monitoring the implementation of the Code and, at its latest session, it proposed that a specific section on the matter be included in *The State of World Fisheries and Aquaculture*. Much of this publication relates indirectly to the implementation of good practices in line with the Code. However, the present special section is the first of what will probably become a regular feature in it.

Countries worldwide view the Code as an essential guide for the development and improvement of their fisheries and aquaculture sectors – one that gives due

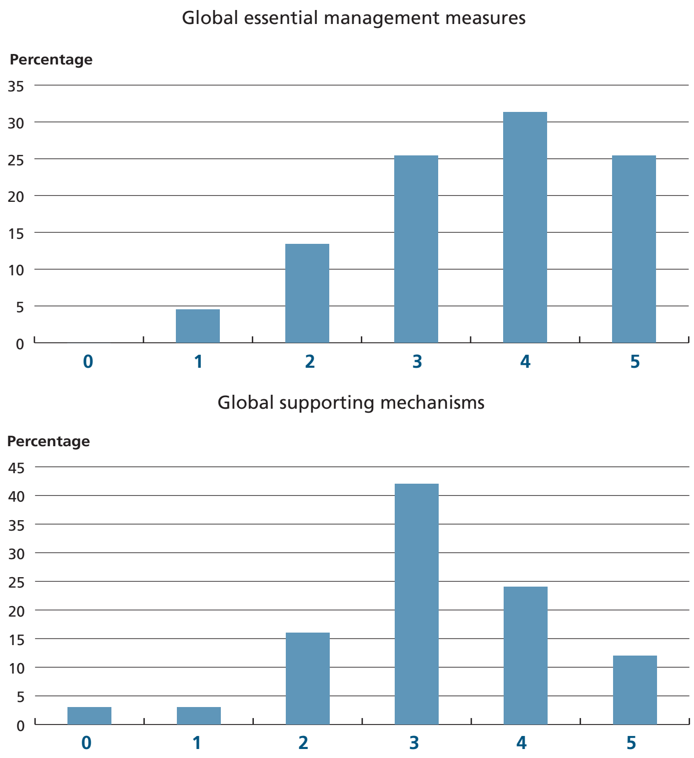
Box 2

Code questionnaire on aquaculture: more governments engaging in self-assessment

In 2009, in order to better address aquaculture and to improve the reporting rate and implementation of the Code, the FAO Committee on Fisheries (COFI) asked FAO to develop a questionnaire to specifically assess the status of compliance of States with the aquaculture provisions of the Code. After a long participatory process involving expert workshops, consultations with Members, testing and training in pilot countries, a new questionnaire was used globally and the responses were presented for the first time to the COFI Sub-Committee on Aquaculture in October 2013.[1]

The new questionnaire has four components. The first three are: (i) essential management instruments or measures to achieve the provisions of the Code including the existence of an aquaculture policy, aquaculture development plan and regulations to support the policy; (ii) supporting mechanisms to facilitate the measures listed in (i); and (iii) enhancing mechanisms to improve the implementation of the measures included in (i) and (ii). In addition, there is a section to assess the capacity of States to develop knowledge, information, technology and advice in support of the measures previously described. Questions on capacity to deal with disasters and climate change are also included.

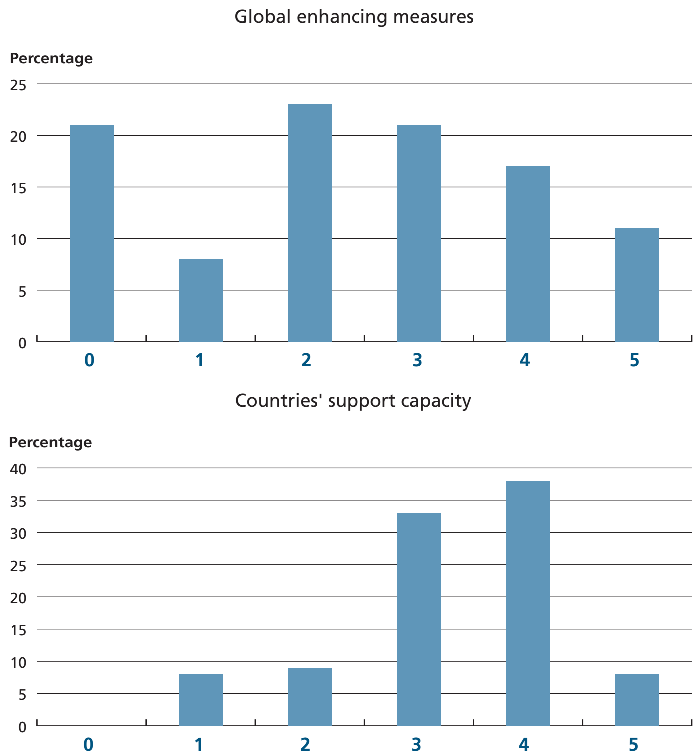
Figure A: Global distribution of responses by category



Sixty-seven countries submitted completed questionnaires in 2012, a significant result compared with previous responses to the aquaculture questions in Code reporting. The current responses represent 36 percent of the Members reporting on aquaculture production and include those contributing about 88 percent of global aquaculture production.

The replies provide a valuable global perspective of Code implementation in aquaculture. Many countries attempted a critical self-assessment and provided additional comments as well as information on their reasoning for the scoring. However, others provided very high scores for every question, thus indicating little or no room for further improvement in the sustainable development of aquaculture, and this may seem unrealistic.

As Figure A shows, overall, essential management measures scored higher than supporting mechanisms and enhancing measures. This is somewhat contradictory as the lower scores in the latter may indicate difficulties at ground



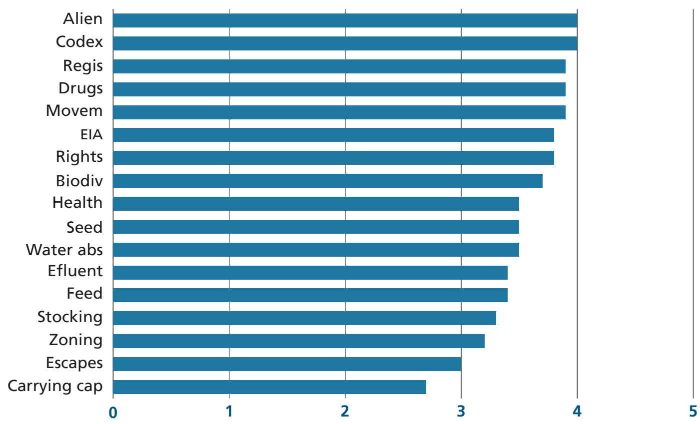
0 = measure non-existent
3 = measure in place but not widely/fully implemented
5 = measure in place, fully implemented and enforced at field level

(Continued)

Box 2 *(cont.)*

Code questionnaire on aquaculture: more governments engaging in self-assessment

Figure B: Global average scores for existence and compliance with specific aquaculture regulations



Notes: 0 = measure or mechanism does not exist; 3 = mechanism exists but is not well implemented; 5 = mechanism is fully implemented at ground level.
Alien (use of alien species); Codex (food safety, Codex Alimentarius); Regis (registration of aquaculture farms and hatcheries); Drugs (use of drugs, chemicals and other substances); Movem (movement of live aquatic animals); EIA (environmental impact assessment and monitoring); Rights (access rights to land and waterbodies); Biodiv (impacts on biodiversity); Health (Fish health management); Seed (use of wild caught seed); Water abs (use of groundwater); Effluent (standards for effluent discharge); Feed (ingredients, and feed quality); Stocking (assessment of impacts previous to stocking); Zoning (zonation of the area for aquaculture); Escapes (escape of farmed fish); Carrying cap (limits set on density according to carrying capacity).

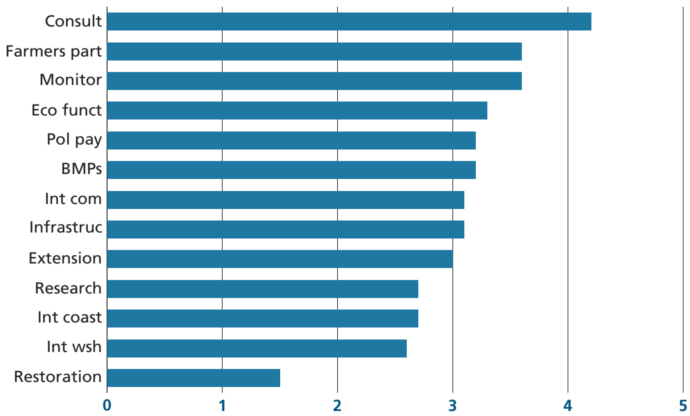
level, suggesting that, in some cases, essential management measures could have been overscored or that good intentions have not always translated into effective implementation.

Regarding specific aquaculture regulations, Figure B shows that regulations concerning carrying capacity, escapes, aquaculture zoning and stocking of waterbodies have the lowest average scores, revealing the need for greater attention for these issues at the global and national levels. Figure C presents the average scores for specific supporting mechanisms, where restoration of impacts stands out as the lowest score.

While global scores provide a general picture, a regional analysis provides a much better understanding of the sector needs, especially when comparing countries where aquaculture is just starting with countries where the sector is well developed. Figure D shows an example for the existence of a government data collection and monitoring system for the sector.

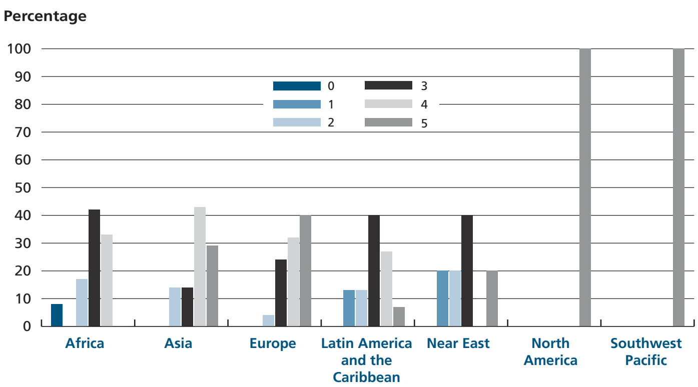
It is expected that governments will increasingly use the current questionnaire as an instrument for self-assessment. It enables them to follow the changes/improvements in the scores for each reporting cycle (every two years) and use a benchmarking approach, for example, against regional or global scores. The questionnaire should be completed following a thorough

Figure C: Global average scores for supporting mechanisms



Notes: 0 = measure or mechanism does not exist; 3 = mechanism exists but is not well implemented; 5 = mechanism is fully implemented at ground level.
Consult (consultation with stakeholders in formulating aquaculture policy/plans); Farmers part (participation of farmers associations in sector planning/ management); Monitor (government monitoring and data collection of aquaculture production/systems, etc.); Eco funct (ecosystems functions are considered in aquaculture planning); Pol pay (application of the "polluter pays" principle); BMPs (better management practices/codes of practice, etc.); Int com (integration of aquaculture in community development/planning); Infrastructure (investment in infrastructure and facilities); Extension (investment in aquaculture extension/training); Research (investment in aquaculture research); Int coast (aquaculture is integrated in coastal planning/management); Int wsh (aquaculture is integrated in watershed planning/management); Restoration (incentives for farmers to restore or rehabilitate resources degraded by their aquaculture activities).

Figure D: Existence and implementation of a government monitoring system of the aquaculture sector, by region



Notes: 0 = measure or mechanism does not exist; 3 = mechanism exists but is not well implemented; 5 = mechanism is fully implemented at ground level.

(Continued)

Box 2 *(cont.)*

Code questionnaire on aquaculture: more governments engaging in self-assessment

assessment of the national situation, and the responses produced after a multidisciplinary discussion among the different national organisms and institutions

involved in the development of the sector. This instrument also provides the opportunity for the aquaculture sector to have a periodical sustainability assessment at the global and regional level, while countries can also opt to make their results public. Nonetheless, the understanding of the tool and the benefits of providing accurate responses remain major challenges, and FAO will continue efforts to engage more countries and to improve the quality of responses.

[1] FAO. 2013. *Progress reporting on the implementation for the Code of Conduct for Responsible Fisheries (CCRF). Provisions relevant to aquaculture and culture-based fisheries with the new reporting system. Committee on Fisheries, Sub-Committee on Aquaculture, seventh session, St. Petersburg, Russian Federation, 7–11 October 2013* [online]. [Cited 21 February 2014]. www.fao.org/cofi/30793-087f8ee9b3253b58dc6e6b44e35910b3f.pdf
FAO. 2013. *Regional statistical analysis of responses by FAO Members to the 2013 questionnaire on the Code of Conduct for Responsible Fisheries implementation in aquaculture* [online]. [Cited 21 February 2014]. www.fao.org/cofi/38662-039567da74d6fb7a74bbe7672b44cc25a.pdf

consideration to the sustainable use of fisheries resources, to habitat conservation, and to food security and poverty alleviation in fishing communities. Although the ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) did not exist as such when it was first developed, the Code does consider ecosystem and biodiversity conservation as well as the nutritional, economic, social, environmental and cultural importance of fisheries and aquaculture, and the interests of all stakeholders. The EAF and EAA have developed into key tools for its implementation.

FAO has produced 28 detailed technical guidelines to assist fishers, industry and governments in taking the necessary practical steps to implement the various facets of the Code. The Code, four IPOAs and two strategies established within the framework of the Code provide the broad framework within which FAO implements its programme of work in fisheries and aquaculture.

The effective implementation of the Code and related instruments by all stakeholders translates into securing adequate supplies of fish and fisheries products for present and future generations, as well as sustained income-earning opportunities. FAO supports implementation in a variety of ways, including through regular and field programme activities. Its activities include regional and national workshops to deepen the Code's implementation, as well as ongoing work for the development of technical guidelines, the translation of some guidelines and assistance to develop national plans of action.

FAO monitors the application and implementation of the Code and promotes it in collaboration with States and international organizations. FAO monitors global progress in implementation of all components of the Code and related instruments. It does so through self-assessment questionnaires sent to FAO Members, RFBs and international non-governmental organizations prior to the convening of each session of COFI. The results of a rigorous analysis of the information submitted are presented to COFI.[21] Following the introduction of a web-based reporting system,[22] the rate of responses to the questionnaire improved considerably in 2013 – enabling more complete and reliable analyses. Periodically, Members also complete other supplementary specific questionnaires on post-harvest practices and trade (Article 11) and aquaculture development (Article 9) (see Box 2 on the uptake of the new Code questionnaire on aquaculture). The information so gathered is processed and presented at the sessions of the COFI Sub-Committees on Aquaculture and Fish Trade respectively.

Recent information acquired by FAO indicates that most countries have a fisheries policy and fisheries legislation in place. In most cases, they are fully or, at least, partially consistent with the Code, while the other countries have plans to align them with the Code. Globally, the top priority objective of the Code to be implemented is the establishment of principles for responsible fisheries with due consideration of relevant biological, technical, economic, social, environmental and commercial aspects. In the survey carried out prior to the Thirtieth Session of COFI, the main constraints identified by States as impeding implementation of the Code were: insufficient financial and human resources; lack of awareness and information about the Code; inadequate scientific research; and statistics and information access. Apart from seeking direct ways to overcome these constraints, improvement of institutional structures and regional and international collaboration were identified as key factors for improving implementation.

FAO has recorded general progress by Members on various aspects of the Code. Several have moved to align their fisheries legislation with the Code and have developed systems for the control of fisheries operations, including the use of vessel monitoring systems (VMS). Particular progress has been made in developing food safety and quality assurance systems for fish and fisheries products, together with the establishment of mitigation measures for post-harvest losses. In addition, States have given increasing importance to the drawing up and implementation of national plans of action to combat IUU fishing and to curtail fishing capacity. Considerable efforts have also been made in conducting assessments in relation to the IPOAs on sharks and seabirds, and in adopting the guidelines contained in the strategies to improve the status and trends of capture fisheries and aquaculture. Members are showing more commitment towards the implementation of the EAF, and are directing research towards the impact of climate change on fisheries and the development of mitigation and resilience programmes.

However, there remain recurring major concerns. In most cases, fish-stock-specific target reference points are being either approached or exceeded, signifying a steady trend in managed fisheries either nearing full fished or being overfished states. Moreover, data gaps often undermine management measures, and bycatch and discards frequently occur in major fisheries – these are not always monitored and mitigation measures are often lacking. Many States still lack complete and enabling policy, legal and institutional frameworks for integrated coastal zone management and aquaculture development.

The contribution by RFBs in promoting responsible fisheries practices in line with the Code is noteworthy. Several RFBs have, *inter alia*, implemented stock recovery plans and management measures to ensure sustainable fisheries, together with measures related to the protection of endangered species, selectivity of fishing gear and the prohibition of destructive fishing methods and practices. There has been extensive work by RFBs in implementing monitoring, control and surveillance (MCS) measures, as well as in monitoring bycatch and discards and establishing measures to reduce them. Assistance to the RFB's respective members in the implementation of the IPOAs (and other activities related to implementation of the Code) has also been recorded. International NGOs have also contributed to raising awareness on the benefits of implementing the Code. In recent years, they have stepped up cooperation with countries to address IUU fishing, and have worked with civil society to increase recognition of access rights to fishery resources.

The 2012 independent evaluation[23] of FAO's support to the implementation of the Code rated FAO's performance highly commendable and the quality of its work as consistently high. It underlined the importance of implementing the Code as being central for sustainable fisheries and aquaculture management and a key pillar of FAO's mandate and mission. The evaluation team suggested that, in order for the Code to become a living and meaningful source of inspiration for transformative change in fisheries and aquaculture, the huge chasm between the formal authority of the Code and its users had to be bridged in numerous ways. It called for more strategic and prioritized development and support to implementation, improved outreach, closer articulation between normative and operational work (including capacity development), and more attention to the human dimensions.

The authors of one study[24] found that compliance with the Code correlates negatively with biodiversity, supporting the need for international development efforts to focus on regions with poor management performance, high biodiversity, rapidly increasing human populations and a high dependence on fishery livelihoods. They also promote – favouring SSFs – the effective implementation of community- and ecosystem-based management (aspects of which are embedded *inter alia* in the Code). These approaches can help to address the growing challenges in fisheries management that are exacerbated by factors such as climate change, pollution, destruction of coastal habitats, and unpredictable environmental fluctuations.

The results of another study[25] highlight the benefits of implementing the Code and underpin the importance of the work of the FAO Fisheries and Aquaculture Department in assisting developing countries to adopt responsible fishing practices in line with the Code. On the basis of a series of analyses focusing on five ecological indicators that quantify the ecosystem effects of fishing, the authors demonstrate that compliance with the Code (specifically Article 7) contributes to an increase in the sustainability of fisheries regardless of geographical location. The study also warns of the negative ecological repercussions if international instruments such as the Code are ignored. In addition, it determines a minimum compliance threshold above which the Code would be effective in increasing the ecological sustainability of fisheries ecosystems.

Blue Growth – a framework for the future

Oceans, seas, coastal areas and the associated blue economy are critical to global and national development, food security and the fight against hunger and poverty. They are both engines for economic growth and sources of food and jobs. However, overfishing, pollution and unsustainable coastal development are contributing to irreversible damage to habitats, ecological functions and biodiversity. Climate change and ocean acidification are compounding such impacts at a time when the rising global population requires more fish as food,[26] and as coastal areas are becoming home to a growing percentage of the world's population.[27]

Building on the challenges identified in the Rio+20 outcome document *The Future We Want*[28] and the post-2015 development agenda,[29] FAO is promoting "Blue Growth" as a coherent approach for the sustainable, integrated and socio-economically sensitive management of oceans and wetlands. For FAO, this means focusing on four components: capture fisheries, aquaculture, ecosystem services, and trade and social protection of coastal communities.

Investing in Blue Growth – the sustainable management and use of aquatic resources and the adoption of ecosystem approaches – can help to reduce stressors and restore the functions and structure of aquatic ecosystems. The initiative is of particular significance to small island developing States and to coastal areas and wetlands around the globe. It offers an integrated approach in response to the increasing need for cooperation and coordination among all stakeholders and at all levels for more sustainable fisheries management and more effective conservation. It is an approach that could reap an estimated potential economic gain of US$50 billion per year for fisheries alone.[30] In addition, Blue Growth can further the capacity development efforts needed to strengthen the policy environment, institutional arrangements and the collaborative processes that empower fishing and fish farming communities, civil society organizations and public entities.

Grounded in the principles of the Code and its associated guidelines, Blue Growth provides a global framework to promote responsible and sustainable fisheries and aquaculture. Building on recent international and national initiatives,[31] FAO will assist its Members and regional institutions in developing, fostering and implementing the blue economy agenda to help turn commitment into action.

Blue Growth builds on the three pillars underpinning sustainable development by addressing the environmental, social and economic issues and challenges facing the sustainable and responsible management of aquatic resources. This translates into recognizing and addressing the rights of those dependent on fisheries and aquaculture for their livelihoods – some 12 percent of the world's population. Their rights relate to tenure, income, market access, and decent living and working conditions. By dynamically supporting an integrated approach, Blue Growth can foster and sustain the valuable contribution of oceans, seas and coasts to food security, nutrition and decent employment for future generations.

Small-scale fisheries

The contributions of SSFs to poverty alleviation and food security continue to receive greater attention at the international level. The plight of SSFs has recently been taken up by a number of fora and policy processes, where, at a normative level, member States continue to call for a greater focus on the sector.

Countries have demonstrated their recognition of the importance of SSFs through, among others, the outcome document of the 2012 United Nations Conference on Sustainable Development (Rio+20), *The Future We Want*. This document strongly emphasizes the role of SSFs as catalysts of sustainable development in fisheries. In it, the signatories – both States and civil society organizations (CSOs) – committed "to observe the need to ensure access to fisheries, and the importance of access to markets, by subsistence, small-scale and artisanal fishers and women fish workers, as well as indigenous peoples and their communities particularly in developing countries, especially small island developing States." *The Future We Want* thus echoes similar provisions in the Voluntary Guidelines for the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VG Tenure) regarding tenure security and access.

Other favourable or enabling policy processes include the growing interest in the contribution of SSFs to food security and nutrition. This is illustrated by the recent adoption of the VG Tenure as well as by the recent report of the Special Rapporteur on the right to food to the United Nations General Assembly.[32]

The VG Tenure, approved in 2012 by the Committee on World Food Security and also explicitly called upon in *The Future We Want*, contain a strong fisheries component. This instrument represents one of the first occasions in which fisheries are considered in an intersectoral approach to development, and it recognizes the idea that tenure security is necessary for the achievement of human rights and the progressive realization of the right to food. The VG Tenure provide both guidance and instruction on approaching tenure issues in fisheries. At the small-scale level, this could strengthen the security under which fishers access and use living aquatic resources, thereby enhancing stewardship and promoting sustainable management of the resource. In addition, the VG Tenure are guided by a human rights-based approach to development. This provides a framework for overcoming obstacles such as illiteracy, ill health, lack of access to the means for traditional livelihoods and lack of civil and political freedoms – factors that not only hinder development but also drive the "race to fish" and significantly contribute to resource overfishing.

The report of the Special Rapporteur is the first such report on fisheries in the context of food security and the right to food. It identifies the challenges facing global fisheries and examines how the individuals most vulnerable to negative impacts (the residents of developing coastal and island countries, especially low-income food-deficit countries) can be supported to ensure the progressive realization of the right to food. It stresses the need to protect and support SSFs – as key to the realization of the right to food. It also welcomes the development of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines), noting that linking their content to the norms and standards of international human rights law, including the right to food, is essential.

The issues and arguments highlighted by the Special Rapporteur have been focal issues in the long-lasting and inclusive consultation process on the development of the SSF Guidelines. More than 4 000 people have been directly involved in the consultation to develop the SSF Guidelines, an instrument proposed by COFI at its Twenty-ninth Session. The process has received high engagement by both Members and CSOs, and the SSF Guidelines will be considered for endorsement by COFI in 2014. They will require commitment and investments from donors, governments, CSOs and other relevant stakeholders in order to become effective tools for change (see Small-scale fisheries: promoting collective action and organization for long-term benefits on pp. 99–104).

At a general level, the SSF Guidelines seek to enhance the contribution of SSFs to food security and nutrition. They also aim to contribute to and improve the equitable development and socio-economic condition of small-scale fishing communities alongside sustainable and responsible management of fisheries.

There is now a real drive towards more participatory and decentralized governance with improved multistakeholder dialogue. In combination with greater accountability in state, corporate, donor and NGO programmes, this provides an enabling context for the application of, among others, the SSF Guidelines. So too do processes that recognize cultural values as part of the "goods and services" provided by SSFs – such as the implementation of the "ecosystem services" context in sustainable development processes (see also *The Future We Want*), the promotion of the EAF, and "green economy" processes.

Furthermore, the strengthening of community-based and professional organizations in the small-scale fishers sector, both formal and informal, enhances the opportunities for SSF stakeholders to exercise their right to organize, participate in development and decision-making processes and influence fisheries management outcomes. Strong organizations could also improve fishers' and fish workers' participation in policy dialogues, as well as their access to markets, finance and infrastructure.

However, consolidating the above advances still requires strong political commitment and increased awareness. This is especially the case at the national and regional levels in order to improve SSF governance and foster the development of fishers, fish workers and their communities at large, while applying the principles and guidance developed in international fora, policy dialogues, and instruments.

Trade and traceability

The need for traceability in the food supply chain is now widely recognized. Food safety scandals such as "mad cow disease" (bovine spongiform encephalopathy) have attracted considerable media and consumer attention. These have perhaps been the main driver for implementing traceability in the food industry. When a potential food safety problem is identified, traceability enables corrective action such as a product recall to target the affected batch or lot rapidly and specifically, thus minimizing trade disruptions and preventing such products from reaching consumers.

The Codex Alimentarius Commission Procedural Manual[33] defines traceability as: "the ability to follow the movement of a food through specified stage(s) of production, processing and distribution". Traceability is included in the regulations in major seafood importing regions and countries such as the European Union (Member Organization), the United States of America, and Japan. It is also required in order to demonstrate that fish has been caught legally from a sustainably managed fishery or produced in an approved aquaculture facility. Thus, it could be a tool to combat IUU fishing. It is an important component in many private ecolabelling schemes.

Such schemes have evolved prompted by concerns of NGOs, retailers and consumer organizations about regulatory systems failing to guarantee that fishery resources are used in a sustainable manner. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) uses traceability to ensure that endangered or protected species are not traded.

Traceability in food safety and animal health area

The Codex Guideline CAC/GL 60-2006 "Principles for traceability/product tracing as a tool within a food inspection and certification system" elaborates a set of principles to assist competent authorities in recognizing traceability as a tool within their food inspection and certification systems. The guidance covers the context, rationale, design and application of traceability to explain its possible use as a tool by a competent authority within its food inspection and certification system. The standards are not specific about minimum requirements for traceability but rather about how they should or should not be used (as well as their limitations), thereby establishing principles that guide traceability implementation in the supply chain. The Codex "Code of practice for fish and fishery products" (CAC/RCP 52-2003) recommends the implementation of traceability lot numbers for lot identification and recall purposes but is not prescriptive and does not give detailed guidelines. The Codex "General principles of food hygiene" include a recall procedure that relates to traceability (CAC/RCP 1-1969, Rev. 4-2003 Section V.5.8). The guidelines require that effective procedures be in place to deal with any food safety hazard and to enable the complete, rapid recall of any implicated lot of the finished food from the market.

The International Animal Health Code issued by the World Organisation for Animal Health (OIE) emphasizes that traceability should be a demonstration of the capacity of government veterinary services to exercise control over all animal health matters, and not a description about the responsibility of private stakeholders in the chain. The ISO 22005 Standard gives the principles and specifies basic requirements for the design and implementation of a feed and food traceability system. The standard can be applied by an organization operating at any step in the feed and food chain. The ISO 12875:2011 standard specifies the information to be recorded in marine-captured finfish supply chains in order to establish the traceability of products originating from captured finfish.

Traceability in certifications related to sustainability

Codex and OIE standards are most often adopted by governments in national food safety and animal health regulations. The emergence of private certification schemes in the sustainability area and their impact on international fish trade led FAO Members to request the development of guidelines for certification in this area. The FAO technical guidelines for the ecolabelling of products from marine and inland capture fisheries summarize principles that certification schemes should observed. The schemes should ensure that labels communicate truthful information. This implies that any claims on the labels (such as that the fish is of a particular species and from a specifically identified sustainable source) should be accurate and verifiable, essentially through a traceable chain of custody. FAO technical guidelines for aquaculture certification provide guidance for the development, organization and implementation of credible aquaculture certification schemes. As for capture fisheries, the schemes should include adequate procedures for maintaining chain of custody and traceability of certified products and processes.

Regional fisheries management organizations (RFMOs) and other natural-resource management intergovernmental organizations such as the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) have addressed traceability issues through their attempts to deal with IUU fishing. In developing a number of different systems, these organizations have progressed to varying degrees in establishing traceability for the products of their fisheries. However, traceability is not a primary, or in some cases even an explicit, objective of RFMO catch documentation schemes. Instead of focusing on separate documentation of each link in the supply chain, e.g. "one up, one down", the schemes aim to maintain traceability throughout the supply chain in order to combat IUU fishing. Thus, users judge the effectiveness of each scheme on the maintenance of multiple links and by the match between documented traded quantities and catch, neither of which is required in standard (one up, one down) traceability schemes.

Examples of current regulations

In the European Union (Member Organization), Regulation (EC) No. 178/2002 lays down the general principles and requirements of food law, establishes the European Food Safety Authority, and lays down procedures in matters of food safety. Its Article 18 makes traceability compulsory for food and feed operators and requires these businesses to implement traceability systems. Regulation (EC) No. 1005/2008 provides a legal basis to identify IUU fishing as a violation of products traded with the European Union (Member Organization), by means of a catch certification scheme. Importers of seafood into the United States of America are required to notify the Food and Drug Administration (FDA) prior to receiving the shipment. Among other things, the notice should include information on the product (name, product code, lot number or other identifiers, pack size), identification of the shipper, country from where shipped and ultimate consignee in the country. The country's 2011 Food Safety Modernization Act empowers the FDA to order mandatory recalls and establish a food product tracing system. It requires the FDA to use pilot studies and stakeholder recommendations to develop food product tracing systems. In Japan, the Ordinance for Enforcement of the Food Sanitation Act (enforced in 2007) advocates labelling and traceability systems for food products to expand information available to consumers, foster consumer confidence in food safety, and allow rapid containment of any contamination incidents.

Traceability tools

The technologies in place for implementing traceability range from simple documentation to sophisticated electronic systems. Traceability of certified products through a chain of custody can be maintained with relatively straightforward handling and record-keeping procedures implemented by legitimate suppliers, processors, packers and traders. These could include hand-recorded logbooks in fishing vessels, landing declarations, inspection reports at landing sites, sales and transport documents, and processing establishment logbooks. The most widely used principles and components of traceability are: (i) identification of the lot or production batch and identification of any actor in the supply chain that modifies the product or has an impact (e.g. mixing or splitting of lots) on the product; (ii) data capture and management in all steps of the supply chain; and (iii) data communication. The TraceFish project funded by the European Union (Member Organization) resulted in an output detailing a "technical standard" for fish traceability. This standard is a set of programming instructions providing guidance on how to implement traceability in a standardized and structured way, by recording data needed to trace origin, process history, product properties and distribution route in an electronic system. The standard (for software) defines a trading unit, and criteria are set out for monitoring trading units through handling until dispatch. There is no advocacy as to what the unit should consist of or how much mixing of units there should be.

The GS1 Global Traceability Standard, developed by an international not-for-profit organization, can help provide a single traceability process to comply with all quality and regulatory requirements. It ensures interoperability with trading partners, allowing for efficient recall or tracing of raw materials originating from upstream suppliers. It is a business process standard describing the traceability process independently from the choice of enabling technologies. It defines minimum requirements for companies of all sizes across industry sectors in relation to traceability standards and best manufacturing practices.

Other privately developed tools are in use by some of the standard setting bodies. For example, the Global Aquaculture Alliance uses the Trace Register system in its best aquaculture practice standard. TraceTracker Fish Pass was developed to "streamline IUU regulation compliance" by allowing supply chain partners to exchange, evaluate, approve and archive required documentation through a common portal. Gulf Fish Trax is a traceability tool used in the United States of America. For example, the Gulf of Mexico Reef Fish Shareholders' Alliance uses it as a market-based tool for consumers to trace fish back to its capture.

Challenges for the small-scale sector

Implementation of traceability could be a challenge for SSFs in developing countries, although the documentation is well-practised in processing establishments. A container of frozen products can transport processed products obtained from raw material supplied by hundreds of artisanal boats. A recent study indicated that full tracing of industrial catches from the fishing vessel to the export container is not possible in 24 percent of the countries trading with the European Union (Member Organization), and this proportion rises to 49 percent in the case of artisanal fisheries.[34] However, countries are working to improve the situation.

There are good examples of traceability systems providing information linking quality factors to specific causes. For example, studies in Iceland show that fishing ground and volume in haul can influence gaping (the undesirable separation of muscle blocks in a raw fillet) and fillet yield.[35] Traceability systems could also provide information on fishing grounds with fish showing a high or low prevalence of parasite infestation.

The eleventh session of the COFI Sub-Committee on Fish Trade noted that traceability in a number of areas is becoming a requirement in international trade, and that efforts should be made to integrate traceability requirements in order to avoid unnecessary barriers to trade. The Twenty-eighth Session of COFI agreed that FAO should develop best practice guidelines for traceability. The FAO Secretariat is currently reviewing the existing standards for a range of traceability purposes, analysing traceability practices, and performing gap analysis. This process will facilitate the development of best practice guidelines. The ongoing work will be presented to the COFI Sub-Committee on Fish Trade and, eventually, to COFI for further guidance on the development of best practice guidelines.

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 considerably. Today, FAO liaises with 50 RFBs, and these include inland and marine capture fisheries bodies, fisheries research and advisory bodies, aquaculture bodies, and management or conservation bodies for other ecologically related species (e.g. albatrosses, petrels and whales). Thus, the term "RFB" is a generic one and it embraces RFMOs, which are those RFBs that have the competence to establish binding conservation and management measures.

The concept of States cooperating together, particularly at the regional level and for the purpose of fisheries management, is a prominent theme in the 1982 United Nations Law of the Sea Convention, where provisions articulate specific obligations to cooperate on a variety of subjects including the conservation and management of high seas fisheries and those of EEZs.[36] In addition, subsequent international law-of-the-sea and fisheries law instruments have articulated an increasingly important role for regional (and subregional) cooperation through RFBs.[37]

Most recently, the 2013 UN General Assembly Resolution on Sustainable Fisheries notes an obligation on all States, in accordance with international law, to cooperate in the conservation and management of living marine resources. All relevant States to a fishery are urged to give effect to their duty to cooperate by becoming members of the RFMO (where there is one) or to establish such an organization where none currently exists.

Liaison between FAO and RFBs

Liaison between FAO and the global RFB community occurs in three ways.

First, FAO provides the secretariat services for the Regional Fishery Body Secretariats Network (RSN). The RSN enables RFB secretariats to share information and exchange views on themes, challenges and emerging issues of relevance to fisheries governance. Information is exchanged among bodies by a quarterly newsletter, and biennial RSN meetings are conducted in tandem with COFI. In 2014, for the first time, the RSN plans to conduct two meetings, one prior to COFI (the first to be held outside FAO headquarters – at the offices of the General Fisheries Commission for the Mediterranean) and a follow-up meeting at the conclusion of COFI.

As part of the invitation to attend the 2012 RSN meeting (RSN-4), RFBs were invited to provide information on the five most important issues or trends currently confronting them (for more details, see p. 174). Owing to the way this question was expressed, most RFBs responded by identifying problem issues. However, some bodies chose to respond by describing their management programmes or goals, subjects that were not necessarily problematic. Such exercises are important for other RFBs and FAO to understand the practical issues and problems that underpin or undermine effective fisheries management.

The RSN-4 responses to the FAO survey reflected a wide range of issues that were relevant across many RFBs, regardless of their specialization. Subjects identified as priority issues included: climate change impacts; establishment of marine protected areas; the status of fish stocks; ongoing problems with IUU fishing and the most effective means of combating it; safety at sea; fishers' livelihoods; the impact of recreational fishing; child labour in the fishing industry; fish trade; bycatch; shark management measures; trust funds established by wealthier RFB members for the benefit of developing state members; decision-making processes within RFBs (consensus versus majority voting for decision-making on governance); and the need for greater political commitment on behalf of States to support the work of their RFBs.[38]

In 2013, FAO conducted a second survey to monitor RFB activities at a given point in time – August 2013. Its results are presented on pp. 174–180. A comparison of the 2012 and 2013 issues and activities reveals the dynamic nature of regional fisheries management where issues such as Blue Growth, the socio-economic aspects of fishing, and shark management measures present new challenges for RFB managers and for their interactions with one another and with FAO.

The second way that FAO liaises with RFBs is through its Regional Fishery Bodies Task Force. In October 2012, the Assistant Director-General of the FAO Fisheries and Aquaculture Department established this task force for the purpose of creating an enabling environment to provide better assistance and improve coordination between FAO and the various RFBs around the world. The task force liaises between FAO and the existing RFBs, and assists in the establishment of new RFB mechanisms where Members consider this necessary. Its mandate scope extends to the promotion of FAO and UN fisheries policies and instruments. It also promotes FAO policies and programmes as stated and endorsed by COFI.

The third area of liaison between FAO and the broad RFB community can be seen in collaborative work, such as global information sharing partnerships and reporting through the Fisheries and Resources Monitoring System or the database on Vulnerable Marine Ecosystems, areas beyond national jurisdiction (ABNJ) projects that deal with tuna and the five tuna RFBs, or the ABNJ Deep Seas initiative and the deep-seas RFBs. In addition, there is cooperative work on, *inter alia*, climate change, SSFs, IUU fishing, emergency work (e.g. piracy in the Horn of Africa), fishing capacity, fish trade, and workshops to promote FAO instruments of fisheries governance.

New RFBs

Since publication of *The State of World Fisheries and Aquaculture 2012*, two new RFBs, the South Pacific Regional Fisheries Management Organisation and the South Indian Ocean Fisheries Agreement, have held their inaugural meetings. These new bodies represent a significant step forward in extending the global coverage of RFBs, which ideally will eventually result in all marine and transboundary inland aquatic regions being covered by some form of RFB or arrangement.

In addition, a preparatory conference for the North Pacific Fisheries Commission has been established to prepare for the entry into force of the Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean.

In late 2011, a regional intergovernmental meeting between FAO and the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden established a task force for the purpose of developing a memorandum of understanding for cooperation in the management of marine fisheries and aquaculture in the region. This memorandum is currently under final review by the Members prior to it being included as part of the regional legislation that comprises the Jeddah Convention (1982).[39]

Performance review of RFBs

The need for RFBs to modernize their mandates and ensure fuller compliance with international fisheries instruments following the United Nations Conference on Environment and Development has led to numerous RFBs undergoing independent reviews of their performance. The 2013 UN General Assembly Resolution on Sustainable Fisheries urges those RFMOs that have not yet done so to undertake performance reviews on an urgent basis. The general criteria for assessing RFMO performance have been refined through the Kobe Process (itself developed through joint meetings of the five tuna RFMOs that commenced in Kobe, Japan, in 2007). Thus, RFB performance reviews should use transparent criteria and take into account the best practices of regional fisheries management organizations or arrangements, and they should have some element of independent evaluation. Of particular importance is the fact that performance reviews should take place on a regular basis, and some bodies are already conducting their second review.

The distinction between RFMOs and other RFBs is important when considering the need to undertake performance reviews. In a performance review, the primary subject of evaluation is the fisheries management process. This is relevant to all RFMOs because they have a prescribed management mandate. However, the duties of other RFBs are less directly concerned with management. They are advisory or scientific research bodies, but some do offer advice on management issues. Where this occurs, such RFBs can also benefit from a performance review. 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 that mandate.

The State of World Fisheries and Aquaculture 2010[40] reported that seven RFMOs had undergone performance reviews: North Atlantic Salmon Conservation Organization (2004–05); North East Atlantic Fisheries Commission (2006); Indian Ocean Tuna Commission (2007); Commission for the Conservation of Southern Bluefin Tuna (2008); Commission for the Conservation of Antarctic Marine Living Resources (2008); International Commission for the Conservation of Atlantic Tunas (2009); and South East Atlantic Fisheries Organisation (2009). In addition, the Western Central Pacific Fisheries Commission completed its performance review in late 2009.[41]

The State of World Fisheries and Aquaculture 2012[42] reported that another three bodies had completed a performance review: North Pacific Anadromous Fish Commission (2010); General Fisheries Commission for the Mediterranean (2011); and Northwest Atlantic Fisheries Organization (2011).

Also in this period, the International Council for the Exploration of the Sea commissioned an independent review of its advisory services. The main objectives were to evaluate: the quality and reliability of the scientific advice it provides; the appropriateness of the process used to prepare the advice; the relevance, responsiveness and scope of the advice; and whether the human and financial resources available to deliver the advice are appropriate to the workload.[43]

Since publication of *The State of World Fisheries and Aquaculture 2012*, a further 11 bodies have conducted performance reviews. These include FAO RFBs: Fishery Committee for the Eastern Central Atlantic; Southwest Indian Ocean Fisheries

Commission; Regional Commission for Fisheries; and Committee on Inland Fisheries and Aquaculture of Africa.

The following non-FAO RFBs have also conducted performance reviews: International Pacific Halibut Commission; Permanent Commission for the South Pacific; North Atlantic Salmon Conservation Organization; Central American Fisheries and Aquaculture Organization; Caribbean Regional Fisheries Mechanism; and Pacific Salmon Commission. The Secretariat of the Pacific Community notes that although there has been no performance review at the organisational level, several reviews have been conducted at the project level.

Finally, another two performance reviews are in process, one for the Western Central Atlantic Fishery Commission, and a second performance review for the North East Atlantic Fisheries Commission. Both anticipate completion in early 2014. The Mekong River Commission has scheduled its first performance review for December 2013, and the Indian Ocean Tuna Commission is planning its second performance review for 2014.

The number of RFBs conducting their first and second performance reviews demonstrates they are acknowledging the need for their mandates to be sound, and for their practices, procedures and advice to be best practice. All recent RFB reviews have adopted similar methods and criteria, albeit with some adaptation to the organization as appropriate, and all are publicly available.[44] Importantly, having completed their respective reviews, most RFBs have prioritized plans for implementing the review recommendations and all are effectively monitoring their progress in implementation, most commonly under standing agenda items at their annual statutory meetings. In some cases, the recommendations have been so fundamental as to require modification of the basic convention or agreement (e.g. for the Northwest Atlantic Fisheries Organization and the General Fisheries Commission for the Mediterranean). Thus, RFBs are taking their performance seriously and demonstrating their willingness to address shortcomings so as to implement best practices. A further and collective benefit of these RFB reviews is that, as more are completed, some commonalities among the recommendations can serve as potential best practices for the future.[45]

Illegal, unreported and unregulated fishing

Illegal, unreported and unregulated (IUU) fishing remains one of the greatest threats to marine ecosystems, undermining national and regional efforts to manage fisheries sustainably and conserve marine biodiversity. Motivated by economic gain, IUU fishing takes advantage of corrupt administrations and exploits weak management regimes, especially those of developing countries lacking the capacity and resources for effective MCS. It is found in all types and dimensions of fisheries, occurs both on the high seas and in areas under national jurisdiction, concerns all aspects and stages of the capture and utilization of fish, and may sometimes be associated with organized crime.

Fisheries resources available to bona fide fishers are poached in a ruthless manner by IUU fishing, often leading to the collapse of local fisheries, with SSFs in developing countries being particularly vulnerable. Moreover, products derived from IUU fishing illegally find their way into local or overseas trade markets, thus undermining the local fisheries economy and depriving local communities of guaranteed food supplies. Hence, IUU fishing threatens the livelihoods of fishers and other fishery-sector stakeholders and also exacerbates poverty and food insecurity.

It is well known that IUU fishing has escalated in the past 20 years, especially in high seas fisheries. However, its dynamic, adaptable, highly mobile and clandestine nature prevents a straightforward estimation of its impacts. Rough estimates indicate that IUU fishing takes 11–26 million tonnes of fish each year, for an estimated value of US$10–23 billion.[46]

In 2001, in view of the urgent need to address the issue, FAO Members adopted the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (IPOA–IUU). This voluntary instrument, concluded within the framework of the Code, is a toolbox for use by all States – in general, flag States, coastal States and port States. Mindful of the requirements of developing countries, it calls upon all countries to develop and implement a consistent national plan of action, and it highlights the central role of RFBs in promoting and coordinating efforts to implement the IPOA–IUU. Over the years, RFBs have engaged in vigorous campaigns to combat IUU fishing, and they have contributed extensively to the implementation of the IPOA–IUU. Efforts comprise strengthening of MCS measures including port State measures, trade monitoring and control, listing of fishing vessels authorized to fish (with a regional register of fishing vessels), listing of IUU fishing vessels, use of VMS, prohibition of transshipment, establishment of dispute settlement processes, cooperation and coordination with other RFBs (with information sharing on IUU fishing activities), joint enforcement activities, and the organization of regional workshops to combat IUU fishing.

Soon after adopting the IPOA–IUU, the international community recognized the importance of developing internationally agreed standards for the implementation of port State measures, already a central feature of the IPOA–IUU. In this regard, and considering that port State measures constitute an efficient and potent tool to combat and reduce IUU fishing, FAO Members worked on the drafting of a Model Scheme on Port State Measures to Combat IUU Fishing, which was concluded in 2005. This scheme was later taken to a higher level when it provided the basis for the drafting of the binding FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), approved by the FAO Conference on 22 November 2009. The PSMA 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. To date, there have been ten ratifications, acceptances, approvals or accessions (as at 6 May 2014).

The PSMA lays down a minimum set of standard measures for port States to apply when foreign vessels seek entry into port or while they are in port. Through the implementation of defined procedures to verify that such vessels have not engaged in IUU fishing (and other provisions relating to the denial of access to ports, port inspections, prohibition of landing, detention and sanction), fish caught from IUU fishing activities can be blocked from reaching national and international markets. The PSMA also addresses the requirement for flag States to take certain actions, at the request of the port State, or when vessels flying their flag are identified as participating in IUU fishing. In addition, it seeks to prevent the occurrence of "ports of non-compliance", and calls for effective cooperation and information exchange among parties to the agreement, as well as with relevant international and regional organizations, including RFBs. The PSMA places a particular responsibility on RFMOs to foster regional cooperation among their members to implement regionally agreed port State measures that are compatible with national and regional conditions and compliant with the provisions of the PSMA. Used in conjunction with other tools such as catch documentation schemes, port State measures have the potential to be one of the most cost-effective and efficient means of combating IUU fishing and ensuring compliance with the regional conservation and management measures adopted by RFMOs.

The entry into force of the PSMA would not only strengthen international efforts to curb IUU fishing but would, as a result, also contribute to strengthened fisheries management and governance at all levels. However, to be effective, parties would need to move ahead with developing implementation strategies, supported by sound policy, legal and institutional frameworks, as well as operational mechanisms sustained by sufficient human and financial resources. The PSMA calls on parties to provide assistance to developing States, directly or through FAO and other international entities, to enhance their capacity to implement port State measures. In addition, it provides for the establishment of funding mechanisms for this purpose, managed by an ad hoc working group set up specifically to address the needs of developing States that are parties to the PSMA. In November 2011, FAO convened an informal open-ended technical meeting to review draft terms of reference for this working group. COFI endorsed these terms at its Thirtieth Session in 2012.

Meanwhile, FAO has embarked on the delivery of a global series of regional capacity-development workshops, in collaboration with relevant regional and international organizations, to facilitate accession to the PSMA. The aim is to bring the PSMA into force as soon as possible and ensure that it gains the widest possible international acceptance. The workshops also aim to contribute to the development of national capacity to maximize the benefits available through the effective use of the PSMA and promote bilateral, subregional and/or regional coordination. FAO's guide to the background and implementation of the PSMA[47] serves as a principal resource document during the workshops.

The fulfilment of responsibilities by flag States, as set out in international law and various international instruments related to fisheries, complements the implementation of effective port State measures in combating IUU fishing. In this context, a technical consultation on flag State performance produced the "Voluntary Guidelines for Flag State Performance" to prevent, deter and eliminate IUU fishing through the effective implementation of flag State responsibilities and thereby ensure the long-term conservation and sustainable use of living marine resources and marine ecosystems. The agreed guidelines are wide-ranging and address their purpose and principles, the scope of application, performance assessment criteria, cooperation between flag States and coastal States, a procedure for carrying out an assessment, encouraging compliance and deterring non-compliance by flag States, cooperation with and assistance to developing States with a view to capacity development, and the role of FAO. They are expected to provide a valuable tool for strengthening compliance by flag States with their international duties and obligations regarding the flagging and control of fishing vessels. The guidelines will be presented for endorsement to COFI at its Thirty-first Session in June 2014.

Furthermore, FAO is working in close collaboration with the International Maritime Organization (IMO) in combating IUU fishing. In 2013, the IMO Maritime Safety Committee approved a paper submitted by several IMO member States, together with FAO and WWF, proposing amendments to IMO Resolution A.600(15) in order to extend the IMO Ship Identification Numbering Scheme to fishing vessels on a non-mandatory basis. Then, on 4 December 2013, the IMO Assembly adopted a new resolution, A.1078(28), revoking resolution A.600(15) on the IMO Numbering Scheme. Thus, the scheme now applies to both merchant ships and fishing vessels of 100 gross tonnage and above. Consequently, the preconditions have been met for using the IMO number as the global unique vessel identifier, recognized by COFI as a key component of the FAO Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels. In addition, FAO and IMO are also working together through the Joint FAO/IMO Ad Hoc Working Group on Illegal, Unreported and Unregulated Fishing and Related Matters.

FAO Members highlighted the persisting problem of IUU fishing in the self-assessment questionnaire on the implementation of the Code and related instruments submitted prior to the Thirtieth Session of COFI. Most Members indicated that they had taken steps to develop a national plan of action to deter, prevent and eliminate IUU fishing, and several had engaged in improving MCS setups and introduced cross-border cooperation between authorities and legal framework improvements. This suggests that a global, resilient and growing commitment is in place to tackle IUU fishing.

Bycatch and discards – global and regional initiatives

Calls for action on bycatch and discards have been raised at the United Nations General Assembly, including in UNGA Resolution A/RES/64/72 on Sustainable Fisheries adopted by the Sixty-fourth Session. States, subregional and regional fisheries management organizations and arrangements (RFMO/As) and other relevant international organizations were urged to reduce or eliminate bycatch, catch by lost or abandoned gear, fish discards and post-harvest losses, and to support studies and research to reduce or eliminate bycatch of juvenile fish.

At the Twenty-eighth Session of COFI in March 2009, FAO was requested to develop International Guidelines on Bycatch Management and Reduction of Discards At the Twenty-ninth Session (February 2011), COFI endorsed the Guidelines and recommended that FAO provide support in capacity building and implementation of the Guidelines.[48] At the Thirtieth Session of COFI, the Committee suggested continued attention to bycatch and discards to ensure that they were addressed comprehensively in conservation and management assessments, within an ecosystem approach.

Since COFI endorsement, and following the successful conclusion of the global bycatch project of FAO, United Nations Environment Programme (UNEP) and Global Environment Facility (GEF),[49] FAO and its partners have been proactive in developing a series global and regional bycatch initiatives.

Regional bycatch project in Southeast Asia

The FAO–GEF "Strategies for Trawl Fisheries Bycatch Management" project (2012–16) involves stakeholders from Indonesia, Papua New Guinea, the Philippines, Thailand and Viet Nam.[50] It takes a holistic approach to trawl fisheries bycatch management and works directly with fishers, the fishing industry and other stakeholders. Project activities will be carried out in a number of main trawl areas, e.g. Arafura Sea (Maluku-Papua), Gulf of Papua, Samar Sea, Gulf of Thailand, and Kien Giang Province in Viet Nam. In each area, the most pertinent issues will be identified and public and private sector partnerships established for finding appropriate solutions, with technical support from the project and its partners.

Regional bycatch project in Latin America and the Caribbean

An FAO–GEF regional project "Sustainable Management of Bycatch in Latin America and Caribbean Trawl Fisheries" is currently under preparation.[51] Countries partnering in the project are Brazil, Colombia, Costa Rica, Mexico, Suriname, and Trinidad and Tobago. The project's technical components focus on: (i) improved collaborative institutional and regulatory arrangements for bycatch management; (ii) strengthening management and optimizing utilization of bycatch; and (iii) sustainable livelihoods, diversification and alternatives.

FAO global and regional projects on tuna fisheries

Bycatch in tuna fisheries forms a major element of the FAO–GEF project "Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction (ABNJ)".[52] This project, involving all five tuna RFMOs, FAO Members, the private sector and NGOs, was operationalized in early 2014 and is scheduled to run for five years. Its strategy is to foster technical cooperation and partnering among the key stakeholders, to incorporate up-to-date best practices, to broaden the stakeholder base and to facilitate dialogues for improvement at all levels in order to generate additional critical human and financial resources to catalyse and accelerate priority activities of the tuna RFMOs. One of its components focuses on integrated and improved bycatch mitigation technologies and practices in regional- and national-level planning processes and the adoption of such practices by tuna vessels.

A second tuna project involving the United Nations Development Programme, FAO and GEF is under formulation for the Western and Central Pacific.[53] This project will be executed by the Pacific Islands Forum Fisheries Agency and the Secretariat of the Pacific Community with the bycatch focus being on integrating bycatch species into management planning processes at the national level and aligned with relevant subregional or regional measures or global instruments.

Bycatch and ghost fishing

The Guidelines also address pre-catch losses (fish and other animals killed but not part of the catch) and ghost fishing by abandoned, lost or otherwise discarded fishing gear (ALDFG). In regard to the latter, FAO has provided technical inputs to the IMO in review of the MARPOL Annex and with the UNEP and IMO on ocean sources of marine litter and their mitigation. Seed funding to FAO through UNEP will be allocated to ALDFG policy and legislation cases studies and to promoting and raising awareness on ALDFG (through the Global Partnership on Marine Litter) and its mitigation. Extrabudgetary funding is being sought to assist with multistakeholder projects to remove ALDFG from fishing grounds and to reduce ghost-fishing impacts on endangered, threatened and protected species of fish and other animals.

Aquaculture governance

With an average annual growth rate exceeding 6 percent in the last decade, aquaculture expansion continues to outpace that of the other food-producing industries. This growth rate varies across regions, and, within regions, across countries, with a large bias towards Asian countries. It also occurs in the context of an increasing world population and almost stable global capture fisheries production. If the trends in demographics and capture fisheries production persist, global aquaculture production will need to continue growing in order to ensure a sufficient supply of safe and quality fish and other aquatic foods to the world's population. This requirement seems to have been generally understood worldwide. At recent FAO regional conferences, high-level policy-makers in Africa, Asia and Latin America have ranked aquaculture high in their national development agendas, and requested international assistance for the rapid development of the sector.

Maintaining the momentum of aquaculture development is a considerable challenge on several accounts. The number and severity of risks from adverse processes of nature are rising. As the land, water, financial and other essential productive resources needed to grow fish and other aquatic products become increasingly scarce, the competition for them grows stiffer, so threatening the sustainability of the growth of the sector.

Sustainability, the principal goal of aquaculture governance, enables aquaculture to prosper over a long period. It entails economic viability, social licence, environmental integrity and technical feasibility. Economic viability requires that aquaculture operations be profitable over time, and be competitive. Profitability underlines the market orientation of aquaculture ventures and implies an enabling business-friendly approach by government. It also implies the rule of law to ensure security of property rights. Social licence means the acceptance of aquaculture by neighbouring communities and the wider society, and determines, therefore, where aquaculture development occurs. The principle of environmental integrity requires the mitigation of negative impacts so that farmers can continue production activities at the same site over a long period. Environmental concerns also influence consumer acceptance of farmed products. The principle of technical feasibility requires the adaptation of productive resources, technologies and growing conditions to local conditions.

Most countries understand that governance can help address issues related to these sustainability principles and enable the latter to prevail. They understand why aquaculture governance matters. This awareness is exemplified by recent developments in international cooperation in aquaculture to enable the sector to prosper. In addition to training and capacity building in nations in need, international cooperation in aquaculture has enhanced technology transfer and diffusion among countries. It has also led to harmonized regional aquaculture development strategies in some places. The goal has been sustainability of the sector for the well-being of society. Indeed, because of improved cooperation, aquaculture productivity has increased, food security and nutrition have been enhanced, and employment and income generation have increased along the value chain. The principal platforms used to advance this cooperation have been: major international conferences (such as the 1976 Technical Conference on Aquaculture organized by FAO in Kyoto, Japan) together with the COFI Sub-Committee on Aquaculture; the network of FAO RFBs; bilateral and tripartite cooperation arrangements, including South–South

cooperation; and regional aquaculture networks. One of the outcomes of the Kyoto Conference included the establishment of regional networks of aquaculture centres in the world's less prosperous regions. Two examples in this respect are the Network of Aquaculture Centres in Asia-Pacific and the Network of Aquaculture in the Americas.

Improved cooperation, information and experience sharing have in particular boosted national and regional capacities to implement the Code in its articles pertaining to aquaculture. The capacity to develop and implement own codes of practice has also improved, thus ensuring the sustainability of the sector's development and its benefits to society. A recent FAO global survey of 56 countries on the implementation of the Code indicates a good overall status of governance in aquaculture, including through policies, planning (plans and strategies) and regulations. In this regard, 44 percent of the countries responding to the survey have a national aquaculture policy framework either almost completed and/or implemented, whereas 36–39 percent of respondents have national legal and institutional frameworks. In addition, 75 percent of responding countries have government-developed codes of practice for aquaculture that are in accordance with the Code. The survey also noted a significant level of involvement by stakeholders in developing and implementing these codes.

Two instruments are becoming important in support of the implementation of the Code: the EAA, and spatial planning. The two instruments are proving especially useful in regard to social licence and the environmental integrity of aquaculture sustainability/governance.

In an attempt to control or prevent inappropriate development of the aquaculture sector, several countries have adopted the EAA. The EAA is an approach to sector development and management that, simultaneously, considers physical, ecological, social and economic systems as well as a wide range of stakeholders, spheres of influence and their interlinkages. Its application follows three main principles: (i) aquaculture development and management should take account of the full range of ecosystem functions and services and should not threaten their delivery to society; (ii) aquaculture should improve human well-being and equity for all relevant stakeholders; and (iii) aquaculture should be developed in the context of other sectors, policies and goals. FAO has elaborated and extended technical guidelines to facilitate comprehension and implementation of the EAA.

A major challenge to sustainable aquaculture development is to allocate productive resources, such as land and water, among competing users with minimum conflict. In many countries, the lack of adequate coastal zone management plans and subsequent site allocation have led to conflicts among competing users for land and water. In particular, these conflicts continue to occur for aquaculture and tourism purposes; they have become a major constraint on the expansion of marine aquaculture in many parts of the world. Unplanned development of aquaculture in some areas of the world has also triggered environmental and social concerns, which, in turn, have led to a negative public perception of aquaculture. Spatial planning, including zoning and site selection, is increasingly being used to tackle these issues. Where aquaculture is a new activity, zoning is used to identify and establish potential areas for its development; where it is well established, aquaculture zoning helps regulate its development. For example, to minimize land- and water-use conflicts and for equity purposes, some countries have established authorized areas for aquaculture activities, called aquaculture exclusive zones (or allocated zones for aquaculture). They have also established parks by providing zones for clusters of small-scale farmers that can be monitored on a strategic basis. By ensuring that production activities are conducted in a sustainable manner, such a strategy has also resulted in increased socio-economic benefits to communities. Various other countries have also started using marine spatial management to achieve sustainable use of resources and biodiversity conservation in ocean and coastal areas. The enabling tool here has been marine spatial planning. This is a public process of analysing and attaining spatial and temporary distribution of human activities in marine areas, with the aim of achieving ecological, economic and social objectives as set forth by political processes.

An important governance issue that remains to the fore in aquaculture debates is aquaculture certification. Public concerns have been expressed that some forms of aquaculture are neither environmentally sustainable nor socially equitable, and that they yield unsafe products for consumers. In response, many countries have put in place policies and regulations governing environmental stability and requiring aquaculture producers to comply with more stringent environmental mitigation and protection measures. Food safety standards have been raised. Nevertheless, interest in the certification of aquaculture production systems, practices, processes and products is increasing. The motives are to address environmental and consumer concerns and secure better market access. In response, aquaculture certification schemes have been developed and implemented at the international and national level. Certification of aquaculture farms, inputs, marketing and processing is under way, both individually and collectively. A good example is the application of the Global Aquaculture Alliance's Best Aquaculture Practices to certified processing plants all over the world such as in Australia, Bangladesh, Belize, Canada, Chile, China, Costa Rica, Ecuador, Guatemala, Honduras, Indonesia, Malaysia, Mexico, New Zealand, Norway, Thailand, the United States of America, and Viet Nam. The aim is to prove to the public that aquaculture production systems and processes are not sources of pollution, disease vehicles, threats to the environment or socially irresponsible. Some countries are also introducing state-mediated certification procedures to assure consumers as to the safety of the products they eat.

Concerned by the confusion and unnecessary cost of the multiplicity of certification schemes and accreditation bodies, the international community requested that FAO lead the preparation of international aquaculture certification guidelines. Thus, FAO developed the Technical Guidelines on Aquaculture Certification, which were approved by the COFI Sub-Committee on Aquaculture in 2010. Noting the absence of a clear international reference framework for the implementation of the minimum criteria set forth in the Technical Guidelines, FAO Members expressed the need for a "conformity assessment framework for aquaculture certification guidelines". The fear was that, in the absence of such an instrument containing appropriate standards for their implementation, certification systems could become unjustified barriers to trade. Hence, FAO developed the Evaluation Framework for Assessing Conformity of Public and Private Certification Schemes with the FAO Technical Guidelines on Aquaculture Certification. The COFI Sub-Committee on Aquaculture approved this framework in October 2013. However, an outstanding issue with respect to aquaculture certification is capacity development on aquaculture certification in developing countries.

Another important emerging issue is the governance of offshore mariculture. In recent years, mariculture, including in coastal, off-the-coast and offshore areas, has grown considerably. Most mariculture operations occur in coastal sheltered waters, which are within national jurisdictions. However, because of competition between mariculture and many other activities close to the coast, mariculture operators are increasingly tending to move their farms farther out to sea. There are concerns that as aquaculture operations expand farther offshore, especially should they extend to the high seas, serious issues of law and governance may arise.

The general principle of the freedom of the seas, according to which all States have the freedom to construct artificial islands and other installations permitted under international law, hints at the right to conduct mariculture, but current public international law affects mariculture only in minor ways. Mariculture is incidentally affected by a number of provisions of general international law as well as by treaties designed to deal with other issues, including those addressing fisheries and the marine environment. However, the existing applicable principles of international law and treaty provisions provide little specific guidance on the conduct of aquaculture operations in these waters. This indicates a regulatory vacuum as aquaculture activities extend from a State's EEZ to the high seas.

An inference from the foregoing is that aquaculture governance is an important dimension of the industry and is likely to become even more so as the sector continues to expand. The major challenge is to ensure that the right measures are in place to guarantee environmental sustainability without destroying entrepreneurial initiative and social harmony. Risks to society must be reduced, but so also must risks and transaction costs to farmers. As the driver of wealth creation, the private sector may enjoy cost-effectiveness and transparent procedures or face obstacles in doing business. Thus, the rule of law must prevail to ensure the sustainability of the sector. The demand for spatial planning tools and techniques is likely to increase as the sector expands and as resource allocation among competing users becomes more problematic. So too, the use of the EAA development and management will increase in an attempt to lessen the environmental, economic and equity issues resulting from an expanding sector under resource-scarcity conditions. Certification is also likely to remain an important issue for some years as consumers continue to demand ecolabelled produce and conformity to international high quality standards for the products on their table. However, aquaculture is only one sector, and often a minor one, competing for priority and resources against more powerful lobbies. Therefore, robust governance measures will always have to be in place and implemented for strong growth over time.

Areas beyond national jurisdiction

The oceans cover about 70 percent of the planet's surface, and they are a source of health and wealth for millions of people around the world. They serve as waterways for trade and contain rich, valuable and diverse ecosystems. In addition to producing nutritious food, the oceans and coastal areas provide many socio-economic benefits in terms of employment, recreation and commerce as well as other crucial goods and services. More than ten percent of the world's population depend on fisheries for their livelihoods and well-being. Travel and tourism, ports and associated infrastructures, mining activities and energy production also use oceans and seas to create jobs and other opportunities. However, numerous threats are compromising the ability of the oceans to provide vital ecosystem services and essential food resources.

The marine ABNJ are those areas of ocean for which no one nation has the specific or sole responsibility for management. They are the common oceans that make up 40 percent of the planet's surface, comprising 64 percent of the surface of the oceans and almost 95 percent of their volume. The ABNJ comprise the high seas and the sea bed beyond the EEZs (which include most of the continental shelf areas) of coastal States. They include complex ecosystems at vast distances from coasts, making sustainable management of fisheries resources and biodiversity conservation in those areas difficult and challenging. Such ecosystems are subject to impacts from a variety of sectors, including shipping, pollution, deep-sea mining and fishing. Addressing these impacts can be compounded by problems in coordinating, disseminating and building capacity for best practices and in capitalizing on successful experiences – especially those related to the management of fisheries in ABNJ. Without urgent action, marine biodiversity and socio-economic well-being will decline, and the value and benefits of fisheries resources for the current and future generations dependent on them will diminish.

Seeking to generate a catalytic change, in November 2011, the Council of GEF approved the "Global sustainable fisheries management and biodiversity conservation in the Areas Beyond National Jurisdiction Program" (ABNJ Program) – also known as Common Oceans.[54] FAO is the coordinating agency, working in close collaboration with two other GEF implementing agencies, UNEP and the World Bank. Executing partners include RFMOs, industry and NGOs. Focusing on tuna and deep-sea fisheries, in parallel with the conservation of biodiversity, the ABNJ Program aims to promote efficient and sustainable management of fisheries resources and biodiversity conservation in ABNJ to achieve the global targets agreed in international fora. Improved governance and policies will be an essential part of the overall ABNJ Program.

The five-year ABNJ Program is an innovative, unique and comprehensive initiative comprising four projects that bring together governments, regional management bodies, civil society, the private sector, academia and industry. Two of these projects – one on the sustainable management of tuna fisheries and biodiversity (see p. 87), and the other on strengthening global capacity to manage ABNJ effectively – kicked off in early 2014, with the other two set to follow in late 2014.

NOTES

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4 Op. cit., see note 1, FAO (2012).

5 Ibid.

6 Previously, FAO categorized this group of stocks as non-fully exploited and fully exploited stocks.

7 Previously, FAO termed this category overexploited.

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9 Fernandes, P.G. & Cook, R.M. 2013. Reversal of fish stock decline in the Northeast Atlantic. *Current Biology*, 23(15): 1432–1437.

10 Fish silage is a liquid product made from whole fish or parts of fish to which no material has been added other than an acid that enables liquefaction of the fish mass by enzymes already present in the fish.

11 The World Bank. 2014. *Global economic prospects* [online]. Volume 8, January 2014. Washington, DC. [Cited 13 March 2014]. www.worldbank.org/content/dam/Worldbank/GEP/GEP2014a/GEP2014a.pdf

12 The FAO Fish Price Index is published in the biannual FAO Food Outlook (available at www.fao.org/GIEWS/English/fo/index.htm) and in the quarterly GLOBEFISH Highlights (available at www.globefish.org/price-reports.html).

13 National Fisheries Institute. 2014. Top ten consumed seafoods. In: *Aboutseafood.com* [online]. [Cited 14 March 2014]. www.aboutseafood.com/about/about-seafood/top-10-consumed-seafoods

14 Statistics reported in this section are based on data from the Food Balance Sheets published in *FAO yearbook. Fishery and Aquaculture Statistics. 2011* (FAO, 2013). Consumption data for 2010 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.

15 In this section, the term "fish" indicates fish, crustaceans, molluscs and other aquatic invertebrates, but excludes aquatic mammals and aquatic plants.

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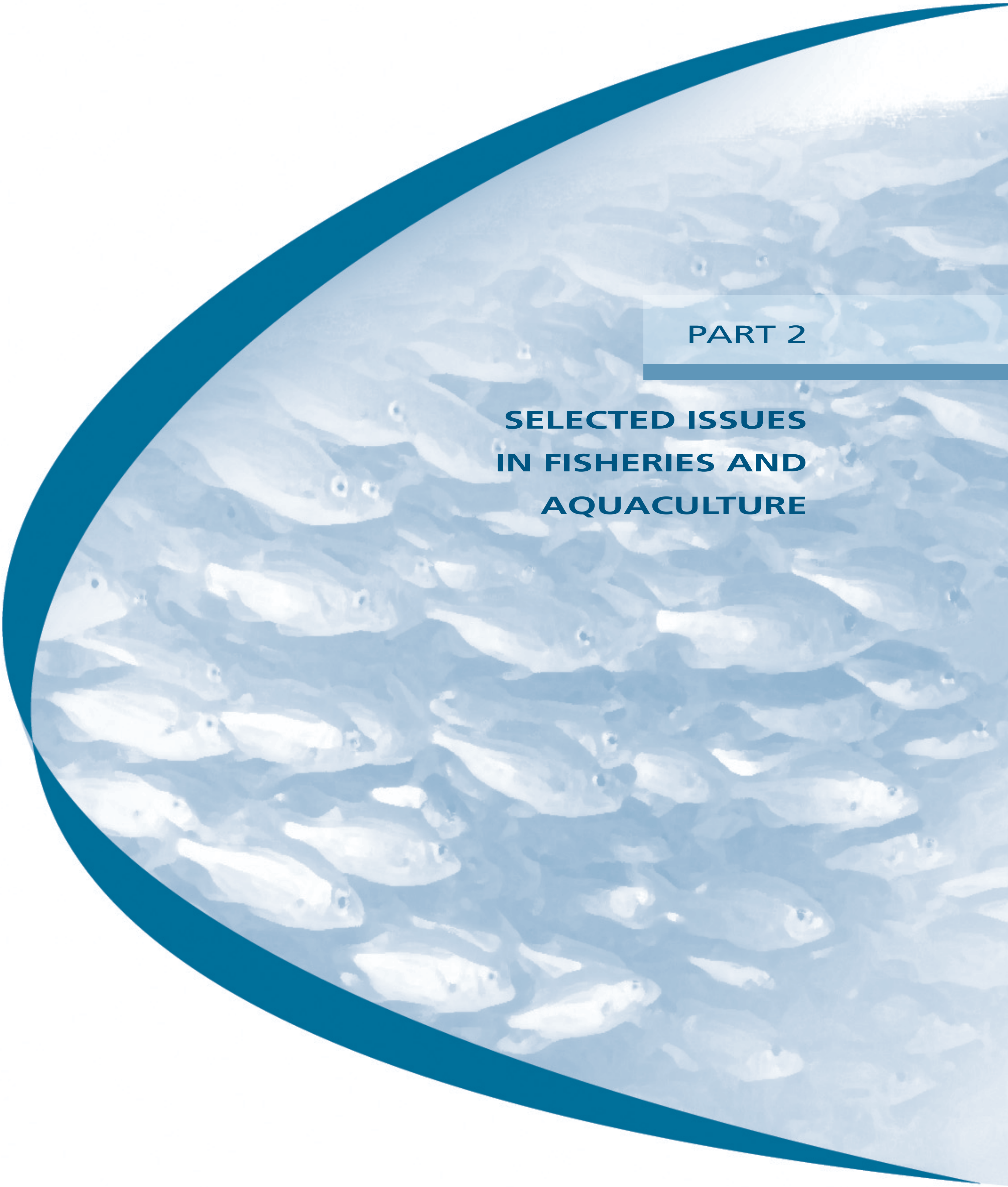


PART 2

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

SELECTED ISSUES IN FISHERIES AND AQUACULTURE

Small-scale fisheries: promoting collective action and organization for long-term benefits

THE ISSUE

The United Nations declared 2012 the International Year of Cooperatives, with the theme "Cooperative Enterprises Build a Better World". This provided important political momentum to champion fishers and fishworkers organizations and collective action as instruments and drivers in promoting responsible fisheries as well as for achieving human and ecosystem well-being. The right to organize is one of the fundamental human rights enshrined in the Universal Declaration of Human Rights. Strengthening organizations and collective action in small-scale fisheries (SSFs) is crucial to empowering the sector's operators to secure their livelihoods and to contribute to food security, nutrition and rural poverty reduction. The important role of organizations in SSFs had already been underscored during the Global Conference on Small-scale Fisheries held in Bangkok, Thailand, in 2008, and in a series of consultative workshops on securing sustainable SSFs facilitated by FAO between 2010 and 2012.[1] FAO's work on fishers organizations and cooperatives dates back to 1959, when, with the International Labour Organization, it organized a technical meeting on fishery cooperatives.

The drivers and motivations for establishing fishers and fishworkers organizations include the need for empowerment as a means to engage with and challenge government authorities on fisheries management issues. In addition, there is the need to strengthen the bargaining power of small-scale operators along the value chain, to reduce vulnerability and to resolve conflict (for example, between fishers and other users over access to land and water). Such organizations enable stakeholders to participate and have a voice in social, economic and political processes and to share in the responsibility of promoting and practising sustainable fisheries. The motivations and structures of these organizations can change or adapt over time. They can become multipurpose organizations that use collective action to also support social development and promote welfare functions, including the distribution of wealth. Such organizations can also be, or become, part of a larger political movement or agenda.

Fisheries cooperatives have the potential to contribute to responsible fisheries, food security, the empowerment of women and poverty eradication (see Box 3). Successful fishers and fishworkers organizations are possible, feasible and desirable, and they can play an important role in community development. They give their communities greater resilience to deal with environmental and socio-economic shocks such as fluctuating catches, disease and death in their families, natural disasters and hunger. However, internal challenges and external factors can seriously jeopardize the effectiveness of such organizations and their associated benefits.

In the past, some customary as well as newly established fishers and fishworkers organizations have failed to achieve their objectives. A major internal challenge for such organizations is the need for a sustained level of commitment and active participation of members over time. Migration – whether resource-driven or due to political circumstances – is common in fisheries and can be a disruptive factor for organizations in this regard. Internal challenges can also relate to power imbalances (due for example to differences in ownership of boats and gear) or to age and sex. These factors influence the role a person takes within an organization. There is potential for abuse of power relating to privileges of members as well as the exclusion

Box 3

Examples of cooperatives in Latin America

Mexico

Two associated cooperatives manage sustainable lobster fishing in the Sian Ka'an Biosphere Reserve (State of Quintana Roo, Mexico), involving all cooperative members in resource management decision-making. Capacity building to strengthen local technology and practices has facilitated the responsible and equitable use of lobsters – the income base of the local economy. Achievements include: a drastic decrease in illegal and environmentally destructive fishing practices; the introduction of well-defined, secure and dispersed lobster fields, improving the survival of the local lobster population; the practice of capturing live lobsters and releasing young lobsters and eggs; and the replacement of palm tree traps with concrete cabins, reducing the local use of an endangered palm species.

Another Mexican success story comes from Tamiahua lagoon, where cooperatives receive concessions for their members to harvest resources.[1] In order to ensure the protection of habitats, only selective fishing gear is allowed. Fishers deliver their catches to the cooperative, which selects and sorts the fish, lightly processing some species. Tamiahua fishers receive fair prices for their production, and there are clear benefits for the cooperative and its members. During its 40-year existence, the cooperative has received renewable concessions for extracting resources from inside and outside the lagoon and for processing oysters.

Brazil

The Cananéia Oyster Producers' Cooperative (known as COOPEROSTRA) in Mandira on the southern coast of São Paulo, Brazil, was created in the 1990s. It supported the community in establishing new rules and practices to reconcile oyster harvesting with the conservation of local mangrove forests and their high biodiversity. Cooperative members are allowed three harvests a year[2] and now receive twice as much for their oysters as they used to from market intermediaries. Before the cooperative was established, intermediaries dominated the oyster market chain and paid little attention to local regulations, sanitation and health standards for shellfish processing. Mandira's oysters have enhanced appreciation of artisanal production, and the availability of high-quality local seafood has encouraged tourism.

[1] FAO & INFOFISH. 2008. *Present and future markets for fish and fish products from small-scale fisheries – case studies from Asia, Africa and Latin America*. FAO Fisheries Circular No. 1033. Rome, FAO. 87 pp. (also available at ftp://ftp.fao.org/docrep/fao/010/i0230e/i0230e00.pdf).
[2] Diegues, A.C. 2008. *Marine protected areas and artisanal fisheries in Brazil*. Samudra Monograph. Chennai, India, International Collective in Support of Fishworkers. 68 pp.

Source: FAO & IFAD. 2012. *Cooperatives in small-scale fisheries: enabling successes through community empowerment* [online]. International Year of Cooperatives. Issue Brief Series. [Cited 21 October 2013]. www.fao.org/docrep/016/ap408e/ap408e.pdf

and marginalization of non-members when access rights are being allocated and negotiated through an organization. Research has identified leadership by highly motivated, respected and entrepreneurial skilled individuals as the most important attribute in the success of co-management in fisheries.[2] The role of women in fisheries is often significant, yet their representation in associations is limited by cultural barriers. The complexity of arrangements that guarantee successful leadership and appropriate representation are therefore important internal challenges that organizations have to face. Access to and availability of financial and physical capital are also crucial for the functioning of organizations over time, as are communication processes and infrastructure. Past negative experiences with organizations are difficult to overcome unless prospective members perceive the real benefits and advantages of joining or establishing an organization.

External factors are also critical for the success or failure of an organization and collective action. An enabling environment in the form of legal and political frameworks that favour democratic decision-making will help organizations to thrive. On the other hand, political interference, regime shifts, instabilities and lack of autonomy can constrain their range of possibilities and impose inappropriate organizational structures, often with a short-term orientation.

POSSIBLE SOLUTIONS

To be effective, fishers and fishworkers organizations need strengthening in terms of their ability to exercise the right to organize and participate in policy dialogues and resource management initiatives, as well as to access markets, financial services and infrastructure. In addition, to ensure sustainability and effectiveness, human capital development must be made a core function of any organization (e.g. through capacity development for youth, specific leadership training, business and administrative capacities, and negotiating a more creative role for women). In order to survive, organizations have to adapt to changing circumstances. Thus, processes within organizations are as important as form and function.

In newly established fishers and fisherfolk organizations, women are often mandated to take an active role (Box 4), including, for example, through participation in key committees. Thus, the often implicit role of women in customary organizations becomes explicit in newer or reformed organizations. However, this change needs to be supported by training in administrative, technical and entrepreneur skills for women in order to reduce inequalities and to encourage and enable them to take leadership roles. The need to reduce inequalities applies also to the question of access to and ownership of assets, as well as the issue of access to income-earning opportunities. Women's access to productive tools is critical for increasing incomes, building self-confidence, improving mobility, balancing power relations by raising women's status in their families, and improving decision-making – all of which reinforce women's role in fisheries cooperatives. The ratification and implementation of the Convention on the Elimination of All Forms of Discrimination Against Women[3] mean it is an important instrument to create the enabling environment for empowering women. Article 14, Section 2(e), is particularly relevant as it calls upon States Parties to ensure to women the right to organize self-help groups and cooperatives in order to obtain equal access to economic opportunities through employment or self-employment.

To ensure transparency and appropriate representation of fishers and fisherfolk organizations, their leaders should be accountable. A clear definition of roles, functions, lines of communication and appropriate accountability mechanisms are elements of a sound organizational structure, along with visionary and diligent leaders.

Many customary organizations are of a local scale, while some of the challenges they deal with are larger. This makes upscaling an important issue for organizations. Bridging fishers and fishworkers organizations with other entities, for example, non-governmental organizations, to form larger networks can also strengthen them to strategically influence governments and intergovernmental organizations,

Box 4

Women's role in cooperatives

The TRY Oyster Women's Association, operating in 15 villages in the Greater Banjul area of the Gambia, and the Isabela Women's Association Blue Fish, in Ecuador, illustrate women's role in cooperatives. Both cooperatives aim to promote responsible fisheries. The pathway to achieving this is to empower fisherwomen by facilitating access to microfinance and appropriate equipment and technologies. At the same time, in order to improve their bargaining position, the associations are also setting higher standards for the processing, packaging and marketing of value-added products. They provide employment opportunities for unemployed women, and identify sustainable economic alternatives for fishers to alleviate pressure on the fisheries resources. The members of the associations also engage in reforesting local mangroves, the development of environmental awareness and the promoting of the use of destructive invasive tree species for smoking fish. The associations are recognized as valid partners in the transition to responsible fisheries management, and they provide policy guidance to government officials.

Source: FAO & IFAD. 2012. *Cooperatives in small-scale fisheries: enabling successes through community empowerment* [online]. International Year of Cooperatives. Issue Brief Series. [Cited 21 October 2013]. www.fao.org/docrep/016/ap408e/ap408e.pdf

build alliances, disseminate information, establish dialogues and support informed community mobilization.

The critical mass of organizations' membership is an important element with regard to marketing. Organizations involved in marketing and trade need to be able to negotiate prices, to strategically diversify markets, to manage product stocks, to establish collective marketing agreements that discourage the sale of fish outside the organization, and to work effectively with intermediaries. Well-organized fishers or women, who are generally the ones more involved in marketing, can even aim at obtaining an ecolabel, as shown by several successful fisheries improvement projects.

Access to and availability of financiai recourses, as well as the capacity to manage them efficiently, are key factors of success for fishers and fishworkers organizations. They require adequate services and good financial management skills, including proper bookkeeping.

An enabling environment also needs supportive institutions, such as decentralized fisheries governance systems that empower communities to become stewards of their resources (Box 5). The right degree of public intervention is important, as excessive interference can harm organizational development as much as too little public support.

RECENT ACTIONS

There is a need for supporting mechanisms such as special policies and strategies that strengthen fishers and fishworkers organizations. FAO has facilitated the development of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). These promote a human-rights-based approach to development, bringing together social development and responsible fisheries. They thus complement important international instruments, in

Box 5

Elinor Ostrom's eight principles for managing a commons

Elinor Ostrom, the winner of the Nobel Prize in Economics in 2009, devoted the bulk of her research to understanding why communities succeed or fail at managing common pool resources. Based on this work, she developed eight principles for the sustainable and fair governance of commons through a community:

1. Define clear group boundaries.
2. Match rules governing use of common goods to local needs and conditions.
3. Ensure that those affected by the rules can participate in modifying the rules.
4. Make sure the rule-making rights of community members are respected by outside authorities.
5. Develop a system, carried out by community members, for monitoring members' behaviour.
6. Use graduated sanctions for rule violators.
7. Provide accessible, low-cost means for dispute resolution.
8. Build responsibility for governing the common resource in nested tiers from the lowest level up to the entire interconnected system.

particular the FAO Code of Conduct for Responsible Fisheries (the Code), the Right to Food Guidelines, and the Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security endorsed in 2012 by the Committee on World Food Security (CFS).

In this context, FAO organized the workshop "Strengthening Organizations and Collective Action in Fisheries: a way forward in implementing the SSF Guidelines" at FAO, Rome, Italy, in March 2013. It was attended by SSF experts representing civil society organizations (CSOs), governments and academia. Its purpose was to support the future implementation of the SSF Guidelines by examining the diversity of existing organizations and collective action, discussing their strengths and weaknesses, and proposing elements for a capacity development strategy to strengthen them to reduce poverty while promoting responsible fisheries. As follow-up, FAO is currently undertaking in-depth case studies to assess the key factors and principles that enable and promote successful self-organization and collective action and to design a capacity development strategy to strengthen fishers organizations. Research institutions and global research partnerships, such as the Too Big to Ignore research network,[4] could play a role in evaluating how cooperation and collective action in fisheries and aquaculture can contribute to improving livelihood conditions.

Among the CSOs that played a key role in developing the SSF Guidelines were the World Forum of Fishers People, the World Forum of Fish Harvesters and Fish Workers, and the International Collective in Support of Fishworkers. They greatly supported the consultation process by organizing many of the consultations that took place worldwide. The CSOs were also well represented during the technical consultation on the SSF Guidelines held in May 2013 in Rome, and they will play a major role in their implementation.

OUTLOOK

The important role of organizations, in particular in the form of CSOs, was stressed in the outcome document of the United Nations Conference on Sustainable Development (Rio+20), *The Future We Want*, and in a report on fisheries submitted by the Special Rapporteur on the Right to Food to the United Nations General Assembly in October 2012. Both recognize the crucial role that organizations of the fisheries and aquaculture sector play in ensuring sustainable development. In *The Future We Want*, the signatories state: "We acknowledge the role of civil society and the importance of enabling all members of civil society to be actively engaged in sustainable development. We recognize that improved participation of civil society depends upon, *inter alia*, strengthening access to information, building civil society capacity as well as an enabling environment." Documents and processes such as these contribute to an enabling environment that empowers organizations to become full partners or even drivers in development processes.

Donors and international agencies will have a role to play in supporting the development of capacities of fishers and fishworkers organizations. So too will government agencies. Through enabling legislation and policy development, they can create strategies to stimulate organization as a means to promote better and fairer options for fishing communities. Government policies to facilitate access to and the development of alternative markets for artisanal fisheries products (such as institutional markets and fish fairs) as well as rural financial service schemes are additional attributes of an enabling environment to empower fishing communities.

The SSF Guidelines can serve as an important advocacy tool for different levels of organizations for guiding, leveraging and legitimizing policy that is conducive to participation and collective action. Fishers and fishworkers organizations therefore have the appropriate incentives to implement the SSF Guidelines at the local level. They also have the capability of adapting the SSF Guidelines to their local realities, which are often characterized by highly complex and dynamic systems governed by customary laws and local norms. Therefore, capacity development strategies to support implementation of the SSF Guidelines should direct efforts towards strengthening leadership to empower and support such organizations (including youth and women), allowing them to also engage with broader development debates (e.g. sustainable development goals, and the sustainable oceans initiative).

Researchers and scholars have a role to play in terms of monitoring and conducting research to deepen the understanding of factors of success and failure of fishers and fishworkers organizations. The lessons learned can be disseminated to inform enabling policy development and implementation.

The role of aquaculture in improving nutrition: opportunities and challenges

THE ISSUE

Micronutrient deficiencies affect hundreds of million people, particularly women and children in the developing world. More than 250 million children worldwide are at risk of vitamin A deficiency, 200 million people have goitre (with 20 million have learning difficulties as a result of iodine deficiency), 2 billion people (more than 30 percent of the world's population) are iron deficient, and 800 000 child deaths per year are attributable to zinc deficiency.

Rural diets in many countries may not be particularly diverse and, thus, it is vital to have good food sources that can provide all essential nutrients in people's diets. People have never consumed so much fish or depended so greatly on the fisheries and aquaculture sector for their nutrition as they do today, but the demand for fish is growing and there are still huge numbers of hungry and malnourished people in the world. Aquaculture plays an essential role in meeting these challenges. However, to do so sustainably, it needs to become less dependent on whole wild fish for feeds and to modify culture species and practices, which, in turn, will require influencing consumer preferences.

There is strong and increasing evidence that, in addition to providing food, fish contributes to the nutritional security of poor households in developing countries in various ways. These include a consumption pathway (where direct consumption of fish boosts intakes of micronutrients and omega-3 oils) and a cash-income pathway (where commercialization of fish contributes to wider product distribution, economies of scale and higher overall food consumption). In addition, commercialization, fish processing and small-scale aquaculture also offer important livelihood opportunities for women in developing countries through their direct involvement in the production, processing and sale of fish. These activities reinforce the economic and social empowerment of women, thereby making an additional contribution to the nutritional security of households as women are inclined to spend more on food for their families.

Fish and fisheries products play an important role in food and nutrition security, poverty alleviation and general well-being. This is especially true for the aquaculture sector, where production is steadily growing and will soon provide most of all the fish consumed by humankind. Consumption of fish provides energy, protein and a range of essential nutrients. Eating fish is part of the cultural traditions of many peoples, and fish and fishery products are a major source of food and essential nutrients for some populations. In many cases, there may be no alternative affordable food sources for many of these essential nutrients.

Fish accounts for about 17 percent of the global population's intake of animal protein. However, this share can exceed 50 percent in some countries.[5] In West African coastal countries, where fish has been a central element in local economies for many centuries, the proportion of animal protein that comes from fish is very high, e.g. 44 percent in Senegal, 49 percent in the Gambia, 51 percent in Ghana, and 70 percent in Sierra Leone. The same holds for some Asian countries and small island States, where the contribution from fish as a source of protein is also significant: 54 percent in Indonesia, 56 percent in Bangladesh, 57 percent in Sri Lanka, 65 percent in Cambodia, and 71 percent in Maldives.

Furthermore, foods from the aquatic environment have a particular role as a source of the long-chain omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are important for optimal brain and neural system development in children. Consumption of fish is therefore particularly important during pregnancy and the first two years of life (the 1 000 day window). While many vegetable oils provide an alternative source of omega-3 fatty acids, this is alpha-linolenic acid that needs to be converted into, for example, DHA. However, this conversion is not very efficient in the human body, making it difficult to rely only on vegetable oil during the most critical periods of people's lives. A recent FAO/WHO expert consultation concluded that fish in the diet lowers the risk of women giving birth to children with suboptimal development of the brain and neural system compared with women not eating fish.[6]

Fish consumption also has health benefits for the adult population. Strong evidence underlines how consumption of fish, and in particular oily fish, lowers the risk of coronary heart disease (CHD) mortality. Coronary heart disease is a global health problem affecting more and more populations in developing countries. It is estimated that, thanks to the long-chain omega-3 fatty acids found mainly in fish and fishery products, fish consumption reduces the risk of dying from CHD by up to 36 percent, and aquaculture products are a major source of these long-chain omega-3 fatty acids.[7] A daily intake of 250 mg of EPA and DHA per adult gives optimal protection against CHD. For optimal brain development in children, the daily requirement is 150 mg. Evidence on the role of DHA in preventing mental illnesses is also becoming more convincing. This is particularly important as brain disorders are increasing dramatically all over the world, and in the developed part of the world the cost related to mental disorders now exceeds the cost related to CHD and cancer combined.

Greater attention is focusing on fisheries products as a source of micronutrients such as vitamins and minerals. This is particularly true for small-sized species consumed whole with heads and bones, which can be an excellent source of many essential minerals such as iodine, selenium, zinc, iron, calcium, phosphorus and potassium, and also vitamins such as A and D, and several vitamins from the B group. There can be significant variations between species and between different parts of the fish.

The unique nutritional composition of fish derives not only from fatty acids, amino acids and micronutrients (vitamins and minerals) – studies on other less well-known nutrients such as taurine and choline show probable additional health benefits. Fish is an excellent source of protein, but what makes fish a truly unique food is all the additional nutrients that it contains in significant amounts.[8]

Although the importance of including fisheries products in a healthy diet is related to its unique nutritional value, growing evidence underlines its beneficial role in replacing less healthy foods. By replacing a less healthy food with fish, the benefits of eating fish will also be linked to a lower consumption of the less healthy food.

It is sometimes suggested that farmed fish is a less healthy food than wild-caught fish. At times, claims are made regarding the quality of water, feed or the alleged misuse of veterinary drugs. In most cases, these are shown not to be true.[9] Indeed, many of the factors that might affect the quality and nutritional value of fish can and should be monitored and controlled in a farming system.

Wild fish usually have a higher proportion of EPA and DHA in their lipids compared with farmed fish. However, as the total fat content in farmed fish is often higher, the total amount of these fatty acids could be higher in the farmed counterpart in some cases.[10]

These essential fatty acids originate mainly from what the fish feed on. In the case of fed fish, they come from fish oils in the diet; and in the case of filter feeders, they come from the naturally occurring algae they feed on. The aquaculture sector currently consumes about 75 percent of global fish-oil production. This percentage seems to be declining owing to the increasing demand for fish oil for supplements and other food purposes, but there are no good alternative sources of EPA and DHA for feeding cultured fish at present. In particular, fish oil goes into feed for carnivorous fish such as salmon and trout to ensure an end product rich in omega-3 fatty acids (EPA and DHA). The industry claims that 50 percent of omega-3 fatty acids, from either fish oil or fishmeal, consumed through its reared lifetime are retained by the fish at the day of slaughter. This is in line with scientific studies showing retention of EPA and DHA in salmon of 30–75 percent depending on the level of fish oil in feed.[11]

Currently, about one-third of the raw material used for producing fishmeal and fish oil is based on by-products and waste rather than whole fish. This share is growing, replacing rather than adding to the volumes of small pelagic fish used for feed purposes. Fishmeal and fish oil are highly traded products, an important source of revenue for some countries, and a very important feed ingredient for the aquaculture sector, which is the fastest-growing food production sector in the world.

The increasing focus on the benefits of fish consumption has brought corresponding and increasing concern about fishery products as a source of contaminants. Consumption of fish, as with any food, may lead to ingestion of harmful substances such as heavy metals, dioxins, pesticides and residues of veterinary medicines. However, sustainably produced aquaculture products are not major sources of these contaminants. Aquaculture products are sometimes rejected as posing a potential threat to human health, but these products are usually withdrawn before they enter the market. The control mechanisms generally work very effectively, ensuring that only safe products reach the consumers. As a result, farmed fish is not considered to pose a higher health risk compared with other farmed meat products or even wild fish. Rather, it is an excellent alternative in a healthy diet. Given the low potential for increased production of food fish from wild stocks, aquaculture products are likely to constitute an even larger share of the market in the future.

Changing consumer preferences can have negative influences on nutritional value. For example, in some cases, small indigenous fish species have been replaced by larger farmed species whose bones and heads are not consumed. This has led to a decrease in the availability of essential micronutrients in some diets. Polyculture of carp and some small indigenous fish species is an example of how aquaculture could add, rather than replace, essential nutrients in vulnerable diets.

POSSIBLE SOLUTIONS

With a growing human population worldwide, the demand for fish and fish products will increase even if the per capita consumption remains at the present world average level of almost 19 kg/year.[12] Capture fisheries production has, in general, levelled off. The increasing demand for fish products will drive improved utilization of present resources, which could reduce wastage and divert more fish into food and less to feed. However, the growing demand for fish will, in practice, mainly be met by increased production from aquaculture, thus, also driving the demand for feed.

Most fish feeds contain a minimum level of fishmeal in order to ensure an optimal content of amino acids and other nutrients needed for fish growth and flesh quality. The use of fish-derived products in feed formulas could pose a dilemma if this fish could be used as human food. If less than one kilogram of fish in feed were needed to produce one kilogram of farmed fish, it would in many cases be more acceptable. Progressively less fishmeal and fish oil are being used for aquaculture despite their steadily rising production.

To reduce production costs, cheaper vegetable alternatives are also increasingly replacing expensive fish oil. This is probably a direct consequence of better-paying markets for fish oil, particularly for nutraceutical purposes, which are absorbing a growing share of the available fish oil. The increased focus on the benefits of fish oils has boosted the demand for fish oil for direct human consumption, with an annual growth rate of 15–20 percent.[13] Unless carefully monitored, the reduced levels of fish oil in aquafeed might result in fish with a less-favourable fatty acid profile. Fish oil in feed should be, and in many cases is, optimized to ensure that the long-chain omega-3 fatty acids end up in the final product, and are not metabolized by the fish during growth.

Fishmeal and fish oil are still major ingredients in most aquaculture feeds. In order to ensure healthy fish and final products comparable with those from their wild counterparts, farmed fish need to receive EPA and DHA largely through their diets. In nature, marine microalgae are the main producers of these valuable fatty acids. Freshwater fish seem better able than their marine relatives to elongate short-chain omega-3 fatty acids into EPA and DHA.

In practice, fish oil is the only economically viable source of long-chain omega-3 fatty acids for feed purposes. Alternatives such as EPA and DHA production based on microalgae seem to be too costly for feed purposes and not a viable option in the near future. As a result of the increasing focus on reducing levels of fish oil and fishmeal in diets for aquaculture, the sector is now probably set to become a net provider of the valuable and essential fatty acids, mainly owing to the large production of carps.[14]

Cyprinids and tilapias represent a significant proportion of global aquaculture production. As they are to a great extent filter feeders or non-fed fish low in the food chain, their production, at least in theory, does not require feed with fishmeal and fish oil. Although many cyprinid species are produced using supplementary feed, the levels of fishmeal and/or fish oil included in the feeds are minimal. In theory, non-fed fish species should have a great potential for expansion as feed inputs are minimal – this also applies to molluscs. Although the demand for carnivorous species such as Atlantic salmon and North African catfish is still high, non-fed fish species are excellent providers of nutrients, are highly acceptable in many food cultures and do not necessarily compete for already limited feed resources.[15] The potential for increasing the production and consumption of these species should be studied and, if appropriate, promoted.

Although the main farmed fish species, carps and tilapias, have a much lower level of the long-chain omega-3 fatty acids compared with, for example, salmon, they should still be considered good sources of these fatty acids. Compared with beef and chicken, the levels in carp and tilapia are much higher.[16] Wild and farmed fish are a healthy and better alternative to almost all other meats. Farmed fish have a more constant nutrient composition compared with their wild counterparts, whose environment, food and access to food vary during the year. The environment of farmed fish can be monitored and managed to secure an optimal product. By controlling the composition of aquaculture feeds and other inputs, healthy fish and healthy fish products with optimal nutritional composition can be produced.

For capture fisheries, most contaminants are difficult to control, whereas for aquaculture there is a greater possibility to manage and control the aquatic environment and all inputs such as feed and veterinary medicines. However, control mechanisms for domestic and local markets are sometimes less rigid, and these should in many cases be strengthened.

RECENT ACTIONS

In view of increasing concerns about fisheries products being a major source of dietary contaminants and the growing awareness of fish as a source of essential nutrients, FAO and the World Health Organization (WHO) held an expert consultation on the health risks and benefits of fish consumption in 2010. Its conclusion was that the benefits of eating fish outweighed the risks, even if consumed more than seven times a week (for any farmed species studied). It also concluded that the consumption of any amount of fish had a positive impact on health. In particular, pregnant women and nursing mothers should ensure they eat enough fish. Fish farmed under controlled conditions should be considered a good and healthy component of people's diets.[17]

The role of fish in nutrition and food security is attracting more attention. The CFS recently requested the High Level Panel of Experts to undertake a study on the role of sustainable fisheries and aquaculture for food security and nutrition. Similarly, the Second International Conference on Nutrition has requested a separate paper highlighting the role of fish in nutrition. Moreover, the role of fish in nutrition was included as an agenda item at both the recent Sub-Committees on Aquaculture and on Fish Trade of the FAO Committee on Fisheries. These recent actions highlight both the heightened interest in, and the more pressing need to discuss and decide on, the role that fish, from both capture and aquaculture, could and should play in improving nutrition at the global level.

OUTLOOK

In November 2014, the Second International Conference on Nutrition will be held in Rome. This high-level ministerial conference will propose a flexible policy framework to address today's major nutrition challenges and identify priorities for enhanced international cooperation on nutrition. The CFS is an intergovernmental body that meets on a yearly basis and serves as a forum for review and follow-up of food security policies. At its 2014 meeting, a paper on the role of sustainable fisheries and aquaculture for food security and nutrition will be presented. As fish products are an important provider of essential nutrients, existing knowledge on the role that aquaculture and fisheries could play in combating malnutrition and food insecurity seems set to be highlighted more than ever.

All foods have benefits and risks associated with their consumption, but very few foods provide the benefits to the same levels as do fish products. Where there is a need to communicate risks of any particular fish consumption, the actions should be well planned, objective, transparent and clear in order to ensure that consumers do not become confused and scared of consuming fish in general. The increasing demands to control both feed and fish quality are significantly reducing the risk of placing unhealthy farmed products on the market. This is particularly true for the export market, where stringent quality and safety control mechanisms ensure that only high-quality and safe products reach the market.

Fish oil is, and will for the foreseeable future remain, a highly demanded ingredient in fish feed. Other marine sources of long-chain omega-3 fatty acids are too expensive. However, genetically modified plants can now produce seed oils with DHA and EPA levels comparable with those found in traditional fish oil.[18] Will the aquaculture sector and consumers be willing to accept the use of oils from genetically modified plants? Plant-based proteins from genetically modified plants are already used as feed ingredients in many cases.

Fish species that spend at least part of their life in freshwater have some ability to convert short-chain omega-3 fatty acids of vegetable origin into long-chain ones such as EPA and DHA. Studies have shown that fish species such as salmon can grow and provide EPA and DHA even with a total replacement of fish oil in their diet. Salmon fed with a diet high in short-chain omega-3 fatty acids and no fish oil can convert alpha-linolenic acid into levels of EPA and DHA in their flesh that are higher than in most other alternative sources.[19] This could become a viable replacement for fish oil for some species, but levels would be lower than in traditionally fed salmon and less than what many consumers would expect. However, it would still be a healthy alternative to most other meats.

Non-fed farmed species are a good alternative source of EPA and DHA. A single meal of carp can cover up to several days' requirements of EPA and DHA. The role that consumption of farmed carp plays in food and nutrition security is particularly evident in many Asian countries, where the bulk of this fish is consumed. Carps alone can cover the yearly need for long-chain omega-3 fatty acids of more than one billion people, significantly more than the contribution from all salmon species combined.[20] Increased farming of fish species that require minimal feed inputs for growth, such as silver carp, bighead carp and grass carp, could be one way of increasing the availability of highly nutritious fisheries products without using whole wild fish for feed purposes. However, this should not replace but rather add to traditionally eaten fish species, such as the small indigenous fish consumed in many areas. Polyculture of carp together with these latter could be a viable option.

Although there is some evidence on the processes and mechanisms through which different nutrition pathways operate, the contribution of fish is still poorly documented and should be more systematically and rigorously demonstrated. Data and information on fish and nutrition remain scarce in many developing countries; hence, more efforts should be made to rectify this important shortfall. It is also important to study the consumer side and determine how aquaculture can better contribute to the nutritional security of rural and urban poor consumers through improved trading and marketing systems.

Post-harvest losses in small-scale fisheries

THE ISSUE

Total global food losses have been estimated at 1.3 billion tonnes per year, which is about one-third of the total world food production for human consumption. This figure includes post-harvest fish losses, which are reductions in the quantity, quality or monetary value of fish in the supply chain. The FAO definition of food wastage (loss and waste), which cuts across all commodities, is currently under discussion but it is expected to eventually also include waste of inputs to production, such as water or energy, e.g. fuelwood in SSF operations. Moreover, greater attention is focusing on the loss in the monetary value of fish (not necessarily a result of loss of fish as food, but a downgrading in value irrespective of quality) because it is a key target of the rural poverty elimination goal. Given the above, three types of losses are considered in SSFs: (i) physical (fish not used after capture/harvest or landing – totally lost from the supply chain and not consumed or utilized); (ii) quality (products that are spoiled or damaged but not to the extent that they are thrown away, the nutritional value may or may not be affected, i.e. products of lower quality); and (iii) market force (loss due to market reaction affecting the selling price to such an extent that, irrespective of quality, the fish sells for a lower price). As discussed below, this latter loss is not necessarily a fish food loss in the first instance, but it can later lead to quality or physical loss, and influence supply stability.

Post-harvest fish losses occur globally in all fisheries, from the point of production to the final sale to the consumer, but the magnitudes and types vary. Because of their structural shortcomings, SSFs incur greater losses compared with large-scale fisheries. As in any food system, losses of fish affect the four dimensions of food security: availability, access, stability and utilization. The socio-economic impact of post-harvest losses is significant because the post-harvest domain comprises several activities at all stages of the supply chain, including handling fish on board, unloading, processing, storage and distribution. These activities are vital to fishers' livelihoods and also provide employment to many rural people. Losses also affect resource sustainability. Recent investigations reveal a direct relationship between high fish losses and increased fishing effort, the latter used as a coping strategy (see FAO Fisheries and Aquaculture Technical Paper No. 550).[21] This buttresses the principle that post-harvest loss control is a resource management tool, and that the loss level and dynamics determine the performance of the post-harvest systems.

Estimates of post-harvest fish losses range between 20 and 75 percent. The severity of the situation is described in FAO Fisheries and Aquaculture Technical Paper No. 550 – focusing on a better understanding of losses and setting loss reduction objectives, reference points and performance criteria that can be objectively measured. The paradox is that these losses occur against a backdrop of stagnant capture fisheries production, and, despite increasing aquaculture production, the supply–demand gap is still evident. This demonstrates that the most obvious means of increasing fish supply, without increased landings, is by reducing the post-harvest losses from current production. Recognition of the significance of fish loss is reflected in Article 11.1 (Responsible fish utilization) of the Code, which encourages loss reduction. Given the multifaceted dimensions of losses, a holistic approach that caters for the contextual occurrence and dynamics of these losses requires an effective loss reduction strategy. Disregarding this would lead to piecemeal interventions based on quoted data derived from limited and unsystematic observations and studies. Considering the important role of SSFs in many developing countries, it is rational to believe that curbing losses would enable significant improvements in their contribution to domestic market supply and employment, as well as in their direct or indirect involvement in cross-border trade at the regional and international levels through the supply of raw material for export-oriented fish processing industries.

The perishability of fish makes it more susceptible to losses in hot tropical developing countries. There may be several different types of loss occurring in a particular fishery, distribution chain or geographical area. Some losses may be more important and some minor, and, at the same time, development resources to address them may be restricted. Therefore, there is a need to prioritize losses after an initial qualitative assessment so that attention can focus on the more significant ones. These can then be quantified and a sustainable reduction intervention implemented to address the losses effectively. Reducing losses is not just about improving technology but also practices and behaviour that potentially higher returns may not be sufficient to change. The following sections discuss the magnitude of the problem, its relevance to rural poverty and aspects of effective loss reduction, capitalizing on experience from various initiatives.

POSSIBLE SOLUTIONS

Food loss has been an important topic on the development agenda since the 2008 food crisis and in the headlines for the past 3–5 years. Several initiatives in fisheries have echoed the concerns about post-harvest losses in SSFs. Given that there may be multiple root causes, whether technical, technological, financial, managerial, policy or behavioural, it would be unrealistic to generalize from one fishery to another or even within the same fishery. The situation is further complicated in SSFs because many fisheries, particularly tropical ones, are multispecies and catches lack uniformity in terms of composition, weight and shape. In addition, spoilage rates vary under different conditions for different fish, and value chains can have fragmented distribution systems involving many stakeholders. Moreover, landing sites and markets often use non-standardized units of measurement for trading and pricing purposes. These challenges have been identified and addressed through the collaborative work of FAO, the Department for International Development of the United Kingdom of Great Britain and Northern Ireland, and a project funded by the European Union (Member Organization) in West Africa in the mid-1990s, capitalized by the regional post-harvest loss assessment (RPHLA) in an SSF programme implemented by FAO. The subsequent initiatives in addressing post-harvest losses have generated substantial information that is available for reference in framing national and regional strategies.

Addressing quality losses

Small-scale fishers do not usually throw fish away. Their physical losses are caused by animal and bird depredation, insect infestation, fish being washed back into the water or spilling on the ground, and some issues related to food safety. From most assessments conducted in the past decade, deliberate discarding of fish is found to be a highly undesirable act by fishers, under the prevailing scarcity of aquatic resources. Studies indicate that physical losses in SSFs are low, probably ranging from less than 5 percent up to 10 percent, whereas quality losses are much higher. In climate-dependent post-harvest operations, such as the widespread open-air drying of fish in the tropics, and the subsequent stages (storage and packaging), the losses can be significantly magnified. Drying becomes difficult or even impossible during the rainy season or cloudy periods. Climate variability is adding more uncertainty to the efficiency of the drying process. Tackling this issue would significantly curb losses. A recent development is a dual processing technique (improved smoking and mechanical drying) known as the FAO–Thiaroye Technique. The name comes from the town in Senegal where it was first developed, but conceptually it was inspired by a prototype dryer piloted within a project in Indonesia (a project funded by the American Red Cross and implemented by FAO). Support is required for the extension of this technique and further initiatives geared towards the use of renewable energy in fish processing.

All factors combined, cumulative physical losses in SSFs are significantly less than the quality losses, which may account for more than 70 percent of total losses. At the Kirumba-Mwaloni wholesale fish market in the United Republic of Tanzania, quality losses made up the bulk of the more than US$40–60 million in lake sardine losses annually. Quality changes in fresh or processed fish, whether on board the fishing vessel, at the first sale point, at the processing site or during the storage stage, lead to substantial loss in terms of volume, value and frequency of occurrence. Common deficiencies include: (i) infrastructure (electricity, adequately equipped landing site, road and transport logistics); (ii) weak technical expertise; (iii) financial constraints to acquire the required production inputs (e.g. ice, cold room, insulated container, improved kilns and racks, storage facilities, packaging and retailing equipment); and (iv) access to market information and the ability to bring the product to the right market at the right time. There may sometimes be a single cause, but usually the causes are interwoven, and a thorough analysis is required to design a tailored solution. The introduction of improved handling, processing and value-addition methods could address the technical aspects. Regarding the required inputs, rural communities have the basic human, social, natural, physical and financial assets that can be combined with support from research and development institutions to trigger interventions through appropriate policy formulation and practical solutions.

The role that the fishing method plays in affecting fish quality and influencing the loss level is well documented. A recurrent issue that deserves consideration in the analysis of quality loss is the use of harmful fishing techniques (dynamite, chemicals, etc.) by small-scale fishers (see Box 6). These practices affect not only the quality of fish being landed and the subsequent end products, but also have potentially detrimental

Box 6

Women fish processors in Ghana and Liberia report effects of harmful fishing practices

In Ghana, some fishers combine light fishing with the use of explosives. They use explosives such as carbide in an attempt to catch all the fish aggregating around their lights. At landing, the fish look normal, but upon smoking they turn dark and brittle and are of poor quality. Efua Awotwe, a 52-year-old woman in Axim, had a whole consignment of fish (8 baskets, about 480 kg) affected in this way. From the sale, she received less than half of what she had been expecting. She also said that some fishers would always use carbide while there was competition among them. As a result of the use of carbide, some women have developed whitlows on their fingers.

Another group of women fish processors in Liberia reported their story about purchasing illegally caught fish (with chemicals) and the poor-quality end product, which sometimes broke into small pieces during the smoking process. They were keen to voice their concerns during focus group meetings, and they reported them openly at a plenary meeting of a national consultative workshop (TCP/LIR/3403 – Support to reduced post-harvest losses and improved income of fishers through a product-centered community support fishery model in Buchanan, Grand Bassa County). They were interested in receiving training to identify illegally caught fish, and they called for effective enforcement, including security for people reporting known perpetrators.

effects on the ecosystem and human health. They represent a serious breach of the principles and standards set out in the Code and undermine the triple areas of responsibility of the primary producer set out in its Article 11.1 (Responsible fish utilization):

- To the consumer of the food – to ensure that it is safe to eat, is of expected quality and nutritional value.
- To the resource – to ensure that it is not wasted.
- To the environment – to ensure that negative impacts are minimized.

The malpractices usually perpetrated by the primary producers, i.e. the fishers, do not always translate into fish or monetary losses for them, but rather for the fish processors unless appropriate enforcement mechanisms deter such practices or preclude such fish from being landed for sale.

Where harmful fishing practices are established and have been reported, they can result in the downgrading of a whole consignment of fish and substantial losses to fish traders and processors, as highlighted in, but not restricted to, the cases cited in Box 6. Such cases also raise the critical issue of law enforcement or governance in deterring illegal fishing. The triple responsibility of fishers referred to above is engaged, as is the government’s responsibility, in ensuring the right of consumers to safe, wholesome and unadulterated fish and fishery products and that post-harvest operations are carried out in a manner that maintains the nutritional value, quality and safety of the products, reduces waste and minimizes negative impacts (as stated in Articles 6.7 and 11.1.1 of the Code).

Mainstreaming socio-economic and policy dimensions in post-harvest loss reduction

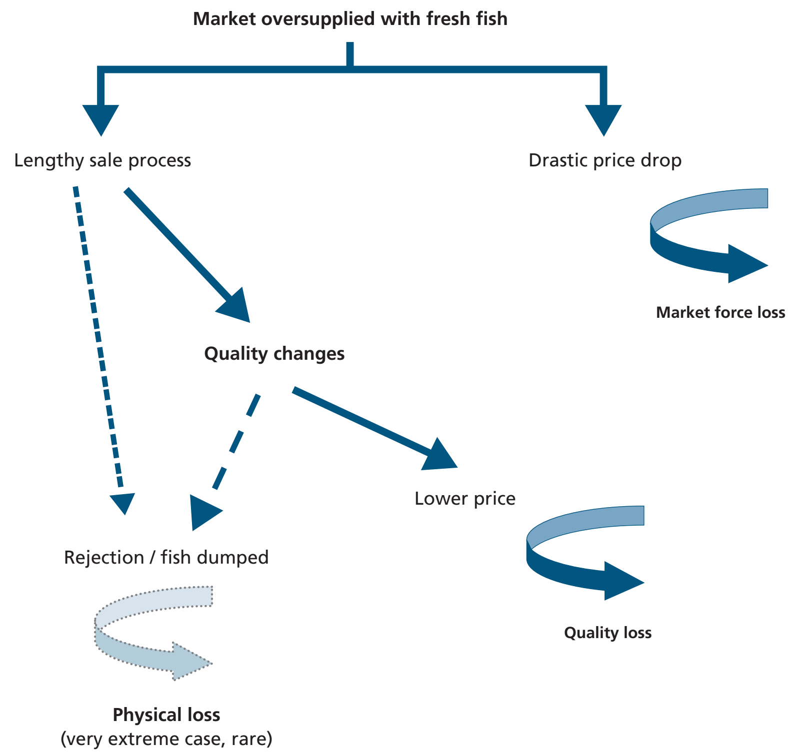
Ineffective deterrence of illegal fishing techniques demonstrates how weak policy instruments or poor law enforcement capacity can undermine the performance of post-harvest systems. With the predominance of women and youth involved in the post-harvest domain, it is worth noting that they are the ones most affected by the quality or physical losses (as a result of irresponsible fishing practices) incurred within a non-conducive policy framework. Sensitive issues relating to the use of harmful methods may be difficult to discuss in open fora such as community-level semi-structured interviews or meetings. Disadvantaged stakeholders and women negatively affected often lack trust in the mechanism that should protect them if they report perpetrators. Thus, they are usually more vocal and comfortable discussing these issues in small groups. Consequently, the extent of the information currently available about these practices and the magnitude of the resultant loss incurred by fish processors may be only the tip of the iceberg. A thorough investigation is needed and due attention must be given, with gender equity being put into a proper perspective.

Supply exceeding demand has recurrently been linked to glut seasons or an oversupplied market with a bumper harvest at times of stable or lower demand, leading first to a price cut in good-quality fish and then to quality and physical losses. Figure 34 (illustrating the result of case studies conducted within the RPHLA programme) shows the intricate dimensions of this type of loss.

A similar situation occurs in cases where tradition means that other food items, e.g. meat, are preferred to fish at specific times of the year or where the bulk of the supply from a fisher is not purchased despite the obvious potential need/demand. This illustrates the limitation of the assumption that technical interventions to reduce losses (e.g. chilling fish to ensure quality preservation) will automatically reward the fisher in terms of greater income. In fact, this requires appropriate measures to

Figure 34

Occurrence of different types of losses in fresh fish



secure the incentives and sustain the changes in post-harvest practices. In the context of SSFs, limited purchasing power characterizes many fishing communities, and the smallest operators and poor consumers form the majority of buyers. They purchase and then process fish to sell. Experience shows that even if the benefits of preserving quality exceed the extra costs, other reasons such as sociocultural patterns or consumer ignorance may impede improvements. Hence, addressing losses requires more than technical or technological solutions. If the improvement (here, basically, icing fish) led to fish products being beyond their economic reach, the first reflex action of poorer customers would be to stop buying the product until the fisher or the seller, now desperate for customers, were forced to cut the price in order to dispose of a deteriorating batch. A realistic solution to prevent or curb loss in this case would be to facilitate access by this fish operator to a more rewarding market. Conversely, this measure may deny fish to the poorest stratum within the population, resulting in threats to employment, sources of livelihoods or food security.

A study in the Volta Basin countries (to be published by the NEPAD-FAO Fisheries Programme [NFFP]) highlights the issue of misguided or mismanaged imports of fish products as a contributing factor to SSF losses. Imported frozen fish from local cold stores help to fill domestic supply gaps and sustain the continuity of small-scale activities during lean fishing seasons. They also constitute the raw material for small-scale fishmongers and processors in many countries. However, ill-controlled imports can hamper SSF development because of their perceived linkage with post-harvest losses. Indeed, although the operators surveyed for the study did not report not experiencing any physical loss, badly timed fish imports can weaken the position of domestic small-scale fishers where they coincide with periods of glut or bumper seasons. As fish importers pay volume-based import taxes, it is likely that the interests of domestic small-scale fishers will become less prominent in such situations. This is exacerbated by the fact that, in some cases, importers and cold-store owners agree on prices that reduce the competitiveness of domestic products. In these cases, the bulk of fish sold at critically low prices and the "unsold" and deteriorated fish meant for smoking, drying or fermenting constitute significant losses, sometimes at levels of 40 percent for a poor fishmonger.

The above issues emphasize the socio-economic impact and the current policy patterns in relation to post-harvest losses as well as the need for policy measures within and beyond fisheries to ensure that the objective of reduced food losses is met. Proper policy support and governance are necessary in regard to illegal fishing, import planning and management, and purchasing power. In the latter case, a change in policy to enable access by poorer customers to fish while ensuring that high-value products reach more rewarding markets would make sense. For example, if improving quality leads to an increase in price and leads to fish becoming less affordable to low-income consumers, then policy support to promote the purchase of fish by these consumers should be seen as a remedy. This may involve encouraging greater access to alternative and cheaper sources of protein, including cheaper species or fish products. For all products, reducing wastage should help counter higher prices for the consumer.

Small-scale fishers at the heart of loss reduction interventions

It is important to present credible data to SSF stakeholders to encourage their ownership of the initiatives on controlling losses. Locally collected data and figures on financial losses are powerful awareness-raising tools. While fishers and fish processors and traders are more interested in the financial impact of losses (money/income value as a result of an identified cause), some consumers focus more on the price of fish, while others are interested in fish quality and safety issues. Development practitioners and government officers are concerned with both aspects, as well as food security and resource sustainability. It is not surprising that small-scale fishers seem very concerned about revenue loss, which is illustrated by their ranking market force loss (which is not necessarily a loss of fish as a food) second after quality loss and ahead of physical loss (see aforementioned NFFP publication). This underlines the importance of being inclusive when considering post-harvest losses and not focusing only on loss of fish. Besides the "how much" fishers lose and involving them right from the identification of the solution, it is important for fishers to adopt and sustain fish loss reduction plans. A recent FAO Save Food Initiative study[22] provided an insight into a country case, where the government, using donor funding, intervened against food loss with very expensive facilities. Despite the high costs of establishing such "ultra modern" facilities that comply with the fish-handling standards of the European Union (Member Organization), they are not being used by fishers and are in a state of disrepair, a major reason being that the primary beneficiaries were not part of the "solution identification".

RECENT ACTIONS

The rationale behind centring interventions on a proper understanding of the context and dynamics of post-harvest losses in order to prevent piecemeal interventions without sustainable impact has now been sufficiently substantiated. As a consequence, several programmes in support of SSFs have adopted a more holistic approach. Almost to the end of the RPHLA programme, the collected field information acted as a powerful awareness-raising tool for the stakeholders, and helped to convince development institutions to support loss reduction programmes. An example was the use of the loss assessment results to help secure funds to promote the production of value-added products from low-value fish species, including lake sardine, which became a priority because of the research in the United Republic of Tanzania. The two subsequent regional programmes in the Africa region, namely the SmartFish programme and the NFFP, have made loss reduction a priority component among their activities for informed investment and decision-making processes.

The approach being used follows the logical setting of loss reduction objectives – developing understanding, designing interventions (including feasibility and criteria for monitoring their effectiveness) and identifying good practices to be introduced and scaled up. The socio-economic and governance focus in the exploratory phase of loss assessment is given attention, which features raising issues such as gender and climate variability effects on post-harvest efficiency and the policy measures conducive to loss reduction. SmartFish is piloting an innovation that consists of digitizing one of the three loss assessment methodologies validated within the RPHLA in order to facilitate the profiling of losses in specific geographic areas. A particular need in this digital profiling is the development of tools for food-insecurity risk and resilience planning. One vehicle to support such endeavours is the FAO Global Initiative on Food Losses and Waste Reduction, which has undertaken a programme on case studies in selected countries around the world. The exercise was initiated in Africa and will expand to Asia, with India as a first target. With the strong involvement of public, private and civil society organizations, commensurate measures will be taken to develop awareness, collaboration and knowledge and to advocate for effective solutions to reduce post-harvest losses.

OUTLOOK

With changing demographics and consumption patterns, the need to make healthy food available is increasing. Fish features in this context because of its nutritional value, and the international development community is increasingly acknowledging that post-harvest loss reduction is an important means of reducing food insecurity. Therefore, addressing losses will be at the centre of the development agenda in coming years. This is especially important for SSFs, given their role and the poverty eradication target set by FAO. Building on current programme achievements, extending good practices to more small-scale fishing communities would help to reduce fish losses, while at the same time efforts continue to build partnerships, raise awareness, and develop capacity and relevant policies and strategies.

Management of inland waters for fish: a cross-sectoral and multidisciplinary approach

THE ISSUE

As the world strives to accommodate 9 billion people by 2050, there are real concerns that biological diversity, ecosystem services and many fishery resources will be lost. The increased human population and demands for water, energy and food will require a cross-sectoral and multidisciplinary approach to the development and management of aquatic resources and ecosystems; this may require more targeted management of inland waters than in the past.

Value of water for fish, fisheries and aquaculture

Although inland fisheries production has increased (see Table 1 on p. 4), inland waters are also used for navigation, irrigation, waste disposal, municipal uses, hydroelectric power generation, etc. The monetary value of these can be several orders of magnitude greater that the value of fish produced. Besides fish, inland aquatic ecosystems provide other ecosystem services, such as regulation of hydrological cycles, flood control, supporting riparian communities, nutrient cycling, carbon sequestration, and cultural and recreational services. Although difficult to value, these have been estimated at US$4.9 trillion.[23] Policy-makers do not usually consider these services when deciding on industrial, agricultural and urban development activities or water development projects in a basin. The valuation of inland fisheries and inland aquatic ecosystems is greatly underestimated, and the nutritional and livelihood contributions fisheries make to rural populations, although extremely significant, are often not adequately considered. As a result, other uses of inland waters are often perceived to be of higher importance than fisheries in national development programmes.

Increasing demands on water and their impact

About 9 percent of the freshwater from rivers, lakes and groundwater is withdrawn for human uses. Agriculture accounts for about 70 percent of all freshwater withdrawals, followed by industry (20 percent) and domestic uses (10 percent),[24] reducing the availability and quality of water for inland fisheries and aquaculture. Water abstraction is expected to double by 2050; water withdrawal by irrigation may increase by 11 percent by 2050 and irrigated land may increase by 17 percent. Although consumption of fish and fish products is expected to increase, so will that of other food commodities. Production from agriculture will need to increase by 70 percent (by almost 100 percent in developing countries) to match a 40 percent increase in world population and to raise per capita average food consumption to 3 130 kcal/day by 2050. This means an extra billion tonnes of cereals and 200 million tonnes of meat annually by 2050 compared with 2005–07 production.[25]

Rivers are a main aspect of inland water ecosystems and about 65 percent of river discharge is under moderate to high threat.[26] This threat could affect more than 60 million people in developing areas who directly depend on river fisheries and about 470 million people downstream of dams in riverine communities.[27]

The threats to rivers are exemplified by the continued development of dams, primarily for hydroelectric generation. Although the World Commission on Dams and others[28] have identified the negative impacts of dams on rural communities, dam development is continuing. The loss to fisheries from the 11 mainstream and 70 tributary dams planned for the Mekong River is estimated at about US$1 000 million in 2015 and about US$2 000 million per year by 2030 with further development.[29] Fish resources in the lower Mekong Basin are estimated to be worth US$2.1–3.8 billion at first sale and US$4.2–7.6 billion on retail markets.[30] In addition, subsistence fisheries can be an important source of food to local communities. In the inner delta of the Niger River in Mali, two existing dams and one planned one have resulted in, or will lead to, an annual economic loss of about US$20 million from the fisheries.[31]

Allocation of waters to these competing uses is generally to the detriment of fisheries and aquaculture. Inland waters are being managed with little regard for their fishery resources or the full range of ecosystem services they provide.

POSSIBLE SOLUTIONS

The increased need for food and power, and mitigation of climate change, will necessitate human intervention in water management – typically meaning reservoirs, dams, irrigation schemes and accompanying aspects of fish production such as aquaculture, culture-based fisheries and capture fishery management. Given a current fisheries and aquaculture production for human consumption of about 136.2 million tonnes (animals from capture fisheries and aquaculture), with annual per capita fish consumption remaining at 19.2/kg, a similar proportion of fish going into fishmeal, fish oil and other non-food uses as today, and a world population of 9.6 billion people, approximately 47.5 million additional tonnes of food fish will be needed in 2050. Marine fisheries have plateaued and aquaculture will play a role, but the scope for inland fisheries to also contribute to increased food production has been neglected or even compromised. Food and nutritional security will be more difficult to achieve in many rural areas if water development and management programmes neglect inland fisheries.

There is justifiable concern that managing water for economic opportunity, such as the production of electricity, will jeopardize both human water security (water needs for human survival and well-being) and aquatic biodiversity and fisheries. Pollution and water resource development are the major stressors of the world's rivers in this regard.[32]

To ensure human water security, developed countries have invested huge sums of money in policies, enforcement and infrastructure to mitigate the impacts of pollution and water development programmes. Developing countries lack the resources or adequate governance structure to do the same. Economic interests of powerful sectors of society usually prevail over rural unempowered fishing communities. Thus, solutions must be found that attribute fair shares of the resource "water" to all sectors, including fisheries and aquaculture. Rural fishing communities can no longer be deprived of livelihoods and aquatic biodiversity. The solutions will involve changes in: water and ecosystem management; development infrastructure and technology; governance; and fishery management.

Interventions needed

There is a need for rehabilitation and management interventions towards balanced objectives that allow for aquatic ecosystems to produce fish, maintain biodiversity and provide, *inter alia*, electricity, water for irrigation and human consumption, and flood control in the face of climate change.

Reservoirs and dams are obvious examples of managed waterbodies. However, rice paddy and irrigation systems can affect fisheries, both negatively and positively. There are about 60 000 reservoirs worldwide with a total volume exceeding 10 million m^3 and covering 400 000 km^2.[33] Awareness of the significant environmental and social impacts of dams has led to some being removed or altered, and dam construction has slowed in developed countries. However, numerous large dams are being planned in developing countries and on river systems with major inland fishery resources, such as the Mekong River.[34] Management options to assist reservoir fisheries must consider the environment of the reservoir, the environment of the upstream and downstream river system and fish migration needs. Managing reservoir stratification, sediment levels, fish passages, aquatic vegetation, discharge rates and "lake" levels can promote fish production in the reservoir and associated rivers.[35]

Dams disrupt migration routes of important species of fish. Structures and modifications that allow fish to pass around or through dams and other impediments to migration include pool-type fish passes (such as vertical-slot passes), nature-like bypasses going around impediments, fish lifts or locks, and physical transport of fish around barriers.

However, the use of fish passage devices has met with uneven success and is controversial owing to: inappropriate design, dimensions and attraction flow for the species that need to pass; inappropriate design for the height of the dam; neglect and disrepair of fish passes; and incorrect or no management and operation of passes.

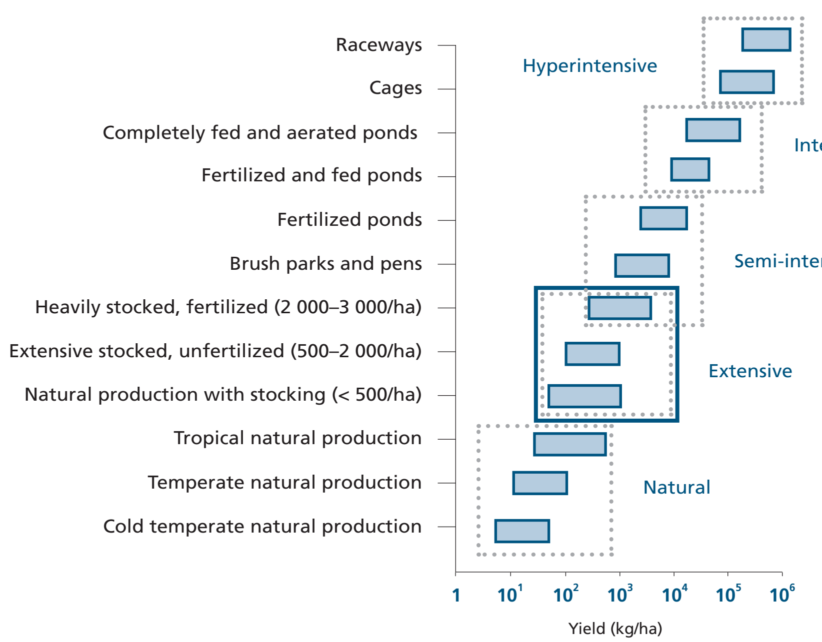
Fish passes are easier to design and construct when incorporated into a water development project from the outset; and low-head dams are easier to equip than high dams. Where dams have been retrofitted with fish passes, such passes have often failed to restore or maintain sustainable diadromous fish migrations. This is because they do not restore ecological continuity. Although they may assist migration over dams, they can only help to ensure generation of eggs and larvae if suitable spawning and rearing habitats are present in the reservoir or upstream habitats.

Water release from dams is critical for generating electricity and maintaining fisheries downstream. Fish require sufficient good-quality water, and at specific seasons in order to migrate, feed and spawn. By timing releases over spillways and through turbines appropriately, water can be used for both electric generation and fisheries. At the Pak Mun dam in Thailand, seasonal opening of the dam gates allowed species to access formerly closed areas of the river. However, the overall efficacy of the Pak Mun fish passage system has been questioned.[36]

Some fishery interventions are compatible with several current water management actions, e.g. the use of culture-based fisheries and aquaculture in reservoirs, and the management of rice paddy for aquatic animal diversity. Managed properly, rice fields in Asia can contain about 80 animal species and yield 120–300 kg/ha of animal products.[37] Fisheries can also fit with irrigation schemes by using appropriate species with high

Figure 35

Enhancements of inland waters: production from different capture and culture systems



Source: Welcomme, R.L. & Bartley, D.M. 1998. An evaluation of present techniques for the enhancement of fisheries. *In* T. Petr, ed. *Inland fishery enhancements.* FAO Fisheries Technical Paper No. 374. Rome, FAO. 463 pp. (also available at www.fao.org/docrep/005/w8514e/w8514e00.htm).

environmental tolerance and rapid growth. Cage culture, species introductions and culture-based fisheries are effective means to increase productivity from inland waters (see Figure 35) with adequate attention to carrying capacity and maintenance of environmental quality.

A holistic approach to water management that includes fishery resources and the people dependent on them is needed and can be effective. International initiatives and river basin authorities have been set up to take this broad approach and deal with water management, but many ignore the fishery sector even when it is in their mandate.[38]

The Columbia River Basin in the United States of America provides an example of a governance structure that tries to maintain fisheries and wildlife while providing for other uses of the river. It has 31 federal multipurpose dams that are part of the Federal Columbia River Power System. The operations of these dams and the mitigation actions taken are guided in part by the Northwest Power and Conservation Council. The 1980 Pacific Northwest Electric Power Planning and Conservation Act[39] directs the council to prepare, using the best available science, a fish and wildlife programme that mitigates for the impact of the hydrosystem and that protects and enhances fish and wildlife of the river basin and related spawning grounds and habitat affected by the hydropower system.

RECENT ACTIONS

There are both encouraging and disturbing signs in relation to managing water for multiple purposes. Recent reviews have highlighted the gains in inland fisheries through rehabilitation of inland ecosystems and wetlands.[40] Numerous techniques are available, ranging from dam removal to placing large woody debris in streams, that will assist in rehabilitating fishery resources and the aquatic habitats that support them. However, several of these techniques would limit other uses of freshwater, e.g. dam removal would limit hydroelectric generation or irrigation.

One study[41] developed a prioritization matrix that assessed the efficacy of mitigation measures on barriers to fish migrations, i.e. characteristics of streams and barriers where fish passes would promote longitudinal connectivity, and where outfalls for adding "fish friendly" flap-gates would re-establish lateral connectivity. The prioritization process acknowledged that not all barriers would be appropriate for mitigation and helped to identify those areas most likely to produce positive results.

Dam removal can be a management option when dams have outlived their usefulness or when other water management options are more attractive. By taking a whole river approach to mitigation and upgrading structures, water managers were able to propose decommissioning outdated and harmful dams on the Penobscot River in Maine (the United States of America). They also identified dams that could be equipped with state-of-the-art fish passage facilities or bypasses and advanced turbine systems to allow improved migration and more efficient electricity generation.[42] The US Fish and Wildlife Service's National Fish Passage Program facilitated the removal of 442 artificial barriers, opening 5 600 km of river.[43] The removal of four dams on the Klamath River (the United States of America) is predicted to generate an additional US$9 million in gross revenue (US$7.6 million coming from fisheries) with benefits for local people in terms of health, water quality, aesthetics, traditional lifestyle, cultural and religious practices, living standards, improved hydrology, and deterrence of toxic blue-green algae. In addition, removing the dams will probably cause a more than 40 percent increase in employment, labour income, and output.[44]

On the Elwha River dam (the United States of America), removal and ecosystem restoration was predicted to yield more than US$340 million in benefits, including a US$36.7 million increase in commercial fisheries.[45] Dam removal can be less expensive than dam repair or retrofitting with fish passage facilities.[46]

Dam-free stretches of rivers in Viet Nam have been identified through strategic assessments of where to site large dams or where to use run-of-river dams, bypasses or small hydroelectric generating stations. This work has reduced conflicts between water developers and local communities.[47]

Dam management should include the entire river system. By taking advantage of various ecosystem services, dams can operate more effectively and with multiple objectives. Incorporating downstream floodplains into water management to handle infrequent flood events allows more water storage in reservoirs while providing fish habitat in the floodplains.[48]

OUTLOOK

Producing food to feed the world can seriously undermine biodiversity and the ability of ecosystems to maintain their full range of services. To continue producing food for an increasing population, ecosystems will need to be managed for multiple uses. The authors of *Blue Harvest* stated: "As rivers have been dammed and lakes and waterways polluted, inland fisheries have declined, yet growing demand for the world's freshwater resources will increase these pressures further in coming years. There is therefore an urgent need for major investment in policy and management approaches that address the direct and indirect drivers of aquatic ecosystem degradation and loss of inland fisheries taking into account their role in sustainable development and human well being."[49] Several studies have shown that biodiversity and agriculture, including fisheries and aquaculture, are mutually dependent.[50]

The assessment, upgrading and removal of dams in some areas is encouraging. However, it is necessary to solve the problems of poor and inaccurate environmental impact assessments of water development projects or projects that affect fisheries, the inappropriate design and dimensioning of fish passes and the lack of valuation of inland fishery resources and other ecosystem services from inland ecosystems. One study[51] provides reasons for a pessimistic outlook for integrating fisheries and ecosystem considerations into hydroelectric dam development on the Mekong River:

- Investment in dam construction is a stronger driver than environmental sustainability.
- Technical capacity to engineer appropriate infrastructure is lacking.
- Scientific capacity to develop new technologies is limited.
- Awareness of environmental impacts of dams is lacking.
- Environmental governance is lacking.
- Multistakeholder debate and discourse in national fora are lacking.

Many of these constraints apply to areas beyond the Mekong Basin.

There is debate on whether investments in water development projects that ignore fisheries will have overall benefits on fishing communities because of increased economic returns from development of hydropower, irrigation, flood control, etc.[52] Convincing economic arguments for managing water for fish are needed. On the Mekong River, hydroelectric revenues from dam construction were estimated at US$235 million. With increased development, there could be a loss of US$476 million in fish production; the loss would fall on the rural communities, which may not benefit much from the hydroelectric revenues. Replacing the lost fish production would also require a larger environmental and carbon footprint.[53] Moreover, there are major concerns about biodiversity and ecosystem conservation, whose benefits are harder to value in economic terms.

Water management projects need economic models and analyses that accurately describe the cost and benefits of taking into account all uses, including the impact on fishery resources and livelihoods. Such analyses can demonstrate the importance of fish in the overall system to be relatively high. In its oversight of several dams on the Columbia River (mentioned above), the Federal Energy Regulatory Commission estimated that, on average, implementation of actions that benefit fish reduced hydroelectric generation by about 10 percent. The total financial obligation for the fish and wildlife programme was estimated at US$750–900 million per year, which included ordinary and capital expenditures, power purchases, and revenues forgone

associated with operations to benefit fish and wildlife. These estimates should be seen in the context of a power generating system whose operating revenue exceeds US$3 300 million.[54]

Assessments of the trade-offs between managing water for fish and other uses must consider more than monetary aspects. More than two billion people are thought to be undernourished because of diets deficient in nutrients often best provided by fish, e.g. proteins, trace elements, minerals and lipids.[55]

The report of the Thematic Consultation on Environmental Sustainability[56] states: "The key theme that binds human development and environmental sustainability is the ideal of integrated development solutions. This is embodied in the following four principles ... :

1. **Integrated development** that simultaneously advances multiple benefits across the three dimensions of sustainable development (social, environmental, and economic) ensures that poverty eradication and environmental sustainability go hand-in-hand;
2. **Equality** in relation to access to natural resources and the benefits of a healthy environment as well as engagement in related decision-making processes is fundamental for both environmental sustainability and human development;
3. A **human rights**-based approach to environmental sustainability recognizes that the realization of human rights depends on a healthy environment; and
4. The **resilience** of communities to resist tomorrow's shocks without reversing today's achievements in human well-being depends on the vital role of natural resources and ecosystems."

The multisectoral and multidisciplinary approach advocated here is in line with FAO's new Strategic Objectives of food security, sustainable production, poverty alleviation, stable and accessible markets and disaster risk management. However, the fishery and aquaculture sector is still a relatively weak player. It needs to raise its profile and influence in order to serve well the hundreds of millions of people dependent on functioning freshwater ecosystems.[57]

Continuing challenges for the conservation and management of sharks

THE ISSUE

Many vulnerable and fished shark[58] species (cartilaginous fishes, chondrichthyes) are declining. The growing awareness of the precarious situation of these populations led to the adoption of the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA–Sharks) in 1999, and, for the last two decades, FAO has undertaken a number of activities to improve the understanding of shark biology, utilization and management. However, although most main shark fishing countries and entities have introduced conservation measures and also joined the international fight against illegal, unreported and unregulated (IUU) fishing,[59] FAO Members have criticized the overall slowness in implementing the IPOA–Sharks. A recovery in threatened shark stocks has not yet been observed, and the International Union for Conservation of Nature (IUCN) has classified a total of 66 cartilaginous fishes as endangered or critically endangered.

Global shark catches reported to FAO tripled from 1950 to an all-time high of 893 000 tonnes in 2000 (Figure 36). However, since then, a downward trend can be observed, with catches about 15 percent lower (766 000 tonnes) in 2011, mainly attributable to the central regions.

While a simple explanation for the recent trends is not possible, there are a few general factors that – to varying degrees and in different combinations depending on the type of fishery and geographic region – may have contributed to this development.

First, shark conservation measures have been introduced in many national and regional fisheries management regimes (see below). If effectively implemented, these should reduce shark fishing mortality and avoid unwanted shark bycatch, with the result of decreasing catches. Second, in many cases, the reduction in shark catches is unintentional and a consequence of the overall declining abundance of fished sharks; this leads to reduced yields even where the fishing effort remains the same or even increases.

Reporting shark and ray catches to FAO

In comparison with bony fish, the reporting of shark catches is poor (Figure 37). Only 36 percent of cartilaginous fish catches were identified at species or genus level, compared with more than 75 percent for bony fishes. About 34 percent of cartilaginous fishes were reported as "Sharks, rays, skates, etc. nei" and not further identified, whereas only 16 percent of bony fishes were reported at the most aggregated level. Poor reporting at species level is particularly true for skates and rays – a cartilaginous group for which more than 75 percent of the catches were reported at highly aggregated levels (order and family).

The FAO catch statistics depend entirely on the collaboration of FAO Members to faithfully collect and report their capture statistics. The recent reduction in shark and ray catches in the FAO database might indicate poorer reporting to FAO. However, it is not possible to corroborate such a deterioration; on the contrary, the taxonomic detail of shark and ray catches reported to FAO, although still highly deficient, has improved in the last decade (Figure 38), which is evidence of increased attention to data collection.

More than 60 percent of shark catches are reported from central (tropical) regions, in particular from the Indian Ocean (26 percent), followed by the Western Central Pacific (14 percent) and the Eastern Central Atlantic (10 percent). The southern oceans follow with 21 percent of the reported catches, of which more than half are from the Southwest Atlantic alone. Reported shark catches from the northern oceans make up 18 percent of the total, mostly from the North Atlantic. As a result of the disparate geographic distribution of shark captures – with a predominance of the central and southern regions (Figure 36) – developing countries report the vast majority of shark catches (more than 70 percent) (Figure 39).

However, it is developing countries in particular that have difficulties with shark species identification (Figure 39). These countries identify only 17 percent of shark catches to the species or genus level but 45 percent at the highest aggregated level. In contrast, developed countries report 72 percent of their catches at the species or genus level, and just 7 percent at class levels. The differences in reporting quality reflect the general disparity in resources available for fisheries data collection and management for different regions of the world. Many developing countries complain that adequate reporting of their shark resources and fisheries is still hampered by a lack of taxonomists or of trained scientists and officers for the monitoring and assessment of sharks. They also cite poor accessibility to, or a lack of, basic shark identification tools.

Shark management and IUU fishing

Although there has been progress in recent years in the implementation of national and regional shark conservation measures, shark conservation and management is still deficient in many shark fishing countries and regions.[60] The most common shark regulation that has been widely adopted at both the national and regional levels is a ban on discarding shark carcasses after cutting and storing the fins on board vessels, i.e. fishing vessels have to retain both fins and carcasses on board until landing. If properly enforced, this regulation reduces the maximum number of sharks caught during one fishing trip owing to storage limitations. Moreover, the regulation encourages the full utilization of sharks – an important requirement stipulated in the IPOA–Sharks. However, this important and beneficial regulation cannot ensure the sustainable fishing of sharks that are caught not only for their fins but also for their meat.

Figure 36

Global catches of cartilaginous fishes reported to FAO, cumulative

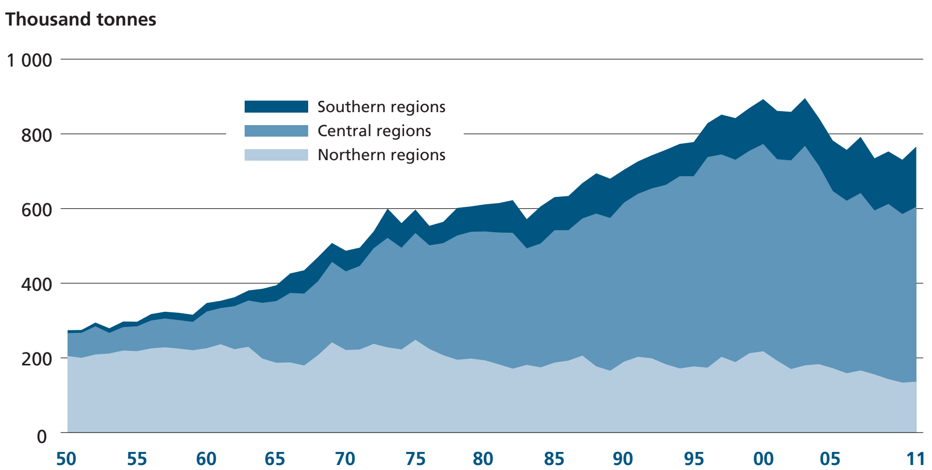
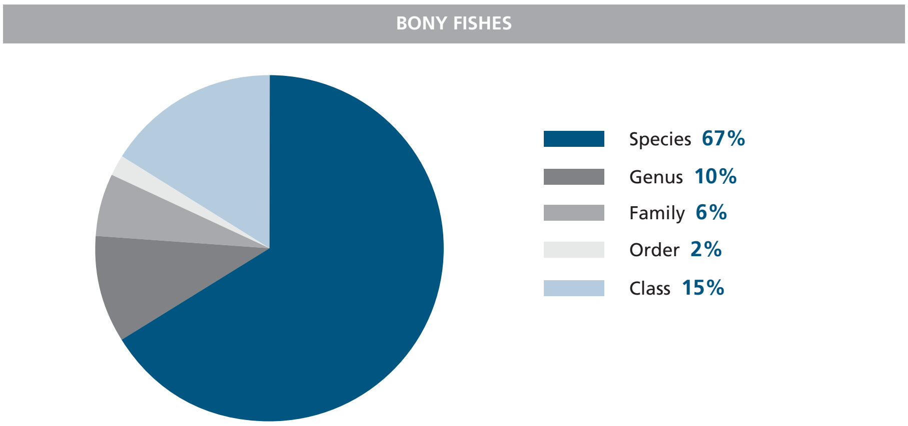


Figure 37

Level of taxonomic detail for reporting FAO catch statistics in 2011 for bony and cartilaginous fishes



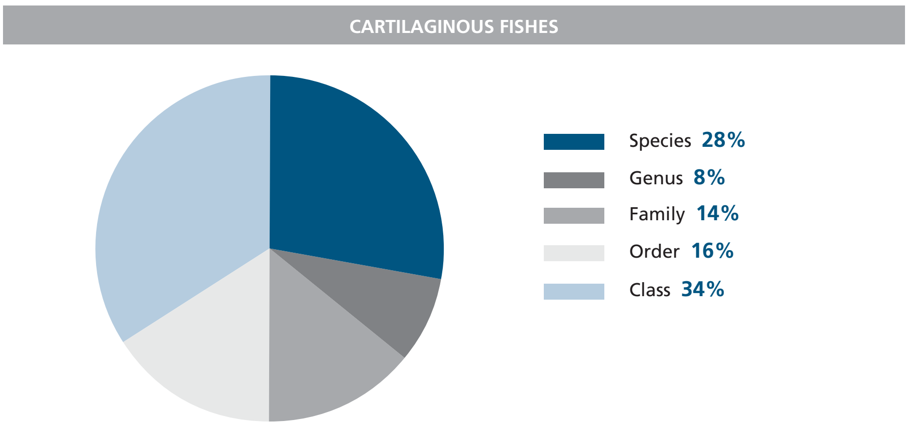


Figure 38

Trends in taxonomic identification of global shark catches, 1995–2011

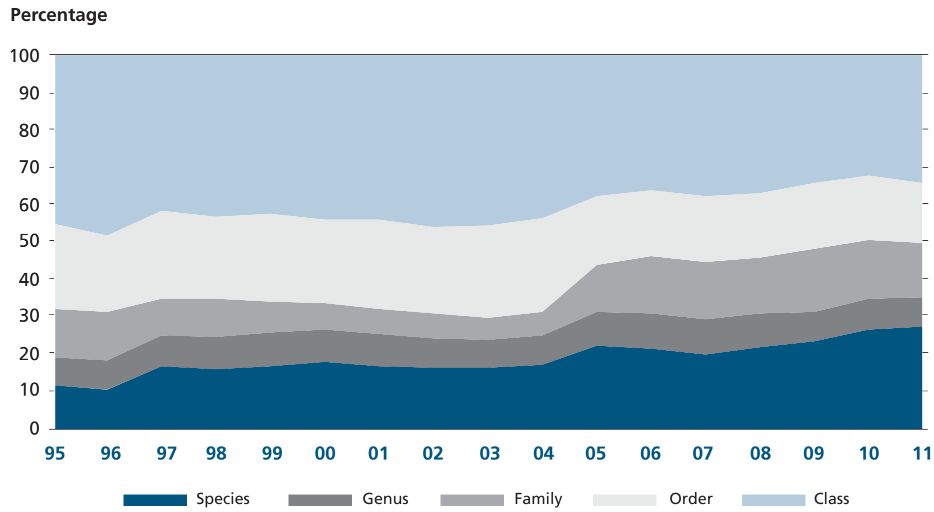
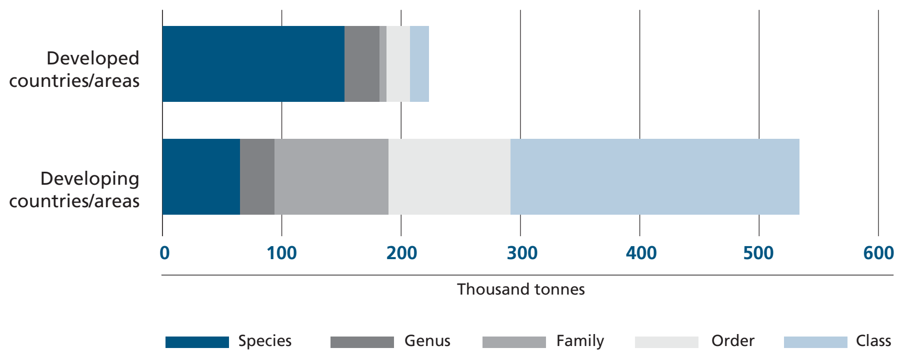


Figure 39

Shark catches and their taxonomic identification reported by developed and developing countries, 2011



Other than shark fin measures, effective national and regional regulations for vulnerable shark species are still incomplete and lacking in many parts of the world.

In the context of shark fishing, IUU fishing activities are often cited as major issues. The magnitude of global IUU shark fishing is not known but it is clear that – in view of deficient specific regulations for fished sharks – unregulated and unreported catches are common even if not illegal. More than two-thirds of the main shark fishing countries, areas and territories have taken steps to combat IUU fishing (Box 7). However, the effective implementation of a monitoring, control and surveillance (MCS) scheme remains problematic in a number of countries, often because of a lack of human and financial resources.

Reporting on international trade

The lack of reliable data reporting on international shark trade, in particular for shark fins, has long been a considerable problem. As the value of world trade in reported shark commodities approaches US$1 billion per year, the need to adequately address this situation grows accordingly. The issues in question range from inconsistencies in

Box 7

The IPOA–Sharks and its implementation

The FAO Committee on Fisheries (COFI) adopted the International Plan of Action for the Conservation and Management of Sharks (IPOA–Sharks) in 1999. It stipulates that shark fishing States should implement national programmes for the conservation and management of shark stocks. These should include:

- regular assessments of the status of fished shark stocks;
- sound data collection on shark fishing efforts and yields (to be shared with regional fisheries management organizations [RFMOs] and FAO);
- implementation of effective shark management measures and monitoring, control and surveillance (MCS) schemes.

The objective of such plans consists in:

- implementing sustainable shark fisheries;
- protecting critical shark habitats;
- minimizing unutilized incidental shark catches as well as waste and discards;
- encouraging full use of dead sharks;
- improving species-specific catch and landings as well as biological and trade data.

The IPOA–Sharks also calls for collaboration within the region and with FAO. It also tasks FAO with supporting States in implementing the IPOA–Sharks and reporting through COFI on the state of progress thereon.

FAO concluded a comprehensive review of the implementation of the IPOA–Sharks in 2012. It focused on the 26 main shark fishing countries, areas and territories as well as 10 RFMOs determined as those reporting at least 1 percent of global shark catches in the decade 2000–09: Indonesia, India, Spain, Taiwan Province of China, Argentina, Mexico, United States of America, Pakistan, Malaysia, Japan, France, Thailand, Brazil, Sri Lanka, New Zealand, Portugal, Nigeria, Iran (Islamic Republic of), United Kingdom, Republic of Korea, Canada, Peru, Australia, Yemen, Senegal and Venezuela (Bolivarian Republic of).

These 26 countries, areas and territories were responsible for 84 percent of the global shark catches reported to FAO in the period, and the first 7 alone accounted for more than half of the global reported shark catches.

The review showed that 18 of these 26 countries, areas and territories already have a national plan of action (NPOA) on sharks in place, and that 5 more are developing one. Thus, only three (12 percent) have yet to seriously address the conservation and management of their shark populations.

The review also concluded that 70 percent of the main shark-fishing countries, areas and territories have taken steps to combat illegal, unreported and unregulated (IUU) fishing, either by signing the FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (46 percent) or at least by adopting an NPOA IUU or similar plan (23 percent). Nonetheless, in some countries, the effective implementation of MCS schemes is problematic, often because of a lack of human and financial resources.

The main problems hindering successful implementation of the IPOA–Sharks are linked to problems with fisheries management in general, such as institutional weaknesses, lack of trained personnel, and deficits in fisheries research and MCS.

commodity coding in the case of countries that do report shark fin trade at least to some extent, to widespread under-reporting and non-reporting of trade in fins. This latter problem is particularly acute in exporting producer countries, even developed countries that provide high-quality catch data. Even where data are provided by customs authorities, trade statistics for shark fins vary significantly in terms of the level of detail recorded. For example, China, Hong Kong SAR – the main shark fin trader (Figure 40) – records trade data at detailed levels, i.e. specifying whether fins are processed or frozen. However, the vast majority of other countries either do not record shark fins as such (or even at all), or record them under a number of different Harmonized System (HS) categories where the degree of processing and/or type of preservation is often unclear.

Furthermore, there are multiple cases of evident significant mismatches between reported shark fin exports from one country and the corresponding reported imports from other countries. It should be noted here that there is a clear trend towards using more detailed HS code categories for shark fin products and better recording of the shark fin trade in general. However, much more progress is still required to obtain an accurate picture of the trade situation from customs statistics. At present, the deficiencies and discrepancies described above obstruct attempts to conduct a meaningful analysis of global trade flows. In particular, estimating shark captures from trade volumes and monitoring trade flows for certain shark species require complete and detailed trade records. The problems are further compounded by the fact that meat and fins from one shark often pass separately through multiple countries (Figure 40) with untraceable and incompatible trade records.

POSSIBLE SOLUTIONS

Improving species identification and reporting

The number of cartilaginous species in catch statistics reported to FAO has increased from 11 to more than 100 since the beginning of the time series in 1950. However, the fact that developing countries are still reporting mainly at aggregated levels indicates a need for improved identification tools in many regions.

While the correct species identification is a prerequisite for the reporting of sharks, much additional effort is required to improve the capture statistics and enable an accurate estimate of global shark fishing. In particular, governments need to ensure that catches are adequately monitored and reported; this will only happen if sufficient numbers of trained personnel are made available and if modern reporting and monitoring schemes are implemented.

Urgent action is also needed to encourage a greater level of detail in trade reporting, with species-specific reporting as well as a description of the level of processing the fin has undergone. This should include a harmonization of shark commodity codes for global trade statistics, which will enable a comparison of figures between importers and exporters.

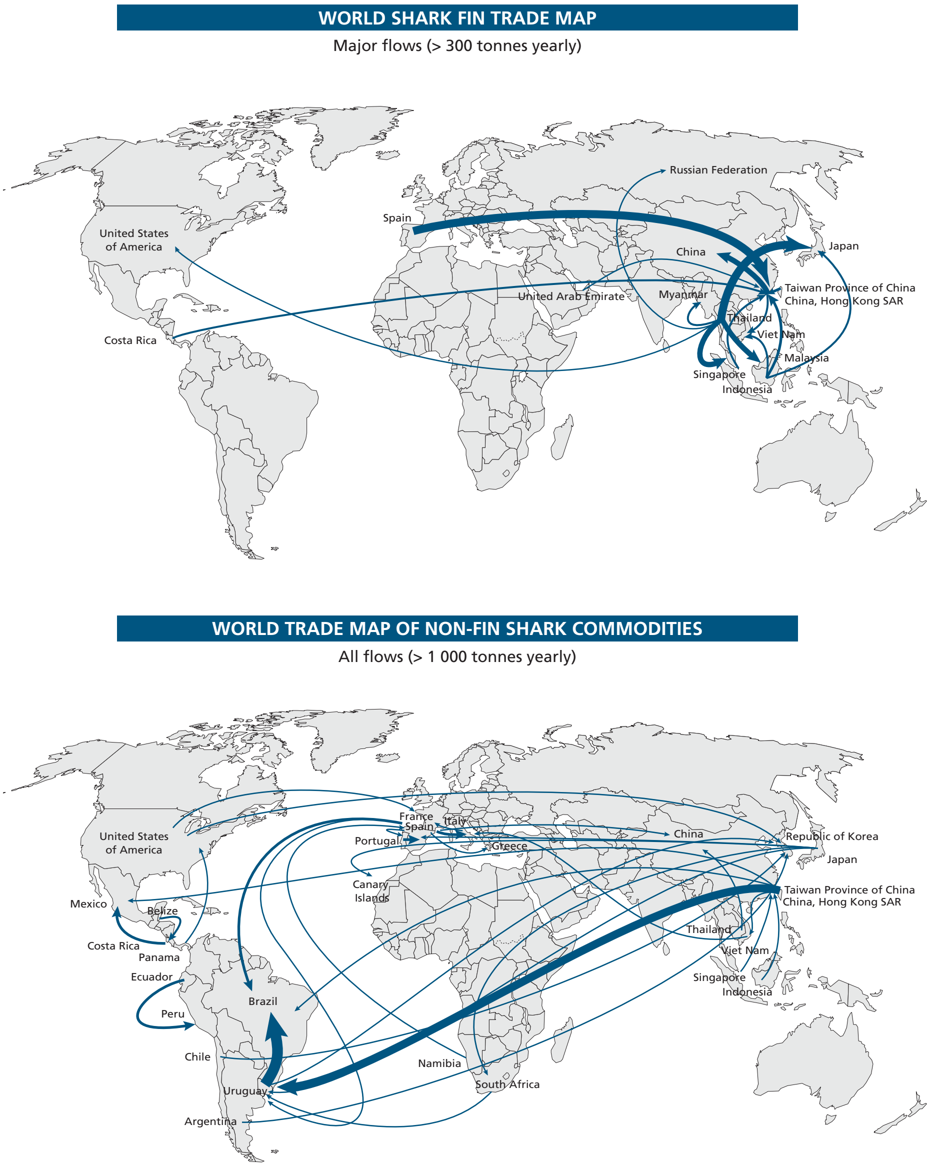
Implementing shark conservation measures

Shark fishing countries and regions need to devise and fully implement meaningful shark conservation measures. Although progress has been made in the past decade, much more effort is required in terms of scientific assessment and advice as well as species-specific catch and other fishery regulations in order to stop the downward trend in many vulnerable shark populations.

The IPOA–Sharks encourages the full use of dead sharks and minimization of shark wastes, i.e. the consumption of shark meats and various uses for other shark parts such as skin, teeth and cartilage. This is often addressed by shark fin measures as described above. However, these often still allow the cutting of the shark fins on board a vessel and thus stipulate a required fin-to-body weight ratio (with fins usually allowed to comprise about 5 percent of the total shark weight on board). An alternative shark fin measure – one that is easier to control – is a ban on shark finning on board a vessel, i.e. only complete shark bodies with fins attached can be landed. While shark fin measures are a good first step, shark conservation should not stop there and other regulations should be considered for vulnerable and endangered populations.

Figure 40

Estimates based on FAO statistics of global trade flows of shark fins and other shark products, 2008–2011



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.

Other possible shark regulations or initiatives include technical measures (e.g. area closures, bycatch/discard regulations, size limitations and gear requirements) as well as protection for certain species, total allowable catches and quotas, licences and permits, reporting and research requirements, MCS, capacity building and the promotion of public awareness about shark conservation issues.

Combating IUU fishing

Even the best fisheries management regime will fail if it is not fully implemented; therefore, an adequate MCS regime is vital to ensure that fishers follow the rules and to combat IUU fishing. Sharks have repeatedly been reported on IUU vessels; but even if they are not caught illegally, they are often neither regulated nor reported.

FAO has developed two important instruments to assist with the global fight against IUU fishing: the 2001 voluntary IPOA–IUU, and the 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA). These encourage countries to: implement measures that deny known IUU fishing vessels access to ports; take steps to strengthen real-time MCS; and raise public awareness about the long-term impacts of IUU fishing. The implementation of a comprehensive suite of port State measures is required to help combat IUU fishing and reduce its impacts. There is a need to harmonize these measures regionally and to ensure that cooperative regional action underpins their implementation.

The international community has also identified strengthening flag State performance as a priority to assist in combating IUU fishing. In many respects, enhanced flag State performance and stronger port State measures will address IUU fishing more directly with improved results.

Improving regional collaboration

Regional collaboration plays an important role in the management of sharks, in particular for migratory species and those with a wide distribution. The foundation for good regional collaboration is in place and all but one of the main shark fishing countries, areas and territories are members of at least one regional fisheries management organization (RFMO). In particular, shark measures adopted by tuna bodies are binding in their areas of competence for all their member States that have not objected to the measure in question.

Labelling and certification

Labelling and certification schemes that enable the following of fishery products from the point of capture to their purchase by end consumers are important parameters in a product strategy, especially in international trade. Such schemes can help to address issues related to under-reporting, lack of regulations and assessments, and illegal fisheries. In addition to adhering to regulatory requirements in the importing countries, voluntary labels and certification schemes permit producers and marketers of fish and fishery products to target specific segments of consumers, thereby gaining a competitive advantage. Ecolabelling schemes are in place for a number of longline fisheries where sharks are important bycatch species. The proper implementation of such schemes also for other shark fisheries could provide much-needed incentives for adequate shark conservation while encouraging sustainable shark fisheries. FAO has provided ample guidance on best practices for ecolabelling.[61]

Some RFMOs and regional fisheries management arrangements have moved to develop catch certification schemes as a means of discouraging IUU fishing. Such schemes are already in use by the Commission for the Conservation of Antarctic Marine Living Resources, the Commission for the Conservation of Southern Bluefin Tuna, and the International Commission for the Conservation of Atlantic Tunas. Their purpose is to track catches in trade. The RFMOs regard them as an important tool in the fight against IUU fishing. FAO is working with RFMOs to standardize these documentation schemes, to the extent that this is possible and advantageous.

RECENT ACTIONS

Conservation and management measures

There has been encouraging progress in the implementation of the IPOA–Sharks (see Box 7). Many countries and RFMOs have adopted shark fin measures and, especially in the context of national plans of action on sharks, other national and regional shark conservation measures are also being progressively applied. For example, many countries and regional bodies have adopted bans on fishing certain shark species. These often apply to species listed in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) or the Convention on Migratory Species (CMS), but a number of countries have developed additional comprehensive lists of vulnerable and protected shark species in their waters. An important result of these recent developments is that internationally binding shark measures are in place in all but one area covered by RFMOs.

CITES has listed ten elasmobranchs in Appendix II[62] and seven in Appendix I.[63] Species listed under Appendix I cannot normally be traded internationally (except by special permit for cultured specimens and for scientific purposes), while those under Appendix II require a certificate that the exported specimens were caught under sustainable conditions, a so-called "non-detriment finding". This provides important incentives for shark-exporting nations and RFMOs to develop sustainable management regimes for the listed sharks. FAO is collaborating with CITES by providing scientific and technical advice on species proposed for listing[64] and by supporting Members in the implementation of CITES provisions.

Migratory sharks have received attention from the CMS, which has listed seven migratory sharks under the Memorandum of Understanding (MOU) on the Conservation of Migratory Sharks.[65] This non-binding international instrument encourages signatories to implement shark conservation plans to: improve the understanding of migratory shark populations through research, monitoring and information exchange; ensure that directed and non-directed fisheries for sharks are sustainable; ensure to the extent practicable the protection of critical habitats and migratory corridors and critical life stages of sharks; increase public awareness of threats to sharks and their habitats; enhance public participation in conservation activities; and enhance national, regional and international cooperation.

With regard to scientific assessments and advice, in additional to national efforts, the IUCN Shark Specialist Group, composed of 171 experts from 55 countries distributed among 12 regional groups (roughly reflecting FAO statistical areas), elaborates scientific advice on shark biology, conservation, management, fisheries and taxonomy.

International trade

FAO is currently undertaking an analysis of international shark trade data. It is working for the improvement of the international trade statistics on sharks, skates and rays through the proposal of introducing specific codes for these species in different product forms in the 2017 edition of the HS classification maintained by the World Customs Organization. Almost all countries in the world use this classification as a basis for the collection of trade statistics. For shark fins in cured form, the FAO proposal includes species such as hammerhead sharks, oceanic whitetip sharks and porbeagle sharks, which are included in Appendix II of CITES.

The CITES listing of 17 elasmobranch species affects the international trade in these sharks and their products, and their export requires the certification of the sustainability of their catches by the range State. The aforementioned collaboration between FAO and CITES includes assistance to facilitate the implementation of the recent legal requirements for the international trade in these sharks and rays.

Improvement of shark identification tools and reporting

FAO has responded to the urgent need for accurate shark identification by prioritizing the production of identification guides on sharks and rays (www.fao.org/fishery/fishfinder/en), in particular so-called pocket guides designed specifically for non-experts and for the use in the field, i.e. on vessels, at ports and at markets. Currently, the FAO FishFinder Programme is finalizing a shark fin guide for about 40 species that includes automatic image recognition software developed for species identification from photographs. This guide is intended for non-experts, in particular vessel, port and customs inspectors, to help implement regulations on shark capture and trade.

These and other efforts to improve species identification are showing beneficial effects and, although the reporting of sharks is far from ideal in many regions, there has been an encouraging trend of global improvement in the last decade. Figure 38 shows that catches reported at species level doubled from 13 percent in 1995 to 29 percent in 2011. While this trend is mainly due to improved reporting by developed countries and areas, it should be mentioned that some developing countries, for example, Indonesia and Senegal, have made significant efforts to ameliorate the situation, which is reflected in the FAO catch statistics.[66]

OUTLOOK

In the last two decades, sharks have received growing attention from the public and from decision-makers worldwide. Several international instruments – some voluntary (e.g. the IPOA–Sharks, IPOA–IUU and CMS MOU on migratory sharks) and others legally binding (e.g. the PSMA and listings in CITES Appendices) – have contributed significantly towards improving national and regional regulations for shark conservation and management. Recent years have witnessed important progress in this regard, which is still ongoing. However, the downward trends in vulnerable shark species cannot be effectively stopped without significant additional efforts on shark research and reporting, species-specific regulations, and improved MCS and enforcement schemes for fisheries that target sharks or where sharks comprise important bycatch.

Shark fishing nations and RFMOs must continue to pay attention to their shark fisheries and ensure their sustainability.

All shark fishing nations should strive to develop their national plans of action on sharks and ratify the PSMA. In addition, complete and species-specific reporting of shark catches and trade is an important prerequisite for their meaningful conservation and management. This is still lacking in many countries and regions, and it requires adequate and trained personnel as well as user-friendly local shark identification tools for non-experts. Therefore, capacity building in countries and regions where this is most needed should be strengthened, and collaboration between countries in this regard is urgently required, either directly or through FAO and other international organizations.

Key approaches to the international fight against IUU fishing

THE ISSUE

With the growing world population and the persistent problem of hunger and malnutrition in many areas, work towards improving food security has become the focus of international concern. Fishery resources are an important source of high-quality proteins, vitamins and micronutrients, particularly for many low-income populations in rural areas. Consequently, their sustainable use to support food security has garnered significant attention. Sustainable fisheries management relies, among other things, on adequate control of fishing operations and enforcement of management measures.

Illegal, unreported and unregulated (IUU) fishing remains a major global threat to the long-term sustainable management of fisheries and the maintenance of productive and healthy ecosystems as well as to the stable socio-economic condition of many of the world's small-scale and artisanal fishing communities. In particular, poverty and food insecurity in developing countries are often the result of economic and social marginalization and the use of unsustainable practices employed by IUU fishing.

By illicitly extracting fishery products from local grounds and reducing the quantity and quality of available catch for local fishers fishing legitimately, IUU fishing has deleterious effects on local communities. It may exacerbate malnutrition, food insecurity and even hunger in some places and losses of livelihood and revenues in others, extending its impact to the trade chain and beyond (negatively affecting development).

Another common negative aspect of IUU fishing is its lack of consideration for working conditions, safety at sea and labour laws in general. It is sometimes linked to indecent working conditions and slavery as well as piracy and criminal actions such as drugs and human trafficking. It often employs harmful fishing gear that produces detrimental effects on the environment, e.g. damaging protected grounds and catching juveniles and untargeted species that are then discarded. By failing to respect conservation and management measures, it leads to fish stock depletion and damaged ecosystems. This can have devastating effects, particularly in some of the poorest countries in the world where dependence on fisheries for food, livelihoods and revenues is high. In particular, IUU fishing often targets high-value species in remote areas with ineffective control measures. It thrives on weak governance, poor traceability and lack of deterrents.

Despite ongoing and often successful initiatives by MCS practitioners, IUU fishing continues to have a devastating impact. By changing fishing locations, vessel names and flag States, and ports for offloading their catches, IUU operators can adapt to enforcement actions, resulting in reduced risks of detection, detention and sanctioning.[67] One study indicates that losses attributed to IUU fishing are worth an estimated US$10 billion to US$23 billion per year globally.[68] Therefore, combating IUU fishing is a key requirement for improving food security and nutrition and reducing hunger and poverty.

In devising new strategies to combat IUU fishing, it is essential to identify measures that either reduce the expected income benefits and/or increase the costs of the activity to the perpetrators.[69] Adaptive governance systems can be effective in tackling IUU fishing.[70]

POSSIBLE SOLUTIONS

The international community has put forward several initiatives, instruments and tools to combat IUU fishing worldwide in a cooperative way. Some examples of recent global initiatives on food security, sustainable fisheries and the fight against IUU fishing are:

- the High-Level Panel Report on the post-2015 development goals (to ensure food security and nutrition), which puts sustainable development at the core of its priority transformations and sets as its fifth illustrative goal "Adopt sustainable agricultural, ocean, and freshwater fishery practices and rebuild designated fish stocks to sustainable levels";[71]
- the new global public goods and challenges instrument of the European Union (Member Organization), which aims at strengthening cooperation, exchange of knowledge and experience and partner countries' capacities on the four pillars of food security (food availability [production], access, utilization and stability), while prioritizing four dimensions – smallholder agriculture, governance, regional integration and assistance mechanisms for vulnerable populations;
- the joint statement on IUU fishing signed by the European Commission and the United States Government, which states that "IUU fishing is a global phenomenon with devastating environmental and socio-economic consequences, particularly for coastal communities in developing countries who rely on fisheries for their livelihood or for protein";[72]
- the IUU regulation of the European Union (Member Organization) on developing a catch certification scheme;
- the adoption of the 2009 FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA);
- the adoption of the 2013 FAO Voluntary Guidelines for Flag State Performance;
- updating and implementation of port State measures and other MCS schemes by a number of regional fisheries management organizations (RFMOs);
- annual resolutions of the United Nations General Assembly on sustainable fisheries.

FAO is working on various fronts to combat IUU fishing through an integrated approach that includes awareness raising, knowledge building, and support to the development, adoption and implementation of global instruments such as the vitally important PSMA. To facilitate implementation, FAO supports the development of global mechanisms and tools such as the Comprehensive Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (Global Record).

When it comes into force, the PSMA and the global implementation of its provisions, along with the use of national and regional MCS schemes, are expected to have an enormous impact on IUU fishing activities. Denying port entry to fishing vessels engaged in IUU fishing and the prohibition of landing their catches are expected to prove a highly effective deterrent to the operators and owners of such vessels. The effective implementation of port State measures by concerned States, strengthened by regionally agreed standards and requirements, will block or disrupt the trade in illegally caught fishery products, making it extremely difficult for such operations to remain economically viable. Advanced MCS schemes and port State measures are already implemented by several States, along with regional fishery bodies (RFBs), some of which have aligned their port State control regulations with the minimum standards set by the PSMA. However, developing countries, the most vulnerable to IUU fishing activities, must have support in strengthening their capacity to survey and inspect the entry into their ports of fishing vessels (and cargo vessels linked to fishing operations) not flying their flag. It is vital that implementation strategies for port State measures be supported by sound policy, legal, institutional and operational setups, with adequate resources. FAO's global capacity development programme for port State measures, conducted in collaboration with relevant regional and international organizations, aims to better place developing countries to strengthen and harmonize such measures. It thereby promotes enhanced social and economic development and food security, and ultimately assists in achieving improved fisheries conservation and management and reduced damage and stress on their related ecosystems.

Despite the high potential benefits, FAO Members have been slow to ratify, accept, approve or accede to the PSMA since its adoption in 2009. However, in the light of statements made by several delegations at the Thirtieth Session of the FAO Committee on Fisheries (COFI) and as a result of FAO's global advocacy and capacity development programme on port State measures, it is hoped that the PSMA will soon come into force. However, once in force, the PSMA will not solve all problems. The realities of corruption and organized crime, which add complexity to the task of combating IUU fishing, need to be addressed through supplementary means extending beyond the realm of fisheries control and enforcement.

The PSMA spells out the role of flag States in the implementation of port State measures. However, flag State responsibilities for the control of their vessels and as a counter to IUU fishing are far more extensive. In this regard, the Voluntary Guidelines for Flag State Performance (adopted by the FAO Technical Consultation in February 2013) incorporate responsibilities as set out in international law and various international instruments related to fisheries. They have been drawn up with a view to prevent, deter and eliminate IUU fishing through, *inter alia*, monitoring, assessing and encouraging the implementation of flag State responsibilities and thereby ensure the long-term conservation and sustainable use of living marine resources and marine ecosystems.

A key element in the fight against IUU fishing is access to information on fishing vessels and cargo vessels linked to fishing operations, including their physical characteristics, ownership and flag histories, previous convictions or suspected offences, and much more. This has been recognized in several international instruments and initiatives.

The Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (adopted in 1993) requires parties to authorize their vessels that are fishing on the high seas and requires FAO to facilitate exchange of certain vessel and authorization information among parties and RFMOs. FAO developed the High Seas Vessels Authorization Record to address the requirements defined in Article VI of this agreement. The database contains descriptive

elements of high seas fishing vessels as well as information on registration and authorization status, infringements, etc. for about 6 300 vessels, some 3 700 of which are currently authorized to fish on the high seas. The vessel coverage is variable, with some parties updating their records regularly and frequently while others have never provided vessel information or provide only occasional updates. Similarly, the quality of the records provided varies from almost 100 percent reporting for attributes such as name, registration number and length (mandatory elements) to less than 15 percent for the International Maritime Organization (IMO) number, an optional element, but one that would serve very usefully as a unique vessel identifier (UVI).

In addition, FAO, at the request of the United Nations General Assembly Resolution 61/105, collects data and publishes specific information voluntarily submitted to FAO on vessels authorized to fish in deep-sea fisheries in areas beyond national jurisdiction.[73]

The Global Record is one of the latest tools being developed to combat IUU fishing. Initially proposed at the 2005 Rome Declaration (Ministerial Meeting on Fisheries), the programme to develop a Global Record has been endorsed as a critical element in the global effort to prevent, deter and eliminate IUU fishing. It has been supported by COFI and a Technical Consultation and has been the subject of study by FAO on many levels following a progressive path of development and advancement of concept and operational processes. It is closely related to other MCS initiatives and shows strong synergies with the implementation of the PSMA and Voluntary Guidelines for Flag State Performance among others. It is recognized that many developing countries will have difficulties in the implementation of such measures and, hence, capacity development is essential.

The major strength of the Global Record is that it will utilize UVIs to ensure each vessel record is unique, thus allowing a vessel's history to be traced accurately and making information available regarding the identification of fishing vessels and fishing activity associated with illegal activities and contribute to the implementation of international instruments such as the PSMA. The UVI will be associated to a vessel for its entire life, even when it is subject to changes of flag, ownership, name, etc.

Various people involved in fishing-related activities can perpetrate IUU fishing. Hence, in order to be effective, the Global Record should include not only fishing vessels but also other vessels linked to fishing operations (e.g. refrigerated transport vessels and supply vessels). This inclusion would thus enhance transparency in transshipment operations and other activities such as refuelling at sea.

However, the task is complex as that there are an estimated 4.3 million fishing vessels around the world.[74] As a realistic approach, the FAO Technical Consultation has recommended phased development and implementation:

- Phase 1: All vessels ≥ 100 GT or ≥ 100 GRT or ≥ 24 m.
- Phase 2: All vessels < 100 GT or < 100 GRT or < 24 m but ≥ 50 GT or ≥ 50 GRT or ≥ 18 m.
- Phase 3: All other eligible vessels, notably vessels < 50 GT or < 50 GRT or < 18 m but ≥ 10 GT or ≥ 10 GRT or ≥ 12 m.

The Global Record can thus provide a universal picture by making available the information essential to support the fight against IUU through strengthened MCS and human and financial resource prioritization decisions, vessel inspection programmes, surveillance programmes and investigation, among others, in support to sustainable fisheries management. The Global Record has been conceived as focusing simultaneously on three major areas: promotion; system development and implementation; and capacity development. Most of the work is being addressed taking a regional approach. Different regions have different specificities and needs and, thus, the provision of capacity development has to adapt to these requirements. The regional approach also involves coordination, collaboration and partnerships with regional entities that could be data providers for the Global Record. For example, the RFMOs often maintain a regional vessel record that could be an effective channel of information towards the Global Record. For this reason, for this tool to be effective at the global level, the information has to be relevant, reliable and updated, and be consistent and harmonized with international standards and procedures.

In order to achieve this, vessel owners, national administrations, RFMOs and other stakeholders need to be informed of the benefits and requirements of participating in the Global Record. This is why, prior to its implementation, it is necessary that the above stakeholders are made aware of the use of the Global Record to combat IUU fishing and are briefed on the procedure for including a vessel in it. The development of the system by FAO has to follow the regional and/or global pace, otherwise there could be a high risk of discouragement, sense of failure and of being left behind.

RECENT ACTIONS

In July 2012, COFI expressed appreciation of FAO's efforts in initiating a global series of regional capacity-development workshops[75] to prepare for the entry into force of the PSMA. COFI encouraged FAO to press ahead with the convening of the regional workshops. In response, FAO contributed to a regional workshop for 19 African States on IUU fishing (organized by the Commission for the Conservation of Antarctic Marine Living Resources) with a particular focus on the development of port State controls.[76] In addition, FAO co-organized a capacity development workshop on port State measures[77] for 13 South Pacific States in September 2013. In consideration of recent specific requests for assistance received from FAO Members, as well as interest expressed by relevant international and regional entities to cooperate in regional capacity-development initiatives, three additional workshops have been scheduled for the Caribbean, South America and West Africa regions.[78] Other regions may be covered within the framework of RFBs' programme of work or in a subsequent phase.

Outcomes of the workshops may also be followed up by specific support at the national level, as appropriate, through supplementary tailor-made capacity development programmes, subject to the availability of funds.

Development of the Global Record has involved a promotional campaign to inform all stakeholders of the detrimental effects of IUU fishing and to motivate them to participate in its development. The first major objective in terms of system development is to put forward a prototype tool focusing on Phase 1 for COFI 2014, including pilot data transmission to the extent possible in order to show its feasibility. The prototype should contain at least UVI-number-related information and some additional information. All countries and regions with a fleet that classifies for Phase 1 will be encouraged to ensure that the relevant vessels have obtained a UVI (IMO number) and to submit the data to the Global Record. FAO has been working on ensuring that a reliable UVI will be available for vessels, and has proposed that the UVI could follow the IMO ship identification numbering scheme – this would be the prerequisite for a vessel to enter the Global Record. A proposal cosponsored by FAO to amend IMO Assembly Resolution A600 (15) to include fishing vessels in the IMO ship identification numbering scheme was adopted as resolution A.1078(28) by the IMO Assembly in December 2013.

In order to support implementation of the Global Record around the world, the programme also counts on several tools already available in FAO for providing technical assistance to countries and regions upon request and following capacity and system development workshops. A capacity development framework has been developed based on regional workshops and individual technical assistance to countries in those regions. This framework has already been applied in Central America (regional workshops in 2010 and 2012) through the Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (seven participating countries), and in Southeast Asia (regional workshop in 2013) through the Regional Plan of Action to Promote Responsible Fishing Practices Including to Combating Illegal, Unreported and Unregulated (IUU) Fishing in the Region (11 participating countries). In addition, collaboration has been established with the Mediterranean region (2012–13) through the General Fisheries Commission for the Mediterranean. In spite of limited funding, capacity development has also been extensively used to prepare and facilitate system development and to promote the initiative. The linkage of Global Record capacity development workshops with those addressing the implementation of the PSMA is a plausible and cost-effective option.

The distinct advantage of the Global Record is that it will provide unique and certified information for each attribute, allowing a rapid and unequivocal ascertainment of the vessel information. A strategic document indicating the way forward for the development and implementation of the Global Record is to be presented at the Thirty-first Session of COFI together with a prototype version of the system focusing on Phase 1 (vessels of 100 GT and above). This new approach is intended to be authoritative, integrative and cost-effective and will result in a prompt launch of the Global Record system as a much-needed tool to combat IUU fishing.

In another initiative, whose specific objective is the enhancement of fishing fleet statistics, and therefore complementary to Global Record, FAO has developed a system – the Vessel Record Management Framework – that brings together historical records of fishing vessel information from diverse sources, and enables the analysis of this archive. Built on this system, the Fishing Vessels Finder[79] is the online portal to disseminate publicly available information on individual fishing vessels. All the information accessible through this portal is shown as originally presented by its sources, with clear identification of data owners and date of retrieval for each detail. The system has the functionality to detect duplicate records referring to the same vessel, to the extent possible, to improve data integrity and traceability of the vessel's past. The Fishing Vessels Finder often provides several values for a single data field (as made available by different sources), and therefore it could also be used to supplement the content of the Global Record with complementary data (official and non-official). Thus, when viewing the information for an individual vessel on the Global Record portal, a link will be shown to allow interested users to view this vessel within the Fishing Vessels Finder and obtain further data, which may, on careful analysis, reveal indications of possible suspicious behaviour, such as outdated or contradictory information on the same vessel from various sources.

OUTLOOK

Without the scourge of IUU fishing, food security can be improved through increased and more stable fishery production from sustainable fisheries. The coming into force of the PSMA and the implementation of the Global Record should herald important progress towards the elimination of IUU fishing.

It is imperative that the PSMA be widely embraced as a global minimum standard upon which States and RFBs can build to eradicate entry into ports by IUU fishing vessels and landing of their fish and fishery products. Legal, institutional and operational frameworks at the national, regional and global levels need to be reinforced to fully implement and maximize the benefits of the provisions of the PSMA. In addition, these frameworks must be buttressed by strong political will and cooperation by nations around the globe that commit themselves to the complete and effective implementation of the PSMA. Concerned States and RFMOs must also be mindful of the needs of developing countries in implementing port State measures, and seek to provide legal, technical and financial assistance with a view to enhancing their capacity in MCS and relevant compliance activities. The worldwide implementation of port State measures, in conjunction with other tools such as the Global Record, catch documentation schemes and satellite monitoring, is believed to be one of the most cost-effective and efficient means of combating IUU fishing. Moreover, it is hoped that the recently adopted Voluntary Guidelines on Flag State Performance will encourage fisheries and maritime administrations to work more closely together, that national regimes and capacities will be strengthened, and that RFMOs will play a meaningful role in using the guidelines to strengthen flag State performance and ultimately to combat IUU fishing.[80]

Improved and better-shared information on fishing vessels is essential. This information will improve monitoring of fishing fleet activities and traceability of fishery products, which will act as a strong deterrent to those engaged in illegal activities and thus improve fisheries management for more sustainable and productive fisheries and the conservation of fishery resources.

Traceability of fishing vessels, refrigerated transport vessels and supply vessels, as well as fishery products, will be enhanced "from the net to the plate" through reliable identification of fishing vessels and inclusion of information about the origin of the fishery products in related documentation. The implementation of the High Seas Vessels Authorization Record has demonstrated that fishing vessel information can be shared, albeit only among parties to the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas and RFMOs as specified in the agreement. Some RFMOs have implemented catch documentation and trade certificate systems that require maintaining records of original capture and landings throughout trade and marketing. There is a need to further develop such schemes to ensure global compatibility and provide linkages to implementation of the PSMA and the Global Record.

Worldwide implementation of the Global Record is a major undertaking that will require considerable time, commitment and resources to deliver, but it is one that can bring immense benefits in terms of combating IUU fishing.

Balanced harvest

THE ISSUE

The concept of "balanced harvest" refers to a management strategy that aims at distributing fishing pressure (mortality) across all trophic levels to ensure the maintaining of trophic relationships across species and sizes. Balanced harvest is often represented using the trophic pyramid and showing how harvesting should take place across the different trophic levels in a way that is proportional to their respective levels of productivity.

Fisheries are usually selective as they tend to target species and/or sizes yielding the highest economic returns. Moreover, any fishing gear is selective, although in different ways, depending on its technical characteristics and how it is deployed. Selectivity takes place at different levels – during fishing operations, e.g. through the use of specific gear types that target preferred species and sizes, or through selection of fishing grounds where given sizes and species are known to occur. Selective fishing may result in altered size and/or species composition in the community or ecosystem. Fisheries that target species belonging to a specific trophic level (e.g. krill, small pelagic fishes or top predators), thus removing one ecosystem component without considering cascading effects on the dependent species, can also be considered a form of selective fishing at ecosystem level. Evidence suggests that fishing spread over more groups and sizes results in higher yields[81] and, conversely, ecosystem structure can be altered and yield lost if fisheries affect trophic levels in a non-balanced way.

Concerns about the impacts of harvest strategies that fail to consider trophic relationships in a given ecosystem have been recognized for decades, and abundant scientific literature exists underpinning its possible negative impacts on the structure and functioning of aquatic ecosystems.[82]

Already in the early 1970s, the growing interest in harvesting Antarctic krill in the Southern Ocean had raised serious concerns because of its key role in the Antarctic food chain[83] and possible negative impacts on predatory species. Fishing on species occupying low trophic levels, such as krill, sardines, anchovies and herring, has raised concerns more recently because of the increasing demand for these species by global markets. Such species are not only important for food security and for their use as

animal feed (including for aquaculture) but they also play a key ecological role in transferring production from plankton to larger predatory fish and marine mammals and seabirds. More conservative sustained harvesting rates, significantly lower than the maximum sustainable yield (MSY), have been recommended in order to leave sufficient forage for marine predators.[84]

Another example of fisheries that have raised concerns in the context of balanced harvest are tropical shrimp fisheries. Usually carried out with various types of bottom trawls (including beam trawls) fitted with very small mesh sizes in their codends, these have been considered harmful for their low selectivity, often resulting in a very high bycatch of species that are usually more vulnerable than the shrimp stocks themselves.[85] A level of effort that may correspond to MSY for a shrimp stock may have a much greater impact on the accompanying species given that these are often less productive (i.e. less fecund and with slower growth rates) and characterized by longer life cycles (i.e. slower replacement rates) than shrimp and, therefore, are more vulnerable. This may result in an altered fish community structure,[86] in addition to having negative impacts on the productivity of species other than shrimp that are targeted by other fisheries.

The concept of "balanced harvest" has recently been used in relation to the impacts of fishing on larger sizes and species (usually higher in the trophic pyramid and of higher economic value). It has also been recognized that conventional fisheries management strategies, based on selective fishing practices such as minimum mesh sizes (attempting to protect fish until their first sexual maturity), may contribute to altering the food chain structure with overall loss of productivity and resilience of aquatic ecosystems as well as phenotypic changes leading to fish growing faster, to a lower maximum size and maturing earlier.[87] In addition, these measures require strict regulations that demand human and financial resources, often making them difficult and costly to implement. Therefore, it has been argued that a cost-effective strategy would be to relax the above regulations.[88] Hence, it has been proposed that management practices based on size selectivity should be abandoned to achieve the dual goal of a more balanced harvest that maintains ecosystem structure and functioning while decreasing the transaction costs of fisheries management. This approach has raised debate and been seen as potentially undermining regulations that are enshrined in most fisheries legislation worldwide.

The idea that maintenance of ecosystem structure and functioning can best be achieved through a more balanced harvest strategy is intuitively meaningful and grounded in scientific evidence. The recognition of the need to move beyond single-species management to a more comprehensive perspective that includes "collateral damage" of fishing on aquatic ecosystems is also broadly accepted. What seems to be more problematic is identifying cost-effective and practical fisheries management strategies and approaches that will result in the desirable fishing pattern while also taking into consideration the social and economic implications and constraints.

POSSIBLE SOLUTIONS

Conventional fisheries management has mainly focused on optimizing productivity at species and/or stock level and the most common approach has been to avoid growth overfishing[89] and recruitment overfishing.[90] Typical ways to avoid growth overfishing have been the use of mesh size or other gear selectivity measures that reduce impacts on juvenile fish. As regards recruitment overfishing, maintaining the spawning stock biomass at a target level has been implemented through placing moratoriums or catch quotas. The above have been combined with other measures (input and output controls, time and area closures, etc.) but all within the single-species management paradigm. In the past decade or so, more attention has been put on developing new management strategies that take account of the broader ecosystem impacts of fishing.

The ecosystem approach to fisheries (EAF)[91] explicitly addresses the need to take account of the interdependences of species and functioning of aquatic ecosystems when managing fisheries. This means recognizing that the range of measures chosen should not only address a series of target species concerns, but also preserve ecosystem health and integrity.

The knowledge base for managing ecosystem impacts of fishing on trophic relationships can be obtained from ecosystem models, and many tools exist to help in this effort.[92] Although these models are often characterized by a high level of uncertainty (and therefore prudent use should be made especially for tactical fisheries management), they can be very useful in helping to understand key trophic links. More complex models have large data requirements that are difficult to meet in many situations, and using a combination of models of intermediate-level complexity can be more practical.[93]

The management approaches that have been proposed under the EAF are not new but based on those used under conventional fisheries management as described above to regulate fishing mortality of target and non-target species. Under an EAF, these controls are considered in the broader context of addressing ecosystem-related objectives (such as maintaining food webs). Catch controls aimed at directly reducing fishing mortality on target species are still considered important. However, in terms of an EAF, in a mixed-species fishery, consideration needs to be given to the different vulnerabilities and productivity of the various species, with the implication that it will be necessary to implement a set of consistent catch limits across the range of target and bycatch species to reflect these differences. Moreover, allocation of quotas (including of bycatch) for species across different trophic levels should consider their role in the trophic web. In most cases, this would lead to more conservative allocations compared with under a single-species management approach.

There are two main approaches to dealing with ecosystem impacts of fishing. One is more "pragmatic", building on existing single species-management by adding, for example, predator requirements for forage species in a piecemeal fashion. Another approach focuses on overall ecosystem structure and functioning as represented by trophic relationships and ecosystem models.[94]

Both approaches, or a mix of them, can be useful in moving towards a more balanced harvest strategy. However, what is most challenging seems to be selecting

Figure 41

Generalized representation of initial steps of the management process to address balanced harvest

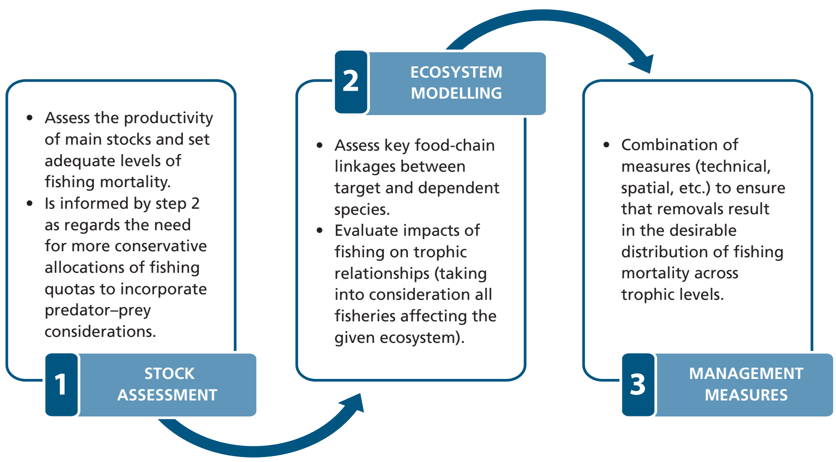
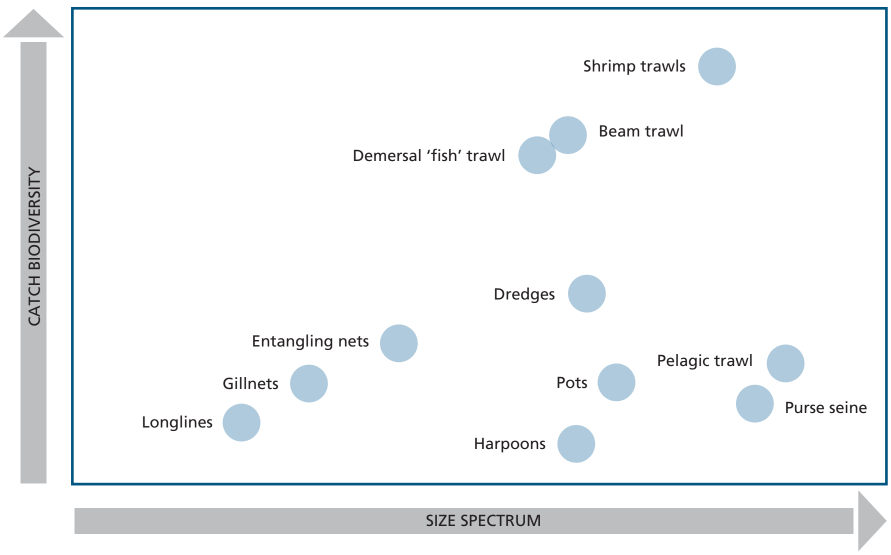


Figure 42

Size and diversity spectrum of the catch from various types of fishing gear



Source: Adapted from N. Graham. 2011. Figure 8. Age spectrum and biodiversity of the catch of various fishing gears. *In* S.M. Garcia, ed. 2011. *Selective fishing and balanced harvest in relation to fisheries and ecosystem sustainability. Report of a scientific workshop organized by the IUCN-CEM Fisheries Expert Group (FEG) and the European Bureau for Conservation and Development (EBCD) in Nagoya (Japan), 14–16 October 2010,* p. 14. Gland, Switzerland, and Brussels, Belgium, IUCN and EBCD. 33 pp.

the most appropriate management strategy and/or set of regulations that will actually lead to the desirable fishing mortality across the food web, while considering the entire set of fisheries operating in an ecosystem (as opposed to for each fleet without consideration of ecosystem connections). Figure 41 provides a simplified representation of initial steps that could be taken to address the balanced harvest objectives.

Developing operational interpretations of balanced harvest through the identification of appropriate management measures (step 3 of Figure 41) can be a major challenge. Marine ecosystems, and the way species interact within them, are complex. Many species occupy different trophic levels throughout their life cycle, while species and/or sizes at the same trophic level often occupy different habitats and ecological niches and are, therefore, not necessarily co-occurring in space and/or time. Impacts of fishing are compounded with natural environmental variations that, in some cases, are the major agent of change in natural systems. The geographical boundaries of marine ecosystems are difficult to define in a rigorous manner and while spatial structure exists, these may vary considerably and not necessarily correspond to management areas of interest to the fisheries management authority. In this situation, the idea that fishing non-selectively will help to achieve a more balanced harvest seems simplistic. Moreover, given that most fishing activities and gear types are selective, a relaxation of regulations on bycatch will not necessarily contribute to overall balanced harvest at ecosystem level. However, ecosystems are usually exploited using a wide range of gear types that act on different components of the ecosystem and display a wide range of selectivity properties in relation to sizes and species (Figure 42). Given the above, a balanced harvest will probably need to be based on a good knowledge of ecosystems and their spatial and temporal dynamics, and fisheries management will have to identify combinations of measures that will result in the desirable overall fishing pattern at ecosystem level.

Another aspect is how to take account of the fact that different fisheries and ecosystems have their own specific issues. Solutions will have probably to be found in each specific case, also considering what will be more cost-effective and socially acceptable. For example, upwelling ecosystems are characterized by high productivity and relatively low species diversity. Major fisheries separately target both small pelagics as well as large demersal stocks. In this situation, the priority for a balanced harvest is to take into consideration the amount of fish removed at the various trophic levels by targeted fishing. Reference points for forage species will have to consider the needs of dependent species. In tropical and highly diverse ecosystems, where fisheries are multispecies and multigear, a more viable strategy will be to look at vulnerabilities of the various species to the gear types used within a fish assemblage and to develop strategies that take those into account. By considering the different fisheries, the types of issues related to balanced harvest, and the possible ways forward, the idea is that initial steps towards a balanced harvest can be taken in a practical way, i.e. without necessarily engaging in the full complexity of aquatic food webs.

Where the chosen strategy is to allow a more diversified catch, this should be accompanied by efforts to utilize the whole catch, for example, by processing fish that are currently discarded, thereby increasing the value of the landings.

RECENT ACTIONS

The recognition of the importance of harvesting marine ecosystems in a "balanced" way has been central in the development of ecosystem-based fisheries management[95] and the EAF.[96] The need for maintaining biomass of species at various trophic levels or maintaining abundance of various sizes at different trophic levels has been recognized and discussed.[97] The main challenge has been translating these concepts into practical fisheries management. Despite this, some examples exist of fisheries management that takes account of impacts of targeted fisheries on trophic relationships.

For more than two decades, the Commission for the Conservation of Antarctic Marine Living Resources has taken into account prey requirements by accounting for these in setting reference points for forage species such as krill.[98]

In the United States of America, already in the 1990s it was recommended that fishery management regions develop fisheries ecosystem plans with detailed information about fisheries and the structure and function of the ecosystems in which they took place.[99] As a result, a series of management measures were gradually implemented in Alaska with the aim of broadening fisheries management objectives and including ecosystem considerations. These included: a cap on total removals from the ecosystem, a ban on forage fish harvests, conservative total allowable catch (TAC) rates, assessment of ecosystem considerations when setting TACs, accounting of bycatch against TACs, designation of trawl closure areas, and industry-funded observer coverage of significant amounts of the TACs. The cumulative effect of these measures was also to be assessed to take ecosystem limits and dynamics into account.[100]

The capelin fishery in the Barents Sea is managed through the Joint Norwegian-Russian Fisheries Commission, and multispecies interactions are explicitly taken into consideration when setting quotas. Capelin is an important forage species for predators such as cod, and management of the stock takes the predator needs into account. This has been implemented since 1991 and further developments will consider predation by harp seals as well as main prey such as zooplankton. Another important aspect, yet to be modelled, is the relationship between capelin recruitment and the young stages of the Norwegian spring-spawning herring, a major predator on capelin larvae.[101]

The above examples need to be strengthened and expanded to other fisheries but they show that, despite the complexities involved, some initial steps can be taken in the direction towards balanced harvest.

OUTLOOK

There is consensus globally that it is no longer sufficient to focus on the sustainability of target species and that broader ecosystem impacts of fishing have to be considered as well. Steps have been taken in some regions and examples exist of management approaches that, in a pragmatic way, take account of species interactions. However, the examples are still few, and moving more systematically from population to ecosystem level will still pose major challenges for both science and management. Given the high level of uncertainty in predicting ecosystem responses to different management strategies, management approaches need to be adaptive, supported by a good monitoring system, including adequate and cost-effective ecosystem indicators, and within a management framework that explicitly sets ecosystem objectives. This will take place against a background of climate variability and change, which will in turn require even more conservative approaches to management to strengthen resilience of these systems to cope with a changing environment.

The drivers of non-sustainable fishing are well known. They include: overcapacity of the fishing fleet; IUU fishing; the open-access nature of many fisheries; poverty in coastal communities of developing countries and fishing as a last resort; intra- and inter-sectoral conflicts with degradation of habitats and resources; and inadequate governance structures. These drivers are present in a situation of rising demand for fish by an increasing human population and escalating demands from local and international markets.

As one of the sectors having the most impact, capture fisheries can do its part by eliminating overfishing and overcapacity of the fishing fleets. This will probably be one of the most effective ways of dealing not only with overfishing of target species but also with most of the problems facing fisheries in an ecosystem context. Eliminating overfishing is also a prerequisite for benefiting from a balanced harvest approach. A balanced harvest can then be addressed using management tools that are no different from those of conventional fisheries management, but applied in the broader context of optimizing not only in relation to target species but within the broader context of sustainability at ecosystem level.[102]

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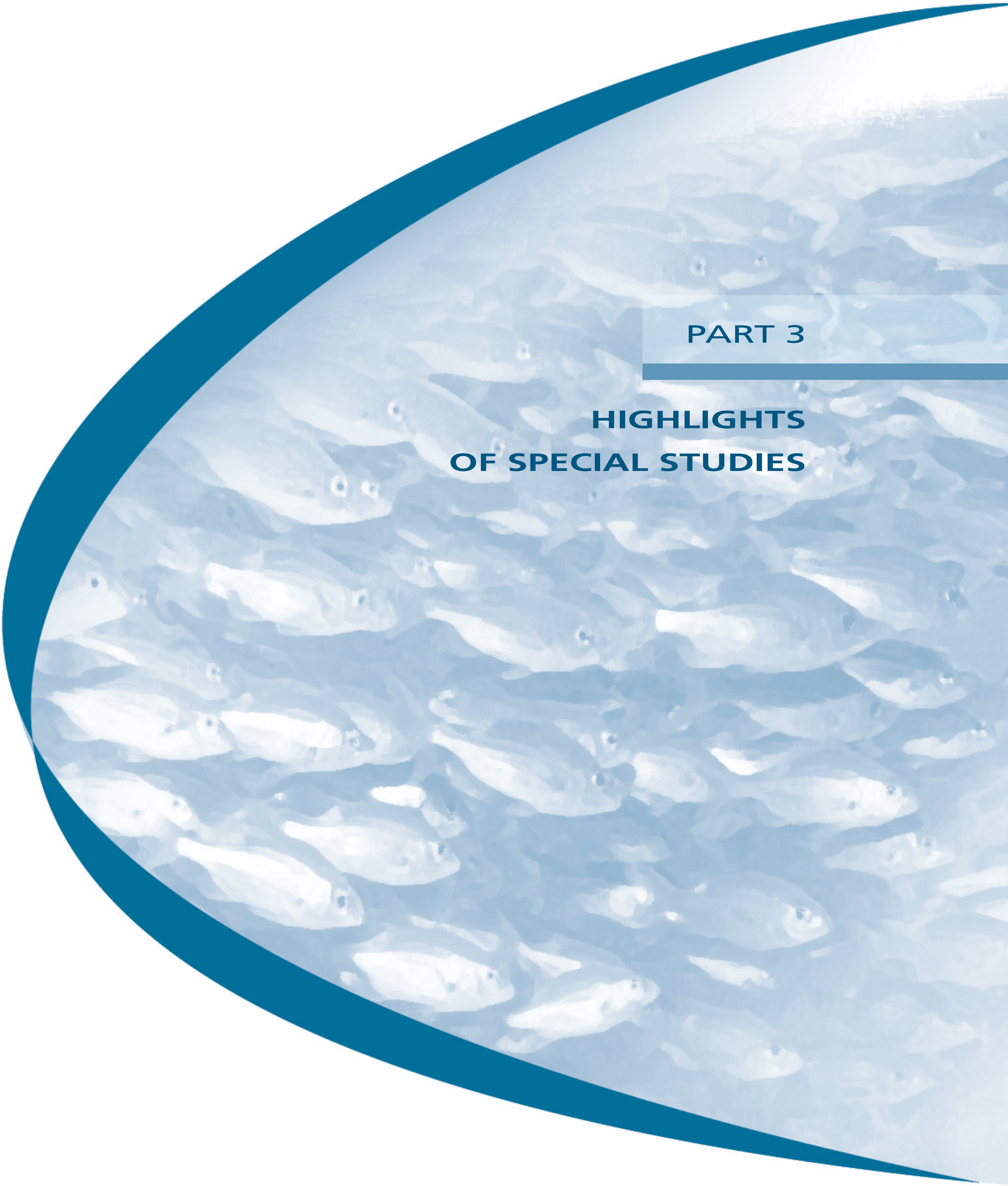
PART 3

HIGHLIGHTS OF SPECIAL STUDIES



HIGHLIGHTS OF SPECIAL STUDIES

Fish consumption in the Asia-Pacific region as measured by household surveys

Fish and other aquatic animals play an important role in diets throughout the Asia-Pacific region. However, gaining an accurate picture of fish consumption in the region is a challenge. In developing countries especially, a large amount of inland water catch as well as that brought to shore by small-scale marine artisanal fishers goes unrecorded. Much of this catch is consumed locally (e.g. from subsistence fisheries) and is not recorded as landings or through sales transactions. Moreover, the numbers of fishers can be underestimated as many of them practise on a part-time or occasional basis and so may not be recorded as fishers in censuses. This further reduces estimates of the total catch.

As part of a study for the Asia-Pacific Fishery Commission,[1] information on fish and fish-product consumption from 30 Asia-Pacific countries and territories was collated and examined. For 28 of these, the information was in the form of national household consumption surveys carried out by government statistical departments. For the remaining two (Cambodia and Timor-Leste), the surveys were carried out by government fisheries agencies with donor support. Dates of surveys (given in parentheses) varied in line with availability of data.

This exercise does not attempt to make a rigorous statistical analysis or comparison of consumption levels in various countries. Rather it attempts to draw attention to the value of household survey information and highlight the importance of fish in diets across the Asia-Pacific region.

UNDERSTANDING FISH CONSUMPTION THROUGH HOUSEHOLD SURVEYS

Household surveys are undertaken on a regular basis in many countries throughout the Asia-Pacific region. These provide a wealth of useful data concerning fish consumption, nutrition supply, species consumed, and urban, rural or other geographical trends and preferences.

Comparing results across countries can be problematic because the methodologies used in various surveys may differ considerably. Some surveys only cover expenditure on food items and do not record consumption. Even where consumption is recorded, the degree of detail on individual food items may vary. For example, certain surveys will simply gather data on whether "fish" has been eaten while others provide information on individual species and the various preserved or processed products consumed. In the detailed surveys on consumption, different calculation methods may be used to adjust for participant recall, protein conversion factors and live weight equivalents of the fish products consumed. Surveys carried out in smaller areas or specific communities may produce very different results, often reflecting the availability of fish and local eating habits.

Despite limitations due to differing assumptions and methodologies, household surveys can provide very useful comparisons for checking purposes and yield additional information, particularly in relation to subnational variations in diets. The fact that national household surveys are usually undertaken by specialist agencies across all regions of a country and within a rigorously devised sampling framework helps deliver large-scale, statistically valid data, which can play a major role in gaining a better understanding of fish consumption across the Asia-Pacific region.

COMPARISON WITH FAO APPARENT CONSUMPTION FIGURES

Household consumption survey results may differ from apparent consumption estimates in FAO's food balance sheets. In the absence of a comprehensive international data set from household surveys, FAO's food balance sheets are important because they represent the only global source of standardized data that allows time-series comparisons to be made.

FAO's food balance sheet data are based on live weight equivalents of available fish for human consumption, while household survey data are based on recollections of edible quantities consumed (i.e. product weight). This means that, typically, values for household consumption from survey data should be lower than the estimates from the food balance sheets. However, in some cases (e.g. Bhutan, Cambodia, the Lao People's Democratic Republic, the Philippines, Thailand and Timor-Leste as well as six Pacific islands), the household survey consumption figure is higher than the FAO apparent consumption figure.

The reasons for these differences were not explored. However, for at least some of these countries and territories, such differences point to underestimates of national fish production. In other cases, they may depend on features of the design and coverage of the consumption study or the conversion factors used (particularly with respect to live weight equivalents and protein contribution).

For food balance sheet data, some countries may not be able to correctly assess small-scale catch/production of fish and fish products that are consumed locally and are thus unlikely to appear in official fish production statistics. It is this type of own production (subsistence fishing) and consumption at the household level that is usually captured by household surveys, thus giving higher consumption estimates.

CONSUMPTION OF FISH AND FISH PRODUCTS

The countries of the Asia-Pacific region have a range of environments, spanning landlocked mountainous areas, large tropical floodplains, arid grasslands and oceanic tropical islands. This affects accessibility to fish in its different forms and, hence, annual fish consumption figures vary considerably, ranging from 110.7 kg/capita on the Pacific island of Tuvalu to 0.18 kg/capita in Mongolia.

The breakdown of annual fish consumption figures across geographical regions is as follows:

- Pacific: Of the 16 States studied, Tuvalu had the highest annual consumption at 110.7 kg/capita while Papua New Guinea had the lowest at 13 kg/capita.
- Southeast Asia: Data were obtained for eight States in Southeast Asia. Of these, consumption in Cambodia was highest at 63.5 kg/capita while it was lowest in Timor-Leste at 6.1 kg/capita.
- South Asia: Data were obtained for four States in South Asia. Sri Lanka recorded the highest consumption with 15.3 kg/capita while Pakistan recorded the lowest with 0.6 kg/capita.
- North Asia: Data were obtained for two States in North Asia. Consumption was highest in Bhutan at 5.6 kg/capita and lowest in Mongolia at 0.2 kg/capita.

Not all surveys examined converted fish consumed into levels of protein consumption. Of the ten that did, fish provided the highest levels of protein in the diet in Cambodia, accounting for 37 percent of total protein consumed, followed by Myanmar at 22 percent. The lowest levels were recorded in India, where fish represented just 2 percent of protein intake, and Mongolia, where the figure of 0.1 percent reflects the negligible levels of fish consumed.

Only six surveys identified the type of fish species consumed and their origin. In Bangladesh, Cambodia and Myanmar, more inland water fish and aquatic animals were consumed than marine counterparts. For example, in Cambodia, the breakdown by weight was 71 percent inland to 27 percent marine. In Indonesia, Sri Lanka and Thailand, more marine fish were eaten than inland fish. In Indonesia, for example, almost 80 percent by weight of all fish consumed were marine species.

Major inland species consumed include tilapia, catfish, carp, perch and snakehead. Marine species commonly eaten include tuna, anchovy, sardines, mackerel, scad, shad and milkfish.

Bangladesh

Annual consumption of fish and fish products in Bangladesh is 11.9 kg/capita (2010), accounting for 11.1 percent of total protein consumption. Annual consumption is highest in the Chittagong area (17.2 kg/capita) and lowest that in Rangpur (7.5 kg/capita). In all, some 76 percent of fish consumed are inland species and 18 percent marine. Urban annual consumption stands at 14.5 kg/capita per year and rural annual consumption at 11 kg/capita, with rural communities eating a higher percentage of inland fish (70 percent) than urban communities do (61 percent). The species most commonly consumed are all freshwater including tilapia, catfish and mrigal carp. Hilsa shad is the most commonly consumed marine species. Annual protein consumption of fish varies considerably by income quintile, ranging from 1.31 kg/capita in the lowest quintile to 3.39 kg/capita in the highest.

Bhutan

Annual fish and fish product consumption in Bhutan is 5.58 kg/capita (2009), while fish accounts for 3.18 percent of all protein consumed. The highest annual consumption figures are for the Transhi-yangtse district at 11.5 kg/capita while Samtse in the far southwest of the country sees the lowest at 2.5 kg/capita. The majority of fish consumed is frozen (61 percent) while fresh fish and canned fish account for 24 percent and 13 percent, respectively. Urban residents consume more fish (6.4 kg/capita) than those in rural areas (5.3 kg/capita). Urban households also eat more than twice as much fresh fish as do their rural counterparts.

Cambodia

The edible quantity of fish and fish products consumed annually in Cambodia would, at 63.15 kg/capita (2011), appear to be among the highest in the Asia-Pacific region. Fish and fish products also represent some 37 percent of protein consumed. With most of the country forming part of the Lower Mekong Basin and with the highly productive Tonle Sap being the largest freshwater lake in Southeast Asia, annual fish consumption figures are relatively high across all regions of the country, ranging from 90.2 kg/capita in coastal areas to 52.2 kg/capita in mountain and plateau regions. Inland fisheries resources account for 71 percent of fish and fish products consumed, and marine fisheries resources 27 percent. Aquaculture accounts for the remaining 2 percent. Apart from coastal areas, all regions consume more inland than marine fish. Among the most commonly consumed species are snakehead, catfish, climbing perch and mud carp.

India

In India, national average annual consumption of fish and fish products is 2.85 kg/capita (2010). This accounts for 2.2 percent of total protein consumption. Annual consumption levels range from 22.7 kg/capita in the coastal province of Kerala to just 0.03 kg/capita in mountainous northern province of Himachal Pradesh. Those in the lowest income quintile consume about four times less protein from fish and fish products as those in the highest quintile. Those in urban areas consume on average 3.1 kg/capita while rural dwellers consume 2.7 kg/capita.

Indonesia

Annual fish and fish product consumption in Indonesia stands at 12.8 kg/capita (2011), representing 16.4 percent of total protein consumed. Consumption levels range from 26.4 kg/capita in Maluku in the east of the country to 4 kg/capita in Yokjakarta. More than 70 percent of the fish consumed is marine fish, with inland species accounting for some 25 percent. Skipjack tuna is reported to be the most commonly consumed marine fish followed by anchovy and Indian mackerel. For inland species, tilapia ranks first followed by catfish and common carp. On a nationwide level, most fish products (70 percent by weight) are consumed fresh, while 30 percent are eaten as preserved or processed products.

Lao People's Democratic Republic

Annual consumption of fish and fish products in the Lao People's Democratic Republic is 19.1 kg/capita (2008), representing 10 percent of total protein consumption. Annual consumption ranges from 7.5 kg/capita in Houaphan Province in the northeast to 32.7 kg/capita in Champasak in the far south. Generally, the rise in consumption mirrors the southwards passage of the Mekong River until it passes into Cambodia. About 80 percent of the fish consumed is captured fresh fish, with processed or preserved fish accounting for 12.5 percent. Fish captured from waterways (as opposed to farmed) accounts for more than 65 percent of rural consumption as opposed to about 25 percent for urban households.

Mongolia

Annual consumption of fish and fish products in Mongolia is 0.18 kg/capita (2008) and accounts for just 0.13 percent of total protein consumption. The highest levels of consumption are recorded in the capital Ulan Bator (0.28 kg/capita). In both the east and west of the country, the figure falls to 0.07 kg/capita. Fresh fish makes up (67 percent) of all fish consumed, followed by canned fish (28 percent). Dried, salted or smoked fish accounts for 4 percent. Urban dwellers consume slightly more than twice as much fish as do rural dwellers – 0.23 kg/capita and 0.10 kg/capita, respectively.

Myanmar

In Myanmar, national average annual consumption of fish and fish products is 21.02 kg/capita (2006). This represents 22.6 percent of total protein consumed. Inland species account for 31.5 percent of fish consumed, and marine species 23.5 percent. Fish paste is the most commonly consumed product, while mrigal carp is the most regularly consumed species, followed by striped snakehead and rohu carp. Of the marine species, hilsa shad is the most commonly eaten. Rural and urban consumption levels are broadly similar although urban dwellers eat more fresh fish (53 percent) than do rural dwellers (45 percent).

Pacific Islands

Tuvalu recorded the highest annual consumption of fish and fish products in the Pacific (surveys dated 2001–06) at 110.7 kg/capita, followed by Samoa at 87.4 kg/capita. Papua New Guinea has the lowest level of consumption at 13 kg/capita, followed by Tonga and Vanuatu, both at 20.3 kg/capita. In Solomon Islands, Papua New Guinea and Kiribati, urban consumption levels are higher than those in rural areas, while rural consumption is higher in all the other Pacific countries and territories covered. With the exception of French Polynesia and Wallis and Futuna Islands, consumption in coastal communities is higher than in non-coastal communities. In other countries and territories, there are considerable differences. For example, in Fiji, national average annual fish consumption is about 20.7 kg/capita compared with figures nearer to 120 kg/capita in coastal settlements.

Pakistan

From household survey results, it would appear that fish and fish products make only a very minor contribution to diets. The national annual consumption figure stands at just 0.6 kg/capita (2011). Fish and fish products also account for 9.1 percent of all animal flesh products eaten. Poultry is the most common animal product eaten (3.4 kg/capita). Fish consumption is highest in Balochistan (2.4 kg/capita) and Sindh (1.6 kg/capita). Consumption tails off farther north, with households in the Punjab consuming just 0.2 kg/capita and those in the mountainous Khyber Pakthunkwa area negligible amounts (0.05 kg/capita). In both rural and urban areas, more than 90 percent of fish products consumed are purchased, with just 3–4 percent self-produced.

Philippines

Annual fish consumption in the Philippines is 40.15 kg/capita (2008). It is highest in Western Visayas and Caraga at 46.7 kg/capita. The Cordillera Administrative Unit in the far north of the country has the lowest levels of fish consumption, at 28.1 kg/capita. Canned fish and sardines, mackerel scad and milkfish are the three most commonly consumed products/species, followed by tilapia. Among consumers, those aged 60 years and above eat the most fish (15.6 percent of total food consumption) – most commonly round scad and milkfish – followed by those aged 20–59 years (14.7 percent). Round scad and canned sardines are the most commonly consumed species/products for all age groups apart from the 60 years and above group.

Sri Lanka

In Sri Lanka, average annual consumption of fish and fish products is 15.3 kg/capita (2010). Of the fish consumed, marine species account for 81 percent and inland species about 11 percent. Sprats are the most commonly consumed marine species followed by skipjack tuna and goldstripe sardinella. Tilapia is by far the most commonly consumed freshwater species, followed by catfish and snakehead. Overall, 71 percent of the fish consumed is consumed fresh and the remaining 29 percent as dried or processed products.

Thailand

Annual consumption of fish and fish products in Thailand is 31.4 kg/capita (2011). This represents 11.7 percent of total protein consumption. The highest levels of consumption are in the southern provinces (41.4 kg/capita), followed by the northeast (32.7 kg/capita). Inland species and other aquatic animals represent 37 percent of fish consumed in comparison with 47 percent for marine equivalents. Miscellaneous processed products that could have been either marine or inland fish-based make up the remaining 16 percent of consumption. Rural dwellers eat more fish and fish products than their urban counterparts – 35.7 and 25.7 percent, respectively. Nile tilapia is the most commonly eaten species in north, central and urban areas; while snakehead ranks first in the northeast and rural areas, and chub mackerel in the south.

Timor-Leste

In Timor-Leste, annual consumption of fish and fish products is 6.1 kg/capita (2011). This represents 33.4 percent of all animal flesh products eaten. Consumption patterns vary considerably from 17.6 kg/capita in coastal communities to 4 kg/capita in non-coastal areas. In urban areas, the figure stands at 6 kg/capita. Consumption in coastal and urban areas is entirely of marine species, while in non-coastal areas 1.8 percent of animal protein consumed is from inland species. Sardines and mackerel are by far the most commonly consumed species followed by longtail tuna, snapper, prawns and long tom. Nile tilapia and common carp are produced in small quantities (45 tonnes/year) by small-scale fish farmers.

Viet Nam

The average annual level of fish and fish product consumption in Viet Nam is 14.6 kg/capita (2011). This represents 8.5 percent of protein consumed. Consumption levels vary considerably throughout the country, ranging from 6.8 kg/capita per year in the midlands and northern mountainous areas to 24.4 kg/capita per year in the Mekong Delta. On a national level, fresh fish and shrimp make up 66.7 percent of consumption, with fish and various dipping sauces accounting for 27.6 percent, and dried/processed fish 5.7 percent. Rural and urban consumption levels are similar at 14.8 and 14.2 kg/capita, respectively.

CONCLUSIONS

From the data analysed, it is clear that per capita fish consumption in the Asia-Pacific region is highest in the Pacific, followed by Southeast Asia, South Asia and North Asia. However, although annual fish consumption in countries such as India and Pakistan is relatively low (2.85 and 0.6 kg/capita, respectively), the large population size of these States results in significant quantities of fish being consumed (e.g. for India, this equates to more than 3.4 million tonnes/year).

Within countries, considerable geographical differences in fish consumption can be identified. Certain geographic reasons are clear such as for populations living along or in the proximity of large waterways or waterbodies (e.g. the Mekong River and Cambodia's Tonle Sap). It is also unsurprising that available data point to higher consumption in coastal communities than in those farther inland.

There is no clear divide between rural and urban areas. In 13 countries where data are available, consumption in rural areas is higher than in urban areas, while in 9 others urban consumption is higher. This may point to greater or easier availability in certain rural areas as well as better purchasing power in some urban centres.

Where data are available, inland species would appear to play a major role in diets. Certain species such as tilapia and catfish feature prominently.

No single country survey is able to provide a wholly accurate figure for fish consumption on the national and subnational levels. Instead, a combination of approaches using the country's food balance sheet (to give an idea of overall consumption) and household surveys (to provide better resolution of the range and types of consumption) can help to paint a picture of how much fish is available and who is accessing it.

Household surveys are uniquely positioned to gather detailed data on fish consumption on nationwide and local scales. Therefore, continued technical support should be provided to national statistics offices to help them put into practice more effective data collection methods in order to enhance the accuracy, quality and value of fish consumption statistics in both quantity and nutrient values. Support should also continue to be provided to technical areas such as the building of national nutrient and product conversion factors, including non-edible proportions of different types of fish.

Where possible, household surveys should seek to place added emphasis on gathering more comprehensive data related to the consumption of fish and other aquatic animals or products. This would, for example, help create a greater understanding of the role that small fish caught in inland waters or from rice fields play in diets, especially in those of the poor. Such information could inform policy relating to poverty, diet and resource management.

Furthermore, survey data can play an important role in identifying apparent anomalies in statistics that can then be addressed at the national level. Deeper analysis should be conducted to understand the mismatches between apparent live weight consumption from food balance sheets and edible quantity figures from household surveys in certain countries. National authorities would, for example, then be better placed to address over- or under-reporting in their figures.

Finally, household survey data are available from most countries in Asia-Pacific region with a few notable exceptions. In order to gain a clearer picture of fish consumption across the region, such data should ideally be made available from all countries and territories.

Key elements of the Voluntary Guidelines on the Governance of Tenure of Land, Forests and Fisheries in the Context of National Food Security for the fisheries sector

INTRODUCTION

In May 2012, the Committee on World Food Security (CFS) endorsed the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security[2] (the Guidelines). This represented a major achievement of an extensive consultation and negotiation process involving government officials, civil society organizations, private sector representatives, international organizations and academia. Based on key international human rights standards, the Guidelines constitute a powerful instrument for improving the lives of millions of people.

The recognition of the importance of secure and equitable access to natural resources for food and nutrition security and sustainable livelihoods that the Guidelines represent is of fundamental significance to fishing communities, in particular to vulnerable and marginalized groups. The inclusion in the process of the people that the Guidelines intend to support – in particular small-scale farmers, fishing communities and pastoralists – ensured that the issues and topics covered by the Guidelines are anchored in real life and address genuine concerns.

For the Guidelines to have their intended positive impact, it is vital to support their implementation. Concerted efforts are required to ensure that the principles and standards of the Guidelines are integrated into policies and plans and utilized to improve governance of tenure, in particular for the benefit of the vulnerable and marginalized and for the achievement of poverty eradication and food security for all. To support the implementation of the Guidelines in the fisheries sector, FAO released a preliminary version of a technical guide[3] in September 2013, and the text is open for comments.

The preliminary technical guide consists of two main parts. The first part explores what tenure rights and governance mean in the context of fisheries and why responsible governance is needed. It examines the issues of who holds rights to fishery resources and the different types of tenure rights that exist, including for shared stocks and resources in international waters. The first part also looks at existing frameworks and approaches relevant to the governance of tenure in fisheries. The second part of the document focuses on implementing responsible tenure in fisheries. It provides practical guidance, including on general principles, setting objectives, improving knowledge, and allocating and administering tenure rights. It also explores the implications of climate change and natural disasters for tenure issues and provides guidance on monitoring, evaluation and compliance. A glossary and an appendix with more detailed information on approaches and tools complement the two main parts.

The following sections present some of the key issues addressed in the preliminary technical guide.

KEY ISSUE 1: UNDERSTANDING TENURE

Tenure systems define and regulate how people, communities and others such as associations, cooperatives and companies gain access to natural resources through both formal law and informal arrangements. Governance of tenure affects whether and how these parties are able to acquire rights and/or to protect already existing rights to use and to manage these resources. Many tenure problems arise because of weak governance, and the quality of governance affects attempts to resolve tenure-related problems. Inadequate and insecure tenure rights to access and use natural resources often result in extreme poverty and hunger, not only by facilitating overfishing but also by reducing incentives for responsible stewardship. The eradication of hunger and poverty – as well as the sustainable use of the environment and the continued provision of ecosystem services – depends in large measure on how people, communities and other groups or entities gain and maintain access to land and other natural resources.

In the fisheries sector, ineffective governance of tenure constitutes a major obstacle to a sustainable and efficient use of natural resources. Consequently, livelihoods and food and nutrition security are jeopardized because many fishing communities suffer from insecure access to the resources on which they depend. However, while access to fishery resources is a key consideration, it is important to understand that fishing communities also depend on access to other resources and services such as land, housing, markets, financial resources, information, legal systems and social services (e.g. education, health care, sanitation). In fact, land and fisheries tenure rights often need to be combined. Fishing communities need secure use rights to fishery resources and to land in coastal, lakeshore or waterfront areas for ensuring and facilitating access to the fishery, for accessory activities (including processing and marketing), and for housing and other livelihood support. This is all the more critical for fishing communities that are likely to be marginalized and/or poor sectors of a society.

KEY ISSUE 2: TENURE RIGHTS IN FISHERIES

The preliminary technical guide notes that tenure rights in fisheries are often referred to as "use rights" and exist in many different forms consisting of various bundles of entitlements that confer both privileges and responsibilities.[4] They can be formal and legally recognized or informal and customary (or traditional). The development of formal tenure arrangements in fisheries has tended to focus on access to fisheries and use of fishery resources, and in this context the terminology of "rights" is often more commonly used than "tenure". Fisheries tenure rights are typically seen as part of a broader fisheries governance and management framework. Thus, tenure is a useful term because it indicates the broader system of rights – formal and informal, traditional and customary – and includes social and societal notions of rights that individuals, groups of people or communities may have to a fishery resource. In addition, because wild fishery resources are common property (i.e. not owned by individuals or groups), live in the water where they are difficult to see and rarely keep within set boundaries, it is often more difficult to determine who is entitled to them or has rights to harvest them than it is for terrestrial resources. This is why the discussion to date has tended to focus on who may "use" (not "own") shares or portions of sustainable catches of fish stocks.

The preliminary technical guide also addresses the frequent misconception that rights-based fisheries management regimes imply the privatization of resources. Most coastal resources are likely to already have some form of (often collective) management systems. These may be either customary arrangements applied by local fishing communities or systems that have been replaced by central management. Customary tenure rights of a community include the collective rights of its members to the natural commons as well as individual rights to specific land parcels or natural resources. Informal tenure rights are tenure rights that lack formal, official protection by the State and often arise spontaneously, e.g. in areas affected by migrations. Nonetheless, these rights can still be legitimate because they are covered by, for example, international laws and conventions, treaties or other legal instruments although not explicitly included in national tenure legislation. While formal tenure rights have been implemented in fisheries in the last 25 years, there is a much longer history of customary and traditional tenure systems in fishing communities[5] that dates back centuries. These have tended to be in the form of rights to fish in certain areas – i.e. spatial access or use rights – and have often been found in conjunction with land tenure, making it important not to view fisheries tenure in isolation but within a broader land and livelihoods context.[6]

Many formal tenure systems are based on rights that were initially customary. In some countries, customary tenure rights have received formal legal recognition equivalent to other statutory tenure rights. However, in other countries, they lack legal recognition. In the latter, rights holders often cannot easily defend their customary rights in cases of competition from other resource users. The expansion of tourism, port or harbour infrastructure projects and industrial progress have increasingly led to claims by other interest groups and resource users on land in coastal areas traditionally held by fishing communities. The move towards rights-based fisheries management systems rests on the notion that fisheries will generate more benefits and do so more sustainably if users have stronger rights. Thus, rights-based fisheries management is a concept that focuses on the privileges and rights – and responsibilities – in the form of common, collective or individual rights relating to catching fish.

KEY ISSUE 3: THE BENEFITS OF RESPONSIBLE GOVERNANCE OF TENURE IN FISHERIES

By giving users a stake in a resource, the logic is that more responsible behaviour will result and that the incentives behind the "race for the fish" will be dismantled, resulting in greater interest in the responsible use and management of the resources. However, for this approach to work, the preliminary technical guide points out that the right given to a user or a group of users has to be secure subject to compliance with agreed conditions – if the risk is high that the right will be taken away without breach of conditions, the incentive to manage the fishery sustainably beyond the period of expected use is diminished. The Guidelines state that (§4.3) "no tenure right, including private ownership, is absolute. All tenure rights are limited by the rights of others and by the measures taken by States necessary for public purposes".[7] While this is a necessary premise of tenure of natural resources in general, it should be noted that long-term secure tenure is an important element in successful rights-based fisheries management. Nonetheless, as with all management systems, rights-based regimes built on the foundation of secure tenure need to be complemented with other management measures to ensure sustainable resource use.

The preliminary technical guide also emphasizes that responsible governance of tenure entails that tenure rights: (i) are recognized, defined, allocated and administered in a fair and equitable way; (ii) respect human rights and reflect societal objectives; and (iii) recognize the potential of the small-scale fisheries sector to contribute to food security and nutrition, poverty eradication, equitable development and sustainable resource utilization. Especially in the context of small-scale fisheries, responsible governance of tenure is grounded in a human rights perspective and the right to secure and just livelihoods, including social and economic rights, as well as rights to related resources (such as land). Linking fishing rights and human rights reflects a move towards an approach more in line with the reality of the diverse livelihoods of small-scale fishing communities and the complexities of poverty, considering also the linkages with poor and weak governance.

KEY ISSUE 4: ACHIEVING RESPONSIBLE GOVERNANCE OF TENURE IN FISHERIES

The Guidelines provide an international framework for the implementation of responsible tenure that can and should be applied at all different scales, from local to national and regional levels. Highlights of this include partnerships and stakeholder involvement, recognition of existing rights, equitable access and capacity development. There are different pathways for improving governance of tenure, and the starting point for the necessary reform is not always the same as it depends on the political-economic context. Opportunities may present themselves that constitute entry points for introducing more responsible tenure governance at the different levels, for example:

- a more general need for overall policy reform and/or adjustments to legal frameworks at the national level with regard to fisheries governance and management;
- a need to address overcapacity and overfishing threatening the economic viability and biological sustainability of resources within a specific fishery;
- a need to resolve conflicts between different stakeholder groups or resource users.

The Guidelines and the preliminary technical guide call attention to the fact that the full implementation of responsible tenure is a long-term commitment requiring partnerships and collaboration and allowing sufficient time for participatory approaches and buy-in by stakeholder groups. Consultation and participation should form the basis for any decision-making and policy formulation with regard to tenure in the fisheries sector. Decision-making at the lowest possible decentralized level (the subsidiarity principle) should be encouraged in a way that results in transparency, accountability and equity. A key first activity when planning and implementing a new or modified tenure rights system is to carry out a stakeholder analysis and to review existing tenure systems. Legitimate customary and traditional use rights, including those of fishworkers, must be considered as part of formalizing and allocating additional rights. In addition, where there are migrant fishers and fishworkers, tenure rights in the context of access to both fishery resources and other resources (including land) and services may be needed in order to formalize customary entitlements so as to secure livelihoods.

Fisheries management and tenure (and, hence, the administration of such tenure) tend to be under the responsibility of a fisheries department or authority, but other authorities may also be involved. To cater for the often multiple and interlinked needs of small-scale fishing communities – including access to land and other resources required for sustainable livelihoods, and taking a holistic rights-based approach to governance and development – the preliminary technical guide highlights that cross-sectoral linkages and collaboration with other government departments and/or stakeholders are required in order to ensure that the competences are available to deliver quality services. A basic premise, especially in the small-scale fisheries sector, is that natural resource and ecosystem management and social and economic development should be viewed together, and so tenure rights arrangements should be assessed, allocated and administered in this context.

Many issues relating to competing uses of resources can be resolved by applying transparency and policy coherence and by using cross-sectoral coordination, broader spatial management frameworks, and consultative and participatory processes for spatial management. However, at the national or local government level, there is a need to put systems in place that allow for legal arbitration of tenure conflicts, both when conflicts have arisen between different users or when there is disagreement with government decisions. In this regard, it is important to ensure that all parties have equal access to the judicial systems and processes. Support mechanisms may be required for weaker stakeholder groups that may be disadvantaged, for example, through illiteracy and low levels of education. In this context, it is essential that all stakeholders are aware of their rights and that governments support awareness raising and capacity development with respect to the Guidelines. For effective participation and decentralization, individuals and communities need to possess, or have the ability to gain, the skills and capacities to participate on an equal basis, and appropriate institutional structures and processes need to be in place to allow for this participation.

With regard to fisheries and related to the decision on the type of rights, the preliminary technical guide emphasizes that it is necessary to determine whether rights should be distributed to individuals, groups of individuals or communities. Decisions on who should receive rights are likely to be based on a combination of current circumstances and historical involvement in a fishery. Where there are customary community rights, these rights may be strengthened and remain with the community or be allocated to a group of users (e.g. a fishers association) as collective rights, to be subsequently further distributed within the community or user organization. Mechanisms for allocating rights range along a spectrum from market-based approaches, by which tenure rights are auctioned or sold in other ways, to allocation panels or boards engaging in a political process that takes account of customary rights, catch history, alternative livelihoods, vulnerability, maintenance of rural communities, etc.

Other questions to address in designing fisheries tenure rights systems include whether the rights allocated by government should be permanent or of some more temporary duration. The choice between permanent and more temporary rights mainly revolves around a balance between two aspects: management flexibility, and sustainable use and conservation incentives. Having some limitations on the duration of rights gives government the possibility to reallocate rights if societal objectives or other circumstances change, but it does make tenure rights less secure and less valuable. Permanent rights require a decision at the outset on who should be a user and, hence, also on who should be initially excluded. Permanent or longer-duration rights give more security to fishery users as well as "a stake in the well-being of the resource further into the future and an incentive to 'plan for the future' in husbanding the resource."[8] There is no optimal trade-off between these aspects, and tenure rights arrangements may need to be given additional features to capture the desired effects, e.g. attaching conservation or other performance criteria to the option of renewing short-duration rights.[9]

The preliminary technical guide also notes that other questions relate to transferability and whether rights holders should be allowed to transfer their entitlements to other users. With regard to transferability, good practices in small-scale fisheries call for attention to local cultural and institutional factors in only allowing limited transferability. For example, temporary transferability could be allowed (e.g. within a fishing season) as a means to provide important short-term flexibility while maintaining long-term stability in the distribution of the rights. Permanent or long-term transfers may be considered reasonable within communities, households or families, not only through the use of market mechanisms (buying and selling rights). This is particularly important in imperfect markets where market mechanisms could lead to a shift of the rights to those with greater access to credit, information and related aspects of power. This could have negative effects on rural livelihoods and on the stability, sustainability and equity in the community and coastal economy.[10] As is often the case, tradable tenure rights (tradable quotas, individual transferable quotas, etc.) may be appropriate in some contexts but not in other situations. What is essential is that States should be aware of the benefits and drawbacks of limiting transferability in relation to securing benefits for small-scale fishing communities.

CONCLUSION

The preliminary technical guide emphasizes that, ultimately, it is the particular circumstances, the outcomes of consultative processes and the political decisions on what the tenure system should achieve that will decide on:

- what type (or types) of rights systems to set up;
- what types of rights should be allocated;
- how rights should be allocated;
- the duration and transferability of such rights.

It is fundamental to have clear objectives for the tenure rights system and to recognize that different solutions are needed in different situations. There are many different variations of the types of rights and tenure systems, and tenure systems may also need to be designed to adapt to new conditions and be able to evolve over time.

Transition from low-value fish to compound feeds in marine cage farming in Asia

INTRODUCTION

Background and rationale

Marine finfish aquaculture is a rapidly growing subsector in the Asia-Pacific region. High-value carnivorous fish species (e.g. groupers, barramundi, snappers and pompano) are typically raised in small cages in inshore environments. However, there is a move towards offshore mariculture using larger and stronger cages in China. The species cultured depend on salinity. Hatchery technology, developed and commercialized in China, Taiwan Province of China, Indonesia, Malaysia and Thailand, has reduced reliance on seed from the wild for a number of species. However, the high-value carnivorous fishes continue to be fed with low-value (trash) fish[11] from the wild, often comprising juveniles of potentially valuable species.[12]

Total production of cultured marine (and brackish-water) carnivorous finfish in the Asia-Pacific region in 2008 exceeded 600 000 tonnes, of which 75 000 tonnes was grouper.[13] Feed conversion efficiency is poor with the use of low-value fish ranging from 7:1 to 15:1 in average grouper farming practices.[14] Farmed groupers are almost exclusively raised on low-value fish, which means that at least half a million tonnes of fish had gone into grouper production in 2008 and about 4 million tonnes overall. The increasing demand for grouper and other carnivorous marine species will further drive mariculture expansion. Unless farmers shift to formulated feeds, this growth cannot be sustained for the following reasons:

- The increasing harvest of low-value fish to feed farmed fish could negatively affect the ecology of the fishing grounds.
- The continuing use of low-value fish could contribute to the deterioration of the environment.
- The use of low-value fish as feed may not be economically sustainable.
- The ethical issue of feeding fish with fish that could be used for human food is an increasing constraint to market access.

Thus, from the social, economic and environmental standpoints, it is highly desirable to promote the transition from low-value fish to formulated feed. Although such feeds may well contain fishmeal and fish oil, these are increasingly derived from sustainable dedicated fisheries or from fish offal that are considered less detrimental to the ecosystem and biodiversity than unselective low-value fisheries.[15] Moreover, using compound feeds requires only about one-third of source fish input compared with low-value fish feed (see below). However, achieving the transition is fraught with complications. The first difficulty is the structure of the sector. Most marine fish farmers are independent small-scale operators, and the supplies of low-value fish come from a mix of small and medium artisanal fishers in Southeast Asia and large commercial trawlers in China. The supply chain includes intermediaries that usually have preferential relations with the fish farmers, and suppliers have yet to develop business arrangements to make formulated feeds easily accessible to the small-scale cage culture farmers, as they have done for the shrimp, tilapia, seabass or pangasiid catfish farmers. The second issue is the lack of an operational understanding of farmers' perceptions of the comparative benefits of the use of low-value fish and formulated feeds and a scientific assessment of their farming practices and livelihood strategies. The third is the lack of organized scientific information and technical assistance to: (i) persuade farmers that it is in their immediate and long-term business interests to switch to formulated feed; and (ii) serve as guidelines for policies that include regulations and market-based incentives to make it more profitable for farmers to use formulated feed rather than low-value fish.

As these issues pervade the mariculture subsector of the region, a regional project to address them was deemed a cost-effective approach – it would create synergies from the sharing of information generated by the country components of the project.

FAO Fisheries and Aquaculture Technical Paper No. 573[16] presents the findings of an FAO Regional Technical Cooperation Project "Reducing the dependence on the utilization of trash fish/low-value fish as feed for aquaculture of marine finfish in the Asian region", which was implemented in four countries in Asia (China, Indonesia, Thailand and Viet Nam) between 2008 and 2011. These are reviewed below.

Objectives

The goal of the project was to reduce fish farmers' dependence on low-value fish. Embodied in this statement were the higher goals of sustaining biological diversity and better livelihoods. Its objectives were to: eliminate misconceptions among farmers on the use of alternative feed resources and demonstrate their economic, ecological and environmental benefits; contribute to the development of better feed management practices in small-scale carnivorous finfish farming that improve the efficiency of feeding practices and market access through compliance with importing country standards for culture practices; improve farmers' management skills; and provide policy, management and technical support that would encourage a shift to formulated feeds. An important social objective, addressed to the fishers and suppliers of low-value fish, was to mitigate the impacts on their livelihoods of switching to pellet feeds.

Project framework

In development terms, the main aim of the project was to contribute to the sustainability of the livelihoods of small-scale marine finfish farmers. Reducing dependence on fish as a feed resource would also conserve inshore fish resources.

The envisioned outcome was the long-term viability of finfish mariculture and improved livelihood of farmers, facilitated by strengthened public and private sector institutions and appropriate policy. A social contribution was the improvement in the welfare of the poorer segment of the population that depends on mariculture for a living. These were attained by eight project outputs:

- information on the livelihoods of people involved in the supply of low-value fish, input marketing channels input, farmers' perceptions, and constraints to adopting pellet feeds;
- farmers associations organized and trained to form the country's nucleus for disseminating project findings;
- scientific data collected and analysed on the technical and economic performance of small-scale farms using low-value fish and compound pellet feeds – including constraints to the adoption of better feed management practices and information on changes in farmers' perceptions;
- information material describing the economic and social advantages of compound feeds;
- identifying business relations between farmers groups and feed suppliers that can facilitate feed procurement and inform a microcredit scheme;
- strengthened capacity of government personnel to provide advice on feed management in small-scale mariculture systems;
- assessment and comparison of environmental impacts of low-value fish and formulated feed;
- monitoring system established to assess farmers' perceptions and attitudes towards formulated feeds and their environmental impacts.

PROJECT ACTIVITIES

The sequential and simultaneous activities carried out to produce the above outputs included:

- an inception and planning workshop;
- four in-country planning and awareness-raising stakeholders workshops;
- assessment of the livelihood assets, opportunities and perceptions of fishers and traders;

Table 18
Locations and species used for the farmers participatory trials

	China	Indonesia	Thailand	Viet Nam
Region / administrative areas	Guangdong	Bandar Lampung	Phuket, Krabi and Phang Nga	Nha Trang
Implementing institutions	Guangdong Provincial Aquatic Animal Epidemic Disease Prevention and Control Centre	Main Centre for Mariculture Development	Phuket Coastal Fisheries Research and Development Centre	Research Institute for Aquaculture No. 3
Species	Crimson snapper (*Lutjanus erythropterus*) Orange-spotted grouper (*Epinephelus coioides*)	Brown-marbled grouper (*Epinephelus fuscoguttatus*)	Barramundi (*Lates calcarifer*) Brown-marbled grouper (*Epinephelus fuscoguttatus*)	Snubnose pompano (*Trachinotus blochii*) Crimson snapper (*Lutjanus erythropterus*)

- on-farm participatory trials to compare the performance of both feed types (Table 18);
- analysis of the farmers' perceptions of low-value fish and pellet feeds before and after the trials;
- environmental impact assessments to compare the effects of low-value fish and pellet feeds on the culture site;
- second set of in-country workshops to report on the progress of the trials and the environmental impact assessments, suggest improvements for increasing feed efficacy, feed management efficiency and farmer practices, and suggest means to facilitate access to formulated feeds;
- organization of farmer clusters and development of extension materials;
- final regional workshop to consolidate the results from the project components and formulate recommendations;

Table 19
Results and envisioned outcomes of the project

Component	Findings	Key results	Contribution to objectives	Recommended products
Farmers participatory trials	• Comparative technical and economic efficiencies • Farmers feed management practices • Quantitative and qualitative variations associated with efficiencies	• Critical factors of efficiency and profitability: – practices – feed quality – feed specificity to species and size – reliability and quality of seed supply	• Biological, technical and economic arguments for promoting the use of pellet feed • Better feed management • Feed manufacturers' awareness of technical constraints to adoption • Improvement of breeding, seed production and supply systems	• Better management practices (BMPs) • Technical manuals • Farmers associations • Capacity building programme • R&D programme
Survey of farmer perceptions on feed type and credit	• Technical basis of perceptions • Technical and social-cultural constraints to adopting pellet feeds	• Economic, social and cultural basis for changes in perceptions • Attitude towards microcredit	• Communication, extension strategy • Credit access	• Extension materials • Advisory on credit provision • Crop insurance (market and public)
Environment study	• Risk factors from: – feed type – feed quality – feeding practice • Impacts of feed type on culture site • Energy use by feed type • Fish resource use by feed type	• Feed quality control • Feeding practice • Farm management • Farm siting	• Arguments and some guides for zoning • Site selection, carrying capacity study, regulations	• BMPs • Technical guides for site selection • Guides for licensing and area management
Livelihood analysis of fish suppliers	• Characterize threats to traditional livelihoods • Assess livelihood strategies and options	• Adaptation strategy • Alternative livelihoods	• Fishery resource management	• Policy guides: incentives vs subsidies • Key areas for technical and economic assistance

- a mission, 16 months after the trials, to Indonesia, Thailand and Viet Nam to assess the status of the marine cage farming industry, evaluate farmer uptake of the project recommendations, refine the recommendations and develop follow-up projects to address common issues.

SYNTHESIS OF PROJECT FINDINGS

Project components

The project components were: (i) participatory on-farm trials to compare the performance of low-value fish and pellet feed; (ii) surveys to assess farmers' perceptions of the use and performance of the two feed types and their access to and preference for credit; (iii) environmental study to determine the impacts of the use of low-value fish and pellet feeds; and (iv) livelihood analysis of fishers and suppliers of low-value fish.

Outcomes

The long-term outcome of the project would be the transition from low-value fish to commercial feed. Two shorter term outcomes are the reduction in farmers' dependence on low-value fish and their adoption of better management practices (Table 19).

Farmers' participatory trials

The farm trials demonstrated the technical feasibility and economic viability of using pellet feed to replace the direct use of low-value fish in marine finfish culture in cage. Generally, feed type did not make much of a difference in fish growth or cost performance.

Between countries, there were differences in the feed cost of production – more a result of the prevailing cost of pellets and low-value fish in each country rather than of fish growth performance.

Management practices, fish growth and feed utilization varied widely between farmers in a country and between countries. Lack of experience in managing pellet feeds curtailed the effectiveness and the results of using pellet feeds. Management practices were not standardized.

The trials in the different countries were not strictly comparable because of differences in species, feed types used, environment and sites, and the varying management practices between farmers.

Species-specific diets for marine fish species are lacking for the majority of species cultured. The differences in performance were the result of feed management practices or possibly poor-quality low-value fish.

Practices and perceptions toward feed type and access to credit

Across the countries, marine cage farmers' practices and perceptions had some similarities with some differences in their perceptions towards the two feed types and their access to and usefulness of credit.

Most farmers culture more than one species. The number of cages per farm varied from 2 to 590, with averages of 96 in China, 53 in Indonesia, 25 in Thailand and 28 in Viet Nam.

Satiation feeding is practised by most Chinese farmers and more than half of Vietnamese farmers. Farmers in Indonesia and Thailand follow more controlled ration feeding. Almost all farms in China and Indonesia and more than half of Vietnamese farms use pellet feeds; the practice is not so common in Thailand.

Farmers have to cope with variations in fish quality, especially during the monsoon and closed fishing seasons, when sourcing low-value fish. Farmers in Indonesia, Viet Nam and Thailand believe more than Chinese farmers that feeding low-value fish results in better growth and quality. Most farmers in China and Viet Nam believe feeding pellet feeds is profitable, most farmers in Indonesia and Thailand do not think so.

Most farmers are willing to use pellet feeds, but prefer that the feed be species-specific and suited for the growth stage. While farmers understand the pros and cons of using low-value fish and pellets, they lack the scientific management guidelines.

Microcredit sources are mainly the banks. Farmers complained of high interest rates, difficult and lengthy procedures and the limited amount they were eligible to borrow. Loans were used to build farm structures and purchase inputs.

Environmental impact study

The study found:

- There were no significant differences, regardless of species, in the environmental impacts associated with feeding either low-value fish[17] or commercial pellets. However, there were increases in the bacterial loading and release in low-value fish stored on ice before feeding. Pellet feeds leached more nutrients into the waters.
- The energy (including fuel) required to produce a kilogram of fish using low-value fish was lower than that required when using pellet feeds. However, the "fish in, fish out" ratio for the production of a unit weight of marine fish was about three times lower with pellet feeds than with low-value fish.
- The lack of significant measurable differences in the impacts of feed type on water and sediment quality could be attributed to the low stocking densities used in the farm trials. Higher stocking densities and input levels could have produced different results. This affirms the significance of control measures such as zoning to limit farm numbers, and fish and feed inputs to ensure that effluent loads remain within the assimilative capacity of the environment.

However, the study reveals that, depending upon the feed type and source, there are significant differences in the energy required to produce one kilogram of fish. For example, the energy used ranged from 3.96 MJ/kg fish in Thailand when using a small boat to catch low-value fish, to 44.35 MJ/kg fish in Thailand and Viet Nam when using pellet feeds, and 81.48 MJ/kg fish for commercial trawlers catching low-value fish as a bycatch in Indonesia. These values show that much higher energy is embodied in the amount of pellet feeds[18] required to produce one kilogram of farmed fish than in low-value fish. While this might raise concern, the issue should be framed not in terms of pellet feed vs low-value fish, but rather the use of fishmeal vs other ingredients in pellet feed formulations. The study notes that reducing the energy cost and the amount of fish needed to produce a unit weight of marine fish are issues that can be addressed at the farm level. Ultimately, the pollution, energy and "fish in, fish out" issues are to be addressed at the farmer level by improving general farm management, in particular by promoting the efficient use of feed and better management practices.

Livelihood analysis and perceptions

The baseline survey of the livelihood status, prospects and strategies of fishers and traders of low-value fish showed differences between fisher households across countries. Chinese suppliers use large vessels, with fishing as the sole source of income of most households. These larger boats generate higher incomes than those in the other countries, where fisher households engage in diverse activities to supplement incomes. Some earned more from these than from fishing.

The livelihood patterns of fisher households vary between the countries as does their access to livelihood assistance. Sources of advice and assistance are widely available and accessed in Thailand, least available in China.

Fishers in China appeared to be the most vulnerable to a shift to pellet feeds as their livelihood options are limited.

Cross-cutting issues

The central issue is how the reliance of small-scale farmers on using low-value fish as a feed can be reduced, their profitability improved, and the sector sustained. A number of biological, technical, economic and social-cultural issues were associated with this problem. Their discussion identified practical issues of policy, capacity building and institutional strengthening. The list of cross-cutting issues generally reflects the recommendations of an FAO Expert Workshop held in Kochi, India, in 2007.[19]

CONCLUSIONS

Overall, the project findings support the view that pellet feeds are a viable alternative to low-value fish. Although low-value fish is likely to remain the predominant feed source for farmed marine fish in most countries for the foreseeable future, a better understanding of the dynamics of its use, quality, and price, and its role in fishers' livelihoods, is required to inform strategies to ease the industry's transition to pellet feed without disrupting the livelihoods of fishers and fish suppliers.

In general, the pellet feeds used in the farm trials were non-species specific and of varying quality. Inexperience probably reduced their efficacy in the trials. The greatest potential for improvements lies in better management practices. Improvements in feed management practices regardless of feed type would improve feed utilization, environmental sustainability and profitability. In the project, the farmer trials generally changed farmers' perception that feeding with pellet feeds leads to poor growth and lower quality.

Banks are usually reluctant to lend to the subsector because of the high risks associated with marine cage culture. Microcredit would improve farmers' ability to take up better management practices, possibly facilitate a switch to pellet feeds, and remove dependence on low-value fish traders. The high risks of marine cage fish culture make small-scale farmers economically vulnerable.

Farmers' clubs/associations can achieve benefits such as bulk order discounts on feed and joint marketing of products. Organizing small-scale farmers increases leverage and generates economies of scale. It is possible to achieve a step-wise recognition of organized farmer groups by government authorities, technical institutions, and commercial input providers that leads to the provision of credit, crop insurance, cluster development, certification, production, marketing and other services. Often, a poor understanding of the value chain and the lack of access to market information mean that farmers receive low prices for their fish.

The lack of marine cage culture site selection, zoning and integrated coastal zone management policy and regulations are issues in China and Indonesia. The study sites suffered from overcrowding, conflicts with other resource users, and problems with water quality, disease and fish mortalities. Zoning and better management planning of current and new sites would avoid these social and environmental problems.

Marketing issues are common with many farmers having a minimal understanding of the market chain. There can be large discrepancies between prices paid at the farm gate and wholesale prices. Measures to resolve such issues include providing real-time information on fish prices in the destination markets, group marketing and shortening the market chain by reducing reliance on intermediaries.

In terms of environmental impacts, the study highlighted that it is the intensity of feeding rather than the feed type that has more local impact on water and sediment quality. Overfeeding is one of the greatest influences on the amount of excess nutrients entering the environment. Feed conversion ratios can be improved by providing the correct feed amount, and optimizing feed duration, frequency and timing.

The estimated energy cost (including fuel) of producing one kilogram of farmed fish was significantly lower when using low-value fish than pellet feeds if the low-value fish were harvested using small boats in artisanal fishing. The reason is that the embodied energy in the pellet feed is much higher than it is in the low-value fish. This is a useful consideration in terms of farm level feed use efficiency.

"Fish in, fish out" ratios showed that up to three times more fish is needed to produce one kilogram of fish when low-value fish is used compared with pellet feed. This finding can reinforce the feed conversion ratio as an economic argument to farmers to use pellet feeds.

In terms of fishers' livelihoods, the project showed that the transition by farmers to pellet feeds has consequences on income earned from fishing and the availability of other livelihood options. However, the livelihood capitals available that would enable them to cope with threats to their fishery-based livelihoods are adequate for the Thai, Indonesian and Vietnamese fishers. They have land for crop cultivation, a mix of informal and formal sources of credit, and adequate family labour for cage culture and fishing. Chinese fishers enjoy subsidies for fuel (as well as a government pension plan). However, the subsidy may work against the sustainability of their livelihoods as it maintains pressure on an already depleted fishery resource.

Traders in low-value fish perform an important service by providing fish on terms convenient to the farmers. This strong social relation could slow farmers' transition to commercial pellet feed. An easy-access institutional credit scheme for farmers could reduce this dependence.

RECOMMENDATIONS

The project generated a number of recommendations relating to the countries involved in the study. However, some of these have a more general validity and wider application in the region and beyond.

Regarding pellet feeds, it is important to develop species-specific diets for marine finfish species, defining the nutritional quality, type of ingredients and formulation. The public and private sectors should be encouraged to study the nutritional requirements of important cultured marine finfish species under different environmental conditions. Manufacturers should be encouraged to develop appropriate pellet feeds for marine species and make them easily available and affordable to the small-scale farmers.

Low-value fish will continue to be widely used in marine finfish culture for the forseeable future but there is a limited knowledge of its origins, seasonal availability, the seasonality of the dominant species, quality changes, price changes along the value chain, and its other attributes. Studies need to be undertaken on low-value fish to determine the quantities used, product quality, and its impact on the ecosystem, biodiversity and the environment.

It is necessary to develop and promote the use of better management practice (BMP) guides. Some of the findings on feed types and management can be incorporated into the BMPs. The BMPs could also be modified into specific technical guidelines for marine cage finfish farming in accordance with the Code of Conduct for Responsible Fisheries.[20] The BMPs should emphasize the resource, economic and environmental impacts of using both types of feed, and the different feed management practices required in small-scale marine cage culture.

Technical manuals on better feed management practices at the farm level should be developed. Farmer clusters, clubs or associations should be encouraged and assisted to facilitate the adoption of BMPs and generate economies of scale for small farmers.

The findings of this and other similar projects should be disseminated widely to farmers and other stakeholders. The media to be used would include reports and documents, extension materials and BMP manuals for farmers translated into local languages. Articles could be written for scientific journals. A number of dissemination activities have been tried at the project scale; these and other means need to be scaled up to open up opportunities for cooperation between government, the private sector and farmers associations.

At the policy level, the orderly expansion of mariculture will be facilitated by zoning, development of an integrated coastal management plan for existing and potential sites, and identification of new sites for mariculture. The regional workshop recommended the development and implementation of integrated coastal zone management and the development of policy and technical guidelines for offshore mariculture.

The formation of small-scale farmer groups operating as clusters or organized as clubs should be encouraged and promoted further, also using the models developed in India and Viet Nam. These models use a step-by-step approach to club formation and result in improved access to technical and financial services, marketing, and the promotion of good governance.

Challenges and opportunities in the utilization of fisheries by-products

Globally, almost 70 million tonnes of fish are processed by filleting, freezing, canning or curing.[21] Most of these processes result in by-products and waste. For example, in the fish filleting industry, the product yield is often about 30–50 percent. Global production of tuna species was 4.76 million tonnes live weight in 2011 while that of canned tuna was almost 2 million tonnes in product weight. Solid wastes or by-products generated by the tuna canning industry could be as high as 65 percent of the original material, and this includes heads, bones, viscera, gills, dark muscle, belly flaps and skin. The tuna loin industry reportedly generates about 50 percent of raw material as solid wastes or by-products. Global production of farmed salmon was about 1.93 million tonnes in 2011; most of the fish are filleted, and some of these fillets are smoked before marketing. The fillet yield in salmon is reportedly about 55 percent. A large proportion of farmed tilapia (global production about 3.95 million tonnes in 2011) is marketed in filleted form, and the fillet yield in this species is about 30–37 percent. Annual production of *Pangasius* exceeds a million tonnes, most of it going for distribution in filleted and frozen form. The fillet yield in this species is about 35 percent. Thus, fish processing generates considerable quantities of by-products and meat from most portions such as heads, frames, belly flaps, liver and roe. These contain high-quality proteins, lipids with long-chain omega-3 fatty acids, micronutrients (such as vitamin A, D, riboflavin and niacin) and minerals (such as iron, zinc, selenium and iodine).

UTILIZATION OF BY-PRODUCTS FOR HUMAN CONSUMPTION

Cod processing industries in Iceland and Norway have a long tradition of using by-products for human consumption. In 2011, Iceland exported 11 540 tonnes of dried cod heads, mainly to Africa, and Norway exported 3 100 tonnes.[22] Cod roes can be eaten fresh after heat treatment, or they can be canned or processed into roe emulsions for use as sandwich spread. Cod livers can be canned or processed into cod liver oil, which people were consuming long before the health benefits of long-chain omega-3 fatty acids were recognized. A 2010 study[23] in the Norwegian salmon industry showed that, of the 45 800 tonnes of heads, frames, belly flaps and trimmings generated by five of the largest companies in the filleting industry, 24 percent (11 000 tonnes) went for human consumption, with the rest processed into feed ingredients. Production of salmon mince or scrape meat from by-products for use in patties and sausages is gaining in popularity. When gutting and filleting of salmon takes place at the end of the supply chain (e.g. in supermarkets), customers may purchase the heads, frames and trimmings for use in soups or other dishes.

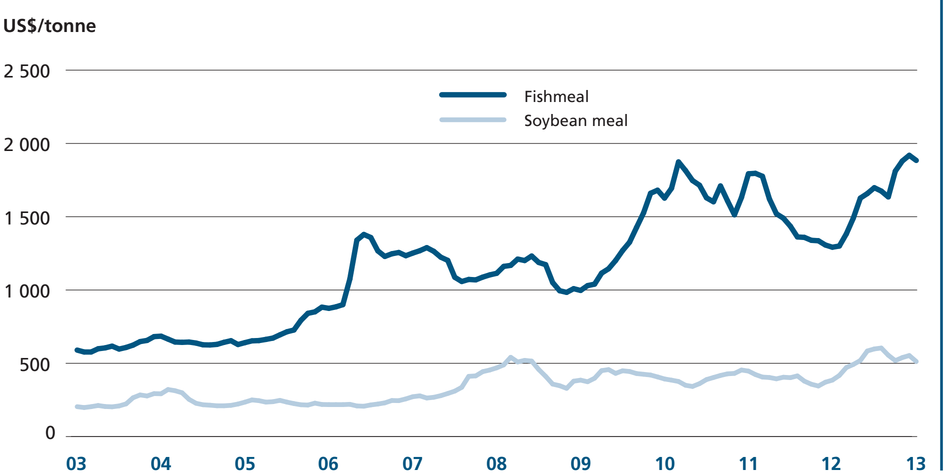
The tuna industry has made significant progress in the utilization of by-products for human consumption. Thailand is the world's largest producer of canned tuna and annually exports about half a million tonnes of it, utilizing domestic landings and imports of about 0.8 million tonnes of fresh or frozen raw material. What goes into canned tuna is only about 32–40 percent of the raw material. The dark meat (10–13 percent) is packed in cans or pouches as pet food. One by-product company in Thailand produces about 2 000 tonnes of crude tuna oil annually, which is further refined for human use. Fully refined tuna oil has 25–30 percent docosahexaenoic acid (DHA) in addition to eicosapentanoic acid (EPA), and it helps to fortify food products such as yoghurt, milk, infant milk formulas and bread.[24] During the canning process, tuna is precooked before trimming and packing into cans. The cooking juice has up to 4.8 percent proteins and a chemical oxygen demand of 70 000–157 000 mg/litre. In Thailand, the canneries hydrolyse the cooking juice with commercial enzymes and concentrate the juice, and this concentrate is used as a flavouring agent or sauce or condiment.

After Thailand, the Philippines is the second-largest producer of canned tuna in Asia. In 2011, its tuna catch was 331 661 tonnes live weight, with a meat recovery rate for canned tuna of about 40 percent. The dark meat (accounting for about 10 percent) is canned and some is exported to countries such as Papua New Guinea.[25] Dark meat is of higher nutritional quality than light meat owing to a higher content of long-chain omega-3 fatty acids, minerals such as iron (mainly in the form of haem iron, which has high bioavailability), and some vitamins.[26] However, it is necessary to preserve dark meat under antioxidative conditions, such as canning, as the polyunsaturated fatty acids are prone to oxidation. The local population use the heads and fins in fish soup. Visceral organs such as liver, heart and intestines are ingredients in a local delicacy, "sisig" (traditionally made from diced ears, bits of brain tissue and chopped skin from the head of a pig, cooked in oil with spices and served sizzling on a heated earthenware plate). Visceral organs of tuna are also raw material for fish sauce production. Tuna roe, gonads and tail parts are frozen and sold for human consumption on the domestic market in the Philippines. The Philippines also produces fresh-chilled/frozen yellowfin and bigeye tuna for export. By-products such as heads, bones, belly, fins, ribs, tail and black meat account for about 40–45 percent of the weight of the raw material. These are sold on the local market for human consumption. Heads, bones and fins are main ingredients in soups. The tail, belly and collar bone are frozen, sometimes vacuum packed and distributed through grocery stores, supermarkets and seafood restaurants throughout the Philippines. Before consumption, they are fried, grilled or stewed. Scrap meat goes into sausage, nuggets, burger patties, tuna ham, tuna fingers and local recipes such as "siomai" and "embutido".

Snack foods from tilapia skin are popular in Thailand and the Philippines, where skin with the scales removed is cut into strips, deep fried and served as an appetizer. In some countries, the trimmings and heads from the filleting industry are used in soups and ceviche. Equipment to recover flesh through deboning is available, and the recovered flesh forms a base for fish sticks, fish sausages, fish balls and fish sauce.[27] In Viet Nam's Pangasius processing industry, the fillet yield is about 30–40 percent and the by-products go mainly to fishmeal, but some companies do produce Pangasius oil suitable for human consumption. Dark muscle and trimmings are used along with potato or rice in fish minces that are marketed locally in Viet Nam.

Figure 43

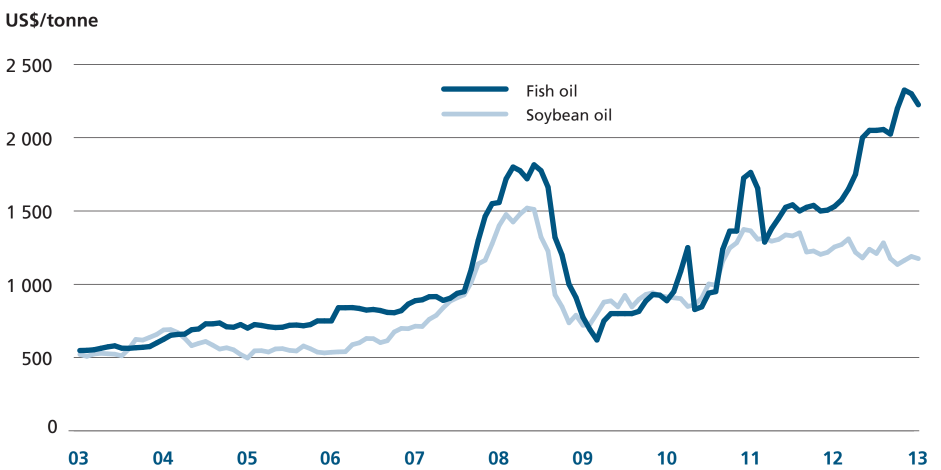
Trends in the price of fishmeal and soybean meal



Source: FAO. 2013. FAO Fisheries and Aquaculture Information and Statistics Branch. Rome.

Figure 44

Trends in the price of fish oil and soybean oil



Source: FAO. 2013. FAO Fisheries and Aquaculture Information and Statistics Branch. Rome.

UTILIZATION OF BY-PRODUCTS FOR ANIMAL FEED

Global demand for fishmeal and fish oil has been increasing, as have their prices (Figures 43 and 44). Hence, these are no longer low-value products. There is an increasing trend in the use of pelagic fish directly for human consumption rather than for fishmeal and this, combined with measures such as tight fishing quotas and improved regulation and control of feed fisheries, has contributed to the increase in the prices of fishmeal and fish oil. As a result, the proportion of fishmeal coming from fish processing by-products increased from 25 percent in 2009 to 36 percent in 2010.[28] Thailand, Japan and Chile are large producers of fishmeal from by-products.[29] According to estimates by the International Fishmeal and Fish Oil Organisation, the aquaculture industry utilized 73 percent of the fishmeal produced in 2010 and, therefore, this product contributes indirectly to food production. In the case of fish oil, the estimates are that 71 percent goes for aquafeed and 26 percent for human consumption.

In many countries, fish processing establishments are small or medium-sized, and the amount of processing by-products generated may not be sufficient to justify running a fishmeal plant. Producing silage from these by-products would be a convenient and relatively inexpensive way of preserving them. This is common practice in Norway, where silages from different farmed salmon slaughtering plants go to a centralized processing plant. The pooled silage is then processed into an oil and aqueous phase that evaporates to a concentrated fish protein hydrolysate with a dry matter content of at least 42–44 percent.[30] This is used along with fish oil in feed for pigs, poultry and fish other than salmon. Some large fish-slaughter plants process by-products using commercial enzymes to obtain hydrolysates and oil of very high quality.

NUTRACEUTICALS AND BIOACTIVE INGREDIENTS

Long-chain polyunsaturated fatty acids, EPA and DHA are perhaps the most commercially successful marine lipids derived from fish oils. Despite starting slowly in around 2000, the market for omega-3 has grown considerably. According to some market studies, the global demand in 2010 for omega-3 ingredients was US$1.595 billion.[31] The pharmaceutical and food industries use gelatine as an ingredient to improve properties such as texture, elasticity, consistency and stability. Global gelatine production in 2011 was about 348 900 tonnes, with 98–99 percent coming from porcine and bovine hides and bones and about 1.5 percent from fish and other sources. The market price for fish gelatine tends to be 4–5 times higher than that of mammalian gelatine, but it has applications in halal and kosher foods. Because of its rheological properties (in terms of physical consistency and flow), gelatine from warmwater fish can be an alternative to bovine gelatine in food and drug coatings. Gelatine from coldwater fish has applications in frozen and refrigerated foods.

Chitin and its deacetylated form, chitosan, have many applications in food technology, pharmaceuticals, cosmetics and industrial processes. Chitin is present in shrimp shells. Industry estimates suggest that the global market for chitin and chitosan in 2018 could be 118 000 tonnes in terms of product weight. Chitin is used instead of chemicals as a flocculant for water treatment, and this application is common in Japan, which is the largest market for chitin and chitosan. The next-largest application is in the cosmetics industry – in hair and skin care products such as shampoo, conditioners and moisturizers. Glucosamine, the monomer of chitosan, has nutraceutical and pharmaceutical applications. Glucosamine, along with chondroitin sulphates, is used in products to improve the health of joint cartilage and also in the food and beverage industry. Among aquaculture producing countries, China, Thailand and Ecuador have well-established chitin and chitosan industries.

A number of nutritionally valuable proteins/peptides from fisheries by-products with functional, antioxidative or other bioactive properties have been reported. Commercial peptide products derived from hydrolysed dried bonito with claimed health benefits, such as lowering blood pressure, are available on the market.[32] There are also products from hydrolysed whitefish with health claims such as lowering glycaemic index, improving gastrointestinal health, acting against oxidative stress and having relaxing effects. It is possible that some of these involve the use of fillets rather than by-products. The United States market for protein ingredients in 2010 was worth an estimated US$45–60 million,[33] but fish peptides have to compete with products from milk proteins such as caseins and whey and soy proteins.

CHALLENGES FACING THE FISHERIES BY-PRODUCT INDUSTRY

Fish processing by-products are highly perishable and, therefore, they need preserving as soon as they are produced. However, fish processing establishments in many developing countries are medium or small scale, and may not have facilities to preserve small volumes of by-products generated. Thus, investments (in terms of finance, infrastructure and human resources) in this area may not be profitable. Where the by-products are for human consumption, they need to be handled and processed in compliance with systems based on good hygienic practice, good manufacturing practice and Hazard Analysis Critical Control Points (HACCP) safety management. Major challenges facing the fish gelatine industry, for example, are certification of the raw material, and the variable quality of the raw material in regard to parameters such as colour and odour. Moreover, fish gelatine is not able to compete with mammalian gelatine on price. The recovery yield of chitosan from shrimp waste is reportedly only 10 percent, and to produce good-quality chitosan, proper preservation of the shrimp waste is essential. In addition, the use of corrosive acid and alkaline conditions in its production requires specially adapted equipment and working conditions.

There are many scientific studies on the development of by-products for neutraceutical and pharmaceutical applications, but there are certain hurdles in commercializing these products. For example, pigments such as astaxanthin found in crustacean shells have to compete with synthetic astazanthin and native astaxanthin from microalgae that can be produced much more economically. Genetically engineered micro-organisms are in commercial use for the production of enzymes such as shrimp alkaline phosphatase and cod uracil-DNA glycosylase isolated from the liver of Atlantic cod. These enzymes were originally detected and characterized in by-products from the processing of shrimps and Atlantic cod, respectively.

For nutraceuticals and health supplements on the market, specific health claims have to gain approval from regulatory authorities such as the United States Food and

Drug Administration, European Food Safety Authority, or Food for Specified Health Uses (Japan). To obtain such approval, it is necessary to provide positive results from studies on humans, and such studies are usually very expensive.

The most realistic uses of by-products from fish processing are as food or indirectly as food by producing feed ingredients. The use of by-products for the isolation of high-value bioactive compounds is, with the exception of long-chain omega-3 fatty acids from certain sources, not realistic in many cases. Important reasons for this are: the lack of existing markets; the too limited amounts of high-quality by-products available on a regular basis; the high costs of isolating specific components often present in small amounts; and the challenges connected with providing the necessary documentation for a potential nutraceutical or health supplement.

Overcoming these and other challenges will allow the current trend of reducing wastage and increasing utilization of fish by-products to continue, resulting in enhanced economic, social, conservation and environmental benefits. New developments in science and technology, combined with investments and improved practices in the processing industry, can all contribute to this.

Snapshot of the activities of regional fishery bodies as a basis for enhancing collaboration

INTRODUCTION

In October 2012, FAO established six new task forces in its Fisheries and Aquaculture Department to promote and strengthen global fisheries and aquaculture management. One of these task forces deals with the regional fishery bodies (RFBs). Its aim is to create an enabling environment to provide better assistance to, and improve coordination with, RFBs. It is the view of the task force that this enabling environment is best achieved by FAO working together with all RFBs, and with other UN Agencies and international organizations, including non-governmental organizations (NGOs).

In mid-2013, the FAO Regional Fishery Bodies Task Force undertook an important research initiative to monitor and promote the work of all RFBs. This initiative involved:

- a comprehensive updating of all the FAO RFB databases (e.g. fact sheets and maps);
- producing the information paper "A Review and Analysis of the Food and Agriculture Organization (FAO) Article VI and XIV Regional Fishery Bodies (RFBs)" for the Thirty-first session of the FAO Committee on Fisheries (COFI);
- liaising with Interpol, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the United Nations Office on Drugs and Crime, the International Maritime Organization, and the United Nations Environment Programme on the development of RFB-focused initiatives;
- commencing work on a new FAO fisheries and aquaculture circular to describe RFB cooperative/collaborative activity with other RFBs, intergovernmental organizations and NGOs.

This work highlighted the fact that RFBs operate on a multitude of levels, in cooperation with many organizations, and that they address a vast range of issues extending from human rights to environmental protection. They run meetings, workshops, social media networks, and websites. They prepare publications, reports, legal advice, documentary films, national and regional plans of action and trade measures.

In view of all these various activities, it was decided to conduct a survey to assess the range and complexity of issues confronting regional fishery managers and advisers around the world at a given point in time, specifically, in the month of August 2013.

In the survey, the August 2013 Snapshot, RFBs were asked to summarize the types of activities that were the focus of their attention in that month. Two FAO RFBs were without staff at the time of the survey and, accordingly, there was no response from either body. The other 47 RFBs with which FAO is liaising include inland and marine capture fisheries bodies, fisheries research and advisory bodies, aquaculture bodies, and management bodies for other species related to sustainable oceans such as seabirds, turtles and whales.

Many of these RFBs are members of the Regional Fishery Bodies Secretariats Network (RSN). The RSN is an affiliation or network of RFB secretaries who share information and exchange views on themes, challenges and emerging issues of relevance to regional fisheries governance. As part of the invitation to attend the fourth RSN meeting (RSN-4), held in Rome in July 2012, the RFB secretaries were invited to provide information on the five most important issues or trends currently confronting their RFB.[34] The responses for the RSN-4 survey were categorized into four general subject areas that had some level of application to all RFBs, regardless of their specialization:

- Science and research – this category attracted the most prolific of responses. It included collection of, accuracy of, and gaps in, fisheries data. Responses in this category also included general matters relating to the welfare of the marine environment.
- Institutional – this category also attracted a significant number of responses. It included matters relating to RFB secretariats, member countries, funding and mandates.
- Fishing – this category included illegal, unreported and unregulated (IUU) fishing; monitoring, control and surveillance (MCS); the use of observers; recreational fishing; bycatch; and safety at sea. This category clearly has a particular relevance for marine capture bodies, but some aspects of the category (such as IUU fishing and the use of observers) also have some application to inland capture fisheries.
- Post-harvest – this category included fish trade and the enhancing of fisher livelihoods.

Many of the data received for the RSN-4 survey were elaborated at the actual meeting. Thus, while only five RFBs responded to the survey by commenting that the impact of climate change was an issue for their body, the RSN-4 meeting revealed that this subject was actually a major issue for almost all RFBs. Other subjects addressed at the RSN-4 meeting were: biosecurity in aquaculture; application of the precautionary approach to catch quotas; consensus versus majority voting in RFB decision-making processes; and child labour in fishing.

It is interesting to compare aspects of the 2012 RSN data compilation with the data collected for the August 2013 Snapshot. Although the RSN-4 feedback was from fewer RFBs (32 compared with 47 in the Snapshot) and although the RSN survey and the Snapshot have a different primary focus, it is clear that regional fisheries management is both fluid and dynamic. The RFBs are continuing to investigate new ways to deal with old problems (e.g. IUU fishing), but they are simultaneously grappling with new subjects that are emerging as priorities of the international community of States (e.g. Blue Growth).

THE AUGUST 2013 SNAPSHOT

The responses FAO received to its request for information on activities that occupied RFB time in August 2013 ranged from a short paragraph to several pages of detailed activities. Table 20 summarizes the responses in eight general subject areas that have some level of application to most RFBs.[35]

Aquaculture

Aquaculture is probably the fastest-growing food-producing sector and now accounts for almost 50 percent of the world's fish that is used for food. In addition to its growing importance in food and nutrition security and as a provider of earnings and livelihoods, aquaculture has major interactions with capture fisheries, for example, the use of wild fish stocks for feeds for aquaculture, biodiversity concerns about aquaculture escapees, and environmental impacts of aquaculture. These are of increasing interest to the work of RFBs. Almost one-third of the RFBs listed in this study have mandates that include aquaculture, and the trend of RFBs expanding into this area seems set to continue. It has been predicted that by 2030 global aquaculture production will need to increase by two and half times to prevent the present global per capita fish supply from falling.

Blue Growth

In addition to increasing the output from aquaculture, the 2012 Rio+20 Conference emphasized that the growing global population (predicted to reach nine billion by 2050) will require more wild capture fish in order to better ensure food security for all. To address this need, FAO is promoting "Blue Growth" for the sustainable, integrated, socio-economic sensitive management of oceans and wetlands (seas, lakes, rivers and reservoirs). However, the aquatic ecosystem is already under stress from overfishing, pollution, declining biodiversity, expansion of invasive species, climate change and ocean acidification. Moreover, the plight of those who work in the fisheries sector needs greater recognition. Fishing continues to be one of the most hazardous occupations in the world, leading to more than 24 000 deaths annually, mainly on board small fishing vessels. There is an urgent need to ensure the safety of these fishers as well as their livelihoods. This includes recognizing their human rights, including those relating to income, fair access to markets, and their living and working conditions.

In August 2013, the Blue Growth initiative took many forms among RFBs, for example: broadening the implementation of the ecosystem approach to fisheries (EAF) or the ecosystem approach to aquaculture (EAA); researching the impact of climate change on the spatial distribution of fisheries; pursuing habitat restoration; establishment of marine protected areas (MPAs); identification and regulation of vulnerable marine ecosystems; control of invasive species; reducing pollution; safeguarding the rights of small-scale fishers; and establishing a group insurance scheme for fishers in Bangladesh.

As an extension of the Blue Growth initiative, it is important for RFBs to monitor and act on the ecosystem consequences of: overfishing; lost, abandoned or destructive fishing gear; and destructive fishing practices that result in bycatch. Many RFBs are attempting to deal with ongoing ecosystem impacts caused by bottom trawling, drift net fishing, wire leaders in longline fishing, and fish aggregating devices.

In 2013, after years of examining evidence from observer reports, stranded carcasses and wounds on live animals, the International Whaling Commission's Scientific Committee agreed that the entanglement of large whales in fishing gear is a substantial problem, occurring in all the world's oceans, and yet it is severely under-reported. The information demonstrates that it is not just other fish that are victims of ghost fishing, and that lost and abandoned fishing gear has implications for the entire ecosystem. The subject of biodegradable fishing nets and lines is certain to become more topical and urgent at future RFB meetings.

Many RFBs also face complex issues surrounding shark conservation and management. In March 2013, in Bangkok, Thailand, the CITES Conference of the Parties 16 adopted several proposals for the listing of manta rays and five species of sharks under CITES Appendix II: oceanic whitetip, scalloped hammerhead, great hammerhead, smooth hammerhead, and porbeagle. These sharks are widely hunted for their meat, and most particularly for their fins, so that their abundance levels have become very low. A CITES Appendix II listing recognizes that a species might become endangered unless international trade in it is regulated. Accordingly, all future trade in these sharks will require a CITES permit (a so-called non-detriment finding) confirming that they were harvested sustainably and legally and that the trade is reported to the CITES secretariat.

Seabirds, turtles and red corals are included within the other ecologically related species that are frequently caught as bycatch, and they are included in many RFB regulations and/or recommendations relating to bycatch mitigation.

IUU fishing

On 21 August 2013, the Pacific Islands Forum Fisheries Agency (FFA) commenced Operation Bigeye – a ten-day-long surveillance exercise to monitor the legal

Table 20
Summary results of the August 2013 Snapshot of regional fishery bodies

Regional fishery body	Name in full	Aquaculture	Blue Growth	IUU fishing	Law and policy	Meetings/ workshops	Publications	Small-scale fisheries & socio-economics	Stock status
ACAP	Agreement on the Conservation of Albatrosses and Petrels		■			■	■		■
APFIC	Asia-Pacific Fishery Commission	■	■	■	■	■	■		
ATLAFCO (COMHAFAT)	Ministerial Conference on Fisheries Cooperation Among African States Bordering the Atlantic			■		■	■		
BOBP-IGO	Bay of Bengal Programme Inter-Governmental Organisation		■		■	■	■	■	
CACFish	Central Asian and Caucasus Regional Fisheries and Aquaculture Commission	■	■		■			■	■
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources		■		■	■			■
CCBSP	Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea								■
CCSBT	Commission for the Conservation of Southern Bluefin Tuna		■			■			
COPESCAALC	Commission for Inland Fisheries and Aquaculture of Latin America and the Caribbean	■			■			■	
COREP	Regional Fisheries Committee for the Gulf of Guinea	■		■	■			■	
CPPS	Permanent Commission for the South Pacific		■	■	■				
CRFM	Caribbean Regional Fisheries Mechanism	■	■	■	■	■	■	■	■
CTMFM	Joint Technical Commission of the Maritime Front					■			■
EIFAAC	European Inland Fisheries and Aquaculture Advisory Commission	■	■					■	■
FCWC	Fishery Committee for the West Central Gulf of Guinea								■
FFA	Pacific Islands Forum Fisheries Agency			■		■	■		
GFCM	General Fisheries Commission for the Mediterranean	■		■	■	■		■	■
IATTC	Inter-American Tropical Tuna Commission				■				■
ICCAT	International Commission for the Conservation of Atlantic Tunas					■			
ICES	International Council for the Exploration of the Sea		■			■	■		

compliance of fishing activity in 10 percent of the FFA region. Under Operation Bigeye, 6 patrol boats, 4 aircraft and 300 people from 6 countries collaborated in the inspection of 35 fishing vessels in order to monitor levels of fishing licence possession

Table 20 Cont.

Summary results of the August 2013 Snapshot of regional fishery bodies

Regional fishery body	Name in full	Aquaculture	Blue Growth	IUU fishing	Law and policy	Meetings/ workshops	Publications	Small-scale fisheries & socio-economics	Stock status
IOTC	Indian Ocean Tuna Commission		■			■			■
IPHC	International Pacific Halibut Commission				■	■	■		■
IWC	International Whaling Commission				■	■	■		
LTA	Lake Tanganyika Authority		■	■	■			■	■
LVFO	Lake Victoria Fisheries Organization	■			■	■		■	
MRC	Mekong River Commission	■			■			■	
NACA	Network of Aquaculture Centers in Asia-Pacific	■			■			■	
NAFO	Northwest Atlantic Fisheries Organization		■	■	■	■			■
NAMMCO	North Atlantic Marine Mammal Commission						■		■
NASCO	North Atlantic Salmon Conservation Organization	■	■		■			■	■
NEAFC	North East Atlantic Fisheries Commission			■	■				
NPAFC	North Pacific Anadromous Fish Commission			■		■	■		
NPFC	North Pacific Fisheries Commission		■	■		■			■
OLDEPESCA	Latin American Organization for Fisheries Development				■			■	
OSPESCA	Central American Fisheries and Aquaculture Organization	■	■		■	■			
PERSGA	Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden		■	■	■	■	■		■
PICES	North Pacific Marine Science Organization		■			■		■	
RECOFI	Regional Commission for Fisheries					■		■	
SEAFDEC	Southeast Asian Fisheries Development Center			■	■				■
SEAFO	South East Atlantic Fisheries Organisation			■		■	■		■
SIOFA	South Indian Ocean Fisheries Agreement					■			
SPC	Secretariat of the Pacific Community	■			■		■	■	■
SPRFMO	South Pacific Regional Fisheries Management Organisation			■	■	■			
SRFC	Sub-Regional Fisheries Commission				■				
SWIOFC	Southwest Indian Ocean Fisheries Commission					■			■
WCPFC	Western and Central Pacific Fisheries Commission			■	■				■
WECAFC	Western Central Atlantic Fishery Commission					■			■

and verify whether their fishing activity complied with their licence requirements. The results were encouraging. All 35 fishing vessels boarded for inspection had their fishing licences and were fishing in accordance with their licence requirements.[36]

Despite the positive levels of compliance in Operation Bigeye, it is clear that many RFBs continue to regard IUU fishing as a major problem in fisheries management. The data collected from RFBs for the RSN-4 survey revealed that IUU fishing was the most common concern across all marine capture and inland capture bodies. The variety of measures they were applying to address the problem warranted a separate annex to the RSN-4 report.[37]

The August 2013 Snapshot revealed that IUU fishing was less of a priority issue than it had been one year earlier for the RSN-4 meeting. Nevertheless, more than one-third of the responding RFBs were involved in measures to address IUU fishing. Activities included: a training workshop on port State measures; developing a regional action plan on IUU fishing; promoting flag State responsibilities; a workshop on vessel monitoring systems; planning an IUU fishing road map; improving MCS on Lake Tanganyika; monitoring of patrols in the convention area; establishing a regional record of fishing vessels; and updating of IUU vessel lists.

Some RFBs were focusing on the monitoring of third States, while others prioritized improving the levels of compliance of their members with conservation and management measures.

For those RFBs that believe they are having some success in the fight against IUU fishing, much of the credit for this is attributed to sharing active cooperative enforcement among their members. Thus, the North East Atlantic Fisheries Commission (NEAFC) notes that its contracting parties cooperate on MCS. In addition, its list of IUU vessels continues to be an important tool, as does the Port State Control system, in preventing IUU products from entering the market. Similarly, the North Pacific Anadromous Fish Commission (NPAFC) noted that its overall reduction in sightings of vessels engaged in illegal fishing activity in the North Pacific testifies to the effectiveness of its cooperative model of enforcement.[38] This is reinforced by the commission noting that continued vigilance is crucial to the ongoing curtailment of the large-scale, high seas, drift net threat.

Law and policy

In the 2012 RSN-4 survey, more than one-third of the RFBs responded that there was a need to strengthen RFB policy, legal and/or institutional aspects of fisheries governance.[39] Three bodies also noted the need for greater transparency in RFB governance processes.[40] The concerns raised relating to law applied both to the need to update RFB regulations and constitutions and also to the domestic fisheries legislation of RFB members, which sometimes required updating in order to better comply with the changing values of international law.

Similar concerns emerged in the August 2013 Snapshot survey, and some RFBs noted their role in assisting their members to comply more fully with “soft” and “hard” law international fisheries instruments. The capture RFBs participating in the survey have mandates that allow them to be either regulatory management bodies or advisory bodies. However, it seems that an increasing number of advisory bodies are using recommendations to advise their members of management measures needed to strengthen or protect fisheries. The RFB responses in this category were numerous, lengthy and varied from promoting multilateral conventions to formulating policies on a wide raft of issues, including:

- coordinating responses in relation to reporting to international conventions and arrangements such as UN General Assembly Resolutions;
- providing advice, on request, in relation to the implementation of the decisions of an organization;
- assisting, on request, with the review of domestic legislation to ensure it supports national policy and is consistent with regional or international obligations.

However, in 2013, one of the main RFB-based legal issues was the request for an advisory opinion submitted by the Sub-Regional Fisheries Commission (SRFC)[41] to the International Tribunal for the Law of the Sea (ITLOS) on matters relating to flag State responsibilities.[42] The ITLOS invited a number of organizations (including RFBs) to provide written statements on the questions submitted by the SRFC in its request for an advisory opinion. Feedback from many RFBs suggests that only a few chose to respond directly, with most preferring to pass the request to their members for comment.

Meetings and workshops

There were more RFB responses for this category of the survey than for any other. The period from September to December is the most popular time of year for RFBs to hold their annual meetings. Hence, many RFB secretariats spend their August engaged in meeting preparations. In addition, most large RFBs have subcommittees or working groups dealing with specialist areas such as compliance, science, or specific species (such as the Atlantic Swordfish Stock Assessment by the International Commission for the Conservation of Atlantic Tunas), and such subcommittees are also active. The Commission for the Conservation of Antarctic Marine Living Resources held its second-ever intersessional meeting for further discussion on proposals to establish two MPAs in the Antarctic. In addition, there were numerous workshops being either conducted or planned on subjects ranging from the socio-economic aspects of fisheries (Regional Commission for Fisheries) to MCS on Lake Victoria (Lake Victoria Fisheries Organization). A particularly interesting response came from the NPAFC, which conducted its 2013 meeting by e-mail. Earlier in 2013, the International Pacific Halibut Commission held its annual meeting with all sessions being webcast and interactive with the web audience, who could submit questions to participants in real time. Electronic meetings in some form or another may offer a cost-saving and environmentally sustainable future for all RFBs.

Publications

The RFBs are active disseminators of data, and this applies to highly technical data as well as attempting to reach the more mainstream community by alternative media. Thus, in addition to the publication of RFB annual reports, scientific studies and management assessments, several RFBs are working on public awareness raising of their work and the outcomes they achieve. In August 2013, two RFBs released films. The Secretariat of the Pacific Community produced two films on women spearfishers in Timor-Leste and coral farming for aquarium exports in Solomon Islands. The NPAFC also produced a film dealing with the arrest and prosecution of an illegal fishing vessel: "From Seizure to Scrap – the *Babnun Perkasa* Story". Many RFBs maintain social network sites, and others have commenced the publication of regular newsletters. Finally, the International Council for the Exploration of the Sea has begun publishing a popular version of its fish stock advice. This is an easy-to-read, accessible digest of its official advice and is available for 104 stocks in European waters.

The responses received and categorized under this heading suggest that, beyond the purely technical data, which are of primary value only to statisticians and fishery managers, RFBs are increasingly engaging in activities to reach out to a wider audience such as NGOs and fish consumers. They are now "publicizing" their publications, reports, films and websites.

Socio-economics of fishing (including small-scale fisheries)

From 20 to 24 May 2013, FAO hosted a technical consultation to develop voluntary guidelines for securing sustainable small-scale fisheries. The occasion marked a significant step in recognizing the contributions of small-scale fisheries to food security and poverty alleviation and exemplified the efforts to undertake a global exercise to collaboratively improve the sustainability of the sector. While the technical consultation did not complete negotiations on a draft text, several key issues were agreed upon. Among other results, the meeting marked the first occasion where social aspects were given prominence in an international fisheries instrument, and this important development is accompanied by the increasing global attention on the Blue Economy and Blue Growth. In the data submitted to FAO by RFBs, the most significant change in the past 12 months has been the increased focus given by RFBs to the social dimension of fisheries management, and fisheries management problems (such as IUU fishing). There is considerable overlap between this category and the other categories in this survey. Thus, Blue Growth, law and policy developments, meeting and workshop themes, publications and videos, and stock status assessments are all weighted more towards the socio-economics of fishing than in previous RFB surveys.

Stock status

The list of RFBs covered in this survey includes the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (CCBSP). Pollock stocks in the Central Bering Sea high seas area have never recovered from overfishing in the late 1980s and early 1990s. A moratorium on commercial pollock fishing has continued since 1993 but, 20 years later, there is still no relief in sight. The six parties to the convention continue to monitor the stock status. Should the stocks recover, they are fully prepared to reactivate their RFB and manage the pollock sustainably. The plight of this RFB is an important reminder for all RFBs of how easily overfishing can occur, and the gravity of its results. Many RFBs are focused on researching declining fish stocks, restoring depleted fish stocks, and managing overfished stocks. At the same time, and similar to developments in CITES Appendix II listings, other international governmental organizations are focusing on an increasing number of aquatic species.

CONCLUSION

By sharing experiences of successes and failures, RFBs can improve their ways of working, become more effective and coordinate their efforts where there are mutual benefits to be gained. The August 2013 Snapshot survey attracted a 100 percent response rate from those RFBs that are active and have a secretariat. Moreover, with particularly short notice and at a busy time of year, the RFB responses were of an excellent quality. Most of the responses were circulated to all RFB secretaries, which demonstrates a preparedness of RFBs to share their activities, knowledge and experiences.

The diversity of RFB responses is noteworthy, particularly when compared with the data received in 2012 for the RSN-4 meeting. It is clear that some longstanding issues such as IUU fishing persist, but there are also new and important emerging priorities, such as Blue Growth, with more specific attention being given to the socio-economic aspects of fishing, including small-scale fishers. This is in line with the EAF and EAA, which, by definition, incorporate the human dimension as an integral part of the ecosystem. Other emerging priority subjects from 2013 include the status of Appendix II sharks and rays (from CITES), the monitoring of the SRFC ITLOS advisory opinion, and the need for RFBs to engage in improved, clearer and more engaging public relations, especially through their publications and other outputs.

It is clear from the responses that, despite the broad categorizations, RFBs are continuing to deal with complex issues. However, they are not complacent, and the global picture of fisheries and aquaculture management is always changing and posing new challenges. The clients and stakeholders of RFBs are becoming ever more diverse, particularly with increasing implementation of ecosystem approaches. The RFBs are recognizing the need for closer collaboration with one another and with other organizations. This study of the activities of RFBs is a first step in promoting closer collaboration with the aim of improving the effectiveness of their essential work.

Initial assessments of vulnerabilities to climate change in fisheries and aquaculture

INTRODUCTION

Global reviews of climate change impacts on fisheries and aquaculture systems carried out in 2009[43] revealed a paucity and patchiness of relevant information. FAO then launched six follow-up regional case studies[44] in an attempt to start filling such gaps, and to provide direction and initial steps in adaptation planning. Fisheries and aquaculture systems were selected across the globe, allowing for diversity. The approach of the case studies followed a template: (i) define vulnerability to climate change by understanding potential impacts to the system, the sensitivity of the system to such changes and the current adaptive capacity of the system; (ii) identify gaps in the existing knowledge to assess vulnerability in this system; (iii) identify potential strategies for reducing vulnerability to climate change; and (iv) provide policy guidance to reduce the system's vulnerability. However, authors were allowed the flexibility to define the system, issues and options according to the prevailing conditions of the area or system under study. The case studies were desk-based and relied mainly on available secondary information. A range of stakeholders subsequently discussed, elaborated and refined each case study at six regional workshops. A major potential benefit of assessing vulnerabilities is the development of adaptation strategies and measures aimed at minimizing negative impacts and seizing new opportunities (see Box 8). To be of practical utility to policy-makers addressing the implications of climate change, such assessments need to take into account both social and ecological vulnerabilities (see Box 9 for an example).

SUMMARIES OF VULNERABILITIES WITHIN CASE STUDIES

This section summarizes the conclusions reached by the authors of the case studies – unless specified otherwise – on the overall vulnerability to climate change of the fisheries and aquaculture systems they investigated.

Lake Chad

The main threat to Lake Chad and the people living in its basin is drought. One study[45] concludes: "The location of the Lake Chad Basin in the Sahel means that it is highly vulnerable to the climatic perturbations in the region and climatic events have greatly influenced ecology, natural resources, and thus livelihoods". They also find that "the adverse socio-economic implications on riparian communities who are dependent on the basin's natural resources for their livelihoods and well-being are obvious". However, the capacity to tackle and manage climate-related threats is hampered by poverty, weak political and economic stability, poor institutional capacity, and a limited knowledge base and information.[46]

Caribbean

Key climate-related drivers in the Caribbean are a decrease in wet season rainfall, increased temperatures, sea-level rise, and an increase in tropical cyclone activity. Although without a concluding statement on the vulnerability of the area, the assessment gives the general impression that aquaculture may be better placed than fisheries to cope with the rapid rate of change and compounded effects of multiple drivers of vulnerability (both climate and non-climate related, e.g. some disasters). This is because the aquaculture systems of the region seem to exhibit more flexibility and a wider adaptive capacity. They may also be more amenable to human interventions to assist in their adaptation. A main recommendation by the stakeholders involved in the study was that analyses should not be split by hazard or sector, but rather be treated in a comprehensive and integrated manner under the umbrella of institutional and governance analyses in order to pool and increase the effective use of resources.

Box 8

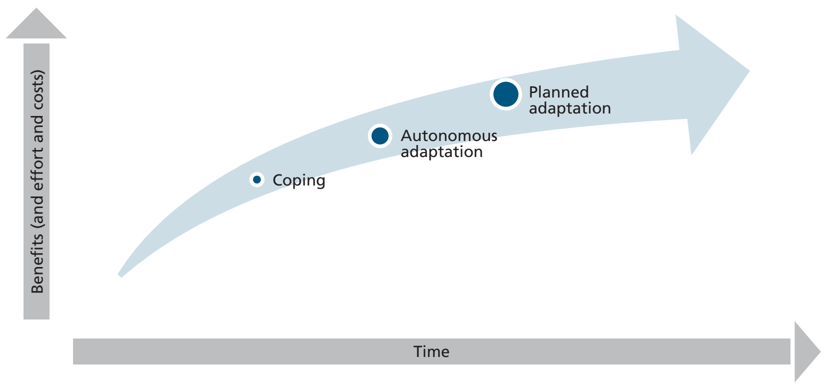
Examples of climate change adaptation in fisheries and aquaculture

Although the sector has always been influenced by climatic factors, fisheries and aquaculture have only recently begun to address climate change adaptation formally. To assist in the sharing of information on adaptation options appropriate to the sector, a recent FAO circular details 26 current and recent climate change activities and programmes relating to fisheries and aquaculture, primarily in developing countries, as examples highlighting the diversity of adaptation actions at the local to regional scales.

Adaptation can be planned (based on climate-induced changes) or autonomous (i.e. spontaneous reaction to environmental change). It can include a variety of policy and governance actions, specific technical support or community capacity building activities that address multiple sectors not just capture fisheries or aquaculture farmers. Planned adaptation may mean research funding for finding species appropriate to high-salinity environments and temperature fluctuations. Autonomous adaptation may mean changing the timing or locations of fishing as species arrive earlier/later or shift to new areas. A "no regrets" approach to adaptation relies on building general resilience of the fisheries and aquaculture system in the face of uncertainty regarding climate change projections and their impacts on the systems. Adaptation activities may address short- or long-term impacts (see figure), whereas coping is a short-term response (e.g. to storm impacts for a single season) and can undermine longer-term adaptation activities if it places addition stress on already vulnerable systems.

Included in the examples are adaptation activities that may address issues not specifically focused on fisheries or aquaculture, such as mangrove restoration for the primary purpose of buffering coastal areas from storm surge and coastal erosion. The study notes that, although the primary driver of mangrove restoration may not be related to, say, livelihoods, fisheries, biodiversity or water-quality improvements, mangrove restoration may positively affect all of these if the needs of

Time scale and amount of benefits and costs required for various types of adaptation



the sectors and vulnerable communities are incorporated into the adaptation planning. Otherwise, there is a potential for maladaptation leading to new or reinforcing inequalities, for example, if vulnerable landless groups are restricted from accessing certain areas, or if resource extraction is not managed well and newly planted areas are overutilized, preventing full restoration and therefore full benefits.

As another example, adaptation may involve adjusting capture fisheries efforts to sustainable levels to support the resilience of the natural system. Setting catch limits based on changes in recruitment, growth, survival and reproductive success can be done via adaptive management, monitoring and precautionary principles. If new fisheries opportunities become available, adjusting to new target species may also require changes in vessel or gear types. This may entail high transition costs and, if not properly managed, may lead to maladaptation in the form of fishing overcapacity.

Adaptation planning may also occur at the regional scale if relating to changes in shared or transboundary stocks or to migration of fishers. This may require cooperation and discussion between neighbouring countries and regions, including developing or modifying fishing agreements and collaborative management.

Within the study, adaptation examples are organized by the impact pathways they seek to address: sea-level rise, precipitation changes, temperature fluctuations, increased storm variability/severity, ocean acidification, and salinity changes. Although context-specific, examples of current and recent adaptation activities for fisheries and aquaculture include those listed below.

Diverse and flexible livelihood strategies

- Introduction of fish ponds in areas susceptible to intermittent flood/drought periods, providing for direct food security as well as irrigation water storage.
- Flood-friendly small-scale homestead bamboo pens with trap doors allowing seasonal floods to occur without loss of stocked fish.
- Cage fish aquaculture development using plankton feed in reservoirs created by dam building.
- Supporting the transition to different species, polyculture and integrated systems through technology transfer and access to financial resource, allowing for diversified and more resilient systems.
- Promotion of rice–fish farming systems developing salt-tolerant rice varieties in the face of sea-level rise and storm surges – reducing overall water needs and providing integrated pest management.
- Supporting transitions to alternative livelihoods to reduce reliance on vulnerable systems and sectors, such as business planning and professional association development.

Flexible and adaptable institutions

- Public awareness raising through appropriate media – radio, posters, etc.
- Strengthened local community-driven institutions for improved fisheries management and adaptive capacities of natural and social systems, including community-level vulnerability assessments and adaptation planning.

(Continued)

Box 8 *(cont.)*

Examples of climate change adaptation in fisheries and aquaculture

- Flexible effort (e.g. vessel day) schemes to provide adaptive regional management of transboundary stocks among a group of collaborating countries.
- Participatory fisheries data collection, including monitoring systems and local knowledge, increasing local knowledge and change management.

Risk reduction initiatives

- Community- and ecosystem-based coastal erosion protection activities, such as the construction of perpendicular and parallel groynes, sandbars, oyster reefs, mangrove rehabilitation and replanting, restoration of wetlands and rehabilitation of coral reefs.
- Improved spatial planning to identify vulnerable habitats through marine species identification, monitoring techniques and protocols to develop baseline information for planning.
- Improving post-harvest systems in the face of decreasing catches to provide alternative livelihoods for fishers while limiting impacts on supporting ecosystems, such as forests and waterbodies.
- Innovative weather-based insurance schemes in agriculture being tested for applicability in fisheries and aquaculture.
- Climate risk assessments introduced for integrated coastal zone management, supporting climate smart investments.

Source: Shelton, C. 2014. *Climate change adaptation in fisheries and aquaculture – compilation of initial examples* [online]. FAO Fisheries and Aquaculture Circular No. 1088. Rome, FAO. [Cited 24 January 2014]. www.fao.org/docrep/019/i3569e/i3569e.pdf

Mekong Delta

One study[47] recognizes that the Mekong Delta is "significantly vulnerable" to sea-level rise (and associated changes in salinity) and flooding. Its fisheries and aquaculture activities are "likely to be impacted, albeit to varying degrees" by these two particular facets of climate change. Another vulnerability analysis confirmed that "aquaculture would be more vulnerable to climate change scenarios than capture fisheries", climate change affecting equally both intensive and extensive production systems.[48] However, the first-cited study concluded that adaptive strategies for the sector were deemed feasible thanks to a greater understanding of climate change impacts on it, and would likely be "pragmatic" and "cost-effective".

Benguela Current

According to one author,[49] the most important driver of change in the Benguela Current region is not climate but overfishing. The most vulnerable fisheries are those with a large number of people living in communities heavily dependent on fish for food, with almost no ability to adapt, such as artisanal and semi-industrial fisheries in Angola, and rock lobster and small-scale line fisheries in South Africa. Other fisheries were deemed less or not vulnerable (i.e. hake fisheries in Namibia and South Africa, respectively). Large, highly organized and capital-intensive industries were found to

Table 21
Vulnerability of fisheries and aquaculture systems

	Vulnerability										
	Overfishing	Drought	Variation in rainfall	Sea-level rise	Variation in sea surface temperature	Variation in currents	Acidification	Extreme weather events	Flooding	Changes in land use, damming	Volcanic eruptions, landslides, tsunamis
Lake Chad fisheries and farming		■	■								
Caribbean fisheries			■	■	■		■	■			■
Caribbean aquaculture							■	■	■		■
Mekong fisheries				■						■	
Mekong aquaculture									■	■	
Mekong rice				■					■	■	
Benguela fisheries	■					■					
Pacific fisheries					■		■				
Pacific aquaculture											
Pacific coastal habitats					■		■				
Latin America fisheries	■				■			■			
Latin America aquaculture							■	■		■	

Table 22
Vulnerability of key fisheries and aquaculture stakeholders

	Vulnerability								
	Conflict	Decrease in production and income	Institutional incoherencies, poor planning, overlapping jurisdictions	Safety at sea, general health issues	Infrastructure damage	Displacement	Decline in cultural heritage	Dependence on global markets and international pressures	Discrimination in access to inputs and decision-making
Transboundary commissions	■		■						
Small-scale fishers		■		■		■		■	
Industrial fishers		■						■	
Aquaculture operators (all sizes)	■				■			■	■[1]
National governments, fisheries and aquaculture authorities		■	■					■	
Other groups (migrants, women, etc.)	■	■		■					
Land farmers and coastal users		■							
Fish processors and employees					■				■

[1] Small aquaculture operators, to feed and broodstock inputs.

be generally most adaptable to variations in species distribution, and this has already taken place to some extent.

Pacific

In the Pacific region, key drivers of change are climate-induced variations in the tropical air, sea surface and ocean temperatures, and projected increases in rainfall. One study[50] concludes that, overall, Pacific island countries and territories are better placed than other nations to cope with the implications of climate change for fisheries and aquaculture, and have good potential to adapt in the longer term and seize the benefits from changes in prevalent fisheries and aquaculture systems. Resulting impacts on fisheries and aquaculture, such as the moving of tuna from west to east and improved environmental conditions for developing pond aquaculture, are likely to benefit those countries and territories with a greater economic dependence on tuna as well as their food requirements for fish protein supply.

Latin America

In Latin America, various drivers of change are affecting fisheries and aquaculture. They include overfishing for capture fisheries and sea temperature changes and sea-level rise for aquaculture in Chile. The Gulf of Fonseca seems to be more exposed to conflicts and extreme weather events (e.g. hurricanes), although variations in temperature, rainfall, sea-level rise, etc. are also likely to affect fish production systems and coastal ecosystems. One study[51] concluded that the vulnerability of different types of Chilean aquaculture systems and operations to climate change was low overall. Although the case study provided no conclusion on the overall vulnerability status of the social-ecological system in Chile's capture fisheries, the relatively high human adaptive capacity in the region suggests a medium level of vulnerability. A similar conclusion is suggested on the vulnerability of fisheries and aquaculture to climate change in the Gulf of Fonseca.

COMMON ISSUES ACROSS THE CASE STUDIES

Tables 21 and 22 highlight the wide range of vulnerabilities threatening fisheries and aquaculture around the world, as well as those factors to which some systems are more vulnerable. For example, conflict, reduced income following climate change impacts and the pressing influences of globalized markets on demand for aquatic products are cases in point for people and countries depending on fisheries and aquaculture.

Other general issues run through all case studies:

- In areas where vulnerability to climate change is heightened, increased exposure to climate change variables and impacts is likely to exacerbate current inequalities in the societies concerned, penalizing further already disadvantaged groups such as migrant fishers (e.g. Lake Chad) or women (e.g. employees in Chile's processing industry).
- Limited access to essential facilities (e.g. health, education, roads and communication infrastructures), either alone or coupled with the threat of decreases in production (catches, harvests, either for sale or direct consumption), increases the vulnerability of small-scale fishers and aquaculture operators.
- Low access to information and communication technologies is a recurrent hindrance to adapting fishing and harvesting practices and to seizing market opportunities.
- Transboundary issues, arising out of the difficult sharing of aquatic resources in a number of systems and the weakness of their management institutions, are vastly complicated by the additional hurdle of climate change and the collective action its overcoming entails.

In terms of knowledge upon which to base the vulnerability assessments, the case study review also highlighted the following:

- There is a general lack of scientific understanding of biophysical processes underpinning aquatic and, in particular, freshwater systems.

Table 23
Summary of proposed strategies for adaptation to climate change in fisheries and aquaculture

	Lake Chad Basin	Caribbean	Mekong Delta	Benguela Current	Pacific	Latin America
Governance						
Stronger partnerships, including outside fisheries and aquaculture		■				
Development of legislation		■		■	■	
Improved governance in fisheries and aquaculture[1]	■	■	■	■	■	■
Information and knowledge						
Dissemination of climate change and adaptation information	■	■				■
Creation of knowledge on adaptation and vulnerability		■	■	■	■	■
Capacity building						
Building of capacity, from schools to ministries		■			■	■
Environment						
Improved management	■ (fisheries)		■ (aquaculture)	■ (fisheries)		■ (fisheries)
Habitat conservation					■	■
Investment and economy						
Investment in climateproof infrastructures		■				
Development and financing of action plans	■			■	■	■
Economic incentives, e.g. insurance			■			
Optimization of employment opportunities in aquaculture, diversification	■				■	
Other						
Increase in preparedness and inclusion of disaster risk management in climate change adaptation strategies	■	■				■
Promotion of aquaculture development in national or international climate change adaptation strategies	■	■			■	■

[1] Examples: integration of fisheries with other sectors at policy level (Caribbean); work with technical agencies and community groups to enable priority adaptations (Pacific); cross-institutional collaboration (Latin America); strengthening of transboundary commissions (e.g. Benguela Current Commission, Lake Chad Basin Commission); holistic approach to climate change policy development, organization of fish farmers (Mekong Delta).

- There is a lack of availability of palaeoecological records (except for the Lake Chad Basin) to understand the past evolution of a system and to predict more accurately its future sensitivity to events of a similar nature, potential for recovery and likely adaptation pathways.
- Data limitations remain, in particular in relation to the scaling of Intergovernmental Panel on Climate Change models to the regional and local case study areas and systems concerned.

Box 9

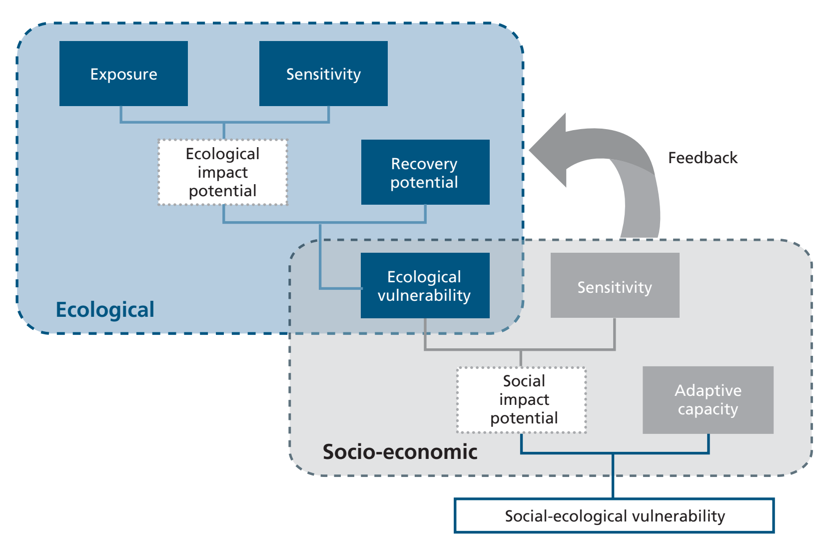
Social-ecological vulnerability to climatic shocks – an example of fisheries communities dependent on coral reefs

Coral reefs and their associated fisheries provide nutrition and livelihoods for millions of people, particularly in developing countries. However, in recent years, periods of high water temperatures across the Indian Ocean have caused corals to "bleach" and die, altering habitat structure and fish communities. As warming continues, the frequency and severity of bleaching episodes are predicted to increase, with potentially fundamental impacts on the world's coral reefs. The scientific challenge is to understand how such impacts will be distributed, and how reef-dependent people will be affected and can adapt.

In Kenya, a community-level vulnerability assessment approach incorporated both ecological and socio-economic dimensions to target and guide adaptation planning to reduce vulnerability. The assessment considered how a site's ecological vulnerability is determined by the combination of: (i) ecological exposure (e.g. predicted levels of bleaching); (ii) ecological sensitivity (e.g. susceptibility of coral species to bleaching); and (iii) ecological adaptive capacity / recovery potential (e.g. factors affecting recruitment of new young corals). This ecological vulnerability is then considered the climate-related exposure experienced by the social system. Social vulnerability is the combination of this exposure plus social susceptibility (e.g. how reliant a community is on coral reef resources) and social adaptive capacity (e.g. resources and conditions that facilitate alternative livelihoods) (see figure below).

The study developed indicators for the different components of social-ecological vulnerability. It collected data on them at sites along the Kenyan coast by: (i) applying multivariate models of coral bleaching impact to oceanographic data to determine ecological exposure; (ii) conducting underwater surveys of coral, fish, habitat and algal production and grazing as indicators of ecological sensitivity to, and ecological adaptive capacity /

Determining social-ecological vulnerability



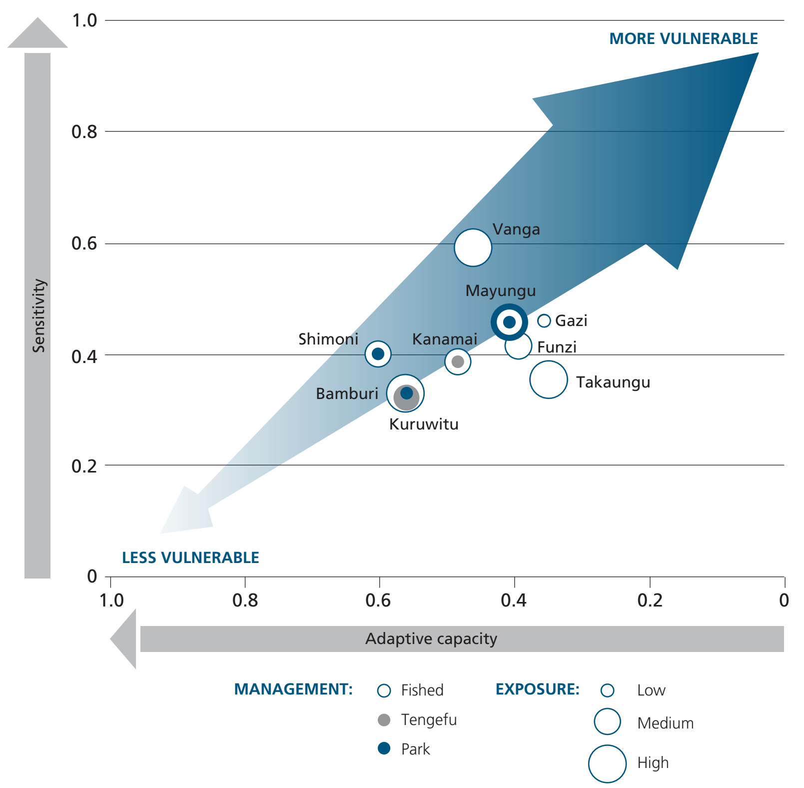
recovery potential from, bleaching in both fished and protected areas; and (iii) carrying out household and community-level surveys of adjacent communities, interviewing key informants and obtaining detailed fisheries data on gear types and catch composition to derive indicators of social sensitivity and adaptive capacity.

The ecological sites covered a range of conditions in terms of coral abundance, fish biomass and herbivore grazing diversity, and rates of algal production and grazing in fished sites, marine reserves and small community-based closures (called tengefus). Despite medium to high exposure, tengefus and no-take reserves were associated with lower ecological vulnerability owing to low sensitivity and high recovery potential. Overall, marine parks had lower vulnerabilities than did tengefus and open fished areas.

Social sensitivity was indicated by the occupational composition of each community, including the importance of fishing relative to other occupations, as well as the susceptibility of fishing with different types of fishing gear to the effects of coral bleaching on the fish species targeted.

Social adaptive capacity (as indicated by, for example, credit access, social capital and community infrastructure) varied considerably among the communities, suggesting relative strengths and weaknesses in terms of adaptive capacity.

Adaptation priorities for sites in Kenya



(Continued)

Box 9 *(cont.)*

Social-ecological vulnerability to climatic shocks – an example of fisheries communities dependent on coral reefs

Ecological vulnerability (social exposure), social sensitivity and social adaptive capacity varied across the sites and contributed to variation in social-ecological vulnerability among the communities, identifying potential site-specific adaptation priorities (see figure above). In general, communities had increased community infrastructure and credit availability in the period 2008–2012 and demonstrated increased adaptive capacity and sensitivity. However, vulnerability was socially differentiated. The study identified young people, migrants and those not participating in decision-making as having both higher sensitivity and lower adaptive capacity and, hence, as being those most vulnerable to changes in reef fisheries productivity. Policies aimed at enhancing adaptive capacity in the region need to consider that there may be different needs between, for example, younger and older people, migrants and non-migrants, and those already involved in co-management and those who are not, and that vulnerability components can also vary over time. Aiming adaptation funding at those with lower adaptive capacity may have a larger pay-off.

The above approach could be adapted and expanded to other areas and, using different indicators, enable vulnerability analyses for other climate change impacts and so help guide adaptation policy.

Source: Cinner, J., McClanahan, T., Wamukota, A., Darling, E., Humphries, A., Hicks, C., Huchery, C., Marshall, N., Hempson, T., Graham, N., Bodin, Ö., Daw, T. & Allison, E. 2013. *Social-ecological vulnerability of coral reef fisheries to climatic shocks*. FAO Fisheries and Aquaculture Circular No. 1082. Rome, FAO. 63 pp. (also available at www.fao.org/docrep/018/ap972e/ap972e.pdf).

Overall, climate change will affect the roles and operations of fisheries and aquaculture stakeholders as follows:

- Transboundary institutions: Overall roles will remain unchanged, but changing circumstances will require modifications to operations. Weak governance impeding the implementation of adaptive strategies runs across the board.
- Ministries and governments: Roles and operations will need to adapt. Those with better governance seem to be both coping with and planning better for the consequences of climate change on the economy and people they are responsible for, and thus are more able to handle another threat.
- Large-scale industrial fishers: Roles and operations will need to adapt. They have very different capacities around the world and are operating at different levels of intensity and economic margins, meaning some are more able than others to absorb the effects of climate change. For example, they have greater ability to relocate their operations to follow changes in fish stock distribution.
- Small-scale artisanal fishers: Roles and operations may need to adapt. Depending on the context (including environment and culture), they have different access to diversification opportunities. All are constrained by limited access to basic facilities and to participation in decision-making.

- Aquaculture operators: Roles and operations will need to adapt, largely owing to the wide-ranging intensity of operations (and slimmer margins for intensive, export-oriented production systems) and to the fact that climate change impacts on aquaculture operations range from positive to negative.

RECOMMENDATIONS FOR ADAPTATION FROM THE CASE STUDIES

The respective proceedings provide detailed information on the adaptation strategies proposed by the case studies and workshops. Only a brief summary is provided here. The recommendations across the case studies tended to be both context-specific and wide-ranging, encompassing management, economic, capacity-building and governance measures at all levels. Table 23 summarizes the propositions across the case studies.

Governance is prominent among the proposed avenues for reducing vulnerability to climate change in fisheries and aquaculture. The generation of new knowledge and information about the impacts of climate change on aquatic ecosystems is also fundamental. Without a fuller understanding of the functioning of ecosystems and of the uncertainty inherent in current climate models, optimal adaptation strategies are likely to be more difficult to design. The case studies repeatedly underscored such gaps as hampering targeted adaptation efforts. Some also reiterated the immediate need to finance and develop action plans, and aquaculture development was found to be one of the activities to capitalize on in a number of cases. The majority of the case studies also recognized that improved management of fisheries and aquaculture operations was undeniably linked to a reduction in their vulnerability to climate change.

NOTES

1 Needham, S. & Funge-Smith, S.J. (forthcoming). *The consumption of fish and fish products in the Asia-Pacific region based on household surveys.* Bangkok, FAO Regional Office for Asia and the Pacific.

2 FAO. 2012. *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*. Rome. 48 pp. (also available at www.fao.org/docrep/016/i2801e/i2801e.pdf).

3 FAO. 2013. *Implementing improved tenure governance in fisheries – A technical guide to support the implementation of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security.* Preliminary version, September 2013. Rome. 71 pp. (also available at www.fao.org/docrep/018/i3420e/i3420e.pdf).

4 FAO. 2000. *The State of World Fisheries and Aquaculture – 2000*. Rome. 142 pp. (also available at ftp://ftp.fao.org/docrep/fao/003/x8002e/x8002e00.pdf).

5 Cordell, J., ed. 1989. *A sea of small boats*. Cambridge, USA, Cultural Survival Inc. 418 pp.

6 FAO. 2011. *Report of the FAO Workshop on Governance of Tenure for Responsible Capture Fisheries. Rome, 4–6 July 2011*. FAO Fisheries and Aquaculture Report No. 983. Rome. 34 pp. (also available at www.fao.org/docrep/015/i2431e/i2431e00.pdf).

7 Op. cit., see note 2.

8 Charles, A.T. 2002. Use rights and responsible fisheries: limiting access and harvesting through rights-based management. *In* K.L. Cochrane, ed. *A fishery manager's guidebook. Management measures and their application*, pp. 131–158. FAO Fisheries Technical Paper No. 424. Rome, FAO. 231 pp.

9 Shotton, R., ed. 2000. *Use of property rights in fisheries management. Proceedings of the FishRights99 Conference. Fremantle, Western Australia, 11-19 November 1999. Mini-course lectures and core conference presentations*. FAO Fisheries Technical Paper No. 404/1. Rome, FAO. 342 pp. (also available at www.fao.org/docrep/003/x7579e/x7579e00.HTM).

10 Copes, P. & Charles, A. 2004. Socioeconomics of individual transferable quotas and community-based fishery management. *Agricultural and Resource Economics Review*, 33(2): 171–181.

11 "Low-value fish" is a generic term. In specific references to the state of the material, "trash fish" is used. Current FAO practice (followed here) is to use the term low-value fish rather than trash fish. Low-value fish have a low commercial value by virtue of their low quality, small size or low consumer preference – they are either used for human consumption or for livestock/fish feeds, either directly or through reduction to fishmeal and fish oil. This definition is based on the one given in: Funge-Smith, S., Lindebo, E. & Staples, D. 2005. *Asian fisheries today: the production and use of low value/trash fish from marine fisheries in the Asia-Pacific region*. RAP Publication 2005/16. Bangkok, FAO. 48 pp. (also available at www.fao.org/docrep/008/ae934e/ae934e00.htm).

12 Hasan, M.R. & Halwart, M., eds. 2009. *Fish as feed inputs for aquaculture: practices, sustainability and implications.* FAO Fisheries and Aquaculture Technical Paper No. 518. Rome, FAO. 407 pp. (also available at www.fao.org/docrep/012/i1140e/i1140e.pdf).

FAO. 2011. *Aquaculture development. 5. Use of wild fish as feed in aquaculture*. FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 5. Rome. 79 pp. (also available at www.fao.org/docrep/014/i1917e/i1917e00.pdf).

13 FAO / Network of Aquaculture Centres in Asia-Pacific (NACA). 2011. *Regional review on status and trends in aquaculture development in Asia-Pacific – 2010.* FAO Fisheries and Aquaculture Circular No. 1061/5. Rome, FAO. 89 pp. (also available at www.fao.org/docrep/014/i2311e/i2311e.pdf).

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38 In 2013, NPAFC member countries continued their successful enforcement collaboration to deter and eliminate illegal high seas fishing. Patrols in the its convention area included the use of about 10 aircraft and 21 surface vessels. Radar satellite surveillance was also used to support long-range aircraft and surface patrols. Regularly scheduled enforcement conference calls maintained real-time coordination among the member countries at the operational level throughout the high-threat season.

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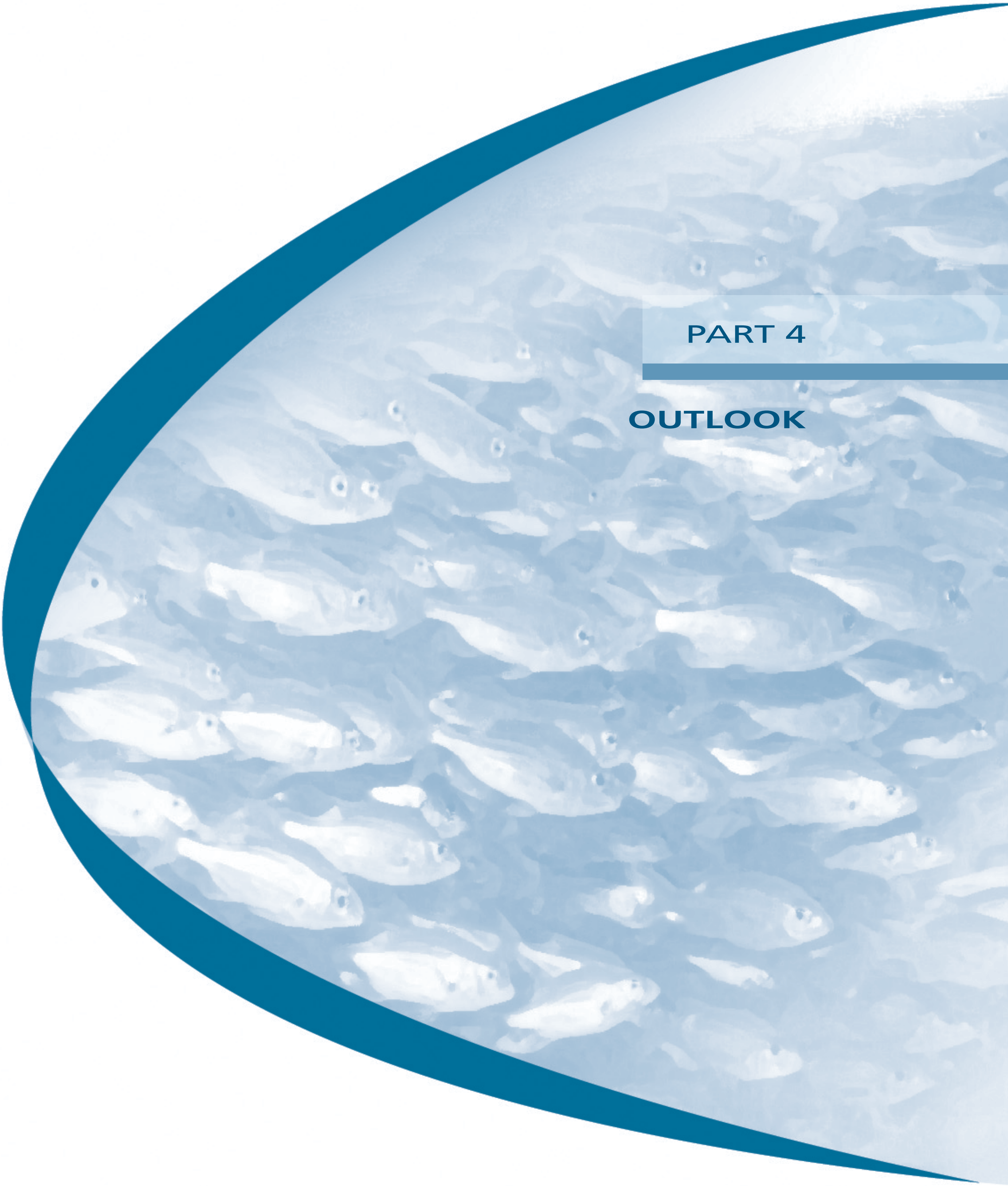
PART 4

OUTLOOK



OUTLOOK

Meeting future fish demand: outlook and approaches

This Outlook section examines projected fish supply and demand for coming decades. It also discusses assumptions used in the models, issues that may threaten the sector's ability to meet future fish demand, and preconditions for the international community to be able to meet the challenges.

It provides the results of two main outlook studies. One is based on the FAO Fish Model (developed with the Organisation for Economic Co-operation and Development [OECD], for the period 2013–2022, the other on the IMPACT (International Model for Policy Analysis of Agricultural Commodities) model of the International Food Policy Research Institute (IFPRI), presenting projections to 2030. Model-based projections are intended to become standard in future editions of the Outlook section.

The overall context is that of a fisheries and aquaculture sector addressing priority areas such as food security and poverty alleviation while ensuring environmental sustainability. The challenge is to translate these goals into practical action and to evaluate trade-offs between different options. Thus, the challenges are to produce more fish, to do so in a sustainable manner and to ensure that fish for food is also available where most needed.

EXPECTED TRENDS IN FISH SUPPLY AND DEMAND

The future of the fisheries and aquaculture sector will be influenced by its capacity to address strategic interconnecting challenges of global and local relevance. Population and income growth, together with urbanization and dietary diversification, are expected to create additional demand for animal products, including fish in developing countries. Thus, the future of the sector will be the result of social development, in its ecological, social and economic contexts, at local, regional and global scales.

In recent years, fish has become more integrated into overall agricultural analysis, including outlook models, with the aim to have a more comprehensive and consistent examination of its medium- or long-term prospects, taking into account interactions with other foods.[1]

Both outlook models provide insights into how the sector may develop. Taking into account key assumptions and uncertainties, the results indicate likely paths of development and constraints in supply and demand, determining regional vulnerabilities, changes in comparative advantage, price effects, and potential adaptation strategies in the sector.

FAO Fish Model

In 2010, FAO developed a model to analyse the outlook for the fisheries and aquaculture sector in terms of production potential, demand, consumption, prices and key issues that might influence future supply and demand.

The projection results are updated annually to describe a plausible scenario in a ten-year horizon under certain assumptions (e.g. macroeconomic environment, international trade rules and tariffs, El Niño phenomena, management constraints on production, and longer-term productivity trends). These assumptions portray a specific macroeconomic and demographic environment that shapes the evolution of demand and supply.

The main outcomes of the latest fish projections, Baseline scenario,[2] were included in the *OECD–FAO Agricultural Outlook 2013–2022*.[3] In addition, three alternative scenarios considered higher growth levels of aquaculture production relative to the baseline. The summary outcomes of all four scenarios are presented in Figures 45 and 46 and in Tables 24 and 25 and discussed below.

Baseline

On the basis of the assumptions used and stimulated by higher demand, world fisheries production is set to rise over the projection period (2013–2022) to 181 million tonnes in 2022, of which 161 million tonnes destined for direct human consumption (Table 24). This represents an increase of about 18 percent above the average for 2010–12, the base period (Table 25), at an annual growth rate of 1.3 percent. Capture fisheries

Figure 45

FAO Fish Model: world fishery production under different scenarios, from 2010–12 to 2022

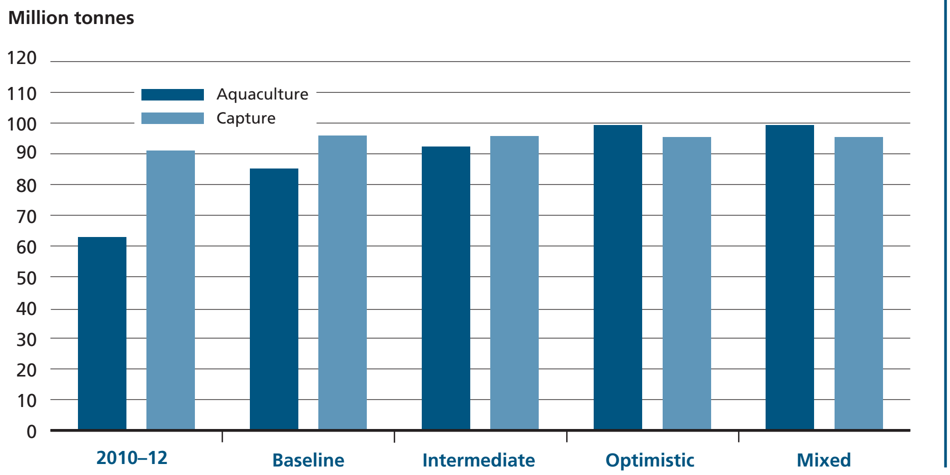
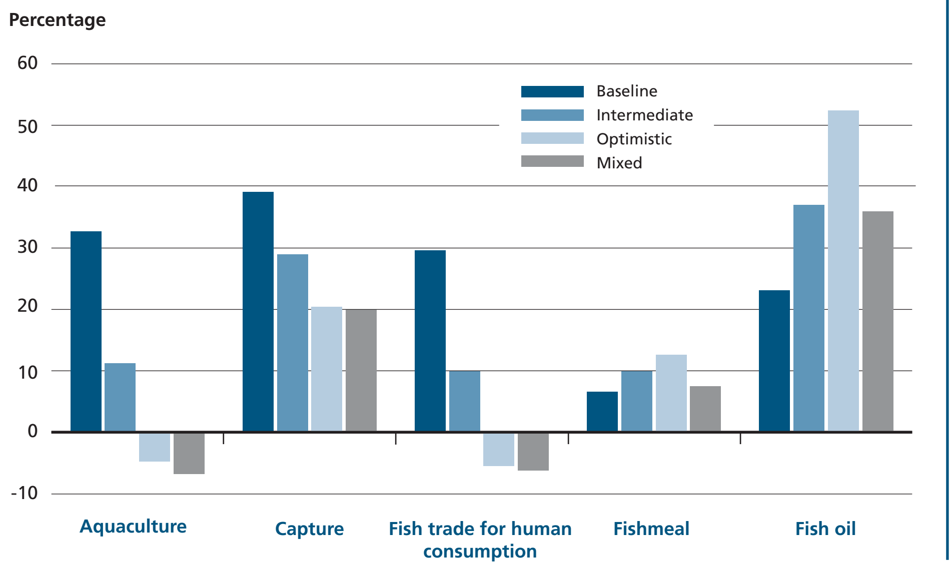


Figure 46

FAO Fish Model: world price changes under different scenarios, from 2010–12 to 2022



production is projected to increase by 5 percent to about 96 million tonnes. This improvement is due to a combination of factors including: recovery of certain stocks following improved resource management; growth in the few countries not subject to strict production quotas; and enhanced use of fishery production, including reduced discards, waste and losses as driven by legislation or higher market prices. However, in some years (2015 and 2020 in the model), the El Niño phenomenon will reduce catches in South America, especially anchoveta. Overall increased supplies will come mainly from aquaculture, which will reach about 85 million tonnes in 2022 (up 35 percent in the period). However, its annual production growth is projected to average 2.5 percent

Table 24
FAO Fish Model: overall trends to 2022

	Base period	2022 scenarios			
	2010–2012	Baseline	Intermediate	Optimistic	Mixed
		(Million tonnes in live weight equivalent)			
WORLD					
Total fishery production	**153.940**	**181.070**	**188.093**	**194.800**	**194.792**
Aquaculture	62.924	85.124	92.402	99.330	99.330
Capture	91.016	95.946	95.692	95.474	95.462
Fishmeal production (*product weight*)	6.103	7.021	7.358	7.679	7.734
Fish oil production (*product weight*)	0.980	1.079	1.087	1.094	1.088
Fish trade for human consumption	36.994	45.082	45.566	46.237	46.566
Fish supply for human consumption	131.741	160.514	167.397	173.969	174.032
Per capita apparent fish consumption (*kg*)	18.9	20.7	21.6	22.4	22.4
AFRICA					
Total fishery production	**9.037**	**10.427**	**10.528**	**10.634**	**10.296**
Aquaculture	1.379	2.034	2.207	2.373	2.034
Fish exports for human consumption	1.874	1.933	1.765	1.628	1.614
Fish imports for human consumption	3.876	4.689	4.924	5.151	5.332
Per capita apparent fish consumption (*kg*)	10.0	9.0	9.4	9.7	9.6
AMERICA					
Total fishery production	**22.275**	**23.795**	**24.120**	**24.428**	**23.781**
Aquaculture	2.911	3.936	4.273	4.593	3.936
Fish exports for human consumption	6.598	8.296	8.190	8.099	7.769
Fish imports for human consumption	7.657	9.358	9.509	9.657	9.762
Per capita apparent fish consumption (*kg*)	14.9	15.1	15.6	16.1	15.9
ASIA					
Total fishery production	**104.935**	**128.506**	**134.833**	**140.868**	**142.378**
Aquaculture	55.822	75.959	82.453	88.635	90.165
Fish exports for human consumption	19.241	24.200	25.032	25.994	26.973
Fish imports for human consumption	14.572	17.666	17.507	17.560	17.475
Per capita apparent fish consumption (*kg*)	21.7	24.6	25.8	26.8	26.9
EUROPE					
Total fishery production	**16.064**	**16.677**	**16.926**	**17.164**	**16.672**
Aquaculture	2.618	2.943	3.195	3.435	2.943
Fish exports for human consumption	8.264	9.712	9.640	9.579	9.292
Fish imports for human consumption	10.260	12.568	12.811	13.041	13.158
Per capita apparent fish consumption (*kg*)	21.2	23.5	24.3	25.0	24.8
OCEANIA					
Total fishery production	**1.381**	**1.374**	**1.396**	**1.416**	**1.374**
Aquaculture	0.190	0.251	0.273	0.293	0.251
Fish exports for human consumption	0.843	0.761	0.760	0.758	0.738
Fish imports for human consumption	0.652	0.797	0.811	0.824	0.835
Per capita apparent fish consumption (*kg*)	26.5	28.5	29.1	29.7	29.6

in 2013–2022, compared with 6.1 percent in 2003–2012. The main causes of this slower growth will be: freshwater scarcity; less optimal production location availability; and high costs of fishmeal, fish oil and other feeds (about 50 percent of global aquaculture depends on external feed inputs). Nonetheless, aquaculture will remain one of the

Table 25
FAO Fish Model: total growth in 2022 over 2010–2012 under different scenarios

	Baseline	Intermediate	Optimistic	Mixed
	(Percentage)			
WORLD				
Total fishery production	**17.6**	**22.2**	**26.5**	**26.5**
Aquaculture	35.3	46.8	57.9	57.9
Capture	5.4	5.1	4.9	4.9
Fishmeal production	15.0	20.6	25.8	26.7
Fish oil production	10.2	10.9	11.7	11.1
Fish trade for human consumption	21.9	23.2	25.0	25.9
Fish supply for human consumption	21.8	27.1	32.1	32.1
Per capita apparent fish consumption	9.4	14.1	18.6	18.6
AFRICA				
Total fishery production	**15.4**	**16.5**	**17.7**	**13.9**
Aquaculture	47.5	60.1	72.1	47.5
Fish exports for human consumption	3.2	–5.8	–13.1	–13.9
Fish imports for human consumption	21.0	27.0	32.9	37.6
Fish supply for human consumption	20.1	25.4	30.4	29.0
Per capita apparent fish consumption	–10.3	–6.3	–2.6	–3.7
AMERICA				
Total fishery production	**6.8**	**8.3**	**9.7**	**6.8**
Aquaculture	35.2	46.8	57.8	35.2
Fish exports for human consumption	25.7	24.1	22.8	17.8
Fish imports for human consumption	22.2	24.2	26.1	27.5
Fish supply for human consumption	11.9	15.7	19.2	17.9
Per capita apparent fish consumption	1.3	4.7	7.9	6.8
ASIA				
Total fishery production	**22.5**	**28.5**	**34.2**	**35.7**
Aquaculture	36.1	47.7	58.8	61.5
Fish exports for human consumption	25.8	30.1	35.1	40.2
Fish imports for human consumption	21.2	20.1	20.5	19.9
Fish supply for human consumption	25.2	31.0	36.5	37.1
Per capita apparent fish consumption	13.7	19.0	24.0	24.5
EUROPE				
Total fishery production	**3.8**	**5.4**	**6.8**	**3.8**
Aquaculture	12.4	22.0	31.2	12.4
Fish exports for human consumption	17.5	16.6	15.9	12.4
Fish imports for human consumption	22.5	24.9	27.1	28.3
Fish supply for human consumption	12.1	15.7	19.0	18.5
Per capita apparent fish consumption	11.0	14.5	17.8	17.3
OCEANIA				
Total fishery production	**–0.5**	**1.1**	**2.5**	**–0.5**
Aquaculture	32.3	43.8	54.6	32.3
Fish exports for human consumption	–9.7	–9.8	–10.0	–12.4
Fish imports for human consumption	22.3	24.4	26.4	28.0
Fish supply for human consumption	23.3	25.9	28.3	27.7
Per capita apparent fish consumption	7.6	9.8	11.9	11.4

fastest-growing food-producing sectors. Its share in global fishery production will rise from 41 percent in 2010–12 to 47 percent in 2022. In terms of fish destined for human consumption, aquaculture should surpass 50 percent of the total by 2015 and reach 53 percent by 2022.

The bulk of total fishery production will continue to come from Asia, whose share will rise from 68 percent in the base period to 71 percent in 2022 (accounting for 55 percent of capture fisheries and 89.2 percent of aquaculture). China will remain the main producer, accounting for 16 percent and 63 percent, respectively, of global capture fisheries and aquaculture production.

The sector is expected to enter a decade of higher prices and production costs, with prices increasing in the medium term in nominal and real terms. This tendency will be the outcome of several factors affecting the underlying positive trend in demand, such as income and population growth, increasing meat prices and a generally weak US dollar. In addition, there are supply-reducing factors such as a limited potential for increased capture fisheries production and cost pressure from some crucial inputs (e.g. energy, fishmeal, fish oil and other feeds). In the period under review, the average price for capture fisheries landings (excluding fish for reduction) is expected to grow faster than that for farmed fish (39 percent vs 33 percent).

In 2022, about 16 percent of capture fishery production will be reduced to fishmeal and fish oil,[4] down 7 percent on the 2010–12 average. However, in 2022, total production of fishmeal and fish oil should be, respectively, 15 and 10 percent up on the base period. Almost 95 percent of the additional gain for fishmeal will stem from improved use of fish waste, cuttings and trimmings. Sustained demand and high prices for fishmeal, combined with reduced raw-material availability and growing value-added fishery products for human consumption, will lead to more residues being used in fishmeal manufacturing. Fishmeal from fish by-products should represent 49 percent of total fishmeal production in 2022. With global demand stronger than supply, prices of fishmeal and fish oil will increase by 6 and 23 percent (Figure 46), respectively, in nominal terms by 2022. Their tight supply is expected to contribute to a medium-term increase in the price ratio between fish and oilseed products.

World annual per capita fish food consumption is projected to rise from 18.9 kg in the base period to 20.7 kg in 2022. However, the annual growth rate will decline from 1.8 to 0.6 percent. Per capita fish consumption will increase in all continents, except Africa (–10 percent as population growth outpaces supply), with Asia showing the highest growth rate (+14 percent). Fish consumption is expected to show little to no growth in many developed countries, with an overall growth of 4 percent by 2022. Developing countries will account for more than 91 percent of the total increase in fish consumption. Even so, their annual per capita fish consumption will remain below that of more developed regions (19.8 kg vs 24.2 kg), although this gap will be narrowing.

Fisheries supply chains will continue to be globalized, with 36 percent of total fishery production being exported in 2022. In quantity terms, world trade of fish for human consumption is expected to expand by 22 percent in the period. However, the annual growth rate of exports will decline from 3.3 percent to 1.8 percent, partly owing to increasing prices, higher transportation costs and slower aquaculture expansion. The average price of traded fish products for human consumption will grow by 30 percent in nominal terms during the period. It will also rise in real terms, while remaining below the levels of the early 1990s. Developing countries will continue to account for about 67 percent of world exports of fish for human consumption, with Asian countries accounting for 54 percent of the total, and China being the world's main exporter.

Alternative scenarios

The Baseline projections (above) are considered to be those that prevail through to 2022. However, three additional scenarios (Intermediate, Optimistic and Mixed) were developed with the growth in aquaculture as their focus as it is considered the main source of additional supply. Achieving such production increases could be constrained by tighter regulations, scarcer and more stressed land and water resources, and feed supply problems. The scenarios investigate higher aquaculture growth with respect to the Baseline but still below the 6.1 percent per year of 2003–2012. They point to different levels of growth, taking into account technological improvements, expansion of cultivated area, intensification (in yield per unit of area or volume) and, for the Mixed scenario, also an increase and/or differentiation in the countries joining the production process. In all three scenarios, capture fisheries is expected to maintain the same growth pattern as in the Baseline.

In the Intermediate and Optimistic scenarios, the overall growth in world aquaculture production will be homogeneously distributed among countries.

In the Intermediate scenario, world aquaculture production increases by 47 percent compared with the base period, at 3.4 percent per year. The increase will affect prices, with average prices (excluding those for fishmeal and fish oil) rising compared with the base period but less than in the Baseline scenario. With aquaculture expansion, more pressure is expected on fishmeal and fish oil. Relative to 2010–12, total production of fishmeal and fish oil should increase by 21 and 11 percent, respectively. In 2022, 51 percent of fishmeal will come from by-products. The sustained demand for fishmeal and fish oil will drive their prices higher. World per capita apparent fish consumption will reach 21.6 kg in 2022, up 14 percent on the base period, with major increases in Asia (+19 percent) and Europe (+14 percent), but a 6.3 percent decline in Africa. In 2022, 54 percent of fish consumed will originate from aquaculture. Although the trade of fish for human consumption will increase by 23 percent, the share of fish production being traded will decrease slightly.

The Optimistic scenario assumes an aquaculture production increase of 58 percent by 2022 (4.3 percent per year). Aquaculture will become the main contributor to total fish supply for human consumption in 2014, and to total fishery production in 2021. In 2022, farmed fish will account for 57 percent of total fish production for human consumption and 51 percent of total fishery production. In that year, total fishery production will reach 195 million tonnes, up 27 percent on the base period. The impact on prices is more marked than in the Intermediate scenario (Figure 46), with aquaculture and trade prices declining by 5 percent with respect to the base period. World fishmeal production should expand by 26 percent with respect to 2010–12, and with 52 percent of it obtained from fish by-products. Fish oil production will increase by 11 percent in the same period. World per capita fish consumption is expected to reach 22.4 kg in 2022, up 19 percent on the base period, with the decrease in Africa (–2.6 percent) the lowest under the various scenarios. The share of fish production consumed domestically will grow slightly, also thanks to reduced fish prices for consumers.

The Mixed scenario assumes the same overall growth as the Optimistic scenario but with the bulk of it occurring in Asia. Aquaculture production in Asia will reach 90.2 million tonnes, up 62 percent on the base period and 14 million tonnes more than in the Baseline scenario. Asian countries are expected to account for 91 percent of world aquaculture production in 2022, with Bangladesh, Thailand, India and China experiencing the highest growth rates. Figure 46 shows the price impacts. Compared with the other scenarios, the share of Asian fishery production exported will increase slightly. World per capita fish consumption is expected to be 22.4 kg, as in the Optimistic scenario, but with minor differences at continental level with respect to it.

Fish to 2030[5]

The *Fish to 2030* report is based on the results of IFPRI's IMPACT model, which simulated outcomes of interactions across countries and regions to make projections to 2030.

Table 26 presents the results under the baseline scenario, considered the most plausible scenario. Total fish production will reach 187 million tonnes in 2030, up almost 45 million tonnes on 2008. With capture fisheries production stable, major growth will come from aquaculture, albeit expanding more slowly than previously. By 2030, capture fisheries and aquaculture will be contributing equally to global fish production, and with aquaculture probably dominating beyond 2030. Aquaculture is projected to supply more than 60 percent of fish destined for direct human consumption by 2030.

China is expected to increasingly influence the global fish sector. In 2030, China should account for 37 percent of total fishery production (17 percent of capture and 57 percent of aquaculture production) and for 38 percent of the fish supply for human consumption. China will remain a net exporter of food fish (net importer of fish if fishmeal is considered). Aquaculture will grow rapidly in South Asia, Southeast Asia and Latin America. Per capita fish consumption is projected to decline in Japan, Latin America, Europe, Central Asia and sub-Saharan Africa. In particular, in sub-Saharan Africa, it is projected to decline by 1 percent annually to 5.6 kg in 2030. Owing to population growth of 2.3 percent per year, sub-Saharan Africa will increase its demand for fish for human consumption by 30 percent by 2030. As its production is projected to expand only marginally, the region's dependence on fish imports will rise from 14 percent in 2000 to 34 percent in 2030.

At world level, looking across species, the fastest supply growth is expected for tilapia, carp and *Pangasius*/catfish. The demand for fishmeal and fish oil will probably grow, given the rapid expansion of aquaculture and stable global capture fisheries. In the period 2010–2030, fishmeal and fish oil prices are expected to rise in real terms by 90 and 70 percent, respectively. Nonetheless, through improvements in feed and management practices, the projected expansion in aquaculture will be achieved with a mere 8 percent increase in the global fishmeal supply.

Six other scenarios (Table 27) were implemented to investigate potential impacts of changes in the drivers of global fish markets under various assumptions.

The Increased Aquaculture Scenario assumes aquaculture can grow 50 percent faster than under the baseline scenario. While technical changes are implicit in the baseline parameters, this scenario accelerates them by 50 percent. Thus, the model predicts that aquaculture production in 2030 would expand to 101.2 million tonnes. This faster growth would stress the fishmeal market, dictating which species and regions would grow faster. In 2030, tilapia production would be about 30 percent higher than in the baseline case, while that of molluscs, salmon and shrimp would increase by about

Table 26
Fish to 2030: summary results under baseline scenario

	Total fish supply (Million tonnes)		Food fish consumption (Million tonnes)	
	Data 2008	Projection 2030	Data 2008	Projection 2030
Capture	89.443	93.229	64.533	58.159
Aquaculture	52.843	93.612	47.164	93.612
Global total	**142.285**	**186.842**	**111.697**	**151.771**
Regional breakdown:				
Europe and Central Asia	14.564	15.796	16.290	16.735
North America	6.064	6.472	8.151	10.674
Latin America and Caribbean	17.427	21.829	5.246	5.200
Other East Asia and the Pacific	3.724	3.956	3.866	2.943
China	49.224	68.950	35.291	57.361
Japan	4.912	4.702	7.485	7.447
Southeast Asia	20.009	29.092	14.623	19.327
Other South Asia	6.815	9.975	4.940	9.331
India	7.589	12.731	5.887	10.054
Near East and North Africa	3.518	4.680	3.604	4.730
Sub-Saharan Africa	5.654	5.936	5.947	7.759
Rest of the world	2.786	2.724	0.367	0.208

Source: IMPACT model projections, Fish to 2030.

Table 27
Fish to 2030: summary results for 2030 under baseline and alternative scenarios

	Baseline	Increased aquaculture	Expansion of feed supply	Disease outbreak	Increased demand in China	Improved capture fisheries	Climate change CC-a	Climate change CC-b
Total fish supply (million tonnes)	**186.8**	**194.4**	**188.6**	**186.6**	**209.4**	**196.3**	**184.9**	**185.0**
Capture supply (million tonnes)	**93.2**	**93.2**	**93.2**	**93.2**	**93.2**	**105.6**	**90.2**	**90.2**
Aquaculture supply (million tonnes)	**93.6**	**101.2**	**95.4**	**93.4**	**116.2**	**90.7**	**94.7**	**94.8**
Shrimp (million tonnes)	11.5	12.3	11.5	11.2	17.6	11.6	11.5	11.4
Salmon (million tonnes)	5.0	5.4	5.1	5.0	6.1	5.0	4.8	4.8
Tilapia (million tonnes)	7.3	9.2	7.4	7.3	7.4	7.2	7.3	7.3
Fishmeal price (US$/tonne; % to baseline)	1 488	13%	–14%	–1%	29%	–7%	2%	2%
Fish oil price (US$/tonne; % to baseline)	1 020	7%	–8%	–0%	18%	–6%	3%	3%
China per capita consumption (kg/year)	41.0	43.3	41.5	40.9	64.6	42.2	40.7	40.7
Sub-Saharan Africa per capita consumption (kg/year)	5.6	5.9	5.8	5.6	5.4	6.4	5.5	5.5

Note: CC-a = climate change with mitigation; CC-b = climate change without drastic mitigation.
Source: IMPACT model projections, Fish to 2030.

10 percent. As a result, relative to the baseline scenario, all fish prices in 2030 in real terms would be up to 2 percent lower, except for the price of the "other pelagic" category (an ingredient in fishmeal and fish oil). Fishmeal and fish oil prices in 2030 would be higher than in the baseline case.

The Expansion of Feed Supply Scenario considers utilizing more fish-processing waste to increase feed supply. Here, fishmeal production in 2030 would be 12 percent higher and its price would be 14 percent lower relative to the 2030 results in the baseline case. This would boost the aquaculture production of freshwater and diadromous fish, salmon and crustaceans.

The Disease Outbreak Scenario hypothesizes a major disease outbreak affecting shrimp aquaculture in China and South and Southeast Asia, reducing their production by 35 percent in 2015. As Asia accounts for 90 percent of global shrimp aquaculture, global supply would contract by 15 percent in 2015. With the simulated recovery, the projected impact of the outbreak would be negligible by 2030.

The Increased Demand in China Scenario is specified such that in 2030 per capita consumption in China of high-value shrimp, crustaceans and salmon is three times higher than in the baseline results for 2030, and that of molluscs double the baseline value. These are higher-value commodities and, except for molluscs, their production requires fishmeal. Here, global aquaculture production could exceed 115 million tonnes by 2030. This scenario would benefit producers and exporters in Southeast Asia and Latin America. While overall fish consumption in China would be 60 percent higher relative to the baseline case, all other regions would consume less by 2030. For sub-Saharan Africa, annual per capita fish consumption in 2030 would drop by 5 percent to 5.4 kg. In 2030, in real terms, fishmeal and fish oil prices would increase relative to the baseline case. Fishmeal production would expand by an additional 300 000 tonnes,

obtained from an additional 1 million tonnes of fish otherwise destined for direct human consumption.

The Improved Capture Fisheries Scenario simulates the impacts of long-run productivity increases in capture fisheries where stocks are allowed recover to levels permitting their maximum sustainable yield (MSY). In *The Sunken Billions*,[6] effectively managed global capture fisheries are assumed to sustain harvest at 10 percent above current levels. Under this scenario, the world would have 13 percent more wild-caught fish by 2030 (relative to the baseline projection). The increase in the production of fish for reduction into fishmeal and fish oil would ease pressure on the feed market (with the fishmeal price 7 percent lower than under the baseline case). Production in all regions would benefit. In particular, sub-Saharan Africa's fish consumption in 2030 would be 13 percent higher than under the baseline scenario. This is because increased production would probably be consumed within the region rather than exported. The relative abundance of wild-caught fish would dampen fish prices so that aquaculture production in 2030 would be 3 million tonnes lower relative to the baseline case.

The Climate Change Scenario considers the impacts of global climate change on marine capture fisheries. Changes in global fish markets are simulated based on predicted MSYs[7] under two scenarios – one with mitigation measures and the other without. The former yields a 3 percent reduction in global marine capture fisheries production in 2030 relative to the baseline scenario, while the latter results in global capture fisheries production being reduced by a further 0.02 percent in 2030. While the aggregate impact is negligible, the distribution of the expected changes in catches varies widely across regions. In principle, high-latitude regions are expected to gain while tropical regions lose capture production.[8] The model predicts that market interactions will attenuate the impact of any changes.

Summary of main issues

The results presented above refer to projections and not forecasts. They provide insights into how the sector may develop, taking note of key assumptions and uncertainties. Changes in the basic assumptions would affect the resulting fish projections.

Overall, modelling outcomes agree on the following expected trends:

- relative stability in capture fisheries production, with possible increase if overexploited/depleted stocks are well managed;
- filling of supply–demand gap by continued growth in aquaculture, particularly inland aquaculture;
- population growth outpacing fish production in Africa, with a resulting overall decrease in per capita fish consumption.

MEETING FUTURE DEMAND FOR FISH

Barriers to growth (or impediments to change) have to be explicitly recognized and addressed. They can be related to the three pillars of sustainability: (i) environmental, e.g. ecosystem carrying capacity and degradation; (ii) economic, e.g. inadequate or perverse incentives, insufficient investment, excessive costs of solutions (cost of compensation, transition and alternative livelihoods), short-term economic gains without consideration of other externalities; and (iii) social, e.g. food insecurity and poverty.

However, poor governance is perhaps the main threat to the sector's ability to satisfy the future demand for fish. Meeting future fish demand requires good governance (see the section Governance and policy on pp. 69–92) that explicitly addresses the objectives of ensuring sustainable growth and equitable distribution of benefits.[9]

The ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) are strategies to strengthen the practical and comprehensive implementation of sustainability principles by improved management approaches coherent with good governance. They provide guidance in operational planning and implementation in order to achieve high-level objectives at different geographical and production scales. The key features of the EAF/EAA process as proposed in FAO Technical Guidelines[10] are:

- Develop a management plan for a specific area/system with operationally defined boundaries.
- Envisage stakeholder participation at all levels of planning and implementation.
- Consider all key components of a fishery/aquaculture system (ecological, social-economic and governance) while also taking external drivers into account.
- Identify and prioritize sustainability issues through a formal process (e.g. risk assessment).
- Reconcile management objectives related to environmental and social/ economic aspects, including explicit consideration of trade-offs.
- Establish an adaptive management process to adjust the tactical and strategic performance based on past and present observations and experiences.
- Use "best available knowledge" as the basis for decision-making, including both scientific and traditional knowledge, while promoting risk assessment and management and the notion that decision-making should take place also where detailed scientific knowledge is lacking.
- Build on existing management institutions and practices.

As part of this process, managers and stakeholders should identify, discuss and agree on the broad objectives and values that the management system is to address. This step is important as different stakeholders have different values, which can lead to conflicts and inefficient management systems. Values should be nested and coherent across scales and sectors.

The sections below examine some of the main model assumptions and how to enhance the ability of the fisheries and aquaculture sector to meet the demand for fish.

The international community has to reconcile environmental sustainability objectives with the growth in fish production that is expected to occur as a result of market forces while enhancing food security and alleviating poverty. Although widely recognized at high political levels (e.g. Rio+20), in practice these objectives remain only loosely and superficially linked. Capture fisheries and aquaculture operate at different scales, from local production systems to the global marketplace, and their institutional and legal frameworks also exist at different scales. Often, there is very poor policy coherence across scales and between stated policy goals and market-driven processes.

Resource managers will also face increasingly competitive use of aquatic ecosystems and having to choose among options for the greatest good for the greatest number of people. An ecosystem approach facilitates the incorporation of multiple objectives into resource management through a risk-based framework. It can also create the enabling environment necessary for the sustainable production and governance of aquatic ecosystems.

Sustaining capture fisheries production

There is a concern that the current stable global catches may not be sustained. Trends show that the percentage of overfished stocks is increasing and that the percentage of underfished stocks is decreasing (see Figure 13 on p. 37). Thus, what is commonly referred to as "stability" in global catches is the result of fisheries moving to underfished resources as others become overfished and depleted. This is happening at various scales, including at the global scale where long-distance fleets move to new fishing grounds as the old ones are depleted. A recent trend has been for open-ocean fishers to move into deeper waters as near-shore stocks decline.[11] Marine capture fisheries on conventional resources have apparently reached their aggregate maximum level of contribution at the price of sequential overfishing. The concern is that if this trend is not halted, there could be a decline in global catches as new fishing grounds become exhausted. None of the outlook studies conducted to date has considered this aspect.

The challenges for capture fisheries are well known and part of the international discourse. Sustaining or increasing present global level of catches will be constrained by, *inter alia*, impaired resource/ecosystem productivity and changing ecosystem structures. Discards and impacts on the ecosystems' vulnerable habitats, species and biodiversity are locally significant, affecting resilience. Economic and social performance is insufficient, and the sector is overcapitalized. Most fisheries are in a de facto open-access situation, and widespread illegal fishing is impairing effective stewardship. Conflicts abound (e.g. between small- and large-scale subsectors), with sectors competing for the same space or ecosystem services. In addition, pollution and coastal degradation are impairing productivity and food quality.

If the capture fisheries projections presented above are to be met, it is essential that the sector implement radical reforms. Continuing with "business as usual" will probably result in the decline of global catches in a not-too-distant future.

What needs to be done to improve the sector's performance has been widely identified and debated, with priorities set at the global level. Actions often referred to when addressing the unsustainability of fisheries include: reducing fishing capacity and effort; establishing area closures (e.g. marine protected areas); improving tenure (resource allocation/user rights); eliminating subsidies; reducing discards, promoting full use of catches and reducing post-harvest losses; and introducing new technology such as bycatch excluder devices. However, the relative importance of different sustainability issues and the identification of appropriate measures is context-specific. The EAF process can identify issues and ways to address them so that priorities can be set as relevant to context and depending on culture, type of fishery/issue and stakeholder perceptions.

Furthermore, the challenge is not only to produce but to do so in a way that is environmentally sustainable and ensures that sector development takes place in the context of priority areas such as food and nutrition security and poverty reduction. Again, it is important that appropriate processes be put in place to translate these goals into decision-making and implementation coherent with them.

It is argued that, to meet these multiple goals, fisheries and aquaculture development should be guided by strong policies and management practices that explicitly address the aforementioned objectives, and that these are put into practice through appropriate holistic, adaptive and participatory management processes.

Managing fisheries as socio-ecological systems

Fisheries have been managed, and many still are, with a focus on the resources being exploited. Many people consider the setting of total allowable catches and the supporting processes of fishery data collection and analysis as being the main activities of fisheries management, without considering that sustainability requires addressing fisheries as socio-ecological systems whose sustainability depends on all its parts. "Sustainable" fisheries are those where fishers can generate, through their work, sufficient resources to cover, at the very least, all the basic needs for food, health and education, while adopting ecologically sustainable exploitation practices. Here, government creates an enabling environment (according to context) for that to happen. The system has to be characterized by transparency, trust and a shared vision by stakeholders, government and society at large. As for the agriculture sector overall, there is now greater awareness of the need to address sustainability issues, also in an integrated way by addressing the three pillars of sustainability. It is essential that stakeholders be actively involved and motivated to adopt more sustainable patterns of resource use.

For example, in *The State of World Fisheries and Aquaculture 2012*,[12] a graph of hypothetical inland fisheries was plotted on two axes: one measuring production parameters and the other social and economic parameters. Rather than categorizing a fishery only according to its state of exploitation, a fishery would be tracked along the two-dimensional space and evaluated according to how it met management's production and socio-economic objectives. For example, before the introduction of Nile perch, the Lake Victoria fisheries would have been plotted as highly productive (many cichlid species) but not very valuable. Following the introduction of high-value species, the fishery would move to the quadrant indicating high economic value – which in fact was the objective of the management intervention. Similarly, recreational fisheries with very low production but high value would be seen as meeting the management objective of increased economic value, but with decreased harvest of biomass.

An example of progress with EAF implementation is the EAF-Nansen project[13] in Africa. It aims to help to achieve food security and alleviate poverty through the development of sustainable fisheries management regimes and specifically through the application of the ecosystem approach in marine fisheries. Key activities include supporting policy development and management practices consistent with EAF principles, developing an expanded knowledge base in support of the EAF, promoting standardized data collection and monitoring. Capacity development is a key, cross-cutting component. Twenty countries have engaged in the preparation of EAF management plans, and these are at different stages of development, including final adoption by the competent authorities. Such plans can be an important tool for addressing capacity and institutional issues in a more systematic and participatory way.

Developing adaptive management systems

Fishery systems are complex and characterized by uncertainty. Management interventions often have unknown or unpredictable effects, and possible impacts need careful consideration and analysis. Some of the constraints include the limited transferability and/or scaling up of experiences, and uncertainty in the outcomes of different management strategies. For many fishery systems, knowledge is poor, particularly on interactions within and between the ecological and human parts of the system. In these situations, adaptive management, embedded within a co-management setting, uses best available knowledge – including fishers' knowledge – to make decisions and learn from outcomes.

Adaptive management allows stakeholders and management institutions to operate in the face of uncertainty, learning from the effects of their resource management practices. It is often presented as a cycle with a number of essential steps: assess problem, design, implement, monitor, evaluate, adjust and restart the cycle. In fact, adaptive management is at the heart of the ecosystem approach and the proposed EAF management cycle presented in Box 10.

Filling the supply–demand gap

The projection scenarios discussed above are based on the interplay of free-market forces and some important assumptions including aquaculture growth trends. However, alternative scenarios could consider a more governance-driven development.

The outlook for aquaculture under all the scenarios involves some major assumptions, such as availability of fishmeal and fish oil, sufficient land and water for freshwater production, unrestricted ecosystem services for aquaculture, a neutral public perception of the sector, and a low mariculture growth rate. The extent to which these assumptions are valid will have an impact on the projections in the baseline and other scenarios.

In addition, although all the scenarios consider the sector's capacity to recover from certain shocks through better management and improved technologies, perhaps some threats (e.g. diseases) should be addressed in a more conservative way.

Some of the above assumptions can be addressed at the global level, for example, through the creation and implementation of global standards, consumer awareness and governance intervention in the form of appropriate incentives, while at the farming and waterbody level, the EAA becomes a relevant strategy.

Use of fish from capture fisheries to feed aquaculture

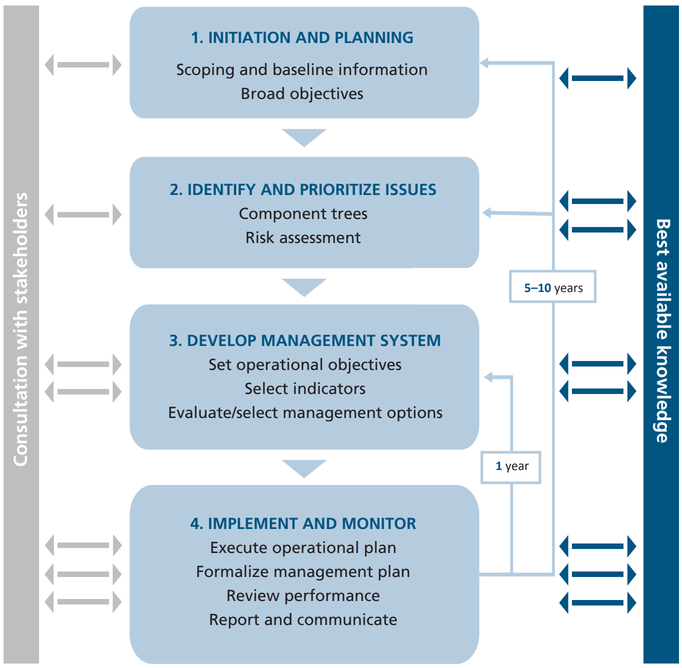
The above models and scenarios make assumptions on the sustainability of small pelagic fish stocks, the costs and availability of fishmeal and fish oil, and how they affect the growth of aquaculture. A reduction in fishing pressure is generally desirable

Box 10

Adaptive management and the EAF management cycle

Setting up a process of monitoring and assessment of fishery performance is key to fisheries management and an essential aspect of adaptive systems.

The EAF management cycle



in order to increase their resilience to climate variability and change, and to take account of the ecological role of these species in food webs. The use of so-called "low-value" fish (see section Transition from low-value fish to compound feeds in marine cage farming in Asia on pp. 161–168) as feed in aquaculture could provide an incentive for continued overfishing of these ecosystems.

The use of wild-caught fish for reduction to fishmeal and fish oil may have important implications for food security and aquaculture in the next 20 years.[14] A similar situation concerns the use of low-value fish. At present, the increase in fishmeal/oil production for animal production (including aquaculture) can create employment and improve living standards and food security among poor communities through employment opportunities.[15]

However, in many areas small pelagic fish are an important part of the human diet. As fishmeal demand and price increase, it may become profitable to divert these resources to fishmeal. High demand could make a traditional source of cheap protein less available to the poor and provide an incentive to overfish the stocks. Governments would need to put measures in place to guard against such impacts and to help ensure that jobs created by increased production of animal feeds benefit local communities.[16]

In some cases, countries experience the above scenario, e.g. in Africa and Asia, where the market for fish as food cannot compete with international fishmeal prices.[17] In other countries, prices for some pelagic species traditionally used for fishmeal favour use for human consumption. This is the case for herring, mackerel and blue whiting in Europe, in particular in Norway and Iceland, and jack and horse mackerel in Chile.[18]

There is also an increasing conflict between the use of low-value fish for animal/fish feeds versus human consumption, especially in Asia.[19] For example, in Viet Nam, where low-value fish is used for fish sauce, there appears to be direct competition between producers of low-cost fish sauce and producers of *Pangasius* feeds. However, operators and people employed on *Pangasius* farms can improve their standard of living and access nutritious food.

The aquaculture sector would benefit from international standards and certification systems[20] to promote socially and environmentally acceptable products and the development of national-level policy frameworks that would consider food security needs in developing fishmeal and aquaculture industries. In this respect, the FAO guidelines on the use of wild fish as feed in aquaculture[21] discourage the practice where this compromises the food security of vulnerable groups.

Availability of land and water

Availability of land and water is another possible main constraint to aquaculture growth. In many developed countries, the space for aquaculture growth is often restricted by other competing uses and priorities. Often, mariculture farms are forced to move farther offshore or somewhere else owing to conflict with tourism or urban development. In Asia, the clear alternative option is intensification, as expansion is not foreseeable. There may be some exceptions in Central Asia, but a shortage of freshwater may become a major threat, especially under climate change.[22] In Egypt, water availability is the main factor constraining the growth of the aquaculture industry. Currently, only agriculture drainage water is used for fish farms, but farmers are requesting freshwater as they reuse this water for crops. Moreover, farmers argue that drainage water negatively affects farmed fish owing to the accumulation of pollutants and potential contamination of fish.[23]

Environmental impacts and their effect on sector growth and market demand

The environmental impacts of aquaculture affect areas where aquaculture takes place. In addition, they are a global concern that can affect consumers' attitudes. For example, the fast-growing Vietnam catfish (*Pangasius*) has attracted strong criticism based on alleged environmental and food safety issues. High-density farming in the lower Mekong Delta has created a negative perception among consumers. Although many of the accusations may not be supported,[24] the local eutrophication impacts cannot be denied.

The role of aquaculture in eutrophication has been demonstrated. For example, one study[25] finds that freshwater aquaculture adds to the nutrient loading of river systems, which is likely to increase in the future. Impacts are and will be greater where aquaculture is concentrated and where nutrient exports exceed carrying capacity.

Many environmental impacts of aquaculture result from the sum of individual farms but they are rarely addressed at this more "ecosystemic level". While environmental impact assessments (EIAs), licensing and certification systems are required for individual intensive/large-scale types of farms, there are no mitigation approaches or management measures covering the overall impact of small farms collectively. Some farms generate impacts that affect the farming systems themselves by causing hypoxia, fish kills, fish stress, facilitating conditions for spreading diseases, etc. There are studies on aquaculture "boom and bust" such as milkfish farming in coastal lakes in the Philippines.[26] Other examples connecting with disease issues are salmon in Chile and shrimp in Thailand.

The equitable share of benefits and a proper accounting of the environmental costs are becoming issues even where the sector is well developed and managed. According to a study in Norway,[27] salmon farming has contributed to potential conflicts, stemming from the fact that local communities should have been more part of the integrated planning process of this industry. In general, there seems to be a problem of poor communication and understanding of aquaculture, its costs and benefits, and issues of equity and sharing. The expansion of salmon farming in Chile faces similar problems.[28]

Given the foregoing, it is important to build the image of aquaculture to widen public acceptance of farmed fish. Concerns such as those above are also key issues in mariculture development, especially cage culture in developed countries.

In some developed countries, governmental decisions constrain aquaculture expansion owing to potential environmental threats. For example, the aquaculture growth scenarios proposed by the models could be wide of the mark if North American countries opened more coastal and inland space for aquaculture growth. In the current

Box 11

Impacts of shrimp early mortality syndrome

Early mortality syndrome (EMS) is a serious emerging disease of cultured shrimp.[1] The causative agent, a strain of *Vibrio parahaemolyticus*,[2] is a marine micro-organism native in estuarine waters worldwide. Three species of cultured shrimp are affected (*Penaeus monodon*, *P. vannamei* and *P. chinensis*). The impacts of EMS[3] include production losses, loss of income and profit for small-scale producers and commercial enterprises, higher shrimp prices owing to supply shortages, and impacts on trade. In Viet Nam, about 39 000 ha were affected in 2011. Malaysia estimated production losses of US$0.1 billion (2011); while Global Aquaculture Alliance estimates indicated US$1 billion. In Thailand, reports from private sector enterprises indicated annual output declines of 30–70 percent. The disease has been reported in China, Malaysia, Mexico, Thailand and Viet Nam. A 2013 FAO workshop[3] made recommendations pertinent to important areas such as: diagnosis; notification/reporting; international trade of live shrimp, shrimp products (frozen, cooked), and live feed for shrimp; advice to affected and unaffected countries; measures at farm and hatchery facilities; advice to pharmaceutical and feed companies and shrimp producers; actions on knowledge and capacity development; outbreak investigation/emergency response; and targeted research on various themes (e.g. epidemiology, diagnostics, pathogenicity and virulence, public health, and polyculture technologies). Shrimp aquaculture needs to develop into a sector that implements responsible, science-based farming practices.

[1] Lightner, D.V., Redman, R.M., Pantoja, C.R., Noble, B.L. & Tran, L. 2012. Early mortality syndrome affects shrimp in Asia. *Global Aquaculture Advocate*, 15(1): 40.
Network of Aquaculture Centres in Asia-Pacific. 2012. *Report of the Asia Pacific emergency regional consultation on the emerging shrimp disease: early mortality syndrome (EMS)/ acute hepatopancreatic necrosis syndrome (AHPNS), 9–10 Aug 2012*. Bangkok, NACA.
[2] Tran, L., Nunan, L., Redman, R.M., Mohney, L.L., Pantoja, C.R., Fitzsimmons, K. & Lightner, D.V. 2013. Determination of the infectious nature of the agent of acute hepatopancreatic necrosis syndrome affecting penaeid shrimp. *Diseases of Aquatic Organisms*, 105: 45–55.
[3] FAO. 2013. *Report of the FAO/MARD Technical Workshop on Early Mortality Syndrome (EMS) or Acute Hepatopancreatic Necrosis Syndrome (AHPNS) of Cultured Shrimp (under TCP/VIE/3304). Hanoi, Viet Nam, on 25–27 June 2013*. FAO Fisheries and Aquaculture Report No. 1053. Rome. 54 pp. (also available at www.fao.org/docrep/018/i3422e/i3422e.pdf).

situation (and in the scenarios), the burden of aquaculture environmental impacts is mainly on developing and emerging economies.

Can diseases hinder the growth of the sector?

Examples of the impact of aquatic animal diseases include: white spot disease in shrimp culture worldwide; outbreaks of early mortality syndrome on shrimp farms in Asia and Mexico (see Box 11); and infectious salmon anaemia, which affected salmon production in Chile. The simulation of a shrimp disease in the Fish to 2030 projections demonstrates the shock and the ability to recover. Nevertheless, the social and economic impacts at the national and local levels cannot be ignored. Disease impacts could be worse if the affected species are those more important for human consumption and food security, e.g. tilapia or carps. Appropriate biosecurity schemes need to be implemented worldwide with special attention to the movement of live aquatic animals such as seed and live feeds.[29]

Improving global aquaculture governance

All the above scenarios and projections ignore the environmental costs of aquaculture, resource depreciation and the need for ecosystem services. However, in some countries, the consideration of these costs is hidden in the more restrictive regulations that attempt to preserve ecosystem services.

Policy and legal frameworks for aquaculture development remain weak in many countries. At the global level, the most important negotiated instruments concerning aquaculture are the Code of Conduct for Responsible Fisheries and, most recently, the technical guidelines on aquaculture certification.[30] Their effective implementation will probably remain the major challenge for the foreseeable future.

The huge aquaculture development of recent decades has been primarily driven by market forces and not always aligned with development priorities related to conservation, food security and poverty alleviation. Nevertheless, there are important efforts to reduce key negative social and environmental impacts through compliance with standards at the farm level, as for example through various certification schemes, supported or guided by globally agreed schemes such as the FAO aquaculture certification guidelines. However, greater efforts are needed for implementation, especially focusing on small-scale producers in developing regions.

Global efforts needed to reduce eutrophication risks

Global standards should also be developed and agreed to regarding, for example, the facilitation of aquaculture systems that reduce eutrophication risks and other environmental costs while providing income and extended social benefits (Box 12). A global review[31] on integrated mariculture indicated that farming systems such as multitrophic aquaculture may have many advantages including equity aspects, ecological resilience, minimizing environmental impacts, and economic benefits (and therefore be an ideal system for promoting under the EAA). However, there may not be sufficient economic incentives to promote such farming systems over monoculture.

There could also be global concerted efforts to increase attention on mariculture and especially to move aquaculture off the coast. This could represent a significant opportunity to increase fish production while avoiding direct use of freshwater resources and minimizing conflicts with coastal users. The EAA has much to offer to improve the planning and management of the sector and also in assisting in the move farther offshore.[32]

Although this option can reduce many impacts, there are other risks and good governance is required. According to one study,[33] the global offshore mariculture potential is large. However, moving mariculture offshore has a cost, and the use of the marine environment for the production of fish will not increase substantially unless investments are profitable.[34]

Box 12

Farming systems with important social benefits and lower environmental costs

Integrated aquaculture including multitrophic aquaculture is a practice in which by-products (wastes) from one species are recycled to become inputs (fertilizers, food and energy) for another. Fed aquaculture species (e.g. finfish/shrimps) are combined in appropriate proportions with organic extractive aquaculture species (e.g. suspension/deposit feeders, herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweeds).[1] Other such systems include aquaculture–agriculture (e.g. rice–fish/shrimp farming) and aquaculture–silviculture.[2] However, biosecurity considerations must be duly addressed.

Rice–fish farming, common in Asia, is an option that can also have social benefits, provide food security and be environmentally friendly. Although relevant in China,[3] it is unlikely to contribute significantly to aquaculture growth worldwide unless global efforts are made,[4] including technological improvements, greater fish-farming efficiency and better planning of rice/fish farms with more focus on fish production.

Culture-based fisheries[5] as a management option offers the possibility to enhance fish biomass while using the natural food sources in the recipient waterbodies and, therefore, not involving the eutrophication potential of aquaculture systems (especially fed ones). This option can offer huge social and food security impacts and potential for improving local fisheries. However, there are some prerequisites (as for all the above options), including the need to establish in advance the carrying capacity of the recipient waterbody to sustain the introduced fish population and deal with the potential environmental impacts (including genetic ones). This approach also implies the implementation of the ecosystem approach to fisheries to make it truly sustainable in the long term.

[1] Barrington, K., Chopin, T. & Robinson, S. 2009. Integrated multitrophic aquaculture in marine temperate waters. *In* D. Soto, ed. *Integrated mariculture: a global review*, pp. 7–46. FAO Fisheries and Aquaculture Technical Paper No. 529. Rome, FAO. 183 pp. (also available at www.fao.org/docrep/012/i1092e/i1092e.pdf).

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[3] Miao, W. 2010. Recent developments in rice-fish culture in China: a holistic approach for livelihood improvement in rural areas. *In* S.S. De Silva & F.B. Davy, eds. *Success stories in Asian aquaculture*, pp. 15–39. London, Springer. 214 pp.

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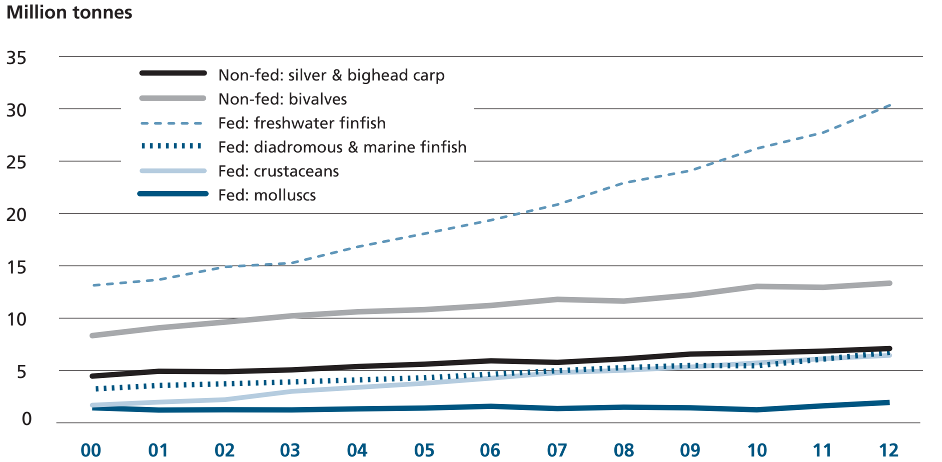
[5] Culture-based fisheries involve the production of seeds in hatcheries and the stocking or restocking of waterbodies and coastal areas. See, for example, a recent review for Central Asia: Thorpe, A., Whitmarsh, D., Drakeford, B., Reid, C., Karimov, B., Timirkhanov, S., Satybekov, K. & Van Anrooy, R. 2011. *Feasibility of restocking and culture-based fisheries in Central Asia*. FAO Fisheries and Aquaculture Technical Paper No. 565. Ankara, FAO. 106 pp. (also available at www.fao.org/docrep/016/ba0037e/ba0037e.pdf).

Figure 47

World aquaculture production, fed and non-fed



Reducing the use of wild fish for aquaculture feeds

Some solutions to reduce the use of fish for aquaculture feeds include the following.

- Increased use of other feed sources: Owing to the high price of and competition for fishmeal, replacement by terrestrial feed sources is the current trend.[35] This has probably also facilitated the increase in farmed herbivorous and omnivorous species, which use much less fishmeal than do carnivorous species per tonne of protein and therefore could be considered more ecofriendly and socially acceptable. However, the availability and price of terrestrial ingredients will also depend on external factors such as freshwater availability. The scenarios and modelling described above are based on the past behaviour of the sector, but tipping points may arise in regard to the availability of terrestrial feed sources.
- Increased use of fish waste: About 35 percent of fishmeal is already produced using fish-processing by-products. Under one of the above scenarios, increased utilization of wastes could significantly increase fishmeal availability and boost aquaculture production. One challenge is the possible ending of restrictions on the use of fish and animal wastes for fishmeal that many countries have. In addition, fishmeal from waste has a lower nutritional value (more minerals and fewer proteins). The model projection without such restrictions increases fishmeal availability by 12 percent by 2030. As a first step, global guidance should be produced on the use of fish waste.
- Greater reliance on extractive species: Aquaculture growth could rely more on extractive species that naturally use available carbon and nutrients, e.g. filter feeders, algae and fish species such as silverhead and bighead carps. This solution has other advantages such as reduced eutrophication potential and contributing to uptake of excess organic matter (especially in the case of algae). However, consumers may not prefer the above species, and recent production trends indicate a progressive emphasis on fed species (Figure 47). In 2012, non-fed species accounted for about 30 percent of culture production worldwide, compared with about 50 percent in 1982. Appropriate awareness campaigns and concerted efforts to facilitate such farming systems could stimulate their increased consumption.
- Promoting herbivorous and omnivorous species: This is partly happening owing to lower feed prices as compared with those for carnivorous species, which explains in part the increased production of tilapia catfish and carps

(although consumer preferences also play a role). However, marine fish farming is dominated by carnivorous species. Therefore, the need to develop and adapt other species for mariculture becomes highly relevant, and investment in research and development should be encouraged.

- Increased investment in innovative technologies: Such technologies include those that produce feed sources for aquaculture (e.g. marine microalgae and bacteria using sunlight and available carbon).[36] Although research institutions and the private sector in developed countries are engaged, more efforts are needed to benefit all fed farming systems and regions. Such innovation could be a tipping point for faster development of mariculture and change the role of some regions such as North America and Europe in global production.

Implementing the EAA at local scales to address constraints to aquaculture growth
The EAA should be applied when planning aquaculture development to explicitly address issues such as the availability of water and space or other external factors such as water pollution and consumer perceptions.

The EAA is also needed to account for the sector's environmental services and minimize its environmental impacts. It can also be useful in implementing biosecurity frameworks and thus help to minimize disease risks, plan the spatial distribution of aquaculture, make carrying capacity considerations, and consider possible impacts on communities' well-being. The implementation of an EAA can significantly improve local acceptance of aquaculture and opportunities for aquaculture to use resources such as freshwater and coastal space.[37]

Development of a spatial plan/design for aquaculture growth and expansion should also be part of the initial planning at the farm/watershed level, based on the ecosystem carrying capacity.[38]

Implementation of the EAA can be best achieved in designated aquaculture management areas. These can be aquaculture parks, clusters or any area where farms share a common relevant waterbody or source and may benefit from a common management system. They must have a management system that strives to balance environmental, socio-economic and governance objectives, and they should consider the sharing of benefits with local communities and their involvement (as appropriate) in the development of a management plan, its implementation and monitoring. Where not directly involved, communities should be informed in a timely manner. The development of management plans for such areas should also consider the impacts of external drivers on aquaculture, e.g. climate change and competition for freshwater.

Regional declines in fish consumption and demand
A priority issue is the projected decrease in fish consumption in Africa, which deserves special attention.

Can Africa increase its fish availability?
Availability of fish from Africa's fisheries could be increased by: (i) rebuilding overfished or depleted stocks and ensuring that small-scale fishers receive sufficient resources; (ii) reducing post-harvest losses; and (iii) ensuring a sufficient portion of small pelagic fish is made available for human consumption. As regards (i), good management is needed to ensure recovery of overexploited and depleted stocks. Globally, good management has been estimated to be able to boost availability from marine capture fisheries by about 20 percent.[39] Applying this percentage to Africa's fisheries, another 1.1 million tonnes of fish might become available. It will also be important to ensure that those fisheries currently exploited by foreign fleets are managed to play a greater role in meeting Africa's food needs. In this respect, governments should more carefully consider allocation of rights and ensure that the small-scale sector, both marine and freshwater, has secure access to resources. In relation to (ii), it is estimated that

25 percent of the fish caught or landed in Africa never reaches consumers' mouths.[40] Adding in fish that loses its nutritional value, an estimated 35 percent of total landings does not benefit the consumer. Improved management of inland fisheries and freshwater resources will further help provide more fish for the continent. Fish stocks in many African waterbodies are declining through a combination of overfishing, invasive species and habitat degradation. The reasons for the decline are complex and interrelated; therefore, addressing them will require a broad, ecosystem approach.[41]

Action is required to improve fish processing and post-harvest practices. Finally, and in relation to (iii) above, the issue of retaining adequate amounts of small pelagic fish for local fishers/consumption has been highlighted in preceding sections. Here, government action is essential as markets are not expected to perform in relation to food security objectives. However, aquaculture certification schemes that consider ethical issues would be of great help.

Aquaculture potential to increase fish availability in Africa

Aquaculture has great potential to help meet fish demand. Current aquaculture development trends in Africa need changing. A stronger focus on increasing sustainable production with an emphasis on supplying local markets should be a goal for national governments, regional institutions and development agencies.

Africa is home to some of the greatest aquatic biodiversity in the world. Thus, it is important to ensure that aquaculture expansion does not threaten the conservation of natural resources for the immediate needs of the users of these ecosystems.

There is increasing consensus that aquaculture in Africa needs to be treated as a commercial activity and that, in order to provide an enabling environment, policy-makers and public-sector personnel need to: understand basic economic and business principles; appreciate the functioning of market mechanisms and business operations; and acquire the skills to design and implement policies and provide assistance and advice that align environmental, social and governance objectives.

Improving the "investment environment" for aquaculture in Africa involves not only opening the door for investors but improving credit and market access for small farmers, as well as their business skills. Seed and feed production needs to be connected to private businesses, also enabling other stakeholders, including women, to link into the value chain.

The market–government interplay is a delicate one, and while the market can provide a boost to the sector, government needs to ensure the provision of goods and services for all today and in the future. Many governments in Africa require some form of EIA of aquaculture businesses. However, EIAs are often perceived as an expensive requirement rather than an investment to guarantee the viability and sustainability of an enterprise. Another issue is boosting aquaculture growth through the use of exotic species, most commonly tilapia nilotica. However, this species can be a threat to biodiversity, fisheries and livelihoods.[42] Some countries have banned the use of exotic species, and this could hinder the development of aquaculture as tilapia nilotica comes with a technology package, improved strains, etc. The implementation of an EAA could offer the possibility to examine the trade-offs and evaluate the costs and benefits (including risk analysis) of using an exotic species, considering both present and future needs from the social, economic and environmental perspective. There is a need to incentivize culture of native species, and greater efforts are needed in terms of research, technologies and business packages to advance such farming. However, domestication and improvement of local strains also brings risks associated with fish escapes for native biodiversity. Therefore, risk analysis, including biosecurity frameworks, must be in place.

In summary, there is a need for increased global support for sustainable development of aquaculture, especially where fish consumption may decrease owing to production gaps and access issues (e.g. Africa and Latin America).

Developing partnerships for sustainable fisheries and aquaculture

An EAF has to consider the negative environmental externalities of fisheries. Often, objectives of conservation groups and fishers are described as diverging and conflicting. However, many examples have demonstrated that sustainability concerns are often shared, and partnerships among stakeholders can generate solutions. These partnerships can more easily develop in an institutional environment that foresees stakeholder participation, where stakeholders are carefully identified (see above).

Examples of successful partnerships range from contribution of data and traditional knowledge by a local group of fishers to more comprehensive forms of partnerships. There are examples of partnerships between small-scale coastal fishing communities and the industrial offshore sector exploiting the same resource. Often, these sectors are in conflict and the decision to favour either of them is a difficult one – the industrial fleet brings cash and foreign exchange for the government while the small-scale sector provides livelihoods, food security and social stability. There are examples of partnerships used to create co-ventures between capital-intensive fleets and community-based fisheries. These have developed thanks to governments creating an enabling environment through the allocation of community quotas.

Integration of fisheries and aquaculture in broader multisectoral management systems

Fisheries issues are generated not only by the sector itself. Natural resources and ecosystems are also suffering from increasing global pressures, including from international trade. This is happening in a context of climate change, which is expected to produce major changes in species distribution and ocean productivity, although little is known about impacts at the regional and local levels. Population growth, with a high percentage living in coastal areas, will increase impacts on the health, productivity and resources of coastal marine ecosystems. More than 60 percent of coral reefs are under immediate threat, 20 percent of mangroves have been destroyed, and high-nutrient waters from land-based activities are increasing oxygen-depleted zones.[43]

Inland fisheries are seldom mentioned when considering increased future supplies of fish and fish products (see section Management of inland waters for fish on pp. 116–121). This is partly because poor information on inland fisheries production makes accurate assessments of status and trends difficult. For example, it is often difficult to know whether changes in production are real or simply a result of changes in reporting. However, it is also because inland fisheries production is largely dependent on factors external to the sector.[44] Such factors are often considered more important than inland fisheries. With agriculture expected to double its current extraction of the world's surface waters by 2050 and dams planned on many large river systems, the prospects for real increased production from inland fisheries will not improve without changes in water management (see p. 120).

Taking an optimistic view, one study[45] estimated that inland fisheries could produce about 100 million tonnes. Although it used dated models, it indicates that inland fishery production can be much higher than the 11 million tonnes officially reported. Stock enhancement practices can contribute to such an increase.

Global predictions about inland fisheries production are vague guesses at best. However, in areas where fishery production is known and water development projects are planned, there is scope for predictions. The EAF/EAA approach also helps in identifying external factors beyond the control of the fisheries and aquaculture authorities and stakeholders. Examples include draining wetlands for agriculture, hydroelectric development, coastal development, and pollution from land-based activities. If any of these are identified as undermining the sustainability of the resource base, links have to be developed with the competent authorities to find ways to mitigate these impacts and/or negotiate trade-offs. For example, fish production could take place at a reduced level in modified habitats that also provide irrigation or electricity (as in the case of the Columbia River, see p. 119). Managing such a fishery under an ecosystem approach would imply engaging with water managers to allow more water to by-pass the diversions or turbines at critical times of year to support the fisheries and modifying harvest quotas in recognition of reduced production potential.

In light of the fact that many of the most serious impacts on inland fisheries and aquaculture originate outside the sector, there is a need to address these external factors and develop integrated management plans accordingly.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

The above projections of fish supply and demand can provide valuable guidance for policy- and decision-making, both for governments and civil society. However, the uncertainty that characterizes the models has to be recognized. This uncertainty stems not only from the quality of data available but also from the inherent complexity of the systems modelled, and the validity of the assumptions. The projections should not be seen as prophecies but rather as starting points from which to act to improve policy-making and planning.

Presenting the results of the FAO modelling is intended to become a standard feature of the Outlook section. The various scenarios serve as "sensitivity analyses" to the model assumptions. For example, in the Fish to 2030 model, to achieve higher fish consumption in Africa, improved fishery management rather than aquaculture development is cited. However, one assumption in the Increased Aquaculture Scenario is that production per feed input will remain constant, and this may not be the case. Improvements in feed formulation, feeding technologies, farm management and selective breeding will increase production output per feed input. Both improved fishery management and aquaculture technology will play a role in improving fish consumption, provided appropriate governance structures are in place to assist and protect small-scale operators. The new format for the Outlook section will enable more in-depth examination of the models to assist in improving projections and in identifying areas for possible intervention.

The steering of fisheries and aquaculture development through good management and, more broadly, good governance is essential in order for the sector to contribute to meeting the demand for fish, including in a way that is environmentally sustainable and contributes to reducing food insecurity and poverty. This can only be achieved if ecological, social and economic sustainability concerns are addressed in an integrated way, and the EAF/EAA provides a practical framework to enable managers and stakeholders to do so. In addition, the sector has to be integrated in multisectoral management. This is particularly important in the context of ensuring that water resources are available for both inland fisheries and aquaculture; none of the scenarios examined water availability issues.

The aquaculture sector warrants special attention if it is to provide most of the increase in fish production. Its continued growth has to be directed in a way that is environmentally sustainable, also in relation to required inputs, and to ensure that increased fish supply will also sustain those who are most dependent on fish for food and livelihoods. To this end, it is highly desirable that appropriate international mechanisms, instruments and standards on responsible fisheries and aquaculture be developed and agreed to by the international community.

NOTES

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Food and Agriculture Organization of the United Nations

OUR PRIORITIES

The FAO Strategic Objectives

HELP ELIMINATE HUNGER, FOOD INSECURITY AND MALNUTRITION

MAKE AGRICULTURE, FORESTRY AND FISHERIES MORE PRODUCTIVE AND SUSTAINABLE

REDUCE RURAL POVERTY

ENABLE INCLUSIVE AND EFFICIENT AGRICULTURAL AND FOOD SYSTEMS

INCREASE THE RESILIENCE OF LIVELIHOODS TO DISASTERS

2014

The State of World Fisheries and Aquaculture

Opportunities and challenges

The fisheries and aquaculture sector – a vital source of livelihoods, nutritious food and economic opportunities – has a key role to play in meeting one of the world's greatest challenges: feeding a population set to rise to 9.6 billion people by 2050. This issue of *The State of World Fisheries and Aquaculture* reveals how aquaculture is continuing its impressive growth, in both increased quantity and improved quality. However, to meet rising demand from a growing population, the sector as a whole needs to increase production sustainably and reduce wastage in a context of climate change, greater competition for natural resources, and conflicting interests. Improved science, technology and governance are all combining with greater global understanding and commitment to help meet the goals of responsible and sustainable use of aquatic resources. In efforts to boost the supply of fish and fishery products, innovative approaches that adopt ecosystem approaches and safeguard social rights aim to secure valuable resources for the benefit of present and future generations.

This edition uses the latest available statistics on fisheries and aquaculture to present a global analysis of the sector's status and trends. It also discusses wider related issues such as shark conservation and management, post-harvest losses in small-scale fisheries, and management of inland waters for fish. Selected highlights provide insights on specific topics such as tenure governance and utilization of fisheries by-products. Finally, the document explores the outlook and approaches for meeting future fish demand.

To cite
FAO. 2014.
The State of World Fisheries and Aquaculture 2014. Rome. 223 pp.

ISBN 978-92-5-108275-1 ISSN 1020-5489
9 789251 082751
I3720E/1/04.14